

# OPERATION & MAINTENANCE MANUAL

**For Motor Technical / Service related query address your enquires at :**

Addl. General Manager  
Industrial Machines Sales Division  
Bharat Heavy Electricals Ltd.  
Piplani, Bhopal (M.P.) - 462 022  
Tele fax : 0755-4201653  
webistie : [www.bhelbhopal.com](http://www.bhelbhopal.com)

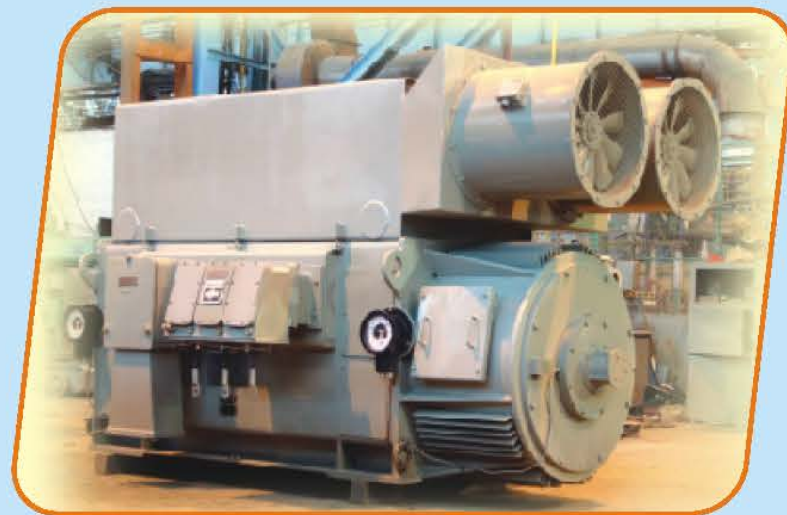
**For motors price quotation address your enquires at :**

Addl. General Manager  
Industry Sector  
Integrated Office Complex  
Lodhi Road, New Delhi - 110 003  
Fax : 011-24365367

**For motors spares quotation address your enquires at :**

Addl. General Manager  
Electrical Machine Repair Plant  
Plot No. D/1, Cross Road-C  
Road No. 16, MIDC, Andheri (East)  
Mumbai - 400 093  
Tele fax : 022-28364587

Note :- Product development & improvement are our continuous endeavour, hence the product may slightly differ from that indicated in this manual



Printed at : Anupam Mudran # 9425025574



**SLIP RING INDUCTION MOTORS**



**Bharat Heavy Electricals Limited**

PIPLANI, BHOPAL (M.P.) - 462 022



INDUSTRIAL MACHINES SALES DIVISION

**Bharat Heavy Electricals Limited**

BHOPAL



## INDEX

		Page No.
<b>CHAPTER - 1</b>	<b>DESCRIPTION OF MACHINE</b> Introduction, Ventilation/Cooling Arrangement, Stator frame and Winding, Rotor and rotor winding, Slip rings, Brush holders, Carbon Brushes, Bearings, Terminal Boxes, Anti Condensation Heating Description, Coolers Construction, Operation and Maintenance, Resistance Temperature Detector.	5-26
<b>CHAPTER - 2</b>	<b>RECEIPT, INSPECTION AND STORAGE</b> General Instructions: General, Inspection, Short Term Storage, Long Storage, Care of Bearings.	27-28
<b>CHAPTER - 3</b>	<b>INSTALLATION</b> Terminal box Check, Measuring the insulation resistance and Drying of windings, Polarization Index Check, Drying Out Procedure, Drying Methods.	29-34
<b>CHAPTER - 4</b>	<b>OPERATION</b> Commissioning Instructions.	35-36
<b>CHAPTER - 5</b>	<b>MAINTENANCE</b> Inspection Schedule, Slip Ring Maintenance, Filter Cleaning Instruction, Rolling Contact Bearings Maintenance, Maintenance of Sleeve Bearings.	37-45
<b>CHAPTER - 6</b>	<b>DISMANTLING AND REASSEMBLY PROCEDURE</b> General, Sequence of Dismantling, Dismantling of Other Parts/Assemblies, Reassembly.	46-48
<b>CHAPTER - 7</b>	<b>FAULT DIAGNOSIS CHART</b>	49-50
<b>CHAPTER - 8</b>	<b>PRESERVATION MEASURES</b>	51-52
<b>CHAPTER - 9</b>	<b>SAFETY PRECAUTIONS</b>	53
<b>CHAPTER - 10</b>	<b>ENVIRONMENTAL GUIDELINES</b>	54
<b>CHAPTER - 11</b>	<b>LIST OF RECOMMENDED SPARES</b>	55-57
	<b>NOTES</b>	58-60

## MOTOR DESCRIPTION

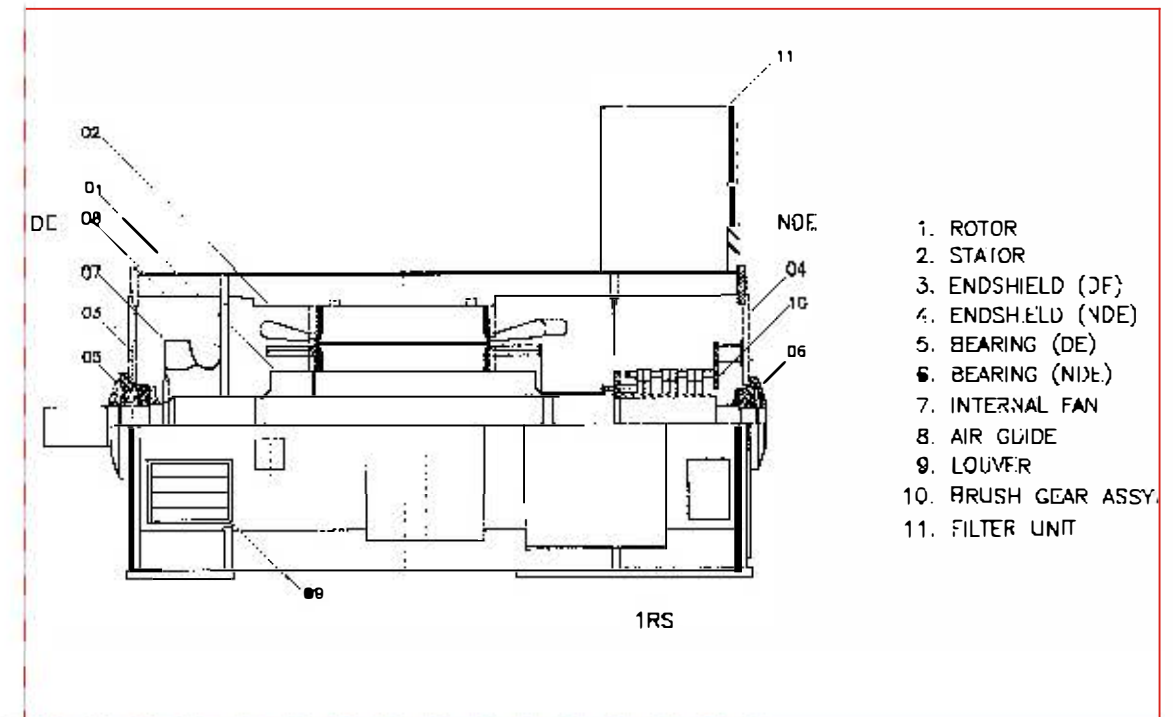
### 1.1 Introduction :

This O & M manual gives description of Open type and Closed type 3-phase Slipring Induction motors. Open type motors conforming to IP23 protection have frame designation beginning as "1RS" and Closed type motors conforming to IP44 / IP54 / IP55 protection have frame designation beginning as "1RB or 1RR or 1RU or 1RE, 1LS, 1RC". These motors generally comply with all relevant Indian and International Standards on rotating electrical machines like IS326, IEC 34. The machines can be suitable either for horizontal mounting (B3) or vertical mounting (V10).

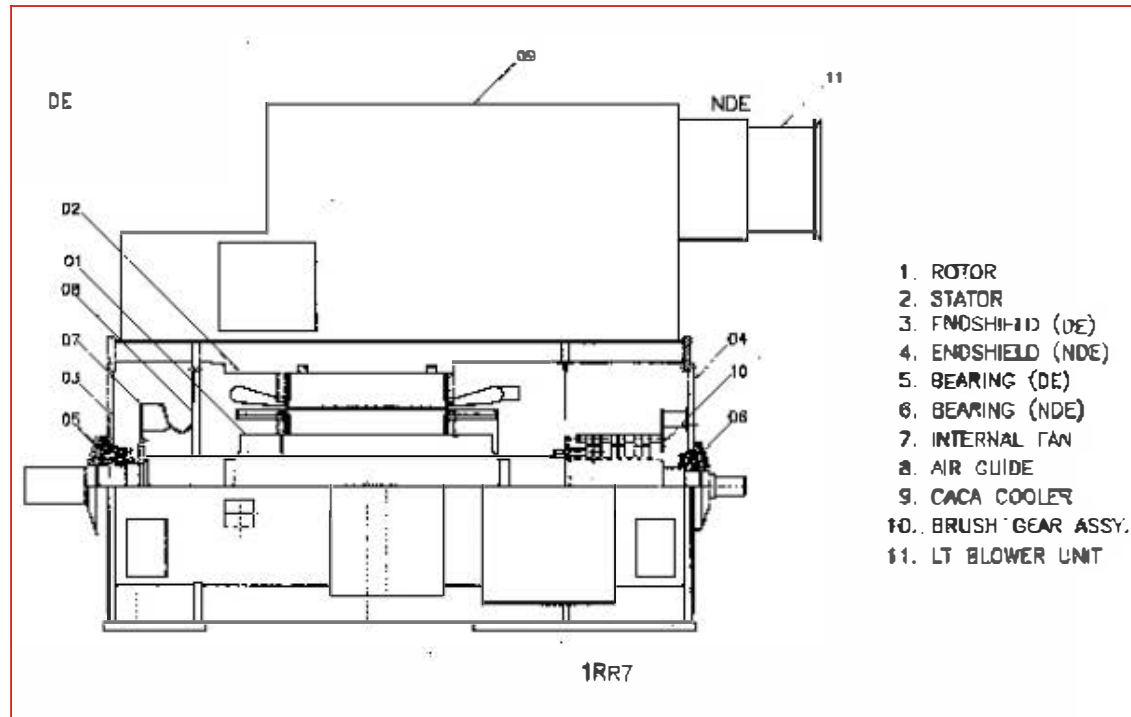
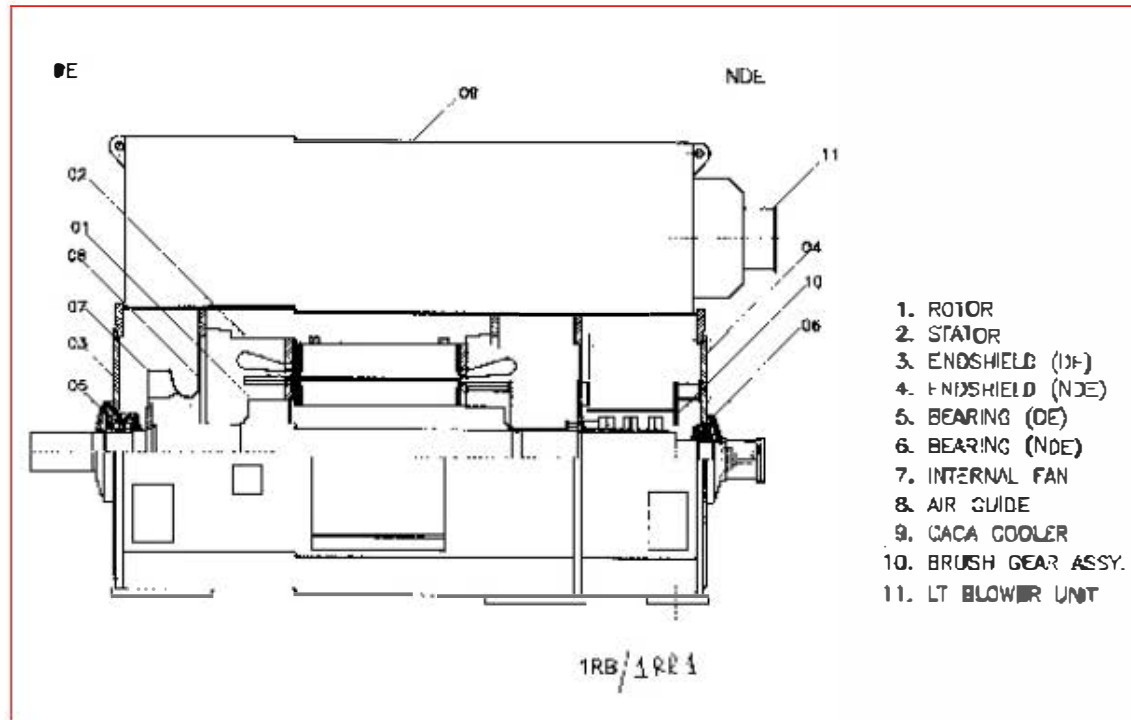
This manual enables user to know the machine in respect of construction, storage, operation and maintenance of motors of this type having a wide range of output from smallest to highest frame. To know external dimension details & performance parameters of any specific motor, user has to refer to Outline Drawing & Technical Data sheets submitted by BHEL.

### 1.2 Ventilation / Cooling Arrangement:

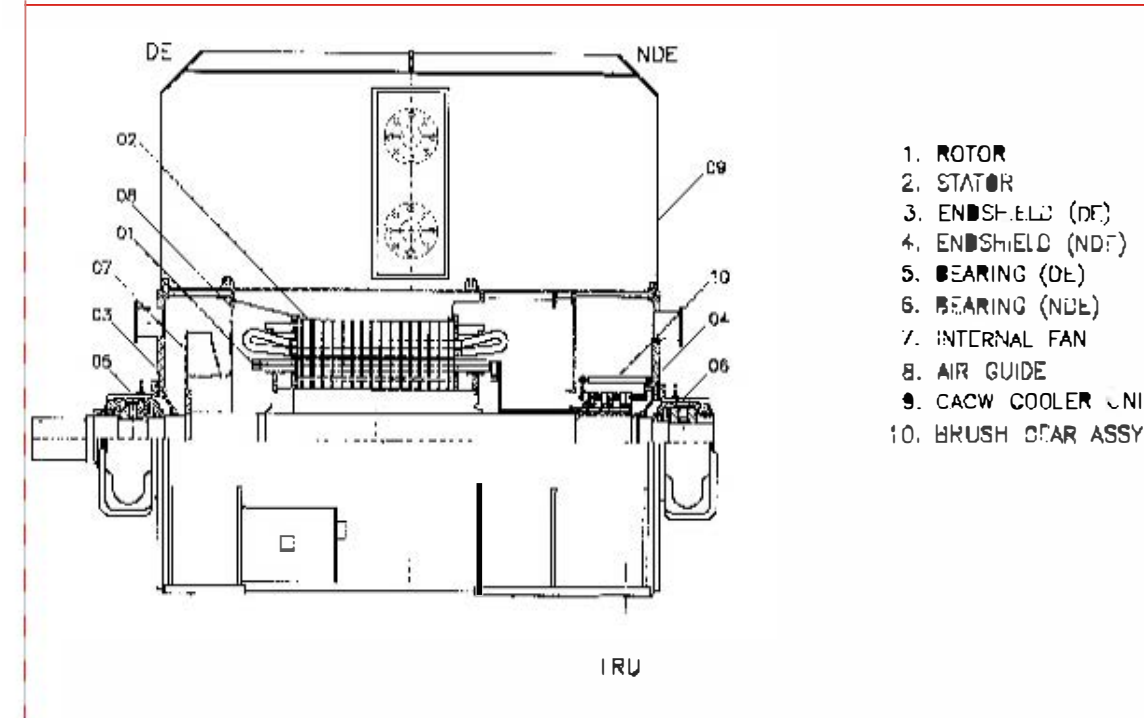
Open type motors (1RS) have a single shaft-mounted fan which draws atmospheric air into the motor through louvers and filter at one end and, after cooling the core and windings, forces the air out of the motor at other end.



