EE7091191

INSTRUCTION MANUAL

THREE-PHASE INDUCTION MOTOR

With SLEEVE BEARING

This manual shall be
hand to the motor end user.

Toshiba Mitsubishi - Electric Industrial Systems Corporation

Preface

Thank you for purchasing the Toshiba Mitsubishi - Electric Industrial System Corporation Three-Phase Induction Motor.

This manual covers the squirrel cage (plain bearing) three-phase induction motor models (hereafter referred to simply as "motor").

It contains primarily handling procedures and check points pertaining to motor installation, pre-operational checks, maintenance and inspections, and has been designed for use by the persons who will actually handle the equipment. We hope it will prove useful for not only first-time users but experienced users as well, as a means of checking their knowledge and procedures.

Every effort has been made to ensure that the information in this manual accurately reflects the configuration and use of this product. However, due to Toshiba Mitsubishi - Electric Industrial System Corporation 's continuing research and development efforts aimed at improving its motors, some of the details in this manual may differ from the actual motor. If you have any questions regarding either the product or the information in this manual, please do not hesitate to contact a Toshiba Mitsubishi - Electric Industrial System Corporation customer service representative.

NOTE

- Please make sure this manual is delivered to the personnel who will actually use the equipment.
- Be sure to include this manual when installing the motor on a driver and delivering it to the end user or other user.
- Be sure to read the instruction manual before use.
- Store this manual nearby where it can be referred to when needed.
- Reproduction of the information in this manual, in whole or in part, is prohibited without the written consent of Toshiba Mitsubishi - Electric Industrial System Corporation Corporation.

Safety Precautions

This instruction manual and the labels on the motor itself contain important safety information designed to prevent equipment damage and injury to the work personnel who transport, install, maintain, inspect and use the equipment and other persons. Make sure that you have read and thoroughly understood the following information (regarding the types of warning labels and the safety symbols) before reading the rest of the manual.

Safety

IMPORTANT MESSAGES

Read this manual and follow its instructions. Signal words such as DANGER, WARNING, CAUTION, and NOTICE will be followed by important safety information that must be carefully reviewed.

⚠ DANGER	**Indicates an imminently hazardous situation, which will result in death or serious injury if you do not follow instructions.**
⚠WARNING	**Indicates a potentially hazardous situation, which could result in death or serious injury if you do not follow instructions.**
⚠CAUTION :	**Indicates a situation which if not avoided, may result in minor injury or property damage.**
NOTICE:	**Gives you helpful information.**

Safety signs

Safety symbol	Meaning
	Indicates a PROHIBITED action (one that must not be done). The exact nature of what is prohibited is indicated in pictorial or text form in or near the symbol.
	Indicates a MANDATORY action (one that must be done). The exact nature of what must be done is indicated in pictorial or text form near the symbol.
	Indicates WARNING. The exact nature of danger is indicated in pictorial or text form in or near the symbol.
	Indicates CAUTION. The exact nature of caution is indicated in pictorial or text form in or near the symbol.

QUALIFIED OPERATORS ONLY

Only qualified persons are to install, operate or service this equipment according to applicable codes and established safety practices.

A qualified person must;

(1) Carefully read the entire instruction manual.

(2) Be skilled in the installation, construction or operation of the equipment and aware of the hazards involved.

(3) Be trained and authorized to safely energize, deenergize, clear, ground, lockout and tag circuits in accordance with established safety practice.

(4) Be trained and authorized to perform the service, maintenance or repair of this equipment.

(5) Be trained in the proper care and use of protective equipment such as rubber gloves, hard hat, safety glasses, face shield, flash clothing, etc. in accordance with established practices.

(6) Be trained in rendering first aid.

⚠ DANGER	
 PROHIBITED	• **Do not attempt to modify the motor.** This may result in fire or electric shock. If modification becomes necessary, contact a Toshiba Mitsubishi - Electric Industrial System Corporation customer service representative and follow his or her instructions.
 CONTACT PROHIBITED	• **Do not touch high-voltage electrical circuits and rotating parts.** This may result in electric shock.
 MANDATORY	• **Turn off the power before touching the motor surface or terminals.** Conducting operations with live wires may result in electric shock.
 PROHIBITED	• **Do not touch the motor during the withstand voltage test. Also be sure to discharge the coils after the withstand voltage test; do not touch them until this has been done.** Failure to observe this precaution may result in electric shock.
	• **During operation, NEVER touch or come near rotating parts.** You may be caught in the mechanism and injured.

⚠WARNING	
PROHIBITED	• **Do not allow all personnel other than those handling the equipment to go close to the motor.** Failure to do this may result in injury or electric shock.
	• **Do not use materials handling equipment that is not suited to the weight restrictions noted on the weight nameplate.*** This may cause the motor to fall, resulting in injury. * Noted in specifications (outline drawing) or on nameplates attached to the motor itself.
	• **Do not attach wire ropes for hoisting to the locations other than the hoist lugs on the sides of the stator frame, and do not attempt to hoist more than one motor at a time.** Failure to observe these precautions may cause the motor to fall, resulting in injury.
	• **NEVER enter the area directly beneath the motor while it is being hoisted.** You may be seriously injured if the motor should fall. When entering this area is unavoidable, place the hoist load on a pedestal.
MANDATORY	• **Make sure the load is applied vertically to wire ropes and that it is balanced during hoisting.** If the load is hoisted improperly, it may fall, resulting in injury.
PROHIBITED	• **Do not excessively bend, pull or kink electrical cables and motor lead wires.** This may result in electric shock or fire.
MANDATORY	• **Use cables of the proper size.** Failure to do this may result in overheating and fire.
	• **Install the motor in a proper location that matches the operating conditions (temperature, humidity etc.) noted in specifications.** Failure to do so may result in fire or electric shock. Be sure to check the operating conditions noted in specifications.
	• **Be sure to remove the protective gear attached for transport before attempting to operate the unit.** **Before starting operation, be sure to remove the key attached to the shaft.** Failure to do this may result in breakage or overheating and subsequent burnout and lead to fire or electric shock.
MANDATORY	• **During the withstand voltage test, ground all coils to which voltage is not applied.** Failure to ground these coils may cause current leakage, resulting in electric shock.
MANDATORY	• **Attach a ground relay or other suitable protective relay to the power source side and be sure to attach a ground line to the ground terminal on the motor.** Failure to ground the motor may result in electric shock in the event of current leakage.

Continued

⚠WARNING	
 MANDATORY	• **Attach covers to the machine and coupling sections to guard against being caught in the equipment and provide protection from recoil and splashing.** You may be caught in the equipment or otherwise injured.
	• **Be sure to operate within the output, current, line voltage, frequency, speed of rotation and operation time ranges designated in specifications, standards, rating plate, etc.** Failure to operate the unit within these ranges may result in fire or injury, or in burnout or other damage.
	• **If a separate power source is used for ventilation and cooling equipment, it shall be turned on the power before turning on the power of the motor. Also remember to keep the space heater on even when the motor is off.** Failure to do this may result in overheating and lead to fire.
	• **If a water cooler is used to cool the equipment, the cooling water shall be flow by specified temperature and flow rate.** Failure to do this may result in overheating and lead to fire.
	• **During installation and maintenance, always wear long-sleeved work clothes, safety belts, protective goggles and other designated protective gear.** If you fail to wear protective gear, you may suffer electric shock or become caught in the machinery.
 PROHIBITED	• **Do not operate after removing or disabling protective fixtures and safety equipment (including lids and covers).** This may lead to fire, injury, or motor damage.
 MANDATORY	• **Before starting work operations, turn off the power to all units connected to the motor.** Failure to do this may result in electric shock.
	• **When working at elevations of more than 1.5 meters, be sure to wear a safety belt.** If you fail to do this, you may fall and be injured.
	• **Rope off the work area to prevent people other than work personnel from entering.** Failure to do this may result in people suffering electric shock or becoming caught in the machinery.
	• **Be sure to perform daily and periodic maintenance and inspections.** Failure to perform maintenance and inspections may prevent discovery of failures and errors and result in fire or electric shock.

⚠CAUTION	
PROHIBITED	• **Do not place flammable materials near the motor.** They may ignite and burn out.
	• **Make sure to discharge after insulation measurement. Never touch with hands before discharge.** Failure to do this may result in electric shock.
MANDATORY	• **Make sure the direction of motor rotation matches that shown in external view diagrams and nameplates.** If the direction of rotation nameplate that provided with the motor show only one direction, the motor cannot be operated in reverse. Improperly connecting the motor and operating it in reverse may cause it to suffer overheating and damage.
	• **When using a source of flame with the bearing section dismantled, be careful of the following:** • Wipe away any lubricant from the bearings. • Be sure to protect the bearing section from being heated. • Use sources of flame only in places where there is no danger of fire. • Do not use heaters, cigarettes or other general sources of flame near the bearing section. Failure to observe these precautions may result in fire.
	• **On motors equipped with filters, clean the filter periodically.** Filter clogging may result in overheating and burnout.
MANDATORY	• **In the event of a power outage, be sure to set the power switch to the OFF position.** Failure to do this may result in unforeseen accidents if the power should come back on suddenly.
MANDATORY	• **Wear gloves, etc. when touching machined or pressed components.** As these parts often have sharp edges, touching them with unprotected hands may result in injury.
	• **Unless otherwise designated, use the tightening torque listed in Table 3 (page 18) when tightening bolts.** If bolts are not tightened to the proper torque, they may come loose or break or may not contact properly, resulting in overheating and fire.
	• **Before rewinding coils, contact a Toshiba Mitsubishi - Electric Industrial System Corporation customer service representative and follow his or her instructions.** The insulation used on coils, etc. may generate toxic fumes during heating.
	• **When the motor must be discarded, have this done by a specialist disposal firm, or contact a Toshiba Mitsubishi - Electric Industrial System Corporation customer service representative.** Failure to do this may result in damage to the environment.

Checking the warning labels

Check to make sure that the warning labels are attached at the designated locations. If the labels are missing or soiled and difficult to read, please contact a customer service. This applies to labels that give instructions as well.

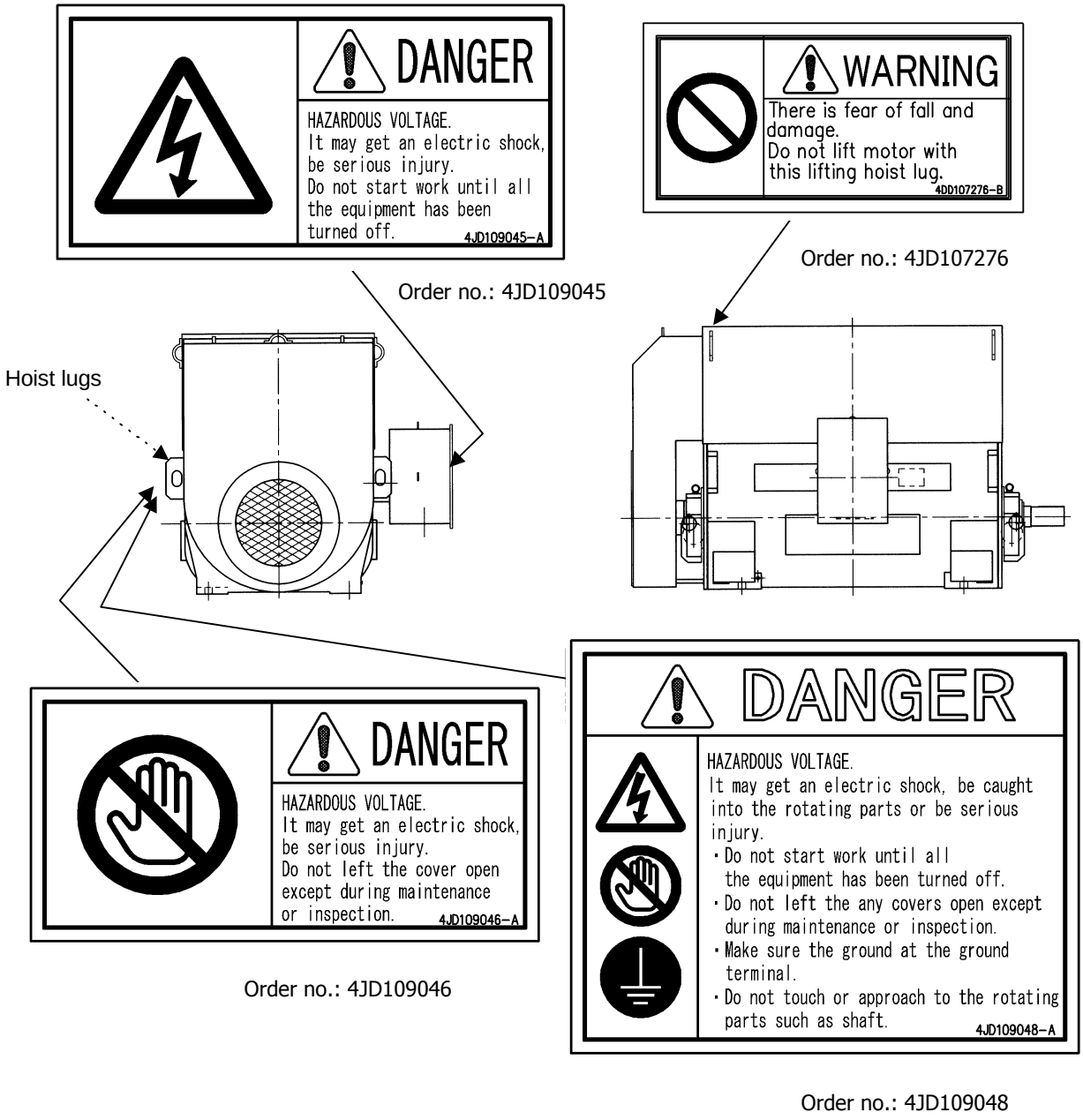

Figure 1 Warning Label Locations and Sample Labels

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1. Explanation of Nameplate

It is obligatory, according to specified motor standards, to indicate necessary items on the nameplate. This nameplate is called a rating plate, and a typical example is shown in **Figure 2**.

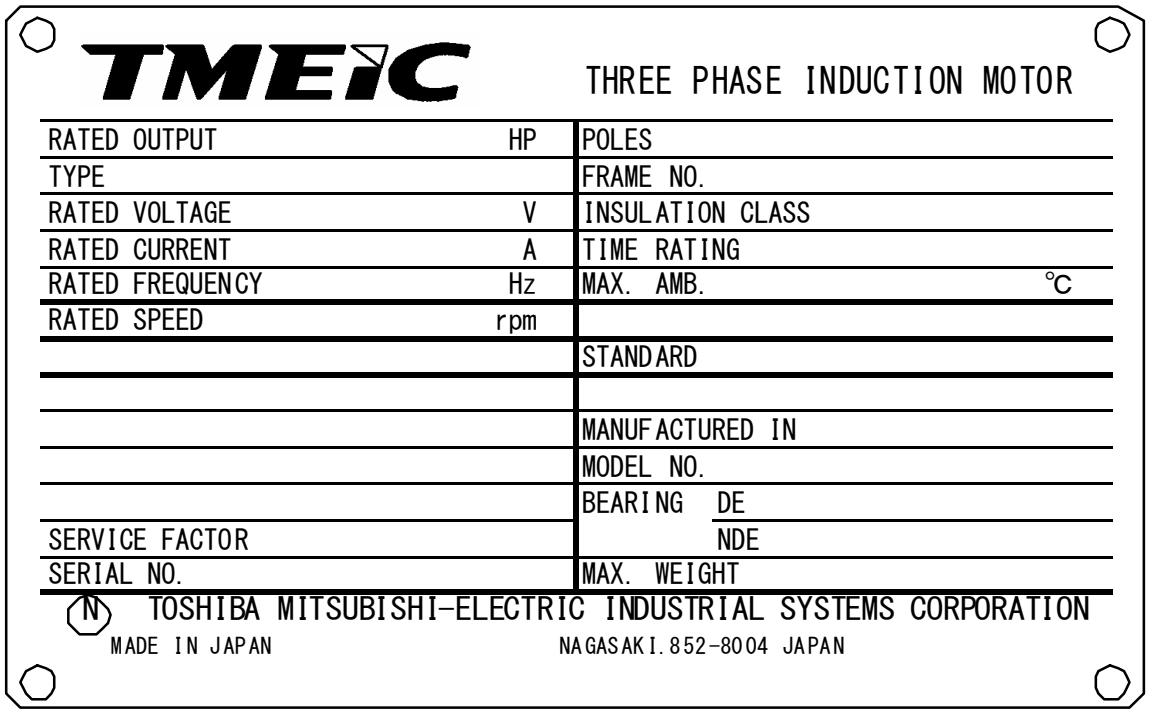


Figure 2 Rated Nameplate

In addition to the rating plate, supplementary nameplates are attached as needed. Be sure to check these nameplates before operating the equipment. The following section describes how to read the rating plate.

1.1 Type and Form code

The type and form codes show our typical letters. It shows electrical and mechanical characteristic.

1.2 Number of poles/speed of rotation/frequency

The letter "P" indicates the number of N and S poles on the stator coil. If the power frequency is f Hz, the speed of rotation for one minute N min^{-1} is:

$$N = \frac{120 \times f}{P} \quad (\ min^{-1}\ )$$

Before use, always compare the power frequency with the frequency value noted on the nameplate.

At the rated load, the rotor speed of rotation for 1 minute should be almost exactly equal to the value on the rating plate.

