

# **INSTRUCTION MANUAL**

---

**FOR LARGE-CAPACITY  
THREE-PHASE INDUCTION MOTOR**

---

## **GENERAL INSTRUCTIONS**

---

PLEASE SEND THIS MANUAL  
TO THE END USER SURELY.

## CONTENTS

Introduction.....	3
Safety precautions .....	3
1. How to interpret the nameplates.....	7
1.1 TYPE, FRAME NO. ....	7
1.2 POLES, RATED SPEED, RATED FREQUENCY .....	7
1.3 RATED OUTPUT, RATED VOLTAGE, RATED CURRENT .....	7
1.4 SEC. VOLTAGE, SEC. CURRENT .....	8
1.5 RATING.....	8
1.6 MAX. AMB., ALTITUDE .....	8
1.7 THERMAL CLASS .....	8
1.8 STANDARD, PROTECTION, COOLING METHOD.....	8
1.9 SERIAL NO, MANUFACTURED IN.....	9
2. Acceptance inspection .....	9
3. Storage.....	10
4. Installation .....	13
4.1 Foundation design and engineering .....	14
4.2 Centering and alignment.....	14
4.3 End play and damage prevention of sleeve bearings .....	16
4.4 Mortar grouting .....	17
4.5 Prevention of shaft current.....	18
4.6 Piping.....	19
5. Wiring.....	21
5.1 Wiring procedures .....	22
5.2 Grounding(Earth).....	22
5.3 Precautions for driving inverter.....	22
5.4 Precautions for Y- $\Delta$ starting.....	24
6. Preparations and inspections before trial run.....	25
6.1 Measurement of insulation resistances.....	25
6.2 Inspection of electrical circuits.....	25
6.3 Terminal connection in auxiliary terminal box.....	25
6.4 Inspection of grounding wires.....	26
6.5 Bearings.....	26

---

6.6 Dielectric strength test .....	28
6.7 Others .....	29
7. Trial run .....	30
8. Normal run .....	31
8.1 Starting.....	32
8.2 Running.....	33
9. Maintenance .....	33
9.1 Contents of inspection .....	34
9.2 Interval of regular inspection .....	34
9.3 Major inspection items.....	35
9.4 Test run after inspection .....	36
10. Basic knowledge for maintenance and inspection .....	45
10.1 Starting duty.....	45
10.2 Limit of temperature rise.....	45
10.3 Insulation resistance.....	46
10.4 Vibration.....	46
10.5 Noise.....	50
10.6 Influences of power source fluctuation.....	52
10.7 Influences of unbalanced voltage of the power source .....	54
11. Troubleshooting .....	55

## Introduction

Thank you very much for purchasing our company motor. This manual has been published to ensure safe and efficient use of your motor. Please be sure to read through this manual carefully as it has been prepared to provide you with a full knowledge of installation, operation, maintenance and inspection.

Besides this manual, be sure to read other manuals and all Danger / warning / caution name plates which are attached to the motor.

## 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.

### 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 Systems Corporation.

### Qualified persons only

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

A qualified person must :

1. Carefully read and comprehend the entire instruction manual.
2. Be skilled in the installation, construction or operation of the motor and be aware of the hazards involved.
3. Be trained and authorized to safely energize, deenergize, clear, ground, lock out and tag circuits in accordance with established safety practices.
4. Be trained and authorized to perform the service, maintenance or repair of the motor.
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.

### Important messages

Signal words such as DANGER, WARNING and CAUTION will be followed by important safety information that must be carefully reviewed.

**DANGER :** Indicates a hazard with a high level of risk which, if not avoided, will result in death or serious injury.

**WARNING :** Indicates a hazard with a medium level of risk which, if not avoided, could result in death or serious injury.

**CAUTION :** Indicates a hazard with a low level of risk which, if not avoided, could result in minor or moderate injury.

Safety signs







indicates Warning












indicates a Prohibited action (one that must not be done)











indicates a Mandatory action (one that must be done)

 <b>DANGER</b>	
	The use of electrical equipment in hazardous locations is restricted. Customers must read, understand and apply local rules for installation and use of all equipment in such locations and consult local code inspection and enforcement agencies as necessary to insure compliance. Failure to do this may result in explosion or fire.
	Before any work is started on the machines, particularly before covers are removed from live parts, make sure that the machine has been correctly disconnected from the supply. Conducting operations with live wires may result in electric shock.
	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.

 <b>WARNING</b>	
	Only qualified persons are to install, operate, or service this motor according to all applicable codes and established safety practices. Failure to do this may result in electric shock, injury or fire.
	Do not touch high-voltage electrical circuits and rotating parts. This may result in electric shock or injury.
	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.
	Do not allow all personnel other than those handling the equipment to go close to the motor. This may result in injury or electric shock.
	Put neither finger nor the thing in the opening of the electric motor. This may result in electric shock, injury or fire.

	Do not install or energize motor that has been damaged. This may result in fire or injury.
	Do not open to the door and the lid of the collector except the maintenance. This may result in injury or electric shock.
	Do not attempt to modify the motor. It doesn't assume the responsibility because it is outside the guarantee range of our company.

 <b>CAUTION</b>	
	When using a source of flame with the bearing section dismantled, be careful of the following : <ul style="list-style-type: none"> <li>• Wipe away any lubricant from the bearings.</li> <li>• Be sure to protect the bearing section from being heated.</li> <li>• Use sources of flame only in places where there is no danger of fire.</li> <li>• Do not use heaters, cigarettes or other general sources of flame near the bearing section.</li> </ul>
	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.
	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.
	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.
	Use the motor specifically designed for converter supply when your drive the electric motor with the inverter. Failure to do this may result in overheating, damage of insulation or fire.
	Keep to seeing the nameplate.
	Do not detach the nameplate.

<b>TMEiC</b>		THREE PHASE INDUCTION MOTOR	
RATED OUTPUT	HP	POLES	
TYPE		FRAME NO.	
RATED VOLTAGE	V	INSULATION CLASS	
RATED CURRENT	A	TIME RATING	
RATED FREQUENCY	Hz	MAX. AMB. °C	
RATED SPEED	rpm	STANDARD	
		MANUFACTURED IN	
		MODEL NO.	
		BEARING DE	
SERVICE FACTOR		NDE	
SERIAL NO.		MAX. WEIGHT	
TOSHIBA MITSUBISHI-ELECTRIC INDUSTRIAL SYSTEMS CORPORATION		MADE IN JAPAN	
		NAGASAKI 1.852-8004 JAPAN	