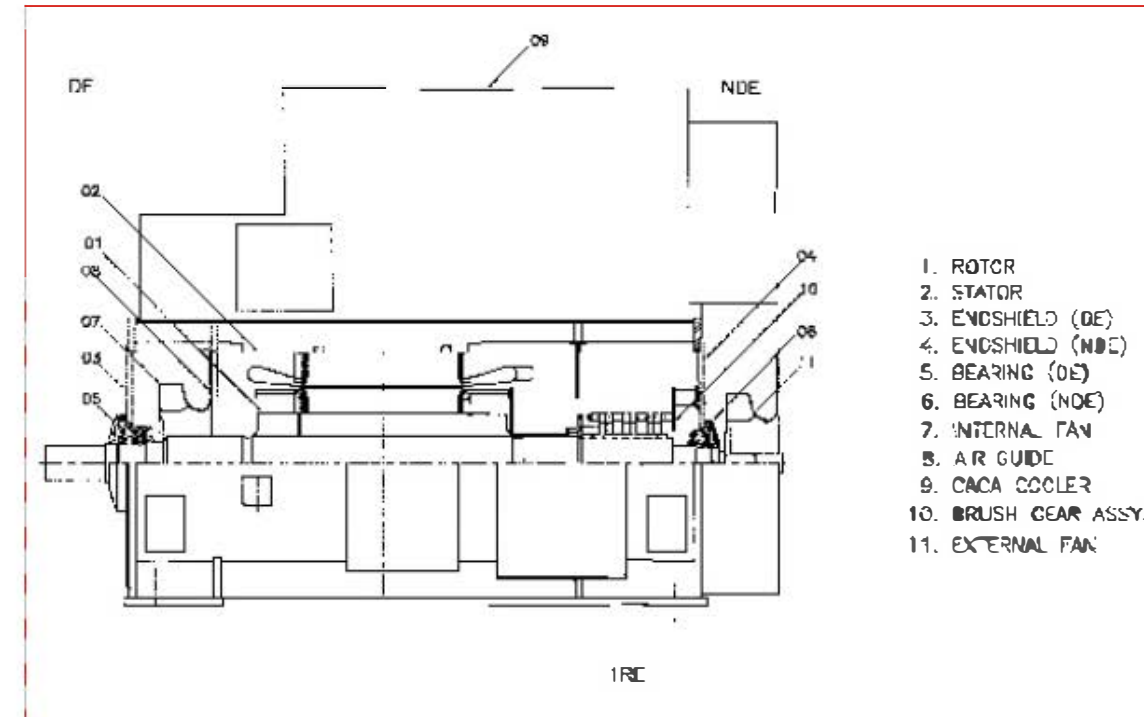
Closed type motors 1RB / 1RR have a shaft-mounted fan for internal air circulation. These will also have an air-to-air heat exchanger mounted externally on to motor frame. In addition to main motor shaft-mounted internal fan, these will also have LT motor driven fan to force external atmospheric air thro' the externally mounted heat exchanger.



Closed type motors 1RU has a shaft-mounted fan for internal air circulation. It also has an air-to-water heat exchanger mounted externally on to motor frame.

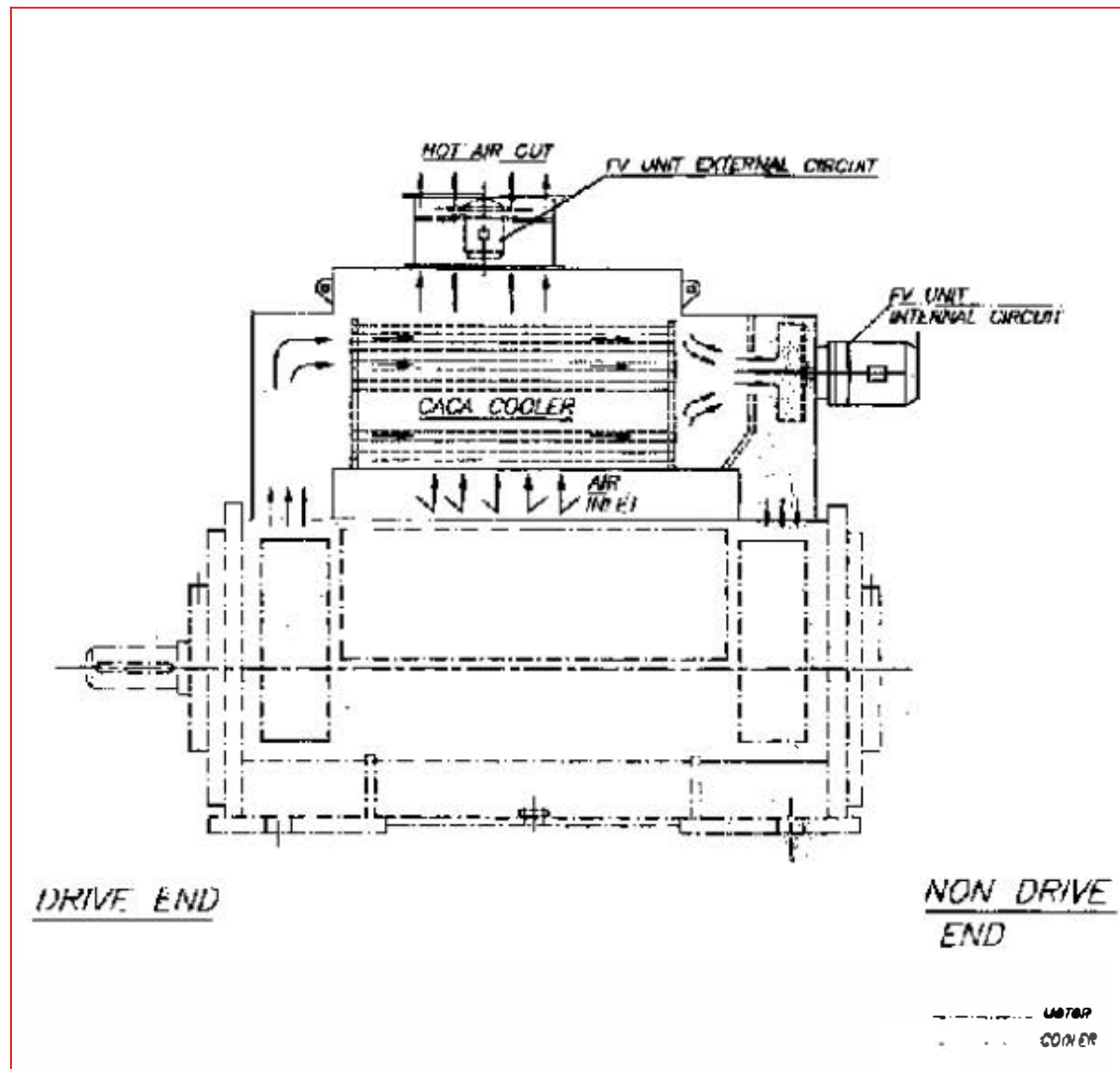


Closed type motors 1RE has two shaft-mounted fans, one for internal air circulation and the other for external atmospheric air circulation. These will also have an air-to-air heat exchanger mounted externally on to motor frame



Closed type motor 1RC has LT blower motors both for external and internal air circuit.

The shaft-mounted internal fan will usually have a fixed direction of rotation only. Fans suitable for both directions of rotation can be provided if specifically ordered.



### 1LS motors

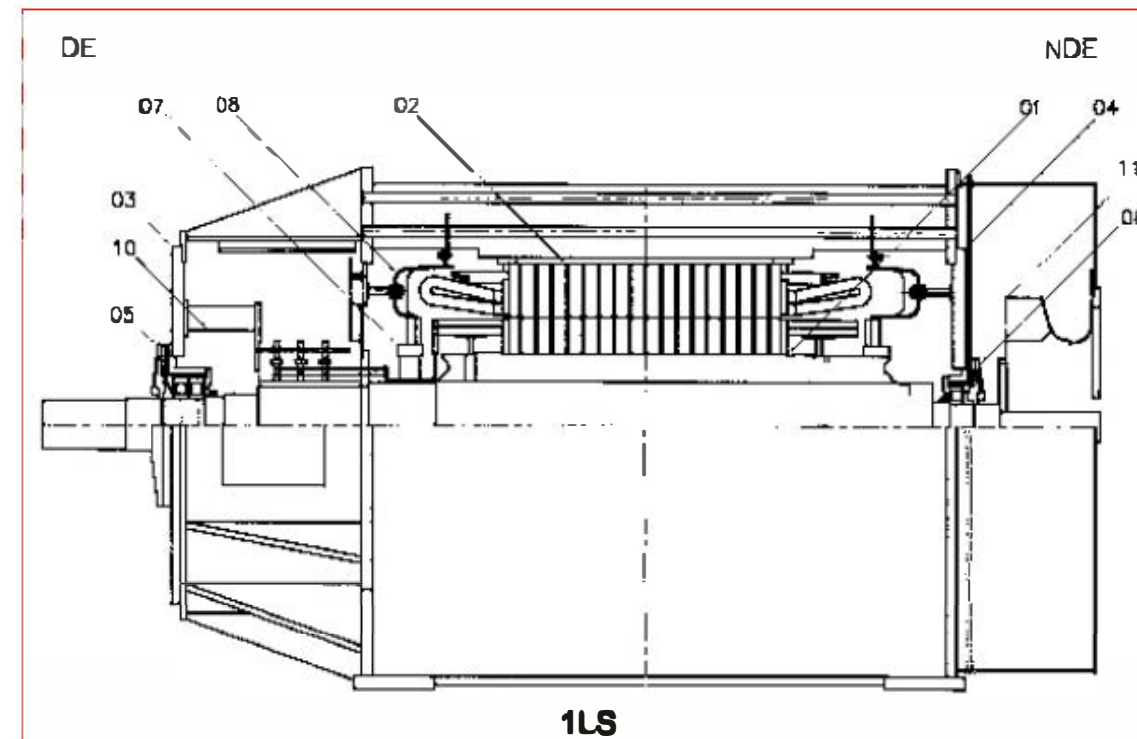
Totally enclosed tube ventilated motors

These machines have closed-circuit cooling with a concentric tube nest cooler, which is integral with the frame, and with shaft-mounted fans (external fan, slip ring compartment fan and two main compartment fans).

The external fan is normally unidirectional, but a bidirectional variant can be fitted if specially ordered.

The external fan is located in the fan shroud on the nondrive end and forces the atmospheric air through the cooling tubes of the stator frame and subsequently past the external fins of the slip ring compartment housing.

The two internal fans in the main compartment cause the primary air to circulate in two symmetrical sub-circuits. Circulation is intensified by the radial ducts in the laminated rotor core. The primary air circulates through the end windings and the ducts in the core packs and carries the heat loss to the cooling tubes.



1. ROTOR
2. STATOR
3. ENDSHIELD (DE)
4. ENDSHIELD (NDE)
5. BEARING (DE)
6. BEARING (NDE)
7. INTERNAL FAN
8. AIR GUIDE
9. CACW COOLER
10. BRUSH GEAR ASSY.
11. EXTERNAL FAN

### 1.3 Stator frame and winding

The stator frame is of welded construction. The stator core pack is fitted centrally in the stator frame and secured against rotation and displacement.

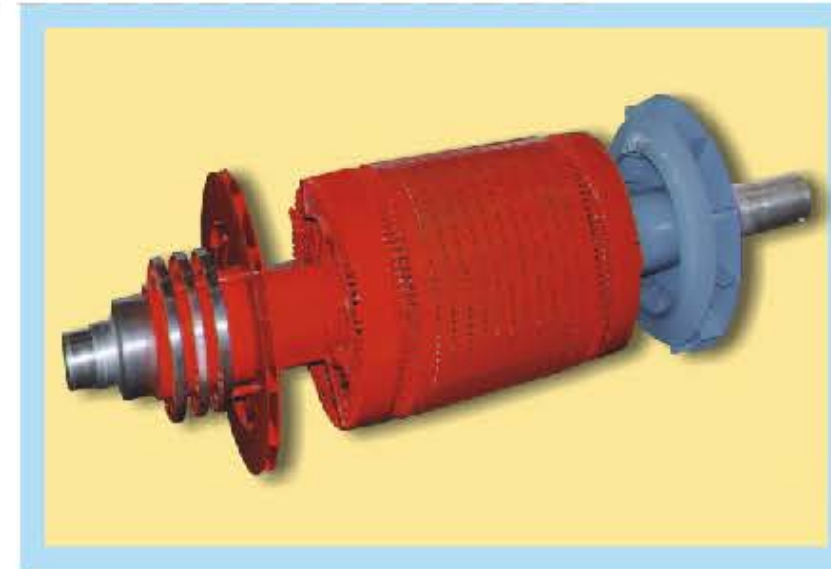
The stator winding of the HV machines is a double-layer coil winding and is provided with MICALASTIC® insulation complying with class F insulation requirements. This insulation system is based on integrated mica and is made by a special synthetic resin impregnation process. The insulation possesses high electric strength, high resistance to moisture and aggressive gases and vapors, excellent mechanical stability and long life.



### 1.4 Rotor and rotor winding

The shafts have two journals (drive end and non-drive end) and a cylindrical shaft extension at the drive end. A second shaft extension may be provided at the non-drive end. The laminated rotor core is pressed onto the shaft, clamped and secured against axial displacement, and carries the rotor winding.

The winding bars are provided with an insulating layer, inserted in the slots of the rotor core and connected into a winding by brazing. The end windings are reinforced against the centrifugal forces by banding with fiber glass tape. The rotor winding is impregnated with synthetic resin and subsequently cured at increased temperature. The rotors are dynamically balanced with half key inserted in the keyway of the shaft extension.



