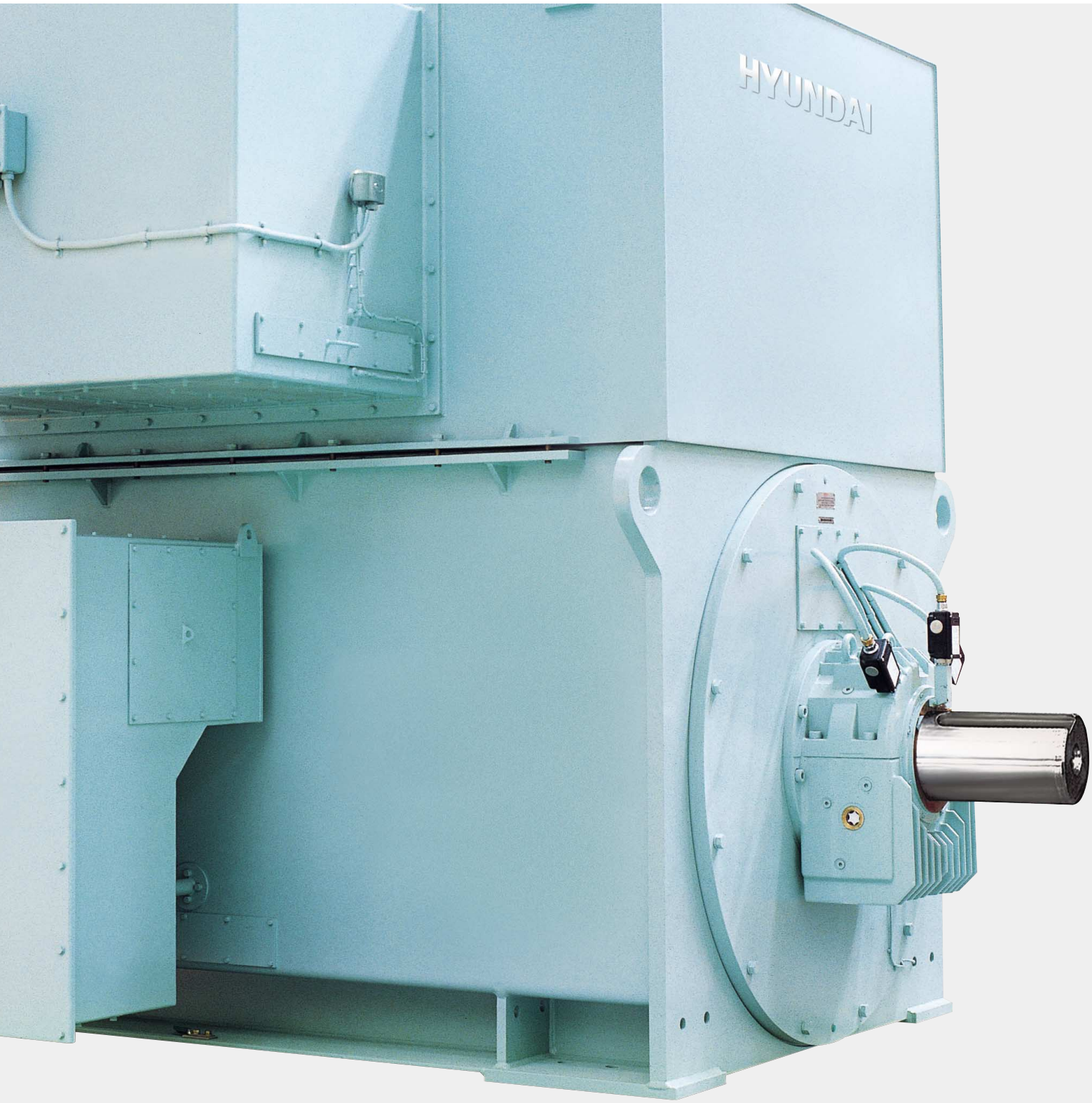
Instructions for

Three-phase Induction Motor

Common Items | Instruction Manual

HYUNDAI ELECTRIC



Safety Procedures

This equipment contains hazardous voltages. Death, serious personal injury or property damage can result if safety instructions are not followed.

The successful and safe operation of motors is dependent upon proper handling, installation, operation and maintenance, as well as upon proper design and manufacture. Failure to follow certain fundamental installation and maintenance requirements may lead to personal injury and the failure or loss of the motor as well as damage to other property.

Only qualified personnel should work on or around this equipment after becoming thoroughly familiar with all warnings, safety notices and maintenance procedures contained herein. Only qualified personnel should be involved in inspection, maintenance and repair procedures and all plant safety procedures must be observed.

Qualified Person: For the purpose of this manual and product labels, a Qualified Person is one who is familiar with the installation, construction and operation of the equipment, and the hazards involved. In addition, he or she:

a. is trained and authorized to energize, de-energize, clear, ground and tag circuits and equipment in accordance with established safety procedures.
b. is trained in the proper care and use of protective equipment, such as rubber gloves, hard hat, safety glasses, face shields, flash clothing, etc., in accordance with established safety procedures.
c. is trained in rendering first aid.

DANGER	For the purpose of this manual and product labels, Danger indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

WARNING	For the purpose of this manual and product label, Warning indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION	For the purpose of this manual and product label, Caution indicates a potentially hazardous situation which, if not avoided, may result in property damage or minor or moderate injury. It is also used to alert against unsafe practices.

Motors should be installed and grounded per local and national codes.
Do not operate this equipment in excess of the values given on the nameplate or contrary to the instructions contained in this manual. The equipment (or a prototype) has been factory tested and found satisfactory for the conditions on which it was sold. Operation in excess of these conditions can cause stresses and strains beyond design limitations. **Failure to heed this warning may result in equipment damage and possible personal injury.**

DANGER 	**Hazardous Voltage.** Will cause death, serious injury, electrocution or property damage. Disconnect all power before working on this equipment.

NOTE: Many squirrel cage induction machines are driven by various types of prime movers as induction generators. This instruction manual applies to both motors and induction generators. However, for reasons of clarification, the machine will be referred to as a "motor."

Contents

01 Foreword

This instruction manual describes and provides instructions for installation, operation and maintenance of induction motors.

These instructions do not support to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently, the matter should be referred to the nearest HYUNDAI ELECTRIC business office.

NOTE

For service shop requirements, refer to

Service Center in Korea
(Hyundai Electric Co., Ltd.)
Address: 1000, Bangeojinsunhwan-doro Dong-gu, Ulsan, Korea
Tel: 82-52-202-6671, 6672
Fax: 82-52-202-6996

02 Receiving, Handling and Storage

2.1 Receiving

Each shipment should be carefully examined upon arrival. If the packing is damaged, unpacking should be made immediately to check whether or not the motor and its fitting are in good condition, and any damage to contents should be photographed and reported to the carrier and to the nearest HYUNDAI ELECTRIC business office.

All large motors are equipped with a locking device, which protects the bearing from damage due to the movement of the rotor in transit. Do not remove this device until transport is complete and coupling is ready to be fitted.

⚠ WARNING

Heavy Equipment
Improper lifting can cause death, severe injury, or damage. Check eyebolts, lifting lug and eyenuts before lifting. Use proper slings and spreaders.

2.2 Handling

To ensure proper handling after unpacking, the motors require the chain hoist, wire ropes and other handling equipment. When hoisting the motor, wire ropes should be attached to the lifting holes on the side of the motor frame, and should be put in hard rubber, thick cloth, etc. between the external covers for protective purposes. Then the motor is slowly and carefully raised and moved to the intended position.

⚠ CAUTION

When unpacking and handling the motor, attention should be given to the following points:
- Anticorrosive agent which is applied to the coupling shaft ends should be removed right before starting the motor. The coupling or shaft ends should be checked to ascertain whether or not they are in abnormal condition.

2.3 Storage

If the motors are not put into service at the time of delivery, they should be stored according to the following conditions.

⚠ WARNING	**Top Heavy.** Can cause severe injury or property damage. When lifting motor, 1. Lift only at designated locations. 2. Use spreader for lifting. 3. Apply tension gradually to cables. 4. Do not jerk or attempt to move unit suddenly. 5. Do not use cover lugs when lifting.

Outdoor Storage is Not Recommended.

Variations in temperature and humidity can cause condensation, resulting in corrosion of metal parts and possibly in insulation failure. Therefore, the following cover the minimum acceptable storage arrangements in an unheated but protected environment:
It is preferable to use a heated facility, which would simplify meeting these conditions.
When outdoor storage cannot be avoided, contact HYUNDAI ELECTRIC for specific instructions on minimizing damage, giving full particulars of the circumstance.

Storage Facility Requirements

⚠ CAUTION	**Damp Location.** Can cause property damage if equipment is operated intermittently. Use space heaters to prevent dampness. Grease machine fits when unit is reassembled to prevent corrosion.

The storage facility must provide protection from contact with rain, hail, snow, blowing sand or dirt, accumulations of groundwater, corrosive fumes and infestation by vermin or insects.
There should be no continuous or severe intermittent floor vibration. Power for the space heaters and illumination should be available. There should be fire detection and a fire-fighting plan. The motors must not be stored where it is liable to be accidentally damaged or exposed to weld spatter, exhaust fumes or dirt and stones kicked up by passing vehicles.

If necessary, use guards or separating walls to provide adequate protection. Avoid storage in an atmosphere containing corrosive gases, particularly chlorine, sulfur dioxide and nitrous oxides.

Protecting the Cooling-water System

When the motors are delivered, the cooling water system is not filled with cooling water.

- When you place the motor in storage after use, drain the cooling water systems and purge them with air so that they are completely empty.
- The detail instructions are as follows and the caution name plates are installed on the motor

1) Air-to-Water Coolers

While a motor is not in its operation, and if the ambient temperature goes below the water freezing point, please drain the cooling water completely to prevent cooler pipe damage from water freezing.
The temperature of the cooling water must be over 5°C (41°F).

2) Water Cooled Type Ball or Roller Bearings

While a motor is not in its operation, and if the ambient temperature goes below the water freezing point, please drain the cooling water completely to prevent cooler pipe damage from water freezing.
The temperature of the cooling water must be over 5°C (41°F)

3) Water Cooled Type Thrust and Guide Pad Bearings

While a motor is not in its operation, and if the ambient temperature goes below the water freezing point, please make the cooling water flow continuously to prevent cooler pipe damage from water freezing.
The temperature of the cooling water must be over 5°C (41°F)

⚠ CAUTION	**Frost Damage to the Cooling Circuit.** The cooling circuit can be damaged if the cooling water freezes. If the ambient temperature falls below 0°C during operation, add anti-freeze to the cooling water.

Temperature Control.

DANGER

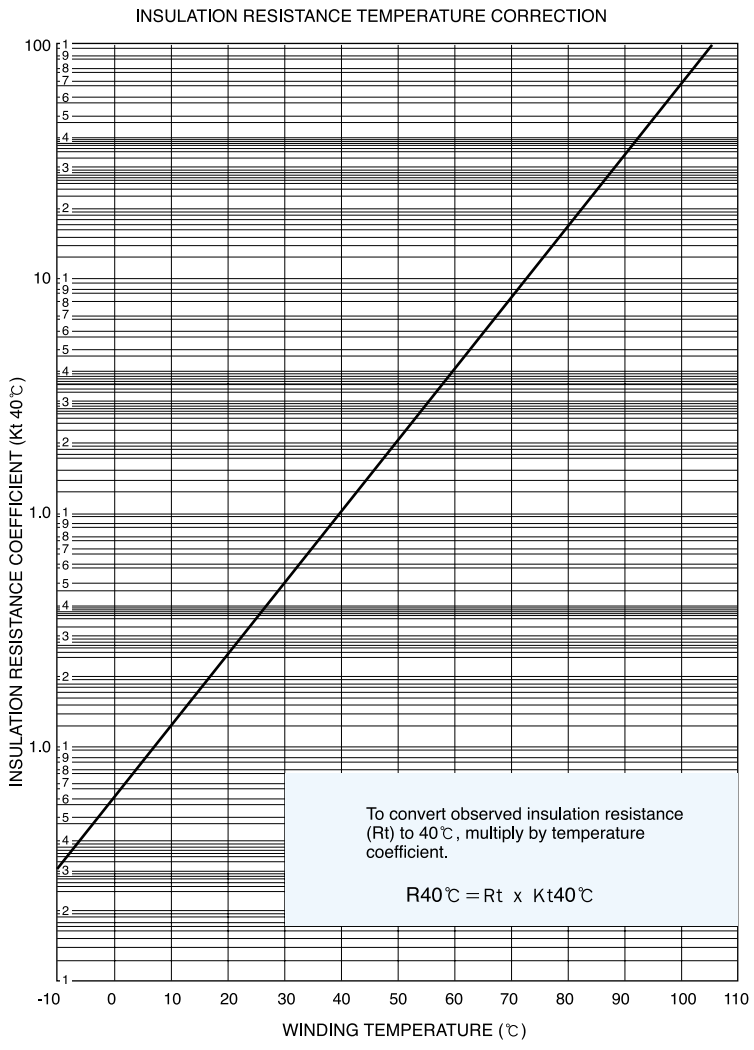
Hazardous Voltage.
Will cause death, serious injury, electrocution or property damage. Disconnect all power before working on this equipment.

Whenever the motor temperature is equal to and below ambient temperature, water vapor can condense on and within it, promoting rapid deterioration.
Prevent this by energizing the space heaters to keep the motor temperature above ambient temperature by at least 3°C However, during periods of extreme cold or rapid temperature drops, the space heaters may not be adequate to maintain this differential and supplementary heating may be required.

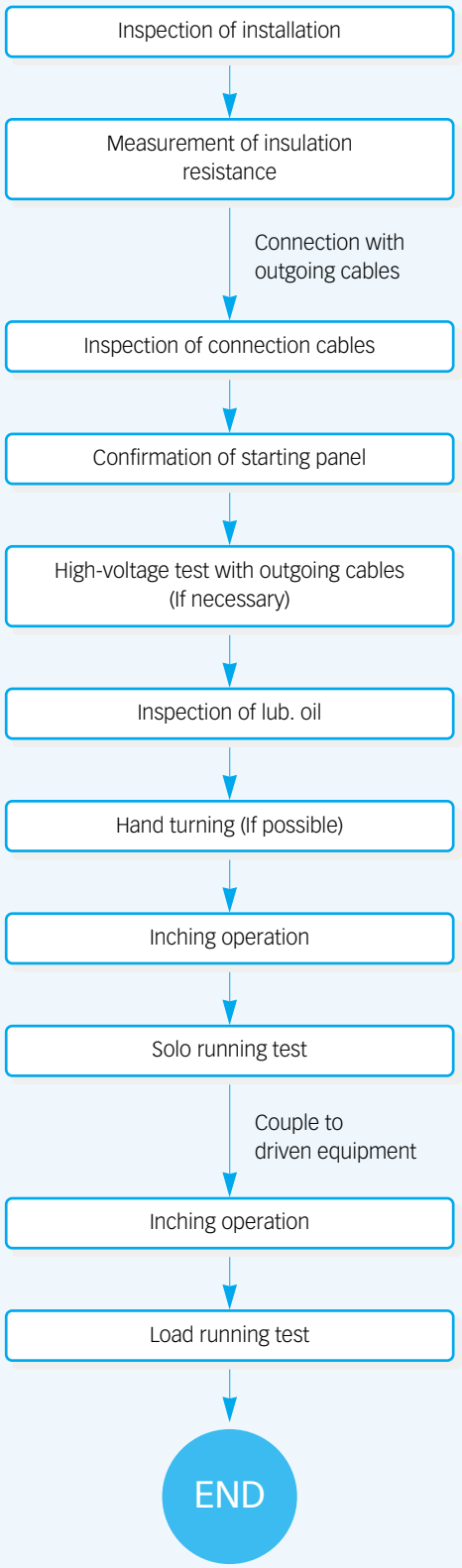
CAUTION

If the motor is boxed or covered in any way when the space heaters are energized, there should be thermostatic control and sufficient surveillance to detect an over-temperature condition quickly. Ensure that temporary packaging does not contact the space heaters.
When windings of motor are uninjured and their insulation resistance to ground is well above the minimum of rated voltage (kV) plus 1 megohm when corrected to 40°C according to IEEE 43 or as below in Fig. 1, low temperature is not a problem.
However, if the resistance drops, the windings can be permanently damaged by freezing. Therefore, the motor temperature should be kept above freezing point.

➡ Fig. 1 Insulation Resistance Temperature Correction



Generally, inspection and test of motors are performed as in the following chart for initial start-up on site.



3.1 Installation

General

Ensure that the motor enclosure is suitable for its environment, that the ambient temperature is less than specifications for operating the motor at all times and that all bearings are lubricated before operating the motor.

Foundation

Motors should be mounted on solid and rigid foundations to ensure proper vibration and free operation. The desirable foundation and anchor bolt design will

– accommodate at least the maximum static and dynamic foundation loads indicated on the motor outline dimension drawings.
– have sufficient rigidity to maintain acceptable alignment after the application of load.
– be free of natural frequencies, which are likely to be excited during normal operation (this could result in vibration problems on the motor).

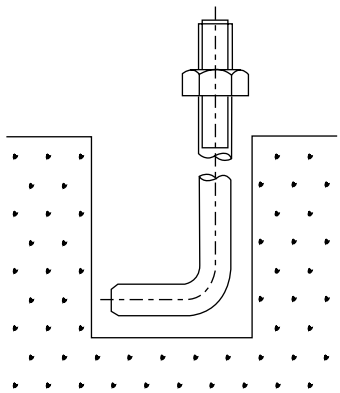
In some cases where precision is required, a study of these factors should be conducted to determine the natural frequencies of the motor support.

NOTE: If normal vibration or noise will be objectionable (as in office buildings), it may be advisable to use vibration dampeners between the machine or driven/drive unit and the foundation.

Foundation Bolt

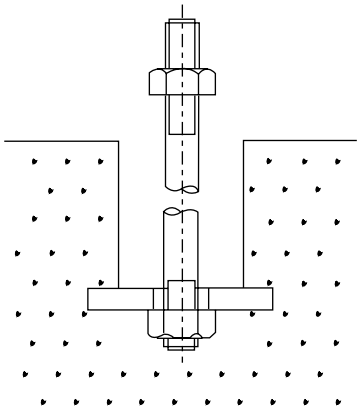
There are some different methods of installing the foundation bolt as shown in Fig. 2. The methods depend on the capacity and construction of the motor.

Fig. 2 Type of Foundation Bolt



< J-Type >

Fig. 2 Type of Foundation Bolt



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Mounting

After removing the package from the skid of the motor, remove the polyethylene shroud. Remove the motor from the skidding. The motors should be mounted on a flat surface and packed about with shims (shim allowance is generally 2-3 mm thick).
The shims should support the maximum length of each motor foot. It is preferable to use corrosion-resistant shims such as brass or stainless steel; otherwise "shim swell" due to corrosion may be detrimental to good alignment. Care should be taken not to distort the frame during "bolting down".

⚠ CAUTION

A basic rule is to not have more than 5 shims in a shim pack under any one machine foot. Thick shim packs consisting of many thin shims will cause a soft foot and cause vibration or twisted frame (machine foot out of plane).

NOTE: Experience has shown that any base-mounted assemblies of motor and driven units temporarily aligned at the factory, no matter how rugged or deep, may twist during shipment. Therefore, alignment must be checked after mounting.

Remove the Locking Device of Large Motors

All large motors are equipped with a device for preventing the shaft from movement in order to protect the rolling face of bearing from damages due to vibration in transit.

This locking device is fitted on the drive side or on the non-drive side. Before connecting a motor to a machine, the fitting bolts should be loosened, and the fitting device should be taken off.

⚠ CAUTION

The rotor is locked by a rotor locking device for the purpose of protection during transportation. These are normally locked on the drive end shaft, but sometimes locked on the non-drive end shaft. The locking device shall be taken off by simply loosening the screw bolt. As the locking device is generally painted in yellow-brown, it can be easily visible.

Bolt Tightening Torque

The following table provides the general guidance of Max. bolt tightening torque, especially mounting bolt tightening situation. The values are maximum for each case, thus care should be taken not to exceed the values.

Material / Thread Size	Tightening Torque(kgf • m)	
	SS400 (For anchor bolt)	S45C (Strength grade: 8.8)
M6 X 1	0.4	1.1
M8 X 1.25	0.8	2.1
M10 X 1.5	1.6	4.3
M12 X 1.75	2.8	7.5
M14 X 2	4.6	12.1
M16 X 2	6.7	18
M20 X 2.5	13.3	35
M22 X 2.5	18.3	49
M24 X 3	22.4	60
M30 X 3.5	46.9	124
M36 X 4	80.5	215
M42 X 4.5	128	343
M48 X 5	194	518
M56 X 5.5	310	822
M64 X 6	463	1233
M72 X 6	667	1776
M80 X 6	922	2454
M90 X 6	1325	3540
M100 X 6	1855	4929

⚠ CAUTION

For the maximum tightening torque for main power cable connection bolt, please refer to '7.4 Operation, 3) Tightening Torque', page 24.

3.2 Inspection of Installation

After installation, check for looseness of bolts and nuts on the terminal boxes, cooler boxes and so on. Then, the foundation and centering of the motors should be checked. These items are normally checked and reviewed on the erection records.

Checklist for inspection of installation

1. Outside view of machine
   - No rusted portions.
   - No damaged portions/parts.
   - Confirmation of caution, nameplate.

