EE7091190

INSTRUCTION MANUAL

THREE-PHASE INDUCTION MOTOR

With ANTIFRICTION 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 Systems Corporation Three-Phase Induction Motor. This manual covers the squirrel cage (antifriction 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.

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 withstanding voltage test. Also be sure to discharge the coils after the withstanding 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, injury, 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 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.
	• **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 outline drawing 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.
PROHIBITED	• **Do not insert foreign objects or long-handled stethoscopes or other long-handled objects into the motor.** When performing vibration or acoustic tests of the motor using long-handled stethoscopes, do not touch rotating parts, as this may result in injury or damage.
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 2 (page 16) 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.

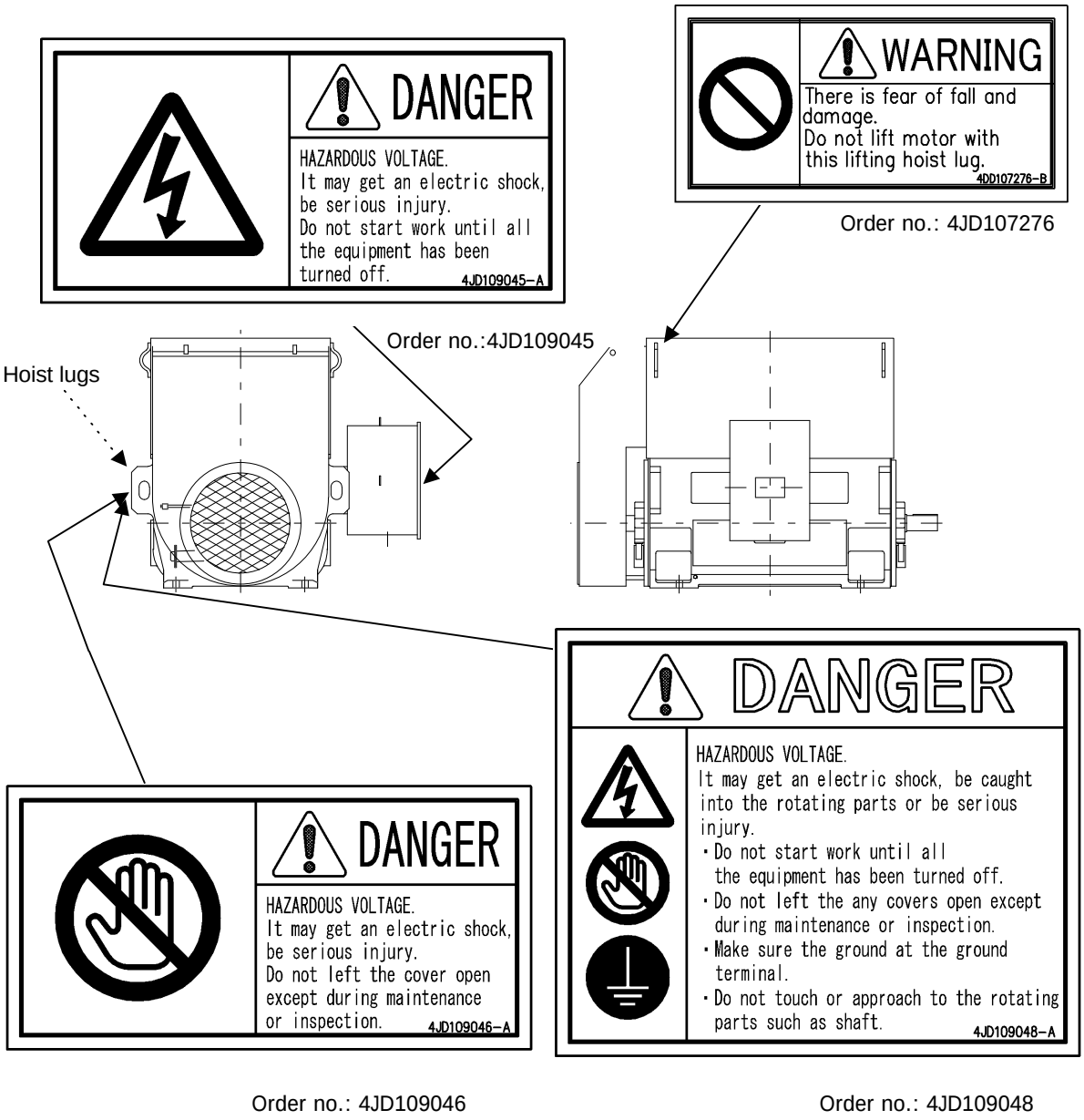


Figure .1 Warning Label Locations and Sample Labels

Contents

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.

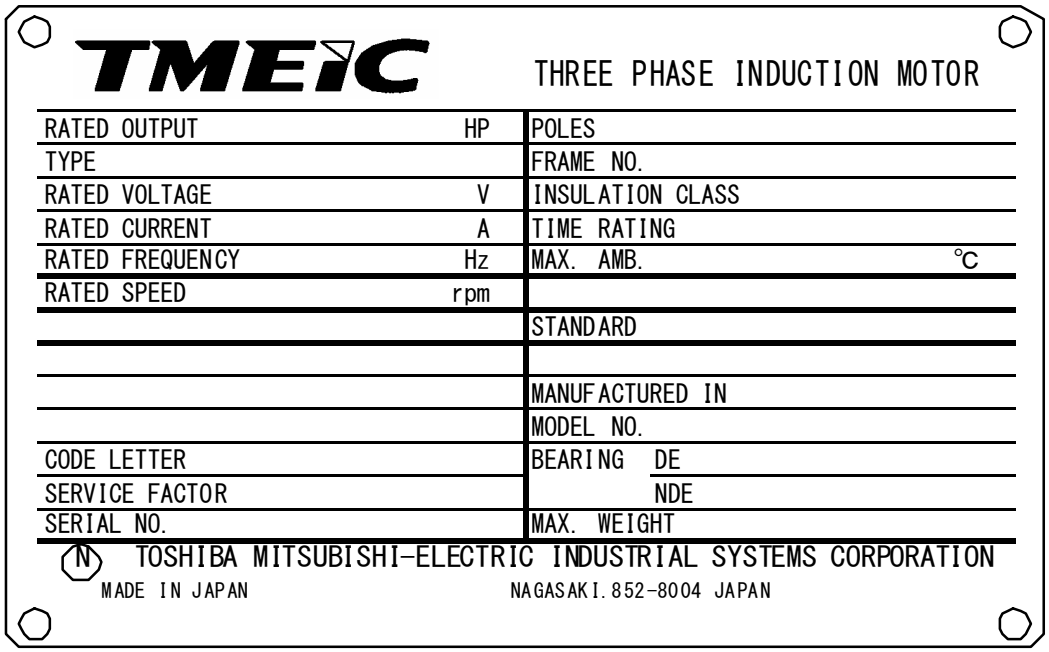


Figure.2 Rated Nameplate

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 a 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 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 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 (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.

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 removing lubricating oil, if it is an oil lubrication method.

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 temperature 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 common 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 (natural vibrations)

Avoid the system resonant frequency from following motor basic frequency:

1. The n times of rotation speed: n x min^{-1} ±10% : n=1,2,3
2. Double the power line frequency: f ±5%.

(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 bolts hole 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) Attach a dial indicator to the motor side coupling (see Figure 3).

(2) 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.

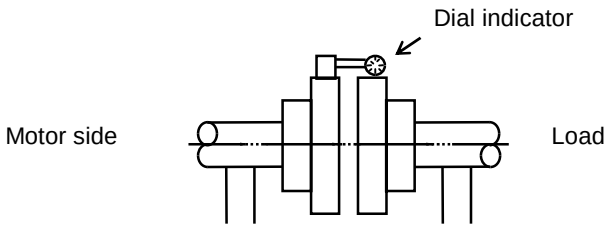


Figure .3 Aligning the Coupling References

3.4.2 Gap Adjustment

(1) Using a thickness gage, measure the gap between the coupling surfaces and adjust until the gap is uniform into a maximum accuracy of 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.

3.5 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.

3.6 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 4.

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

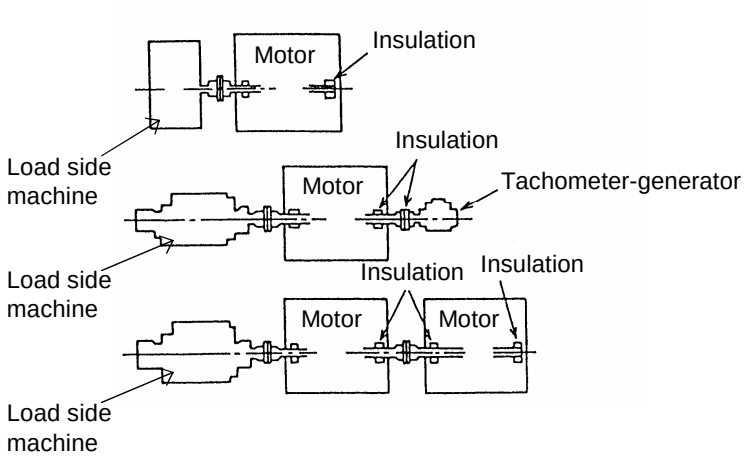


Figure .4 Position of the Shaft Current Preventive Device

3.7 Piping Work

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

- Use an oil drain pipe of a size equal to or larger than the size noted in the external view diagram; install so it drops at a steep angle and make the head larger.
- Use a large diameter pipe for the main pipe leading to the oil tank and be sure to install it at a 1/30 to 1/50 inclination.
- Install pressure gages and flow meters on the oil and water inlet pipes and install oil sight and water sight on the oil and water outlet pipes to enable the fluid pressure and flow rate to be inspected at all times.
- Whenever possible, make sure the pipes follow the motor body, and fasten them in place with support brackets.