Rating nameplate

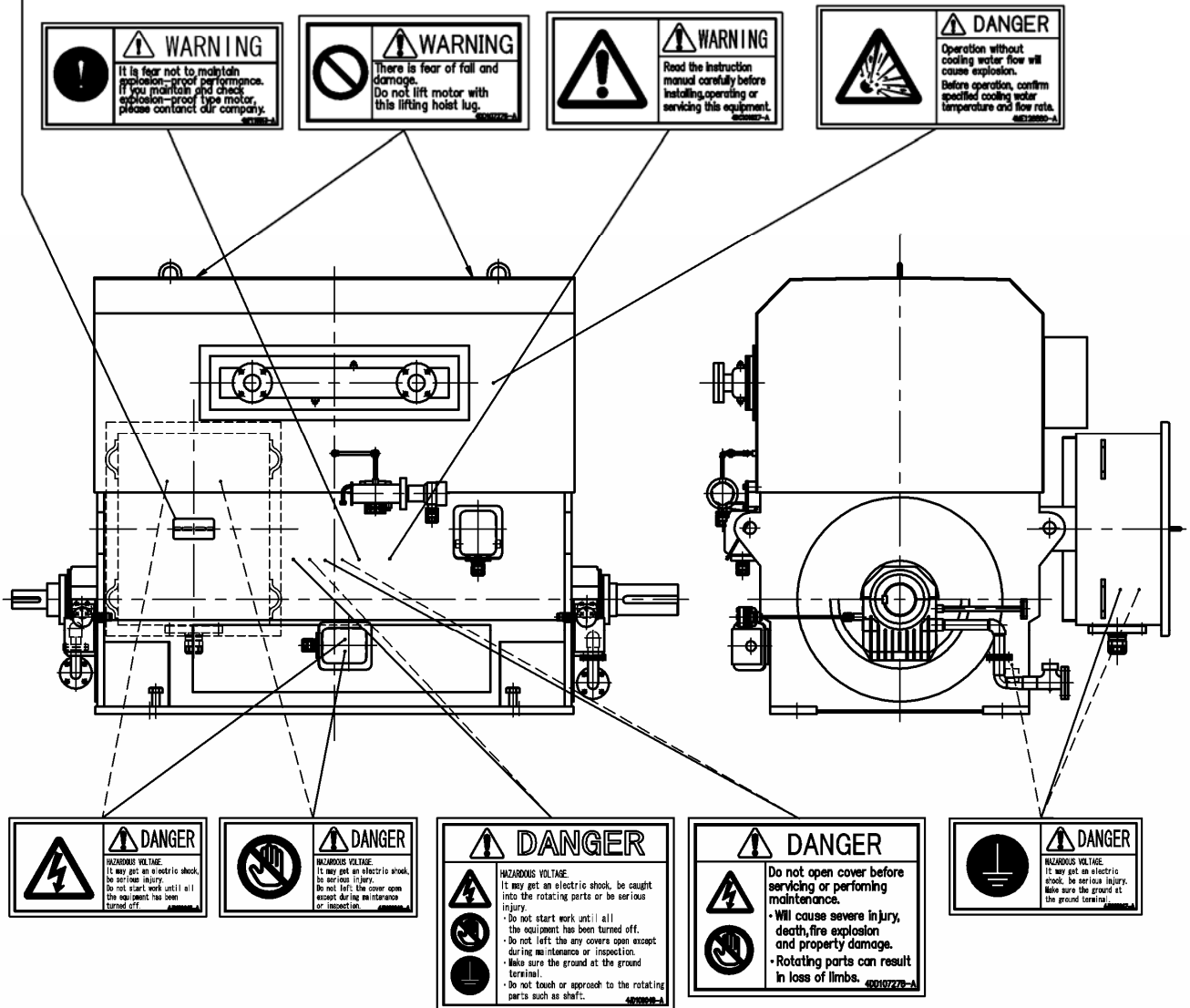


Fig. 1 Position of name plates and warning labels (example)

## 1. How to interpret the nameplates

Every motor is fitted with a name plate containing the basic rating data according to relevant standards. A typical rating nameplate is shown in Fig. 2.

<b>TMEiC</b>		THREE PHASE INDUCTION MOTOR	
TYPE		FRAME NO.	
RATED VOLTAGE	V	INSULATION CLASS	
RATED CURRENT	A	TIME RATING	
RATED FREQUENCY	Hz	MAX. AMB.	°C
RATED SPEED	rpm		
		STANDARD	
		MANUFACTURED IN	
		MODEL NO.	
SERVICE FACTOR		BEARING DE	
SERIAL NO.		NDE	
		MAX. WEIGHT	
TOSHIBA MITSUBISHI-ELECTRIC INDUSTRIAL SYSTEMS CORPORATION			
MADE IN JAPAN		NAGASAKI. 852-8004 JAPAN	

Fig. 2 Rating nameplate

In addition, auxiliary plates are attached depending on necessity. The interpretation of the rating nameplates is given below.

### 1.1 TYPE, FRAME NO.

The symbols specified by our company are described to indicate the electrical and mechanical characteristics of the motor.

### 1.2 POLES, RATED SPEED, RATED FREQUENCY

The number of North & South poles is determined by the stator coil connection and is indicated by P.

The power frequency in Hz is as f, the synchronous speed N ( $\text{min}^{-1}$ ) of the motor becomes:

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

Before using the motor, be sure to check the power frequency against the frequency indicated on the rating nameplate.

At the rated load, rotational speed (full load speed) is slightly below the value indicated above and is indicated on the nameplate.

### 1.3 RATED OUTPUT, RATED VOLTAGE, RATED CURRENT

The output is shown by the maximum shaft output power (P) in kW or HP at which the motor can be operated continuously.

The voltage is the value of the power source voltage (V). Rated current (A) is



the value when the motor generates rated load under the rated voltage and frequency.

The relationship among these values is given by the following equation when the motor power factor (Pf) and efficiency ( $\eta$ ) are shown by %.

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

Before using the motor, be sure to check the power source voltage against the value indicated on the rating nameplate.

Operate the motor with current at or below the value indicated on the rating nameplate.

#### 1.4 SEC. VOLTAGE, SEC. CURRENT

These values are only applicable in the case of wound rotor motors.

The secondary current is the current value of the rotor when the motor generates rated load at voltage and frequency.

Operate the motor within the range of the secondary current indicated on the rating nameplate.

The secondary voltage is the open circuit voltage of the rotor circuit.

Care should be taken during start up because this voltage is generated in the brush/collector ring area.

#### 1.5 RATING

This shows the kind of duty cycle the motor is designed for.

In the case of continuous duty or unspecified, the motor is capable of continuous running.

When the value is expressed by the hour or minute, the motor is capable of operation only for the time indicated on the rating nameplate. Run the motor again only the motor has cooled down.

#### 1.6 MAX. AMB., ALTITUDE

When unspecified, operate the motor with an air inlet temperature of 40°C or less, and with altitude below 1000 m. Operate the motor with the ambient temperature and altitude within the range specified on the rating nameplate. For water cooled motors, water inlet temperature will be indicated.

#### 1.7 THERMAL CLASS

This shows the insulation class.

As the value of temperature rise varies with the measuring method, refer to the conforming standard.

#### 1.8 STANDARD, PROTECTION, COOLING METHOD

The specified standard will be applied. Otherwise, our standard is JEC-2137.

The protection type is specified as IPXX. The first characteristic indicates the degree of protection provided by the enclosure with respect to persons and also to the parts of the machine inside the enclosure. The second characteristic indicates the degree of protection provided by the enclosure with respect to harmful effects due to ingress of water.

The cooling method is specified as ICXX. For details, refer to the standard.