1.3 Output / voltage / current

Output, expressed in kW, is the maximum shaft output (P) that can be obtained continuously from the motor. Voltage, expressed in volts (V), is the line voltage. Current, expressed in amperes (A), is the current value at the rated voltage and rated frequency when the rated load is applied. The following formula expresses the relationship between these three values as a percentage of the power factor (pf) and efficiency (η) of the motor:

$$P = \frac{\sqrt{3} \cdot V \cdot I \times \eta \times pf}{10^7} \quad (kW)$$

Before operating the equipment, be sure to compare the line voltage with the value on the nameplate, and always operate the motor within the output and current values shown on the nameplate.

1.4 Rating

This indicates the type of rated load. When nothing is noted here, the motor can be operated continuously. If a value is noted here in hours and minutes, the motor can only be operated for the amount of time specified on the plate. In such cases, it is necessary to wait until the coil temperature has dropped to ambient temperature before resuming operation.

1.5 Startup method

This indicates the startup method. "Direct" indicates that the voltage indicated on the plate may be applied directly. "Reactor," "Korndorfer," "Rotor-Resistance" or other notations indicate that the startup unit indicated should be used.

1.6 Cooling maximum temperature / elevation

When nothing is noted here, it means that the cooling maximum temperature should be no more than 40°C and the elevation no greater than 1000 meters.

1.7 Insulation

This indicates the type of insulation. The temperature rise value will differ depending on the method of measuring the temperature; see the applicable standard (JEC-2137).

1.8 Protection method / cooling method / standards

The protection method is noted as "IPXX" where the first digit is the protection used for the human body and solid foreign matter and the second is the protection against water penetration.

The cooling method is noted as "ICXX." For further information, see the applicable standard.

"Standard" indicates the applicable standard, normally JEC-2137.

1.9 Serial no. and manufacture

The serial number is specific to each machine; it is assigned so records for that machine can be located. "Manufacture" indicates the year that the product was manufactured.

2. Points have to be Checked During Receipt

Check the following points:

(1) Check the delivered product against the accompanying invoice.

(2) Unpack the product and check to make sure it is not damaged (check for discoloration, warping and exterior damage).

(3) Make sure that the motor output, voltage, frequency, and model mentioned on the nameplate are the same as what was ordered.

(4) The bearing of the motor may be protected during transportation. Remove the protective equipment in accordance with the instructions on the attached Motor Transport label.

(5) Check other parts of the motor carefully checking for damage, rust, staining, or foreign matter.

If questions arise during the inspection, contact a customer service representative.

In such a case, please specify the following items of information:

- Rating on nameplate (type, model, number of poles, output, voltage, frequency)
- Serial number (stamped on nameplate)
- Description of problem or question

3. Installation

3.1 Delivery

⚠WARNING	
MANDATORY	• **Make sure the load is applied vertically to wire ropes and that it is balanced during hoisting.** If the load is hoisted improperly, it may fall, resulting in injury.
PROHIBITED	• **Do not use materials handling equipment that is not suited to the weight restrictions noted on the weight nameplate.*** This may cause the motor to fall, resulting in injury. * Noted in specifications (external view diagrams) or on nameplates attached to the motor itself.
	• **Do not attach wire ropes for hoisting to the locations other than the hoist lugs on the sides of the rotator frame, and do not attempt to hoist more than one motor at a time.** Failure to observe these precautions may cause the motor to fall, resulting in injury.
	• **NEVER enter the area directly beneath the motor while it is being hoisted.** You may be seriously injured if the motor should fall. When entering this area is unavoidable, place the hoist load on a pedestal.

When moving the motor, consider the size of the body, weight, packing status and other considerations, and be particularly careful of the following. When using a crane or performing slinging work to transport and move the motor, make sure this is done by work personnel certified by applicable government agencies, or given the requisite training by the work supervisor.

- When hoisting and moving the motor, fasten the hoist wires to the lugs on the sides of the stator frame and make sure it is stable.
- Be sure to use wires long enough to ensure that the vertical angle of the hoist wires is no greater than 30°.
- The weight of the motor is noted on the weight plate. Be sure to use wire ropes and other transport materials capable of supporting this weight.
- Place wood or heavy cloth between the hoist wires and the outer covers so the wires will not damage the motor exterior.

NOTICE

- A bracket is mounted on the shaft of the motor to protect it during transport. Be sure to remove this bracket before operating the motor. If the motor must be transported again, be sure to fasten the bracket to the shaft again.
- Transport it after wipe off lubricating oil inside the bearing.

3.2 Selecting the Installation Site

⚠WARNING	
MANDATORY	• **Install the motor in a proper location that matches the operating conditions (temperature, humidity etc.) noted in specifications.** Failure to do so may result in fire or electric shock. Be sure to check the operating conditions noted in specifications.

Install the unit in a location that fulfills the following conditions. When the unit is to be placed somewhere temporarily for receipt or storage, make sure that the location fulfills these same conditions.

When installing in places higher than 2 meters, installation of a platform is also required. Be sure to secure sufficient space to install the platform in such cases.

Places not subject to high humidity

- Make sure there is no danger of water leaking from pipes.
- Make sure water will not condense on glass or metal roofs and drip on the equipment.
- If the motor is to be installed on the floor, install it slightly higher than the foundation level to improve drainage.

No excessive dust

- Dust may lower the insulation resistance of the coil.
  It may also contaminate the lubricant and cause wearing of the bearing metal or other bearing problems.

Well-ventilated location

- Maintain the ambient environment at 40°C or less or the temperature on the nameplate.
  The motor cannot be used at the rated output in places where the ambient temperature and the temperature of the cooling medium exceed specifications.

Places where maintenance and inspection will be easy

- Make sure the motor can be easily removed for future disassembly and inspections.

No harmful gases

- Make sure the location is not subject to corrosive or poisonous gases.
- Avoid installing the motor near places where explosive gases or liquids are stored.

Places not subject to external vibrations

- Make sure vibrations from other machinery are not transmitted through the foundation or floor.

Places with no fluctuations in line voltage

- Make sure voltage fluctuations during operation and the voltage drop at startup are within the values determined by specifications and applicable standards.
- Install protective equipment to prevent damage from lightning and other external power surges and switching surges caused by the operation of circuit breakers.

NOTICE

- Protective units are installed only when requested. Depending on the equipment, we recommend installing a thermostat and RTD or other temperature sensor.
  Be sure to contact a Toshiba Mitsubishi - Electric Industrial System Corporation customer service representative when protective equipment must be installed.

3.3 Design and Installation of Foundation

Professional knowledge of civil engineering is necessary for designing and installation of the foundation. Be particularly careful of the following:

(1) Make sure the static load and dynamic load of the motor will enable it to withstand equipment vibrations.

Requirements for installation rigidity.

Avoid the system resonant frequency from following motor basic frequency:

1. The rotation speed: min^{-1} / 60 ±10% Hz
2. Double the power line frequency: f ±5% Hz.

(2) The foundation bottom area, shape, and weight must be considered so as to avoid subsidence, sliding, floating, and revolving. When the foundation is poor, drive piles or take other means to ensure that the design will support the weight of the unit.

Normally it is not necessary to take the supporting force of the foundation into consideration.

(3) When introducing cooling air by opening a ventilation duct in the foundation, sufficient care should be taken so that underground water does not leak out from the wall. If water leaks occur, moisture is sucked into the motor, and the winding insulation may deteriorate.

(4) It is advisable to cure sufficiently for about 1 week in the summer and 2 weeks in the winter, keeping it slightly wet by covering the concrete surface with a cloth and sprinkling it with water. Concrete reaches its maximum strength about 4 weeks after being placed, drying very rapidly in the first 1 or 2 weeks in particular. Curing of the concrete surface during this period is important.

(5) Cover foundation bolt holes to make sure no foreign matter gets inside.

(6) Finish the foundation's surface horizontally.

(7) In order to achieve a strong adhesion between the mortar and the foundation's after base alignment and installation, chip the foundation about 50 mm from the surface making undulations and exposing the rigid surface of the foundation.

3.4 Alignment

Alignment should be done after the foundation has hardened enough. This is the most important procedure for installation.

The alignment operation will differ depending on the motor configuration. This manual describes the alignment of the standard bearing bracket type motor. If the load machinery has already been installed, alignment should be done using the load machinery coupling as a reference. Use the following procedure:

3.4.1 Shaft Center Adjustment

(1) A magnetic center gage is attached to the end of the bearing. Adjust the end play of the rotator observing the rotator reference line matching status so that it is as described in the drawing. "End play" refers to the maximum movable distance of the rotator in the shaft direction. The allowable errors for the end play other than the case where a special thrust bearing is provided or other value is requested by the directly connected unit are shown in **Table 1**. Adjust and fix the stator center position in the shaft direction measuring the relative position of the stator and the rotator iron core.

(2) Attach a dial indicator to the motor side coupling (see **Figure 3**).

(3) Using the coupling, gently turn the motor rotor and center the shafts to an accuracy of less than 0.025 mm (the value of rigid coupling).

This procedure may differ depending on the type of other machinery, so the manufacturer of this machinery should be consulted.

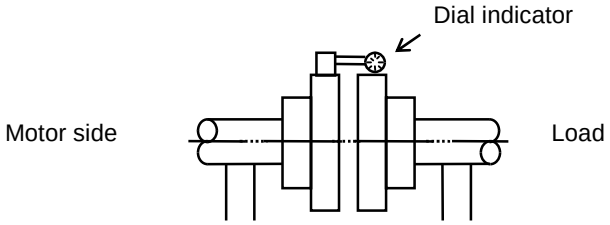


Figure 3 Aligning the Coupling References

3.4.2 Gap Adjustment

(1) Using a thickness gage, measure the gap between the coupling surfaces and adjust until the gap is uniform to an accuracy of less than 0.025 mm. (the value of rigid coupling).

On large and high-speed units, a high level of technical expertise is needed, including the need to give special consideration to the following (regarding slackness of the rotor and the relationship between the danger and operating speeds):

- Levelness in the journal and the center positions of the two shafts in the coupling
- Adjustment of the gap between the coupling surfaces

Accordingly, we recommend that you arrange for technical supervision for each individual case by a Toshiba Mitsubishi - Electric Industrial System Corporation technician or personnel from the machine manufacturer.

Table 1 End Play Tolerance

End play on one side (mm)	Tolerance (mm)
8 (End float 16)	+2.5 –2.5

3.5 Bearing End Play and Preventing Burnout

When the motor is operated independently, the rotator will rotate at the magnetic center.

A force acts to return the rotator when it deviates from the magnetic center, but this force is very slight. As a result, when an external force exerts pressure on the rotator, it will easily deviate from the magnetic center.

On high-speed motors equipped with a flexible joint, the greater the contacting force of torque transmission, the more difficult it will be for the flexible joint to slip. If the flexible joint moves some distance in the shaft direction and this is greater than the motor bearing end play, then the following will occur:

① When the motor is at rest, there is no torque transmission, so the joint will act freely and the motor end play may reach zero. In such cases, when the motor is started up again, the joint will be fixed in that position and the sides of the motor bearing will experience metal contacting.

② When there is thrust in the shaft direction during motor operation, the same phenomenon will occur as above.

③ In **figure 4**, if A < E, contacting will occur at surface X on the bearing; when B < C + D, contacting will occur at surface Y on the bearing.

④ Measure the iron core gap on both the direct-coupled side and the opposite side, either at four locations (up, down, left and right) or at three locations (up, left and right). Check to make sure that the average of the maximum and minimum gap values is no greater than 20%.

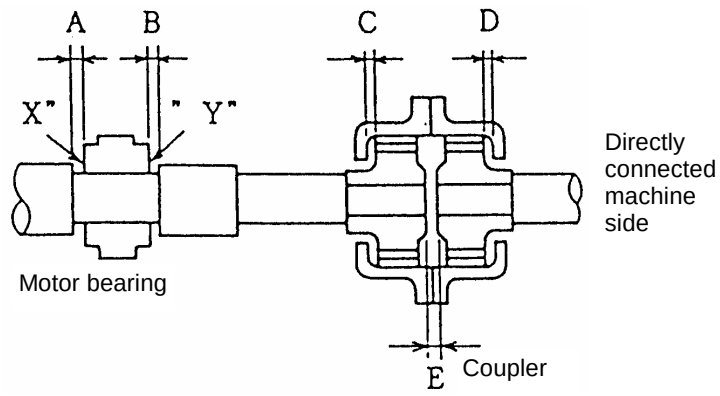


Figure 4 Relationship Between Coupler and End Play

3.6 Pouring of Mortar

After complete alignment, installation of all motor parts in their specified positions and fastening the tightening bolts, pour mortar beneath the base and into the foundation bolt holes. At this time, pay attention to the following points:

(1) Clean the concrete surface after the foundation work and roughen the surface to allow the mortar to adhere sufficiently.

(2) Tamp the mortar while pouring so no cavities are left.

(3) Be careful not to mistakenly move the packer or sub-packer while filling with mortar.

(4) Cure the mortar, in the same procedure as in foundation work, or 1 week in the summer and 2 weeks in the winter.

After the concrete hardens, perform the followings:

- Retighten the foundation bolts and check the alignment record and make sure there are no abnormalities.
- After checking, assemble the floor plate, piping etc.; if there is a knock hole on the stator foot, use this as a guide for reaming.

  In certain motors, however, the knock pins are driven in after trial operation and readjustment.

3.7 Shaft Current Preventive Device

Certain motors are equipped with shaft current preventive devices. Its position is generally on the non drive end bearing as shown in **Figure 5**.

Therefore, in the case of a twin shaft type, it is necessary to insulate at the coupling.

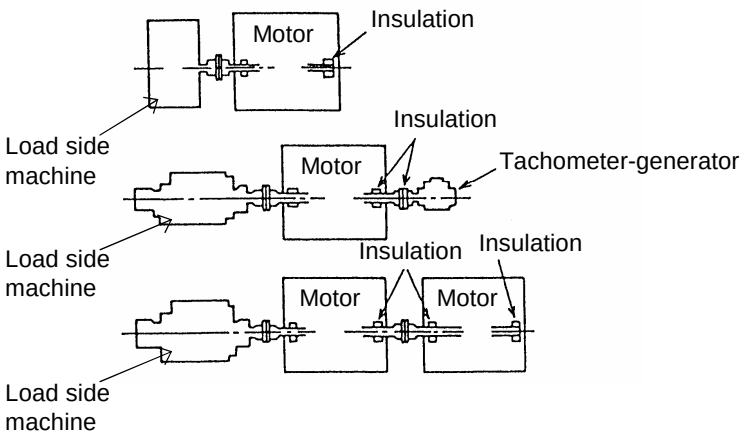


Figure 5 Position of the Shaft Current Preventive Device

3.8 Piping Work

When designing and performing the piping work by yourself, be careful of the following:

1) Prepare the oil discharge system of the motor as described below, in order that the vapor in the bearing on the machine side and the oil tank may not cause the counter flow into the bearing of the motor.

   a) Separate the oil discharge pipes of the motor from those of the machine. Do not connect them in the middle.

   b) Establish the oil tank with a vapor drain, which is big enough to have either [1] or [2], in order to decrease the inside pressure of the oil tank and of the pipes to a natural atmospheric pressure.

      [1] a discharge drain without a fan.

      [2] a drain with an exhaust fan

   c) As for the oil draining pipes from the common pipes to the oil tank, the gradient must be between 1/30 and 1/50. If the gradient of the oil draining pipes is not sufficient, and/or its cross section is too small, then, the oil won't flow smoothly, and it may overflow or cause a leak.

   d) The pipe diameter must be large enough.

2) Be sure to attach a pressure gauge and a flow meter to the oil inlet line and the water supply line. Also provide an oil sight for the oil outlet line and a water sight for the water drain line to facilitate inspection of the pressure and flow of the fluids.

3) Install the piping along the machine body, and saddle them with proper fittings to prevent them from shaking.

4) Be sure to attach the orifice plate (refer to attached caution card) or flange type adjusting valve to the oil inlet. Since the size of the orifice plate or the valve opening has been adjusted in our factory, it should not be tampered with.

5) The oil piping should be designed and adjusted with account taken of the oil pump, pressure regulator and other pipes so that the pressure and flow rate specified in the outline drawing can be attained at the motor bearing inlets.

6) Make sure that there are no foreign objects like rags left inside the pipes. Then, clean them thoroughly and connect them. The cleaning before the pipe connection is accomplished in one of the following two methods. One method is to blow in steam at a pressure of 196 to 294 kPa. The other is to pickle with 10% aqueous solution of sulfuric acid or hydrochloric acid, neutralize immediately with a 20% aqueous solution of caustic soda, and then rinse with water.
   Either method should be followed by lubrication with turbine oil for preventing rust.

7) After the piping has been completed, it should be flushed thoroughly before being fitted to the motor bearings. The flushing can be carried out by using the oil feed pump furnished together with the motor or a separate oil pump which doubles as a filter. When the flushing has been carried out by using the oil feed pump, be sure to clean the oil tank thoroughly before a trial run. Since flushing oil circulating in the piping system is including foreign matter, it should not be run into the bearing metals. Specifically, the piping should be modified to bypass the bearing metals and to connect the inlet and outlet lines at the outside of the bearing housing.
   The flushing oil returning to the oil tank should be passed through an 80 to 100 mesh wire filter. The flushing will be complete when foreign matter is no longer trapped by the filter.
   The filter should be replaced at an interval of several hours.
   The flushing will take 24 to 48 hours, or as long as a week if the piping is long. For the purpose of flushing, prepare reclaimed oil as well as fresh oil.
   The flushing oil is used by heated to 70℃ to 80℃. During flushing operations, hammer the pipes to dislodge incrustations from the pipe inner walls and scour them away with the running oil. Clean the bearing housings, bearings, oil tank and oil cooler thoroughly, and make sure that there is no foreign matter left in the piping system.
   After the flushing has been completed, set up the original piping, charge fresh oil, and check for oil leaks and adjust the oil quantity to prepare for the trial run.