↓

2. Removal of rotor locking device
   (If necessary)

↓

3. Check for no looseness
   - End covers.
   - Terminal boxes.
   - Cooler boxes.

↓

4. Check around foundation
   - Motor levelling.
   - Tightness of foundation bolts.

↓

5. Inspection of accessories
   - Thermometers
     (indication checks at amb. temp.).
   - Temperature detectors
     (indication checks at amb. temp.).

↓

6. Confirmation of centering

3.3 Measurement of Insulation Resistance and Polarization Index

Hazardous Voltage.
Will cause death, serious injury, electrocution or property damage. Disconnect all power before working on this equipment.

The insulation resistance of stator, rotor and auxiliaries shall be measured before the initial start-up of the machine or after a long period of standstill. The insulation resistance testing is available method for determining the extent of moisture absorption and dirtiness of the insulation. The insulation resistance of new machines with dry windings is very high. If the machine has been subjected to incorrect transportation and bad storage environment such as high humidity, salty and dirty, the insulation resistance can be extremely low. Based on the result of insulation measurement, correct cleaning and drying action shall be determined and conducted.

3.3.1 Procedures for insulation resistance test

The insulation resistance is measured by using an insulation resistance meter (Megger). Guidelines for test voltage are presented in the following table.

Winding rated voltage (V)*	Insulation resistance test direct voltage (V)
< 1000	500
1000 - 2500	500 - 1000
2501 - 5000	1000 - 2500
5001- 12000	2500 - 5000
> 12000	5000 - 10000

* - Rated line-to-line voltage for three-phase AC machines, that is the rated voltage of machines.
- The test voltage guidelines were quoted from IEEE 43-2000.

The test voltage is applied between the winding and the frame for 1 minute. The test is usually performed to the whole windings as a group. In case that the test is conducted to each phase winding, the frame and other windings not under test shall be grounded. Before the insulation resistance test is conducted, the following actions shall be taken.

– Verify that all power supply cables are disconnected.
– The winding temperature is measured.
– All resistance temperature detectors are grounded.
– All other external equipment such as surge capacitors, lightening arrestors, current transformers and etc are disconnected and grounded.

3.3.2 Correction to temperature of insulation resistance

The insulation resistance value varies inversely, on an exponential base, with the winding temperature. In order to be able to compare measured insulation resistance values, it is recommended that all insulation test values be corrected to a common base temperature of 40°C.
The correction is made by using the following equation :

$$R_C = K_T R_T , \quad K_T = (0.5)^{(40-T)/10}$$

Where:

R_C is insulation resistance (in MΩ) corrected to 40°C
K_T is insulation resistance temperature coefficient at temperature T°C
R_T is measured insulation resistance (in MΩ) at temperature T°C

Example:

R_T = 3000 MΩ at 35°C
$K_T = (0.5)^{(40-35)/10} = (0.5)^{5/10} = (0.5)^{1/2} = 0.707$
R_C = 0.707 x 3000 MΩ = 2121 MΩ

3.3.3 Polarization Index (PI)

The measured insulation resistance will usually rapidly increase when the voltage is first applied, and then gradually approach a relatively constant value as time elapses. The insulation resistance of a dry winding in good condition may approach a constant value of insulation resistance in 4 min or less. If the winding is wet or dirty, a low steady value will usually be reached 1 min or 2 min after the test voltage is applied.
The polarization index is normally defined as the ratio of the 10 min resistance value (IR_{10}) to the 1 min resistance value (IR_1). The polarization index test is less dependent on the temperature than the insulation resistance. So, it is not necessary to make a temperature correction to the PI. If the 1 min insulation resistance is above 5000 MΩ, the polarization index is not an indication of the insulation condition and is therefore not recommended as an assessment tool.

3.3.4 Recommended minimum values for insulation resistance and polarization index

The actual winding insulation resistance to be used for comparison with IR_{1min} is the observed insulation resistance, corrected to 40°C, obtained by applying a constant direct voltage to the entire winding for 1 min. Generally, the insulation resistance value for dry windings exceeds the minimum values significantly. It is impossible to give definite values, because resistance is affected by the machine type, humidity, temperature, aging, operation period and etc. Therefore, the following values can only be considered as guidelines.

• Recommended value for Insulation Resistance (IR)

New stator windings	Used stator windings	Wound rotor windings
IR_{1min} > 1000 MΩ	IR_{1min} > 100 MΩ	IR_{1min} > 5 MΩ

※ If the measuring conditions are extremely warm and humid, IR_{1min} value of stator windings above 100 MΩ may be accepted.

• Recommended value for Polarization Index (PI)
The minimum PI value for class F insulated windings is more than 2.

3.3.5 Suitability for operation

Recommended minimum values of the IR or PI may be used to estimate the suitability of the winding for operation. If the IR or PI is low because of dirt or excessive moisture, it may be improved to an acceptable value by cleaning and drying. It may be possible to operate machines with PI and IR values lower than the recommended minimum values; however, it is not recommended. In all cases where the test values fall below the recommended minimum values, investigations should be undertaken to determine the cause to such low readings.

3.3.6 Insulation resistance measurement for auxiliaries

To ensure correct operation of the machines protections and other auxiliaries, their condition can be determined by an insulation resistance test. The test voltage for the space heater shall be 500 VDC and for other auxiliaries 100 VDC. The recommended minimum value of the space heater is over than 1MΩ. The insulation resistance measurement for temperature sensors is not recommended.

3.4 Inspection of Lubrication Oil

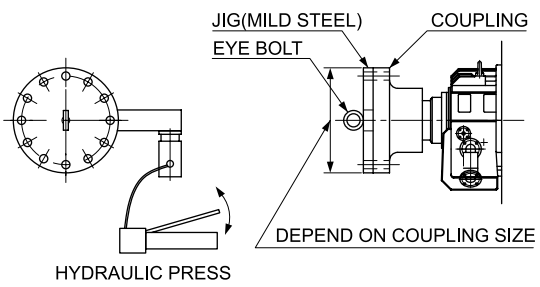
Before the initial running test, inspection of lubrication oil is very important, that is, confirmation of no oil leakage and proper oil level.
Refer to bearing maintenance manual.

⚠ CAUTION	Before starting the machine, fill the bearing chamber to the center of the oil gauge. Always fill through the pipe or plug at the side of the motor. Do not overfill, as the oil may then escape along the shaft and enter the unit. Avoid adding oil while unit is running.

3.5 Manual Rotation

If possible, rotate the rotor manually to ensure that it is free to move without rubbing or scraping and to lubricate the bearing surfaces. A minimum of 10 revolutions is recommended. If start of turning is very difficult by hand. The JIG for starting as per the below sketch is requested depend on actual coupling size. Couple the JIG with coupling and push or pull the handle using hydraulic jacking or chain block. Once Shaft is moving, turn is using pipe to eye bolt. It is easy to turn continuously once the shaft is moving.

➡ Manual Rotation



3.6 Connection to Power and Grounding

Examine the nameplate data to know the correct power supply. Also check heater power where applicable. Check all connections to ensure that they have not come loose during transport. Make certain that the correct cable size has been selected and connected to phase rotation as shown in motor terminal box. The motor and control wiring, overload protection and grounding should be done in accordance with the National Electrical Code and local requirements.
In case of the wound rotor, check to see that brushes are "free" in the holder and the pressure of the brushes is applied correctly. Ensure that the slip ring surface is clean and free from contamination. Avoid "fingerprint" marks on ring surface. To maintain the proper degree of protection, make sure all gaskets and cover plates are properly fixed and sealed. Any unused entry holes should be plugged.

⚠ WARNING	- Ensure that the motor starter (supplied by others) is open. - Make the connections as in the required rotation. - Drill the cable entry plate (at bottom of box) to suit your power cable and its fitting. - Connect the station ground to one of the ground pads provided on the stator frame.

3.7 Solo Run Test

⚠ CAUTION	**Do not exceed number of HYUNDAI-specified hot and cold starts per hour.** Will cause overheating. Allow time between starts to permit stator windings and rotor cage to cool.

Before coupling with the load machine, the motor is normally run through a solo running test. At the initial start, the motor is inching operated for approx. 1-2 sec. At that time, inspection of the correct direction of rotation, abnormal noises, and lubrication conditions are checked during the idling. If these items have any problems, the supplied power shall be taken off, checked and reported in detail.

The motor is then restarted. The motor is run 1-2 hrs. and vibration amplitude on the bearing housing and bearing temperature are measured and recorded.

⚠ WARNING	**Do not operate equipment beyond design limitations.** Can cause personal injury or damage to equipment. Operate in accordance with instructions in the manual and nameplate ratings.

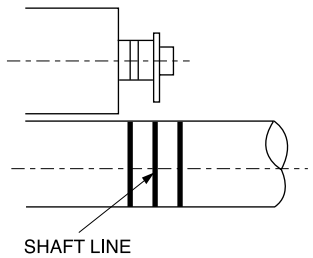
3.8 Alignment

The correct alignment of machinery is very important for reducing the stress and vibration of the shaft and the wear of the bearing and coupling. In case a coupling maker gives those instructions, it is recommended that the instructions be followed.

Flexible Coupling

The flexible coupling set forth herein means the one driven through the rubber brush or the leather brush including the gear coupling. In aligning the motor equipped with the sleeve bearing, attention is to be paid to the endplay of the motor bearing and to the position of the coupling. The center of the motor bearing endplay is indicated by the endplay indicator.
The bearing endplay can be equally divided by setting the endplay indicator to the standard line of the shaft as shown in Fig. 3.

Fig. 3 Endplay Indicator



CAUTION

In case the coupling is used, it may be considered that the rotor can be easily moved in the axial direction. In fact, however, it hardly slides in the axial direction at the coupling as the torque grows greater. When by some reason the rotor has undergone some axial movement, and the coupling does not provide enough slip to allow the rotor to return to the magnetic center of the motor, it will continue to operate with the bearing end in contact with the shoulder of the journal.

Rigid Coupling

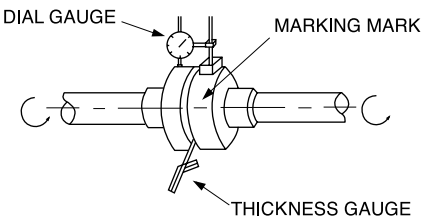
In case of the sleeve bearing, when both flanges are connected to each other, the endplay indicator is referred to install the flexible coupling in order to determine the position of the motor.

Alignment

NOTE: The foot plane is of concern for each unit of rotating equipment. Check driven equipment if necessary.

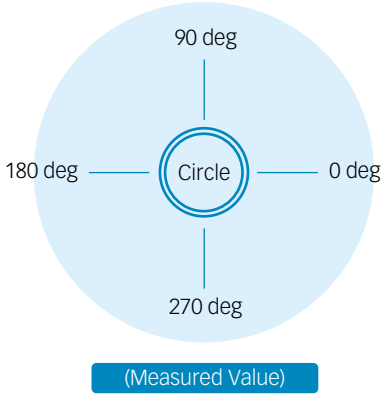
Alignment is made to bring the shaft centers of the motor and machine combined with it into the same line; the parallel and eccentricity are measured through the coupling. Generally a thickness gauge or a taper gauge is used in measuring the parallel, and in measuring the eccentricity, a dial gauge is to be fitted to the coupling on one side; the both shafts are to be turned by 0 deg, 90 deg, 180 deg and 270 deg; and the dial gauge reading is to be taken at the four points as shown in Fig. 4. The alignment accuracy is to be generally 0.025 mm or less (both plate and circle).

Fig. 4 Procedure for Alignment

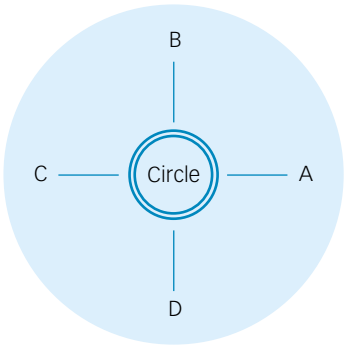


Measurement of Eccentricity

The both shafts are to be simultaneously turned; the values shall be obtained from the measurement made at four points by means of a dial gauge and are to be recorded; and the corrected value is to be obtained in the following manners.



(Measured Value)



(Measured Value)

$$\text{Corrected value of left and right} = \frac{A - C}{2}$$

$$\text{Corrected value of top and bottom} = \frac{B - D}{2}$$

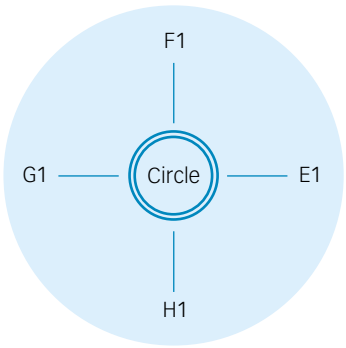
(Corrected Value)

CAUTION

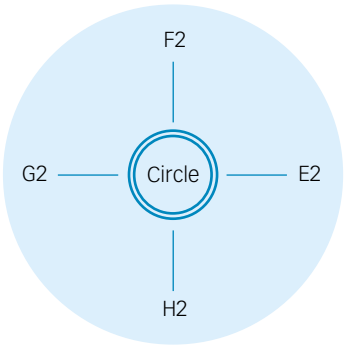
The difference between the total of the measured values at the left and right points (A-C) and the total of the measured values at the top and bottom points (B- D) should not exceed 0.03 mm. The improper fitting of the dial gauge and the erection of the fitting arm, if any, may cause greater difference.

Measurement of Parallelism

The values at the four points of E1, F1, G1 and H1 are to be corrected after measurement made by means of a thickness gauge at the position where both shafts were connected to each other at the time of eccentricity measurement; and measurements are to be made again at the points of E2, F2, G2 and H2 after turning both shafts.



(Measured Value)



(Measured Value)

$$\text{Corrected value of top and bottom} = \frac{(F1 + F2) - (H1 + H2)}{2}$$

$$\text{Corrected value of left and right} = \frac{(E1 + E2) - (G1 + G2)}{2}$$

(Corrected Value)

Belt Connection

If it is intended that the motor will be directly coupled through a flexible coupling to a machine, no check for the minimum sprocket diameter will be necessary. However, if a chain, gear, V-belt, or flat belt drive is used on the output shaft a check should be made.

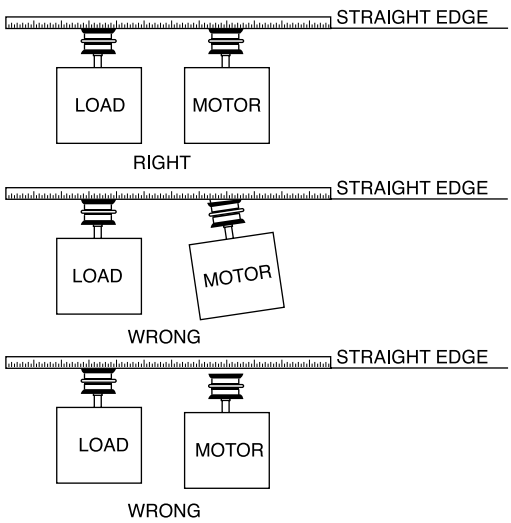
Direction of Belt Tension

In the case of the motor with roller bearing, belt tension may be applied in the horizontal or the vertical direction. In case of the motor with the sleeve bearing, the belt tension should be applied in the horizontal direction only.

Alignment of Belted Drives

Aligning a belted drive is much simpler than aligning a direct coupling drive. To check alignment, place a straight edge across the faces of the drive and driven sheaves. If properly aligned, the straight edge will contact both sheave faces squarely.

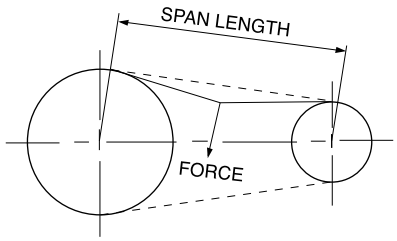
Fig. 5 Alignment of Belt Drive



Belt Tension

The V-belt is to be stretched in the following way. There is calculated deflection force to be applied perpendicular to the belt at the center of the belt span as shown in Fig. 6.

Fig. 6 Belt Tension

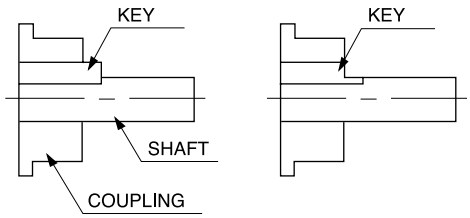


The drive is properly tensioned when the deflection of the belt caused by the deflection force is equal to 1.6 mm for span length of 100 mm. If the deflection force is higher than normal values, this will result in reduced belt life, reduced bearing life and could cause shaft failure.

Coupling Balance

The coupling should be dynamically balanced to G2.5 or better. The motor is dynamically balanced with a half key fitted; therefore, the proposed coupling should be balanced accordingly, and the correct key profile fitted.

Fig. 7 Coupling Balance



Incorrect key profile Correct key profile

Frame Distortion Check

In addition to ensure the proper alignment of the coupling, care should be taken to ensure that the motor frame is not distorted during alignment.

To confirm that distortion has not occurred, we recommend the following procedure be adopted:

1) Align the motor within tolerances as required by section “alignment.”
2) Apply a dial gauge between the motor frame adjacent to one mounting foot and the foundation and set indicator to zero.
3) Loosen hold down bolt and record movement of dial gauge measurement.
4) Re-torque hold down bolt.
5) Repeat steps 1-4 for all hold down bolts, one at a time.

3.9 Test Run of Motor

⚠ CAUTION	Carry out the initial operation in accordance with contractual agreements. The initial operation may only be carried out by trained personnel who have been assigned to do this by the person responsible for the plant.

After coupling with the load machine, the motor is inching operated at first.
When both motor and load machine show no abnormality, the motor is restarted with a minimum load. At that time, the current, supplied voltage is checked and recorded.
While the motor is running continuously, the motor vibrations on the bearing housing are controlled by Fig. 8.

⚠ CAUTION	**Do not exceed number of HYUNDAI-specified hot and cold starts per hour.** Will cause overheating. Allow time between starts to permit stator windings and rotor cage to cool.

The following maintenance and inspection schedules cover the necessary steps for inspection of the motors. Since the conditions under which the motors are required to operate may differ considerably, the maintenance and inspection schedules can only be recommended for the intervals at which at least first inspection should be carried out if operating conditions are normal. On the basis of the experience gained with the plant, the inspection intervals should therefore be selected to meet such conditions as contamination, frequency of start-ups, load, etc.

Interval			Inspection and Maintenance Work	Machine Part
A	B	C		
A: Daily Inspection. B: First Inspection, no later than 6 months. C: Following Inspection, no later than two (2) years. (when required, dismantle the machine)				
○			Check the machine for irregular noise and excessive vibration. (Fig. 8)	
○			Where possible, measure and record the bearing temperature.	
			Relubricate the grease lubricated bearing. Oil-lubricated bearing: Change the oil. Clean and inspect the bearings. For the intervals of maintenance work, see the lubrication instruction plate on the machine.	
	○	○	Check the shaft sealing rubber ring for deterioration.	
○			Where possible, measure the bearing temperature, oil pressure and flow rate.	Sleeve (white metal) bearing
○			Check that the oil-rings are operating correctly.	
○			Check the oil flow, oil level and any oil leaks.	
	○	○	Check the contamination of lubricating oil and change the lubricated oil.	
	○	○	Carry out the following oil changes with normal amb. temp. Self oil lubricated: 5000-8000 operating hours. Forced feed oil lubricated: 15,000-20,000 operating hours.	
		○	Check the axial play.	
	○	○	Check the shaft sealing for deterioration.	
		○	Inspect the bearing surface.	
	○	○	Clean and inspect the bearing insulation and insulation of the pipe.	
	○	○	Check the system, connections and piping for leaks.	Forced feed oil lubrication system
	○	○	Check the oil level.	
	○	○	Clean and inspect the oil filters and oil coolers.	
	○	○	Check to see that the enclosure is not clogging (blocking) the machine ventilation.	Enclosure
	○	○	Check the gaskets for deterioration.	
	○	○	Check the enclosure for any deformities or damage.	
	○	○	Check the noise-suppression material for damage.	

Interval			Inspection and Maintenance Work	Machine Part
A	B	C		
	○	○	Check and clean the external cooling air paths.	Enclosure
		○	Drain the drain plug, when provided.	
	○	○	Replace and clean the air filter, when provided.	
	○	○	Check the clearances to rotating parts.	
	○	○	Check the enclosure for corrosion.	
		○	Check earthing (grounding) terminals.	
	○	○	Check the enclosure including external cabling conduit connection for ingress of water or dust.	Junction (terminal) box, terminals
		○	With loose leads: Check to see that the cable connections are properly insulated.	
		○	Check connection for good contact.	
		○	Check terminal insulators for damage.	
○			Measure and record the winding temperature detectors, when provided.	Stator winding
	○	○	Check and record the insulation resistance of windings.	
	○	○	Clean the windings, as far as possible.	
		○	For totally enclosed machines, clean the winding if required.	
		○	For the wound rotor machine with continuous sliding brushes and open enclosure machine, clean the entire winding and cooling air paths, including the core packs-air duct.	
		○	Check the slot wedge for tight fit.	
		○	Check condition of winding insulation, including end connections.	
		○	Check winding and bracing for tightness.	
	○	○	Clean the winding, as far as possible.	Squirrel-cage rotor
		○	For totally enclosed machine, clean entire winding if required.	
		○	For the open enclosed machine: Clean entire winding and cooling air paths including the core packs-air duct.	
		○	Check cage bars and end rings for fractures and loosely soldered connection.	
		○	Check cage for axial displacement.	
		○	Check end rings and support rings and the associated locking elements for tight fit.	
	○	○	Check and record the insulation resistance of windings.	Wound rotor winding
	○	○	Clean the winding, as far as possible.	
		○	For totally enclosed machines, clean the winding if required.	