When unspecified, operate the motor with an air inlet temperature of 40°C or less, and with altitude below 1000 m. Operate the motor with the ambient temperature and altitude within the range specified on the rating nameplate. For water cooled motors, water inlet temperature will be indicated.

#### 1.9 SERIAL NO, MANUFACTURED IN

The serial No. is specified for each machine to permit finding the records of the machine. The manufacture indicates the year of completion of machine.

## 2. Acceptance inspection

Upon receipt of your motor, please take care of the following points.

- (1) We have already provided a packing list or an invoice with your motor. Check the motor against the invoice.
- (2) First unpack carefully. Check each component for shipping damage.
- (3) Make sure that the output, voltage, frequency and model designation indicated on the rating nameplate comply with your ordering specifications.
- (4) Special shipping protectors are fitted on the bearing housing.

To prevent damage to the bearings during transportation, the red painted bearing protective devices are attached on this motor. Refer to the attached caution card and remove the protectors. As there is case that this protective devices are not only attached on the load side bearing but also on the opposite load side bearing, confirm certainly that the protective devices on the both bearings are removed before trial run



#### CAUTION !!








1. Remove the red painted bearing protective device before putting the motor into operation.
2. Put the bearing protective device in case of re-transport the motor after fitting the shaft end with coupling or pulley.

- (5) Check the entire motor carefully for damage, rust parts, fouled parts and intrusion of harmful objects. If you have any question about your motor, please do not hesitate to contact our representative.

The following should always be referred to any correspondence with us.

- Data indicated on the rating nameplate (type, frame No., number of poles output, voltage and frequency)
- Serial No. (indicated on the rating plate)
- Your specific requested information or questions.

## 3. Storage

 <b>WARNING</b>	
	Never enter the area directly beneath the motor while it is being hoisted. You may be seriously injured if the motor should fall.
	Do not lift the motor using the auxiliary lifting lugs, e.g. on terminal box, top-mounted heat exchangers etc., which are not designed for carrying the machine weight. This may result in injury.
	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.
	Put wood or thick cloth between the housing or covers and the ropes to protect the housing of the motor and wire ropes. Failure to this may damage the motor or the wire ropes.
	Do not use materials handling equipment that is not suited to the weight(*) This may cause the motor to fall, resulting in injury. * Noted in specifications (outline drawing) or on nameplates attached to the motor itself.
	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 and resulting in injury.

## (1) Temporary storage

If the motor remains in the packed condition for some time before installation, it should be kept in a dry place free from direct sunlight and drastic temperature change.

If the motor is stored at a place where the ambient temperature changes sharply, its metallic surfaces are sure to sweat and corrode by the decreasing of temperature.

After it is unpacked, the motor should be provided with careful protection until the installation is ready of from installation until it is put into actual service, to prevent damage due to moisture, contaminants, entry of foreign objects, insects, etc., physical abuses, tampering or violence.

The motor windings are sometimes subjected to the reduction of insulation resistance due to moisture absorption, and metallic surfaces such as cores, terminal box, etc. may rust due to condensation during storage, if proper precaution are not taken.

Anti-friction bearings are filled with grease; however, since sleeve bearing are without a lubricant, they should be supplied with oil quantity specified in the motor outline drawing or up to the mark indicated on the oil level gauge. Turn the rotor at regular intervals to lubricate and protect the journal from rust.

Machined metal surfaces have been protected with rust inhibitive paint, rust inhibitive oil or grease in our factory.

If damage on these surfaces is found, then repaint rust inhibitive agent for protection after removing rust and moisture thoroughly.

If the motor has a space heater, be sure to turn the heater on.

When turning on the space heater source, check to see that the heater surroundings are free from foreign objects and be sure that the voltage is normal. Check for abnormal temperature rises during the first several hours after the power is turned on.

(2) Long term storage

The following explains what to do if the motor is to be stored or left unused for more than six months.

In this case, the countermeasures shown in Table 1 should be provided in addition to the ones specified for the temporary storage above.

The countermeasures for long term storage vary depending on the type of construction or installed conditions, etc. Please be sure to consult our representative for further information if you have questions.

Final inspection, treatment and adjustments before operation require expert knowledge and skill. Our supervisors are available if needed.

**Lifting of the motor**

- I) Lift and move the motor using wire rope at lifting lugs with crane.
- II) Lift the motor properly balanced, using chain hoist for adjusting motor horizontally.
- III) When lifting the motor, ensure safety and take care, use wire rope support or lifting beam etc. so as not to cause damage to any parts by wire rope. (see an example shown in right)
- IV) If the wire rope comes in contact with any sharp corners, use padding materials.

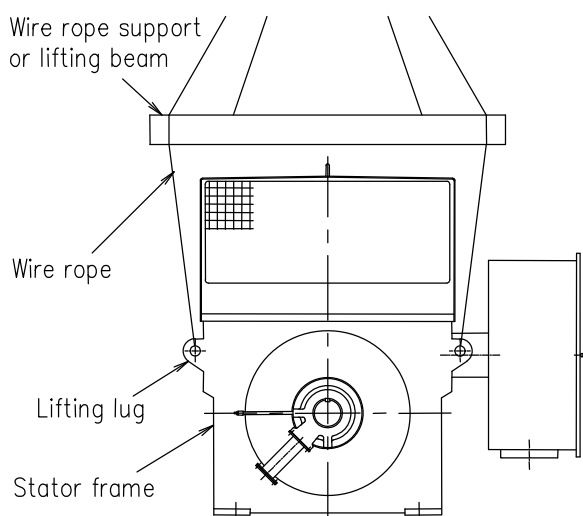















Table 1 Styles of long-term storage and methods of quality preservation for AC motor assemblies

Item Com- ponent	Place of storage	Style of storage	Measure for quality preservation		Inspection method	Inspection cycle
			Rust inhibition and moistureproof	Protection from deformation and damage		
Stator	Indoors	(1)Wrap with a poly-ethylene sheet, and put on sleepers in order to prevent the creepage of moisture from the floor.  (2)Pack by sealing a desiccant in the poly-ethylene sheet. (silica-gel 300 to 500 g/m <sup>3</sup> )	(1)Pretreat and apply an air-dry type coil varnish on the base mounting surface.  (2)Pretreat and apply air-dry type coil varnish on the exposed parts of machined surfaces.  (3)Attach a space heater inside the motor, and keep it energized at all times.	(1)Put a canvas sheet over for protection from damage and rain and air borne contaminants.  (2)Never stack the components and parts on top of each other.  (3)Protect any instruments with plywood boards.	(1)Unpack and check the appearance for damage.  (2)Measure the insulation resistance of windings.  (3)Every six months, remove the rust inhibitor from the shaft ends and couplings, and check visually for rust development.  (4)Inspect the shaft journals every six months.  (5)For the anti-friction bearings, turn them every six months, and supply grease or replace the grease completely.	Every six months
Rotor			(1)Pretreat the shaft journal and oil slingers, and apply rust inhibitive oil.			
Bearings			(1)For sleeve bearings: Pretreat the spherical surface and babbitt metal, and apply rust inhibitive oil.  (2)In case of anti-friction bearings: Supply grease.			
Air cooler			Seal N <sub>2</sub> gas into the tube. 49kPa (0.5kg/cm <sup>2</sup> )	Protect the cooling fins to prevent damage.	Attach a pressure gauge, and monitor the N <sub>2</sub> gas sealed condition.	Every three months