### 1.5 Slip rings

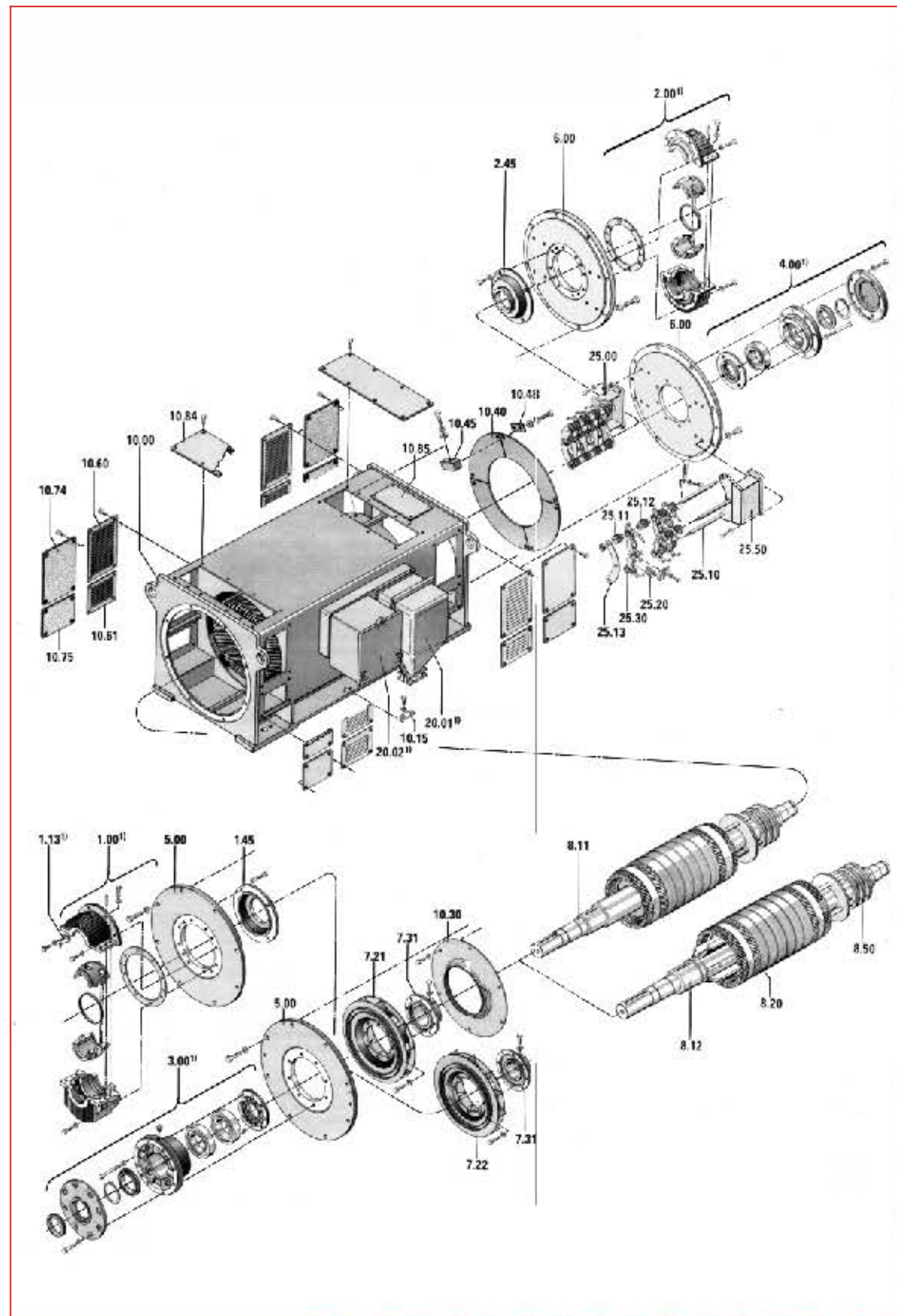
The slip ring assembly consisting of slip rings and an insulated hub is connected to the rotor winding by means of insulated conductor bars and connecting bolts.



### 1.6 End shields

The end shields at the drive and non-drive ends are disk shaped and arranged for taking the bearing assembly which is appropriate for the type and type variant of the machine. Bolted to the inside of the end shield are the brush-holder supports with the brush-holder and brush assemblies.

## EXPLODED VIEW OF MOTOR



1.00	Sleeve bearing Drive End	10.48	Straps
1.13	Pointer (in case of two sleeve bearings without axial location)	10.40	Airguide wall
1.45	Sealing cover	10.45	Fbding supports
2.00	Sleeve bearing Non Drive End	10.60	Hooded-louver plate
2.45	Sealing cover	10.81	Hooded-louver plate
3.00	Rolling-contact bearing unit (locating bearing)	10.74	Side cover with gasket
4.00	Rolling-contact bearing unit (floating bearing)	10.75	Side cover with gasket
5.00	End shield Drive End	10.84	Top cover with gasket (insulators)
6.00	End shield Non Drive End	10.85	Top cover with gasket
7.21	Fan impeller unidirectional	20.01	Stator terminal box complete
7.22	Fan impeller bidirectional	20.02	Rotor terminal box
7.31	Fan hub (with parallel key)	25.00	Brush Gear Unit
8.11	Solid shaft	25.10	Isolation Bolts with Insulation
8.12	Spider shaft	25.11	Outer spacing bushes
8.20	Rotor core with winding	25.12	Inner spacing bushes (insulators)
8.50	Slip ring assembly	25.13	Bracket with rule
10.00	Stator frame (with core and winding)	25.30	Clamping brush holder
10.15	Clamping strap for earthing	25.20	Carbon brushes
10.30	Air guide wall Drive End	25.50	Support

### 1.6 Brush holders, carbon brushes :

The brush-holders guide the brushes in the preset position relative to the slip rings and ensure the necessary contact pressure.

In machines without brush-lifting gear, i.e. with brushes in permanent contacts, one or two blocks of clamping type brush-holders in V arrangement are provided over or at the sides of the slip rings.

### 1.7 Bearings :

Depending on the design and the operating conditions specified in the order, the machines are fitted with grease-lubricated rolling-contact bearings or with sleeve bearings with or without forced-oil lubrication.

Sleeve bearings of machines with brushes in permanent contact are of the floating type without axial restraint. Axial restraint for the rotors of such machines must be provided from the locating bearing of the driven machine via a suitable coupling having limited play.

For a full description and special instructions, reference should be made to the supplementary instructions.

### 1.8 Terminal boxes :

The electrical connections of the stator and rotor windings are made in separate terminal boxes. Any auxiliary circuits for functions such as anti-condensation heating, temperature monitoring, etc. are connected in additionally fitted auxiliary terminal boxes. The terminal boxes at least comply with degree of protection IP 54 to IS-325 or IEC 34-5.

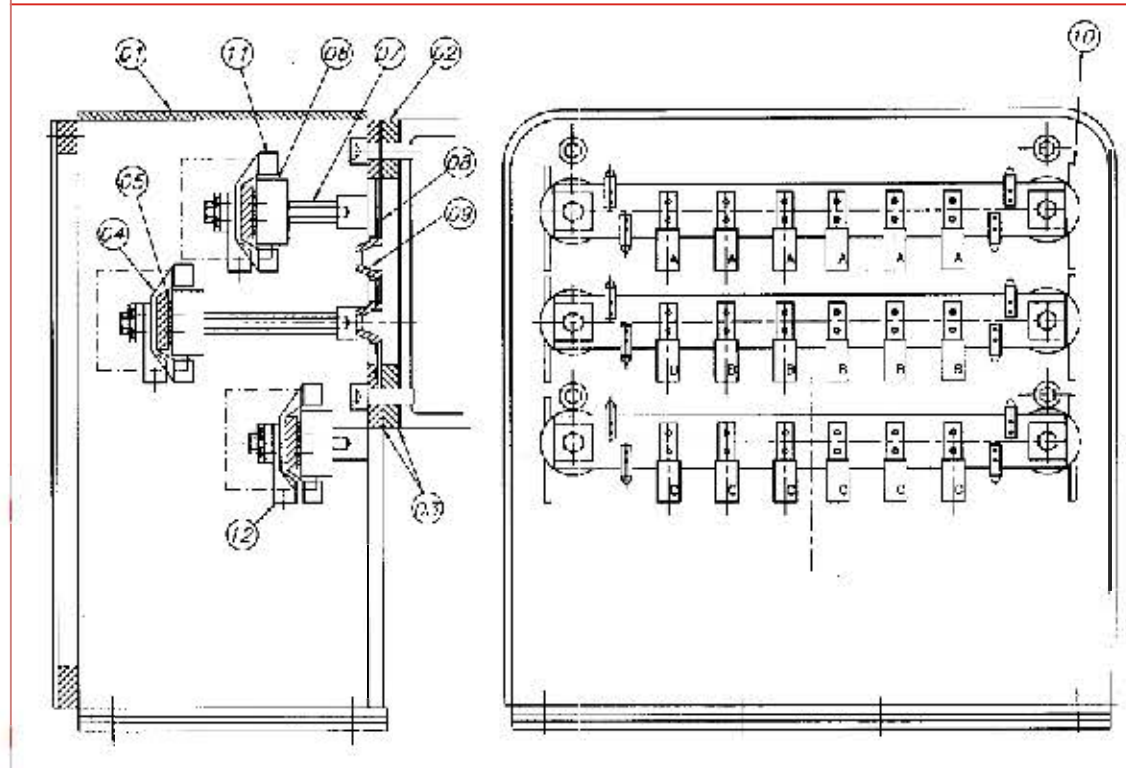
The number, location and type of terminal boxes can be seen from the dimension drawing of the machine; the kind, circuit arrangement and connections of the main and auxiliary circuits are documented in the accompanying circuit diagrams.

### 1.8.1 Rotor Terminal Box Arrangement

Rotor Terminal Box is fitted to the machine for making connection to the starting system, may be Liquid rotor starter or Grid Resistance starter. The cables coming externally from starting device and internally from motor rotor are terminated in this Box.

The connection between the motor rotor and external cables is made on the Bus Bar (Item 4). Three such bus bars are provided: one for each phase. On each of these bus bars a total of six external cables can be connected. The Bus bar is supported on the Insulated pin assembly (Item 7).

#### ROTOR TERMINAL ARRANGEMENT



ITEM	DESCRIPTION
01	TERMINAL BOX
02	ADAPTOR PLATE
03	GASKET
04	BUSBAR
05	BUSBAR STIFFENER
08	INSULATOR PIN ASSY.
07	STUD BOLT
06	SEALING PLATE
09	GROMMET
10	END BARRIER
11	MOTOR TERMINAL
12	CUSTOMER TERMINAL

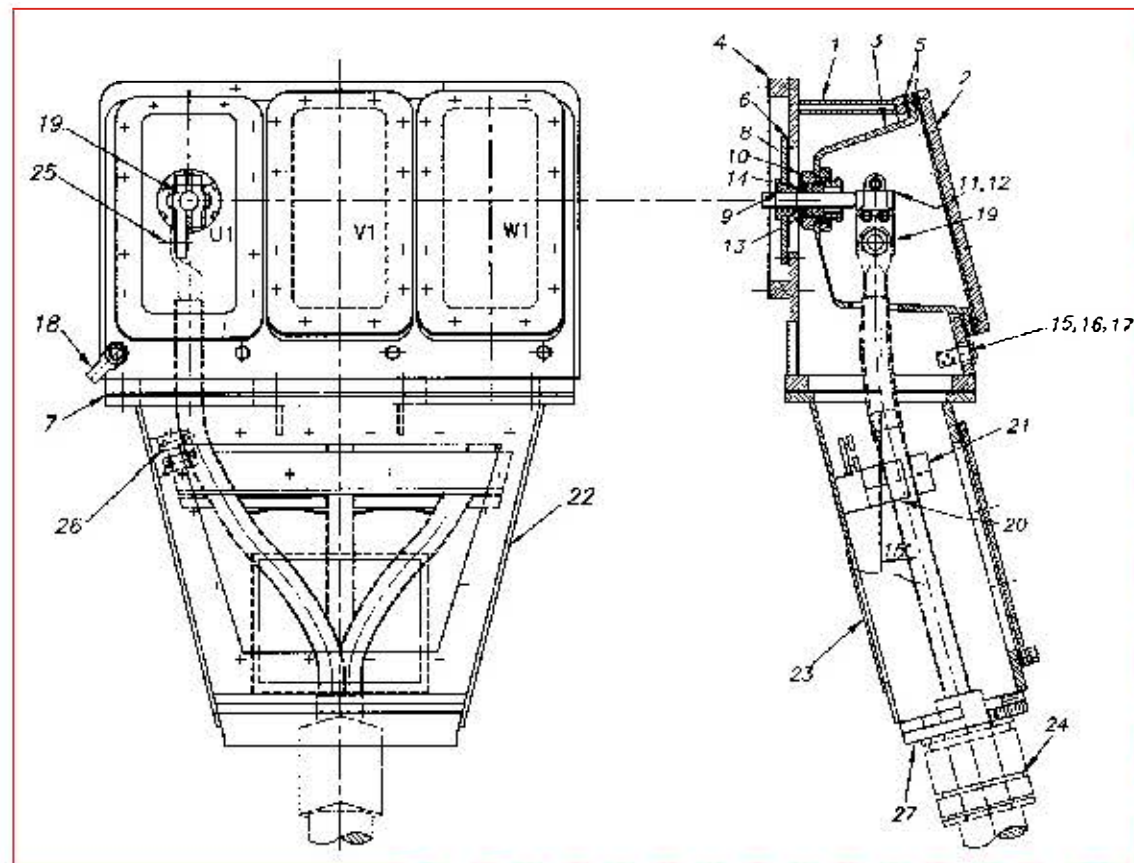
## STATOR TERMINAL BOX AND ARRANGEMENT (For High Voltage Motors)

### 1.8.2 Phase-Segregated Terminal Arrangement:

When a high fault capacity Phase-Segregated Terminal Box is fitted to a machine connected to a high fault level system, the incoming supply cables should be terminated in the sealing chambers and not in the Terminal Box itself. The connection between the motor and supply cable tails is by means of split cable clamp (19) provided along with the box. The cable tails terminate with copper ferrules (11) and a set of 3 ferrules is supplied for fitting to the tails of the incoming supply cables. It is normal to leave a 3 mm gap between the clamped tail cable ends. If desired the clamps and ferrules from both motor and supply cables can be omitted and the joints made by crimped connectors.

Each terminal box is provided with three desiccators (15.) on examination, the desiccators when dry, show the inner ring of the indicator to be blue in color. If this inner ring show up pink in contrast to the blue outer ring, the desiccators will have to be dried out and refitted...

### PHASE SEGREGATED TERMINAL ARRANGEMENT



### TABLE OF FITTINGS

IT. NO.	DESCRIPTION	MATERIAL
01	Terminal box	Steel
02	LID	Stl. with FRP Lining
03	Joint Box	FRP Moulding
04	Gasket	Neoprene Rubber
05	Gasket	Neoprene Rubber
06	Gasket	Neoprene Rubber
07	Gasket	Neoprene Rubber
08	Sealing Plate	Bakelite paper board
09	Grommet	Neoprene Rubber
10	Gland Part	Nylon
11	Ferrule for stator cable	Copper
12	Filler Pin	Steel
13	Gland Bush	Synthetic Rubber
14	Split Washer	Bakelite Fabric Board
15	Desiccator	Assy
16	'O' Seal	Synthetic Rubber
17	Retaining Bush	Steel
18	Tub. Socket (for 14#) Earthing Pad (For MS Flat)	For Earthing Copper
19	Terminal Connector (Split cable clamp)	Brass
20	Bottom Clamp	Epoxy Glas Mat Laminated Sheet
21	Top Clamp	Epoxy Glas Met Laminated Sheet
22	Trifurcating Box	Steel
23	Explosive Vent (Relief Vent)	Bakelite Board
24	Double Comp. Type Cable Gland	Brass Nickel Plated
25	Bolt M16 with locking plate	Steel
26	Earthing Pad	Steel
27	Gland Plate	Steel

### 1.8.3 Phase-Separated Terminal Arrangement:

When a high fault capacity Phase-Segregated Terminal Box is fitted to a machine connected to a high fault level system, the incoming supply cables should be terminated in the sealing chambers and not in the Terminal Box itself. The connection between the motor and supply cable tails is by means of terminal connector (19) provided along with the box. The cable tails terminate with copper ferrules (11) and a set of 3 ferrules is supplied for fitting to the tails of the incoming supply cables. It is normal to leave a 3 mm gap between the clamped tail cable ends. If desired the clamps and ferrules from both motor and supply cables can be omitted and the joints made by crimped connectors.

Each terminal box is provided with three desiccators (15.) on examination, the desiccators when dry, show the inner ring of the indicator to be blue in color. If this inner ring show up pink in contrast to the blue outer ring, the desiccators will have to be dried out and refitted.