4.Wiring

4.1 Wiring procedures

Always use proper wiring equipment. Follow the Electric Facility Technology Standards and any other applicable standard. If the wiring distance is long, the voltage drop could increase and cause problems when starting the motor. Therefore keep the wire length as short as possible or adjust the applied voltage for the voltage drop.

The motor insulation type is shown on the nameplate. The temperature around the terminal box will be relatively high on motors that use a high-temperature insulation(insulation class "F").

Therefore use high heat-resistance wiring cables and insulation tape around the terminal box.

Be careful of the lead not to pull out from the inside of the motor, or not to push into the inside of the motor at the time of lead connection.

4.2 Grounding(Earth)

The motor insulation acts both as an insulator as well as an inductor. Therefore a capacitance is formed between the insulation and the ground. If the motor is not ground, an induced voltage approximately 50% to 60% of the power voltage could occur between the frame and ground. To prevent electrical shock, always ground the motor and follow the Electric Facility Technology Standards. Grounding bolts or terminals are provided on the motor's frame. When using the grounding terminal of a terminal box, connect a terminal box with a frame with an earth wire

	Class	Groundi1ng wire(mm^2)
1	Above 1000kW	100
2	Above 750kW to 1000kW	80
3	Above 300kW to 750kW	60
4	Above 37kW to 300kW	38

4.3 Precautions for driving inverter

If the common mode voltage of an inverter that carries out high-speed switching is applied to the induced voltage of a motor or the driven machine (including reduction gears), the bearings can be electrically corroded. Observe the following to prevent electric corrosion. (See Figure. 6 .)

(1) Wire the main circuit cable between the inverter and motor with the shortest possible wire to reduce the inductance. Use a shield cable with three conductors (The both ends of a shield cable are connected with a motor at an inverter.) when possible to reduce the induced voltage.

(2) Wire the grounding wire of the inverter with the shortest possible wire to reduce the inductance.

(3) Wire the grounding wire of the motor with the shortest possible exclusive wire to reduce the inductance.

Connect the wire to a grounding pole that has low impedance*.

* The impedance of the motor is less than or equal to the machine side impedance.

(4) If the motor and driven machine (including reduction gears) are installed on separate base plates, connect the base plates of the motor and driven machine to earth (ground). Also connect both bases together.

*When adding earth (grounding) wires:

・Use a flat mesh wire with high harmonic properties.

・Use a wire that is equivalent to or thicker than the motor's grounding wire.

・Use the shortest wire possible that uses two or more bars.(Three bars when 1000kW is exceeded.)

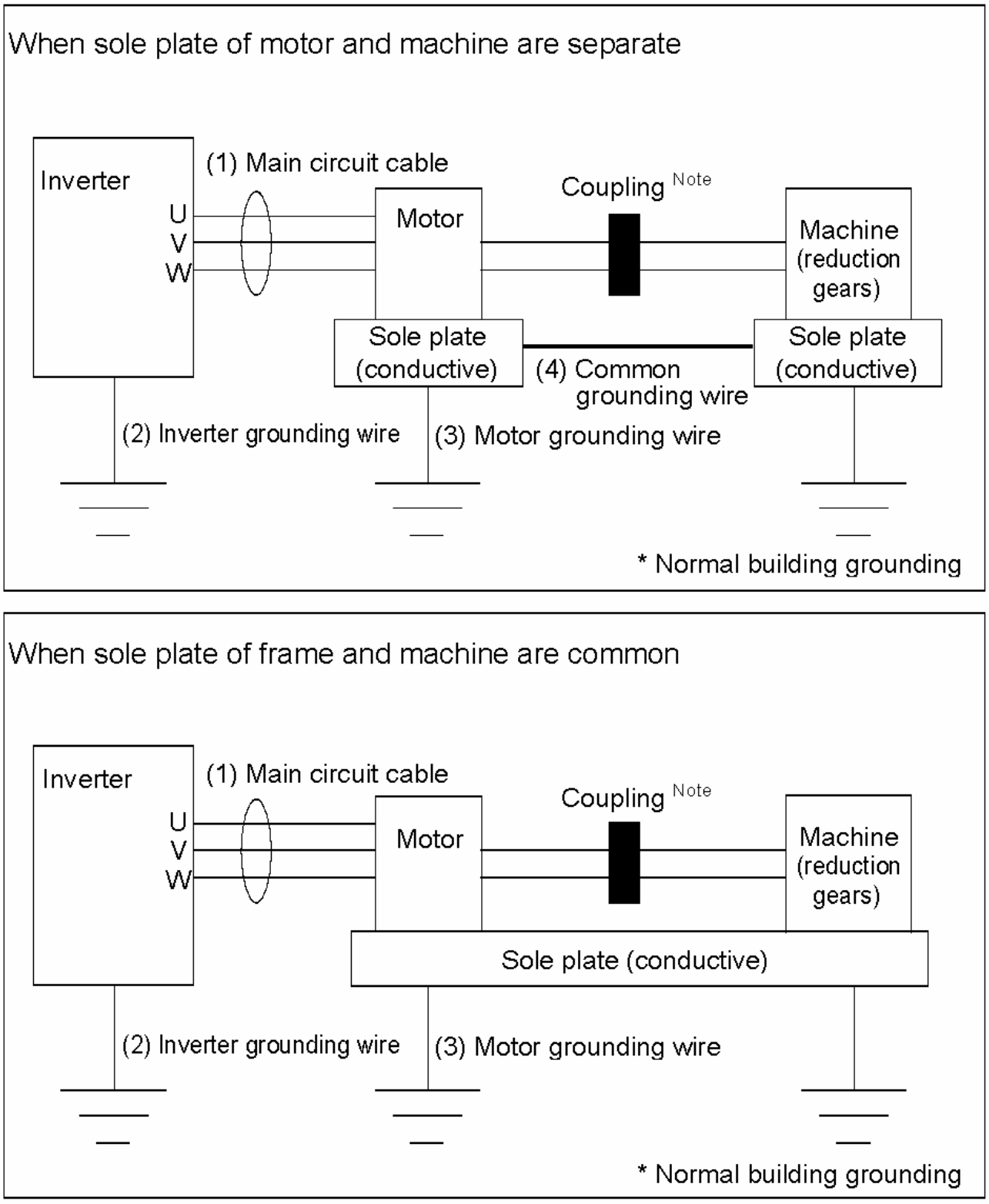


Figure 6. Grounding wire connection

Note: Use of an "insulated coupling" between the motor and driven machine (including reduction gears) is also effective. This may not be possible on large capacity machines due to strength problems.

(5) Earth Brush (Grounding Brush)

1) Function

When an inverter drives the motor, shaft voltage occurs between the shaft and earth (ground) due to electrostatic induction. This voltage is different than the motor and inverter capacitance. When this voltage is large, bearing failure will occur due to the shaft current passing through the bearing.

TMEIC installs an earth brush (grounding brush) to prevent shaft current. The current will pass through the brush to the bearing bracket(ground), thus protecting the bearing. The brush is subject to spark, therefore take caution.

2) attachment

The brush is commonly attached on the drive end bearing bracket. Replace the brush after the power supply has been turned off, under the motor stop.

3) Maintenance

Brush wear varies due to running speed and environmental conditions. Check the brush once every 1-2 month. **Figure 7** shows the earth brush maintenance nameplate. Replace the brush before it reaches the indicated limit.

4) Replacement

If you need to change the brush, contact your nearest TMEIC Representative for more details. A brush performance is influenced depend on materials.

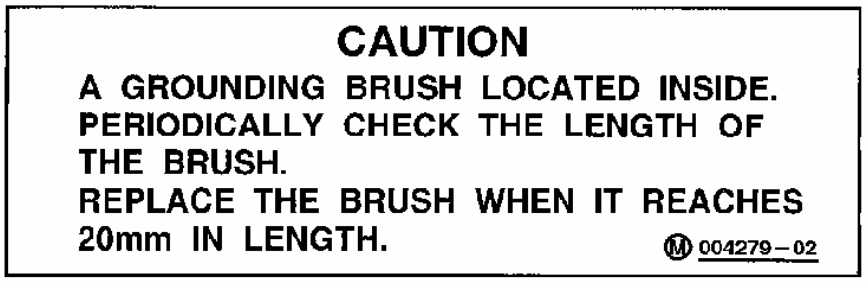


Figure 7. Shaft earth brush inspection methods

4.4 Precautions for Y-△starting

If the neutral point is released and the constant voltage is applied, the winding could deteriorate and be damaged when the motor is not running in a dusty or highly humid environment. Observe the following points.

(1) When selecting the Y-△ starting device, select a device that uses a magnetic switch on the primary side to prevent the voltage from being applied to the motor winding when the motor has stopped.

(2) If there is no magnetic switch on the primary side, always open the switch on the power source side when the motor has stopped.

(3) When using high-voltage Y-△ starting, install a protective device to suppress the switching surge when turning On and OFF the motor (especially a vacuum switch).

5. Checking and Preparation Before Trial Run

Although the motors are shipped after inspection at the shop, unexpected accidents during transportation or the effects of long-term storage must be considered. Check the following items again:

5.1 Measurement of Insulation Resistance

Use a 500 VDC megger for the motor of which rated voltage is less than 600 V, and measure with a 1000 VDC megger if the rated voltage is 600 V or higher. As for the value of the insulation resistance, see the **section 11.3** (**page 47**).

5.2 Checking the Wiring

Check the power supply and protective device wiring against the wiring diagrams. Also check the tightness of the connections, insulated parts, and the gaps where electric contact must be avoided.

⚠WARNING	
 **MANDATORY**	• **Use cables of the proper size.** Failure to do this may result in overheating and fire.
 **PROHIBITED**	• **Do not excessively bend, pull or kink electrical cables and motor lead wires.** This may result in electric shock or fire.
 **MANDATORY**	• **Attach a ground relay or other suitable protective relay to the power source side and be sure to attach a ground line to the ground terminal on the motor.** Failure to ground the motor may result in electric shock in the event of current leakage.

5.3 Checking the Grounding Cable

Grounding terminals are provided on the stator frame and terminal box. Check against the external view diagrams and make sure the grounding cables are connected to the specified positions correctly.

5.4 Bearing Inspection

Inspect in accordance with the bearing cooling method noted in the motor specifications and external view diagrams. If the bearing cooling method is not noted in the specifications and external view diagrams, natural cooling should be used, with oil lubrication performed by the bearing ring.

Be sure to use the types of oil noted on the nameplate or in the external view diagrams.

(1) Natural cooling (plain bearing)

The motor is greased before being shipped from the factory, but in some cases it will need to be regreased. Check the amount of grease and make sure that no grease is leaking from around the shafts, the oil shield, and around the brackets.

(2) Force-lubrication method

Check to see if there is a plate noting restrictions on the amount of oil near the bearing oil fill hole. After inspecting the lubrication unit in accordance with the piping diagram, circulate the designated type of oil and then check the quantity of oil and the oil pressure and look through the oil sight to make sure that oil is actually circulating. Then check the pipes to make sure there is no oil leakage.

5.5 Dielectric Test

⚠ DANGER	
PROHIBITED	• **Do not touch the motor during the withstand voltage test. Also be sure to discharge the coils after the withstand voltage test; do not touch them until this has been done.** Failure to observe this precaution may result in electric shock.

⚠WARNING	
MANDATORY	• **During the withstand voltage test, ground all coils to which voltage is not applied.** Failure to ground these coils may cause current leakage, resulting in electric shock.

The dielectric test is conducted after making sure the insulation resistance meets the specifications.

Be sure to observe the following:

- For the test voltage, use the effective values prescribed below that do not include higher harmonics and can be varied to the required voltage.
- Apply the voltage, increasing it in increments of 1000 V per second to the prescribed value. When the prescribed amount of time has elapsed, immediately reduce the voltage to zero. Use equipment capable of varying the voltage; do not use a switch to turn the voltage on and off.
- Connect all terminals with the same rated voltage together and apply the rated voltage between these connected terminals and the ground. Be sure to ground all coils to which voltage is not applied.
- When conducting dielectric testing on a certain phase or on a portion of a certain winding, cut off that phase or the terminal of that portion completely. Bundle the terminals and apply voltage between the bundled set and the ground. At this time, ground all other phases and windings.

Refer to the Electrical Facility Technology Standards (JAPAN) for the specified dielectric test voltage.

Electric Facility Technology Standards Clause 15

Use the maximum applicable voltage for the generator, motor, phase modifier or other rotating machines (excluding rotating transformer). Test the insulation resistance across the winding and ground with the following test voltages. The device must be able to withstand the voltage when applied continuously for 10 minutes.

When maximum applicable voltage is 7,000 volts or less: 1.5-times maximum applicable voltage. (If the test voltage is less than 500 volts, 500 volts shall be applied.) When maximum applicable voltage is 7,000 volts or more: 1.25-times maximum applicable voltage. (If the test voltage is more than 10,500 volts: 10,500 volts)

*The withstand voltage mentioned above is the rated value when a motor is new. Therefore, it is necessary to examine a voltage value, if carrying out a withstand voltage test after checking.

5.6 Fastening Inspection

⚠WARNING	
PROHIBITED	• **Do not excessively bend, pull or kink electrical cables and motor lead wires.** This may result in electric shock or fire.

⚠CAUTION	
MANDATORY	• **Unless otherwise designated, use the tightening torque listed in Table 2 when tightening bolts.** If bolts are not tightened to the proper torque, they may come loose or break or may not contact properly, resulting in overheating and fire.

The table below shows the screw sizes corresponding to the size of the mounting holes.
Check to make sure bolts, nuts and knock pins are tight. Unless otherwise specified, fasten screws with the sizes shown in the table below to the corresponding torque values.

Table 2 Tightening Torque

Screw size	Tightening torque (N · m)			Standard hole size (motor supports)
	Standard	Allowable range		
M6	5.49	4.71 TO 6.37		
M8	13.2	11.3 TO 15.3		
M10	26.5	22.6 TO 30.4		
M12	46.1	39.2 TO 53.0		ϕ14.5
M16	110	93.2 TO 127		ϕ18.5 or 19
M20	216	181 TO 245		ϕ24 or 25
M24	363	314 TO 422		ϕ28 or 29
M30	735	628 TO 843		ϕ35 or 36
M36	1280	1090 TO 1470		ϕ42 or 43
M42	2050	1750 TO 2350		ϕ48

NOTICE

- During the operation, do not stand or step on top of the motor.
- When working above or around the motor, make sure the motor is completely covered to prevent it from being damaged by tools or soiled by dust and dirt.

6. Checks and Inspections at Trial Run

⚠ DANGER	
MANDATORY	• **Turn off the power before touching the motor surface or terminals.** Conducting operations with live wires may result in electric shock.
CONTACT PROHIBITED	• **Do not touch high-voltage electrical circuits and rotating parts.** This may result in electric shock.

⚠WARNING	
MANDATORY	• **Be sure to remove the protective gear attached for transport before attempting to operate the unit.** **Before starting operation, be sure to remove the key attached to the shaft.** Failure to do this may result in breakage or overheating and subsequent burnout and lead to fire or electric shock.
	• **Attach covers to the machine and coupling sections to guard against being caught in the equipment and provide protection from recoil and splashing.** You may be caught in the equipment or otherwise injured.
	• **If a separate power source is used for ventilation and cooling equipment, it shall be turned on the power before turning on the power to the motor. Also remember to keep the space heater on even when the motor is off.** Failure to do this may result in overheating and lead to fire.
	• **If a water cooler is used to cool the equipment, the cooling water shall be flow by specified temperature and flow rate.** Failure to do this may result in overheating and lead to fire.
PROHIBITED	• **Do not operate after removing or disabling protective fixtures and safety equipment (including lids and covers).** This may lead to fire or injury.

⚠CAUTION	
MANDATORY	• **Make sure the direction of motor rotation matches that shown in external view diagrams and nameplates.** If the direction of rotation nameplate provided with the motor show only one direction, the motor cannot be operated in reverse. Improperly connecting the motor and operating it in reverse may cause it to suffer overheating and damage.

When operating the motor for the first time, remove the fixing plate etc. and operate the motor with no load to make sure there are no problems. Then connect it to the load side machine and operate again. When power is supplied, including during trial operation, make sure that the terminal box cover is attached.

Inspect the following points:

(1) Measure the supply voltage and make sure that the three phases are balanced and it matches the rated voltage of the motor.

(2) When starting the motor, do not apply load to the coupled machined. Turn off the power right after starting to stop inching, and check as follows while rotating by inertia:
- Does the direction of motor rotation match that shown in external view diagrams and nameplates?
- Is the oil ring of the bearing rotating?
- Check for any abnormal noises or abnormal vibrations, and any smoky smell from the insulator.

(3) If no problems are discovered in the inspection in (2) above, restart the motor and check the bearing temperature, vibration, end play and rotation status of the oil ring.

(4) Continue no-load operation until the bearing temperature is saturated, and check for any abnormalities. Then full load operation can be conducted.

7. Normal Operation

⚠WARNING	
MANDATORY	• **Be sure to operate within the output, current, line voltage, frequency, speed of rotation and operation time ranges designated in specifications, standards, rating plate, etc.** Failure to operate the unit within these ranges may result in fire or injury, or in burnout or other damage.
	• **If a separate power source is used for ventilation and cooling equipment, it shall be turned on the power before turning on the power of the motor.** • **If a water cooler is used to cool the equipment, the cooling water shall be flow by specified temperature and flow rate.** **Also remember to keep the space heater on even when the motor is off.** Failure to do this may result in overheating and lead to fire.