Interval			Inspection and Maintenance Work	Machine Part
A	B	C		
		○	For the machine with continuous sliding brushes or open enclosure machines, clean entire winding and cooling air paths including the core packs-air duct.	Enclosure
		○	Check the slot wedge for tight fits.	
	○	○	Check the winding-end for deposits of oil and carbon dust.	
		○	Check the banding for tightness, and check for any loosely soldered joints.	
		○	Check bracings and wedges of winding end and ring circuits for tightness.	
		○	Check leads of stator winding, slip ring leads of wound rotor machine and their locking elements for tightness.	Water air cooler (heat exchanger)
○			Vent the cooler while in operation.	
○			Where possible, measure and record the water temperature. (Caution that cooling pipes are not damaged by freezing when the operation is stopped)	
	○	○	Check the cooler, connection and piping for leaks.	
	○	○	Check and clean the cooler.	
	○	○	Inspect the corrosion protection. (when provided)	
○			Compare brush noise, sparking and contact marking with conditions found in previous inspection.	Slip ring, brushes
	○	○	Check to see that the brushes can move freely in the brush holders.	
	○	○	Check the pigtail (connection) leads for discoloration and damage.	
	○	○	Take out and clean the air filter.	
A or at least within 1 month			Check the brush length and replace as necessary.	Slip ring, brushes (cont'd)
			Inspect contact surfaces; they should be bright, free from rubbing or threading and have a uniform skin.	
1 week			Remove deposits of carbon dust from the slip ring chamber, slip ring and brush holders.	
3 or 6 months			Check the holder for damage.	
			Check the tightness of slip ring, including separators and fixing studs.	
	○	○	For arm type brush holder, check brushes for screw tightness.	
○			Avoid continuously sliding the brushes.	Brush lifting mechanism
○			Avoid continuously rotating the thrust roller.	
	○	○	Check to see that the mechanism, including the sliding surface of the shaft to the short-circuit ring, is free from dust.	
	○	○	Check the abnormality of thrust roller and limit switch.	
	○	○	Check the sliding surface of short-circuit ring for corrosion.	
		○	Check setting of short-circuit ring to shaft.	
	○	○	For arm type brush holders, check brushes for screw tightness.	
	○	○	Re-lubricate the reduction gear assembly.	
	○	○	Check the manually operated gear unit for damage.	

04 Inspection and Maintenance Schedule

Interval			Inspection and Maintenance Work	Machine Part
A	B	C		
○			Axial rotor placement should be kept by indication of the shaft on its magnetic center.	Shaft and coupling
	○	○	Check and adjust the belt tension.	
	○	○	Check the external and internal fan for damage or corrosion.	
		○	Check rotor alignment.	
		○	Check the balancing weight for tightness.	
		○	Check all coupling bolts and locking elements for tightness.	
		○	Check the oil leakage of gear coupling.	
		○	Check the shaft keys for tightness.	
		○	Check the monitoring instruments and contact device for proper function.	Monitoring instruments
	○	○	Check the brush length and replace as necessary.	Ground brush
		○	Check the holder for damage.	

➡ Fig. 8 Values of Vibration

Speed, rpm	Rotational Frequency, Hz	Velocity, in/s (mm/s) peak
3600	60	0.15(3.8)
1800	30	0.15(3.8)
1200	20	0.15(3.8)
900	15	0.12(3.0)
720	12	0.09(2.3)
600	10	0.08(2.0)

05 Maintenance of Windings

5.1 General

It is important to keep the machines in good condition by performing periodical maintenance to prevent the insulation from being damaged by moisture, dirt and other foreign matter.

If the machines have been operated under high humidity conditions, not been used for a long time, or been subjected to sudden changes in ambient temperature, the insulation may have absorbed considerable moisture, causing deterioration of the insulation.

Other causes of insulation breakdown include operation of the machines at an overcurrent exceeding the rated current, use under an ambient temperature exceeding the specified values as may be possible with a heated air blower which directly radiates heat over the machines, and overheated windings resulting from dust accumulating on the core packs and coil ends. All of the above items impair insulation and reduce the life of the machine.

5.2 Cleaning of Coils

The method selected will depend on the type of machines, type of insulation, kind of dirt, and other conditions and circumstances.

Cleaning by Wiping with Cloth

Wiping cloths can be used for cleaning when the machine

is small, the surfaces to be cleaned accessible, and the dirt to be removed dry.
Waste should not be used, as lint will adhere to the insulation and increase the collection of dirt, moisture, and oil. This is particularly objectionable on high-voltage insulation, as it tends to cause concentration of Corona.

Cleaning by Means of Compressed Air

Compressed air, used to blow out dirt with a jet of air, is usually effective especially where dirt has collected in places that cannot be reached with a wiping cloth.
Cleaning can be done more quickly with compressed air than with wiping cloth especially on the large machines. If blowing with compressed air results in simply transferring dirt from one place to another on the machine, little is accomplished.

There are a number of precautions to be observed when using compressed air: Air being blown should be dry, especially if blowing against insulation. Moisture condenses and accumulates in air lines and hoses.
Care should be taken to assure this has been completely dried out before using the compressed air on insulation.
Compressed air should never be more than 3~4 kg/cm^2 (42-56 psi) pressure. Higher pressures can damage insulation and force dirt under loosened tape.
Care should be taken not to blow loosened dirt into inner recesses where it will be difficult to remove and where it might obstruct ventilating ducts.

⚠ WARNING	Wear goggles when blowing dirt out with compressed air and be careful not to direct the air jet toward others. Failure to heed this warning can result in injury to the eyes.

Cleaning by Means of Solvents

Solvents are usually required to remove grease and oil dirt. A lint-free cloth wet with solvent may be dipped in the fluid.
Petroleum distillates are the only solvents recommended for cleaning electrical apparatuses. These solvents, classed as Safety-Type Solvents, have a flash point of above 37.8 C deg and are available from most oil companies and other supply sources under various trade names:

- Mineral spirits, cleaner's naphtha, and similar products with a flash point above 37.8 C deg.
- Gasoline, naphtha, and similar grades must not be used for cleaning. They are highly volatile and present a great fire hazard.

⚠ WARNING	Avoid prolonged or repeated contact with petroleum distillates or breathing their vapors. These solvents can cause severe skin irritation, are toxic, and are readily absorbed into the system. Failure to heed this warning can cause severe personal injury or death. Do not use carbon tetrachloride or mixtures containing carbon tetrachloride for cleaning purposes. Carbon tetrachloride and its fumes are highly toxic. Failure to heed this warning can result in serious illness or death. Avoid excessive contact with cleaning solvents and breathing their vapors. Some solvents are extremely toxic and readily absorbed into the system.

5.3 Use of Space Heaters

When the motor is operating, its interior is not humid and in a dry condition. But it absorbs humidity at rest.
In order to prevent absorption of humidity, the space heater installed inside the frame should be immediately energized after the motor comes to a stop, and the temperature inside of the motor should be controlled 3 to 5 C deg higher than the ambient temperature.
If there is no space heater, a 100-150-W incandescent lamp may be used.

⚠ CAUTION	Connect this heating system according to its output and reference voltage. Arrange the control so that the heating system - switches on after the electrical machine switches off. - switches off before the electrical machine switches on.

5.4 Drying Insulation

Should the insulation resistance for the winding have poor insulation resistance due to the ingress of moisture, then the windings must be dried to improve the insulation resistance to the minimum specified value before the application of insulation resistance. The preferred method of drying windings is the external heat method. The alternative is the internal heat method.

1) The External Heat Method.

* Temperature-controlled oven
  The best method is to dismantle the motor (including

bearings) and place the motor in a temperature-controlled oven at 110°C max. for 8-10 hours depending on oven efficiency to remove moisture.

* The alternative external heat method is to remove end shields and covers, connect the anti-condensation heaters, and fit additional "low intensity resistance heaters" in and around the motor.

A temperature controller should control additional resistance heaters with a probe adjacent to the winding at the top of the motor. The temperature should be set for 100°C to 120°C. The drying process will take approximately 10-16 hours once the correct temperature is achieved.

< Key Points to Remember >

1) Heaters must be the "low intensity resistance heaters" types otherwise the insulation might be burnt.
2) The motor may need to be covered by some thermal insulation to retain the heat.
3) A vent opening should be placed in the tip of the thermal insulation tent for the evaporated moisture to escape.
4) Sufficient space should be allowed between the heaters and any winding insulation so as not to generate local excess heating of the winding insulation.

2) The Internal Heat Method

With this method, the heat is applied by passing current through the windings to generate heat. Extreme caution should be exercised using this method so that you do not damage the internal insulation before the windings are up to optimal temperature.

⚠ WARNING	This method should only be used if all winding resistance is greater than 1 megohm.

< Key Points to Remember >

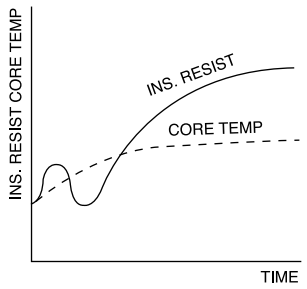
1) Remove brushes and short the ring together with a copper link in case of a slip ring motor (wound rotor).
2) Connect an AC supply voltage to the stator windings. The applied voltage should be approximately 12%. In this case the stator nominal voltage is 3,300 V and since 415 V AC represents 415/3,300 x 100 = 12.5%, this will be a convenient supply voltage. In case the current is taken from the supply, it would be typically 70% of the full load rated current.
3) The power supply should be controlled with a temperature controller operating from the internally connected RTDs supplied by the motor manufacturer.
4) The shaft should be locked to prevent rotation.
5) Set the temperature controller to 110°C maximum.
6) Drying will take approx. 8-12 hours once the windings have reached 100°C. The windings should take 6-8 hours to heat up to 110°C.

Determination of Dried Insulation

During the drying process the insulation resistance should be checked with a 500-V (low-voltage machine) or 1,000-V (only high-voltage machine) DC low-energy source meter (e.g. megger) and then recorded after 1 minute.
This process should be repeated every hour until the results show the winding is dry.

Once the winding is completely dry, the insulation resistance will stabilize. After the windings cool down, the insulation value should increase.

➡ Fig. 9 Change in Insulation Resistance



Notes on Drying Insulation

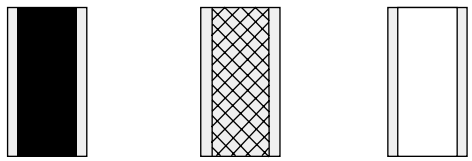
1) A temperature-controlled oven should be used if the windings have been completely immersed in water.
2) Should the windings contain contamination, the windings should be properly cleaned before attempting to dry windings. Contact your factory representative for further advice.
3) All processes for drying insulation should be performed under the supervision of qualified personnel. Failure to observe proper procedures may result in permanent damage to the insulation or winding system. For further advice contact your factory representative.

6.1 Slip Rings

Good Conditions

The slip ring must run true to the center of rotation. The maximum permissible TIR (Total Indicator Runout) must be no greater than 0.2 mm. If the TIR is greater than this, the slip rings must be machined true. The surface of the slip rings must be a smooth finish. The slip ring will normally show a running band under the brush contact area. This can be from light straw in colour to dark brown (almost black). The most normal colour is "light brown". The surface should be consistent in colour around the periphery and across the brush track. Sparking should not be evident during operation and the rings should be dry with no signs of contamination.

Fig. 10 Examples of Good Condition



The Brush Running Band is a film on the ring basically consisting of copper oxide and carbon. This film occurs naturally during normal operating and it is essential for good brush and ring condition. Do not try to remove it. The film is easily maintained by ensuring the area is free from contamination and the machine is properly loaded.

Poor Conditions

Poor ring conditions can be caused by several conditions. The common causes of poor ring conditions are:

1) ***Brush loading is not optimum correction***:
See Section "Optimizing Brush Wear".

2) ***Contamination***:
Such as oil, salt air, H_2S or silicone vapours (even from Silastic) may destroy the film built up on the rings.
Correction: The contamination should be removed and a new set of brushes fitted and bedded in. It is preferred that slip rings be cleaned with a dry lint-free cloth. If required, some "non-residue/noncorrosive" electrical cleaning solvent could be used.

> **WARNING**
> Electrical solvent, if inhaled or absorbed through the skin, can be dangerous to your health. Please refer to the manufacturer safety information for proper advice

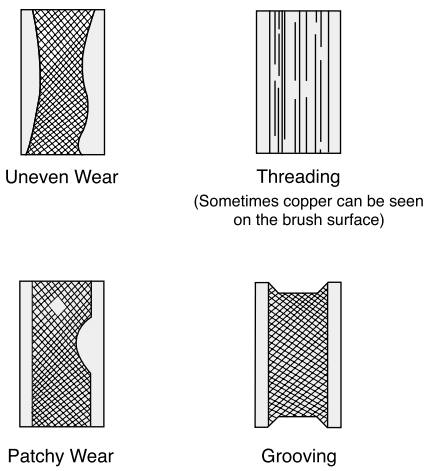
3) ***Corrosion of Brush Rings***
This condition may occur if the motor has been at standstill for a long time (e.g. after extended storage).
Correction: This should be removed by using a fine "grinding stone" stone available from most service shops or brush suppliers. Rotate the motor either with a small pony motor or run the motor on no load and uncoupled with the slip rings short-circuited after accelerating to full speed (do not start without rotor resistance starter).

> **WARNING**
> Although no voltage is present across the rings during this operation you should
> - ensure the rings cannot open circuit, otherwise high voltages could be present.
> - follow electrical safety rules.
> This procedure should only be performed by qualified and experienced personnel.

4) ***Threading***
If threading occurs, brush optimization should be corrected first.
(1) Light threading can be corrected the same way as "corrosion".
(2) Heavy threading should be corrected by machining the slip rings.

5) ***Out of Round Rings***
This must be corrected by machining the slip rings.

Fig. 11 Examples of Poor Conditions



Machining Slip Rings

Method 1 - Preferred:
Dismantle the motor and remove bearings. Place the rotor in a lathe, centre bearing journals true and machine slip rings.

Method 2 - Alternative:

The rings are removed from the shaft with a puller which can be attached to the hub of the slip ring assembly. Access to the rings can be gained by removing the drive end endshield and carefully disconnecting the rotor leads. After the rings have been removed they can be machined in a lathe.

Method 3 - Alternative:

Some motor repair shops offer on-site machining. This is not a preferred method, but may be required for emergency repair. If on-site machining is performed, the following precautions should be adhered to

- replace brushes after machining operation is complete.
- all ring scrap to be removed from slip ring enclosure.
- this operation should only be performed by experienced personnel.

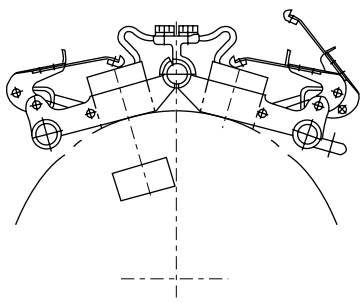
After machining, the rings should be kept clean and free from fingerprints until ring film has developed during operation.

6.2 Brushes and Brush Holders

General

The brushes must make good contact with the slip ring surface. To ensure this, they must move freely within the brush holder and pressure lever must apply the correct pressure. The brush holder assembly is fixed. To replace brushes, unclip the pressure lever and undo the "pigtail" from the holder assembly.

Fig. 12 Brush Holder Assembly



If satisfactory brush life has been obtained, replace the brushes with the same grade as the original. Always make sure brushes are bedded in after replacement.

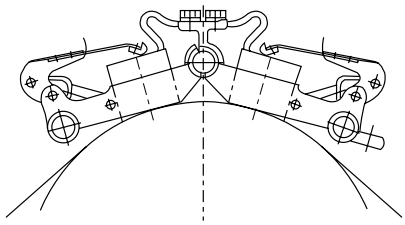
It may be possible that brushes wear out quickly. A common cause for this is a light load or brushes not making proper contact with the rings. In this case consult Section "Brush Optimization" or your carbon brush supplier. If brush holders need replacing, the brush assembly may be removed by taking off the drive end endshield.
The brushes are to be changed when they have worked down to about 1/3 of their original length. The wear is not the same for all brushes. It is important to keep the brush housing clean and grease from excess carbon dust.
Clean out housing periodically, using vacuum cleaner and clean, dry compressed air (max. 4 bars or 58 psig max.) where possible.

⚠ WARNING	Cleaning while operating is not recommended, except in case of experienced operators. High velocity compressed air can lift brushes or short pigtails together.

Bedding Brushes

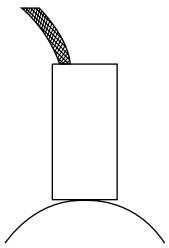
When new brushes are fitted they should be bedded in. If the slip rings wear, the diameter can vary, so the diameters of the brush face and the diameter of the rings may not be exactly the same. So, in all cases, brushes should be bedded in.

Fig. 13 "Bedding" Brushes In



Some abrasive sandpaper should be placed around the slip ring and the brush fitted in the holder with the tensator in place. The abrasive is drawn back and forth until all of the brush is in contact with the ring.

Fig. 14 Example of Poor Surface Profile



The brush surface contact area must not be less than 80% of the surface of each individual brush.
During the initial run, if possible, it is desirable to apply some bedding chalk to the rings before entering under the brush surface, this will promote the final bedding in of the brush.

NOTE: Bedding chalk is usually available from most service shops or carbon brush suppliers.

7.1 General

Transport, Storage

Always keep the cover and the cable entries tightly closed.

7.2 Description

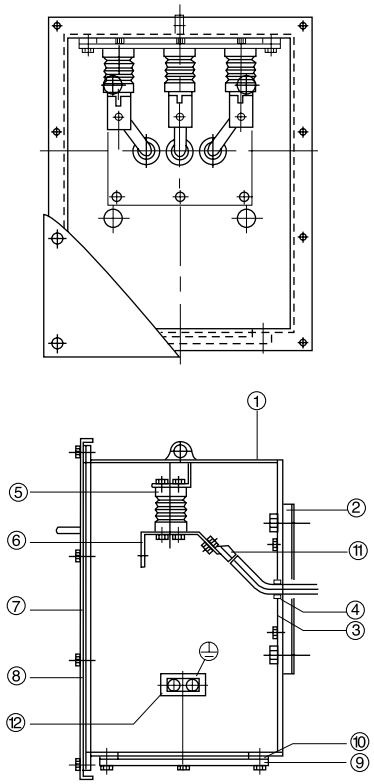
1) Application

In the terminal box, the connection is made between the stator winding and the supply cable from the system. The terminal box is mounted on the machine frame at an easily accessible location.

2) Construction

A typical construction is shown in Fig. 15

➡ Fig. 15 Construction of Terminal Box
(Example, delivered design may deviate in details)



① Terminal box body
② Packing
③ Cable holder
④ Cable grommet
⑤ Insulator
⑥ Connector
⑦ Packing
⑧ Terminal box cover
⑨ Gland plate
⑩ Packing
⑪ Terminal lug
⑫ Grounding terminal

3) Degrees of Protection

The terminal boxes comply at least with degree of protection IP55 as per IEC 34-5.

4) Connection Part for Main Terminals

The connection part is suitable for connection with cable lug depending on the equipment complement.

7.3 Installation

1) Termination

General

Ensure that the power supply agrees with the rating plate data. The supply cables should be matched to the rated current and plant-specific conditions (e.g. ambient temperature, method of cable installation, etc.). Connect the supply-cable conductors.

⚠ CAUTION	Connection cables and cable ends must not exert any bending or torsion forces on the connection bolts!

Connection by Means of Cable Lugs

The size of cable lugs must be matched to the size of the supply cable. Use appropriate units with sufficient current-carrying capacity.

Direction of Rotation

When the power supply phase conductors L1, L2, L3 are connected to terminals U, V, W respectively, the motor will rotate in a correct direction. If the connections to any two terminals are reversed, i.e. if lines L1, L2, L3 are connected to terminals V, U, W (or U, W, V or W, V, U) respectively, the motor will rotate in a reverse direction.

Installing and Entering the Cable

The following steps are recommended for split entry:

- Cut the sealing insert so that its opening is some millimeters smaller than the cable diameter.
- Introduce the cable into the cable gland. In the case of a very small cable diameter, the cable diameter should be increased by applying insulation tape at the securing point to ensure concentric positioning of the cable in the sealing insert.
- Provisionally attach the terminal box cover in order to check whether perfect sealing is achieved both at the flange surfaces and at the entry point with sufficient prestressing. If this is not the case enlarge the sealing insert cut out or adjust the cable diameter by means of insulation tape. The securing bolts should then be tightened alternately in steps.
- Unused entry openings always must be closed off by suitable plugs.

These must

- be of permissible resistant material,
- conform to degree of protection IP55,

- be tightened so that they can be removed only by means of a tool.

Earth Connection

An earth terminal for connecting the cable earth conductor is provided in the terminal box.

The minimum connection cross-section of earth connections should be selected according to IEC 34-1 with reference to live conductors.
Make sure in any case of installation and maintenance work that the equipotential bonding is maintained.