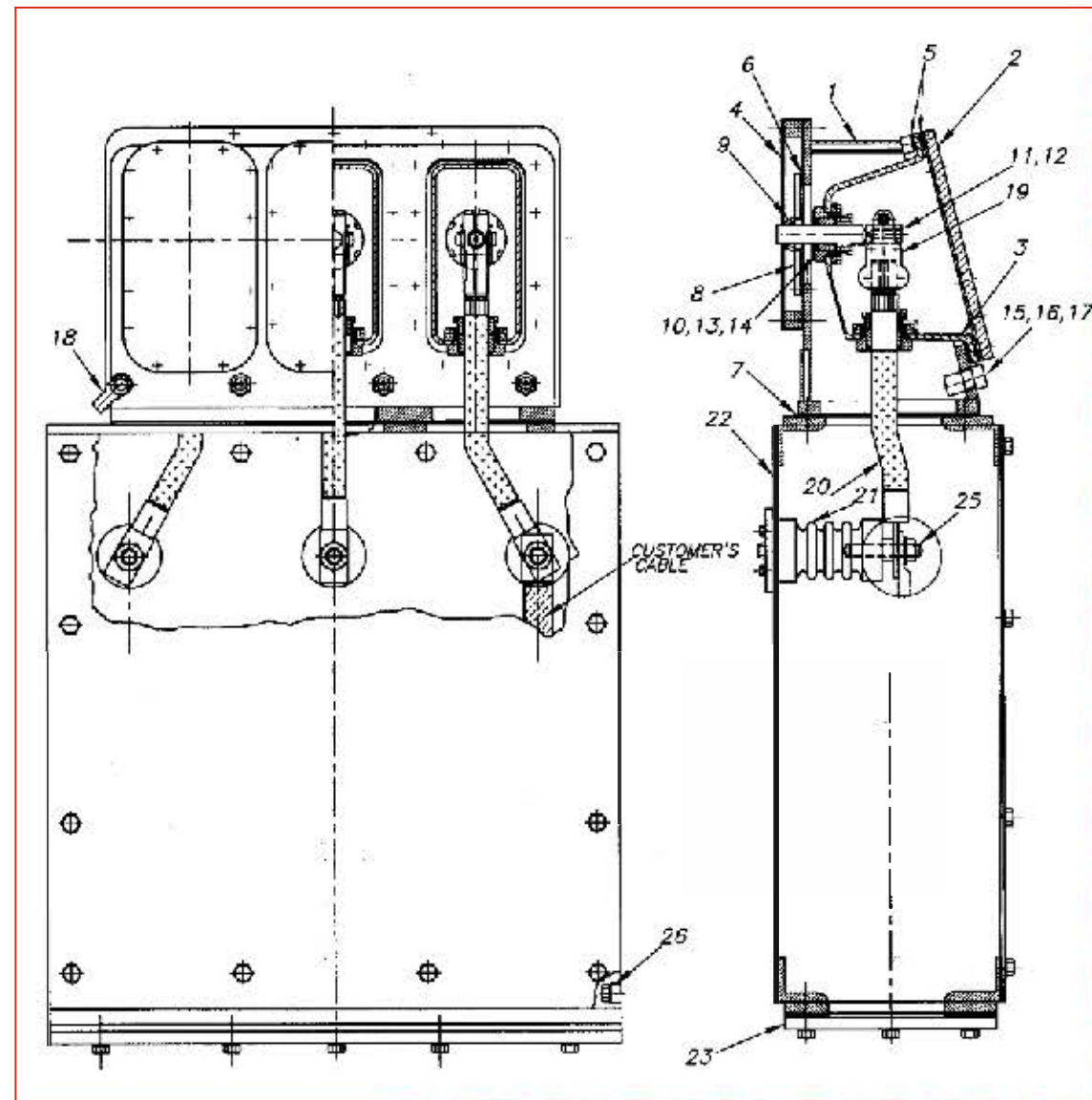


TABLE OF FITTINGS		
IT. NO.	DESCRIPTION	MATERIAL
01	Terminal box	Steel
02	LID	Stl. with FRP Lining
03	Joint Box	FRPMoulding
04	Gasket	Neoprene Rubber
05	Gasket	Neoprene Rubber
06	Gasket	Neoprene Rubber
07	Gasket	Neoprene Rubber
08	Sealing Plate	Bakelite paper board
09	Grommet	Neoprene Rubber
10	Gland Part	Nylon
11	Ferrule	Copper
12	Filler Pin	Steel
13	Gland Bush	Synthetic Rubber
14	Split Washer	Bakelite Paper Board
15	Desiccator	Assembly
16	'O' Seal	Synthetic Rubber
17	Retaining Bush	Steel
18	Tubler Socket (for ø14) Earthing Pad (For MS Flat)	For Earthing Copper
19	Terminal Connector	Brass
20	Tail Cable (95 Sq. mm.)	Copper
21	Insulators	Porcelain
22	Trifurcating Box	Steel
23	Gland Plate	Staal
24	Double Compression Type Gland	Cast Brass
25	Bolt	Steel
26	Earthing Pad	Steel

## 1.9 Anti Condensation Heating Description

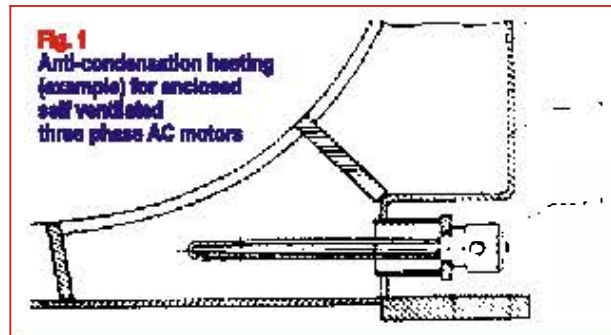
### Application :

Anti condensation heaters fitted in motors warm the air inside the stationary machine above that of the surroundings, thus effectively preventing moisture condensation.

### Installation :

Depending on the size and type of the machine the anti-condensation heater consists of two or more heating tubes connected together. They are combined to form units which are normally built into the stator frame on the drive and non drive ends.

For these motors Immersion heater screwed into the stator frame so as to be accessible from the outside (Fig. 1) are used.



### Heating tubes :

The heating tubes have a heating conductor which is embedded in insulating material and arranged inside a corrosion-resistant metal tube. The tube ends are sealed to prevent the ingress of moisture.

### Connecting :

The heater connections are brought to terminals which are located in a separate terminal box in the case of high-voltage machines.

Connection must be made in accordance with the diagram shown in the terminal box. Examine the rating plate or the dimension drawing to see that the voltage and the power of the heating agree with the mains supply. The supply connection of the heaters must be interlocked with the main breaker of the machine to ensure that the heaters are switched off when the machine is running and switched on once the machine has come to standstill.

## 1.10 CACACoolers

### 1.0 Introduction :

The cooler consists of a bank of tubes. Tube ends are held in tube plates. On inlet end, air equalizer chamber is provided. In this chamber air either from LT blower or shaft mounted fan comes before entering cooler nest. The tubes are secured in the tube plates by roller expanding. The arrangement provides for flow of cooling air from atmosphere through tubes whereas hot air present inside the motor, flows over the tubes in a cross flow manner. The tubes are pitched/spaced to give the most efficient performance. The efficiency and high quality of these units are the result of careful designing and

proportioning of the cooling surface. This ensures the required duty under prevalent operating conditions at minimum running costs. A careful selection of materials and craftsmanship ensures a product capable of trouble free service.

### 2.0 Construction :

The cooler consists of cooler housing, tube nest and fan motor unit. In some designs polyester fibre filters are also provided in the cooler for arresting carbon dust.

#### 2.1 Cooler Housing :

This consists of sheet metal walls which are fabricated & substantially stiffened. One side of frame acts as flange with required arrangements for fixing the cooler on the stator frame.



#### 2.2 Tubes :

The tubes is of robust construction. Tube ends are roller expanded into tube plates with adequate expansion length to prevent leakage.

#### 2.3 Fan Motor Unit :

LT motor with axial fan unit of suitable power rating is provided at one end of the cooler to facilitate the flow of secondary air through cooler tubes.

### 3.0 Maintenance :

3.1.0 Coolers should be inspected at regular intervals of time. The effectiveness of coolers will be reduced if there is tube choking. If unit is allowed to run under above condition, loss of performance will result which will eventually necessitate complete overhaul. Therefore, it is necessary to clean the cooler tubes regularly.

#### 3.2.0 Dismantling of Cooler :

Remove the coolers from the stator frame by removing bolts fastening them. Due care to be exercised before dismantling as explained at chapter 6 on "Dismantling and reassembly procedure."

#### 3.3.0 Cleaning of Tubes :

For the removal of deposits from the inside of tubes in a straight portion only brushing with bristle of soft brass wire brushes/nylon brushes usually give satisfactory results.

#### 3.4.0 General Instructions :

- DO's**
- (1) Cooler should be periodically cleaned.
- DON'TS:**
- (1) Do not use hard wire or steel brushes for cleaning the tubes.
  - (2) Do not take the cooler out from the stator frame unless essential for maintenance.

#### 4.0 Trouble Shooting :

FAULT	PROBABLE CAUSE	REMEDY
Insufficient cooling of machine	1) LT motor not working	1) Attend LT motor
	2) Tubes dirty	2) Clean the tubes
	3) Air Filter choked	3) Clean the filter

#### 1.11 CACW Coolers

##### 1.0 Introduction :

The cooler consists of a bank of tubes. Tube ends are held in tube plates on which inlet, outlet and return and water boxes are mounted. The tubes are secured in the tube plates by roller expansion. The arrangement provides for flow of cooling water through tubes whereas hot air flows over the finned or wire wound tubes in a cross flow manner. The tubes are pitched/spaced to give the most efficient performance. Water boxes are internally divided to provide multiple water passes. The efficiency and high quality of these units are the result of careful designing and proportioning of the cooling surface. This ensures the required duty under prevalent operating conditions at minimum running costs. A careful selection of materials and craftsmanship ensures a product capable of trouble free service.

##### 2.0 Construction :

The cooler consists of tube nest, tube plates, water boxes and casing plates.

##### 2.1 Tubes :

The tubes have crimped fins or copper wire wound all over, in the form of loops and is of robust construction. The basic tube material can be changed to suit cooling water chemistry. Tube ends are roller expanded into tube plates with adequate expansion length to prevent leakage.

##### 2.2 Tube Plates :

Tube plates are placed between water box and at the tube ends.

##### 2.3 Water Boxes :

Water boxes are either cast or fabricated from steel plates and are amply proportioned to reduce turbulence and pressure drop. These are divided internally into suitable compartments for requisite number of water passes. The thickness of water boxes includes a generous corrosion allowance.

Two flanged connections are provided in the inlet/outlet end water box for inlet and outlet of cooling water. Water boxes are provided with the air vent, drain valves and lifting



arrangement also.

#### 2.4 Casing Plates :

The casing plate consists of top & bottom segments which are fabricated & substantially stiffened. The holes have been made in the stiffeners for lifting of cooler. One side of frame acts as flange with required no. of holes & cutouts for fixing the cooler on the stator frame.

##### Important :

3.1 Air in the system encourages corrosion and causes pulsating and non-uniform flow. Pipe layouts, therefore, should be planned to avoid air locks. It should be ensured that the cooling water supply is under positive pressure so as to flood the unit under all operating conditions.

3.2 When coolers are operating in parallel, provision should be made for regulating the flow through various coolers and account should be taken of the variation in pressure losses through difference in the length of piping.

3.3 The cooling water should be reasonably clean and free from suspended solids. When the water contains suspended solids, a suitable strainer should be used.

##### 4.0 OPERATION:

##### 4.1 INITIAL START-UP

4.1.1 Flush the entire system thoroughly, including piping.

4.1.2 Prime tube side, release entrapped air by opening vent cocks and ensure elimination of all air pockets. Care should be taken to open inlet valves gradually to avoid water hammer.

4.1.3 The flow of water should be controlled by regulating the valve at the outlet while inlet valves are kept fully open in general. Never throttle inlet valves for this purpose.

##### 4.2 NORMAL OPERATION:

##### 4.2.1 DOS :

1) Regulate cooling water to maintain required water flow by regulating outlet valves only.

2) At the start up, operate vent cock so that water inside is free from air. Coolers should be immediately isolated, whenever leaky tube is detected. It should be repaired at the first opportunity.

3) Keep a continuous watch on cooling water and air temperature to assess the performance of the cooler.

5) In case of tube leakage, cooler should be isolated and replaced by spare cooler. However 10% plugging of tubes is possible before tube replacement.

6) Ensure spare cooler is hydraulically tested before use.

##### 4.2.2 DON'TS:

1) Never throttle inlet valve to control the flow of fluids.

2) Never allow the cooler to run with entrapped air in the circuit.

- 3) Never allow the cooler to contain stagnant water in the tubes during shut downs.
- 4) Never run the cooler if the cooling water leakage is suspected.

### 5.0 Maintenance :

5.1 Coolers should be inspected at regular intervals of time. The effectiveness of coolers will be reduced if there is deposition inside the tubes or tube choking. If unit is allowed to run under above condition, loss of performance will result which will eventually necessitate complete overhaul. Therefore, it is necessary to clean the cooler tubes. The period between successive cleaning will depend upon the cleanliness of the cooling water and the surrounding atmosphere. Hence the actual time can be determined from experience only and at least once in a year.

### 5.2 Dismantling of Cooler:

Cut-off the water supply by closing the appropriate valves. Drain tube side of cooler by operating drain plug. Disconnect piping connected to cooler. Remove the coolers from the stator frame by removing bolts fastening them. To dismantle the water boxes from tube nest, remove nut of bolts fastening the water box with tube plate and nut of studs fastening the water box with tube plate and frame. Ensure the breaking of joint seal of tube plates & water box flange with the help of forcing screws, screwed in the water box flange.

### 5.3 Cleaning of Tubes :

#### 5.3.1 External Surfaces :

The outside surface of air cooler tubes should first be cleaned with compressed air, then it should be washed with clean water. Compressed air should be passed over the cooler tubes after washing to dry out the cooler's tubes. Finally clean with cleaning solvent.

#### 5.3.2 Internal Surfaces :

For the removal of deposits from the inside of tubes in a straight portion only, brushing with bristle of soft brass wire brushes/nylon brushes usually give satisfactory results. Clean water should be passed inside the tubes after above cleaning.

If the deposits found are in the form of hard scale which can not be brushed off easily, it may be necessary to resort to chemical treatment.

### IMPORTANT:

Chemical treatment should be done only under the supervision of a chemist who will decide the nature and strength of cleaning solution suitable for particular kind of scale present. Remove the tube nest if cleaning with chemical solution is required. Ensure that after cleaning, all traces of cleaning solution are removed before reassembly.

### 5.4 Testing for leakage :

Pressurize the water boxes with clean water at test pressure to locate leaking tubes by watching on the air side.

### 5.5 Plugging of tubes :

If a cooler tube is found leaking, it should be sealed by inserting taper turned wooden plugs tightly at both ends of defective tubes. Never use metal plugs.

### IMPORTANT:

Hydrostatic testing should be conducted at 10 kg/cm<sup>2</sup> for 30 minutes after the tube holes have been plugged. If the tube plate to water box joint is found leaking, the corresponding joint should be replaced.

In clean coolers it is possible to plug up to ten percent of tubes without effecting performance. However, when this stage is reached it is necessary to replace tubes.

### 5.6 General Instructions :

#### DO's

- (1) Replace the CAF gaskets between tube plate and water box whenever re-assembly of water box is done.
- (2) Replace defaced and worn out fasteners.
- (3) Hydrostatic test of cooler should be conducted once in every year to check the leakage of tube.
- (4) Leaking tubes should be plugged as temporary measure by inserting taper turned wooden plugs tightly at each end and can be replaced during shutdown if desired.
- (5) Hydrostatic test should be conducted after plugging the leaking tubes.
- (6) Use forcing screws for breaking joints.
- (7) Cooler should be periodically cleaned.

#### DO NOTS:

- (1) Do not use the old gaskets.
- (2) Do not plug leaking tubes with parallel plugs.
- (3) Do not use hard wire or steel brushes for cleaning the tubes.
- (4) Do not resort to chemical cleaning without consulting the chemist.
- (5) Do not take the cooler out from the stator frame unless essential for maintenance.
- (6) Do not use levers under tube plate to break the joint. This may damage the tube plate surface and may cause leakage during operation.

## 1.12 Resistance Temperature Detector Stator Winding

### Description :

The temperature of the stator winding is monitored by resistance thermometers embedded in the stator winding to protect the winding against thermal overloads.