## 4. Installation

 <b>WARNING</b>	
	<p>Be sure to remove the protective gear attached for transport before attempting to operate the unit. Failure to do this may result in breakage or overheating and subsequent burnout and injury.</p>

 <b>CAUTION</b>	
	<p>Do not place flammable materials near the motor. They may ignite and burnout.</p>
	<p>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.</p>
	<p>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.</p>
	<p>Do not touch the key groove of the electric motor shaft end by bare-handed. This may result in injury.</p>
	<p>Install the motor in a proper location that matches the operating conditions (temperature, humidity etc.) noted in specifications. Failure to do this may result in fire or electric shock.</p>
	<p>Prevent vibration more than specified condition generated by other machines from being transmitted to the motor through the foundation and floor. Failure to do this may result in injury because of damage and loosening of parts etc.</p>
	<p>Install the protection cover so as not to touch the rotation parts. Failure to do this may result in injury.</p>
	<p>Make sure the direction of motor rotation matches that shown in outline drawing and nameplates. Improper motor connecting may cause it to suffer overheating and damage.</p>
	<p>Do not put the obstacle that disturbs ventilation of the motor. This may result in the explosion, a fire or the burn because of an abnormal overheating.</p>
	<p>In the case of the motor with a fan cover, set distance from a fan cover to a wall to 200mm or more and don't bar an exhaust air. If distance is short, cooling will become insufficient, the motor could overheat and lead to burning.</p>

#### 4.1 Foundation design and engineering

For the design and construction of the foundation, expert knowledge of civil engineering is necessary that cannot be explained in detail here, but in the foundation preparation the following points should be considered.

- (1) The foundation should not only have enough strength to support static and dynamic loads of the motor itself, but also it must endure the mechanical vibrations.
- (2) The load supporting areas, shape and weight of the foundation should be determined so as not to develop ground subsidence, sliding, floatation and wandering.  
If the subsoil conditions are poor, the usual practice is to drive in piles and it should be considered that all loads are borne only by the piles. In this case, the supporting capacity of the soil is usually neglected.
- (3) When a ventilation duct is to be set in the foundation, care should be taken not to allow ground water into the duct. If water seeps into the duct, the coil insulation will deteriorate due to moisture.
- (4) During the first four weeks after concrete is poured, and particularly in the first one to two weeks, the concrete will increase its strength sharply. Thus, the concrete surfaces and boards should be covered with mats, cloths or sand and sprayed with water. They should be kept wet for at least one week in summer and at least two weeks in winter in order to ensure thorough curing.
- (5) Be sure to cover the anchor bolt holes to prevent foreign objects entering.
- (6) The upper surface of the foundation should be finished as flat as possible in order to facilitate the motor installation.
- (7) Chip the concrete foundation surface to a depth of about 50mm and roughen in enough to allow easy centering or increase adhesion between mortar and foundation.

#### 4.2 Centering and alignment

After the foundation has been cured completely, the centering and alignment work which is the most important in the motor installation is performed. The centering and alignment practices vary depending on the type of motor to be installed. Here we shall show a typical example, that is, a bracket type motor. When the driven machine has already been installed, the installation of the motor should be carried out with the coupling of the driven machine as a reference.

- (1) While checking the magnetic center gauge at the bearing end, adjust the rotor end play to the value specified in the drawing. The end play means the maximum axial play of the rotor. Standard end-play tolerances are as shown in Table 2, except when equipped with special thrust bearings, when requested from directly-coupled machines or when the end-play is slightly restrained as in the case of wound-rotor motors with brush-lifting devices. Adjust the axial center of the stator by measuring the relative positions of the stator and rotor cores.

Table 2 End play tolerances

End play (mm)	Tolerances (mm)
8 (End float=16)	+2.5 -2.5

- (2) As shown in Fig. 3, install the dial indicator onto the coupling of the motor side, measure the parallelism and the degree of eccentricity while quietly turning the rotor of the motor by using the coupling section, and adjust the shaft center. However, since this may vary depending on the type of the machine, also contact the machine manufacturer for further details.

Generally, for measurement of the parallelism, the thickness gage or taper gage is used, whereas, for measurement of the degree of eccentricity, a dial gage is installed on the coupling of one side and the shaft is turned by 0 degree, 90 degrees, 180 degrees and 270 degrees to read the values of the four locations. (see Figures 4 and 5)

Table 3 Alignment Reference Values (Unit: mm)

Speed of rotation		Over 1500 min <sup>-1</sup>	Over 1000 up to 1500 min <sup>-1</sup>	Up to 1000 min <sup>-1</sup>
Rigid coupling	Deviation of degree of eccentricity	0.02	0.03	0.04
	Deviation of parallelism	0.03	0.04	0.05
Gear coupling		0.06	0.08	Less than 0.1

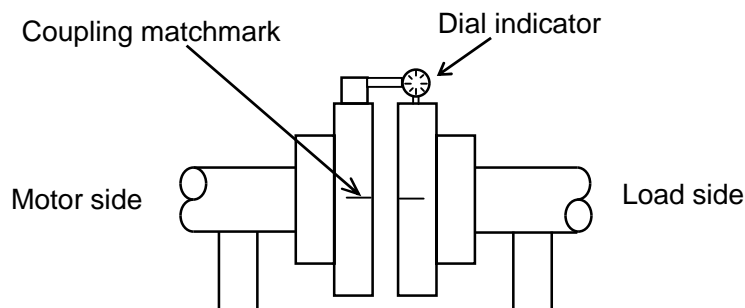


Fig. 3 Centering and alignment method with the coupling as a reference

**Measurement of degree of eccentricity**

Measure and record the values of the four locations with the dial gage by turning both shafts. Find the corrected value as shown below.

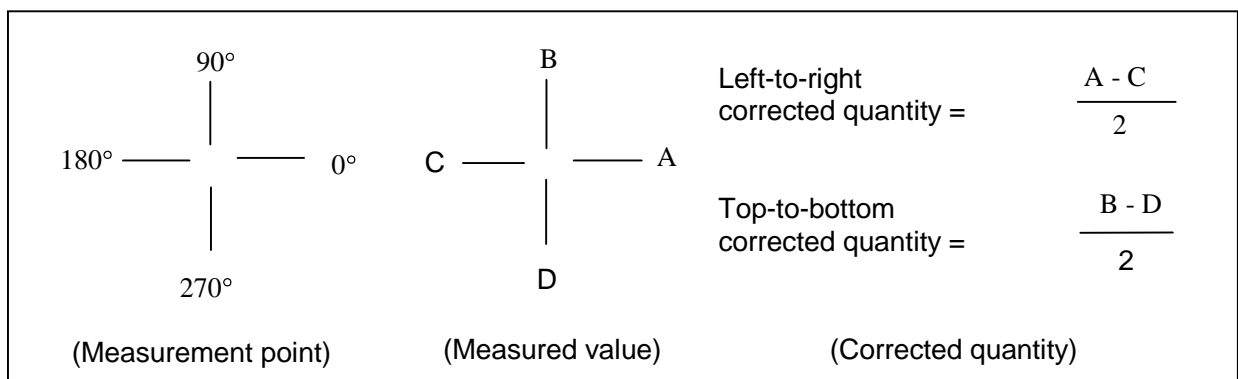


Fig. 4 Measurement of degree of eccentricity



### Measurement of parallelism

Measure and record the values of the four locations, E1, F1, G1, and H1, with a thickness gauge at the combination position of both shafts for the measurement of parallelism. Next, rotate the both shafts by 180 degrees, and then measure and record the values of the other locations, E2, F2, G2, and H2. Find the measured values as shown below.