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.5.)

(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.)

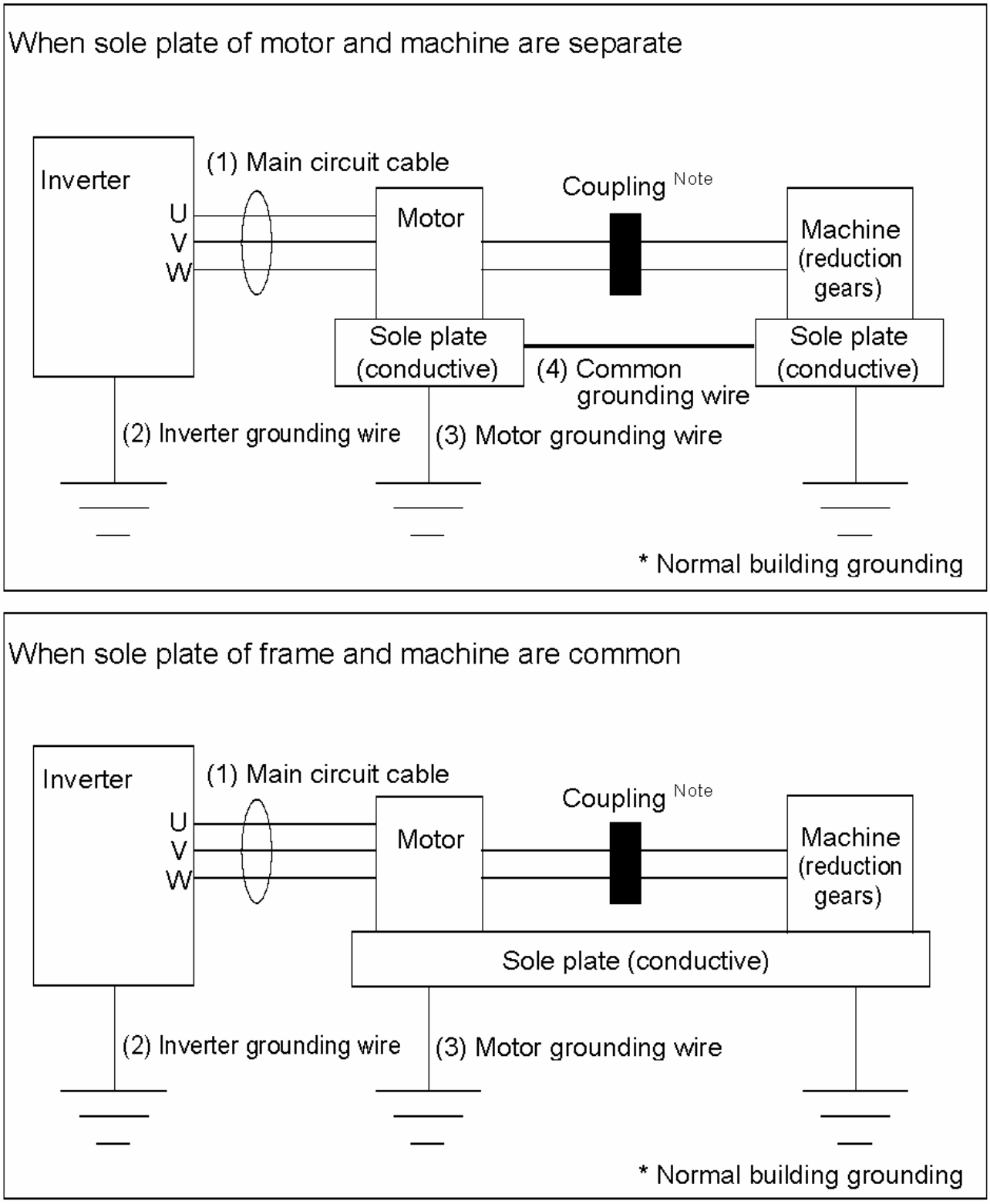


Figure.5 Grounding wire connection

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-attachments for driving motor

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 6 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.

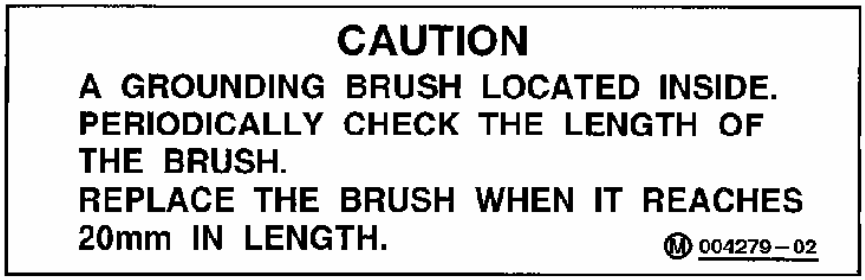


Figure.6 Shaft earth brush inspection methods

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 50).

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 outline drawing 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 outline drawing. Use a natural cooling method in places where the bearing cooling method is not specified.

Of the natural cooling methods, grease lubrication for antifriction bearings and oil lubrication by oil ring are used.

- Natural cooling (grease lubrication)

  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.
- Natural cooling (oil bath lubrication)

  While the motor is not operating, fill the motor with lubricant up to the level designated on the oil gage.

  If the oil is above this level, leakage will occur; if there is too little oil, the motor will heat up.

5.5 Dielectric Test

⚠ DANGER	
PROHIBITED	• **Do not touch the motor during the high potential voltage test. Also be sure to discharge the coils after the high potential 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 high potential 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 torques 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 1. 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 During 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, injury, or motor damage.

⚠CAUTION	
MANDATORY	• **Make sure the direction of motor rotation matches that shown in outline drawing and nameplates.** If the direction of rotation nameplate provided with the motor shows 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 outline drawing and nameplates?
- Is the oil ring of the bearing rotating?
- Check for any abnormal noises or abnormal vibrations, and any smoky smell from the -.

(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 turn the power on the equipment before turn the power on 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 48).

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 3 (on page 24).

(5) Startup error

Check the items in Table 14 (on pages 58 and 59). If you are unable to locate the cause of the problem, contact a Toshiba Mitsubishi - Electric Industrial System Corporation customer service representative.

7.2 Points to Check During Operation

During operation, check the items in Table 3 (on page 24) 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.
- The lubricant oil is not enclosed in the rolling bearing of the oil bath lubricating system. It always covers with lubricating oil which is directed to the outline drawing or the name plate, so that it does not get rusty in a bearing box.
- Metal surfaces that may rust, particularly machined surfaces, are coated with rustproof paint, rustproof fluid or grease before the unit is shipped from the factory. If the rustproof paint has peeled away from these surfaces, remove all rust and dampness and then repaint with rustproof 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 heater 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 2 (page 20) 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 2 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
			Rustproof and moisture-proof	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 pretreatment of the base mount surface, allow it to dry naturally and then coat with varnish. (2) Wipe any oil from exposed machine surfaces, then it is allowed to dry 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. (5) Every 6 months, run the motor in idling status and refill bearings with grease.	Every 6 months
Rotor			(1) Wipe the shaft journal and oil guard and coat with rustproof fluid.			
Bearing			(1) Pack with grease			
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	
PROHIBITED	• **Do not insert foreign objects or long-handled stethoscopes or other long-handled objects into the motor.** When performing vibration or acoustic tests of the motor using long-handled stethoscopes, do not touch rotating parts, as this may result in injury or damage.
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.
	• **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 3 through 7 (pages 24 to 28). 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
- Oil level
- Blackening of worn-out oil or grease discoloration
- 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.

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

(7) Re-seal the sealant, liquid packing and etc. to the point where they were applied, at the time of the re-assembling,

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 14 to 16) and Chapter 6 "Checks and Inspections During Trial Run" (page 17).