Final Checks

Before closing the terminal box, check the following:
- Conductor connections and, if applicable, the circuit connections have been made correctly.
- Interior of the terminal box is clean and free from remainders of cable material.
- All terminal screws and the appropriate cable entry parts are firmly tightened.
- Clearance in air of ≥8 mm at 500 V, ≥10 mm at 660 V, ≥14 mm at 1 kV, ≥60 mm at 6 kV, ≥100 mm at 10 kV are maintained. Remove any projecting wire ends!
- Connection leads are not subject to strain and the insulation cannot be damaged.
- Unused entry openings are closed off by suitable plugs.
- All seals and sealing surfaces are in perfect condition. If sealing of the joints is effected by metal-to-metal joints only, the surfaces should be cleaned and thinly regreased.
- Entry glands fulfill all requirements concerning degree of protection, conditions of installation, permissible lead diameter.

7.4 Operation

Safety Advice

Covers to prevent accidental contact with live or rotating parts and those required for proper air guidance and thus effective cooling should not be opened during operation.
During maintenance or inspection work in the immediate vicinity of the terminal box or of the rotating machine suitable measures should be taken to protect personnel against hot gases escaping under short-circuit conditions.

⚠ CAUTION	Only switch off the electrical machine during the main running period in an emergency, in order to protect the switchgear and electrical machine.

7.5 Maintenance

⚠ DANGER 	High-voltage power source must be disconnected before working on equipment. Failure to disconnect power source could Result in injury or death. Terminal box only to be opened by skilled personnel.

1) Safety Advice

Before any work is started on the machines, particularly before covers are removed from live parts, make sure that the machine/plant has been correctly disconnected from the power supply.
Please adhere to the general “5 safety rules”
- Isolate the equipment from the power supply,
- Provide a safeguard to prevent unintentional reclosing,
- Verify safe isolation from the supply,
- Earth and short-circuit,
- Provide barriers or covers for adjacent live parts.

2) Tightness, High-current Loading

The terminal boxes should be inspected regularly to ensure that they are tight, that the insulation is undamaged and that the connections are firmly attached.
If the terminal box is subject to extremely high current loading it is recommended that the insulators, connecting parts and cable connectors be checked.
If any dust or moisture has penetrated the terminal box, clean and dry out the terminal box. The seals and sealing surfaces should also be checked and the cause of faulty sealing should be remedied.

3) Tightening Torque

Required tightening torque for current-carrying bolted joints is given in below table.

Screw Strength class	Tightening Torque (Nm)	
	Steel (8.8)	Brass
M5	-	2.9
M6	10.8	4.9
M8	20.7	9.8
M10	42.4	19.7
M12	73.9	34.5
M16	177.4	82.8

※ The tolerance of tightening torques is ± 10%

NOTE: Replace the cover and tighten up the screws (taking safety elements into consideration).

8.1 General

Transport, storage

Always keep the cover and the cable entries tightly closed.

8.2 Description

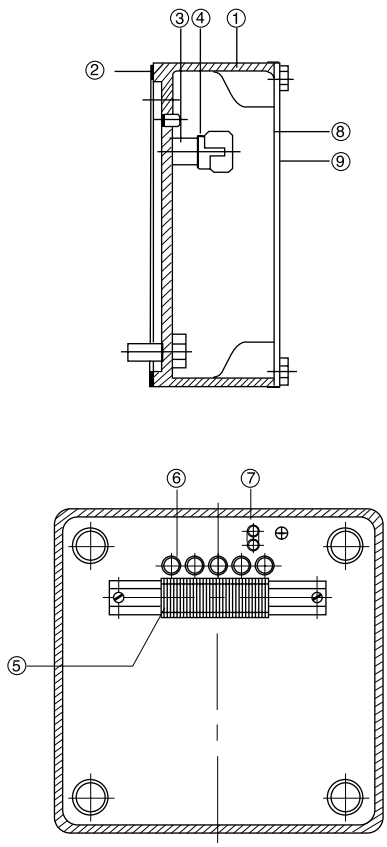
1) Application

The terminal boxes are employed for connection of auxiliary circuits.
If specially ordered for anti-condensation heater, an auxiliary terminal box for anti-condensation heater may be supplied.

2) Construction

The typical construction is shown in Fig. 16.

➡ Fig. 16 Construction of Terminal Box
(Example, delivered design may deviate in details)



① Terminal box body
② Packing
③ Support ring
④ Rail
⑤ Terminal block.
⑥ Cable grommet
⑦ Grounding terminal
⑧ Packing
⑨ Terminal box cover

3) Degrees of Protection

The terminal boxes comply at least with degree of protection IP55 as per IEC 34-5.

8.3 Installation

1) Termination

When making the connections of auxiliary circuits note wiring diagram for auxiliary circuits documented in the approval specification.
The cross-section of a supply cable should be selected on the basis of the rated current and plant-specific conditions.
The connection terminals for auxiliary circuits are suitable for conductor cross-sections of at least 2.5mm².
The ends of the conductors should be stripped in such a way that the remaining insulation reaches almost up to the terminal.

2) Installing and Entering the Cable

Hazardous Voltage.
Will cause death, serious injury, electrocution or property damage.
Disconnect all power before working on this equipment.

In addition to the information given for cable selection and preparation, the following specific notes apply, depending on the type of entry fitting used :
To maintain the degree of protection IP all screwed-in glands must be firmly tightened and sealed by suitable measure, e.g. by means of an adhesive or by fitting sealing ring. The same measures are required when fitting screwed-in plugs.

The center rings of screw glands included in the scope of supply are always screwed in place, fixed in position and sealed in accordance with degree of protection IP55 by use of LOCTITE. These glands also are fitted with blind washers for transport protection.

For adapting the cable diameter to the gland conditions it may be necessary to apply a layer of insulation tape to the leads to enlarge its overall diameter or to cut out some rings of the sealing insert.
With extreme lead diameter it may be necessary to replace the glands by those of appropriate dimensions.
Entry plates of terminal boxes may be supplied undrilled in order to allow selection of cable entry screw glands, whose design, number and size are suitable for the cables employed.

08 Terminal Box for Auxiliary Circuits

The entry elements should be selected so that
- they are suitable for the cable diameter,
- they conform to the degree of protection,
- they are suitable for the installation conditions.

The supply leads-particularly the protective conductor-should be laid loosely in the terminal box with an extra length to protect the cable insulation against splitting. Unused entry openings always must be closed off by suitable plugs.

These must
- be of permissible resistant material,
- conform to degree of protection IP55,
- be tightened so that they can be removed only by means of a tool.

3) Ground Connection

A ground earth terminal for connecting the cable ground conductor is provided in the terminal box.

09 Anti-condensation Heating with Heating Tube

9.1 Description

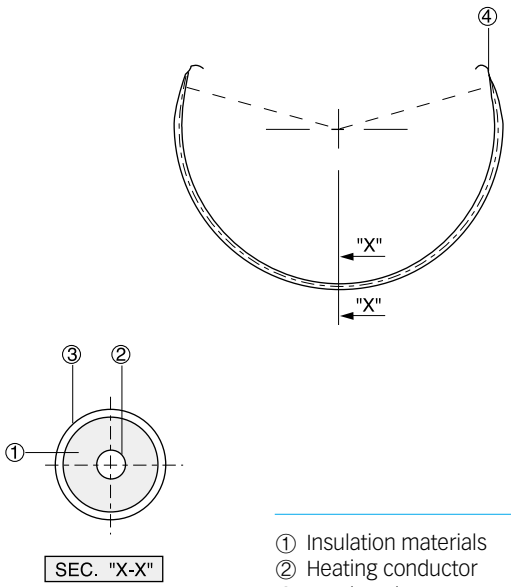
1) Application

Anti-condensation heaters fitted in electrical machines warm the air inside the stationary machine to a temperature above that of the surroundings, thus effectively preventing moisture condensation.

2) Construction

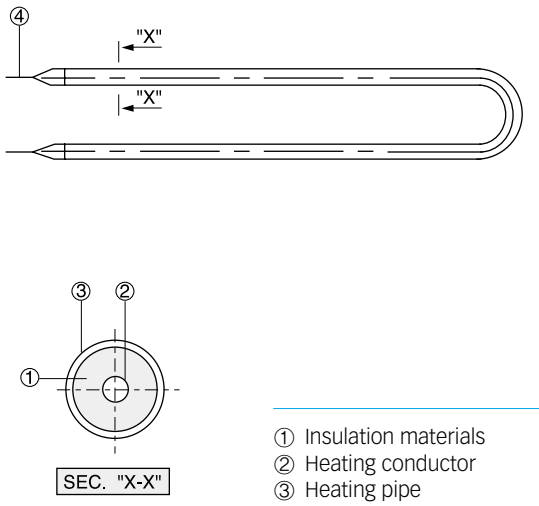
The typical constructions are shown in Fig. 17, 18 and 19.

Fig. 17 O Type Anti-condensation Heater
(Example, delivered design may deviate in details)



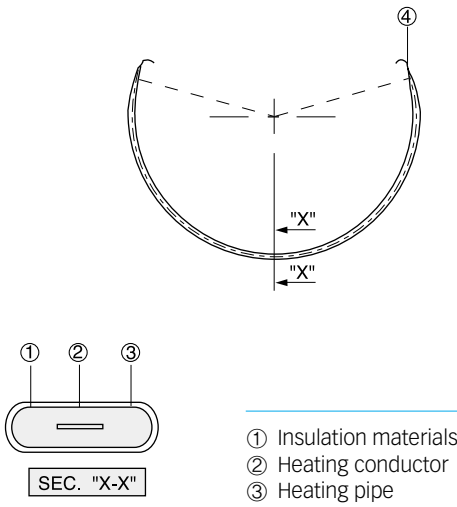
① Insulation materials
② Heating conductor
③ Heating pipe
④ Lead cable

Fig. 18 U Type Anti-condensation Heater
(Example, delivered design may deviate in details)



① Insulation materials
② Heating conductor
③ Heating pipe
④ Lead cable

Fig. 19 Strip Type Anti-condensation Heater for Explosion-proof Machines with "increased safety" (Example, delivered design may deviate in details)



The heating tube has 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.

3) Installation

The anti-condensation heater consists of one or more tubular heating elements connected together. These heating tubes are combined to form units and are installed in the stator frame. The arrangement constitutes the so-called "stabilized design", i.e. the heating temperature stabilizes itself at the rated voltage thanks to the optimum balance of heater rating and heat dissipation. Special temperature monitoring devices are therefore not necessary. This applies to explosion-proof versions as well.

9.2 Installation

1) Connecting the Supply Cable

The heater connections are brought to terminals which are located in a separate terminal box and may be made without cable lugs.
Connection must be made in accordance with wiring diagram documented in the approval specification.
Examine the data plate to see that the voltage and the power of the heating agree with the main 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 a standstill.

Through appropriate series connection of the heating tubes, even the temperature of explosion
– proof machines can be limited such that these machines meet the requirements of "stabilized design" and do not require any additional temperature monitoring measures. For this reason, no changes may be made in the original heating-tube connection!

2) Insulation Testing

The heater may only be put into operation if the specified minimum insulation value of 0.5 Mega-ohm is obtained from measurement of the insulation resistance with the heater connected.
For the period after commissioning of machines equipped for anti-condensation heating, it is assumed that either the machine itself is in operation or the anti-condensation heater is heating the stationary machine.

9.3 Maintenance

Hazardous Voltage.
Will cause death, serious injury, electrocution or property damage. Disconnect all power before working on this equipment.

1) Safety Advice

The anti-condensation heater is switched on when the machine has come to a standstill. Therefore, it must be switched off before any protecting cover is opened for maintenance work.

2) Cleaning

With respect to maintenance, occasional cleaning performed during routine maintenance of the machine and the replacement of any damaged parts is sufficient.

3) Repairs

Should replacement of the heating tubes become necessary use the same type of heaters. Install the new tubes securely and lock the fixing elements.
The heating tube units in explosion-proof machines may only be replaced as a whole and must be purchased as whole preformed units to suit the particular application.
If repairs and modifications to models covered by the certificate for these machines are not performed in a HYUNDAI workshop, an acceptance inspection by an authorized engineer is necessary. If modifications not covered by the certificate are made, the machine must be newly certified.

10.1 Flange-type Sleeve Bearings (Ring Lubrication System)

1) Mounting

The flange-type sleeve bearings of electrical machines are of the split type. They are ring-lubricated and are subject to the following instructions supplementing and modifying the operating instructions of the machine:
Corresponding to the operating conditions the sleeve bearings of new machines have a favorable bearing clearance which should not be changed. Also scraping (spot grinding) is not allowed as it could worsen the antifriction qualities.
It is possible to remove the upper part of the bearing housing for maintenance without removing the coupling. And using the crane or chain block is good method in dismantling.
Before the machines are aligned and commissioned, the bearings should be filled with lubricating oil, because the machines are delivered without oil in the bearings (Oil type is indicated on the nameplate for bearing).

2) Oil Change

⚠ CAUTION	**Maintain Proper Oil Level.** May cause damage to equipment due to improper lubrication. Follow lubricating instructions carefully. Avoid adding oil while unit is running.

Check the bearing temperature regularly. The governing factor is not the temperature rise itself, but the temperature variations over a period of time. If abrupt variations without apparent cause are noticed, shut down the machine and renew the oil.
The lubrication oil indicated on the data plate is used for starting up the machines at an ambient temperature of above +5°C At lower temperatures (to about -20°C), it is sufficient to preheat the oil. If the ambient temperature is below -20°C another type of oil according to the special conditions is used. Do not mix oils of different grades.
Recommended oil changing intervals are about 4,000 hours(6 months) in the case of intermittent duty and 3,000 hours(4.5 months) in the case of continuous duty. When cleaning, first flush the bearings with kerosene and then with oil.
Pour in the kerosene and oil through the top sightglass hole. Leave the drain open until all the kerosene has been removed and clean oil runs out. Now plug the drain and fill the bearing with oil up to the centre of the lateral inspection glass.
When the machine has run up to speed, check the oil ring through the top inspection glass to see that it rotates correctly, and check the bearing temperature, Should the bearing temperature not drop to the normal value after the oil change, it recommended that the surfaces of the bearing shells be inspected.
If the bearings are fitted with thermometers for checking the bearing temperature, fill the thermometer well in the upper bearing shell for thermofeeler with oil to improve heat transfer and top up with oil every time the lubricating oil is changed.

3) Dismantling, Assembling

When dismantling the machine the lower part of the bearing housing need not be unscrewed from the end shield, When opening the bearing housing, determine, if on which side of the machine the adjusting shims.(upper and lower parts) are installed. These shims must be installed at the same place when assembling the machine. Exceptions are possible if the stator core was changed. Drain the oil, take off the upper part of the bearing housing and the upper bearing shell, lift the shaft very slightly and turn out the lower bearing shell and the sealing rings in peripheral direction. The oil ring can be withdrawn by holding it at an inclined position to the shaft.
If only slight damage has occurred to the bearing surface, it may be re-conditioned by scraping as long as the cylindrical shape of the bore is maintained, so that a good oil film can form. The lining must be renewed if more serious damage is found. The oil pockets and grooves of the new lining or scraped shell should be cleaned and finished with particular care

The replacement bearing shells are delivered by the works with a finished inner diameter. Only if the bearing shells were delivered unfinished, the inner diameter is 1mm smaller than the finished diameter. Oil rings which have become bent through careless handling will not turn evenly. Straighten or replace such rings. Replace any damaged sealing rings.

Fig. 20 Oil Pockets and Oil Grooves

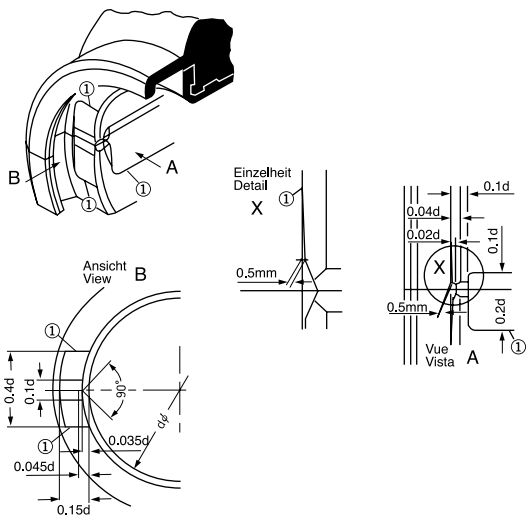
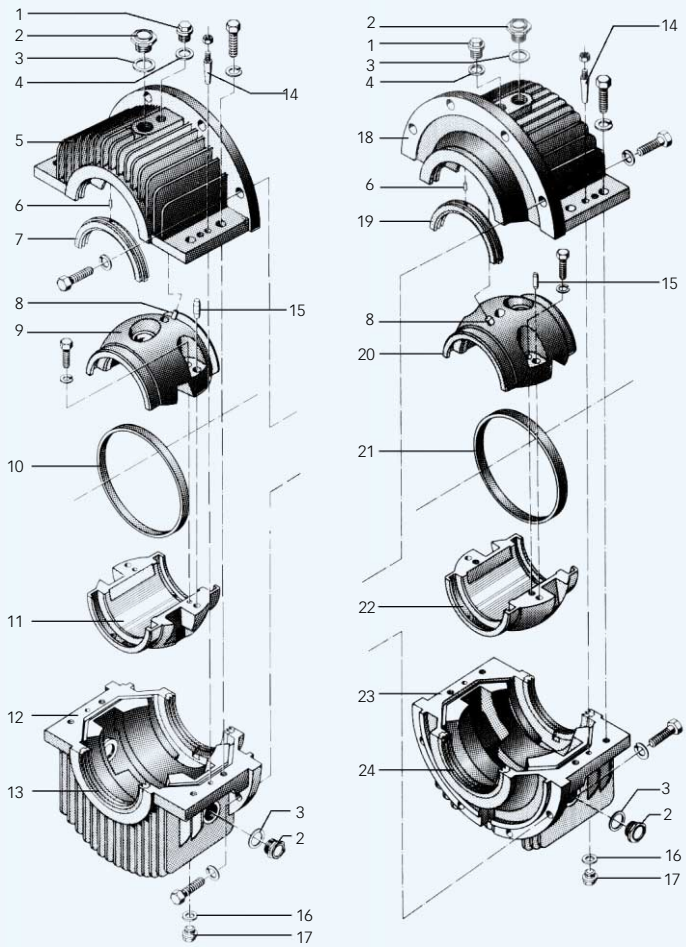
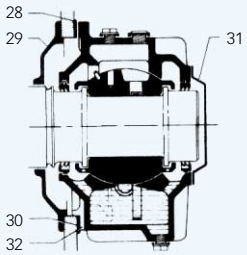
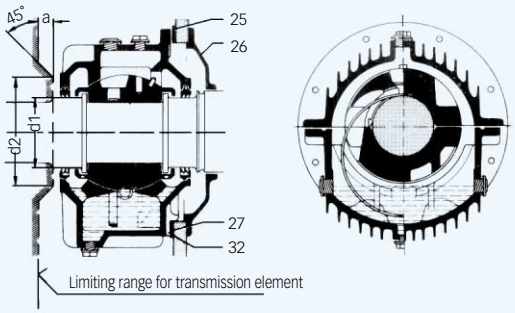


Fig. 21 Ring-lubricated Flange-type Sleeve Bearings (Example, delivered design may deviate in details)







1. Screw plug(thermometer mounting)
2. Inspection glass
3. Sealing ring for 2
4. Sealing ring for 1
5. Bearing housing, upper part drive end
6. Cylindrical pin
7. Sealing ring, upper half, drive end
8. Guide pin to prevent twisting
9. Upper bearing shell, drive end
10. Oil ring, drive end
11. Lower bearing shell, drive end
12. Bearing ring, lower half, drive end
13. Sealing ring, lower half, drive end
14. Taper pin
15. Guide pin to fix bolted parts
16. Sealing ring for 17
17. Drain plug
18. Bearing housing, upper part, non-drive end
19. Sealing ring, upper half, non-drive end
20. Upper bearing shell, non-drive end
21. Oil ring, non-drive end
22. Lower bearing shell, non-drive end
23. Bearing housing, lower part, non-drive end
24. Sealing ring, lower half non-drive end
25. Upper adjusting shim, drive end
26. Sealing cover drive end
27. Lower adjusting shim, drive end
28. Upper adjusting shim, non-drive end
29. Sealing cover, non-drive end
30. Lower adjusting shim, non-drive end
31. Protective cap
32. Pressure compensation opening

10.2 Flange-type Sleeve Bearings (Forced Lubrication System)

1) Mounting

These flange bearings of electrical machines are of the split type. They are lubricated and oil rings are provided for additional forced lubrication. They are subject to the following instructions supplementing and modifying the operation instructions of the machine: Corresponding to the operating conditions the sleeve bearings of new machines have a favorable bearing clearance which should not be allowed to worsen the antifriction qualities. It is possible to remove the upper part of the bearing housing for maintenance without removing the coupling. And using the crane or chain block is a good method in dismantling.

Before the machines are aligned, the bearings should be filled with lubricating oil (oil type is indicated on the nameplate for bearing), because the machines are delivered without oil in the bearings.

Check the oil piping to the bearings, oil pump, oil tank, and cooler before commissioning the machines. No reducers must be fitted in the piping. Install a regulating orifice on the oil supply line to protect the bearing from flooding. If the oil pump fails, the lubrication maintained by the oil ring is effective for about 15 to 30 minutes, provided the oil contained in the bearing does not drain away. As the oil is discharged to the atmospheric pressure, the discharge-end of oil piping shall be positioned at the lower level about over 500mm than the level of oil suface. And the diameter of piping shall be sufficient enough so as not to be clogged during the oil discharging to raise the level of the oil in the bearing. Oil discharge tubes must terminate flush with the inside surface of the bearing housing to prevent the oil rings from rubbing against the tubes.