Thermal overloading means a prolonged excess temperature which may destroy the winding insulation or considerably reduce the life of the insulation.

If the winding temperature at the points where the temperature sensors are installed reaches or exceeds the permissible limit value an alarm signal is given or the machine shut down automatically, depending on the temperature attained.

The bifilar thermometer resistor is wound on a core, covered with glass fibre tape and potted in cast resin, and thus has a high mechanical strength. The temperature sensors are installed in separators of the stator winding. Replacement of the sensors would be difficult.

The number of sensors and their distribution over the slots in the stator core are indicated in the dimension drawing.

The connecting leads of the temperature sensors are taken to an instrument terminal box. The circuit arrangement and the terminal connections can be seen from the diagram shown in the instrument terminal box which forms part of the dimension drawing of the machine.

### Commissioning :

Before commissioning the machine. Check all the leads for correct connection by reference to the circuit diagram.

### Important:

The maximum load permitted for the resistance thermometers Pt 100 ( $100^\circ$  at  $0^\circ\text{C}$ ) is 10 mA. Only use a single button Wheatstone bridge for testing.

### Note :

The temperature monitoring system of the stator winding does not provide complete thermal protection for the entire machine. Owing to the different time constants, parts of the rotor winding may assume a high temperature earlier than the measuring points in the stator winding under conditions of rapidly varying loads.

## CHAPTER 2

## RECEIPT, INSPECTION AND STORAGE

### General Instructions

The rotor of the Machine is locked in position for transport by a shaft block to prevent damage to the bearing. Do not remove this shaft block until the transmission element is fitted. Other measures may be necessary in special cases if the machine is to be transported after the transmission element is fitted.

Machines of vertical type of construction should be transported in a vertical position. In exceptional cases in which machines with angular-contact ball bearings have to be transported horizontally, lock the rotor by a shaft block before carefully moving the machine into a horizontal position. When setting down the machine, make sure that a safeguard is provided to prevent it rolling away, also ensure that the machine is set down squarely only on the flanges of the stator frame because the shell is not designed to take the full weight of the machine. If a machine is not put into service immediately after arrival, store it in a dry, vibration-free room.

### 2.1 General

The machines have been carefully inspected and packed before leaving the factory. After receipt the machine should be removed carefully from its packing and examined thoroughly to see if damage has occurred in transit. Ensure that all parts and accessories are in accordance with packing slip and in proper condition. In the event of any damage or loss in transit the carriers and manufacturer should be advised in writing within the stipulated period.

If goods sent overseas are received in damaged or incomplete condition the communication either to the Insurance Company or to ourselves should be accompanied with surveyor's report and the photographs or other useful evidence.

### 2.2 Inspection

After unpacking the machine should be cleaned to remove all dust and remnants of packing materials and all parts should be inspected thoroughly to ensure that nothing has become loose or detached due to vibrations or interference during transit.

### 2.3 Short Term Storage

If the motor is not to be installed for about 6 months it should be stored in clean, dry and covered area which is not subjected to large variation of temperature.

The condensation of moisture on windings lowers the insulation resistance. This should be avoided. Space heaters are intended to be in operation whenever the motor is switched off and subject to moisture and condensation.

Ensure that all covers are fitted intact and nothing is left open on the frame. Protective axial locking cover on shaft extension should be used to prevent damage to shaft extension.

### 2.4 Long Storage

On arrival of motor at the destination, packages should be examined to determine whether moisture of any kind has entered. After unpacking the machine should be cleaned and thoroughly inspected to see that nothing is loose or detached due to vibration or interference during transit. If the package seems undamaged, it is reasonable to expect that the enclosed machine will be dry.

Measure the insulation resistance of winding by means of megger. If, it is less than specified value than the motor should be dried out as detailed Section 3. If, it is suspected that moisture of any kind has entered into the motor winding then the motor should be dried out irrespective of IR value to earth.

The motor should be stored in clean, warm, dry and sheltered building. Humid surroundings must be avoided. Failure to do so may lower the insulation resistance. The storage room should be well ventilated and reliably protected against ingress of atmospheric sedimentation.

Earthen floors shall not be used. Relative humidity of air should not exceed 70% and the temperature not below + 10 deg C. There shall be no sharp variations in the relative humidity and the temp of air conditions.

No chemicals, acids, alkalis or storage batteries shall be stored in the same location with motors. It is necessary to cover the motor with thick water proof polythene covers with silica gel placed inside. The condition of silica gel for indication of presence of moisture should be checked periodically.

The motor should not be placed on a vibrating floor or in closed proximity of vibrating machinery. If this cannot be avoided, then the motor should be placed on thick blocks of rubber or felt and the shaft turned through a quarter of revolution each week. Space heaters should be put ON whenever motor is idle and is subjected to moisture and condensation.

Ensure that all covers are fitted intact and nothing is left open in the frame. Protective axial locking cover on shaft extension should be used to prevent damage to shaft extension. It is to be removed only for turning the shaft through a quarter of revolution as described above and then put back in position.

The bearing should be re-lubricated if the time between delivery and commissioning of the machine is more than 4 years, assuming that they have been stored in favorable conditions (i.e. in a dry, dust and vibration free room) or more than 2 years they have been stored in unfavorable conditions.

## 2.5 Care of Bearings

### Stationary Vibration

If a machine fitted with roller bearings is subjected to continued vibration for long period while stationary, damage to the rollers and races may be caused by fretting corrosion (commonly called "Stationary Vibration", "Static Vibration Marking" or "False Brinelling").

The following precautions should therefore be taken :-

- (a) Machines fitted with roller bearings should not be allowed to stand on vibrating floor during storage or operation, if this can be avoided.
- (b) If storage on a vibrating floor cannot be avoided, the machine should be placed on thick blocks of rubber, cork or felt, and the rotor turned through about a quarter of a revolution each week. If a shroud/shaft locking device is fitted, it should be temporarily removed and refitted.
- (c) When a machine fitted with roller bearings is installed as a stand by and is subjected to the adverse condition referred to above, IT IS ESSENTIAL that the rotor be turned as stipulated in (b) above.
- (d) Similar damage to rollers and races sometimes occurs in transit, particularly on board ship. When machines are sent abroad the first recommendation given in note (b) above should be observed.

## INSTALLATION

### General

Remove the shaft block, if provided. Adhere to the instructions attached to the shaft extension and shown in the terminal box. The rotor has been balanced dynamically with a half feather key fitted in the shaft extension.

For transport, the feather key in the shaft extension is locked to prevent it from falling out. Operation of the machine without fitted transmission element is not permissible.

Align the machine carefully and accurately, balance the elements to be fitted on the shaft to ensure smooth and vibration-free running. Place thin shims under the feet, if necessary, to prevent the machine from being subjected to strain. Transmission elements must be fitted and removed only by means of suitable tool. If the shaft end of the machine faces vertically upwards, make sure that water is prevented from entering the upper bearing.

If a belt drive is used install the machine in such a manner that it can be shifted on its base (e.g. on slide rails) to permit the correct belt tension to be adjusted and the belt to be re-tensioned. Excessive belt tension may result in damage to the shaft and bearings. Attention is invited to the measures necessary to prevent contact with rotating parts (couplings, belt pulleys, etc.)

Examine the rating plate data to see that they agree with the power circuit to which the machine is to be connected. Select the size of the supply cable as required for the particular current rating. Connect the supply-cable conductors in accordance with the diagram shown in the terminal box.

With pole changing motors with old terminal designations according to VDE570, the indices of terminal designations in the sequence a, b and c indicate rising speeds steps.

Note the direction of rotation specified for the particular plant (non-reversing lock, for instance). Interchanging two supply phase connections in the terminal box can reverse the direction of rotation.

### 3.1 Check to see before closing the terminal box that

- ! The interior of the terminal box is clean and free of cable residue;
- ! All terminal screws or bolts are firmly tightened;
- ! The minimum clearances in air are maintained (more than 10 mm for 500V, more than 14 mm for 1 kV, and more than 60 mm for 6.6 kV, note any projecting wire ends).
- ! Unused entry openings are closed off with the plugging elements firmly screwed-in;
- ! For maintaining the degree of protection, all sealing surfaces of the terminal box are in order, if sealing of the joints is effected by metal to metal joints only, these surfaces should be cleaned and thinly re-greased.

Before starting and during operation make sure that all relevant safety regulations are complied with.

### 3.2 Measuring the Insulation resistance and Drying of windings

Before commissioning and after long periods of storage or stand-still, the insulation resistance (1 minute value) of the windings to the frame must be measured with DC voltage.

The limit values of minimum insulation resistance and critical insulation resistance (for measurement at a ambient winding temperature approx 25 deg C) and for measuring voltage can be derived from following table depending on rated voltage of machine.

	LIMIT VALUE FOR MACHINE	
	Rated Voltage <2 KV	Rated Voltage >2KV
Measuring Voltage	≤500 V DC (Min. 100V DC)	>500 VDC (Min. 1000 V DC)
Minimum Insulation Resistance of new, cleared or repaired winding	10 MΩ	100 MΩ
Critical specific Insulation Resistance after long periods of operation	0.5 MΩ / KV	5 MΩ /KV

Dry new winding have insulation resistance values between 100 megaohm to 2000 megaohm or higher. If the insulation resistance value is in the region of minimum value, damp and/or dirt can be the cause. If the insulation resistance falls below the minimum value the cause must be established and the winding dried. The insulation resistance for clean winding is largely depended on temp. As a general thumb rule, for each 10 deg C rise in temperature IR value falls by half.

During operation the insulation resistance of winding may decrease as a result of environmental and operating condition. The critical specific insulation resistance at ambient winding temperature of approx 25 deg C can be measured/checked depending on rated voltage using above table. If the value is above the critical value, machines can be operated further. If the value is reached below the critical value, winding must be thoroughly cleaned and dried.

### 3.3 Polarization Index Check

The polarization Index (PI) is a figure of merit for dryness and cleanliness of the winding insulation. PI is ratio of two measurements of insulation resistance taken at specified time interval employing the same measuring condition (identical winding temperature and identical measuring voltage).

The procedure for evaluation of the winding condition on the basis of polarization index in order to determine whether drying is necessary or not is given below :

$$PI = \frac{IR \ 10 \ \text{Min}}{IR \ 1 \ \text{Min}}$$

### Evaluation of Insulation Condition based on PI

Insulation Condition	Based on PI	Drying
Hazardous	< 1	Mandatory
Bad	1-1.5	Mandatory
Doubtful	1.5-2	Recommended
Adequate	2-3	No
Good	3-4	No
Excellent	> 4	No

Sometimes in new or completely rewound machines, the 1 minute IR value is very high (of the order of 5,000 MΩ or above) though PI may be marginally less than 2. In such cases, it is recommended that if PI value is between 1.5 & 2, the machines can be commissioned and run on load. Generally in epoxy based insulation systems, IR value establishes after prolonged running of machines. PI shall improve and be more than 2 after prolonged runs.

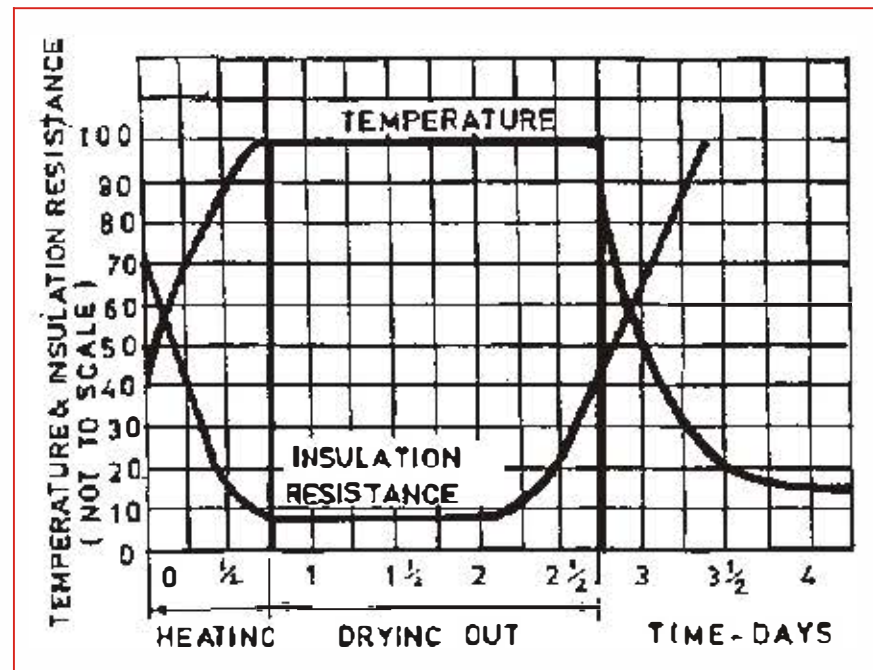
Drying is also necessary when in spite of adequate polarization index and insulation resistance value moisture is visible on the winding.

### 3.4 Drying Out Procedure

Extreme dampness will cause reduction of insulation resistance. New machine which have been standing idle for few weeks or more may need drying out. Particularly if they have been subjected to wide and rapid temperature changes or have been in wet or humid surroundings. For ex. setting concrete quite often results in extreme humidity.

The time required for drying out depends upon the initial degree of dampness and may extend from one day to several days. Out of several drying out processes which ever process is selected, it is essential that the heating process is continuous and that the temperature is maintained constant at a value sufficiently high to ensure drying out but not so high that the insulation is damaged. A suitable temperature for drying out is 60 deg C to 70 deg C measured by using built in slot resistance thermometers.

The temperature of the windings must not be raised faster than a few degree per hour (say max. 10 deg C) in order to prevent damage from differential thermal expansion. It will generally be found that at first as the temperature of the winding increases, the insulation resistance decreases until a minimum value is reached. This is due to a redistribution of the moisture in the winding and the drooping temperature resistance characteristics of the insulation.



It is for these reasons that it is essential to maintain a constant temperature during the plotting of drying out curves a few degrees fall in temperature may give a misleading rise in the value of the insulation resistance.

If the temperature is allowed to fall considerably, re-absorption of moisture will take place. After a lengthy period during which the insulation resistance will remain practically constant at the minimum value, it will commence to rise steadily until a maximum value is reached indicating that the machine is practically dry and ready for service.

A typical curve showing variation of insulation resistance with respect to temperature and time (when in the operation of drying out) clearly shows how the insulation resistance first decreases for initial heating and becomes minimum and remain for long time till it further increases to a maximum value after lapse of certain time (refer sketch).

During operation also the insulation resistance of the winding may decrease as a result of environmental and operating conditions. The critical value of the insulation resistance at a winding temperature of 25 degree C can be calculated depending on the rated voltage as mentioned earlier in this article.

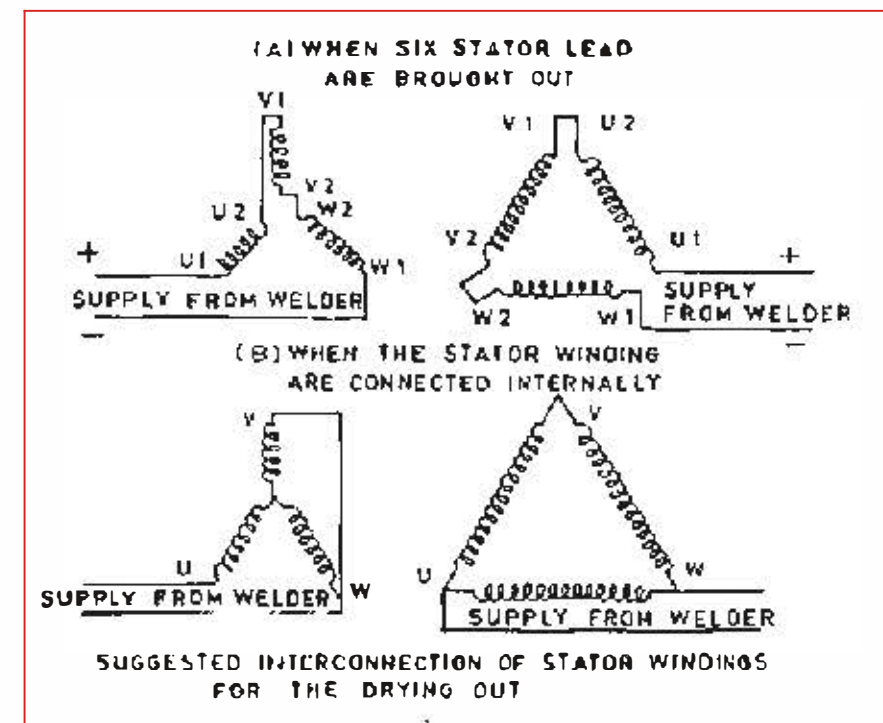
If the measured insulation resistance value is above the calculated critical figure during operation, the machine can still operate further. However the winding must be dried if the IR value falls below the specified values. For the machines in operation the IR value should usually be checked after appropriate short intervals.