Table 3 Maintenance and Inspection Standard: Daily Inspection (In operation)

Object	Procedure			Criterion
	Item	Period	Method	
1. State of power source	Voltage	Daily	Voltmeter	Tolerance: ±10% of rated value (at rated frequency)
	Frequency	Daily	Frequency meter	Tolerance: +3%, -5% of rated value
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 13. (page 51).
	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 Greasing	Rotating noise	Daily	Hearing, noise sensing bar	Normal
	Temperature (Including oil shield)	Daily	Touching, thermometer	If any abnormal temperatures are felt, measure using a thermometer. Bearing temperature limit (readout value): Less than 95℃
	Greasing	When specified	Grease gun	Replenish
4.2 Oil bath lubrication	Temperature	Daily	Touching, thermometer	If any abnormal temperatures are felt, measure using a thermometer. Self-cooled bearing temperature limit (readout value): Less than 95℃ when measured at bottom half of bearing metal
	Oil surface and oil leakage	Daily	Visual	Oil at prescribed level
	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 4 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 Greasing	Discharge grease	Monthly	Drain	Grease should be free from metallic powder or other foreign matter
3.2 Oil bath lubrication	Dirty oil	Monthly	Drain	Lubricant should be free from metallic powder or other foreign matter

Table 5 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 10.3 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 5 (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	Air deflector 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	Open bearing, shake proof washer	Yearly	Visual, Hearing	Rust, transformation, wound, the damage, abrasion (abnormal noise)
6.1 Greasing	Contamination of grease	Yearly	Visual	Change grease
6.2 Oil bath lubrication	Oil shield	Yearly	Thickness gage	Within tolerance
	Oil ring	Yearly	Visual	Free from warping or excessive wear Set screws not loose Free from dirt, deterioration or foreign matter
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 (see Section 3.4 on page 8)
	Centering	As needed	Dial gage	Within tolerance (see Section 3.4 on page 8)
	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. 0.5 MΩ

Table 6 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 22).

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 5)
	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 5
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 6 (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	Open bearing, shake proof washer	Every 4 years*	Visual, Hearing	Rust, transformation, wound, the damage, abrasion (abnormal noise)
6.1 Greasing	Contamination of grease	Yearly	Visual	Change grease
6.2 Oil bath lubrication	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
7. Instruments	Calibration	Every 4 years*	Compare with reference	Within JIS standards
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. 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. Acoustic material	Fan cover, Air duct	Every 4 years*	Visual	Fixed position not loose or out of alignment Connections normal
14. Gland Packing	Fan cover, Air duct	Every 4 years*	Visual	Free from deterioration

10. Maintenance of Bearings

10.1 Points to Implement and Check Before Normal Operation

(1) Replenish grease (grease lubrication)

Immediately after starting normal operation for the first time, or when restarting operation after the motor has been idle for some time, it is necessary to replenish the supply of grease. For details, see Section 10.3.1.2 "Grease Replenishment" under Section 10.3 (on page 35).

(2) Replenish lubricant (oil bath lubrication)

On motors that use antifriction bearings with oil bath lubrication, no lubricant is used for the bearings as with the grease lubrication method. With the motor stopped, fill with the designated lubricant to the designated point on the oil level gage.

In this case as well, check the bearing nameplate attached to the motor.

(3) Make sure the inner and outer oil shields are closed tightly to keep out dust.

(4) Turn the rotor slowly, and check for any abnormal noises.

10.2 Maintenance and Inspection of the Antifriction Bearing

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.

10.2.1 Daily Maintenance and Inspection

10.2.1.1 Bearing Sound During Operation

Abnormality of the antifriction bearing can be most accurately judged by its sound. Therefore check its operating sound everyday.

To check the sound, listen directly to the bearing housing or use a noise sensing bar. Typical abnormal sounds of the bearing are listed below.

(1) Sliding sound

This is a shooing sound caused by undulations or chattering of the raceway surface of outer ring or rolling element surface. It is of no problem if the sound is mild and monotonous.

(2) Metallic sound

This is a high-pitched shrieking sound which is heard when lower grade grease is used, when the bearing clearance is too small, or the lubricant is insufficient.

(3) Rattling sound

This is a tapping sound heard when the bearing clearance is excessive or when the outer ring of the bearing is not assembled correctly.

(4) Sundry noise

This is a discontinuous scratching noise, and it suggests that dust or magnetized metallic powder has mixed in. If the noise is continuous, it means the rolling element or raceway surface is peeled, or there is a flaw due to electrolytic corrosion. This occurs during high speed rotation.

(5) Hauling sound

- This is a resonating sound often heard with ball bearings. When abnormal distortion occurs in the bearing housing due to the weight of the rotor, this distortion is magnified and is transmitted to the bearing outer ring, causing noise.
- A similar sound is heard when the grease lubricating performance is poor and local slipping occurs between the raceway surface of the bearing's inner and outer rings and the rolling element.
- Vibration or creaking sound may be heard due to misalignment or defective squareness. This noise is loud in the roller bearing, with the loudest reverberations occurring at low rotating speeds. A delicate high frequency vibrating sound is heard at high rotating speeds.

(6) Roller and/or ball fall down noise

This noise can occur during low speed operation with radial force. The ball and/or roller become free condition at point of that it is moved from load area to unload area. At this point, the ball and/or roller move and hit to cage and/or race then it become noise.

10.2.1.2 Temperature of Bearing

The temperature of the antifriction bearing is generally lower than that of a plain bearing. Being the bearing temperature high does not necessarily mean, however, that its operating conditions are abnormal and therefore, it is necessary to judge each case individually. In particular, when a high consistency grease is used in a high speed rotating machine, the bearing temperature tends to go up. This means that the temperature rises because the grease is stirred well and it is all right as far as the temperature remains within the service temperature range of the grease. However, if any unusual temperature rise is experienced, some abnormality may be considered such as excess grease, deterioration of grease, cage wear, and peeling. It is, therefore, necessary to record the bearing temperature every day.

To measure the temperature of an antifriction bearing, attach a bar thermometer to the bearing housing surface using glue or similar means and record the temperature. This reading should be used as a reference, and by carefully observing for change every day, an abnormality can be detected.

10.2.1.3 Amount of Oil (oil bath lubrication)

Check to make sure that the oil level is maintained at the point indicated on the oil gage.

This point indicates the proper oil level when the motor is at rest. When the motor is operating, the level of oil will fluctuate or change to some degree. Too much oil may result in oil leakage; too little oil may result in a temperature rise. Make sure the oil is maintained at the proper level.

10.2.1.4 Oil Ring

Monitor the oil ring through the inspection window to make sure that it is rotating properly.

10.2.1.5 Oil Leakage

Check the oil trap area for oil leakage.

10.2.1.6 Vibration of Bearing

When the daily state of vibrations of the bearing is recorded, abnormal vibration can be detected. If the bearing is peeled, worn, bruise, galling, broken, or electrolyically corroded, loud abnormal noise, heating and vibration may occur. In this case, the bearing must be replaced. When such abnormal phenomenon is initially observed, accidents may be avoided if proper measures are taken.

The following items may be considered as a diagnosis of abnormality.

(1) If the vibration or noise increases in a relatively short period, check the loading state described below.

- Affection of excess load due to belt tension, etc.
- Affection of excess thrust load due to thermal expansion by motor or directly coupled machine.
- Affection of excess thrust load on bearing due to failure of direct coupling.
- Affection of excess radial load on bearing due to deflection of bed or misalignment of foundation at the time of installation.

(2) In the case of the ball bearings, vibrations of abnormally high frequency may occur in the axial direction. This phenomenon occurs because the spring constant in the axial direction, which is related with the contacting part of the rolling element between the inner and outer ring of the bearing, housing resonates with the vibrations in the axial direction, causing the rotor to vibrate abnormally. It occurs very irregularly and disappears suddenly, or sometimes the bearing unit in the bearing housing resonates and an abnormal bearing noise is generated. In such a case, the following measures should be taken:

- Replace the bearing (using a bearing having a different spring constant).
- Reinforce the structure around the bearing in the bearing housing.
- Set the fitting of the outer ring and bearing housing somewhat loosely within the tolerance.
- Apply a slight preload to the outer ring in the thrust direction.
- Change the grease that having an excellent lubricating performance.

10.2.1.7 Considerations for Daily Inspection

If dust or metallic powder gets into the bearing, the bearing could be damaged. Therefore when opening the bearing shield, be careful not to let any foreign matter inside.

NOTICE

- Do not open it unnecessarily unless the bearing is obviously acting abnormal.

10.2.1.8 Long-term Stopping and Storage

The following measures should be taken:

- When shutting down the motor for a long period of time or in the case of a standby motor, make sure to operate them once every two weeks to prevent rusting of the journal.
- When storing the bearing for a long period of time, coat with rust preventive oil, and wrap in an oilproof package. Put it in a sealed container and store in a clean, cool and dry place. In the case of a large-sized bearing, put it on a flat shelf for storage.

10.2.2 Maintenance Inspection within a 6- to 12-month Period

10.2.2.1 Change and Supply of Grease

All grease has its own life, and it deteriorates when used over a certain period. Operating the motor with grease that has deteriorated may result in damage due to bearing overheating. Use the procedure below to fill with new grease.

The intervals for changing or supplying grease are shown in Table 8 (page 35). Greasing instruction are also mentioned on the bearing nameplate on the side of the motor.

(1) When motor shut off is possible.