7.1 Points to Check at Startup

(1) Make sure the conditions for startup have been established.
- If the bearings are force-lubricated, make sure they have been lubricated.
- If startup equipment is used, make sure a circuit has been created in accordance with the startup conditions.

(2) Make sure the equipment is in normal startup status.
- Startup current/Startup time

(3) If startup fails, make sure the conditions for frequency of the startup operation have been fulfilled.
- For details, see **11.1** "Starting Frequency of Motor" (on **page 45**).

NOTICE

- Even if restarting is possible, attempting to start up the equipment immediately after the power has been turned off may damage the motor if induced voltage remains and an abnormal startup current is created. Be sure to wait at least 10 seconds after the power has been turned off before attempting to turn it on again.

(4) If the motor is not to be used for two weeks or more, check the following before starting it again.
- Measure the insulation resistance of the motor circuit

  If the value is not equal to those listed in **section 11.3**, warm it up with a space heater until the insulation resistance is restored before restarting.
- Make sure the bearing fluid is at the prescribed level.

- Make sure the startup sound, vibration, and the rotation status of the oil ring is as before.
- Perform the daily inspections listed in **Table 4** (on **page 26**).

(5) Startup error

Check the items in **Table 16** (on **pages 55** and **56**). If you are unable to locate the cause of the problem, contact a customer service representative.

7.2 Points to Check During Operation

During operation, check the items in **Table 4** (on **page 26**) and make sure there are no problems.

8. Storage

(1) Short-term storage

If the motor is not to be installed immediately and must be stored for a certain period of time (less than 6 months) without being unpacked, do so in accordance with the following:

- Store the motor indoors in a dry, well-ventilated location where it will not be exposed to direct sunlight and extreme variations in temperature. Storing the motor in a hot location may cause condensation to form on the metal surfaces when the temperature drops, resulting in rusting.
- When storing the motor after it has been unpacked in the period between installation and operation, be sure to protect it from humidity, foreign matter, small animals, exterior damage and the like. Absorption of moisture by the motor coils during storage may impair insulation resistance and cause condensation to form on the iron core, terminal box or other metal surfaces, resulting in rusting.
- No lubricant is supplied to plain bearings. Make sure the journal is always covered with the proper lubricant as noted in the external view diagrams or nameplates.
- Metal surfaces that may rust, particularly machined surfaces, are coated with rustproofing paint, rustproofing fluid or grease before the unit is shipped from the factory. If the rustproofing paint has peeled away from these surfaces, remove all rust and dampness and then repaint with rustproofing paint.
- If a space heater is included with the motor, be sure to turn on the heater.

NOTICE

- Before turning on the space heater, be sure to check the voltage and make sure there are no foreign objects near it.
- Monitor the heaters for several hours after the power has been turned on to make sure it is operating properly.

(2) Long-term storage

As a rule, long-term storage refers to periods when the unit is stored or shut down for more than 6 months. In such cases, in addition to the procedures for short-term storage, the steps in **Table 3** (**page 22**) are also required.

This table shows the standard procedures needed to maintain motor quality; however, the procedures will differ depending on the type of motor, grounding location and other factors. Always consult a Toshiba Mitsubishi - Electric Industrial System Corporation customer service representative when long-term storage is necessary.

Final inspection, disposition and adjustment before operation require specialist knowledge and techniques. Requesting the dispatch of a Toshiba Mitsubishi - Electric Industrial System Corporation technician to perform these procedures before operation is recommended.

Table 3 Types of Long-Term Storage for AC Motor Assembly Components and Measures to Maintain Quality

Item / Part	Storage location	Type of storage	Applicable standards for maintaining quality		Inspection method	Frequency
			Rustproofing and moisture-proofing	Warping and damage		
Stator	Indoor	(1) Wrap the entire unit in a polyethylene sheet and then place on the floor on a wooden pallet in the same position as the position in which it will be installed. (2) Be sure to pack desiccant inside the polyethylene sheet. (The recommend amount of desiccant is about Siricagel 300 to 500 grams per 1 m3)	(1) After pretreating the mounting surface of the base, allow it to dry naturally and then coat with varnish. (2) Wipe any oil from exposed machined surfaces, then allow to dry naturally and coat with varnish. (3) Install a space heater inside the motor and make sure it is kept on.	(1) Cover with a waterproof sheet to protect it from the rain and prevent the exterior from becoming damaged. (2) Do not stack parts on top of one another, or on top of other types of parts (3) Protect instruments with sheets of plywood.	(1) When unpacking the part, check for exterior damage. (2) Check the coil insulation resistance. (3) Every 6 months, remove the rustproof agent from the shaft end and coupling and inspect visually. (4) Inspect the shaft journal once every 6 months.	Every 6 months
Rotor			(1) Wipe the shaft journal and oil guard and coat with rustproof fluid.			
Bearing			(1) Coat the spherical surface and the metal babbitt surface with rustproof fluid.			
Air cooler			Fill the interior of the tube with N_2 gas	Protect the fins of the cooling fan so they do not become damaged.	Install a pressure gage to check the N_2 seal status.	Every 3 months

9. Maintenance and Inspection

Maintenance and inspection should be done to prevent accidents in advance and extend the life of the motor. The quality of maintenance operations will have an enormous impact on the life of the motor. Be sure to incorporate inspection work into your maintenance schedule, in accordance with the maintenance and inspection standards given below, and be sure to perform these inspections thoroughly.

Also be sure to record the nature and results of inspections at regular intervals during operation. By recording the running condition of the motor, any change in operation can be accurately checked so that serious accidents may be prevented.

⚠WARNING	
MANDATORY	• **Before starting work operations, turn off the power to all units connected to the motor.** Failure to do this may result in electric shock.
	• **When working at elevations of more than 1.5 meters, be sure to wear a safety belt.** If you fail to do this, you may fall and be injured.
	• **Rope off the work area to prevent people other than work personnel from entering.** Failure to do this may result in people suffering electric shock or becoming caught in the machinery.
	• **During installation and maintenance, always wear long-sleeved work clothes, safety belts, protective goggles and other designated protective gear.** If you fail to wear protective gear, you may suffer electric shock or become caught in the machinery.
	• **Be sure to perform daily and periodic maintenance and inspections.** Failure to perform maintenance and inspections may prevent discovery of failures and errors and result in fire or electric shock.

⚠CAUTION	
MANDATORY	• **Wear gloves, etc. when touching machined or pressed components.** As these parts often have sharp points, touching them with unprotected hands may result in injury.
	• **On motors equipped with filters, clean the filter periodically.** Filter clogging may result in overheating and burnout.

9.1 Inspections

There are two types of motor inspections: daily inspections and periodic inspections.

9.1.1 Daily Inspections

From the outside, check the appearance, feel and sound of the motor.

9.1.2 Periodic Inspection

(1) Simple inspection: Disassemble the bearing bracket on the motor and inspect, checking mainly the bearings around the coil end.

(2) Full inspection: Pull the rotor out of the motor and inspect it carefully and thoroughly.
Also be sure to perform regular maintenance for lubrication equipment and other supplementary units, in accordance with the instruction manuals for those units.

9.2 Frequency of Periodic Inspections

Scheduled monitoring is the basis of maintenance and inspection and should be conducted regularly for necessary points at appropriate intervals. When planning the scale and frequency of periodic inspections, consideration should be given to such factors as the operating environment, frequency of startup operations, duration of startup time and the importance of the machinery. Planning should be based on two types of periodic inspections: simple inspections and full inspections.

(1) Simple Inspection

Performed in the intervals between full inspections.

(2) Full Inspection

- Initial inspection
  - 1 to 2 years after the start of operation

    In some cases, failures (called "initial failures") may occur as a result of points that could not be checked when operation was started (for example, appropriateness of the configuration for the environment, etc.; contamination by foreign matter during transport or site assembly; building settling, etc.). The initial inspection is performed at a suitable period after the start of operation to eliminate the causes of such initial failures. It has been found to be extremely effective in ensuring the stability of subsequent operation.
- Interval for periodic inspections (held after initial inspection)
  - Approximately every four years following initial inspection

9.3 Major Inspection Points

Daily and periodic inspections should include the major inspection points listed below and should be done based on the maintenance and inspection standards listed in **Tables 4** through **7** (**pages 26** to **30**). The following section lists points to remember when performing inspections and their importance.

(1) Inspect the stator coil wedge and stator coil end ties to make sure they are tight.

On the stator coil, the electromagnetic vibrations applied to the coil are restrained, by the wedge on the core slot and by the ties on the coil end. The coil insulation, wedge, spacer, binding ties etc. are made of insulation material; electromagnetic vibrations during operation and settling during the heat cycle, etc. may loosen the wedges or bindings.

If this is not corrected, over a long period of time the electromagnetic force and mechanical vibrations may vibrate the coil, resulting in wearing and eventual destruction of the insulation material.

Inspect these points periodically and take corrective action as needed.

(2) Rotor bar looseness, blazed section peeling and movement in the axial direction

On squirrel cage induction motors equipped with copper bar rotors, the rush current at startup may cause heat stress, electromagnetic force, centrifugal force etc. to be superimposed on the rotor bar, short-circuit ring and the blazed section of them, causing fatigue to be accumulated at each startup. This may result in rotor bar looseness or movement of the entire rotor bar in the axial direction, or partial peeling of the blazed section between the rotor bar and the short-circuit ring.

Continued operation in this state may cause cracking of the rotor bar end or damage the short-circuit ring, and the diameter of the end may expand due to centrifugal force, damaging the stator coil and destroying the insulation. Accordingly, it is important to inspect these sections periodically.

(3) Inspection of area around bearings

The area around the bearings must be inspected for temperature, abnormal noise, damage to the journal from vibrations, and foreign matter. Be particularly careful to check for the following:

- Oil ring movement/warping/wear-out
- Blackening or discoloration of oil
- Oil level
- Oil leakage

For more information, see Chapter 10 “Maintenance of bearings”.

(4) Accumulation of dust on stator coil or core ventilation duct

The accumulation of dust on the stator coil will impair the conduction of heat, while the accumulation of dust at the core ventilation duct will reduce the flow of cooling air. Both of these will cause a rise in temperature.

If dust has accumulated, determine a cleaning interval that matches the amount of dust, or take measures to prevent dust from entering.

(5) Inspection of the sound absorbing material on the fan cover and inside the air duct on top of the motor

The sound absorbing material will wear out eventually; inspect and replace it if it has deteriorated.

(Recommended replacement parts: bearings, packing material, etc.)

(6) The other materials are packing rubber parts.

9.4 Items to Check Before Post-Inspection Trial Run

For the trial run following maintenance and inspection, perform the actions listed in **Chapter 5** "Checking and Preparations Before Trial Run" (**pages 16** to **18**) and **Chapter 6** "Checks and Inspections During Trial Run" (**page 19**).

Table 4 Maintenance and Inspection Standard: Daily Inspection (In operation)

Object	Procedure			Criterion
	Item	Period	Method	
1. Stator of power source	Voltage	Daily	Voltmeter	Tolerance: ±10% of rated value (at rated frequency)
	Frequency	Daily	Frequency meter	Tolerance: +3%,-5% of rated value If voltage and frequency vary simultaneously, the sum of the absolute values of both variation rates must be within 10%.
2. Running state	Vibration	Weekly	Touching, vibrometer	If there was an unusual increase in the vibration, measure the vibration. To be judged according to **Figure 20** (**page 48**).
	Current	Daily	Ammeter	Normal current, not exceeding the rate value.
	Smell	Daily	Smelling	Free from smoky smell.
	Abnormal noise	Daily	Hearing, noise sensing bar	To check the origin of any noise, use a noise sensing bar.
	Temperature (frame, bearing, windings)	Daily	Touching, thermometer	Temperature rise should not differ from the value measured at the time of delivery of the motor.
	Covers	Weekly	Visual	No loose or missing bolts
	Ladder platform	Weekly	Visual	No loose or missing bolts and no corrosion
3. Environments	Ambient temperature	Weekly	Thermometer	Within normal standards
	Ventilation	Weekly	Visual	Free from clogged ventilation paths, etc. If there is a motor blower, make sure it is functioning properly.
4. Bearing				
4.1 Plain bearings	Temperature	Daily	Touching, thermometer	If any abnormal temperatures are felt, measure using a thermometer. Self-cooled bearing temperature limit (readout value): max. 92°C when measured at bottom half of bearing metal
	Oil surface and oil leakage	Daily	Visual	Oil at prescribed level
	Oil pressure	Daily	Visual	Normal
	Oil ring	Daily	Visual	Smooth rotation
5. Cooler	Water leakage	Daily	Visual	Free from water leakage
	Water pressure	Daily	Pressure gage	Pressure at designated level
	Flowrate	Daily	Flow sight	Cooling water flowing

Table 5 Maintenance and Inspection Standard: Daily Inspection (Anytime when operation is stopped)

Object	Procedure			Criterion
	Item	Period	Method	
1. Investigation	Check the running data record for defective points	Monthly	Daily inspection record	
2. Appearance	Damage, soiling of frame, terminal unit	Monthly	Visual	Clean
	Cooling pipes/air duct/filter	Monthly	Visual	Unclog, etc. as necessary and clean
3. Bearing				
3.1 Plain bearing lubrication	Dirty oil	Monthly	Drain	Free from foreign matter (sludge, babbitt powder, etc.)

Table 6 Maintenance and Inspection Standard: Periodic Inspection (Simplified inspection, top hat, bearing bracket upper half disassembling)

Object	Procedure			Criterion
	Item	Period	Method	
1. Investigation	Check for abnormality in running state	Yearly	Daily inspection record	Clean or repair if abnormal
2. Measurement	Winding insulation resistance	Yearly	Megger	Please refer **section 11.3** about measure method and target.
	Air gap	Yearly	Gap gauge	$\frac{\text{Maximum} - \text{minimum}}{\text{Mean}} \times 100 \leq 20\%$
3. Appearance	Frame soiling, painting	Yearly	Visual	Clean
	Terminal	Yearly	Visual	Repair if defective
	Filter	Yearly	Visual	Clean (replace if necessary)
	Bolt connections	Yearly	Visual	No loose, missing or damaged bolts

Table 6 (Continued)

Object	Procedure			Criterion
	Item	Period	Method	
4. Stator	Core, windings	Yearly	Visual	Free from dust, oil fumes, water vapor, foreign matter
	Core	Yearly	Visual	Free from misalignment, overheating, discoloration, damage, rust
	Core end	Yearly	Visual	Free from inclination or projection of outer side distance piece. Free from becoming loose, bruising
	Coil ends	Yearly	Visual	Free from deformation, damage, soiling
	Insulator	Yearly	Visual	Free from oozing of varnish, void, tracking
	Wedge	Yearly	Visual	Wedge not loose
	Coil support	Yearly	Visual	Support not loose, missing or out of alignment
	Air deflector	Yearly	Tap/visual	Windbreak not loose or cracked
5. Rotor	Core	Yearly	Visual	Free from rust, looseness, dust, oil fumes, water vapor , foreign matter, overheating, discoloration or damage
	Connecting part between rotor bar and end ring	Yearly	Visual	Free from cracking shifting of bar
6. Bearing				
6.1 Plain bearing	Metal contacting scars	Yearly	(Bearing disassembly/inspection) Visual check (using a magnifying glass)	Make sure bottom metal is appropriate No top metal contacting
	Metal adherence	Yearly	Color check	Value 40% or greater
	Metal clearance	Yearly	Micrometer	
	Oil shield	Yearly	Thickness gage	
	Oil ring	Yearly	Visual	Free from warping or excessive wear Set screws not loose
	Oil	Yearly	Visual	Free from dirt, deterioration or foreign matter
	End play	Yearly	Thickness gage Scale	Within tolerance
7. Instruments	Dirty oil or damage	Yearly	Visual	Free from dust, oil fumes, water vapor, foreign matter or damage
8. Coupling	Shaft end runout	As needed	Dial gage	Within tolerance
	Centering	As needed	Dial gage	Within tolerance
	Direct coupling	As needed	Visual	Bolts and nuts tight
	Damage	As needed	Visual (Check the collar if necessary)	Key grooves free from damage and splitting Gear coupling teeth free from excessive wear
9. Loaded operation	Abnormal noise, vibration, smell	Yearly	Hearing, touching, smelling	Free from abnormality
	Rotating direction	Yearly	Visual	Specified rotating direction
10. Shaft current	Preventive device	Yearly	Visual	After cleaning, insulation resistance measurement
			500V Megger	Min. 0.5MΩ

Table 7 Maintenance and Inspection Standard: Periodic Inspection (Full inspection with rotor removed)

* Interval of 4 years indicates the interval after the initial inspection. The initial inspection should be done 1 to 2 years after the start of operation (see **Section 9.2** on **page 24**).