### 3.5 Drying Methods

For the purpose of drying winding, heat can be applied in three ways:

- By producing heat losses in the machine itself i.e. by operating the machine on short circuit.
 

Avoid temperature variations during the drying process. With totally enclosed machines, provision should be made (by removing covers etc) to permit the moisture to escape and for clean and dry air to enter. Where a drain plug is provided for water condensation on the underside of the motor, the same should be opened.
- By feeding current from external energy sources to produce heat losses in the windings e.g. with the aid of welding sets or controllable high current rectifiers.
- By providing a flow of hot air after suitably covering with tarpaulins. With all these methods some air circulation must naturally be provided to allow the moisture to escape. The magnitude of the current in the winding or the quantity of heat applied should be controlled so as to fulfill the requirement i.e. starting with low values and regulated according to temperature rise. Winding cable leads in terminal boxes should be cleaned with dry rags before drying.



During short circuit drying rotor is blocked to avoid rotation. Apply a balanced three phase very low voltage (about 10% of normal stator voltage) supply across stator terminals. In the first 6 to 8 hours (depending on size of the machine) increase the stator current from about

0.5 times the rated current to a value such that the winding temperature does not exceed 80 degree C. Monitor the progress of drying process by repeated measurement of insulation resistance and also observing the winding temperature.

If DC welding sets are to be used for drying machine windings certain precautions must be taken before connecting them. Because there is no ventilation, adjust the maximum permissible current for winding phase to lower than 0.5 times the rated current. Connect the individual phases of the winding either in series or parallel. With series connection, connect the individual phases unsymmetrically (e.g. plus to U1, U2 to V1, V2 to W2, W1 to minus) in order to keep axial magnetic flux in the shaft low.

Where the neutral point is not brought out, two phases must inevitably be parallel and connected in series to third phase (see sketch). Change the connection order about every hour so that the winding is evenly heated. Measure the insulation resistance hourly. Before switching off a direct current the current should be gradually reduced to prevent winding inductance to cause arcing. Since the temp. distribution of the m/c at a standstill is different from that in running condition, a winding temperature of 80 degree C should not be exceeded and rotor turned through 90 degree every hour.

If methods a & b cannot be applied the machine must be dried with hot air obtained from an external source. The heaters can be arranged so that by means of suitable covers, the winding being heated is in hot air stream without concentrating the heat to the extent that excessive temperature is reached. This requires that the continuous circulation and replacement of the air takes place.

## OPERATION

Commissioning, Starting the machine, Operation, Shutting down.

Covers, which prevent accessibility to rotating and live parts - as well as those required for proper air guidance and effective cooling, must not be opened during operation.

### COMMISSIONING INSTRUCTIONS

#### Instructions :

The following checks and tests should be performed after initial installation and subsequent inspection :-

- | Machine correctly aligned
- | Drive elements correctly adjusted depending upon type (e.g. belt tension with belt drive, tooth flank and crest clearance with gear drives, radial end axial play with couplings, radial play, axial control and correct axial position with couplings of sleeve-bearing machines with two self-aligning bearings).
- | Minimum insulation resistance of the windings satisfactory (also check after extended shutdowns)?
- | Specified direction of rotation?
- | Cooling air-flow not obstructed?
- | Rotor revolves freely without touching?
- | Slip ring contact surfaces are concentric and smooth?
- | Even patterns present (after longer operation)?
- | Brush holders correctly aligned and firmly fixed on brush holder arms?
- | Carbon brushes in the brush boxes and arm-type brushes move freely and spring action is satisfactory?
- | All fixing bolts, fastening devices and electrical connections tight?
- | Earthing and potential-equalizing connections satisfactory?
- | Bearing properly lubricated according to type and supplementary instructions?
- | No bridging of any bearing insulation fitted
- | Any auxiliary devices fitted properly connected and serviceable (e.g. temperature monitoring instruments in windings and bearings, anti condensation heaters, etc.).
- | All protective measures against contact with moving or live parts properly implemented.
- | Any separately driven fans serviceable, properly connected according to the specified direction of rotation and in service running satisfactorily.
- | Any heat exchanger in case of air-to-water cooling system properly connected to the water supply, fitted, vented and serviceable (also check after extended shutdowns).

The following commissioning procedure is recommended after initial installation and subsequent overhauls:

**Starting the Machine :**

- | Set the starter to the "start" position.
- | Close the circuit-breaker and as soon as the machine starts moving open it again. If the machine does not start, do not move the starter to the next step but switch off and ascertain why it has not started. Rectify the fault.
- | As the machine is coasting-down, listen and feel for any mechanical noise or vibration from the bearings and end shields.
- | If the mechanical running of the machine is satisfactory switch on again and move the starter through its steps to maximum. If a brush lifter is fitted, lift the brushes when rated speed has been reached. Observe the machine briefly while it is running off-load (if the run is extended, start up the separate ventilation and cooling if applicable).
- | If the machine runs roughly or there are any unusual noises, switch off and ascertain the causes during the coasting down.
- | If the mechanical running of the machine improves immediately after switch-off it means that the causes are magnetic or electrical. If the running does not improve it means that the causes are mechanical, e.g. inadequate alignment of the set or unbalance in the machine, coupling or driven machine.

**Operation :**

- | If the running is satisfactory start up any cooling system which may be fitted (separate fan, heat exchanger etc.) and load the machine. Check the running smoothness and take and record the readings of voltage, current, etc. As far as possible also take corresponding readings from the driven machine and record them.
- | Monitor and record the temperatures of the bearings, windings, etc. until the steady state is reached.

**Temperature setting:**

- | Motor may be operated with temperature settings, as indicated by RTD, as tabulated below :-

		Permitted Max operating temp. (°C).
Stator winding		125
Bearing	Antifriction bearing	90
	Sleeve BHEL design	80
	bearing Renk design	93
Temperature setting (°C).		
	Initial	Final (based on stabilised operating data)
Alarm	Permitted Max operating temp. +5°C	Recorded max operating temp. +5°C
Trip	Permitted Max operating temp. +10°C	Recorded max operating temp. +10°C

**Shutting down :**

- | Open the circuit-breaker and return the starter to the "start" position. Allow the machine to coast down without braking.

**MAINTENANCE**

**Inspection Schedule**

Careful maintenance and inspection allow any faults to be detected and corrected at any early stage before they are able to develop into serious damage. Therefore, they help to preserve the value of the machine, prevent costly outages and increase its reliability and availability.

Since the conditions under which the machines are required to operate can vary widely, it is only possible in maintenance and inspection schedules to recommend maximum intervals between inspections for normal conditions. Experience gained at the actual place of installation must be used subsequently to adjust the inspection intervals when necessary to take account of factors such as contamination, frequency of startup, load, etc. It is recommended, therefore, that the accessible parts of the machine are inspected visually about 500 hours after commissioning.

Furthermore, the inspection intervals given in the maintenance schedules presuppose no operating disturbances. If any disturbances or unusual operating conditions occur (e.g. over load, short-circuit, machine runaway, etc.) which cause electrical or mechanical over stressing of the machine, the appropriate inspections must be carried out immediately.

If BHEL engineers are not called upon to carry out the inspection work it should only be entrusted to trained personnel who have had adequate experience on large electrical machines.

We suggest that such personnel is instructed by a BHEL engineer during his presence for installation, commissioning or inspections.

Repair work which goes beyond normal maintenance or inspection procedures, and any subsequent modification, etc. should always be carried out by BHEL engineers. Your local BHEL representative will be pleased to make the necessary arrangements.

The relevant safety and protection measures demanded by local regulations must be implemented when carrying out inspection and maintenance work.

The first inspection should be made after approx 500 hours. It should then be determined on the basis of the rate of fouling, whether the cooling air ducts will require cleaning before the second inspection normally carried out after approx one year.

The following checks should also be carried out:

- | Running smoothness of machine satisfactory.
- | Rotor alignment within tolerances.
- | No subsidence or cracks in the foundation.
- | All fixing bolts of mechanical and electrical joints tight.

## Maintenance

Before starting any work on the machine, make sure that it has been isolated from the supply and that a safeguard has been provided to prevent unintentional starting.

Passages, which transfer cooling air from the ambient atmosphere, should be cleaned with dry, oil-free compressed air at regular intervals in accordance with the degree of pollution.

## Slip Ring Maintenance

The slip ring compartment must be cleaned when the brush set has been replaced. Careful and complete removals of brush-dust deposits from the insulating components of the slip ring assembly and the brush assembly are particularly important. Apply special measures, if necessary. Whenever two to three brush sets have to be replaced, the machine should also be stopped and the brush dust carefully and completely removed by thorough cleaning of the entire machine.

If dust or moisture has penetrated into the terminal compartment carefully clean and dry the component, in particular the surfaces of the insulating parts. Check the seals and eliminate the leakage.

The slip rings must run true and have a smooth surface. If they have become rough, scored, out of true or show signs of burning, skim the slip rings on a lathe. For this either remove the rotor or force off the end shield. Disconnect the slip ring leads and carefully draw off the slip ring assembly from the shaft with a tool, which must be applied, to the hub of the slip ring assembly.

The brushes must make good contact with the slip rings. To do this the brushes must move freely in the brush guides or the legs must be hinged easily. The brush gear assembly and the end shield or the stator frame must be firmly tightened by means of fixing elements.

Worn brushes must be replaced in good time. It is recommended to change brushes when the left over brush height is approximately 15mm., when measured at the center of the brush. New brushes must be of the same type as originally fitted and need not be bedded in.

For replacing the brushes of the clamping brush holders, disengage the clips and release the terminal screws for the brush cords.

To replace the clamping brush holders and to facilitate inspecting the slip ring surfaces and brush faces, remove the brush gear assembly. To do so, flip open the clips, release the fixing screws of the brush gear assembly and disconnect the slip ring leads. If the end shield has a centering shoulder for the brush gear assembly, the latter can easily be removed by turning it out in a peripheral direction. The machine need not be dismantled to replace clamping-type brush holders. When fitting new brush holders of this type, make sure that they lie symmetrically in relation to the slip rings.

The legs and brush pressure of adjustable clamping-type brush holders are set at the factory and must not be changed.

For replacing the brushes of the double leg-type brush holders, always take out the brush gear assembly. In doing so the brush holders must not be released or moved on the brush holder arm.

New double leg-type brush holders must be installed in such a manner that the brush holders have a symmetrical position to the slip rings.

Before forcing off a part, it is recommended that two of the upper fixing screws be replaced by longer ones or headless bolts which will support the part after it has been forced out of the centering recess.

## NOTE:

Machines of vertical type of construction may be dismantled in a horizontal position. Refer to "Transport, storage" for the measures required to set down, lift and transport them. Before performing any work on the locating bearing with the machine in a vertical position, first brace the rotor.

## Cleaning Instruction for Polyester Fiber Air Filter

The dust laden Air Filter can be cleaned in the following ways:

1. Remove the Filter Media from the filter frame Assembly.
2. Clean the media by shaking off the filter.
3. Clean with compressed air.
4. Rinse in clean Water.
5. Dip in Detergent Solution for 30 minutes.
6. Rinse with fresh water again.
7. Clean and dry finally with compressed air.

## ROLLING CONTACT BEARINGS

### Instructions

Electrical machines fitted with rolling contact bearings (see Appendix ) are subject to the following instructions supplementing and modifying the operation instructions of the machines.

### Installation

The locating bearings are deep groove ball bearings for horizontally mounted machines. These bearings may also be in pair with cylindrical roller bearings. In the case of bearings in pair, the outer ring of the deep groove ball bearings is not guided radially and is prevented from rotating by compression springs.

The locating bearings for vertically mounted machines are angular contact ball bearings.

The floating bearings are deep groove ball bearings or cylindrical roller bearings. In case of deep groove ball bearings as floating bearings, the axial play is compensated by means of compression springs.

The model of bearing is favorably chosen as for direction and size of load (type of construction, forces acting on the shaft) and therefore it should not be changed. The permissible values of axial and radial forces may please be inquired.

The machines should operate in only one type of construction as shown in the rating plate, because another type of construction required perhaps further measures in addition to a modification of the model of bearing. Always in this case an inquiry is necessary.

The bearings should be re-lubricated if the time between delivery and commissioning of the machines is more than 4 years, assuming that they have been stored in favourable conditions (i.e. in a dry, dust and vibration free room) or more than 2 years if they have been stored in unfavourable conditions.

### Bearing Maintenance

For the initial lubrication of bearings, a lubricating grease IOC Servogem-3 or equivalent, with lithium soap as thickener and with mineral oil as basic oil are usually used.

If special operating conditions necessitating a different kind of grease were known when the machines were ordered, then the grease definition (type of grease, thickener and basic oil) can be taken from the data plate.

Besides the definition of grease, the regreasing interval and the necessary amount are given on the data plate.

It is recommended that the re-greasing instructions be followed strictly. Greases of different thickeners and basic oils reduces the quality and is therefore to be avoided. Only

in special cases should deviations be made from the usual greasing, data. The re-greasing, intervals should be shortened, for instance, if the machines are operated at coolant temperatures higher than originally allowed for if corrosive vapours occur or extremely heavy contamination is present.

Clean the re-greasing nipple and press in the grease stipulated on the data plate using a grease gun. At the same time shaft should be rotated in order to distribute the new grease uniformly in the bearing. After re-greasing, the bearing temperature will rise by a few degrees and will drop to the normal value when the grease has reached its normal service viscosity and the excess grease has been forced out of the bearing.

The old grease from several re-greasing operations gathers in the space inside the outer bearing caps. Remove the old grease when overhauling the machines.

For working on the locating bearing in the vertical position of the machine, support the rotor.

It is recommended that new rolling bearings be installed as follows: heat the ball bearings or the inner ring of the roller bearings in oil or air to a temperature of approx. 80°C and slip them onto the shaft. Heavy blows may damage the bearings and must be avoided.

When installing single angular contact balls make sure that the broad shoulder of the inner ring (and the narrow shoulder of the outer ring) in operation position points upwards, i.e. in a direction opposite to that of the axial thrust.

Care must be taken and during assembly to see that the sealing rings are fitted properly.

When fitting shaft seal rings (V-rings), the correct axial position of the V-rings is attained when the bearing cap end face and outside edge of the V-ring are flush. It is recommended using an appropriate assembly aid for this.

Before new felt sealing rings are fitted in to the bearing caps, they must first be impregnated in 80°C, not high viscosity oil (lubricating oil) they should be dimensioned so that the shaft slides easily in, yet is also well enclosed by them.

The table given at Appendix I helps to trace and remove the causes of faults.

In case it is difficult to find the damages of bearings. It is recommended to replace the bearings.