Fill the oil tank with lubricating oil indicated on the data plate. This oil is used for starting up the machine at an ambient temperature of above +5°C At lower temperatures preheat the oil. It is recommended to use a control system adjusted in such a manner to have an oil temperature of 15 to 20°C in the tank and to have a preheated oil flow through the cold bearings for 5 to 10 minutes before starting up the machine. Do not mix oils of different grades.

The necessary pressure of the oil entering the bearings and the oil flow rates are indicated on the data plate. Adjust to these values when starting up the machine for the first time and correct them when the bearing has attained its normal running temperature. The oil in the bearing housing must not rise above the center of the lateral inspection glass.

If the bearings are fitted with thermometers for checking the bearing temperature, Install the thermometer in the upper bearing shell for the thermofeeler with oil to improve heat transfer and top up with oil every time the lubricating oil is changed.

In the case of insulated bearings, make sure that the insulation is not bridged by the tubes; interrupt the electrical conductivity of the tubes near the bearings, e.g. by installing oil-resistant fittings of plastic material or hoses of rubber or plastic material.

Switch on the oil pump before starting up the machine. The use of a pump driven from the shaft of the main machine is permitted only in special cases, i. e. when the acceleration and coasting times are short.

2) Oil Change

⚠ CAUTION	**Maintain Proper Oil Level.** May cause damage to equipment due to improper lubrication. Follow lubricating instructions carefully. Avoid adding oil while unit is running.

Check the bearing temperature regularly. The governing factor is not the temperature rise itself, but the temperature variations over a period of time, if abrupt variations without apparent cause are noticed, shut down the machine and renew the oil.

Recommended oil changing intervals are about 20,000 operating hours. After the machine has come to a standstill and the old oil is drained out of the bearings and oil tank operate the oil pump with kerosene for a short time and then use oil to clean the bearings, the oil pump, the oil tank, the cooler and the pipe lines. Pour in the kerosene and then the oil through the filling opening of the oil tank. Leave the drains open from time to time until all the kerosene has been removed and clean oil runs out of the bearings and the oil tank. Then, plug the drains and fill the tank with oil. Should the bearing temperature not return to the normal value after the oil change, it is recommended that the surfaces of the bearing shells be inspected.

3) Dismantling, Assembling

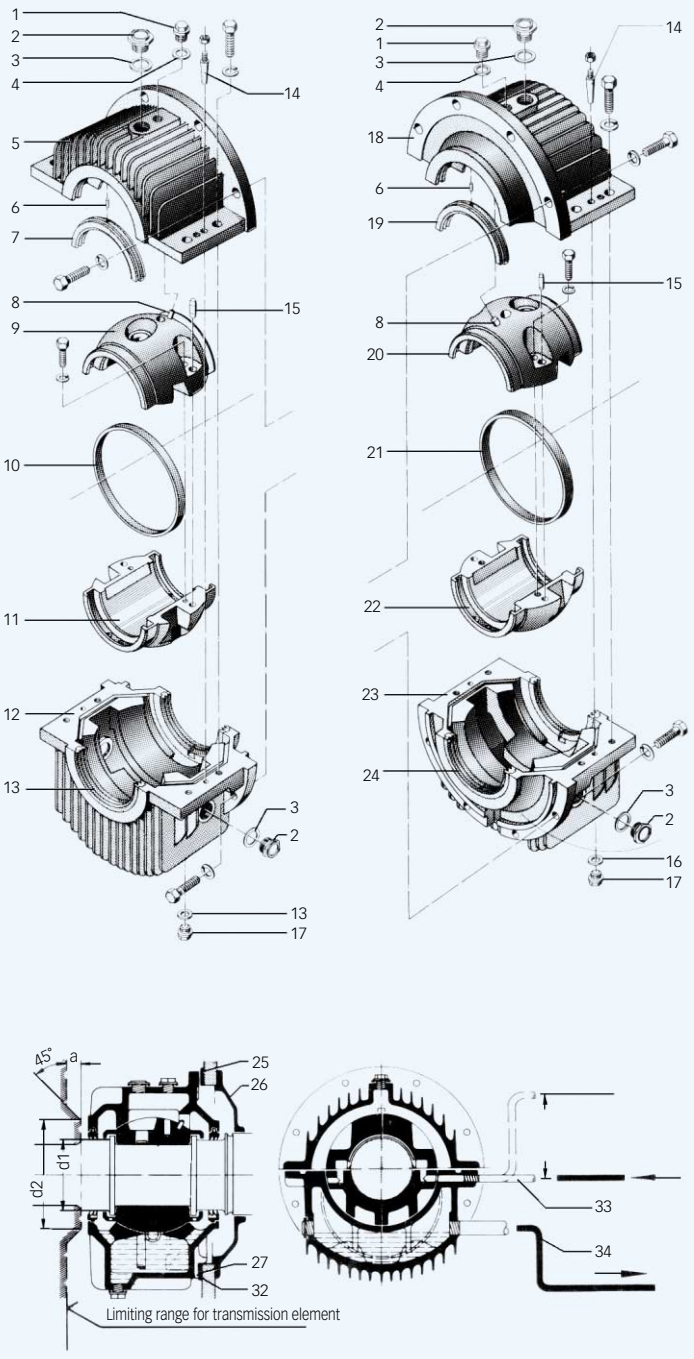
When dismantling the machine the lower part of the bearing housing need not be unscrewed from the end shield. When opening the bearing housing, determine on which side of the machine the adjusting shims (upper and lower parts) are installed. These shims must be installed at the same place when assembling the machine. Exceptions are possible, if the stator core was changed.

Drain the oil, take off the upper part of the bearing housing and the upper bearing shell, lift the shaft very slightly and turn out the lower bearing shell and the sealing rings in peripheral direction. The oil ring can be withdrawn by holding it at an inclined position to the shaft.

If only slight damage has occurred to the bearing surface, it may be re-conditioned by scraping as long as the cylindrical shape of the bore is maintained, so that a good oil film can form.
The lining must be renewed if more serious damage is found. The oil pockets and grooves of the new lining or scraped shell should be cleaned and finished with particular care.

The replacement bearing shells are delivered by the works with a finished inner diameter. Only the bearing shells were delivered unfinished, the inner diameter is 1mm smaller than the finished diameter. Oil rings that have become bent through careless handling will not turn evenly. Straighten or replace such rings. Replace any damaged sealing rings.

Fig. 22 Flange-type Sleeve Bearing for Forced-oil Lubrication (Example, delivered design may deviate in details)



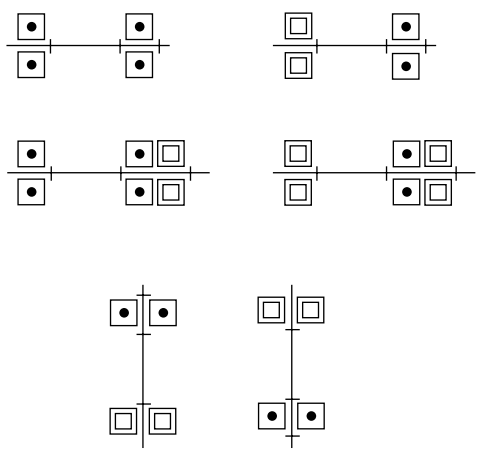
1. Screw plug(thermometer mounting)
2. Inspection glass
3. Sealing ring for 2
4. Sealing ring for 1
5. Bearing housing, upper part drive end
6. Cylindrical pin
7. Sealing ring, upper half, drive end
8. Guide pin to prevent twisting
9. Upper bearing shell, drive end
10. Oil ring, drive end
11. Lower bearing shell, drive end
12. Bearing ring, lower half, drive end
13. Sealing ring, lower half, drive end
14. Taper pin
15. Guide pin to fix bolted parts
16. Sealing ring for 17
17. Drain plug
18. Bearing housing, upper part, non-drive end
19. Sealing ring, upper half, non-drive end
20. Upper bearing shell, non-drive end
21. Oil ring, non-drive end
22. Lower bearing shell, non-drive end
23. Bearing housing, lower part, non-drive end
24. Sealing ring, lower half non-drive end
25. Upper adjusting shim, drive end
26. Sealing cover drive end
27. Lower adjusting shim, drive end
28. Upper adjusting shim, non-drive end
29. Sealing cover, non-drive end
30. Lower adjusting shim, non-drive end
31. Protective cap
32. Pressure compensation opening
33. Oil supply tube with orifice
34. Oil discharge tube with sight glass

10.3 Rolling-contact Bearings

1) Mounting

Electrical machines fitted with rolling-contact bearings mentioned above are subject to the following instructions supplementing and modifying the operating instructions of the machine:
The locating bearings are deep-groove ball bearings for horizontally mounted machines. These bearings may also be in pairs with cylindrical roller bearings in the case of bearings that are not guided radially and are prevented from rotating by compression springs.
The locating bearings for vertically mounted machines are angular-contact ball bearings of type range 72 or 73 (angular-contact ball bearings with increased axial fixation see supplementary operating instructions).
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.

➡ Fig. 23 Examples for Bearing Combination



Deep-groove ball bearing

Cylindrical roller bearing

Angular contact ball bearing

2) Regreasing

NOTE: A common mistake is over-lubrication of bearings. When grease is added without removing the drain plug, the excess grease must go somewhere and usually it is forced into and through the inner bearing cap and is then thrown into the windings. Excess grease in the bearing can cause bearings to run hot and could lead to bearing failure.

Initial lubrication of the bearings is normally carried out in the works with grease satisfying the conditions of running test at a test temperature of 120°C to DIN 51 806. If a different type of grease is required, this is indicated on the data plate, provided that the particular operating conditions were given in the order.
Keep the new grease meticulously clean. Greases having a different soap base should not be mixed since this would reduce the grease quality.
For regreasing, clean the lubricating nipple and press in the grease quantity indicated on the data plate, using a grease gun. The shaft should rotate during regreasing; hence, the machines need not be stopped. After regreasing, 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.
It is recommended that the lubricating instructions be strictly followed. Special cases may require lubrication to special instructions, e.g. where there is an extreme coolant temperature or aggressive vapours. The old grease from several regreasing operations gathers in the space inside the outer bearings caps. Remove the old grease when overhauling the machines.
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 be taken from the list of machine.
The machines should operate in only one type of construction as shown on 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.

3) Lubrication

In case the machines are stored at warehouse or storage area for longer than 6 months, the existing lubricant shall be poured out and be replaced with new one.
The regrease interval for grease is 3 months, and the replacement interval for oil is 6 months. In case of 2 pole motor, refer to the lubrication name plate.

4) Dismantling, Assembling

⚠ CAUTION	**May cause bearing damage(brinelling) if outer race of bearing is struck.** BECAREFUL When replacing bearing. Avoid subjecting bearing to impact.

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

It is recommended that new roller 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 ball bearings, make sure that the broad shoulder of the inner ring (and the narrow shoulder of the outer ring) in operating position points upwards, i.e. in a direction opposite to that of the axial thrust.
When assembling the machines, avoid damage to the sealing rings. Rubber sealing rings (V-rings) should be carefully fitted over the shaft as shown Fig. 28. New felt sealing rings should be so dimensioned that the shaft can run easily while proper sealing is still effected. Before fitting new rings, soak them thoroughly in highly viscous oil (normal lubricating oil N68 to DIN 51 501) having a temperature of approx. 80°C.

5) Locating Faults

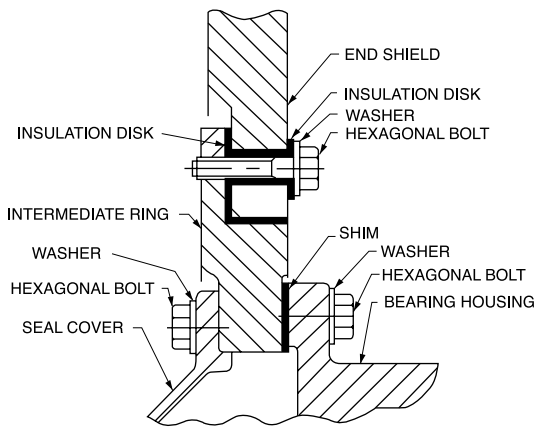
The troubleshooting table helps to trace and remove the causes of faults. It is partly difficult to be found the cause of the damages of bearing. In case of doubt, it is recommended to renew the bearings.

10.4 Insulation to Prevent Shaft Current (High-voltage and Large Machines)

NOTE: Not all machines are equipped with insulated bearings.

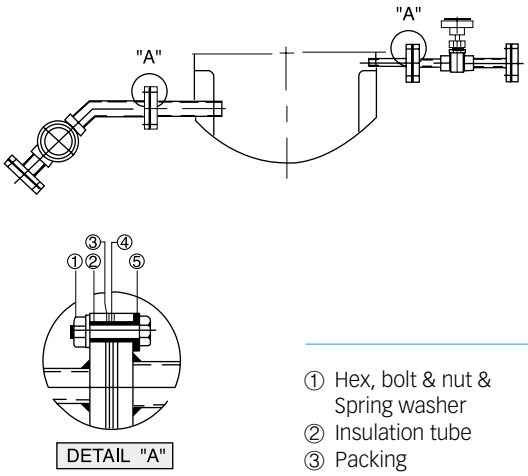
To prevent the risk of bearing damages due to the circulating shaft current, which is induced by shaft voltage, the insulation disk is provided at the end shield as shown in Fig. 24.

Fig. 24 Bearing Insulation



With motors having single shaft extension, the bearing at non-drive end is insulated. In case of motors with double shaft extension, both bearings are insulated. When the motors with the double shaft are coupled with the driven load, one of the couplings must be insulated to prevent the damage of other shaft connected equipments.

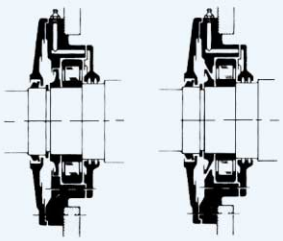
Fig. 25 Bearing Cooling Pipe System for Forced-oil Lubrication



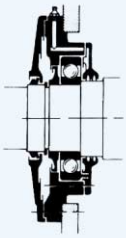
① Hex, bolt & nut & Spring washer
② Insulation tube
③ Packing
④ Insulation flange
⑤ Insulation washer

Care should be taken to prevent shorting out this insulation. All lines (lubrication oil pipes, V.T.D., vibration sensors, etc) fitted at the workshop are insulated from the end shield, but it is necessary to ascertain whether or not the insulation is required for all lines which are connected at the time of the motor installation at the site.
The bearing cooling pipe for forced-oil lubrication is insulated as shown in Fig. 25. The shaft voltage (peak to peak) is usually high frequency voltage of 1 volt or less and rarely several volts. When a shaft current by this voltage flows, the shaft and journal part are tarnished and in the worst case sparking can make minute black spots on shaft and journal parts. There is a possibility that the oil film will be locally broken by electrical spark.
When disassembling or assembling, be sure to measure the insulation resistance. Measure the insulation resistance between the shaft and the earth using no more than 100 VDC. The insulation resistance is acceptable if the resistance value is more than 10 kΩ.

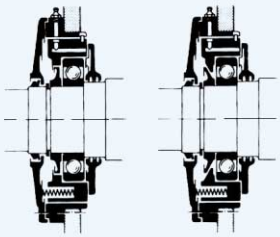
Fig. 26 Floating Bearings (Example, delivered design may deviate in details)



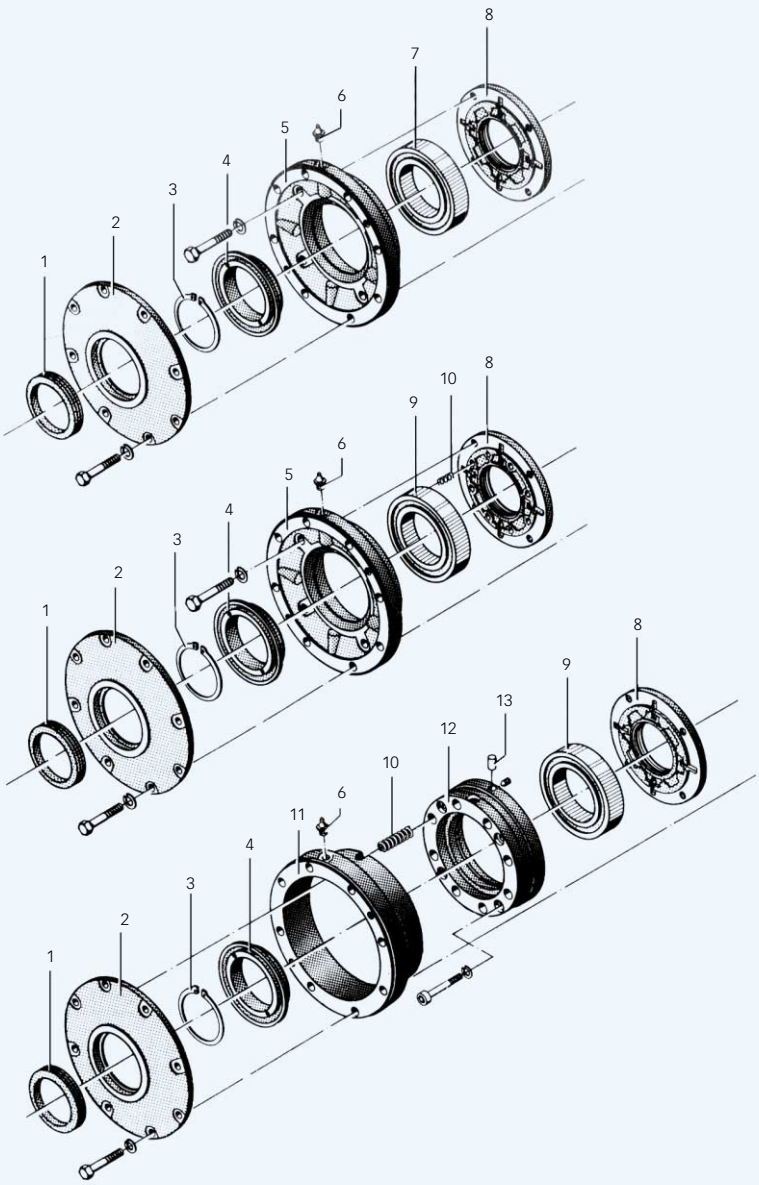
Cylindrical roller bearing



Deep-groove ball bearing
with compensation of axial play



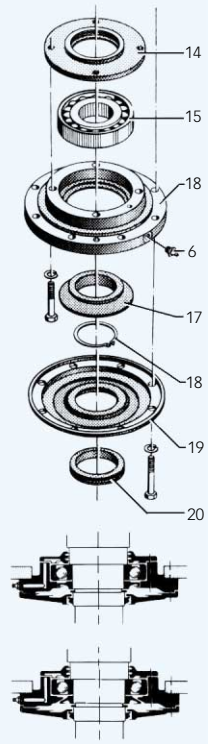
Deep-groove ball bearing with compensation of axial play, with bearing housing bush and intermediate ring



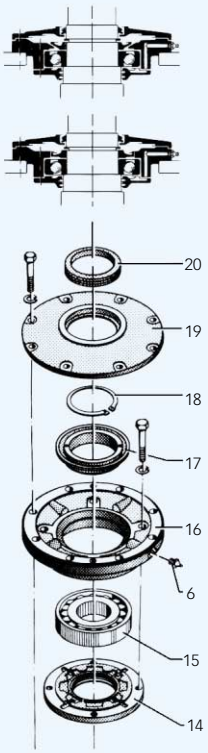
1. V-ring [1]
2. Outer bearing cap [1]
3. Circlip [1]
4. Grease slinger [1]
5. Bearing housing [1]
6. Lubricating nipple
7. Cylindrical roller bearing [1]
8. Inner bearing cap with felt sealing rings [1]
9. Deep groove ball bearing (floating-bearing)
10. Compression spring [1]
11. Bearing housing ring
12. Bearing housing bush
13. Cylindrical pin

[1] Floating bearing side

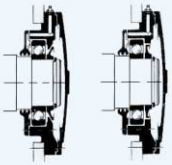
Fig. 27 Locating Bearings (Example, delivered design may deviate in details)



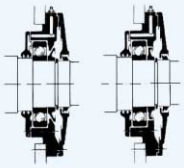
Angular-contact ball bearing placed below



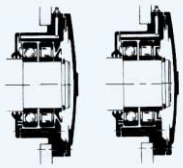
Angular-contact ball bearing placed above



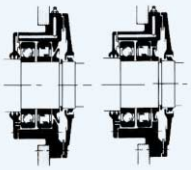
Single bearing, shaft does not pass through the outer bearing cap



Single bearing, shaft passes through the outer bearing cap



Duplex bearing, shaft does not pass through the outer bearing cap



Duplex bearing, shaft passes through the outer bearing cap

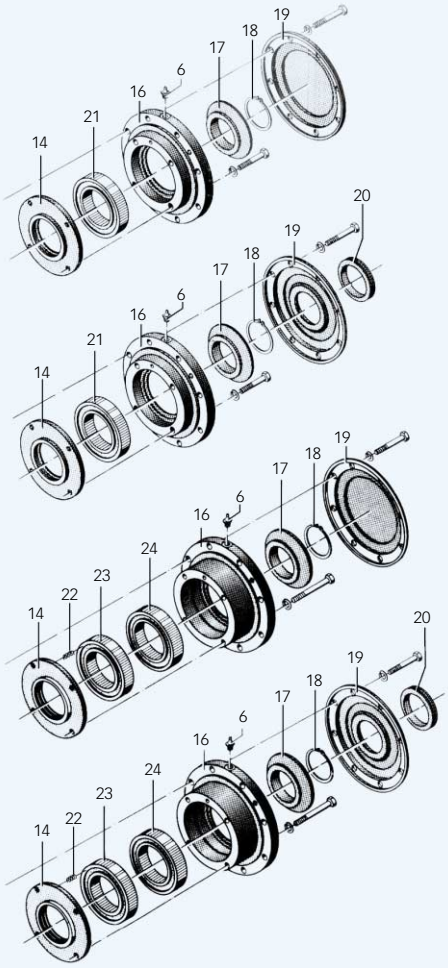
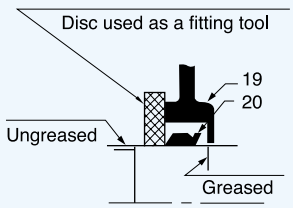
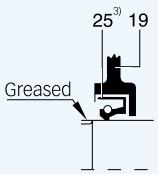


Fig. 28 Fitting Instructions for V-ring and Oil Seal for Shaft



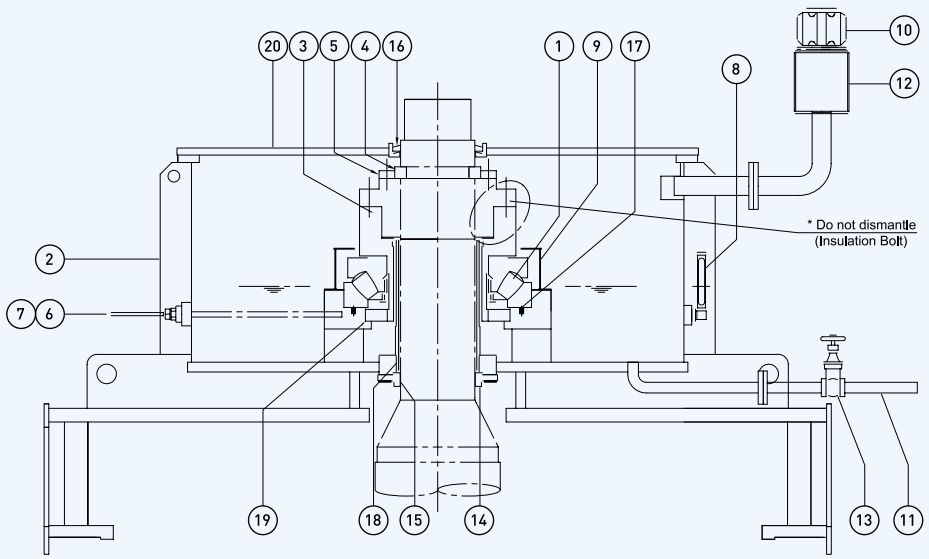


Single bearing, shaft does not pass through the outer bearing cap.