Object	Procedure			Criterion
	Item	Period	Method	
1. Investigation	Check for abnormality in running state	Every 4 years*	Daily inspection record	Clean or repair if abnormal
2. Measurement	Shaft levelness	Every 4 years*	Level gauge	Measure the journals at both ends and make sure the difference in measurements is no more than 0.05 mm per meter
	Winding insulation resistance	Every 4 years*	Megger	Greater than specified value (see **Table 6**)
	Space heater insulation resistance	Every 4 years*	Megger	Min. 1 MΩ when measured with a 500 VDC megger
	Air gap	Every 4 years*	Gap gauge	See **Table 6**
3. Appearance	Frame soiling, painting	Every 4 years*	Visual	Clean
	Filter	Every 4 years*	Visual	Clean (replace if necessary)
	Bolt connections	Every 4 years*	Visual	No missing or damaged bolts
4. Stator	Core, windings	Every 4 years*	Visual	Free from dust, oil fumes, water vapor, foreign matter
	Core	Every 4 years*	Visual	Free from misalignment, overheating, discoloration, damage, looseness, rust
	Core end	Every 4 years*	Visual	Free from inclination or projection of outer side distance piece Free from looseness, bruising
	Air duct	Every 4 years*	Visual	Duct free from clogging
	Coil ends	Every 4 years*	Visual	Free from deformation, damage, soiling
	Insulator	Every 4 years*	Visual	Free from discoloration, oozing of varnish, void, tracking
	Coil support	Every 4 years*	Visual	Support not loose or out of alignment Connections normal
	Wedge	Every 4 years*	Hammering	Wedge not worn, loose or missing
	Coil ties	Every 4 years*	Visual, touching	Coil not loose, discolored, deteriorated or out of alignment
	Lead cable and terminal	Every 4 years*	Visual	Free from damage, deterioration or terminal discoloration Free from dust, oil fumes, water vapor or foreign matter
	Air deflector	Every 4 years*	Visual	Welds normal Bolts not loose
	Space heater	Every 4 years*	Visual	Bolts tight and free from dust, oil fumes or water vapor Free from foreign matter or other deposits

Table 7 (Continued)

Object	Procedure			Criterion
	Item	Period	Method	
5. Rotor	Core	Every 4 years*	Visual	Free from rust, looseness, dust, oil fumes, water vapor, foreign matter, overheating, discoloration or damage
	Connecting part between rotor bar and end ring	Every 4 years*	Visual, check the collar	No cracking and peeling of sliver braze less than 50% on each mating surface No bar movement
	Rotor bar	Every 4 years*	Hammering	Bar not loose
	Fan	Every 4 years*	Visual	Fan blades not warped
	Balance weight	Every 4 years*	Hammering	Connections not loose
	Shaft journal	Every 4 years*	Visual, touching, size measurement	Journal not scratched, dented or bruised
6. Bearing				
6.1 Plain bearing	Metal contacting scars	Yearly	(Bearing disassembly/inspection) Visual check (using a magnifying glass)	Make sure bottom metal is appropriate No top metal contacting
	Metal adherence	Yearly	Color check	Value 40% or greater
	Metal clearance	Yearly	Micrometer	See the instruction manual for the plain bearings
	Oil shield	Yearly	Thickness gage	Within tolerance
	Oil ring	Yearly	Visual	Free from warping or excessive wear Set screws not loose
	Oil	Yearly	Visual	Free from dirt, deterioration or foreign matter
	End play	Every 4 years*	Thickness gage	Within tolerance (See section 3.4)
7. Instruments	Calibration	As needed	Compare with reference	Within JIS standards
8. Coupling	Shaft end runout	As needed	Dial gage	Within tolerance (See section 3.4)
	Centering	As needed	Dial gage	Within tolerance (See section 3.4)
	Direct coupling	As needed	Visual	Bolts and nuts tight
	Damage	As needed	Visual (Check the collar if necessary)	Key grooves free from damage and splitting Gear coupling teeth free from excessive wear
9. Loaded operation	Abnormal noise, vibration, smell	Yearly	Hearing, touching, smelling	Free from abnormality
	Rotating direction	Yearly	Visual	Specified rotating direction
10. Cooler	Internal inspection	Every 4 years*	Visual	Free from abnormal corrosion or pinholes
	Hydraulic test	Every 4 years*	Hydraulic test	Free from leakage or warping
11. Pipes	Damage	Every 4 years*	Visual	Connections not loose and no water/oil leakage or corrosion
12. Shaft current	Preventive device	Yearly	Visual	After cleaning, Insulation resistance measurement
			500V Megger	Min. 0.5MΩ
13.Sound form	Fan cover / Duct	Every 4 years	Visual	No looseness, deterioration, elimination
14.Packing rubber	Fan cover / Duct	Every 4 years	Visual	No deterioration

10. Maintenance of Bearings

10.1 Maintenance of Plain Bearings

The bearings are an important factor determining the life of the motor. Create an inspection plan in keeping with the operating conditions for the motor and implement inspections and maintenance in accordance with this plan.

10.1.1 Daily Inspection and Maintenance

(1) Bearing temperature

The normal temperature of the bearing is the highest temperature that is maintained by that bearing under normal operation.

Bearing temperature rise value = Bearing temperature – Ambient temperature

Problems with bearing temperature will be revealed by keeping daily records. Be sure to keep records of operation every day, as these will serve as important background data in the event of a problem.

There are three ways of measuring the bearing temperature:

(a) Using an accessory measurement device such as a dial thermometer, a thermocouple or a search coil;

(b) Using a stick thermometer;

Here, a stick thermometer is inserted into the temperature measurement port in the bearing bracket (as shown in **Figure 8**).

(The temperature measurement port is normally plugged, but it is possible to remove the plug to install a thermometer.)

(c) Measuring the feed and discharge oil temperature (for bearings cooled by forced circulation);

This method allows one to find the bearing temperature rise directly.

No matter which method is used, one should inspect the bearing promptly should any irregularities in bearing temperature be observed.

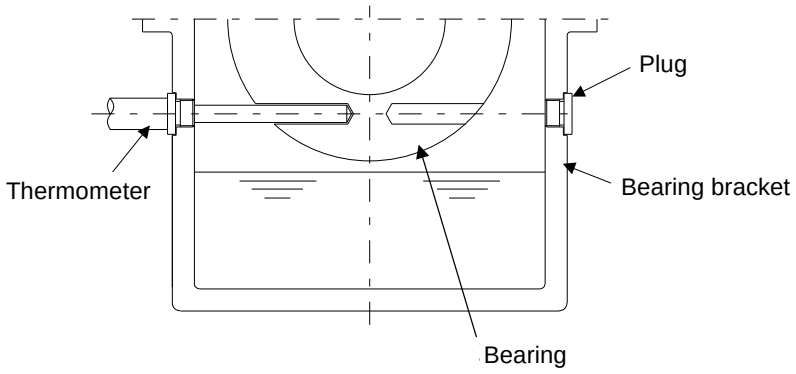


Figure 8 Measurement Using Etched-Stem Type Thermometer, etc.

Furthermore, in cold northern regions, the viscosity of the oil may rise considerably in the winter, causing the bearing temperature to rise. In order to prevent this use a lubricating oil with good cold weather characteristics.

For bearings cooled by forced circulation, we recommend that you install a heater in the feed oil tank.

(2) Lubrication

(a) Natural cooling

Be sure to use the specified lubricating oil. Oil should be added until the oil level gauge (**Figure 9**) resisters about proper oil level. Use the blind plug (in some cases this is an air breather) or the thermometer hole on the side of the motor as the oil fill port. Before supplying the oil, check to make sure that the other blind plugs are securely in place. No particular mechanical problems will occur if you fill oil over the half level. However, excessive oiling tends to encourage leakage and for that reason is to be avoided. As long as the oil level is at or above the minimum level of the oil gauge when the pump is stopped, there is enough oil in the unit. However, be sure that this minimum level is maintained.

NOTICE

- BE SURE TO SUPPLY ENOUGH OIL. Failure to do this will result in irreversible damage to the motor.

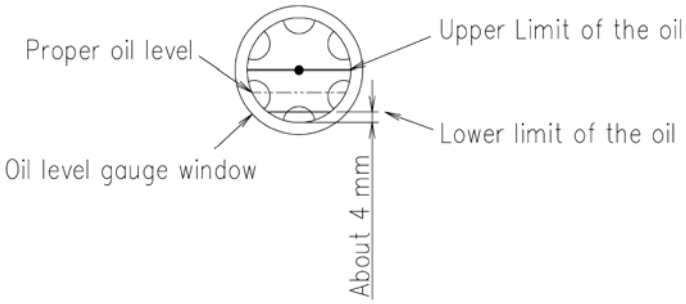


Figure 9 Oil level gauge

(b) Forced cooling

The discharge oil pipe should be slanted at a slope of 15°. Be sure to clean the piping and oil circulation system before use. This should be done with the bearing disconnected.

Check to see that the feed oil pressure is correct with a pressure gauge.

Make sure that the discharge oil is flowing correctly with the oil sight.

As with forced cooling, too much oil may cause leakage and too little oil may cause overheating. Take care to keep the oil at a proper level.

(3) Oil ring

When using natural cooling, look through the inspection window to make sure that the oil ring is rotating properly.

(4) Oil leakage

Make sure there is no oil leaking from the bearing, the piping or the oil feed apparatus. The oil seal of sleeve bearing is floating type. It is contacting to the shaft surface all time and floating at inside of housing. So, the oil may ooze out at the floating gap, then the leaked oil droop from the bottom of housing. But it is normal condition.

(5) Procedures in the event of long-term shutdown

(a) When the motor is to be shutdown for a long period of time, or if the motor is being used as a spare, it should be operated once every two weeks or so to keep the journals from rusting.

(b) After a long shutdown, oil the journals before starting up the motor.

10.1.2 Semiannual and Annual Inspection and Maintenance

(1) Bearing inspection

Remove the upper half of the bearing bracket.

Check to see that the shaft is rubbing evenly on all surfaces and that there are no scratches or other damage on the shaft journals. At this time, also check to make sure that there is no contact with the thrust surfaces in the axial direction.

(2) Oil ring inspection (see Figure 10)

Check to see that there is no abnormal wear on the sides of the oil ring. Also, make sure that the coupling screws are not loose.

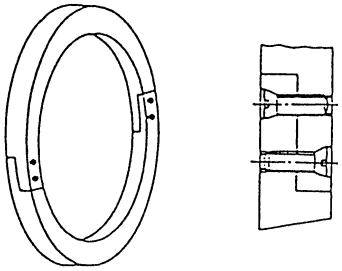


Figure 10 Oil Ring

(3) Lubrication replacement

There is no one fixed period for lubrication replacement since many factors affect the condition of the oil such as ambient temperature, cleanliness of the surroundings, degree of continuous operation, operating severity, etc. However, as a ballpark figure for naturally cooled bearings, we recommend replacing the lubricant once every six months or 4300 hours of operation.

Generally, the degree of deterioration of the oil is judged visually by how dark and grimy it looks. However, a more scientific approach is to change the oil if possible if the oxidation value of the turbine oil reaches 0.2 to 0.3 mg KOH/g, and to change the oil immediately if the oxidation value reaches 0.5 KOH mg/g.

Take advantage of the opportunity to clean the inside of the bearing housing when changing the oil. Also, be sure to use a specified oil.

Be sure to shut off the motor before changing the bearing oil.

NOTICE

- Never try to drain or fill oil while the motor is running.

(4) Air breather (see Figure 11)

Depending on usage conditions, some bearings are provided with an air breather. The purpose of an air breather is to balance the pressure in the bearing housing with the atmospheric pressure. Be sure to clean the air breather regularly.

Oil leakage way result should the air breather get clogged up.

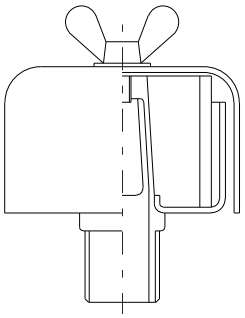


Figure 11 Air Breather

10.1.3 Maintenance and inspection at periodical overhauling

The motor should be disassembled, and check all the parts at regular intervals. For the sleeve bearing, inspect it in the same way as in Section 10.1.2, "Semiannual and Annual Inspection and Maintenance,", and also executes the following:

(1) Measuring the bearing clearance

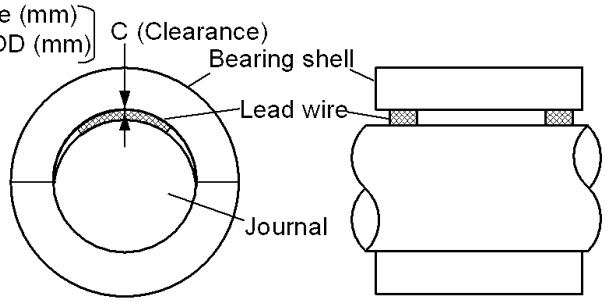
Measure the journal OD and bearing metal ID at several positions with a micrometer to find the bearing clearance. There is one simple way to measure clearance without taking apart the motor as follows:

1. Insert a lead wire between the journal and the bearing shell bore before removing the bearing shell lower half, and then cover the bearing sell upper half in place.
2. Clamp the bearing housing halves together.
3. The thickness of the pinched and flattened lead wire, as measured with a micrometer, is the bearing clearance.

In this procedure, use a lead wire of diameter which is larger than the clearance approximately by 5/100 to 10/100 mm.

Evaluate the clearance by the following equation, and if the clearance exceeds the calculated value, bearing metal must be exchanged.

where C = clearance (mm)
d = Journal OD (mm)



$$C = \frac{0.185}{100} d + 0.1$$

(2) Measuring journal insulation resistance

For those bearing which are equipped with a shaft current arrestor, measure its insulation resistance with a 500V megger. If there are measurements at least 0.5 MΩ at the time of the motor disassembly shall be acceptable.

(3) Problems and Countermeasure

Bearing problems should be handled as shown in **Table 9**, execute the respective repair.

Table 9 Problems and Countermeasure

Problems, other	Countermeasure
Cleaning	Clean thoroughly in new oil while paying special attention to the oil grooves, the oil bypass port, the temperature measurement port and, with forced cooled systems, the oil feed and discharge ports. Afterwards, rub off any oil using clean, non-fraying shop rags.
Uneven rubbing on the journal surface	Look closely at the luster patterns on the white metal to see how the surfaces are rubbing together. If there is uneven rubbing, adjust the direct coupling. If the problem is due to a faulty bearing, use a scraper to scrape off high spots and create a uniform surface. Apply red lead primer and take a close look at how the surfaces are rubbing together. Be careful not to take too much off the babbitt metal in one pass. Instead, try to keep stock removal to the absolute necessary minimum.
Uneven rubbing or abnormal wear on the thrust surface	First, rule out possible external causes by checking: 1. Has the bearing been assembled backwards? 2. Is the motor itself correctly leveled? 3. Is the amount of end play reasonable? If the problem is with the bearing itself, correct by scraping off stock with a scraper as described above.
Oil ring has become eccentric	Correct as required by machining on a lathe.
Oil-ring coupling-screws have become loose	Inspect for looseness. If there is some play in the screws, retap the threads to the next largest size. Be sure to punch as appropriate after coupling.
Small spots or fine strip scars have formed on the metal surface	Take off stock with a scrapper to smooth out high spots. Take care to remove any burrs. Be careful not to take too much off the babbitt metal in one pass. Instead, try to keep stock removal to the absolute necessary minimum.
Electrolytic corrosion has occurred	Check the insulation between the bearing and the bearing housing, the flange insulation for the piping, and the insulation for the temperature element. Condition as appropriate to completely interrupt any shaft current circuits. Remove the corrosion by conditioning the bearing babbitt surface as appropriate with a scraper.
Seizure (burn-on) or flaking have occurred	Replace the bearing metal.
Rust has formed on the journal surface	Soak a hemp string in oil, cover it with chrome oxide powder and polish off the rust. If terrible rust occur then please use sandpaper.

10.2 Lubrication

Use one of the following turbine oils as the lubrication oil for the plain bearings. Note that the three types of oil are not equivalent and that one should carefully read the brand descriptions before deciding which type best matches operating conditions.

Gas Turbine Oil

Type 2 (w/additives) Turbine Oil ISO VG32

Type 2 (w/additives) Turbine Oil ISO VG46

Type 2 (w/additives) Turbine Oil ISO VG68

Do not use any other type of oil.

Table 10 shows the properties of these oils at 40°C.

Table 11 presents a list of commercial suppliers and brand names. Our recommended oil is **Mobil SHC 600 Series** for long term operation. For replacement of lubrication, refer to the maintenance section.

Table 10 Lubricating Oil Properties

	ISO VG32	**ISO VG46**	**ISO VG68**
Kinematic viscosity (cSt)	28.8 to 35.2	41.4 to 50.6	61.2 to 74.8

Table 11 Commercial Suppliers and Brand Names

	Brand name		
	GAS Turbine Oil ISO VG32	**GAS Turbine Oil ISO VG46**	**GAS Turbine Oil ISO VG68**
Exxon Mobil	Mobil SHC 624, 824	Mobil SHC 625, 825	Mobil SHC 626
JX Nippon Oil & Energy	FBK Turbine Oil GT32		
Cosmo Oil Lubricants Co.,LTD.	Cosmo Turbine Super GT32		
Showa Shell Sekiyu	Turbo Oil GT		
Idemitsu	Daphne Super Turbine Oil MG, FX	Daphne Super Turbine Oil HT46	Daphne Super Turbine Oil HT68
	Type 2 (W/additives) Turbine Oil ISO VG32	**Type 2 (W/additives) Turbine Oil ISO VG46**	**Type 2 (W/additives) Turbine Oil ISO VG68**
Exxon Mobil	Mobil DTE Light Mobil DTE 732	Mobil DTE Medium Mobil DTE 746	Mobil DTE Heavy Medium Mobil DTE 768
JX Nippon Oil & Energy	FBK Turbine 32	FBK Turbine 46	FBK Turbine 68
Idemitsu	Daphne Turbine Oil 32	Daphne Turbine Oil 46	Daphne Turbine Oil 68
Showa Shell Sekiyu	Turbo Oil T 32	Turbo Oil T 46	Turbo Oil T 68
Japan energy	RIX Turbine 32	RIX Turbine 46	RIX Turbine 68
Cosmo Oil Lubricants Co.,LTD.	Cosmo Turbine Super 32	Cosmo Turbine Super 46	Cosmo Turbine Super 68

NOTICE

- Do not mix different type oil. It can make deterioration of oil life.
- If you need to change to different type of the oil, please wash off the old oil completely.