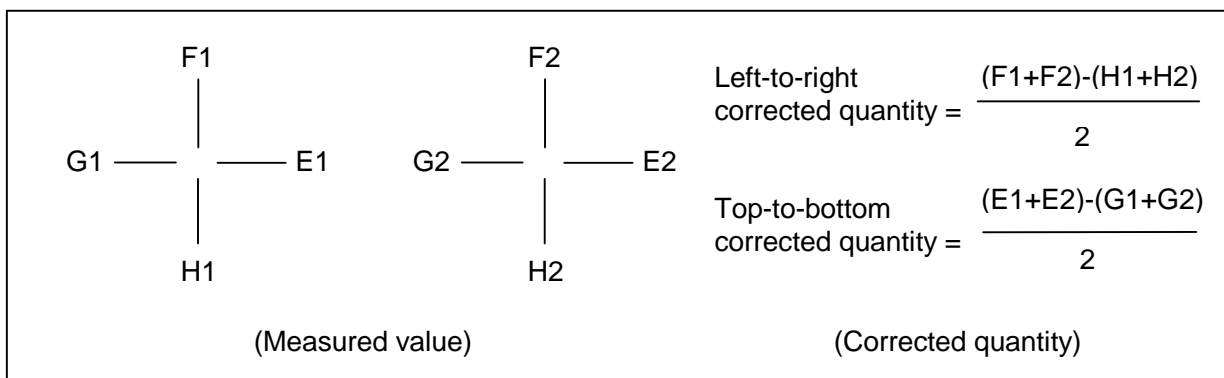


Fig. 5 Measurement of parallelism

If your machine system is large or runs at a high speed, high-level technique is necessary for adjustment at journals, or axial and radial runout adjustment at the coupling etc., because of taking into consideration rotor deflection or critical speed vs. running speed relationship, etc. We recommend that you ask us for expert technical assistance. Note) The end float means the total value of the both-side end plays.

- (3) Next, measure the gap between the stator and rotor at three or four positions for both the coupling side and the opposite side, and be sure that the differences between the maximum and minimum gaps is within 20% of the average values gap measurements.

#### 4.3 End play and damage prevention of sleeve bearings

When a sleeve bearing motor is run independently, the rotor turns at the magnetic center. If the rotor was shifted in the axial direction for some reason, a return force acts. Since this force is very small, the rotor can't return easily to the magnetic center if the rotor is held by an external force. When a flexible coupling is used on a high-speed machine, it becomes more difficult for the flexible coupling to slip in proportion to the increase in contact pressure to transmit the torque.

The flexible coupling has a movable distance in the axial direction, and should be less than the end play of the motor.

[1] There are cases that the motor end play becomes zero, because the coupling can move freely due to the absence of torque to transmit when the motor stops.

If the motor is restarted at this time, the bearing side surface of the motor will be in a state of metallic contact.

[2] If the motor shaft receives an axial thrust during rotation, the result will be the same as above.

In general, the end-play of the bearing of motor should have a greater value than that of flexible coupling or gear coupling, in order to prevent the burning of the bearing.

When installing the motor, check the dimensions in Fig. 6.

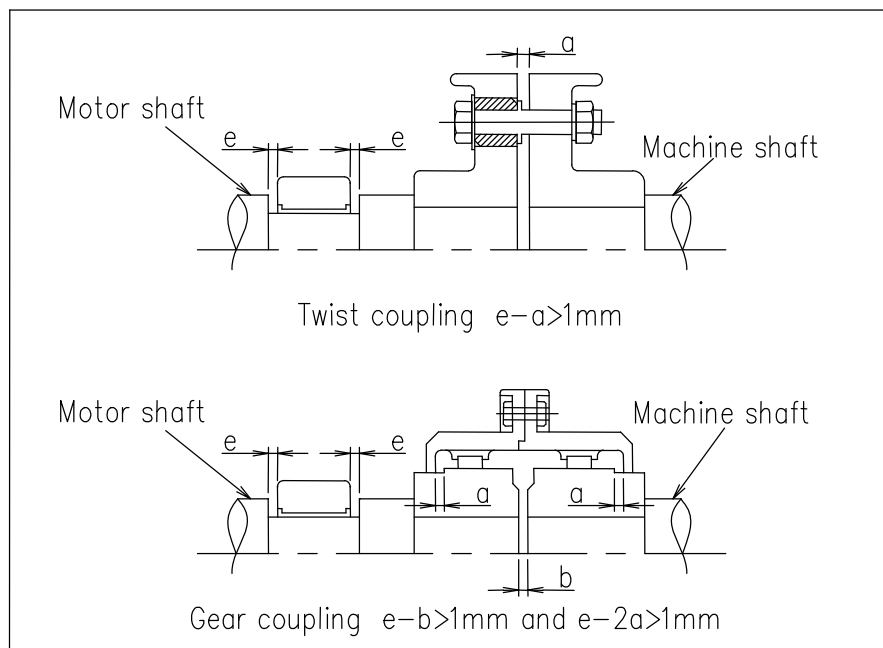


Fig. 6 Relation between the end-play of the bearing and the flexible coupling

The space of 1mm or more is necessary.

When assembling the two flanges, align the magnetic center gauge with the red datum-line of the shaft, in order to decide the position of the motor.

Note: *Examine the connecting surface of the coupling or faucet whether there are scars on it. If any, polish the surface gently with an abrasive stone.*

#### 4.4 Mortar grouting

After the motor has been installed correctly and the anchor bolts have been tightened, grout mortar under the base and into the anchor bolt holes.

In this case, pay attention to the following items.

- (1) Roughen the foundation surface in order to ensure adhesion of mortar after clearing thoroughly.
- (2) Spud the mortar to drive out cavities.
- (3) During mortar grouting work, take care not to move the packers and subpackers by mistake.
- (4) After the mortar has been grouted, thoroughly cure it by the same way as the foundation concrete work.

The curing period should be at least one week in summer and at least two weeks in winter.

After the concrete has cured enough, tighten up the anchor bolts, and check the record of the alignment workmanship. If there is nothing wrong with the installation, assemble the floor deck plates and piping, and drive dowel pins into the foot of the stator frame. For some motors, the dowel pins are driven in after trial run and readjustment.

#### 4.5 Prevention of shaft current

Shaft insulation is applied to the motor for prevention of harmful shaft currents. Usually, the shaft is insulated on the opposite side bearing to the load as shown in Fig. 7.

But when selecting a double shaft-end motor, the couplings should be insulated because it is also necessary to insulate on the opposite side coupling to the main load in addition to the above measure.