Turn off the motor and disassemble the outer oil shield on the bearing section. In the case of a drain collar (see Figure 10), it is necessary to heat the drain collar to remove it. Next, wipe off the old grease and fill with new grease, using the procedure for filling grease for the first time as described in (6) under Section 10.5.3 "Considerations for Bearing Replacement" (page 44). When cleaning, also discharge the old grease that has collected in the grease outlet ⑤, and clean the inside.

(2) When it is impossible to stop the motor (Figure 10: see page 45)

(a) Remove grease outlet ⑤ and rinse out the old grease that has collected inside.

(b) Mount grease outlet ⑤ on outer oil shield ②. Make sure the cover on the grease outlet is open.

(c) Wipe the area around grease nipple ⑦ to remove any dirt or the like.

(d) Using a grease gun, replenish the grease from the grease nipple. The old grease will be pushed out by the new grease and will flow out the oil outlet.

(e) When new grease comes out of the grease outlet, stop replenishment and, with the grease outlet cover removed, operate the motor for a short period of time to discharge the excess grease.

(f) Closing the grease shield cover with the excess grease still inside may cause the bearings to overheat, so be sure to discharge all of the excess grease.

(g) Replace the grease outlet cover when normal operational status is achieved.

10.2.2.2 Replacing the Lubricant (oil bath lubrication)

The frequency with which the oil should be replaced will vary depending on the ambient temperature, the cleanliness of the surrounding area, the extent to which the motor is operated continuously, the severity of the environment and other environmental and operating conditions. In general, however, the lubricant should be replaced every four to six months.

Normally lubricant deterioration is checked by visual inspection how it changed color and become dirty. In more scientific terms, turbine oil should be replaced whenever possible if its acidity reaches 0.2 to 0.3 mgKOH/g, and replacement is mandatory when the acidity value reaches 0.5 mgKOH/g or above.

When replacing the lubricant, be sure to clean the inside of the bearing housing thoroughly and use new lubricant of the designated type. Lubricant replacement should be done with the motor turned off.

NOTICE

- Do not refill the lubricant while the motor is operating.

10.2.2.3 Inspecting the Oil Ring (oil bath lubrication)

Inspect the oil ring to make sure its sides are not abnormally worn and that the connecting screws are not loose.

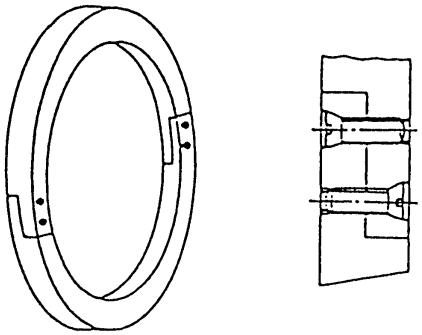


Figure 7. Oil Ring

10.2.2.4 Air Breather (oil bath lubrication)

Some high-speed motors have an air breather mounted on the top of the bearing bracket. This pipe releases the oil vapor to maintain a balance between the inside of the bearing housing and the outside atmosphere. If this pipe becomes clogged, it may cause oil leakage, so be sure to clean it periodically.

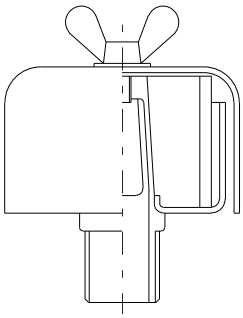


Figure 8. Air Breather

10.2.3 Maintenance and Inspection at the Time of Periodic Inspection

At the time of a periodic inspection, the entire motor is disassembled and all parts are checked and cleaned. At this time, service the antifriction bearing as follows, aside from checking according to the procedure in "Maintenance Inspection within a 6- to 12-month Period".

●Recommended replacement cycle for roller bearings

The roller bearing replacement cycle is indicated in below. Use this as a guideline when replacing roller bearings. Contact your nearest TMEIC Representative for more details.

Recommended replacement cycle for bearings

Condition	Pole	Recommended bearing replacement cycle
Direct couple or no load is applied from machine side	2 poles	4 years
	4 poles or over	4 years
Belt drive or load is applied from machine side	4 poles or over	3 years

10.2.3.1 Considerations for Dismounting the Bearing

(1) Must keep the new bearing in a clean, cool, and dry place.

(2) Clean the area around the bearings: the shaft and bearing housing, especially oiling system inside of the grease induction pipe.

(3) Insulation to guard against shaft current is inserted into the bearing housing on the non-load side. This section should be disassembled to make sure no dirt, etc. It may cause that the currents pass through deposits instead of proper insulation. After checking, reassemble as before.

10.2.3.2 Measuring the Shaft Insulation Resistance

If there is a shaft current protector in the bearing section, measure the insulation resistance at this point.

Instrument: 500 V megger
Judgment: Good if value is at least 0.5 MΩ

10.3 Lubricant Selection and Use

10.3.1 Grease

10.3.1.1 Selection of Grease

(1) Recommended grease

Unless otherwise designated, fill with the Rearemax Super or Alvania S No.2 grease:

Manufacture	Product	Soap
JX Nippon Oil & Energy	Multinoc Super Deluxe	Lithium Complex
Kyodo Yushi	Raremax Super	Polyurea

The following types of grease can be recommended particularly for use in motors. Please contact a Toshiba Mitsubishi - Electric Industrial System Corporation customer service representative if you are considering the use of other types of grease.

Table 7 Types of Grease

Manufacture	Product
JX Nippon Oil & Energy	• Multinoc Delux No.1 (Lithium base) • Multinoc No.1, No.2 (Lithium base) • Multinoc Urea No.2 (Urea base)
Kyodo Yushi	• Multemp SRL, SRH (Lithium base) • Unilube No.2 (Lithium base) • Raremax Super (Urea base)
Showa Shell Sekiyu	• Shell Alvania Grease RL2 • Shell Stamina Grease RL2 (Urea base)
Exxon Mobil	• BEACPM325（Lithium based for low temperature） • Mobilith SHC 100 (Lithium complex base) • Unirex N2 (Lithium complex base) • Polyrex EM (Urea base)
Cosmo Oil Lubricants Co.,LTD.	• Dynamax No.2 (Lithium base) • Cosmo Wide Grease WR
SKF	• LGHP2 (Urea base)

(2) Selection criteria according to the purposes

- For use in a high speed bearing, use grease with high pressure resistance.

  Choose a high consistency type concerning noise, and a low consistency type in terms of stirring loss. Generally, No. 1 or No. 2 grease is used.
- For low speed and high load service, use grease with high pressure resistance and low consistency.
- For long-period oil less service, use grease containing antioxidant and that is high in restorability (the property to return to the previous state while the bearing is stopped).

- For a high temperature bearing in particular, grease with a nonmetallic soap base (nonsoap) may be used.
- For damp places, use a water resistant type.
- For the standard motor of this series, the following grease is used:

  Li + Na soap base, consistency 265 to 295.

  The grease must be selected basically according to the conditions mentioned above, but other grease may be also used. However, do no mix different greases.

  When changing the grease, completely wash away the old grease, and supply new grease.

  However, in the case of a similar soap base (Li + Na) grease to Li soap base grease, a slightly larger volume may be required to force out the old grease.

- The following greases are used for heat resistant, water resistant, or cold resistant requirements.
- Heat resistant (up to 150°C): heat resistant silicone grease (not suitable for high-speed rotating bearings)
- Water resistant, chemical resistant (other than caustic soda): silicone grease (not suitable for high-speed rotating bearings)
- Cold resistant (up to –60°C): cold resistant silicone grease (not suitable for high-speed rotating bearings)

NOTICE

- During operation, the bearing temperature will generally be several degrees higher than the measured temperature of the bearing housing.

  Be sure to select a grease with temperature specifications that enable it to handle this higher bearing temperature.

10.3.1.2 Grease Replenishment

(1) Grease replenishing quantity and interval

The grease deteriorates and its lubricating function lowers as time passes, and adequate replenishment is indispensable. The grease should be replenished at least once each year, or after no more than 4000 hours of use. The following table shows a general guide to replenishment.

Table 8 Grease Replenishing Quantity and Interval (when Shell Alvania S No.2 is used)

Bearing No.	Initial fill (g)	Replenishment (g)	Replenishing interval on 24-hour daily operation (months)					
			2 poles	4 poles	6 poles	8 poles	10 poles	12 poles
6216	105	30	1	—	—	—	—	—
6218	170	45	1	—	—	—	—	—
6221	280	65	—	4	6	9	9	9
6224	410	80	—	3	5	6	6	6
6226	430	85	—	3	5	6	6	6
6228	540	95	—	2	4	6	6	6
6230	640	115	—	2	4	5	5	5
6232	740	130	—	2	3	5	5	5
6234	850	150	—	—	3	5	5	5
NU216	75	30	1	—	—	—	—	—
NU218	130	45	1	—	—	—	—	—

- Initial fill amount: the amount of grease that should be filled after disassembly and cleaning of the bearing section

- Replenishment amount: the amount of grease that should be supplied to the bearings at each refill interval

(2) Considerations and points to check during replenishment

- When starting operation after purchase, or when resuming operation after a 2-month or longer shutdown period, replenish the grease right after operation begins.
- Supply grease while the grease drain is open.
- In order to extend the service life of the bearing and maintain a quiet operation, it is recommended to replenish the grease at the specified interval as calculated on a daily 24-hour operation.