10.3 Failure Diagnosis and Correction

Failure diagnosis and correction for a variety of problems are shown the table below.
Should any major problems occur, please contact a customer service as soon as possible.

Symptom	Direct cause	Subclassification	Root cause	Corrective action
Bearing seizure (burn-on)	1. Insufficient lubrication supply to the bearing surface	(1) Improper oil ring rotation (Rotates too fast, too slow or not at all)	Oil ring deformation, wear, loose coupling screws, misalignment	Replace if deformed or underweight due to wear.
			Inappropriate oil viscosity	Change the oil
		(2) Insufficient oil feed	Insufficient amount of feed oil, oil leakage	Add more oil
			Faulty oil circulation system pump, clogged piping, oil leakage	Repair
			Excessive bearing clearance	Repair
		(3) Poor bearing contact	Metal wear, float-up, foreign object on contact surface	Repair
			Thrust loading	Correct poor direct-connection.
			Vibration (poor direct-connection, shaft bearing, poor installation, etc.)	
			Mechanical shock from load-side	Inspect machinery on the load-side.
	2. Poor lubrication oil	(1) Improper oil properties	Viscosity is too high or too low.	Use a different brand.
		(2) Excessively high oil temperature	Property deterioration	Check color and oxidation.
		(3) Foreign objects in oil	Excessively high room temperature, poor oil cooling	Check the cooling water system.
			Mixed-in water, mixed-in solids (dirt, metal particles)	Check the path by which these substances entered.
	4. Shaft current	(1) Poor shaft insulation	Dirt, water-oil contamination, poor piping insulation	Clean and check insulation resistance.
Excessive rise in bearing temperature	A temperature rise in the bearing is the first stage leading to bearing damage and is due to the exact same causes as those described above.		Keep a record of what the bearing temperature is normally and keep a sharp eye out for increases in temperature. Should a sharp increase be noted, stop the motor and inspect the bearing.	

10.4 Disassembly and Reassembly of Plain Bearing

Below we present a general procedure for disassembling and reassembling plain bearings. However, it should be noted that such work for bracket-type plain bearings does vary depending configuration of the motor.

10.4.1 Disassembly Preparations

(1) First of all, you should take the time to get a good idea of the design and structure of the unit you will be disassembling.
- Make necessary preparations.
- Ready tools for disassembly.

(2) Select a suitable place for work.
- Avoid dusty areas.
- Do not forget about the weather when working on outdoor machinery. If necessary, move the unit indoors first.

(3) Keep the area around the bearings clean (shaft/bearing housing).

10.4.2 Bearing Disassembly Procedures

10.4.2.1 Disassembling Peripheral Parts

(a) Remove the dial gauge or thermocouple.

(b) Drain the lubricating oil in the bearing housing by removing the drain plug.

(c) Disconnect feed and discharge oil pipes (if any) attached to the unit.

10.4.2.2 Disassembling the Upper Half of the Bearing Housing

Disassemble as follows while referring to **Figure 12** and **13**.

(a) Remove the bolt attaching the bracket ① to the cover ⑩.

(b) Remove the bolts attaching the upper half of the bearing housing ② to the cover ⑩.
Remove the cover ⑩.

(c) Remove the bolts attaching the upper half of the bearing housing ② to the lower half of the bearing housing ③.

(d) Slowly and carefully lift off the upper half of the bearing housing ②. Be careful not to hit any other parts. Furthermore, insulation is usually inserted on bearings on the no-load side in order to prevent shaft currents. Disassemble and reassemble the unit carefully. Also, make sure no dirt gets in the area and opens an electrical path.

NOTICE

- Remove the upper half of the bearing housing not to damage the internal floating seal.

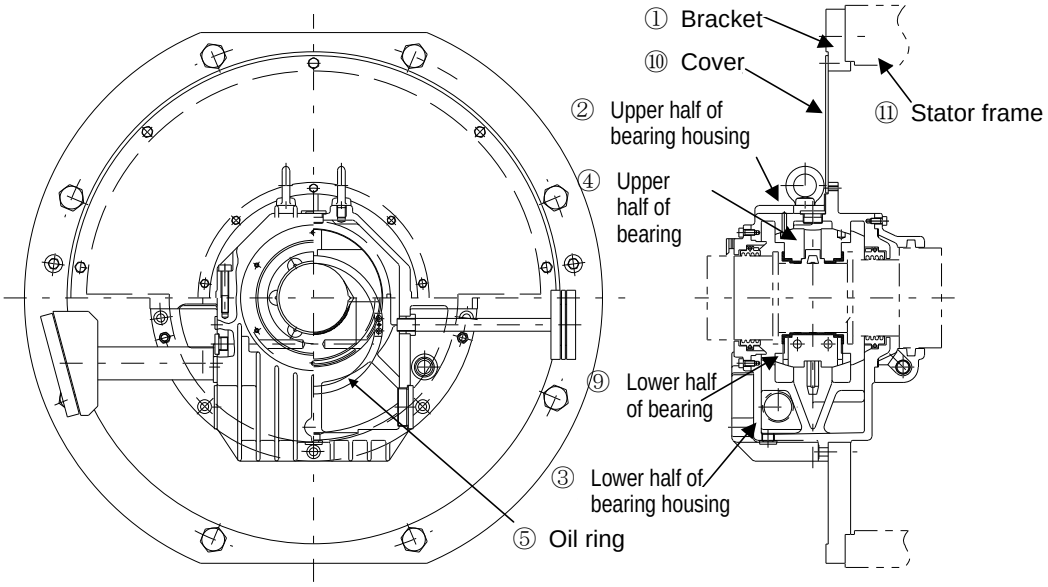


Figure 12 Structure of Plain Bearing

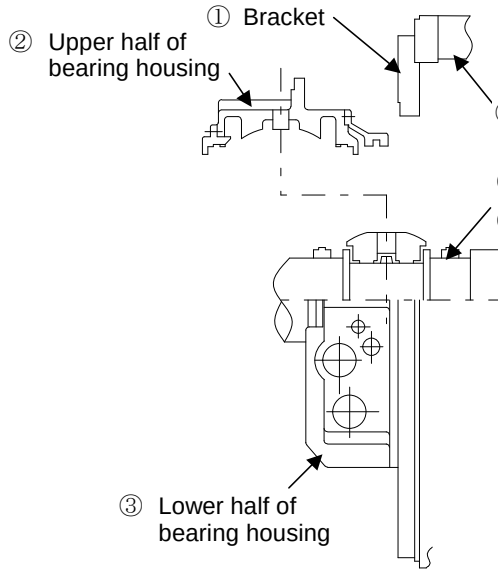


Figure 13 Bearing Housing Disassembly Diagram 1

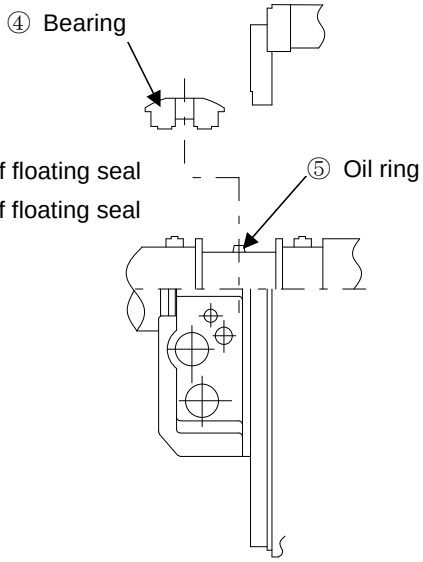


Figure 14 Bearing Housing Disassembly Diagram 2

10.4.2.3 Disassembling the Upper Section of the Bearing (See Figure 13)

(1) Remove the upper section of the bearing ④ by lifting straight up.

When removing the bearing, take care not to scratch the bearing metal. Also, once removed, do not put the bearing directly on the floor. Instead, place it down gently onto a wooden block.

NOTICE

- Be careful when moving around the bearing; move slowly, and don't drop it or hit anything.

10.4.2.4 Disassembling the Oil Ring (See Figure 15)

(1) Move the oil ring ⑤ so that the coupling joint is facing upward. Then, remove the coupling screws.

(2) Remove the oil ring ⑤ from the journal.

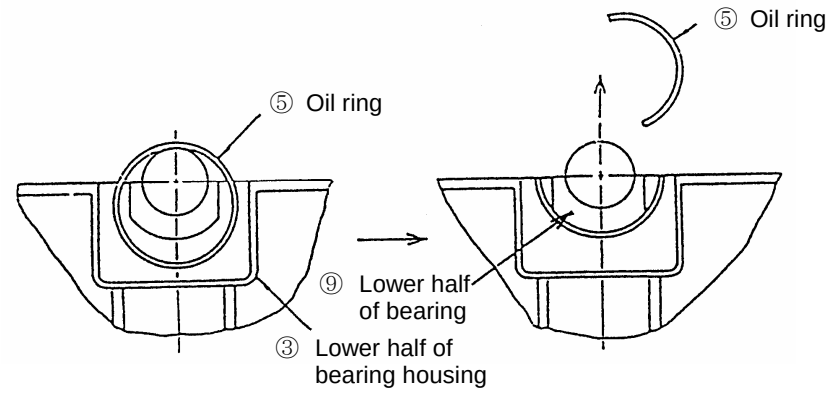


Figure 15 Disassembling the Oil Ring

10.4.2.5 Disassembling the Floating Seal (See Figure 16)

(1) Pull on the fastening spring ⑥ and remove the upper half of the floating seal ⑦.

(2) Move the lower half of the floating seal ⑧ so that it is facing upward.
Remove the lower half of the floating seal ⑧.
Remove the floating seal not to nick or otherwise damage anything.

(3) Release the lock holding in the fastening spring ⑥. Remove the fastening spring ⑥.

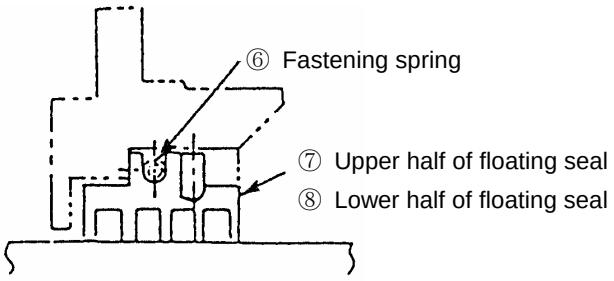


Figure 16 Disassembling the Floating Seal

10.4.2.6 Disassembling the Lower Section of the Bearing (See Figure 17 and 18)

Here, take care to disassemble the direct-connection end and the non-direct-connection end at the same pace and in the same steps.

(1) Lift up the rotor as far as the rotation of the lower section of the bearing ⑨ will permit.

Take care that the air gap between the rotor and stators is not bridged.

[Example of how to lift up the rotor:]

(a) Place a jack under the coupling on the direct-connection end.

(b) Wrap a protective covering around the shaft extension (pipe) on the end opposite the direct-connection end. Then attach a wire rope and a chain block that can be adjusted.

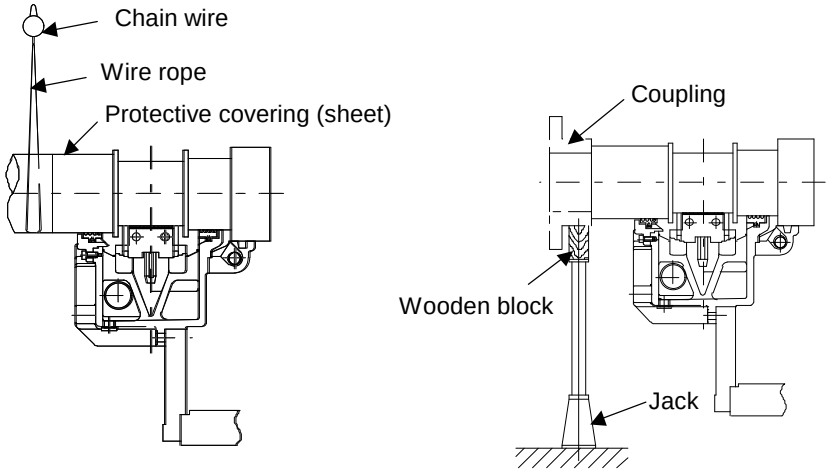


Figure 17 Example of How to Lift Up the Rotor 1, 2

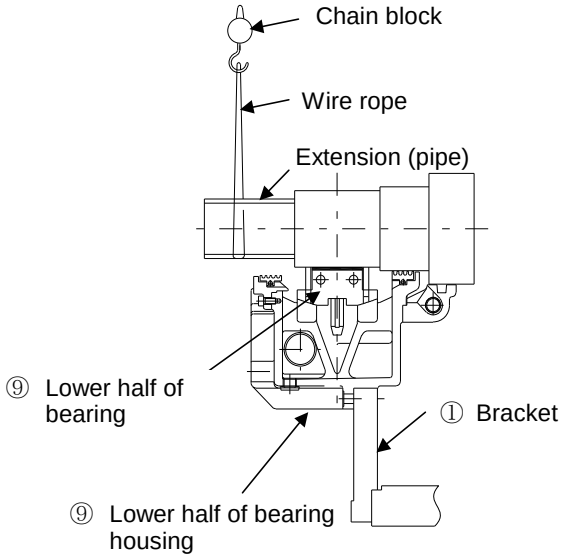


Figure 18 Example of How to Lift Up the Rotor 3

There are several other ways to lift up the rotor. In one method, a jack is used to lift the end opposite of the direct-connection end in the same manner as described in **Section (a)** on the previous page. In another method which is used when the shaft is not extended, a pipe is fitted onto the end of the shaft. A wire rope is then slung around the pipe to support the unit. (See **Figure 18**)

(c) Work should be carried out carefully, painstakingly and by highly experienced employees.

(2) Once the rotor is lifted up, move the lower section of the bearing ⑨ directly over the shaft journal.

(3) Remove the lower section of the bearing ⑨ by lifting straight up.

In all steps, threat all parts gently and with care in the same manner as described in **Section 5.2.3**, "Disassembling the Upper Section of the Bearing."

10.4.2.7 Disassembling the Lower Half of the Bearing Housing

The lower half of the bearing housing is only to be disassembled when one wishes to remove the rotor.

(1) Carefully move the rotor about 5 mm towards the side you wish to disassemble.

(2) Place eye-bolts in the holes used for connecting the upper and lower halves of the bearing housing. Attach a wire rope to these eye-bolts and support the lower half of the bearing housing ③ and the bracket ⑨. Be careful of the center of balance. (take into consideration the location of the center of gravity)

(3) Remove the bolts mounting the stator frame ⑪ to the bracket ① and remove the knocking portions.

(4) Using the bolt holes on the left and right of the bracket ①, remove the bracket ① and the lower half of the bearing housing ③.

(5) Disassemble the bearings on each end in the manner described above. When this is completed, remove the rotor.

10.4.3 Bearing Reassembly Procedures

Before attempting to reassemble the bearing, make sure that all parts are cleaned and conditioned. During reassembly, be careful not to leave out any parts.

10.4.3.1 Reassembling the Lower Half of the Bearing Housing

(1) Insert the rotor. Loosely fasten the lower half of the bearing housing and the bracket to the stator frame.

(2) Insert the knocking portions into the bracket and stator frame. After positioning, securely fasten down the bolts. Disconnect the sling wire supporting the lower half of the bearing housing.

10.4.3.2 Reassembling the Lower Section of the Bearing

(1) As described in **Section 10.4.2.6.** "Disassembling the Lower Section of the Bearing," keep the shaft centerline slightly high so as not to bridge the air gap between the rotor and stators.

(2) Clean the shaft journal with benzene or cleaning oil. Be sure to dry sufficiently with compressed air.

(3) Swab lubricating oil over the shaft journal.

(4) Swab lubricating oil over the babbitt metal of the lower section of the bearing. Then, while turning the lower section of the bearing, place it directly underneath the shaft.

(5) Slowly lower the rotor so that it is supported by the lower section of the bearing.

(6) Lightly tap the lower section of the bearing housing with a rubber mallet to line up the bearing and the shaft.

10.4.3.3 Reassembling the Oil Ring

Make sure that the two halves of the oil ring are fastened together properly. If they are not, the joints may be become misaligned or the oil ring itself may become elliptical. Both will cause poor rotation. Furthermore, make sure that the coupling screws do not extend outside past the ring surface, and punch as appropriate to keep the screws from coming loose.

10.4.3.4 Reassembling the Upper Section of the Bearing

(1) Line up the mating surfaces of the bearing so that the stamped numbers agree with each other.
(2) Carefully inspect the lock pins and other parts to be assembled in the bearing housing.
(3) Inspect to make sure that you did not leave any tools, nuts, bolts or other foreign objects in the bearing housing.
(4) Apply a non-hardening compound to the joints between the brackets in order to prevent oil leaks.

10.4.3.5 Reassembling the Floating Seal

(1) Release the lock holding in the fastening spring. Mount the fastening spring in such a way that it wraps around the shaft at the floating seal attachment position.
(2) Attach the fastening spring to the lower half (the half having the oil discharge holes) of the floating seal. Insert by rotating it into the lower half of the seal carrier.
(3) Attach the upper half of the floating seal. Rotate the floating seal to make sure that it is not distorted and does not catch on anything. If it does catch on something, carefully remove stock as necessary.
(4) After inspection, apply a light layer of non-hardening compound to the outer surface of the lower half of the floating seal.
(5) Before attaching the upper half of the seal carrier, make sure that the revolving stopper is inserted into the lock groove.