CAUSES OF FAULTS AND REMEDY FOR BEARING				
CAUSES	DEFECT BEARING OVERHEAT	BEARING SCRATCHES	BEARING KNOCKS	REMEDY
FELT SEALING RING PRESSING ON SHAFT	.....			FIT RING INTO GROOVES OR REPLACE THEM
STRAIN APPLIED FROM COUPLING	.....			IMPROVE ALIGNMENT OF MACHINE
EXCESSIVE BELT TENSION	.....			REDUCE BELT TENSION
BEARING CONTAMINATED	.....			CLEAN OR RENEW BEARING, INSPECT SEAL.
AMBIENT TEMPERATURE HIGHER THAN 40 C	.....			USE SPECIAL HIGH TEMPERATURE GREASE
LUBRICANT INSUFFICIENT	.....			LUBRICATE TO INSTRUCTION
BEARING CANTED	.....			CHECK MOUNTING CONDITION INSTALL OUTER RING WITH LIGHTER FIT
TOO LITTLE BEARING PLAY	.....			FIT BEARING WITH LARGER PLAY
BEARING CORRODED	.....			RENEW BEARING INSPECT SEALS
SCRATCHES ON RACEWAYS	.....			RENEW BEARING
SCORING	.....			RENEW BEARING AVOID VIBRATION WHILE AT STANDSTILL
EXCESSIVE BEARING PLAY	.....			INSTALL BEARING WITH SMALLER PLAY

**SLEEVE BEARINGS WITHOUT AXIAL LOCATION**

**Instructions**

The machines are characterized by the pointer which is normally fixed to the bearing housing or to the guard ring (for designs with supplementary sealing and also by the corresponding shaft recess. The width of the recess "S" corresponds to the axial float of the respective bearing. The axial float of the other sleeve bearing (normally on the non-drive end) is several millimeters larger than "S" amongst other things to allow for the inherent construction tolerances of the machine and thus does not have to be considered.

The rotor must be located axially by the guide bearing of the coupled machine. For this reason it is necessary to use a suitable coupling having limited float. The axial movement of the rotor which is composed of the axial play of the guide bearing and the axial play of the coupling must clearly be smaller than the bearing float "S" to prevent the shaft collars running against the bearing shoulders. Allowance must also be made here, amongst other things, for the thermal expansion resulting during operation.

In addition to the normal installation and coupling procedure, it is important that the pointer be in alignment with the centre of the shaft recess when the coupling is in its mean play position.

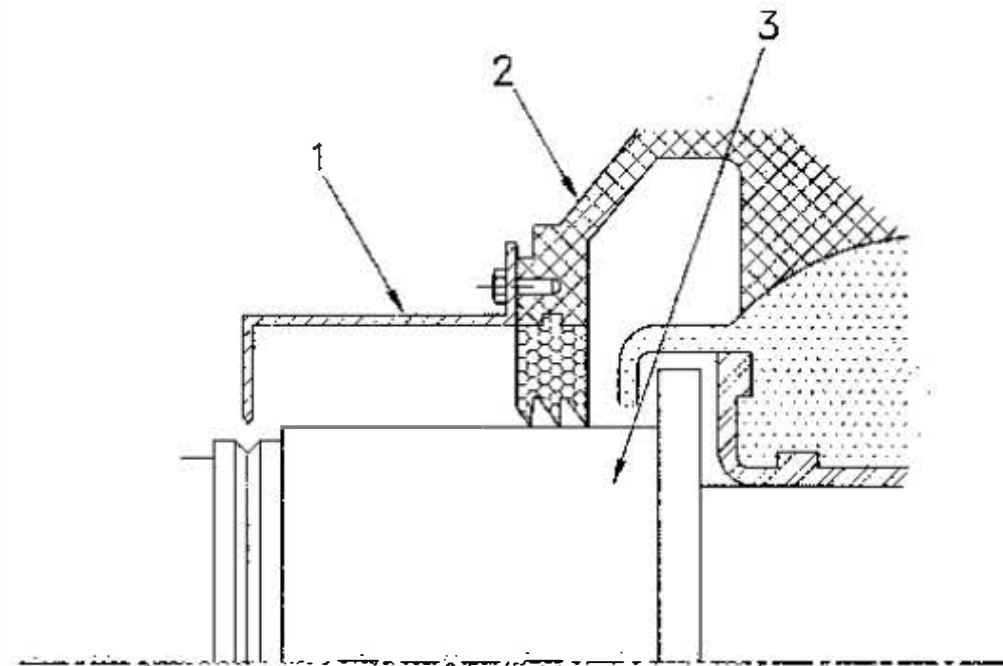
To achieve this the stator is shifted on the foundation in an axial direction until the pointer indicates the correct position.

In most of the machines, the exact axial position of the pointer is achieved by the addition of washers during assembly at the works. The number and the total thickness of these washers therefore must not be altered.

In order to prevent the bearing shoulders accepting load during operation, the pointer must always be clearly within the zone indicated by the edges of the shaft recess.

Electrical machines may have a dust ring in front of the sleeve bearing as an additional external sealing. If during dismantling or other maintenance work on these machines the dust rings are removed then during reassembly they must be slid along the shaft and fixed as they were.

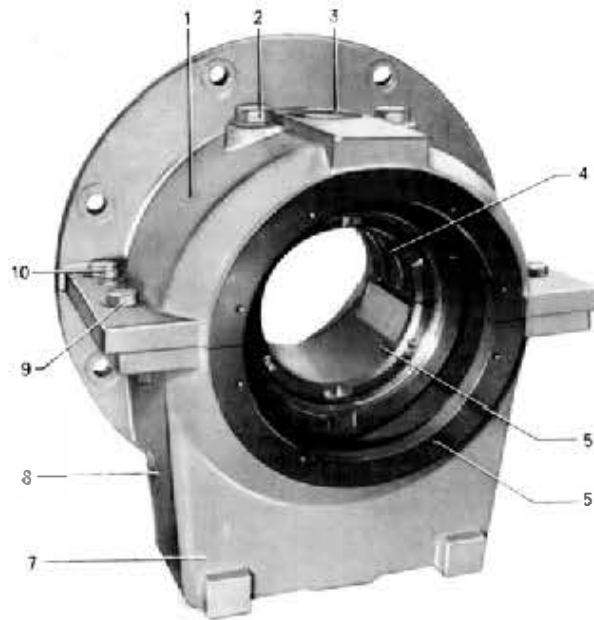
**APPENDIX 'F'**  
**SLEEVE BEARINGS ( WITHOUT AXIAL LOCATION )**



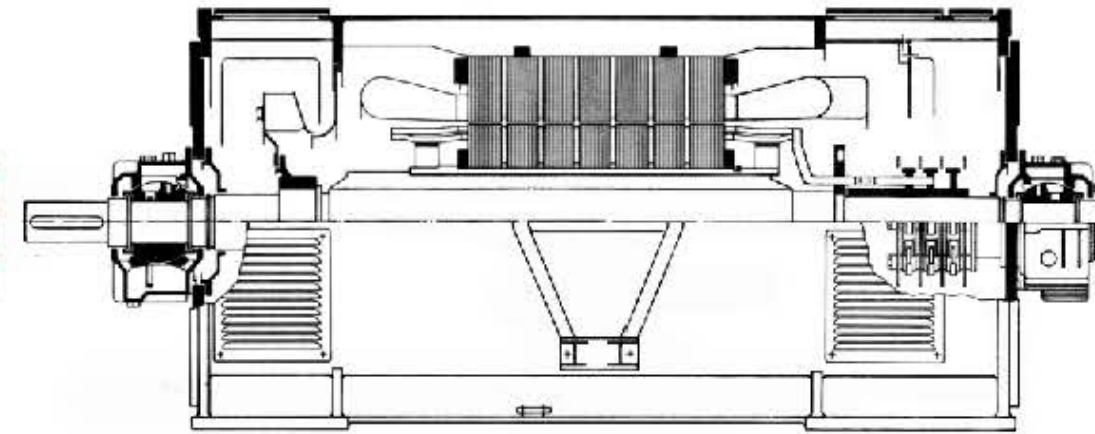
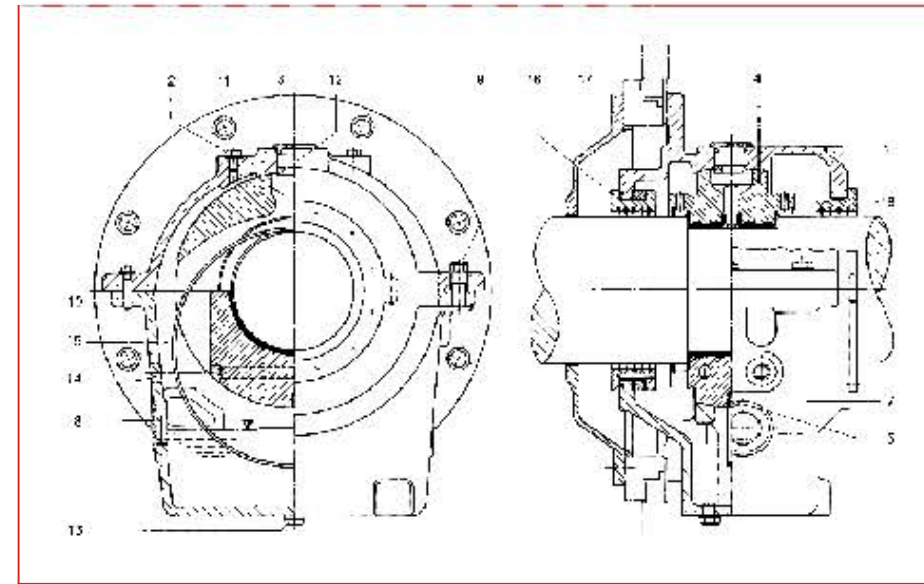
**BEARING FLOAT POINTER**

- (1) Pointer (In Case of two sleeve bearings without axial location)
- (2) Bearing housing upper part
- (3) Shaft

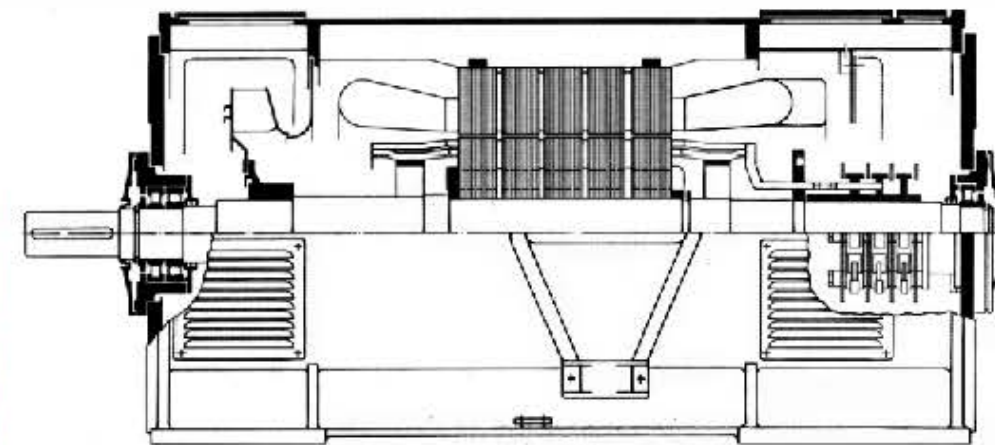
**SLEEVE BEARINGS ( WITHOUT AXIAL LOCATION )**



- 1. Bearing cover
- 2. Oil filling plug
- 3. Sight glass
- 4. Top bearing shell
- 5. Bottom bearing shell
- 6. Tapped hole for insert sealing ring
- 7. Bearing housing
- 8. Sight glass
- 9. Joint bolt
- 10. Tapper pin
- 11. Hole for fixing bolt
- 12. Centring ring
- 13. Oil drain screw
- 14. Thermometer well
- 15. Oil-ring
- 16. Inner insert sealing ring
- 17. Sealing cover
- 18. Outer insert sealing ring



**Motor with Flange-type sleeve bearings**



**Motor with rolling-contact bearings**

## DISMANTLING AND RE-ASSEMBLY PROCEDURE

### 4.1 General

Before dismantling the motor, ensure the availability of crane facility of adequate capacity, sufficient space and tools-tackles. For the purpose of de-threading the rotor, a mild steel pipe of minimum 10 mm wall thickness, ID suiting to accommodate motor shaft extension and length approximately equal to stator frame length, should be available. All loose fittings, accessories like RTDs, BTDs, dial type thermometers, space heater power supply connections, cooler blower motor power supply connections, oil inlet/outlet pipe connections and the cable terminations are to be removed / disconnected before dismantling the machine.

In case of water cooled machines (1RU.) disconnect water inlet and outlet flanges. It is not essential to dismantle the water cooler / air cooler (1RB., 1RR., 1RE..) for inspection or change of bearing / bearing housing components. However, for any maintenance work on stator winding, top mounted air/ water cooler may have to be removed.

Before removing top mounted cooler enclosure from 1RR1 & 1RU1 motors, all cables connections (main and accessories) must be disconnected from respective terminal boxes and properly bunched and identified to facilitate reconnection.

Removing the coupling half at drive end side is left to the choice of site engineer\*. Since the fan is at drive end, this end can be slinged and the dethreading pipe can be inserted at NDE side after carefully protecting both the shaft journals. Refer the longitudinal sectional arrangement of the machine in sub-section 1 and the bearing assembly sketches in sub-section 8, study them carefully before attempting the dismantling of motor or bearing assembly.

\*In case of motors with anti-friction bearings, DE bearing, end shield, fan and air guide baffle can be removed only if the coupling half is removed.

### 4.2 Sequence of Dismantling

**Bearing assembly dismantling for oil lubricated sleeve bearing:**

1. Drain off oil from the sump of bearing housing bottom at DE and NDE. In case of forced oil lubrication system disconnect oil inlet and outlet flanges.
2. The bearing assembly consists of top and bottom half bearing housing and top and bottom bearing half shells (liners).
3. Remove all accessories like BTD and vibration monitoring probes etc.
4. Before dismantling, proper match marking to be ensured between mechanical separable parts.
5. Remove top half bearing housing and preserve the loose spacer labyrinth half rings.
6. Preserve all the dowel pins carefully in their own respective assembly parts.
7. Remove top bearing sleeve.

8. Remove bottom half bearing sleeve after sliding it to top side. For this it is necessary to centrally lift the rotor slightly by using soft slings. Gently lower the rotor. Do not drop rotor abruptly. Preserve oil pick-up brass rings carefully. Remove it by splitting it into two halves.
9. Remove the bottom bearing housing, if required.
10. Remove end shields through jacking holes by suitably supporting them through a sling.

**Bearing assembly dismantling for grease lubricated anti-friction bearings:**

1. Remove all fasteners and take out outer bearing cap (OBC).
2. Unscrew Inner Bearing Cap fasteners.
3. Carefully heat up grease flinger with a thin flame and remove by inserting studs in two threaded holes or by hands after wearing heat-resistant gloves.
4. Remove bearing housing through its jacking holes after carefully supporting the shaft by a soft nylon sling.
5. Unscrew end shield bolts and remove the end shield by jacking.
6. Remove shrink fitted bearings with help of suitable hydraulic/mechanical puller.
7. Remove inner bearing cap (IBC) by unscrewing its four long bolts.

### 4.3 Dismantling of other parts / assemblies

After dismantling of both side bearings, sling the rotor at both ends with almost equal air gap on all sides i.e. parallel to stator bore. Remove internal blower from its hub.

Remove air guide.

Now the rotor can be de-threaded by use of extension pipe suitably either on DE or NDE. Utmost care must be taken that the stator end winding does not come into physical contact with rotor due to movement of rotor in slung position. De-threaded rotor should preferably be kept on wooden logs or soft padded V-blocks.

If required, rotor can be de-threaded partially or fully from DE side by dismantling only NDE bearing and its assembly components. In this case end shield of DE will be required to be unscrewed and jacked out from its spigot. In this case, it is not necessary to dismantle NDE side anti-friction bearing fully. Dismantling of NDE end shield and bearing housing along with OBC will be sufficient.