14. Inner bearing cap with felt sealing rings [2]
15. Angular-contact ball bearing
16. Bearing slinger [2]
17. Grease slinger [2]
18. Circlip [2]
19. Outer bearing cap [2]
20. V-ring [2]
21. Deep-groove ball bearing(Locating bearing) or angular-contact ball bearing
22. Compression spring [2]
23. Deep-groove ball bearing [2]
24. Cylindrical roller bearing [2]
25. Oil seal for shaft [1][2][3]

[1] Floating bearing side
[2] Locating bearing side
[3] Special operating conditions only

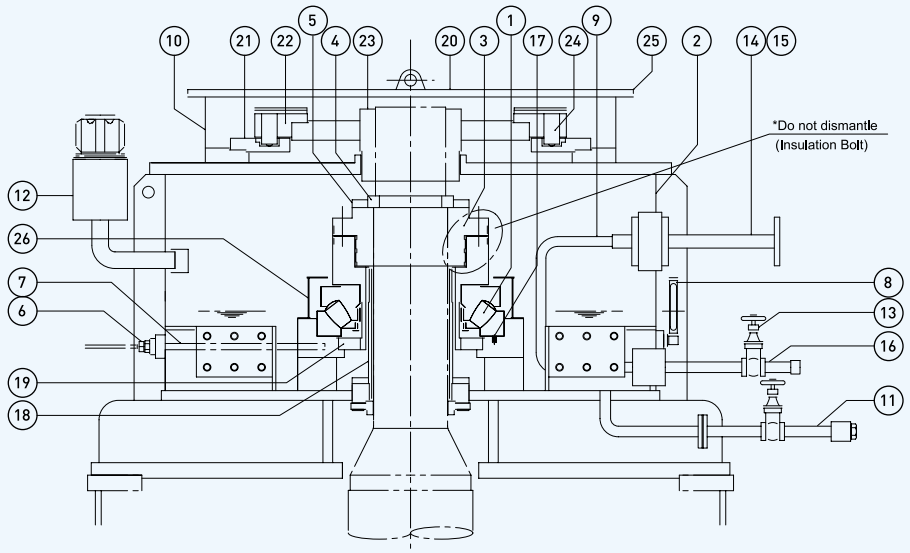
Fig. 29 Replacement Procedure for Upper Bearing(Upper Bearing Assembly Drawing)



NO.	Description	NO.	Description	NO.	Description
1	Bearing	8	Oil Level Gauge	15	Bearing Inner Cap Packing
2	Upper Bearing Support	9	Oil Cover	16	V-ring
3	Bearing Runner	10	Air Breather	17	Spring
4	Ring Key	11	Oil Drain Pipe	18	Guide Pipe
5	Ring	12	Oil Cup	19	Guide Bushing
6	Bearing Temp. sensor	13	Globe Valve	20	Top Cover
7	Thermo well	14	Bearing Inner Cap0		

1. It is requested to check and confirm an availability to lift up pump shaft coupled with motor about 1.0 to 1.5 mm. If not available, motor shall be disconnected with pump and proper measure to lift up rotor shall be established depend on uncoupled status.
2. Dismantle V-ring (Item No. 16 shown on above drawing).
3. Dismantle Top Cover (Item No. 20 shown on above drawing).
4. Fully drain out bearing oil.
5. Dismantle coupling cover to install hydraulic jack.
6. Install hydraulic jack (3 point) on lower of pump coupling. If three (3) points of jack are not available due to space problem, two (2) points are acceptable.
7. To check lift up of shaft, install two (2) points of dial gauge on motor bottom bracket. Dial gauges (1/100 mm) are used for checking.
8. Jacking up to lift 0.5 mm.
9. Dismantle ring (Item No. 5).
10. Dismantle ring key (Item No. 4). If ring key cannot be dismantled, jacking up 0.5 mm additionally and try to dismantle again.
11. Set special JIG using crane and install stud bolts and nuts between top of bearing runner (Item No. 3) and JIG.
12. Install hydraulic jack between JIG and shaft top.
13. Jacking up JIG and dismantle bearing runner.
14. Dismantle bearing from bearing runner after heating by gas torch.
15. Dismantle racer & pressure spring (Item No. 17).
16. Dismantle guide bushing (Item No. 19) and cleaning inside of bearing support.
17. Assemble new bearing to bearing runner after heating by electric heater. If heater is not available, oil heating is acceptable.
18. Start reassembly in accordance with reverse sequence of above.
19. After completion of assemble, try hand turning to confirm condition.

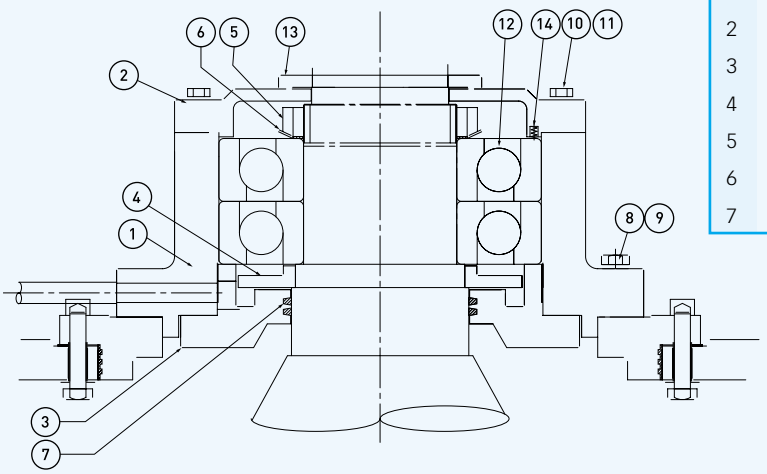
Fig. 30 Replacement Procedure for Upper Bearing(Upper Bearing Assembly Drawing)



NO.	Description	NO.	Description	NO.	DESCRIPTION
1	Bearing	10	Ratchet Housing	19	Guide Bushing
2	Upper Bearing Support	11	Oil Drain Pipe	20	Support Cover
3	Bearing Runner	12	Oil Cup	21	Non-Reverse Ratchet
4	Ring Key	13	Globe Valve	22	Pin Housing
5	Ring	14	Water Inlet Pipe	23	Ratchet Runner
6	Bearing Temp. sensor	15	Water Outlet Pipe	24	Ratchet Pin
7	Thermo well	16	Water Drain Pipe	25	Ratchet Pin Cover
8	Oil Level Gauge	17	Spring	26	Oil Cover
9	Heat Exchanger	18	Guide Pipe		

1. It is requested to check and confirm an availability to lift up pump shaft coupled with motor about 1.0 to 1.5 mm. If not available, motor shall be disconnected with pump and proper measure to lift up rotor shall be established depend on uncoupled status.
2. Dismantle Ratchet housing cover (Item No. 20 shown on above drawing).
3. Dismantle Pin housing, ratchet wheel (Item No.22 and 21)
4. Dismantle Ratchet Runner (Item No.23) and Ratchet housing(Item No.10)
5. Fully drain out bearing oil.
6. Dismantle coupling cover to install hydraulic jack.
7. Install hydraulic jack (3 point) on lower of pump coupling. If three (3) points of jack are not available due to space problem, two (2) points are acceptable.
8. To check lift up of shaft, install two (2) points of dial gauge on motor bottom bracket. Dial gauges (1/100 mm) are used for checking.
9. Jacking up to lift 0.5 mm.
10. Dismantle ring (Item No. 5).
11. Dismantle ring key (Item No. 4). If ring key cannot be dismantled, jacking up 0.5 mm additionally and try to dismantle again.
12. Set special JIG using crane and install stud bolts and nuts between top of bearing runner (Item No. 3) and JIG.
13. Install hydraulic jack between JIG and shaft top.
14. Jacking up JIG and dismantle bearing runner.
15. Dismantle bearing from bearing runner after heating by gas torch.
16. Dismantle racer & pressure spring (Item No. 17).
17. Dismantle guide bushing (Item No. 19) and cleaning inside of bearing support.
18. Assemble new bearing to bearing runner after heating by electric heater. If heater is not available, oil heating is acceptable.
19. Start reassembly in accordance with reverse sequence of above.
20. After completion of assemble, try hand turning to confirm condition.

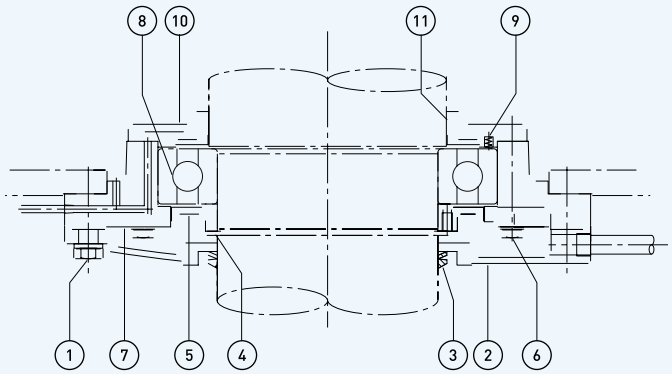
Fig. 31 Replacement Procedure for Upper Bearing(Upper Side Bearing Assembly Drawing)



NO.	Description	NO.	Description
1	Bearing Housing	8	Hex Bolt
2	Outer Bearing Cap	9	Spring Washer
3	Inner Bearing Cap	10	Hex Bolt
4	Slinger	11	Spring Washer
5	Lock Nut	12	Ball Bearing
6	Lock Washer	13	Sealing Disk
7	Inner Cap Packing	14	Compression Spring

1. It is requested to check and confirm an availability to lift up pump shaft coupled with motor about 1.0 to 1.5 mm. If not available, motor shall be disconnected with pump and proper measure to lift up rotor shall be established depend on uncoupled status.
2. Dismantle Grease pipes and Sealing disk (Item No. 13 shown on above drawing).
3. Dismantle Outer bearing cap (Item No. 02).
4. Install hydraulic jack (3 point) on lower of pump coupling. If three (3) points of jack are not available due to space problem, two (2) points are acceptable.
5. To check lift up of shaft, install two (2) points of dial gauge on motor bottom bracket. Dial gauges (1/100 mm) are used for checking.
6. Jacking up to lift 0.5 mm.
7. Dismantle Lock Nut and Washer (Item No.05 and 06)
8. Dismantle Bearing Housing (Item No.01).
9. Heating the bearing(Item No. 12) by gas torch.
10. Dismantle bearing from shaft. Be careful of shaft damage.
11. Dismantle grease slinger after heating by gas torch (Item No.04).
12. Dismantle Inner bearing cap (Item No.03).
13. Cleaning all items
14. Assemble new bearing to shaft after heating by electric heater. If heater is not available, oil heating is acceptable.
15. Start reassembly in accordance with reverse sequence of above.
16. After completion of assemble, try hand turning to confirm condition.

Fig. 32 Replacement Procedure for Lower Bearing(Bottom Side Bearing Assembly Drawing)



1. Dismantle Outer bearing cap and seal ring (Item No. 02 and 03 shown on above drawing).
2. Dismantle Circlip (Item No.04).
3. Dismantle grease slinger after heating by gas torch (Item No.05).
4. Dismantle Bearing Housing (Item No.07).
5. Heating the bearing (Item No. 08) by gas torch..
6. Dismantle bearing from shaft. Be careful of shaft damage.
7. Dismantle Inner bearing cap and Compression spring (Item No.09 and 10).
8. Cleaning all items
9. Assemble new bearing to shaft after heating by electric heater. If heater is not available, oil heating is acceptable.
10. Start reassembly in accordance with reverse sequence of above.
11. After completion of assemble, try hand turning to confirm condition.

11.1 Air Filter

Air Filter Cleaning Period

The cleaning period depends on the site conditions and can change. The cleaning of the filter is required if the record of the stator winding temperature (using the stator winding sensors) indicates an abnormal increase in temperature.

Air Filter Cleaning Procedure

The filter element (flat or cylindrical) is immersed in a tank of cold or warm water (temperature less than 50°C). Use water with detergent added.
Shake the filter gently to ensure that the water flows through the filter in both directions.
When the filter is clean, rinse it with clear water.
Drain the filter properly (there must be no formation of droplets).
Refit the filter on the machine.

> ⚠ CAUTION
> Do not clean the filter using compressed air. This procedure would reduce filter efficiency.

11.2 Cooler

1) General Points

The purpose of the cooler is to remove machine heat losses (mechanical, ohmic, etc). The exchanger is located on the top of the machine.

Normal Operation

The air is pulsed by a fan fixed to the machine shaft.

Description of Air-Water Double Tube Exchanger

The double-tube technique keeps the cooling circuit from being affected by possible water leakage. The double tube provides a high safety level. In case of leakage, the water goes from the inside of the internal tube to the coaxial space between the two tubes. The water is drained axially to a leakage chamber where it may activate a sensor. An exchanger comprises a fin-tube block containing :
- a steel frame
- a fin-tube block expanded mechanically to the tubes.

The tube bundle is roll-expanded in the end plates. The water distribution in the tubes is provided by two removable water boxes. A water box is equipped with collars for fitting the inlet and outlet lines. Neoprene seals ensure the water box and the end plate joints.

2) Cleaning

The frequency of cleaning operations depends essentially on the purity of the water used. We recommend a minimum of one inspection per year. The life of zinc block for anticorrosion is about a year. Therefore, replace it with a new one every year.
Cut off the water supply by isolating the inlet and outlet lines and drain the water. Disconnect the leak sensor (option with double-tube cooler) and make sure that there are no leaks. Remove the water boxes on each side of the machine. Rinse and brush each water box.

> **NOTE:** Do not use a hard wire brush, as this will remove the protective tar-epoxy layer formed on the surface of the water boxes. Clean each tube with a metal scraper. Rinse in soft water. Keep the leakage chamber dry (double-tube water-cooler only).

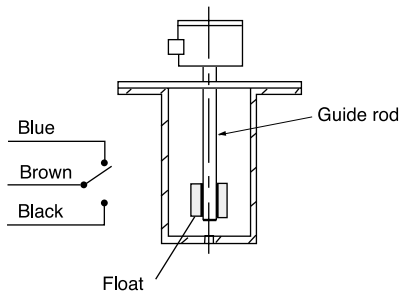
3) Stop the Machine

Leak detection for a double-tube exchanger. If a leak is detected, cut off the power supply of the water in/outlet lines and change to emergency operations, it is necessary to ascertain and repair it. Remove the two water boxes, apply a slight positive pressure in the leakage chamber and thus between the two tubes (only concerns double-tube coolers). If a tube is damaged, plug it at both ends. Use a tapered plug. The plug should preferably be made of saltwater-resistant aluminum bronze or of a synthetic material.

4) Leak Detection (Float System)

A magnet float activates a switch located in the float-guiding rod.

Fig. 33 Leakage Detector



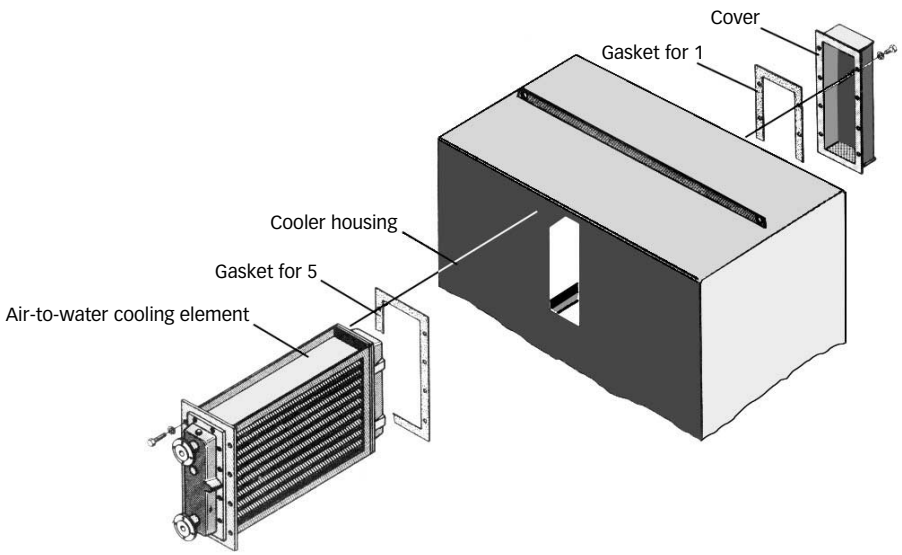
5) Cooler Removal

The cooler unit is slid into its housing. It is possible to remove the cooler from the housing without removing the water boxes. The cooler is fastened to the housing via a series of screws on the housing. Remove the supply and return pipes. Provide two supports to hold the cooler when it comes out of its housing. Remove the cooler using slings that can be attached to the connecting flanges.

6) Cooler Reassembly

Carry out the operations of the "Cooler Removal" in the reverse order. Be careful to push the cooler completely into its housing before tightening the fastening screws of the cooler to the casing.

Fig. 34 Cooler Removal



General

It is our recommendation that all electric motors are fitted with motor protection. The preferred type of motor protection should provide the following protection features:

1) Current limit by a programmable thermal limit curve with thermal modeling based on winding temperature.
2) If RTD is installed for winding temperature detector, winding temperature detection by RTDs should have separated alarm and trip set points.
3) Ambient temperature RTD located in the motor ambient air stream.
4) If a bearing temperature indicator is installed, alarm and trip set points should be separated.
5) Calculation of motor thermal capacity available.
6) Ground fault detection.
7) Current unbalance detection.
8) Capacity for the protection system to learn motor cooling times.

A motor protection system with these features should reward you with better reliability and will allow you to optimize the motor to its maximum performance.

Protection Setting Recommended

Guide values for adjustment of tripping temperature.

Description	Temperature Rise 'B'			Temperature Rise 'F'		
	Permissible Max. Temperature	Alarm	Trip	Permissible Max. Temperature	Alarm	Trip
Winding Temperature	Max. 130 °C	130 °C	135 °C	Max. 155 °C	155 °C	160 °C
Bearing Temperature (Anti-friction*)	Max. 100 °C	100 °C	105 °C	Max. 100 °C	100 °C	105 °C
Bearing Temperature (Sleeve)	Max. 95 °C	95 °C	100 °C	Max. 95 °C	95 °C	100 °C
Current unbalance	Max. 10%	6% (10-sec delay)	10% (Inst.)	Max. 10%	6% (10-sec delay)	10% (Inst.)

- T means operation temperature including ambient temperature.
- Max. permissible temp. rise includes ambient temperature.

* When a suitable heatproof lubricant is used or a greasing interval is changed, the limit of temperature rise shall be determined by agreement between manufacturer and purchaser.

Induction Motor Troubleshooting

Hazardous Voltage.
Will cause death, serious injury, electrocution or property damage. Disconnect all power before working on this equipment.