10.4.3.6 Reassembling the Upper Half of the Bearing Housing

(1) Reassemble the upper half of the bearing housing by following the procedures of **Section 10.4.2.2**, "Disassembling the Upper Half of the Bearing Housing," in reverse order.
(2) Fill the bearing housing by inserting the specified oil into the temperature measurement port. At this time, install the bearing thermometer (such as a dial thermometer or a thermocouple).
(3) For bearings with forced circulation, reattach the oil feed and discharge piping.
Keep on inserting oil into the bearing housing until the oil level gauge registers about half.
(4) Apply non-hardening compound on the mating surfaces.
(5) Check to see that the air gap is consistent around the circumference.

10.5 Structural Drawings

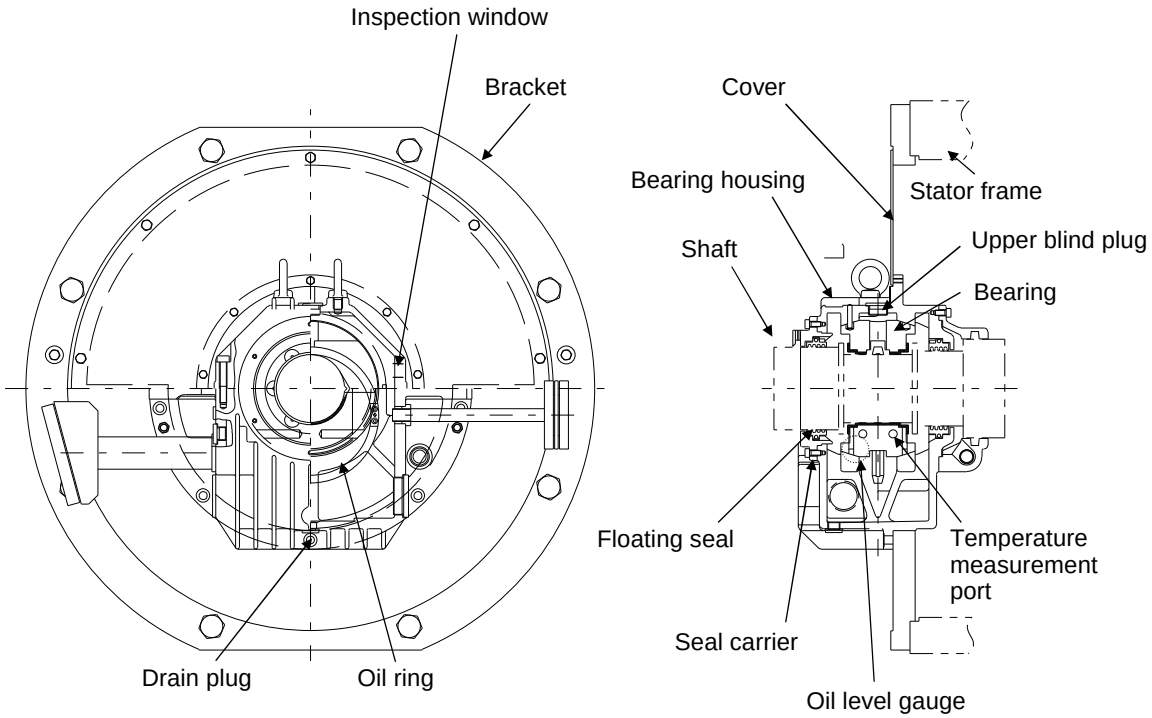


Figure 19 Structural Diagram of Plain Bearing for High-Speed Rotating Equipment

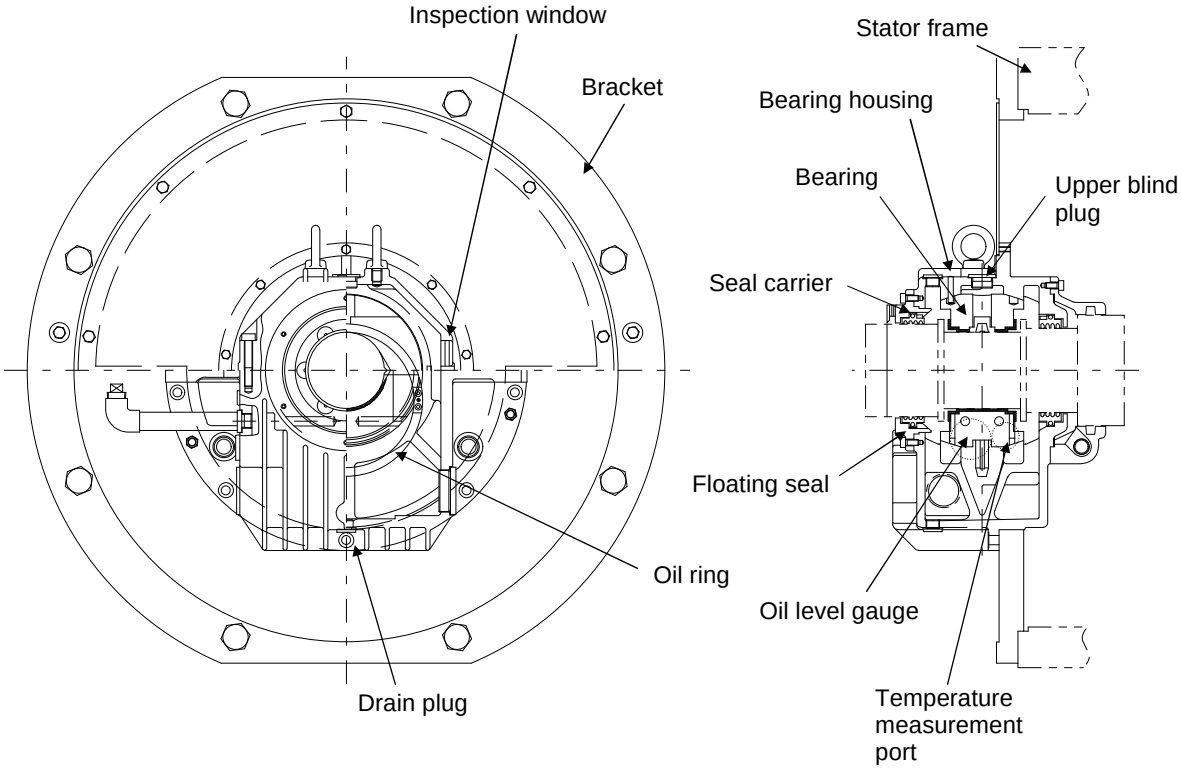


Figure 20 Structural Diagram of Plain Bearing for Medium- and Low-Speed Rotating

11. Correct Knowledge for Maintenance and Inspection

11.1 Starting Frequency of Motor

In the case of a squirrel-cage induction machine, the standard allowable starting frequency is two cold starts or one hot start.

"Two cold starts" means two times in a row from the ambient temperature (cold status), with the second startup being done with the power cut immediately after the first startup and the motor being allowed to coast to rest and then started up again. "One hot start" means one startup performed with the motor being allowed to coast to rest after operation in rated operating status.

If the operation plan requires frequent repetition of starting and stopping, check the starting frequency rank according to **Table 12**.

If not designated in specifications, the frequency rank for startup operations is Normal in the table below.

Startup frequencies greater than this require reinforcement and modification. In particular, if four or more starts per day are planned, it is necessary to use a heavy duty motor.

Table 12 Starting Frequency Rank Indication

Starting frequency indication	Frequency (time/year)
Normal	300 to less than 1000
Heavy	1000 to less than 3000
Extra heavy	3000 or more

11.2 Temperature Rise of Motor

The allowable temperature rise of induction motor parts by insulation class is specified as shown in **Table 13** based on the reference ambient temperature of 40°C. (For details, see JEC-2137. Values may differ depending on the applied standard. For details, see the applied standard.)

Table 13 Temperature Rise Limit (deg.) of Induction Machine

Item	Part of induction	Class A insulation			Class E insulation			Class B insulation			Class F insulation			Class H insulation		
		Thermometer method	Resistance method	Embedded temperature detector method	Thermometer method	Resistance method	Embedded temperature detector method	Thermometer method	Resistance method	Embedded temperature detector method	Thermometer method	Resistance method	Embedded temperature detector method	Thermometer method	Resistance method	Embedded temperature detector method
1	Stator winding															
	a. Over 5000kW	—	60	65	—	75	80	—	80	85	—	105	110	—	125	130
	b. 200 to under 5000 kW	—	60	—	—	75	80	—	80	90	(1)	105	115	—	125	135
	c. under 200 kW except d and e. (2)	(1)	60	—	(1)	75	—	(1)	80	—	(1)	105	—	(1)	125	—
	d. under 600 kW (2)	(1)	65	—	(1)	75	—	(1)	85	—	—	110	—	(1)	130	—
	e. Self cool motor without cooling fans (2)	—	65	—		75	—	—	85	—	—	110	—	—	130	—
2	Rotor winding which insulated	—	60	—	—	75	—	—	80	—	—	105	—	—	125	—
3	Squirrel-cage winding (rotor bar)	The temperature rise of these parts shall in no reach such a value that there is a risk of injury to any insulating or other material on adjacent parts.														
4	Magnetic core and not contacting with winding															
5	Magnetic core and other parts in contact with windings															

Remarks

- (1) If motor manufacturer and purchaser agreed about winding temperature rise limits, then it can use thermometer method.
- (2) If temperature rise test use super pose method for under 200 kW and insulation class A, E, B and F motors, then its temperature rise limit can over 5 degree K from resistance method limit.

The two main causes of deterioration of the winding insulation are heat deterioration and partial discharge deterioration. Other causes include mechanical stress, pollution damage, moisture absorption and other environmental conditions.

Therefore, the insulation deterioration is quickened and the life is shortened if the temperature rises above the allowable limit due to clogging of the duct with dust or foreign matter.

11.3 Insulation Resistance of Motor

⚠CAUTION	
PROHIBITED	• **Make sure to discharge after insulation measurement. Never touch with hands before discharge.** Failure to do this may result in electric shock.

The insulation resistance is an important figure for understanding the state of the insulation of a motor. However, since the insulation resistance varies depending on the output, voltage, rotating speed, and insulation class of the motor, or with temperature, humidity, contamination of insulated surface, test voltage, or test voltage application time, it is difficult to decide using only a certain value.

For this reason, there are no clear standards for allowable values, but the following values have been established as target values.

$$\text{Insulation resistance} \geqq \text{Rating voltage (kV)} + 1 \quad M\Omega$$

Measure the insulation resistance as follows;

- Measured at the motor terminals for both stator winding and rotor winding.
- In stator winding, 500 VDC megger is used if the rating is less than 600 V, and 1000 VDC megger if 600 V or more.
- The insulation resistance is measured one minute after applying the specified voltage. When doing this, it is also important to record the coil temperature during measurement.

11.4 Vibrations of Motor

Although the motor is sufficiently balanced before shipping, when directly coupled with the load side machine, the motor is exposed to the affects of direct coupling precision with the load machine or the vibration transmitted from the load machine. There are also changes due to the state of the foundation or base.

If the vibrations are significant, fatigue breakage of the shaft, bearing, core or winding, or insulation damage or breakdown of the foundation may be caused. It is therefore very important to keep and monitor the vibrations within a allowable range.

11.4.1 Allowable Vibrations

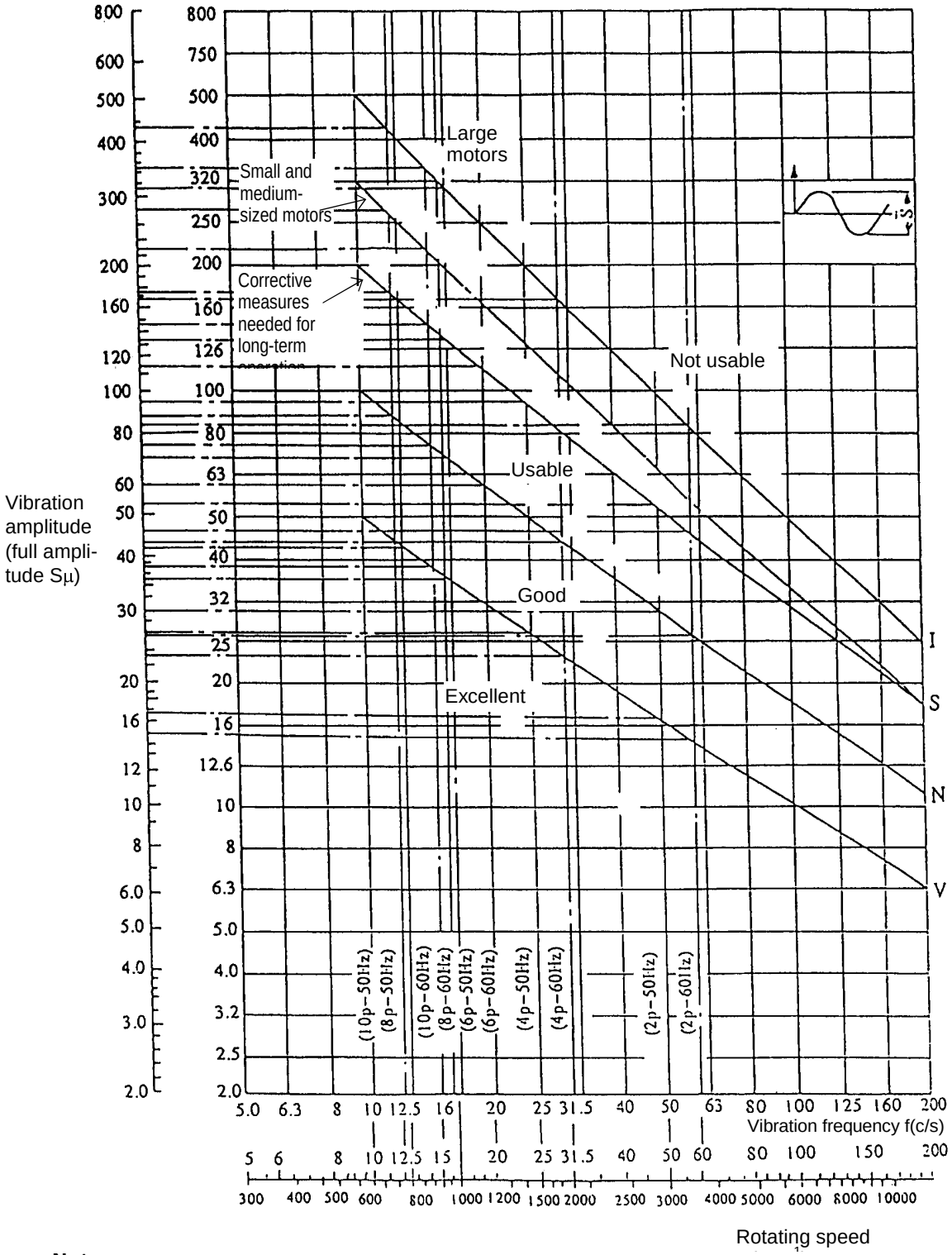
JEC-2137 listed about vibration measure condition. It said " Motor vibration should measure under rating voltage and rating frequency". So it dose not have vibration limits under load. We recommend vibration limits of load condition as follows;

$$\text{Target vibration limit under load} \leqq 4.5 \text{ mm/s r.m.s}$$

The vibration shows by displacement also. The general vibration displacement limits organize at VDI 2056. VDI 2056, compiled by the German VDI Vibration Committee, is generally used as an integrated source for machine vibration tolerance values. Vibration measurements and evaluations have also been compiled by the ISO and IEC.

These tolerances involve empiric factors and indicate recommended values and vary with the conditions of the installation.

Figure 21 shows the values recommended by Toshiba Mitsubishi - Electric Industrial System Corporation for management of vibrations on the bearing housing after direct-coupling. The vibration frequencies (r.p.m.) are those for the maximum amplitude of the measured values; note that these may not necessarily match the motor speed of rotation. When the value exceeds line S ("Corrective measures needed for long-term operation"), the cause must be investigated and all possible corrective measures implemented.



Notes

(1) Measurements should be made at the top of the bearing housing.

(2) Values after direct-coupling.

(3) The vibration frequencies (min^{-1}) are those for the maximum amplitude of the measured values; note that these may not necessarily match the motor speed of rotation.

Figure 21 Site Vibration Allowances

11.4.2 Causes of Vibration

The following causes are considered.

(1) Vibrations by mechanical factors

(1.1) Vibrations at constant amplitude

While the rotating speed and voltage are constant, vibrations do not change in the amplitude with the passage of time. The following cases are considered:

(1.1.1) Vibrations synchronized with rotating speed

(a) Imbalance, due to:

- Imbalance
  - Defective installation ..... stator frame twisting when installing the motor
  - Defective coupling ..... defective parallelism in the squareness of coupling surfaces
  - Defective direct coupling ..... level difference, etc.
  - Imbalance of rotor due to aging ..... deposits of dust on core, fan, etc.; movement of windings and others

(b) Rotor shaft bending

(c) Poor rigidity or resonance of structure
excessive vibrations caused by resonance of structure and weakness of foundation where motor is installed

(d) Metallic contact with stationary parts (bearing, etc.)
rubbing direction is in reverse to rotating direction.

(e) Air-gap imbalance due to eccentricity of rotor
vibrations increase due to electromagnetic force occurring simultaneously with generation of voltage.

(1.1.2) For a vibration frequency that is double the rotating speed

(a) The bearing is elliptical.