Refer to the bearing instruction manual for details of shaft insulation.

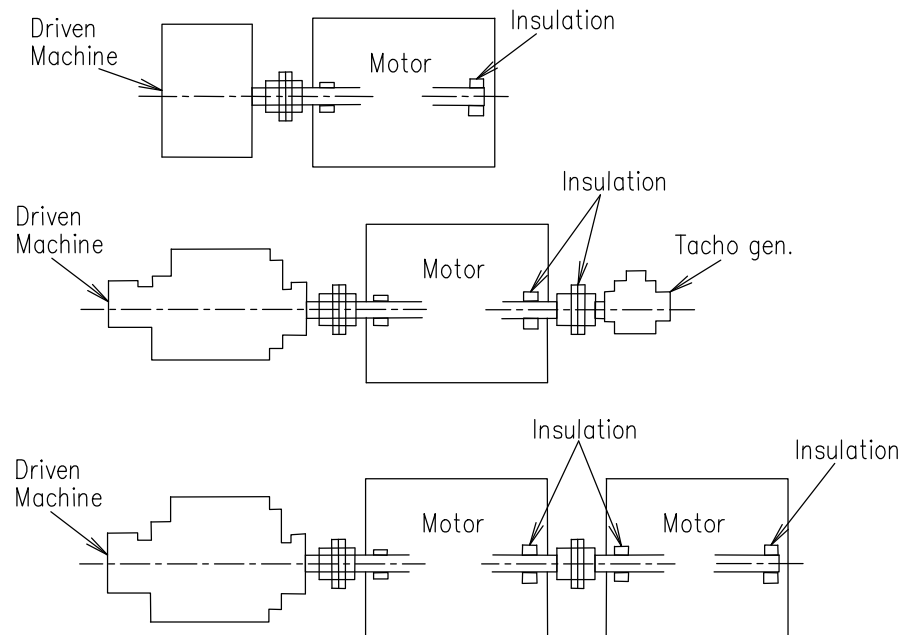
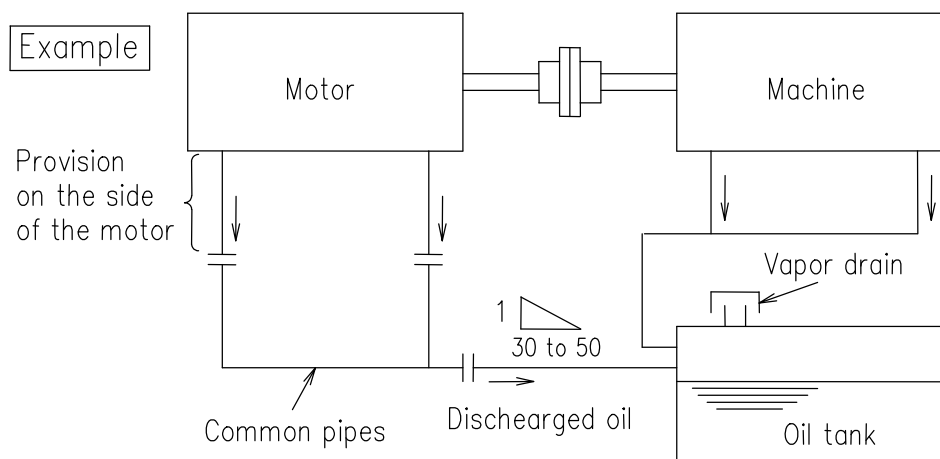


Fig. 7 Shaft insulation arrangement

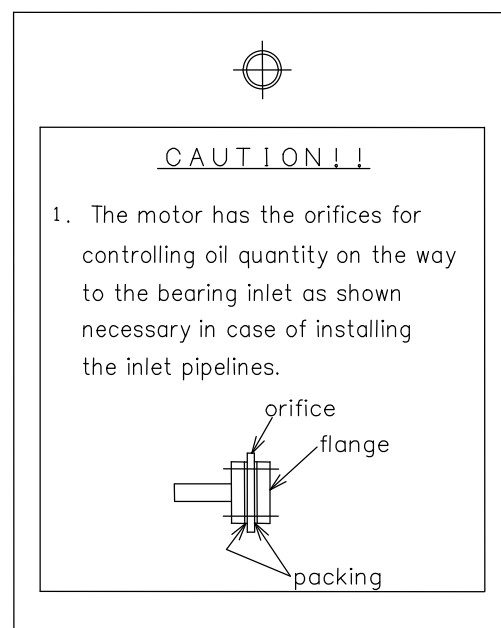
#### 4.6 Piping (For motors requiring external lubrication oil supply or water cooling)

When the piping system is designed and executed on your part, pay attention to the following points.

- (1) Prepare the oil discharge system of the motor as described below, in order that the vapor in the bearing on the machine side and the oil tank may not cause the counterflow into the bearing of the motor.
  - a) Separate the oil discharge pipes of the motor from those of the machine. Do not connect them in the middle.
  - b) Establish the oil tank with a vapor drain, which is big enough to have either [1] or [2], in order to decrease the inside pressure of the oil tank and of the pipes to a natural atmospheric pressure.
    - [1] a discharge drain without a fan
    - [2] a drain with an exhaust fan
  - c) As for the oil draining pipes from the common pipes to the oil tank, the gradient must be between 1/30 and 1/50. If the gradient of the oil draining pipes is not sufficient, and/or its cross section is too small, then, the oil won't flow smoothly, and it may overflow or cause a leak.
  - d) The pipe diameter must be large enough.









- (2) Be sure to attach a pressure gauge and a flow meter to the oil inlet line and the water supply line. Also provide an oil sight for the oil outlet line and a water sight for the water drain line to facilitate inspection of the pressure and flow of the fluids.
- (3) Install the piping along the machine body, and saddle them with proper fittings to prevent them from shaking.
- (4) Be sure to attach the orifice plate (refer to attached caution card) or flange type adjusting valve to the oil inlet. Since the size of the orifice plate or the valve opening has been adjusted in our factory, it should not be tampered with.







- 
- (5) The oil piping should be designed and adjusted with account taken of the oil pump, pressure regulator and other pipes so that the pressure and flow rate specified in the outline drawing can be attained at the motor bearing inlets.
- (6) Make sure that there are no foreign objects like rags left inside the pipes. Then, clean them thoroughly and connect them. The cleaning before the pipe connection is accomplished in one of the following two methods. One method is to blow in steam at a pressure of 200 to 300 kPa. The other is to pickle with 10% aqueous solution of sulfuric acid or hydrochloric acid, neutralize immediately with a 20% aqueous solution of caustic soda, and then rinse with water. Either method should be followed by lubrication with turbine oil for preventing rust.
- (7) Return oil lines utilize gravity for flow. This requires the lubrication oil system to be below the motor bearing elevation and a continually dropping elevation of the return oil piping.
- (8) After the piping has been completed, it should be flushed thoroughly before being fitted to the motor bearings. The flushing can be carried out by using the oil feed pump furnished together with the motor or a separate oil pump which doubles as a filter. When the flushing has been carried out by using the oil feed pump, be sure to clean the oil tank thoroughly before a trial run. Since flushing oil circulating in the piping system is including foreign matter, it should not be run into the bearing metals. Specifically, the piping should be modified to bypass the bearing metals and to connect the inlet and outlet lines at the outside of the bearing housing. The flushing oil returning to the oil tank should be passed through an 80-to 100-mesh wire filter. The flushing will be complete when foreign matter is no longer trapped by the filter. The filter should be replaced at an interval of several hours. The flushing will take 24 to 48 hours, or as long as a week if the piping is long. For the purpose of flushing, prepare reclaimed oil as well as fresh oil. The flushing oil is used by heated to 70°C to 80°C. During flushing operations, hammer the pipes to dislodge incrustations from the pipe inner walls and scour them away with the running oil. Clean the bearing housings, bearings, oil tank and oil cooler thoroughly, and make sure that there is no foreign matter left in the piping system. After the flushing has been completed, set up the original piping, charge fresh oil, and check for oil leaks and adjust the oil quantity to prepare for the trial run.