Abnormality		Probable Cause	Remedy
Motor fails to start	Power source & line	1. Drop in line voltage	A check is to be made with a voltmeter.
		2. Great drop in voltage due to inadequate line capacity and impedance drop	a. A check is to be made on voltage at motor terminal before and at time of starting. b. Similar change in voltage is to be checked at motor terminal.
		3. Cut line or unbalanced	Defective parts are to be repaired.
	Starter	4. Erroneous wire connection	To be repaired.
		5. Cut line or unbalanced voltage	To be reconditioned.
		6. Drop in line voltage	Compensator tap connection is to be raised.
		7. Cut line or unbalance in starting resistor	Resistance is to be measured; repairs are to be made.
	Motor	8. Cutting of stator coil or of rotor coil	Resistance and current are to be measured, and repairs are to be made.
		9. Erroneous connection of stator coil	To be reconditioned.
		10. Defect of rotor	a. Squirrel cage motor, rotor conductor is to be checked for disconnection. b. Wound motor, a check is to be made for line cutting and unbalance. c. Repairs or renewal is to be made.
		11. Stator core is in contact with rotor	a. A check is to be made by turning by hand.
		12. Defective bearing	b. Bearing is to be disassembled and examined.
		13. Insufficient starting torque	a. Squirrel cage motor, motor is to be replaced with the one having larger capacity and of the wound type. b. Wound motor, tap for starting resistor is to be replaced.
	Load	14. Overload	Load is to be reduced.
Length of time required for acceleration after starting		1. Inadequately low voltage	A check is to be made on voltage drop of power source and line.
		2. Defective rotor	a. Squirrel cage rotor, rotor bar and end ring are to be checked for contact. b, Wound motor, a check is to be made on coil for unbalance and on brush for imperfect contact.
		3. Overload or inadequate torque	Load is to be checked, if load is normal, motor capacity is to be changed.

Abnormality	Probable Cause	Remedy
Rotation in reversal direction	Phase reversal	Two phases of U,V,W(or R,S,T) at starter or motor terminal are to be changed..
Motor body overheated	1. Overload	Load is to be reduced. (to rated current)
	2. Overcurrent due to voltage drop	a. A check is to be made with a voltmeter power source Voltage is to be raised. b. Load is to be reduced.
	3. Excessive iron loss due to overvoltage	A check is to be made with a voltmeter power source. Voltage is to be reduced.
	4. Cut line or imperfect contact in one phase	To be reconditioned.
	5. Short-circuiting and grounding of coil	Resistance and current are to be checked and reconditioned.
	6. Contact between stator and rotor	Judgment can be made according to noise; bent shaft, bearing, etc., are to be corrected.
	7. Inadequate ventilation due to dust	Cleaning is to be carried out.
Vibration	1. Unbalance of rotor a. Bending of shaft b. Loose joint c. Residual unbalance d. Critical speed of shafting e. Dust attached to rotor f. Imperfect connection between coupling and shaft	 To be repaired. To be tightened by bolts securely. To be readjusted. To be cleaned. To be reconditioned.
	2. Improper magnetic center	To be reconditioned.
	3. Defective bearing	Refer to the “Bearing” section.
	4. Coupling deflection	To be reconditioned.
	5. Abnormal contact between shaft and stationary part, such as end cover, etc.	a. To be checked by turning manually. b. To be disassembled for detecting defects.
	6. Unsatisfactory contact of brush	Brush is to be checked for contact.
	7. Improper alignment	To be reconditioned.
	8. Sinking of foundation	To be reconditioned.
	9. Transmission of vibration from combined machine	Insulation for vibration.
	10. Unequal pitch of claw coupling	Reconditioning of pitch.
	11. Improper bush of flexible coupling	Reconditioning of pitch.

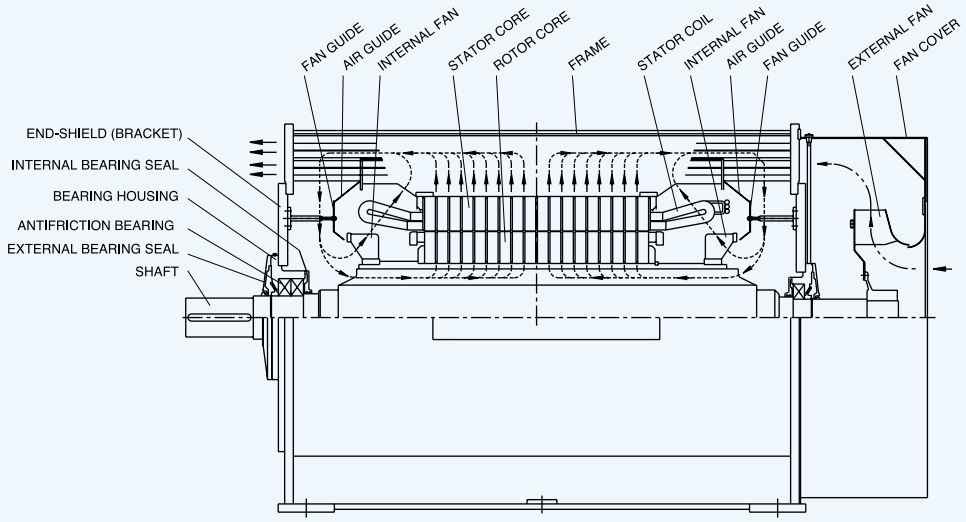
Abnormality	Probable Cause	Remedy
Noise	1. Disagreement of air gap	Causes are to be detected; repairs are to be made.
	2. Single-phase operation	Causes of single-phase operation such as line cutting and imperfect contact are to be detected; repairs are to be made.
	3. Short-circuits of layer and phase of stator coil and rotor coil	To be reconditioned.
	4. Abnormal contact between shaft and stationary part such as end cover	1. A check is to be made by turning manually. 2. To be disassembled for inspection.
	5. Unsatisfactory foundation and installation	Readjustment of installation.
	6. Loose bolts for foundation	Foundation bolts are to be tightened.
	7. Gap between foundation and base	Reconditioning of installation.
	8. Resonance with foundation	Readjustment of foundation.
	9. Crackings at brazed joint rotor bar and end ring	To be disassembled and defective parts are to be repaired.
Unbalance of phase current	1. Voltage unbalance	Power source and lines are to be checked and balanced.
	2. Single-phase operation	Line cutting and improper contact are to be reconditioned.
	3. Secondary circuit	1. Rotor shaft coil resistance is to be measured and reconditioned. 2. Contact of brush or short-circuit ring is to be checked. 3. A check is to be made on endring contact of a squirrel cage motor.
Flaking (a) Flaking of rolling elements	1. Excess of tightening allowance	1. Care should be taken on shaft at time of assembling and on bearing box at time of matching.
	2. Erroneous selection of clearance	2. Clearance is to be reinspected.
	3. Minus operating clearance	3. Care should be taken at time of assembly.
	4. Thermal expansion	4. Examination of working condition.
(b) Local flaking of a race	1. Inclusion of dust and other foreign substances or rust, bruises	
(c) Flaking all over a race (d) Flaking on component parts opposite to a race	1. Shaft or bearing box is distorted elliptically.	Machining accuracy and tightening of bearing box are to be checked.
	2. Improper tightening	
	3. Inaccuracy due to improper matching	
	4. Deterioration with time	

Abnormality	Probable Cause	Remedy
(e) Flaking all over around track center (f) Flaking across a race	Abnormal thrust load 1. Shaft bending 2. Oblique fitting of outer and inner rings	Design of bearing system is to be checked.
(g) Flaking similar to pitting on a race	1. Vibration during stoppage 2. Rust	Examination of working condition.
Seizing (a) Race ring and rolling discolored and turned soft (b) Damage	1. Inadequate clearance	Proper clearance is to be provided.
	2. Inadequate lubrication	Oil amount of lubricant is to be checked.
	3. Improper overload of lubricant	Reconsideration of working condition and handling.
Breakage (total or partial) (a) Fracture (b) Cutting	1. Advancement of flaking caused by shock and below 2. Great tightening allowance & large round corner of fitted part	Careful handling. Examination of tightening. Examination of machining accuracy of shaft & bearing housing.
Breakage of retainer (a) Fracture (b) Nonuniform abrasion (c) Wear of pocket section (d) Biting-off	1. Moment load 2. Rotation at shaft speed 3. Inadequate lubrication 4. Inclusion of foreign substances	Careful handling and reconsideration of working condition Examination of oil supply and lubricant.
Rust (a) Rust formed all over surface (b) Rust on local place (c) Contact erosion on joint surface	1. Unsatisfactory condition of storage 2. Left alone 3. Inadequate cleaning 4. Rust-preventive reagent 1. Unsatisfactory packing 2. Condensation 1. Inadequate allowance of tightening 2. Change in load	Inspection of storage room. Careful handling. Examination of rust-preventive reagent. Reexamination of machining of shaft & bearing housing. Reexamination of working condition.
Wear (a) Abnormal wear of race and rolling element (b) Abnormal wear of retainer	1. Inclusion of foreign substances 2. Occurrences of wear Inadequate lubrication	Examination of lubrication and oil supply.
Electrode (a) Crater-shaped depression and corrugated scars	Passage of current	Examination of design of bearing system.

Abnormality	Probable Cause	Remedy
Dent and scratch (a) Indentation (on a race, etc.) (b) Aventurine hardening (c) Dents given during handling (d) Scratches during assembly	Dust and foreign substances pressed between race and body Careless handling (dropping, etc.)	Examination of handling and assembling conditions Careful handling Careful assembling
Smearing biting-off on a race and rolling element	1. Inadequate lubrication 2. Skewing of rolling element 3. Selection of lubricant	Examination of lubricant and lubricating condition
Creep wear of outer and inner surface, sliking and discoloring	1. Inadequate tightening allowance 2. Inadequate tightening of sleeve	1. Examination of tightening 2. Examination of machining accuracy of shaft and bearing box 3. Examination of design

14.1 HLA7 Horizontal-type Motor Construction

Fig. 1 HLA7 Horizontal-type Motor Construction (SQUIRREL CAGE)



*Disassembly and reassembly of HLA7 Type induction motor with antifriction bearing

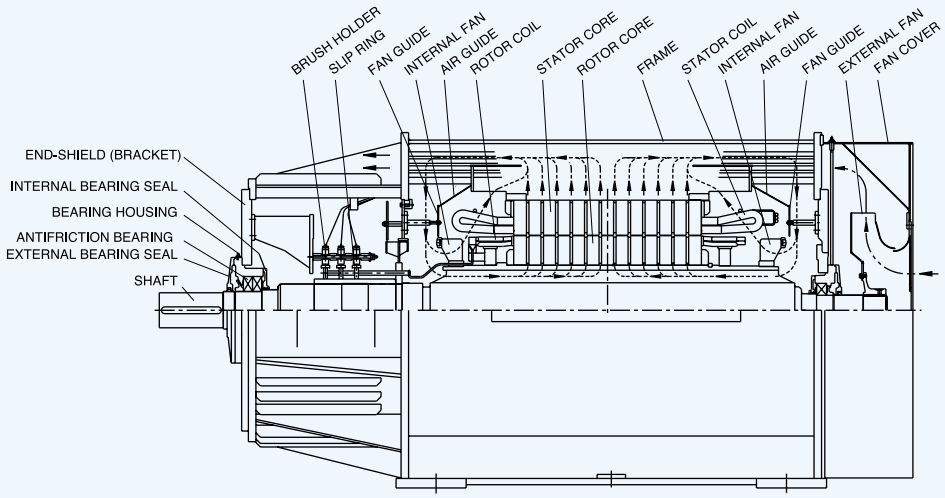
Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing the disassembly steps.
2. Steps 7 to 11 are applied to both the Drive end and Non-drive end of the motors.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perfom an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	*A distance equal to the rotor's length may be required at both ends of the motor drive end and Non drive end.
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, grease pipe, etc.)	
5.	Remove the fan cover	
6.	Remove the external fan	*Heat the fan hub to approx. 80~100°C both for easy assembly and for removal.
7.	Remove the external bearing seal and slinger installed on the bearing housing	
8.	Remove the bearing housing	
9.	Remove the antifriction bearing	
10.	Remove the end shield (bracket) with fan guide	
11.	Remove the air guide	
12.	Remove the rotor from the stator	

14.2 HLS7 Horizontal-type Motor Construction

Fig. 2 HLS7 Horizontal-type Motor Construction (WOUND ROTOR)



*Disassembly and reassembly of HLS7 Type induction motor with antifriction bearing

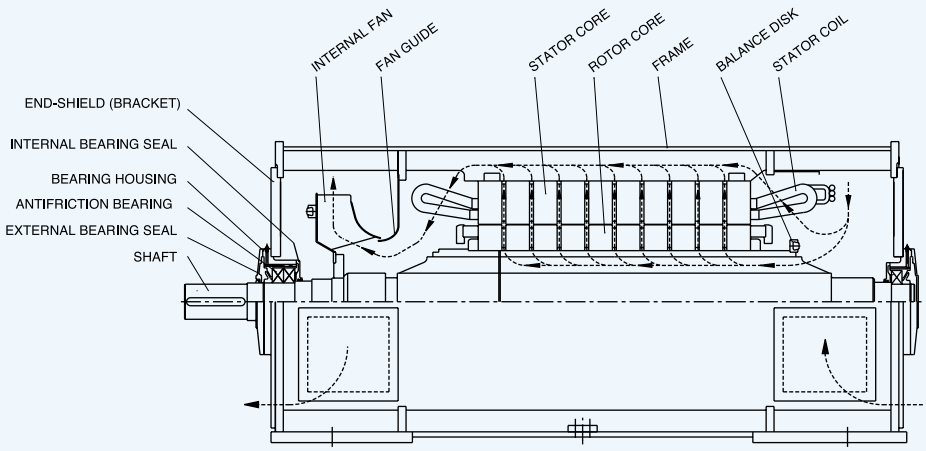
Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing the disassembly steps.
2. Steps 7 to 11 are applied to both the Drive end and Non-drive end of the motors.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perfom an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	*A distance equal to the rotor's length may be required at both ends of the motor drive end and Non drive end.
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, grease pipe, secondary t/box cable, etc.)	
5.	Remove the fan cover	
6.	Remove the external fan	*Heat the fan hub to approx. 80~100°C both for easy assembly and for removal.
7.	Remove the external bearing seal and slinger installed on the bearing housing	
8.	Remove the bearing housing	
9.	Remove the antifriction bearing	
10.	Remove the end-shield with brush holder	
11.	Remove the end-shield with fan guide	
12.	Remove the air guide	
13.	Remove the rotor from the stator	

14.3 HRA3 Horizontal-type Motor Construction

Fig. 3 HRA3 Horizontal-type Motor Construction (SQUIRREL CAGE)



*Disassembly and reassembly of HRA3 Type induction motor with antifriction bearing

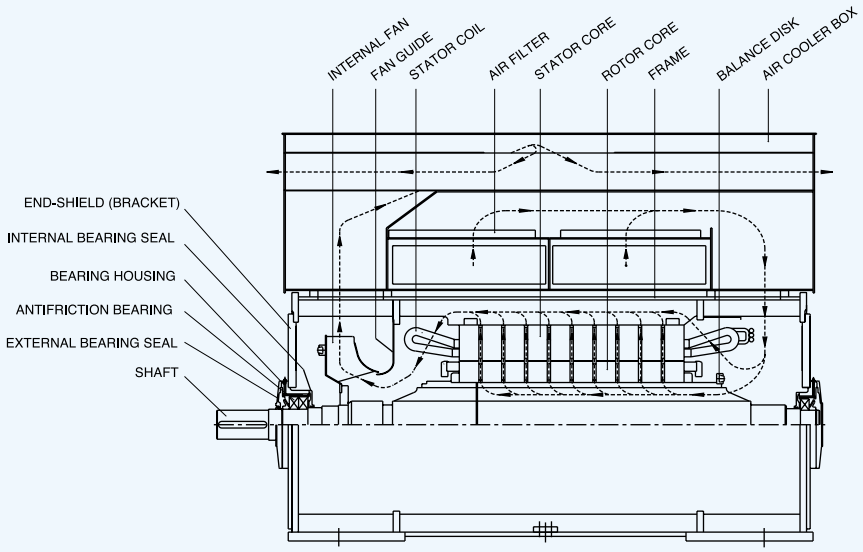
Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing the disassembly steps.
2. Steps 5 to 11 are applied to both the Drive end and Non-drive end of the motors.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perfom an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	*A distance equal to the rotor's length may be required at both ends of the motor drive end and Non drive end.
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, grease pipe, etc.)	
5.	Remove the external bearing seal and slinger installed on the bearing housing	
6.	Remove the bearing housing	
7.	Remove the antifriction bearing	
8.	Remove the internal bearing seal	
9.	Remove the end shield (bracket)	
10.	Remove the internal fan	*Heat the fan hub to approx. 80~100°C both for easy assembly and for removal.
11.	Remove the fan guide	
12.	Remove the rotor from the stator	

14.4 HRP3/HIP1 Horizontal-type Motor Construction

Fig. 4 HRP3/HIP1 Horizontal-type Motor Construction (SQUIRREL CAGE)



*Disassembly and reassembly of HRP3/HIP1 Type induction motor with antifriction bearing

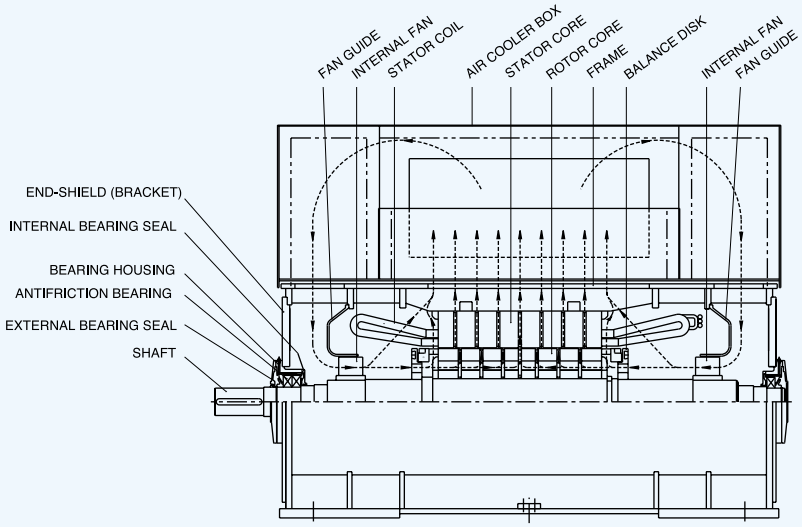
Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing the disassembly steps.
2. Steps 5 to 11 are applied to both the Drive end and Non-drive end of the motors.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perfom an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	*A distance equal to the rotor's length may be required at both ends of the motor drive end and Non drive end.
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, grease pipe, etc.)	
5.	Remove the external bearing seal and slinger installed on the bearing housing	
6.	Remove the bearing housing	
7.	Remove the antifriction bearing	
8.	Remove the internal bearing seal	
9.	Remove the end shield (bracket)	
10.	Remove the internal fan	*Heat the fan hub to approx. 80~100°C both for easy assembly and for removal.
11.	Remove the fan guide	
12.	Remove the rotor from the stator	
13.	Dismantle the air cooler box, if necessary	

14.5 HRP3(2P) Horizontal-type Motor Construction

Fig. 5 HRP3 (355 Fr.~450 Fr.-2P) Horizontal-type Motor Construction (SQUIRREL CAGE)



*Disassembly and reassembly of HRP3 Type induction motor with antifriction bearing

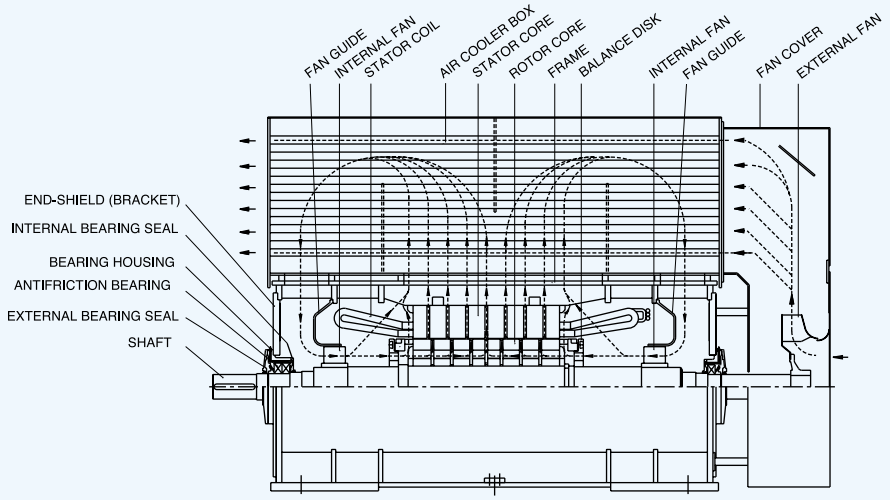
Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing the disassembly steps.
2. Steps 5 to 11 are applied to both the Drive end and Non-drive end of the motors.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perfom an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	*A distance equal to the rotor's length may be required at both ends of the motor drive end and Non drive end.
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, grease pipe, etc.)	
5.	Remove the external bearing seal and slinger installed on the bearing housing	
6.	Remove the bearing housing	
7.	Remove the antifriction bearing housing	
8.	Remove the internal bearing seal	
9.	Remove the end shield (bracket)	
10.	Remove the fan guide	
11.	Remove the rotor from the stator	
12.	Dismantle the air cooler box, if necessary	