  If, however, the operating time is not constant, for example, 12 hours one day, 8 hours next day, and 3 hours some day, determine the replenishing interval using a 12 hour calculation.

NOTICE

- Check the amount of grease for replenishment (noted on the bearing caution nameplate mounted on the motor) and refill to that amount.

  Avoid replenishing with more than the designated amount and then lengthening the interval between refills.

  Filling with too much grease may result in bearing overheating, long-term high temperature, or leakage of grease. On the other hand, insufficient grease replenishment may result in grease not getting inside the bearing section itself.
- In the case of 2-pole motor and large-diameter bearings used in, 4-pole or 6-pole motors, if replenishment after installation, or upon start of operation after shutdown for 2 or more months, or at specified intervals, is skipped, the risk of bearing noise, abnormal wear or burning is very high. Therefore secure replenishing is absolutely necessary.

10.3.1.3 ¸ Discharge of Grease

Occasionally remove the grease outlet cover of the grease drain (about once in every two or three grease replenishments), and scoop out the collected grease.

NOTICE

- When the discharge grease trap in the outer oil shield is full of grease, the bearing may overheat and a grease leak may occur due to stirring resistance of the bearing. Be sure to remove completely any discharged grease.

10.3.2 Lubricant (oil bath lubrication)

Additive turbine oil ISO VG32 or ISO VG46 is used on antifriction bearings that use the lubricant bath method of lubrication. As with grease, avoid mixing different types of lubricants together.

10.3.3 Changing the Lubricant

See the section on maintenance.

10. 4 Bearing Troubleshooting and Corrective Action

(1) Causes of problems that can be found during operation, and their remedial actions.

Check antifriction bearings for troubles in regard to sounds, vibrations, and heating to preclude any major accident that may result from the troubles. If you discover any problems, consult the table below and take the appropriate corrective action.

Trouble		Possible cause	Remedial action
Abnormal sounds	1. Pronounced retainer sound (jingling)	This sound is generated as the retainer vibrates to collide with the balls or rollers. It is normal unless it is excessively large. The sound will increase as the grease is undersupplied or the retainer is worn.	Replenish the grease (into the cage riding clearance to the extent possible). If the sound recurs, replace the bearing.
	2. Shrieking sound (high-pitched metallic sound)	Under lubrication, grease with poor lubrication performance, or excessive radial clearance. (This sound can occur abruptly and its cause may not be readily identified at times.)	The sound is of no problem and has no effect on bearing life unless it is so large as to cause vibrations. Replenish the grease, use the grease that is soft and has good oiliness, or replace the bearing with a one having a smaller clearance.
	3. Remedial action	Scratches on the raceway surface or rolling elements. (Rust sometimes may cause a continuous noise to occur.)	Inject the grease. Replace the bearing if the sound recurs after a short time interval.
	4. Dust sound (intermittent jarring sound)	Presence of dust or magnetized iron chips.	Clean or replace the bearing. If the sound is left unattended, it may develop into bearing damages.
	5. Howling and resonant sound	Grease with poor lubrication performance, shaft out of center, or improper perpendicularly.	Replace the grease with one having good oiliness, or correct for optimal preload or fit.

Continued on the next page.

Trouble		Possible cause	Remedial action
Bearing vibrations	1. The vibration of the bearing section under continuous study has increased.	Scratched or worn bearing, presence of foreign matter, defective lubrication due to under lubrication or degraded grease.	Replace the bearing. Inject a new grease, or discharge the old grease.
	2. Vibration has pronounced after disassembling	Improperly mounted bearing (improper perpendicularly or twisted assembly)	Reassemble the bearing assembly or readjust the mounting after confirming the radial clearance rating.
Excessive temperature rise in the bearing section	Temperature has increased since installation	Presence of scratches or dust on the bearing	Replace or clean the bearing.
		Defective lubrication due to under lubrication or degraded grease.	Inject a new grease or discharge the old grease.
		Excessive grease injection (The temporary temperature rise following injection is not a problem.)	If an over greasing protective device is installed, inject the grease with the discharge port open while running the machine.
		Improperly mounted bearing (twisted or bent).	Correct the mounting.
		Increased bearing loads (increased belt tension, defective direct coupling, increased thrust from loads, etc.).	If the temperature rise still persists after a new grease is injected, examine the sound and vibration considerations as a whole and take appropriate action, such as reassembling or bearing renewal, as required in the circumstances.
		Temperature rise in the rotor due to increased loads.	Remove the overloads.
		Oil bath lubrication	
		Faulty oil ring rotation (warping, wear, loose mating surfaces, misalignment)	
		Insufficient oil supply (insufficient fill amount or oil leakage)	Replace in the event of warping due to wear or reduction in weight
		Faulty lubricant	Fill with oil
		Inappropriate oil type (excessive or insufficient viscosity)	Wrong oil type
		Degeneration or deterioration	Check color and oxidation
		Oil temperature too high (room temperature too high)	
		Oil contaminated by foreign matter (water or solids such as dirt or metal powder)	Check the route by which the foreign matter entered

(2) Causes of problems that may be found by disassembling inspection, and their remedial actions.

It is extremely important to check bearings for their damaged conditions after they are isolated for reasons of abnormal noises, abnormal vibration, breakage, etc., and identify the causes of the faults in order to prevent recurrence of the accidents. Use the following table as a general guide.

Item	Damaged condition	Possible cause	Remedial action
Early flaking (local peeling of metallic surfaces)	1. One-side flaking on the groove of a radial ball bearing.	Increased thrust loads Excessive thrust from loads or poorly adjusted assembly after inspection.	Examine thrust loads Adjust the preload at mounting properly.
	2. Flaking at symmetrical positions on the outer ring raceway surface of self-aligning bearings and the like.	Outer ring pressed by foreign matter in the split housing assembly.	When it is necessary to remove the top half for purposes of inspection, be sure to clean the mating surfaces of the housing before reassembling.
	3. Slanted flaking on the raceway surface of a radial ball bearing.	(1) The opposite bearing centers are misaligned due to a defective bracket or stand assembly. Inclined bearing installation	Perform assembly properly. Use a bearing with a larger bearing clearance.
	4. Flaking on the raceway surface at intervals of the rolling element pitch	(1) Scratches caused by excessive force applied via rolling elements at installation.	Review the mounting method.
		(2) Flaking resulting from scratches caused during mounting of a cylindrical roller bearing and the like.	Prevent mounting scratches by ensuring a proper internal clearance after mounting and by following proper mounting procedures.
	5. Local flaking on the raceway surfaces	(1) Foreign matter caught in fit surfaces. (2) Local deformation of the bearing ring associated with scratches on the fit surfaces.	Clean or correct the fit surfaces of the shaft and housing.
	6. Other early flaking	(1) Increased loads (2) Increased vibration and impact loads (3) Improper bearing clearance. (4) Defective mounting (5) Defective lubrication (6) Rusting	

Continued on the next page.

Item	Damaged condition	Possible cause	Remedial action
Cracks	1. Cracked rolling elements	The rolling elements were subjected to an abnormal impact load due to excessive bearing clearance.	Replace the bearing as promptly as possible whenever it is found worn to have an excessive clearance.
	2. Cracked raceway surface	(1) Foreign matter caused at mounting time.	Recheck when mounting the bearing. Repair properly.
		(2) Friction cracks occurred because the fit was loosened to due to over correcting of the shaft or other causes.	
		(3) Rolling element end-face cracks occurred because the retainer, tightened loosely, slid on the rolling element end surfaces.	
Chips	Chipped rib of a roller bearing inner ring	The rib was directly hit when the bearing was mounted.	Take care when mounting to avoid undue force to the rib.
Bruises	Bruises on the raceway surface at intervals of the rolling element pitch.	(1) The rolling elements were subjected to excessive force at time of mounting.	Take care when mounting the bearing.
		(2) The bearing was subjected to excessive loads when halted.	Handle the bearing with care during transit or mounting.
	Spotted bruises	The raceway surface or rolling elements were bruised as foreign matter entering the bearing unit was rolled by the rolling elements.	Prevent entry of foreign matter at time of mounting. Keep the grease free from contamination by foreign matter.
Fretting	Wear on the raceway surface at intervals of the rolling elements pitch.	The wear occurred as a result of continued inching friction between the raceway surface and the rolling elements caused by following conditions; 1) Vibrations during transit, or under similar conditions. 2) Vibrations form other machine during motor without running on the week base conditions.	Take action to secure the rotating part of the bearing during transit. Make stiffen base. Minimize external machine vibration level.

Continued on the next page.