## 5. Wiring

	
	Connect the earthing conductor to the earthing terminal of the motor. Without grounding may result in electric shock.

	
	Connect the power cable according to the connection wiring diagram in the terminal box or the manual. Failure to do this may result in electric shock.
	Do not excessively bend, pull or kink power cables and motor lead wires. This may result in electric shock.
	Use the tightening torque specified when tightening bolts. If bolts are not tightened to the proper torque, they may break or may result in overheat and fire.

	
	Use cables of the proper size. Failure to do this may result in overheating and fire.
	Wire according to the specification, standards and regulations. Failure to do this may result in burnout or fire.
	Attach a ground relay or other suitable protective relay to the power source side and be sure to attach a ground line to the earthing terminal on the motor. Failure to ground the motor may result in electric shock in the event of current leakage.

### 5.1 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.

### 5.2 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	Grounding wire (mm <sup>2</sup> )
1	1000kW or more~	100
2	750kW or more~1000kW	80
3	300kW or more~750kW	60
4	37kW or more~300kW	38

### 5.3 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.

- (1) Wire the main circuit cable between the inverter and motor with the shortest possible wire to reduce the inductance. Use a shield cable (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.)

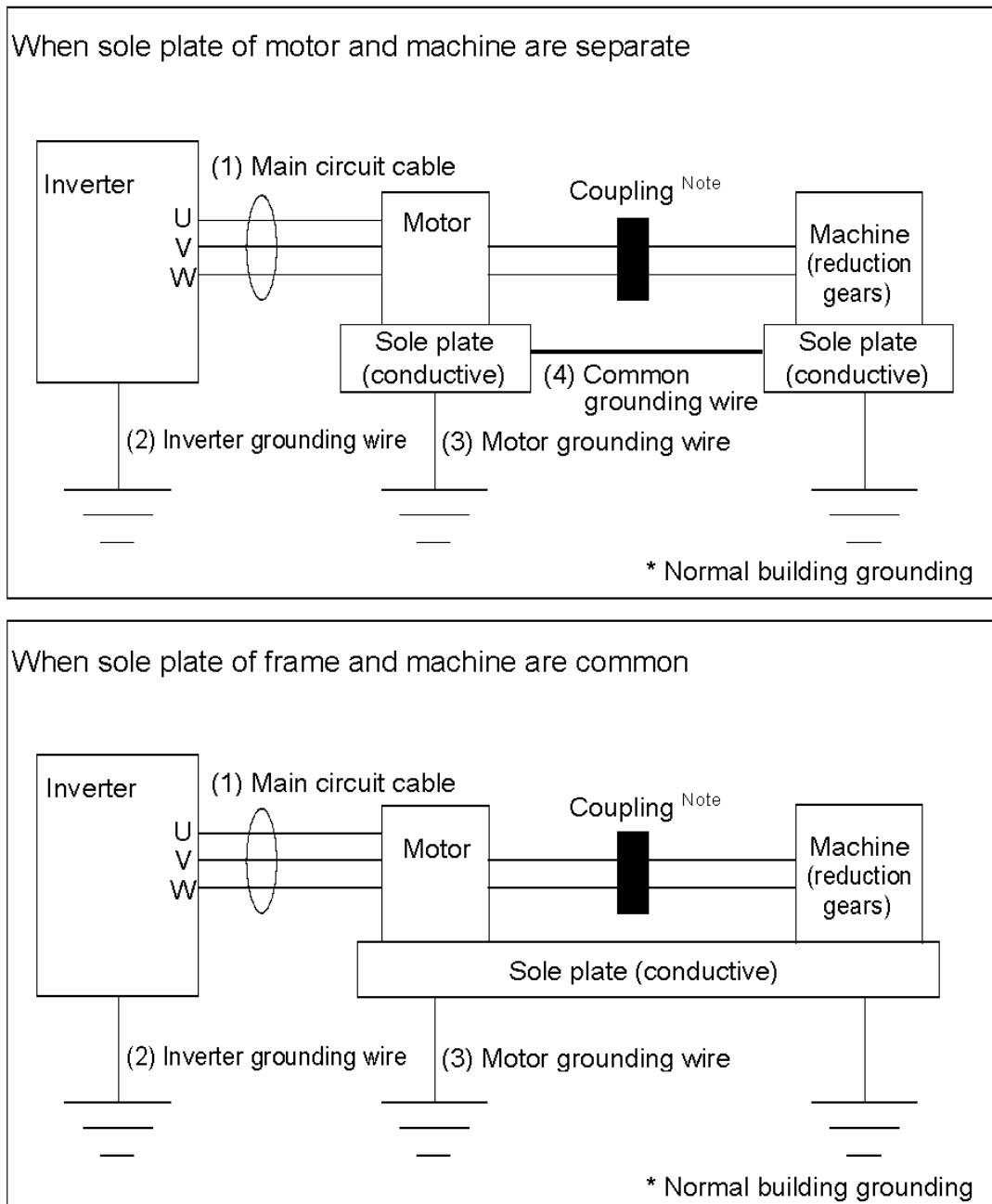


Fig. 8 Grounding wire connection

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



#### (5) Earth Brush (Grounding Brush)

##### 1) Function

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

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

##### 2) Attachment

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

##### 3) Maintenance

Brush wear varies due to running speed and environmental conditions. Check the brush once every 1-2 month. Fig. 9 shows the earth brush maintenance nameplate. Replace the brush before it reaches the indicated limit.

##### 4) Replacement

If you change the brush, contact your nearest TMEIC Representative for more details. A brush performance is influenced.

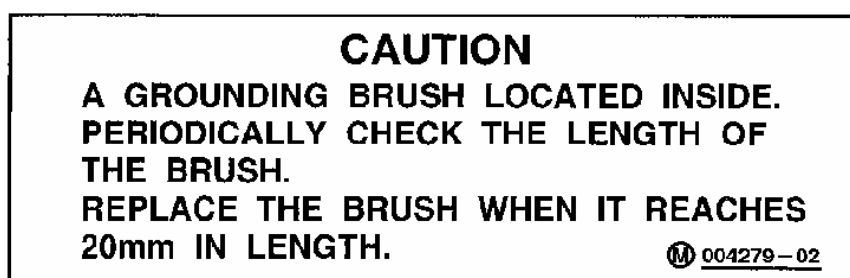









Fig. 9 Shaft earth brush inspection methods

#### 5.4 Precautions for Y- $\Delta$ 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- $\Delta$  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- $\Delta$  starting, install a protective device to suppress the switching surge when turning ON and OFF the motor (especially a vacuum switch).