14.6 HRQ3 Horizontal-type Motor Construction

Fig. 6 HRQ3 (355 Fr.~450 Fr.-2P) Horizontal-type Motor Construction (SQUIRREL CAGE)



*Disassembly and reassembly of HRQ3 Type induction motor with antifriction bearing

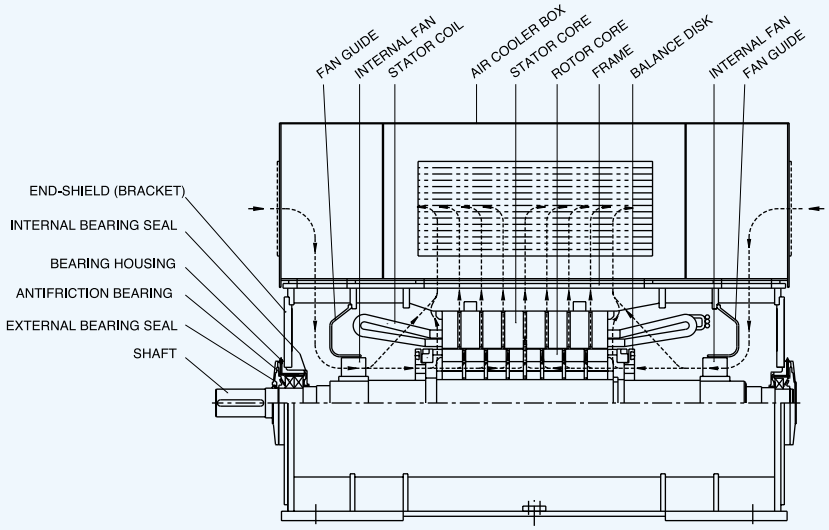
Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing the disassembly steps.
2. Steps 5 to 11 are applied to both the Drive end and Non-drive end of the motors.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perfom an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	*A distance equal to the rotor's length may be required at both ends of the motor drive end and Non drive end.
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, grease pipe, etc.)	
5.	Remove the fan cover	
6.	Remove the external fan	*Heat the fan hub to approx. 80~100°C both for easy assembly and for removal.
7.	Remove the external bearing seal and slinger installed on the bearing housing	
8.	Remove the bearing housing	
9.	Remove the antifriction bearing	
10.	Remove the intermal bearing seal	
11.	Remove the end shield (bracket)	
12.	Remove the fan guide	
13.	Remove the rotor from the stator	
14.	Dismantle the air cooler box, if necessary	

14.7 HRP3(2P) Horizontal-type Motor Construction

Fig. 7 HRP3 (355 Fr.~450 Fr.-2P) Horizontal-type Motor Construction (SQUIRREL CAGE)



*Disassembly and reassembly of HRP3 Type induction motor with antifriction bearing

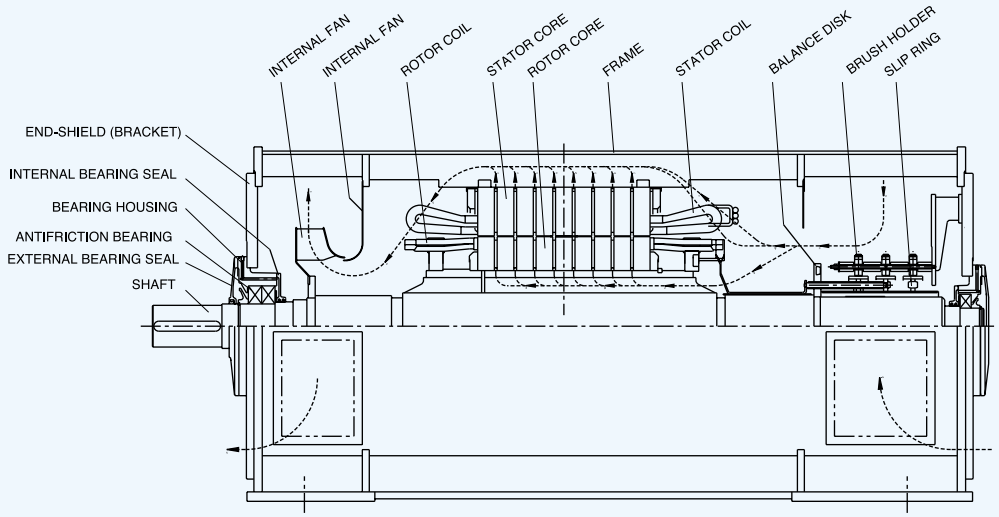
Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing the disassembly steps.
2. Steps 5 to 11 are applied to both the Drive end and Non-drive end of the motors.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perfom an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	*A distance equal to the rotor's length may be required at both ends of the motor drive end and Non drive end.
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, grease pipe, etc.)	
5.	Remove the external bearing seal and slinger installed on the bearing housing	
6.	Remove the bearing housing	
7.	Remove the antifriction bearing	
8.	Remove the internal bearing seal	
9.	Remove the end shield (bracket)	
10.	Remove the fan guide	
11.	Remove the rotor from the stator	
12.	Dismantle the air cooler box, if necessary	

14.8 HRS7 Horizontal-type Motor Construction

Fig. 8 HRS7 Horizontal-type Motor Construction (WOUND ROTOR)



*Disassembly and reassembly of HRS7 Type induction motor with antifriction bearing

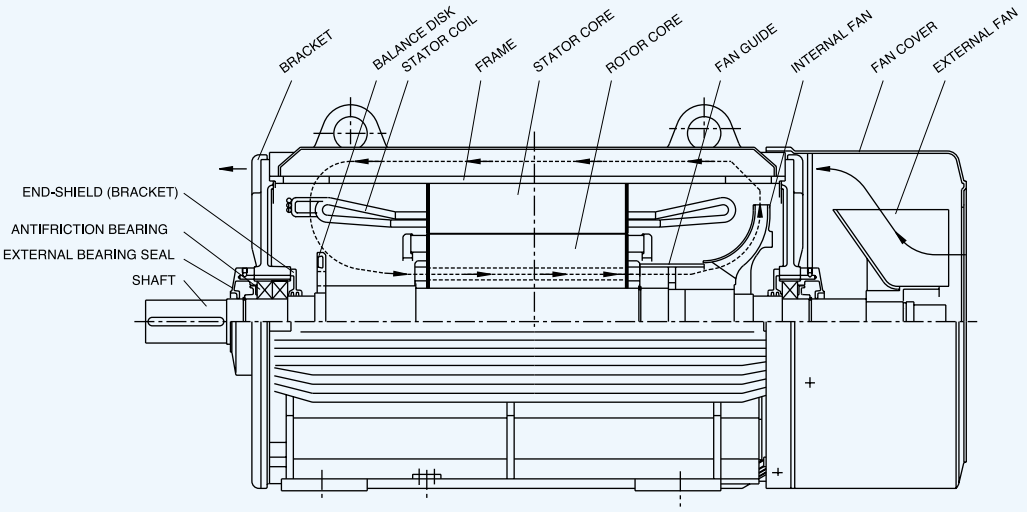
Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing the disassembly steps.
2. Steps 7 to 11 are applied to both the Drive end and Non-drive end of the motors.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perfom an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	*A distance equal to the rotor's length may be required at both ends of the motor drive end and Non drive end.
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, grease pipe, secondary t/box cable, etc.)	
5.	Remove the external bearing seal and slinger installed on the bearing housing	
6.	Remove the bearing housing	
7.	Remove the antifriction bearing	
8.	Remove the end-shield with brush holder	
9.	Remove the end-shield with fan guide	
10.	Remove the internal fan	*Heat the fan hub to approx. 80~100°C both for easy assembly and for removal.
11.	Remove the fan guide	
12.	Remove the rotor from the stator	

14.9 HLE5 Horizontal-type Motor Construction

Fig. 9 HLE5 Horizontal-type Motor Construction (SQUIRREL CAGE)



*Disassembly and reassembly of HLE5 Type induction motor with antifriction bearing

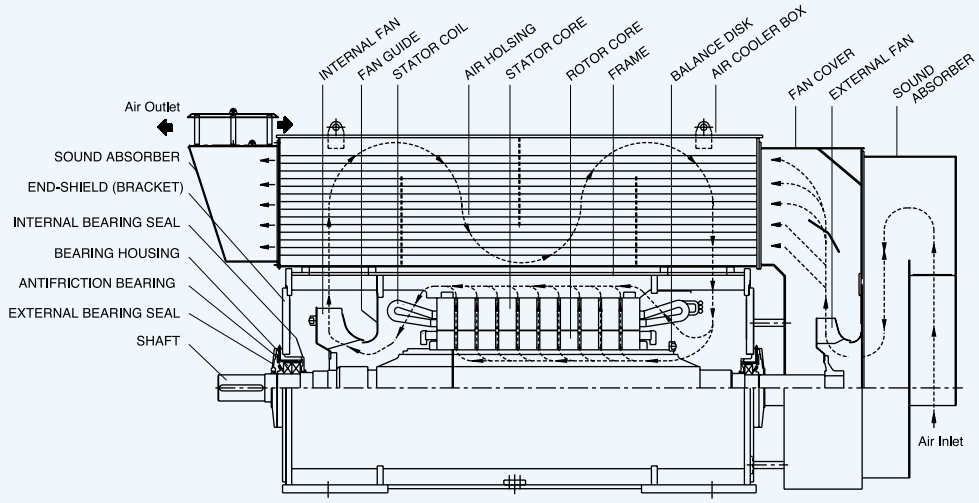
Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing the disassembly steps.
2. Steps 7 to 11 are applied to both the Drive end and Non-drive end of the motors.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perfom an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	*A distance equal to the rotor's length may be required at both ends of the motor drive end and Non drive end.
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, grease pipe, etc.)	
5.	Remove the fan cover	
6.	Remove the external fan	
7.	Remove the external bearing seal and slinger installed on the bearing housing	
8.	Remove the bracket	
9.	Remove the antifriction bearing	
10.	Remove the internal bearing seal	*Heat the fan hub to approx. 80~100°C both for easy assembly and for removal.
11.	Remove the rotor from the stator	

14.10 HRQ3/HIQ1 Horizontal-type Motor Construction

Fig. 10 HRQ3/HIQ1 Horizontal-type Motor Construction (SQUIRREL CAGE)



*Disassembly and reassembly of HRQ3/HIQ1 Type induction motor with antifriction bearing

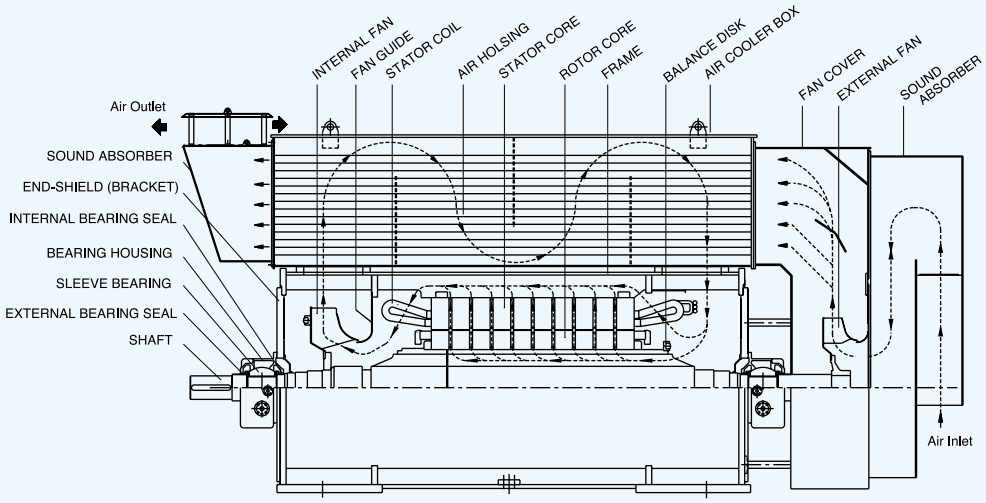
Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing the disassembly steps.
2. Steps 5 to 11 are applied to both the Drive end and Non-drive end of the motors.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perfom an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	*A distance equal to the rotor's length may be required at both ends of the motor drive end and Non drive end.
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, grease pipe, etc.)	
5.	Remove the fan cover	
6.	Remove the external fan	*Heat the fan hub to approx. 80~100°C both for easy assembly and for removal.
7.	Remove the external bearing seal and slinger installed on the bearing housing	
8.	Remove the bearing housing	
9.	Remove the antifriction bearing	
10.	Remove the intermal bearing seal	
11.	Remove the end shield (bracket)	
12.	Remove the fan guide	
13.	Remove the rotor from the stator	
14.	Dismantle the air cooler box, if necessary	

14.11 HRQ3/HIQ1 (Sleeve Bearing) Horizontal-type Motor Construction

Fig. 11 HRQ3/HIQ1 (Sleeve Bearing) Horizontal-type Motor Construction (SQUIRREL CAGE)



*Disassembly and reassembly of HRQ3/HIQ1 Type induction motor with antifriction bearing

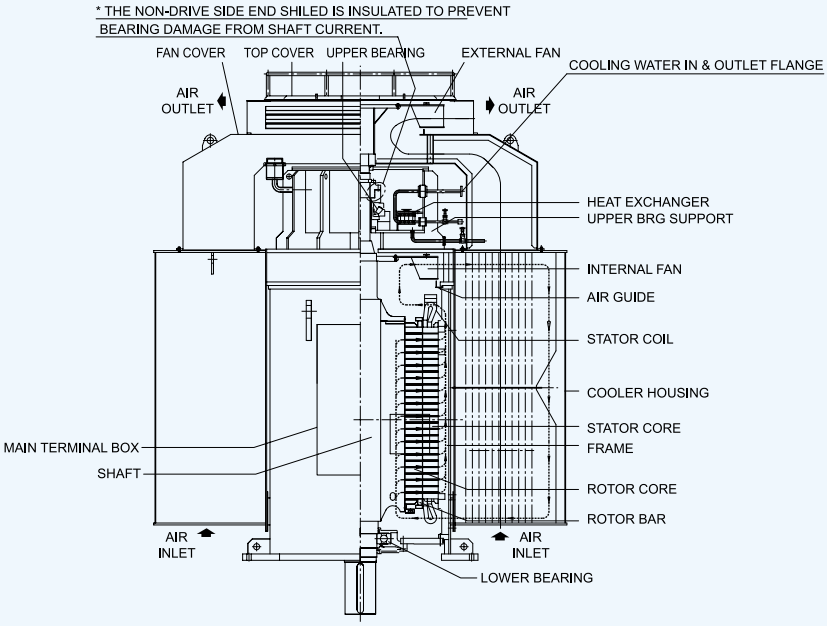
Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing the disassembly steps.
2. Steps 5 to 11 are applied to both the Drive end and Non-drive end of the motors.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perfom an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	*A distance equal to the rotor's length may be required at both ends of the motor drive end and Non drive end.
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, grease pipe, etc.)	
5.	Remove the fan cover	
6.	Remove the external fan	*Heat the fan hub to approx. 80~100°C both for easy assembly and for removal.
7.	Remove the external bearing seal and slinger installed on the bearing housing	
8.	Remove the bearing housing	
9.	Remove the antifriction bearing	
10.	Remove the intermal bearing seal	
11.	Remove the end shield (bracket)	
12.	Remove the fan guide	
13.	Remove the rotor from the stator	
14.	Dismantle the air cooler box, if necessary	

14.12 HRQ3 Vertical-type Motor Construction

Fig. 12 HRQ3 Vertical-type Motor Construction



*Disassembly and reassembly procedure for Vertical Motor

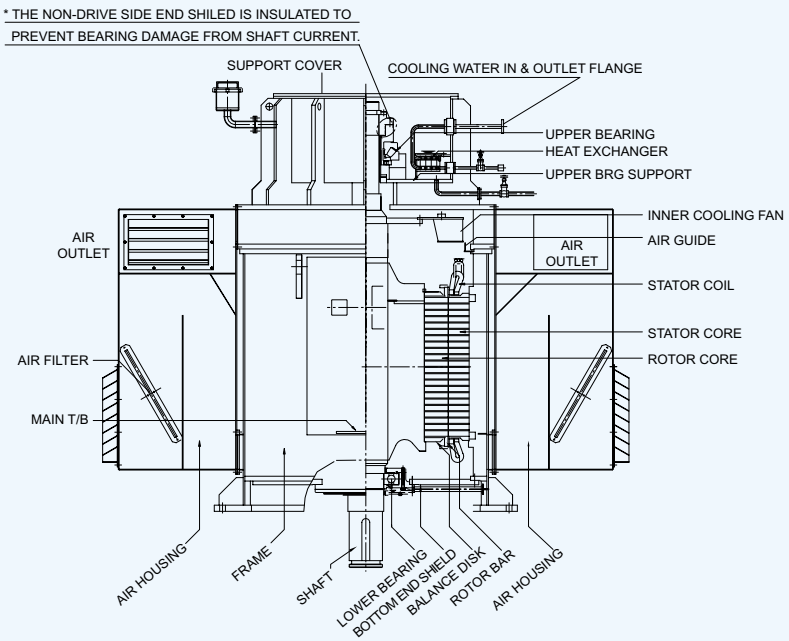
Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing disassembly steps.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perform an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	* A distance equal to the rotor's length may be required at both end's of the motor drive end and Non drive end
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, grease pipe, etc)	
5.	Remove the top cover	
6.	Remove the external fan	*Heat the fan hub to approx. 80~100°C both for easy assembly and for removal.
7.	Remove fan cover	
8.	Remove the cooler housing	
9.	Remove the bottom bearing. Refer to bottom bearing disassembly procedure.	
10.	Remove the bottom end shield	
11.	Remove the upper bearing support cover	
12.	Remove the Upper bearing. Refer to upper bearing disassembly procedure.	* Before disassemble the upper bearing, install the hydraulic jack at the bottom surface of shaft.
13.	Remove the upper bearing support	
14.	Remove the rotor from stator (From DE side to N-DE side	
15.	Remove the inner cooling fan from rotor, if necessary	

14.13 HRP3 Vertical-type Motor Construction

Fig. 13 HRP3 Vertical-type Motor Construction



*Disassembly and reassembly procedure for Vertical Motor

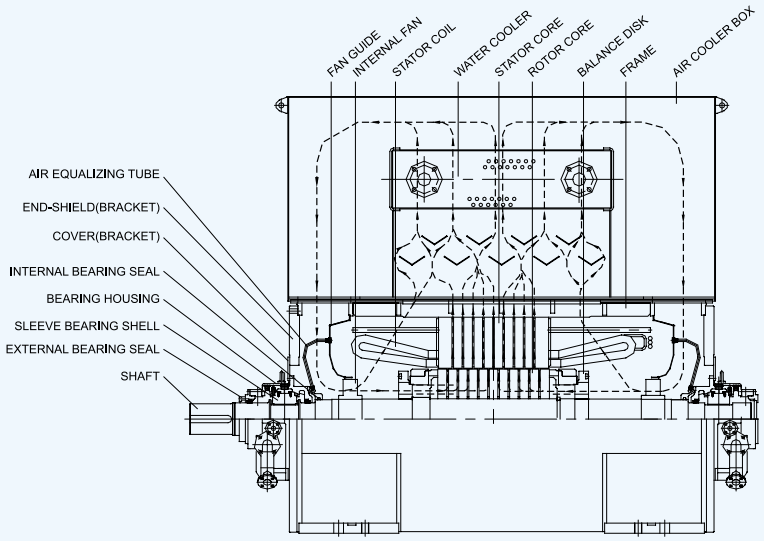
Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing disassembly steps.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perform an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	* A distance equal to the rotor's length may be required at both ends of the motor drive end and Non drive end.
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, grease pipe, etc.)	
5.	Remove the the air housing	
6.	Remove the bottom bearing. Refer to bottom bearing disassembly procedure.	
7.	Remove the bottom end shield.	
8.	Remove the upper bearing support cover	
9.	Remove the upper bearing. Refer to upper bearing disassembly procedure.	* Before disassemble the upper bearing, install the hydraulic jack at the bottom surface of shaft.
10.	Remove the upper bearing support	
11.	Remove the rotor from stator(From DE side to N-DE side	
12.	Remove the inner cooling fan from rotor if necessary	* Heat the fan hub to approx. 80~100°C both for easy assembly and for removal.

14.14 HRN3(Sleeve Bearing) Horizontal-type Motor Construction

Fig. 14 HRN3 Horizontal-type Motor Construction (SQUIRREL CAGE)



*Disassembly and reassembly of HRN3 Type induction motor with sleeve bearing

Notes: 1. Unless otherwise specified, reassembly of motors may be accomplished by reversing the disassembly steps.
2. Steps 5 to 12 are applied to both the Drive end and Non-drive end the of the motors.

FLOW CHART

STEP		Remarks
1.	Uncouple, and perfom an alignment check at the motor and the drive machine	
2.	Lift the motor off and shift it to make enough room to move the rotor	*A distance equal to the rotor's length may be required at both end's of the motor drive end and Non drive end.
3.	Remove the bolts securing the air seal and rest each part on the rotor shaft	
4.	Dismantle the connection box of the frame, if acc'y attached (BTD, oil pipe, etc.)	
5.	Remove the blacket cover	
6.	Remove the external seal for sleeve bearing	
7.	Remove the air equalizing tube	
8.	Remove the sleeve bearing cover	
9.	Remove the labyrinth seal & spring	
10.	Remove the sleeve bearing shell	
11.	Remove the end shield(bracket)	
12.	Remove the fan guide	
13.	Remove the rotor from the stator	
14.	Dismantle the air cooler box, if necessary	

Memo

Memo

Memo

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