Item	Damaged condition	Possible cause	Remedial action
Galling	Galling on the roller bearing raceway surface, rib surface, or roller rolling contact surface.	(1) The rollers fail to perform normally or they slide due to abrupt acceleration or deceleration.	Avoid abrupt acceleration or deceleration.
		(2) Defective lubrication, e.g., grease too solid or oil films liable to breakage.	Use a soft, pressure-resistant grease.
		(3) Abnormal contact due to mounting errors.	Improve the contact by eliminating the mounting errors.
Abnormal wear and rusting	Abnormal wear on the rolling contact surface, rolling elements or rib surface.	Foreign matter such as cement powder, acts as an abrasive to cause abnormal wear on the friction surfaces.	Take care in mounting the bearing to prevent entry of foreign matter or contamination of the grease by foreign matter. Check the sealing device, or improve the operating atmosphere.
		Any rust on the rolling contact surface or rolling elements can also act as an abrasive causing the same trouble as above.	Prevent rusting due to moisture or acids. Improve the operating atmosphere.
		Insufficient, improper or degraded lubricant.	Normalize lubrication.
Creep	Wear or galling on the fit parts	(1) Fit loosened as a result of overcorrecting of the shaft or housing.	Repair properly.
		(2) Vibration or impact.	Check mounting and linkage.
Contact corrosion	Wear or galling on the fit parts	(1) Fit parts are in local contact due to their defective correction.	Repair properly.
		(2) Inching slides occurred as a result of elastic deformation due to excessively large loads.	
Electrolytic corrosion	Pitched pits or corrugations on the rolling contact surface or rolling elements.	A current sparked, flowing through the bearing.	Clean the shaft current preventive insulation device.
Damaged cage	Damaged or worn cage	(1) Defective cage	With a large cage in use, inject a suitable lubricant into the cage riding clearance.
		(2) Defective lubrication	
		(3) Mounting damage	

10.5 Antifriction Bearing Disassembling and Reassembling

⚠CAUTION	
MANDATORY	• **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.

Use the following procedure when disassembling or reassembling horizontal shafts and bracket antifriction bearings to ensure that these parts are not damaged. Also see Figures 10 and 11 (pages 45 and 46).

10.5.1 Disassembling Procedures

(1) Release the bearing from its direct coupling to the connected machine.
(2) Remove attachments such as the thermometer.
(3) In the case of oil bath lubrication, remove the drain plug to drain the lubricant.
(4) In the case of oil bath lubrication, place the oil ring alignment joint so it faces upward and remove the connecting screws.
(5) Remove the bearings using a puller like the one shown in Figure.9 or a commercially available antifriction bearing puller.

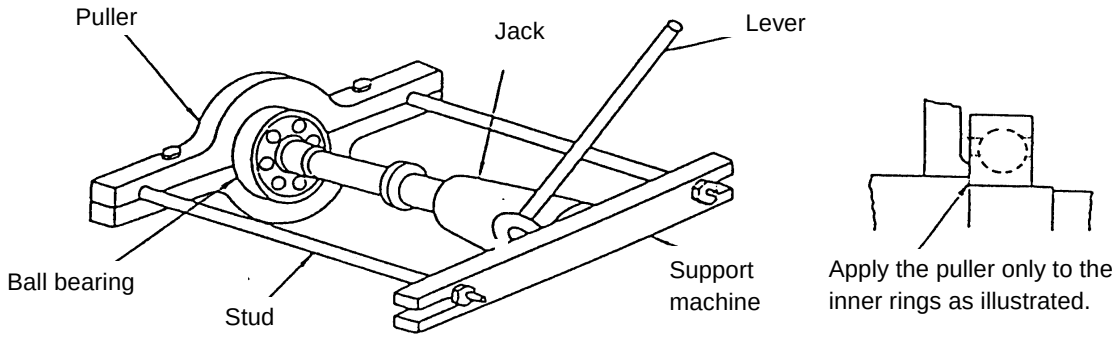


Figure .9 Typical Method of Withdrawing a Bearing

10.5.2 Reassembling Procedures

10. 5.2.1 Reassembling

(1) Preparations

- Keep the assembly, working environment, table, tools, cloths and hands clean. Use cloths which are not fuzzy.
- Check the shaft and bearing box installation surfaces for absence or presence of scratches or rust. Chamfer lightly the edges of the installation surfaces. Clean the installation surfaces with benzine after thoroughly removing metallic chips or dust from them; then allow them to dry completely.
- When using a new bearing, take it out its package just before assembly, and use it without cleaning.
- Check the fitted part dimensions for proper fit length.

(2) Insertion

Mount the bearing, with the side inscribed with the bearing number facing outward, to achieve perpendicularity to the shaft center.

NOTICE

- When press-fitting the bearing, clean the tools to prevent dust and other foreign matter from adhering to the bearing.

- Press-fitting and driving

① Apply a thin coat of oil to the shaft before press-fitting.

② Press-fit the bearing with a small press or jack or drive it with a hammer or equivalent, being careful not to apply force to the outer ring. Ensure that force is always applied only to the inner ring.

- Shrinkage-fitting

① Place in oil at a temperature of no more than 120°C and heat evenly.

Keep the oil clean and free from dust and other foreign matter.

If a drying furnace is available, heat the bearing, contained in a tightly sealed vessel, at a temperature of 100 to 120°C. (The heating temperature is the same when using an induction heater.)

NOTICE

- The bearing materials will begin to deteriorate at about 150°C. Be sure not to increase the oil temperature beyond 120°C.
- It is important to heat the bearing uniformly. Avoid heating with a torch lamp or similar apparatus.

② After shrink-fitting the bearings onto the shaft, allow them to cool naturally.

③ When the parts have cooled to room temperature, attach the lock nuts.

(3) Assembling the oil ring (oil bath lubrication)

① Assemble one oil ring set.

NOTICE

- Be sure to assembling the oil ring set correctly. Incorrect assembly may cause a discrepancy of the mating surfaces and make the ring oblong, resulting in faulty rotation.

② Fasten the screws on the alignment joint so they do not protrude from the sides of the ring, and punch them to prevent them from coming loose.

10.5.3 Considerations for Bearing Replacement

(1) Bearing number: When replacing bearings, use bearings with the same bearing number (including supplementary codes) as that noted on the rating plate.

(2) Fitting the bearing: Fitting of the radial antifriction bearing for a general motor is as follows:

- Fitting of bearing and bearing housing (bearing rotates in its inner race)

  Tolerance of bearing housing bore diameter .....

  J6..... for ball bearing
  K6..... for roller bearing

  Tolerance of bearing outside diameter .....according to the catalog of bearing manufacture. Regular class.

- Fitting of bearing and shaft (bearing rotates in its inner race)

  Tolerance of bearing inside diameter.....according to the catalog of bearing manufacture. Regular class.

  Tolerance of shaft outside diameter .....

  k5 ..... for ball bearing
  m5 ..... for roller bearing

The rotating side should always be set firmly, and the non-rotating side loose, in order to prevent the pressure of the rolling element from concentrating on a small surface of the raceway surface, and also to allow it to move freely due to thermal expansion.

NOTICE

- Make sure the fitting is neither too tight nor too loose.

  If the fitting is too rigid, an immoderate force may act on the raceway surface, and the rolling element will be compressed to cause excessive wear or early breakage. If too loose, slipping may occur when loading, and it may lead to erosion or corrosion, thereby spoiling the function of the bearing and extremely shortening the bearing life.

(3) After mounting the bearings, check to make sure the C type retaining ring is mounted securely in place.

Also, if there is a lock nut, check to see if the pawl of the washer used to fasten the lock nut in place is bent, split or otherwise out of position.

(4) After the checking, cover the area around the bearing with clean paper or cloth to shut out dust.

(5) Make sure the inner and outer bearing cover fit tightly with no clearance to admit foreign matter.

Turn the rotor slowly, checking for abnormal noise.

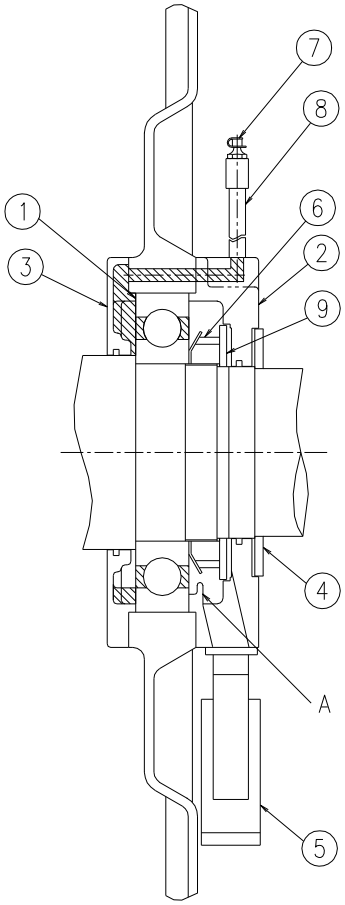
(6) Initial filling with grease. (grease lubrication)

Charge the grease into the shaded areas shown in Figure 10.

Feed the grease to fill up the oiling sector of the inner oil shield, fill the other sector about 2/3 full, and fill the oiling route from the grease nipple and the inside of the bearing. Spread part "A" around the discharge side of bearing.