(b) The rotor fitting allowance is insufficient in a specific direction.

(1.2) Vibrations at varying amplitudes

While the rotating speed and voltage are constant, amplitude of vibrations varies with the passage of time. The following cases are considered:

(1.2.1) Vibrations synchronized with rotating speed

Shaft bending due to thermal case

If thermal factor is involved in the vibration the phenomenon is complicated and it is hard to locate the cause. It is important to sum up the causes and symptoms systematically.

The following cases may be considered as the thermal shaft bending phenomenon.

(a) Shaft bending due to thermal expansion of rotor conductor.

(b) If caused by thermal factors such as slight contact of labyrinth, oil shield or other stationary objects with rotary shaft or uneven contact of bearing, the vibration phase often varies, and in the final case in particular, the phase change is characteristically periodic.

(1.2.2) Unrelated to speed of rotation

(a) Oil whip

The whirling of the shaft caused by the oil film forming on the bearings will result in violent vibrations. The swing speed of this whirling will be about equal to the danger speed of the shaft, and the swing direction of the whirling will be the same as the direction of rotation. Oil whip occurs when the speed of shaft rotation is approximately twice the danger speed or greater. The smaller the bearing eccentricity, the more likely it is that oil whip will occur.

(b) Oil whirl

Even at comparatively low rotational speeds, there is a tendency for swinging to occur at half the speed of shaft rotation. This is called oil whirl. In this case as well, the swing direction will be the same as the direction of shaft rotation. Likewise, the smaller the bearing eccentricity, the more likely it is that oil whirl will occur.

(2) Vibrations due to electric factors

Electric factors act as vibration accelerating forces, and vibrations are usually accompanied by mechanical resonance.

(2.1) Two times of the power source frequency

Caused by air-gap imbalance, power source imbalance, rotor winding imbalance, or defective tightening of rotor core.

(2.2) Integer times of the power source frequency

Due to slot number combination of stator and rotor, radial force waves are generated the core is deformed, and pulsations occur.

(2.3) Two times of the slip frequency

Magnetic imbalance due to air-gap imbalance in 2-pole motor, defective tightening of rotor core, or rotor bar breakage.

(2.4) Beat (hauling sound)

In some cases, beats of double the slip frequency (2sf) may be generated due to slippage and the air-gap imbalance.

11.4.3 Investigation into Cause of Vibration

It is necessary to check for cause of vibration systematically and with a skilled eye.

General methods are as follows:

(1) Decide whether the cause is electrical or mechanical.

Turn off the power and check if the vibration stops or not. If it has stopped, the cause is electrical.

(2) Check if the cause is the load side machine.

Cut off the directly coupled machine, and check.

(3) Measure the vibration frequency, amplitude, and phase changes.

(4) Check if the vibrations vary with the passage of time.

(5) Check the relation between rotating speed and amplitude, and observe for resonance.

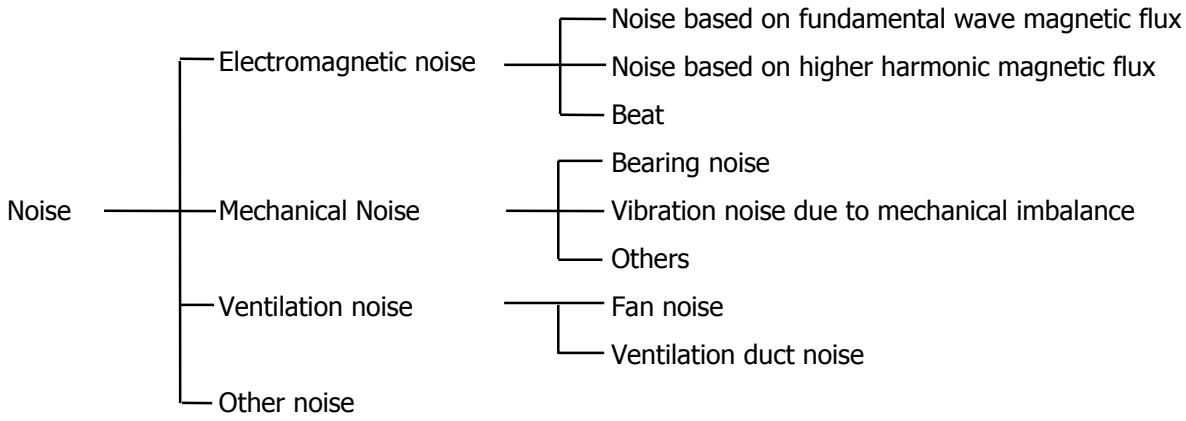
(6) Check the relations of vibrations with oil feed temperature, machine internal temperature, shaft temperature or other temperature changes, and investigate the shaft movement.

(7) Summarize the data, and analyze the cause of vibration.

11.5 Noise of Motor

Motor noises may be classified as shown in **Table 14** by the source.

Table 14 Classification of Noise



(1) Electromagnetic noise

Electromagnetic noise generally occurs when the electromagnetic force caused by air gap magnetic flux of stator and rotor vibrates the stator core, frame, or rotor. Since the electromagnetic noise stops when the power is cut off, it can be easily distinguished from other noises.

(1.1) Noise based on fundamental wave magnetic flux

The electromagnetic wave due to fundamental wave magnetic flux generates vibration noise at a two times of frequency power source. Since this vibration noise is mainly intensified by air-gap length, imbalance of magnetic circuit or imbalance of primary voltage, it is necessary to check the air gap and other possible causes if this noise becomes abnormally loud.

(1.2) Noise based on high harmonic magnetic flux

This noise is due to the electromagnetic wave caused by mutual interference of slot high harmonics of stator and rotor, and it usually occurs at 1000 Hz and above.

(1.3) Beat

This is heard if phase is an imbalance in secondary resistance or the rotor is eccentric or elliptically deformed, and it becomes a two times of slip frequency beat. When this noise occurs, it is necessary to check the rotor. But If motor dose not have current change and/or vibration change then It can be used.

(2) Mechanical noise

Mechanical noise is roughly classified into bearing noise and vibration noise due to frame vibration.

(2.1) Bearing noise

Loud noise do not occur from plain bearings unless the bearing has a large clearance in the radius direction.

(2.2) Vibration noise due to mechanical imbalance

If there is an imbalance in the load of the rotor, a force acts on the bearing, and vibrations based on the rotating frequency occur. Since this vibration frequency is generally low, it is not as influential on motor noises and it hardly ever poses problems.

(3) Ventilation noise

Ventilation noise generally has a uniform spectrum over a wide range of frequencies, and it also contains single-frequency components related with the number of blades or number of ventilation ducts.

(3.1) Fan noise

The fan noise depends on the fan shape, rotating speed, and other conditions, and generally the noise is louder when the speed is higher and the fan size is larger.

(3.1.1) Noise generated by rotation of fan

The noise due to rotation of fan is caused when the blades apply pressure and periodically impact the air. The fundamental frequency of this fan noise is the product of the number of blades and rotating speed.

(3.1.2) Noise due to vortex generated by blades

There is a pressure gradient before and after the blades rotate with the air stream forming a vortex.

Noise caused by this vortex generally becomes a continuous spectrum in a wide range of frequency.

(3.2) Duct noise

If the stator and rotor have ventilation ducts in the direction of the diameter, the air becomes dense or scarce at the inlet and outlet of the ducts as the stator slot and rotor slot change their positions relatively on the circumference, and a so-called siren effect appears.

This noise is generally high pitched, and the product of the number of ducts and rotating speed becomes the fundamental frequency.

11.6 Effects of Power Source Fluctuations

In JEC-2137, the power source fluctuations are defined as follows.

For all practical purposes, there will be no problems if the motor is operated within these ranges. When the power source fluctuates, the characteristics of the motor vary as shown in **Table 15**.

(1) Voltage variation

In an induction motor, except for those specifying particularly the starting characteristics and maximum torque, if the terminal voltage varies by 10% above or below the rated value at rated frequency, there should be no problem if operated at the rated output.

(2) Frequency variation

In the induction motor, if the power source frequency varies within plus 3% or minus 5% of the rated value at the rated voltage, there should be no problems.

If the voltage and frequency of the power source vary at the same time, there should be no practical problem as far as the voltage changes are within plus or minus 10% of the rated value, frequency changes within plus or minus 5% of the rated value, and the sum of the absolute value of both percentage changes is within 10%, when operated at the rated output.

Table 15 Characteristic Variation Due to Power Source Fluctuations

Item / Fluctuation		Starting and maximum torque	Synchronous speed	% slip	Full load speed	Full load current	Starting current	Temperature rise at full load	Magnetic noise, especially at no load
Voltage variation	110% voltage	(+)21%	No change	(−)17%	(+)0.4%	(−)7%	(+)10 to 20%	(−)3 to 4%	(+)Slight
	Relation of voltage	$(\text{Voltage})^2$	Constant	$\frac{1}{(\text{Voltage})^2}$	—	—	(Voltage)	—	—
	90% voltage	(−)19%	No change	(+)23%	(−)0.5%	(+)11%	(−)10 to 12%	(+)10 to 15%	(−)Slight
Frequency variation	103% frequency	(−)3%	(+)3%	No practical change	(+)3%	(−)Slight	(−)3 to 5%	(−)Slight	(−)Slight
	Function of frequency	$\frac{1}{(\text{Frequency})}$	(Frequency)	—	—	—	$\frac{1}{(\text{Frequency})}$	—	—
	95% frequency	(+)5%	(−)5%	No practical change	(−)5%	(+)Slight	(+)6 to 7%	(+)Slight	(+)Slight

11.7 Effects of Supply Voltage Imbalance

(1) Definition of imbalance rate

Generally, the imbalance rate of voltage and current is defined as follows:

$$\text{Voltage imbalance rate} = \frac{\text{Reverse phase partial voltage}}{\text{Normal phase partial voltage}} \times 100\ (\%)$$

$$\text{Current imbalance rate} = \frac{\text{Reverse phase partial current}}{\text{Normal phase partial current}} \times 100\ (\%)$$

(2) Effects of supply voltage imbalance

(2.1) Examples of phase currents when an imbalance voltage is applied to the motor are shown in **Figure 22**. Under the imbalanced voltage, the input increases, and the output, torque and efficiency decline.

As evident from the diagram, the phases in which a large imbalanced current flows have a high risk of being extremely overheated, and the service life of the winding may be significantly shortened. Also the power cost may increase along with the increase of loss. In addition, if the voltage imbalance rate is high, it must be noted because vibration and noise may also increased.

(2.2) If the voltage imbalance is at an extreme end, it may result in single-phase operation. In such a case, the full load slip may be about twice that of three-phase operation, and the wire current becomes larger than $\sqrt{3}$ times. Therefore, if operated continuously, it may lead to burning of the windings. Therefore, such operations must be avoided at all costs.

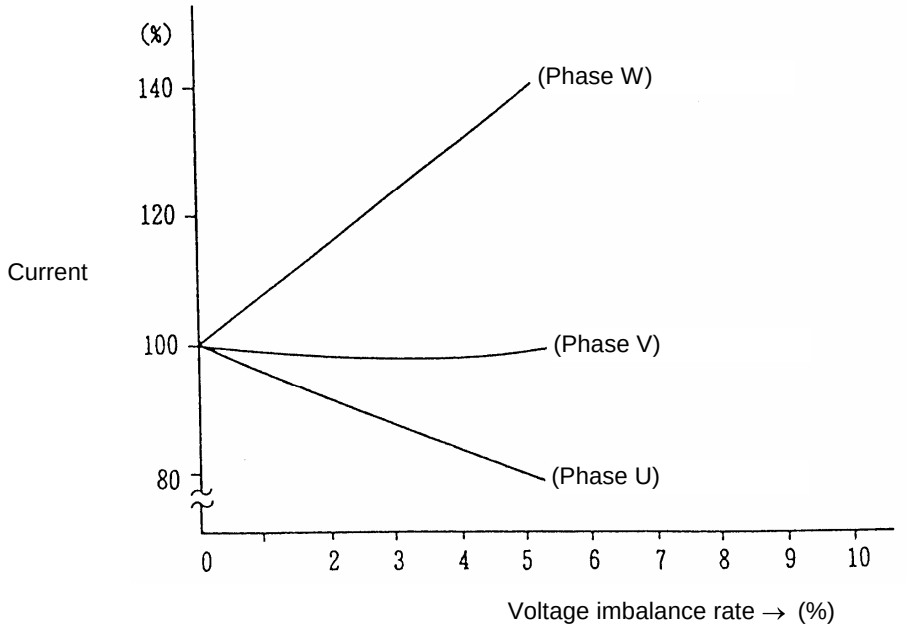


Figure 22 Phase Currents Due to Voltage Imbalance

12. Troubleshooting

Possible causes and remedies of trouble are summarized in **Table 16**. If a major trouble is discovered, please report it to our company as soon as possible.

Table 16 Troubles and Remedies

Trouble	Cause		Remedy
1. The motor does not start up; no sound is heard if power switch is turned on.	Starting condition is not satisfactory.	Interlocks are not unlocked.	Trace the circuit, and check wiring and contact.
	Defective circuit from power source to motor terminal.	Voltage is not being received by starter.	
		Defective contact of start contacter.	
		Two phases of fuse are blown.	Replace fuse.
		Over current relay error	
	Stator winding is broken.		Check terminal unit, repair winding.
2. The motor gives off an unusual noise, without starting up.	Single phase	One phase of starter circuit is open.	Trace the circuit, and check wiring and contact.
		Faulty contact of contacter.	
		Locking of load machine	
	Mechanical lock	Defective linkage (extreme belt tension, misalignment, deviation of installation, etc.)	Check machine and linkage state, and remedy.
		Seizure of bearing.	
		Gap contact due to burning of bearing.	
		Wire disconnection of one phase portion.	
	Disconnection of stator winding		Repair winding.
3. The protective relay is actuated when power is turned on.	Trouble is starter	Deterioration of insulation due to overheating, vibration or impact.	Repair winding.
	Rotor winding is shorted or grounded.		
	Mechanical lock	See item 2.	
	Improper setting of protective relay.		

Table 16 (Continued)

Trouble	Cause		Remedy
4. Abnormal noise and vibration	Single phase operation.	Circuit disconnection, fuse meltdown, faulty contact.	Trace the phase voltage, and remedy.
	Mechanical trouble of voltage.	Improper balance of the rotor.	Disassemble and investigate.
		Crack in the end ring, bar breakage.	Disassemble and investigate.
		Looseness of iron plate.	Disassemble and investigate.
		Uneven gap or contact.	Disassemble and investigate.
		Entry of foreign matter.	Disassemble and investigate.
		Shaft bending, crack.	Disassemble and investigate.
	Load side vibrations	Machine side vibrations	Shut off the motor, and check.
	Defective linkage	Shaft bending	
		Direct-coupling accuracy error	Retighten.
			Correct.
5. Excessive temperature rise or smoking	Power source trouble	Imbalance voltage, single-phase operation	Check power source and starter.
		Wrong voltage or frequency.	
		Voltage drop.	
	Overload	Overload due to trouble of load machine.	Shut off the motor, and check the current.
		Frequent start/stop, reversible operation.	Review the selection of the motor.
	Defective cooling	Clogged filter, closure of ventilation opening with foreign matter.	Clean.
	Winding defective	Stator winding shorted grounded.	Repair winding.
	Mechanical trouble	Contact at gap.	See item 2.
		Bearing overheating due to defective linkage (excessive belt tension, misalignment, etc.).	
6. Plain bearing burnout For details, see Chapter 10 "Maintenance of bearings".	Insufficient supply of oil	Faulty rotation due to oil ring warping or wear Insufficient oil supplied or oil leakage	Replace or repair ring
		Improper bearing contacting due to wear, vibrations, etc.	Disassemble and investigate.
	Insufficient supply of lubricant	Degeneration, unsuitable oil quality, dirt	Change oil
		Contamination by metal dust	Change oil
7. The ammeter sways.	Early signs in the above troubles.	Winding trouble, bearing seizure, nearly disconnected wire, faulty contact, etc. Broken bar/load fluctuations	

13. Repair / Disposal

13.1 Repair

When replacing parts, be sure to observe the following:

⚠CAUTION	
MANDATORY	• **Before rewinding coils, contact a Toshiba Mitsubishi - Electric Industrial System Corporation customer service representative and follow his or her instructions.** The insulator used on coils, etc. may generate toxic fumes during heating.

(1) Inquiry in the event of trouble

The motor has been provided with high-grade insulation. In the event that repairs are needed, be sure to consult the source from which you ordered the product, or contact a Toshiba Mitsubishi - Electric Industrial System Corporation branch or sales office. Please specify the following information when making inquiries.

- Inquiry in the event of trouble
  - No. of problem points (attach photo if available)
  - Information on nameplates (TYPE, FORM, POLE, kW, SERIAL NO.)
  - A description of the problem (status of use, number of days used, connected units)
- When ordering repair parts
  - Information on nameplates
  - Part name and quantity

NOTICE

- When replacing the instruments attached to bearings (dial thermometer, thermocouple etc.), be sure to replace with equivalent instruments.
- The instruments attached to bearings in particular are often insulated (with temperature sensors housed in insulation tubes) to protect the bearings from damage caused by shaft current. When replacing these instruments, be sure to enclose them in insulation tubes.

13.2 Disposal

When it becomes necessary to dispose of the motor, be sure to observe the following:

⚠CAUTION	
MANDATORY	• **When the motor must be discarded, have this done by a specialist disposal firm,** Failure to do this may result in damage to the environment.

Toshiba Mitsubishi - Electric Industrial Systems Corporation