Protect the shaft journal face by enveloping the same with clean rag wool cloth all around and tying with rope.

Do not disturb / remove any of the balancing weights on radial internal blower or on the balancing ring.

#### 4.4 Reassembly

Re-assembly of the motor is generally in reverse of the above respective procedure.

##### Motor with anti-friction bearings:

Clean end insert inner bearing cap (IBC) beyond bearing resting shoulder on shaft. Apply fresh grease on face of IBC to fill grease cavity.

Place all springs in blind holes of IBC & retain them in position by grease. (springs will rest on mean dia of outer race.)

At the same time, ball bearing and roller brg inner-race to be heated to around 100° to 120°C by Induction heating or in a clean oil bath. Now shrink ball brg and inner-race of roller brg square to shaft. Apply fresh grease on accessible face of ball bearing.

Roller bearing cage assy filled with grease can be separately pressed in the housing.

Insert housing on to shaft. Align the IBC holes with holes of housing by suitably supporting the shaft by a soft sling keeping grease in-let hole in bearing housing on top. Use of guide ring avoids marks on inner race & rollers. Start heating of grease filler to about 100° to 120°C.

Now tighten the bearing housing by gradually tightening 4 to 6 bolts at equally opposite location for uniform insertion of housing. At the same time pull the IBC as near as possible and try to hold IBC with its specified longer bolts and tighten the complete bearing assy.

Now ensure that housing to end shield is fully tight and no gap is left between faces. At this stage the rotor should be free to rotate if NDE bearing is also assembled.

Inject grease to check grease path. Shrink grease flinger on to shaft. Insert circlip in groove provided on shaft.

Ensure that circlip is fully seated in groove & there is no gap between flinger & circlip. Unscrew all fixing bolts between bearing housing to end shield and insert outer bearing cap (OBC). Now align the holes of OBC with hole of brg housing and end shield and tighten all three items together.

Assemble the NDE bearing in same order. Springs and ball bearing are to be omitted in NDE bearing assembly.

##### Motor with oil-lubricated sleeve bearings:

During re-assembly ensure that the metal to metal joints between bearing housing and end shields end stator frame terminal box flanges faces and all inspection covers are applied with non-hardening jointing compound as a joint sealant to ensure Ingress Protection. The non-hardening jointing compound should not contain silicon. It is also recommended to use this sealing compound when inserting fastening bolts / screws.

### FAULT DIAGNOSIS CHART

The chart lists general faults due to electrical and mechanical factors. Bearing faults are dealt with in the supplementary instructions for bearings.

FAULT, MECHANICAL				POSSIBLE CAUSE	REMEDY
RUBBING NOISE	EXCESSIVE TEMPERATURE	RADIAL OSCILLATIONS	AXIAL OSCILLATION		
				AIR SUPPLY OBSTRUCTED, FILTER DIRTY, WRONG DIRECTION OF ROTATION	CHECK AIR DUCT, CLEAN FILTER, CHANGE FAN
				REVOLVING PARTS RUBBING	ASCERTAIN CAUSE, RE-ALIGN
				ROTOR UNBALANCED	UNCOUPLE ROTOR AND REBALANCE
				UNBALANCE IN COUPLED MACHINE	RE-BALANCE, COUPLE MACHINE
				ROTOR OUT OF TRUE, SHAFT DISTORTED	DISCUSS WITH FACTORY
				MISALIGNMENT	RE-ALIGN MACHINE, CHECK FOR MISALIGNMENT WHEN HOT, CHECK COUPLING
				INTERFERENCE FROM GEARING	CHECK GEARING
				RESONANCE FROM FOUNDATION	STIFFEN FOUNDATION AFTER CONSULTING FACTORY
				CHANGE IN FOUNDATION	ASCERTAIN CAUSE OF MACHINE AND ELIMINATE, RE-ALIGN MACHINE
				IMPULSES FROM COUPLED MACHINE OVERLOAD	EXAMINE COUPLED MACHINE REDUCE LOAD
				INSUFFICIENT COOLER CAPACITY	CLEAN COOLER AND AIR DUCT VENT/WATER COOLER, CHECK WATER SUPPLY

## PRESERVATION MEASURES

For assembled but non-operative machines (without regular maintenance) & machines not commissioned for a long time after assembling.

### Reactivating

Restore the machine to its machine condition before all above measures were taken, and make everything ready for commissioning. Before starting the machine, carry out all pertinent operations described in "Commissioning and shutting down". Commissioning of machine or restarting of a machine after a period of shutdown can only be taken up after the preservation agents have been removed.

### Preservation

The machines which are not to be taken in operation are to be properly preserved for long duration. The purpose is to prevent condensation from forming in the machine, i.e. keep relative air humidity below 70% and, where necessary, make provision for heating and air circulation.

### Possible measures :

Pack machine moisture proof in sealed polyethylene foil. Place desiccant and humidity indicator inside cover (recommended value: 105 g/m<sup>2</sup> foil surface and month duration of application). Check desiccant periodically and renew if necessary.

In less critical cases (e.g. storage in warehouses) switch on anti-condensation heating or blow a constant stream of warm air through the machine by means of fan heater. Apply a coat of anti-corrosion agent (e.g. Tectyl 506) to all bright surfaces outside the bearings.

If the rotor contains components (e.g. and bells) made of material subject to stress corrosion cracking (if necessary check with manufacturer), these must be protected properly as instructed by manufacturer.

In case of oil lubricated sleeve bearings drain oil from bearings. Open sleeve bearings, coat the bearing parts and journals of the shaft with anti-corrosion agent (e.g. Tectyl 506). Remove bearing shells for this purpose (uncouple the machine if necessary) and refit after coating. Close bearings.

Follow the manufacturer's recommendations concerning preservation of rolling contact bearings.

FAULT, ELECTRICAL								POSSIBLE CAUSE	REMEDY	
Motor fails to start	Motor Amperes exceeds electricity	Alarm start up	Humming noise during start up	Humming noise during operation	Humming noise in rhythm of Double slip frequency	Excessive temperature during no load running	Excessive temperature when running under load	Individual winding condition overheated		
									OVERLOAD	REDUCE LOADING
									ONE SUPPLY OPEN CIRCUITED	CHECK
									ONE SUPPLY PHASE OPEN CIRCUITED AFTER SWITCHING ON	SWITCH GEAR AND SUPPLY CIRCUIT
									OPEN CIRCUIT IN SECONDARY CIRCUIT	CHECK SWITCH GEAR SUPPLY CIRCUIT AND STARTER
									LOW SYSTEM VOLTAGE; HIGH FREQUENCY	CORRECT SYSTEM CONDITION
									LOW SYSTEM VOLTAGE; LOW FREQUENCY	
									STATOR WINDING INCORRECTLY CONNECTED	CHECK WINDING CONNECTION
									INTER-TURN OR PHASE SHORT CIRCUIT IN STATOR WINDING	MEASURE WINDING RESISTANCE AND INSULATION
									INTER-TURN OR PHASE SHORT CIRCUIT IN ROTOR WINDING	RESISTANCE REPAIR AFTER CONSULTING FACTORY
									STARTER INCORRECTLY CONNECTED	CHECK CONNECTION
									RESISTANCE OF FRIST STARTER STEP TOO LOW, FLAM OVER IN LIQUID STARTER	CHECK ELECTROLYTE COMPOSITION, INSULATION RESISTANCE OF STARTER ACCORDING TO THE INSTRUCTIONS

Rotors equipped with rolling contact bearings must be locked radially or axially to prevent the rotor from being damaged by vibration. Spare machines must be kept in a place not exposed to vibration.

Apply a coat of anti-corrosion agent (e.g. Tectyl 506) to all bright surface e.g. couplings. Fill backstops with anti-corrosion oil (like Shell-Ensis 152).

Remove oil lines. If necessary, clean and coat inside with oil-soluble anti-corrosion agent (e.g. Tectyl 472). Carefully seal open pipe ends.

Clean cooler pipes and chambers. Fill clean cooler with mixture of water, anti-freeze and anti-corrosion agent. The composition of the mixture should be suited to the local climatic conditions.

Carefully remove all brushes from the brush boxes and secure them to their boxes with the pressure fingers. Smear acid-free Vaseline like shell 8422, on steel slip ring contact surfaces and cover with polyethylene foil.

Keep a list of preservation measures that have been taken. The effectiveness of these measures should be checked by qualified staff at regular intervals. If any deterioration is noticed, remedy this immediately and remove any perceptible corrosion and other damage.

## SAFETY PRE CAUTIONS

- 1.0 When operating the motor, the following basic safety precautions must be observed.
  - 1.1 No work shall be carried on running motor.
  - 1.2 In order to carry out any work on motor or driven unit, the motor must be disconnected from the mains and fool proof protection be provided to avoid any possibility of accidental switching on of the motor or of rotor revolving from the driven end side.
  - 1.3 Motor frame, main terminal box and sheath armour of the cable must be reliably earthed.
  - 1.4 Rotating parts such as driving end of the motor shaft or coupling must be provided with a trustworthy guard to protect the servicing personnel or people passing close by.
  - 1.5 If the feeding cables are to be disconnected from the motor, the cables ends must be short circuited.
  - 1.6 When working on high voltage starting equipment, all safety rules pertaining to high voltage installation should be observed.
- 2.0 When handling the motor or sub assemblies, it is necessary to take all the safety precautions, a few of which are listed below.
  - 2.1 All lifting equipment and attachments should be in good condition, tested and properly selected.
  - 2.2 Ascertain the weight of the load prior to lifting it and remove all loose items lying on it.
  - 2.3 When lifting the motor and other parts by the lifting bars, hooks of eye bolts, these should be carefully examined.
  - 2.4 Put padding of soft materials at places where the slings touch the stator frame.
  - 2.5 All manipulation should be done carefully without jerks.
- 3.0 While handling the rotor, the followings must be strictly observed.
  - 3.1 Do not let the ropes touch the journal surface of the shaft.
  - 3.2 While lifting the motor do not apply force to the parts of the shaft between the extreme ends up to the surfaces under the bearings including journals.
  - 3.3 Do not support the motor on rotor overhang and fans.
  - 3.4 Do not support the motor on parts of the shaft between the extreme ends up to the surfaces under the bearing including journals.
  - 3.5 Any equipment connected/coupled on the NDE- side the motor, provided with bearing insulation, must be thoroughly, insulated from machine/earth to prevent flow of shaft current in the motor.
  - 3.6 In no case shall any part of rotor touch the winding overhang during insertion or removal of rotor from stator. It is desirable to cover the winding overhangs on both the ends by thick presspahn or leatheroid or Elephantide paper as a protection.

**NOTE :** The safety precautions mentioned in the modules, should also be followed while attending to motor sub-assembly.

**ENVIRONMENTAL GUIDE LINES**

**Safe Disposal of AC Machines Items  
(After expiry of useful life)**

BHEL has adopted an Environmental Policy and pledged to fulfill its responsibility of protecting and conserving the environment on account of its product.

Items/materials of AC machines, served their useful life are to be disposed off in an environment friendly way to protect our resources and control, environmental pollution. (Guidelines furnished below lead to a long way in planning activity for scrapping the above effectively in an eco-friendly manner.

AC machines are basically manufactured by using the following :

- 01- Metals.
- 02- Non Metals
- 03- Lubricating oils.

These items should be disposed off/recycled/re-used as per current environmental laws of the Country.

**METALS** (Structural Steel, Sheet Steel, Copper, Aluminum etc.):  
These may be sold as scrap metal for recycling and re-use.

**NON METALS** (Insulating Materials (Mica, Glass, Nomex, Epoxy/ Polyester/Silicone based bonding materials), Rubber (Synthetic/ Natural) Grease etc.):

Big pieces & useable lengths of insulating materials may be salvaged for re-using as insulation in smaller & lower voltage rating electrical equipment. Materials unfit for economic salvaging, should be stored in an isolated space for further safe disposal.

**Lubrication Oils :**

Oils should be recycled after cleaning and when become unusable, may be disposed off to re-refiners for lower end use as low-grade lubricating oil.

**LIST OF RECOMMENDED SPARES**

When ordering spare parts, please state the serial number & frame designation of the machine as shown on the rating plate and at the Drive-end shaft face in addition to the exact designations of the parts required.

**A-For all machines**

Type of machine	Assembly name	Type	Items	Quantity	Style/ Drawing number			
SCIM 1LA7, 1RA, 1RN, 1RQ 1TC <sup>o</sup> 1MJ 1SJ 19Q 1SN	Bearing (See 'C' for vertical motors.)	Anti-friction	Ball bearing-DE	One				
			Roller bearing-DE	One				
			Roller bearing-NDE	One				
			Outer Rubber seals (DE and NDE)	One each				
			Inner Felt seals (DE and NDE)	One each				
			Bearing bush-DE	One				
		Journal	Bearing bus -NDE	One				
			Sealing ring-DE and NDE	One set each				
			Oil ring-DE and NDE	One each				
			SRIM 1LS, 1RR, 1RS, 1RU, 1RB, 1RE, 1RC 1TT 1TM	Line side Terminal box	Phase segregated box with direct termination	Connector	One set	
						Joint box	One set	
						Dislocators	One set	
Connector	One set							
Insulator	One set							
Tall lead	One set							
Phase separated terminal box with tall lead	Joint box	One set						
	Dislocators	One set						
	Connector	One set						
	Joint box	One set						
	Terminal bushing	One set						
	Insulator	One set						
Syn. Motors 1DL 1DQ 1DM 1DN	Neutral side Terminal box	Neutral terminal box PSTB type	Neutral connector	One				
			NTB suitable for CT mounting used without CT	Bushing/Insulator	One set			
		Instruments	Bearing temperature detector-PT-100	Rigid stem type	One			
				Capillary type	One			
			Air temperature detector	Rigid stem type	One			
				Capillary type	One			
			Space heaters	Plug In heaters	One set			
				Heaters for 1L type motors	One set			
			Dial thermometer for bearing	Rigid stem type	One			
				Capillary type	One			
		Alternators 1DK 1AG	Neutral side Terminal box	Neutral terminal box PSTB type	Neutral connector	One		
					NTB suitable for CT mounting used without CT	Bushing/Insulator	One set	

### B-Additional for slip ring induction motors

Type of machine	Assembly name	Type	Items	Quantity	Style/ Drawing number
SRIM 1LS,	Brush gear assembly		Brush holder	1/2set	
			Carbon brushes	One set	
1RR, 1RS,			Insulators and insulation tube	One set	
1RU, 1RB,	Slip ring assembly	Three ring slip ring	Slip ring assy.	One	
		Six ring slip ring	Slip ring assy.	One	
1RE 1TT 1TM					

### C-Only for vertical motors(in place of bearings as called in section A)

Type of machine	Assembly name	Type	Items	Quantity	Style/ Drawing number
Vertical Motors 1TC	Bearing	Journal bearing	Top Thrust pads	One set	
			Top Guide pads	One set	
			Bottom Guide pads	One set	
		Antifriction	Top Roller bearing	One	
			Bottom Roller bearing	One	
			Outer Rubber seals (DEandNDE)	One each	
			Inner Felt seals (DEandNDE)	One each	

### D-Additional for asynchronous machine exciters

Type of machine	Assembly name	Type	Items	Quantity	Style/ Drawing number
Alternators and VFD syn motors 1DK, 1AG, 1DQ	Exciter	Electronic items	Diodes	One set	
			Varistor	One set	
			Resistance	One set	
	Earthing bush	Complete assembly	Capacitor	One set	
Brush holder			One		
Syn. Motors 1DL 1DM 1DN	Exciter	Electronic items	Carbon brush	One	
			Diodes	One set	
			Resistance	One set	
			Capacitor	One set	
			Thyristor	One set	
			Firing unit	One	

**NOTES**

Lined writing area for page 58.

**NOTES**

Lined writing area for page 59.