Reassembling after periodic disassembling or when replacing the bearing:

First fill the bearing side of inner oil shield ③ and the inside of antifriction bearing ①, and assemble around the bearing, and then apply grease to part "A", finally assemble the grease nipple ⑦ and bearing bracket (or outer oil shield ②).



No.	Part name
1	Antifriction bearing
2	Outer oil shied
3	Inner oil shield
4	Drain collar
5	Grease outlet
6	Clamping nut
7	Grease nipple
8	Grease guide tube
9	Grease valve

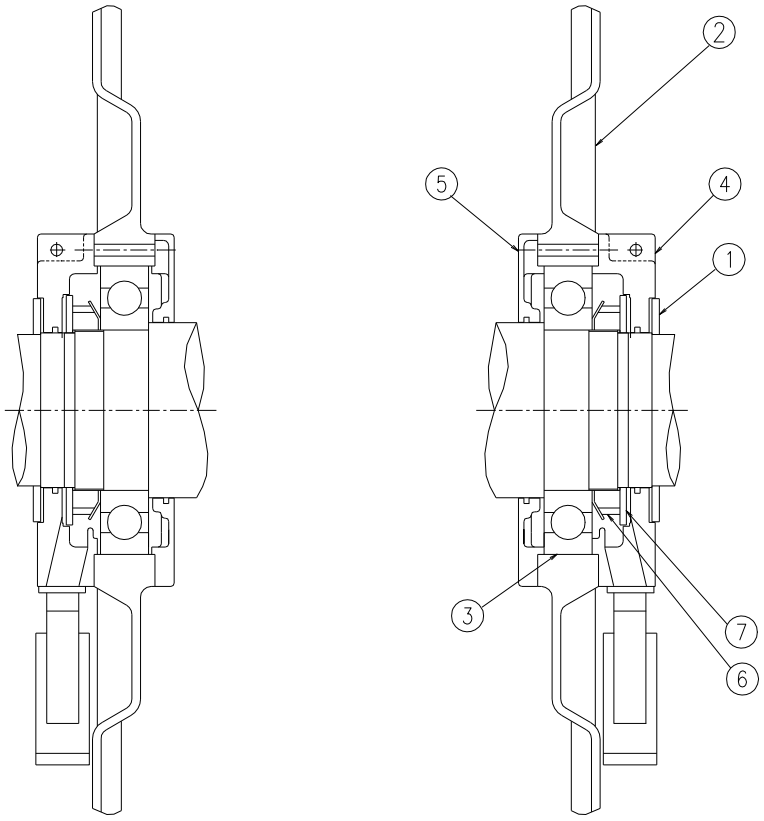
Figure 10. Structure of Antifriction Bearing

(7) Lubricant (oil bath lubrication)

On bipolar motors, antifriction bearings with oil bath lubrication are sometimes used.

In such cases, unlike with grease lubrication, the lubricant is drained for disassembly, and therefore, it is necessary to refill the designated lubricant up to the line on the oil level gage when reassembly is complete.

10.6 Configuration of Antifriction Bearings

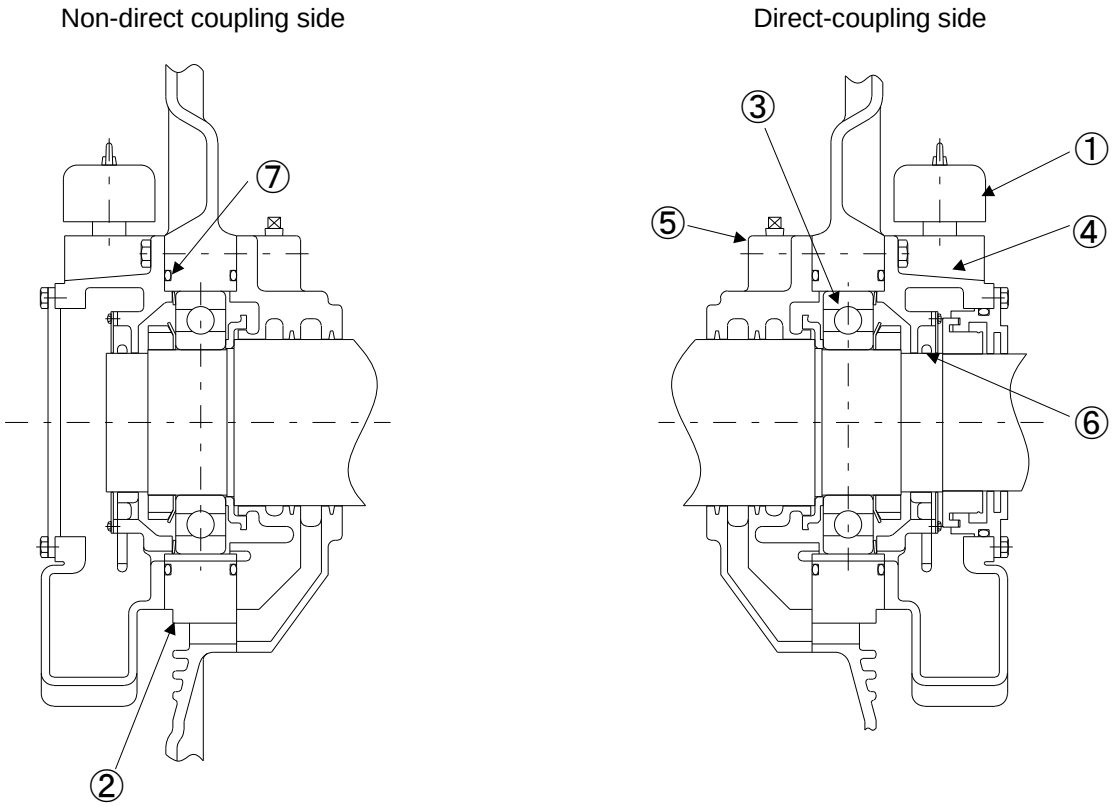


Non-direct coupling side

Direct-coupling side

No.	Part name
1	Drain collar
2	Bearing bracket
3	Ball bearings
4	Outer oil shied
5	Inner oil shield
6	Clamping nut
7	Grease valve

Figure 11. Configuration of Antifriction Bearings With Typical Grease Lubrication



No.	Part name
1	Air breather
2	Bearing bracket
3	Ball bearings
4	Outer oil shied
5	Inner oil shield
6	Oil ring
7	O-ring

Figure 12. Configuration of Antifriction Bearings With Typical Oil Bath Lubrication

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 9.

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 9 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 10 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 10 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 excessive heat and partial discharge generation. 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. Therefore, it is very important to keep and monitor the vibrations within an allowable range. The standard construction motors can allow 5 m/s^2 (0.5 G) of impact vibration. So if motor will get over this values then please ask to our customer service.

11.4.1 Allowable Vibrations

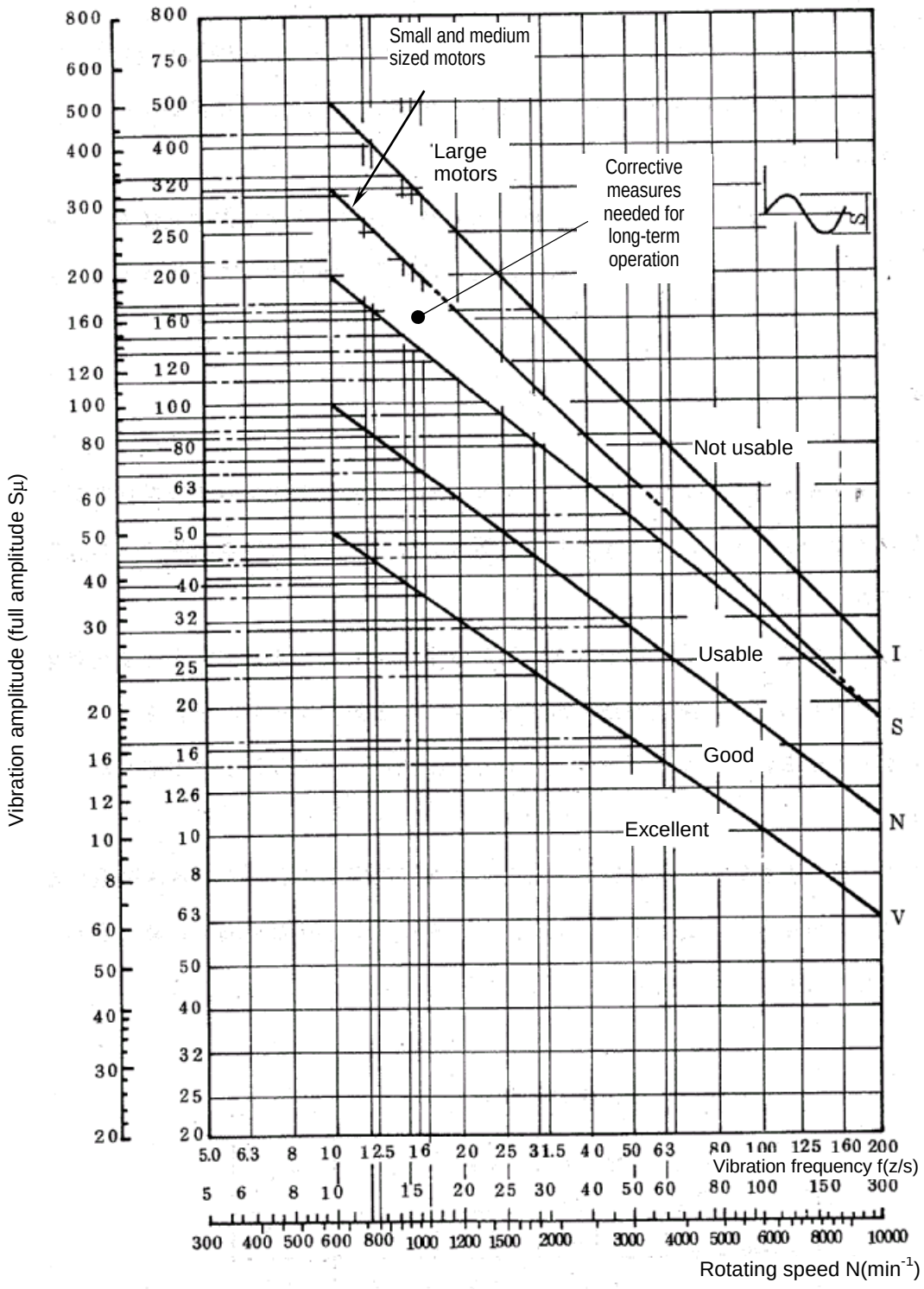
JEC-2137 listed about vibration measure condition. It said " Motor vibration should measure under rating voltage and rating frequency". So it dose not have vibration limits under load. We recommend vibration limits of load condition as follows;

Target vibration limit under load $\leqq$ 4.5 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. The vibration measurement method and evaluations have been compiled by the ISO and IEC also.

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

Figure 13 shows recommended values 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.13 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.

(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.

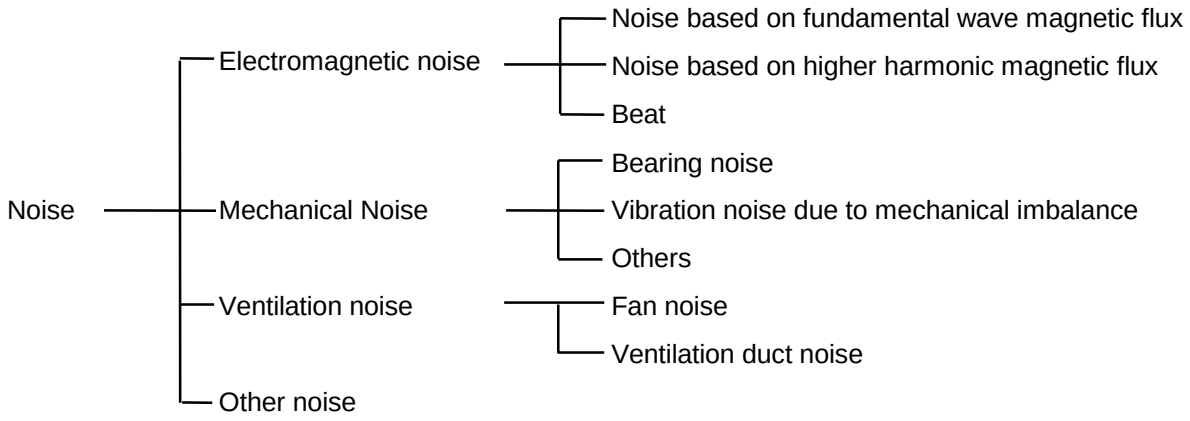
(6) Check the relations of vibrations with oil feed temperature, machine internal temperature, shaft temperature or other temperature changes, and investigate the shaft movement.

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

11.5 Noise of Motor

Motor noises may be classified as shown in Table 11 by the source.

Table 11 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.

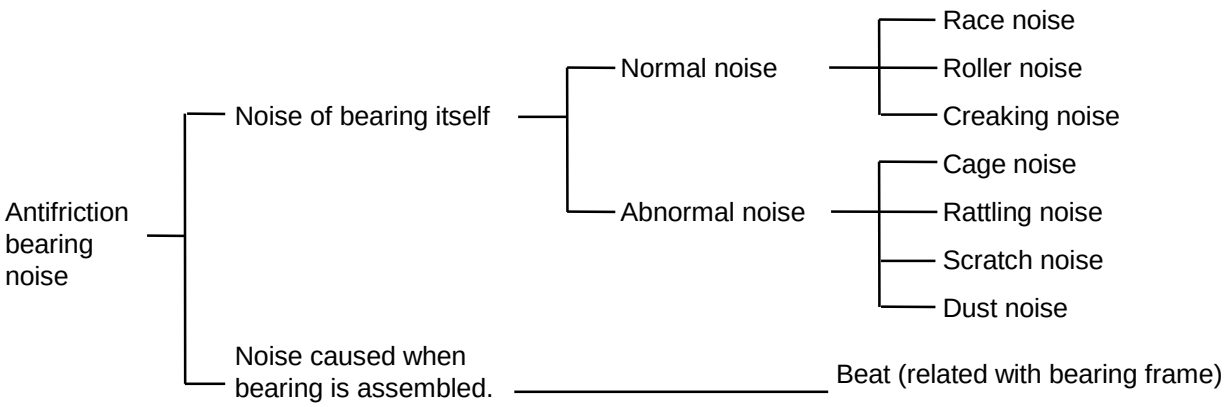
(2) Mechanical noise

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

(2.1) Bearing noise

Forms of generation of noise of antifriction bearing are complicated, and principal causes may be classified as shown in Table 12.

Table 12 Noise of Antifriction Bearing



Of these noises, race noise (the fundamental sound of antifriction bearing, having frequency components of over 1000 HZ), roller noise and creaking noise have normal sounds, while the others have somewhat unusual noise.

Typical abnormal noise is scratch noises.

Scratch noise is caused when there is a flaw in the raceway surface or rolling element, and it is sometimes very loud. The frequency of this noise is proportional to the rotating speed or the number of rolling elements. If this scratch noise is recognized, the bearing must be replaced immediately.

(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-37, 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 13.

(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 3% 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 13 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 14. 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.

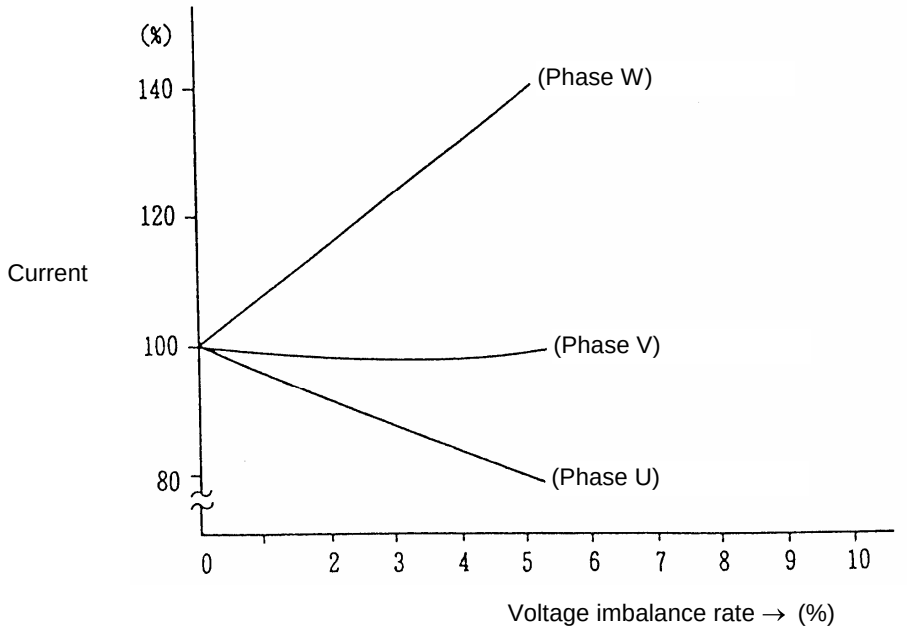


Figure 14. Phase Currents Due to Voltage Imbalance

12. Troubleshooting

Possible causes and remedies of trouble are summarized in Table 14. If a major trouble is discovered, please report it to our company as soon as possible.

Table 14 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 14 (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. Antifriction bearing failure (grease lubrication) For details, see Chapter 10 “Maintenance of bearings”.	A malfunction caused by noise, vibration or temperature has been discovered.	Fatigue peeling of raceway surface, rolling element.	Clean bearing and check; replace if defective.
		Handling bruise and other damages or raceway surface and rolling element.	
	Since many troubles are caused by grease, first try and feed grease and observe the performance.	Insufficient grease, excessive grease, degenerated grease, wrong grease.	Feed specified grease by specified amount.
		Entry of metallic powder or dust.	Clean bearing.
		Deformation or breakage of cage.	Replace bearing.
		Wrong mounting of bearing.	Reassemble and correct motor coupling.
		Excessive thrust load.	Also check load.
		Clearance is too small.	
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 insulation 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