## 6. Preparations and inspections before trial run

	
	During and immediately after measuring, the terminals may in part carry dangerous voltages and must not be touched. This may result in electric shock.
	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.
	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.
	Use a voltage changeable device for the withstand voltage test. Failure to do this may result in electric shock.
	After insulation measurement, never touch with hands before discharge. This may result in electric shock.
	Before starting operation, be sure to remove the key attached to the shaft. Failure to do this may result in injury.

The motor has passed strict factory tests.

But we cannot prevent accidents during transportation or harmful effects during long-term storage.

Thus, pay attention to the following items.

## 6.1 Measurement of insulation resistances

If the rated voltage is less than 600V, use a 500V megger. If it is 600V or more, use a 1000V megger.

For insulation resistances, refer to the section titled as insulation resistance.

## 6.2 Inspection of electrical circuits

Check the wiring for power supply circuits and protective devices based on the wiring diagram.

Also inspect tightening condition in each connection, insulation, and clearance where no electrical contact is allowed.

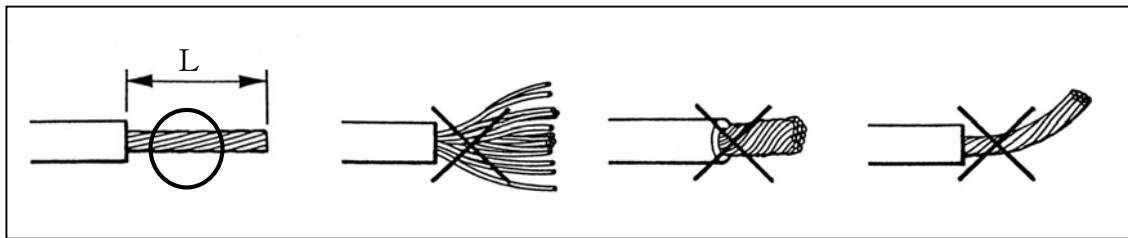
Especially when a current transformer (CT) is installed, confirm that its secondary terminals are connected to a measuring instrument or are short-circuited. If used with the secondary terminals left open, a high voltage will arise between the terminals, which can sometimes damage the CT.

## 6.3 Terminal connection in auxiliary terminal box

If not specified, terminal blocks for wiring of protective devices may be WAGO type without screws. When connecting terminals, please see outline drawing of terminal box or instructions of next page, and connect terminals properly.

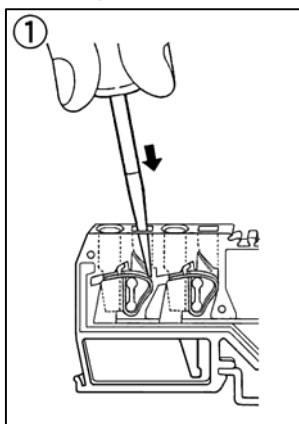
**Instruction for connecting conductor (WAGO Rail Mount Terminal Blocks with CAGE CLAMP)**

**Stripping of Wire** Please strip a conductor's stripped length related as drawings.  
Please fix splayed, bent or twisted wire.

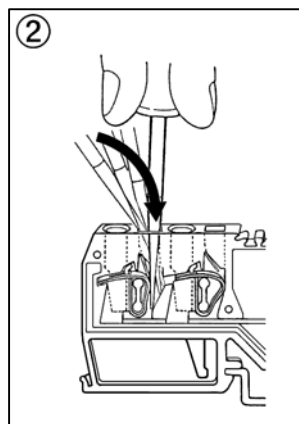


Conductor's stripped length (Std)	For space heaters (WAGO 282)	: 12 to 13 mm
	For RTD's etc. (WAGO 870)	: 6 to 7 mm

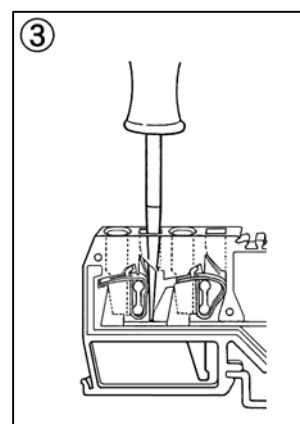
**Connecting** Please follow the instructions.



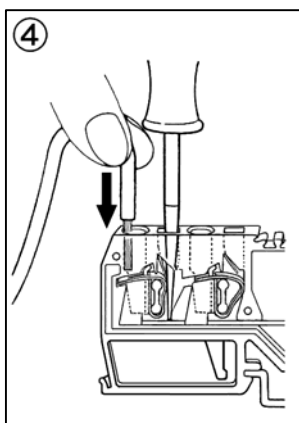
[1] Put a screwdriver to the operating slot.



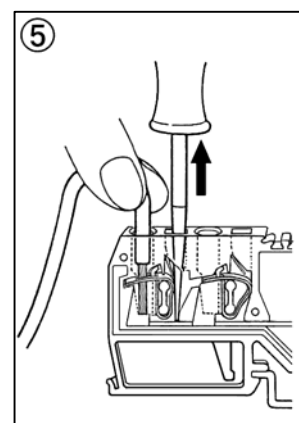
[2] Insert a screwdriver to the inside of the terminal block.



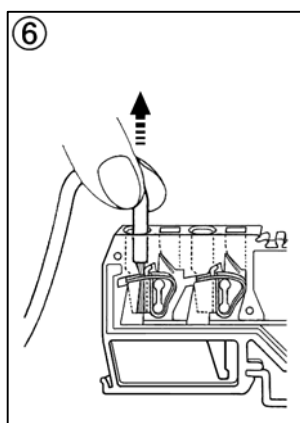
[3] The screwdriver will be fixed when operated correctly.



[4] Insert a wire to the wire hole.



[5] Pull out a screwdriver from the operating slot. (Please hold a wire.)



[6] Pull a wire slightly to check if connecting has been done completely. (Do not pull strongly.)

**Removal** Operate a screwdriver in the same way with connecting.  
Open a spring and pull out wire.

#### 6.4 Inspection of grounding wires

Grounding terminals are provided on the stator frame and terminal box. Check them with the outline drawing and make sure that the grounding wires are connected properly.

#### 6.5 Bearings

For the inspection of the bearings, refer to the bearing cooling system described in the motor specifications and outline drawing. If the bearing cooling system is not stated, the bearings are the natural cooling type; the anti-friction bearings are lubricated by grease, and the sleeve bearings are lubricated by oil rings. Be sure to use greases and oils specified in the nameplate or outline drawing.

- (1) Natural cooling type (anti-friction bearings)  
Grease has been filled in the bearings at the factory.  
Confirm whether there is grease leakage on the shaft, oil slinger, or bearing housing, etc.
- (2) Natural cooling type (sleeve bearings)  
Fill lubricant up to the level marked on the oil gauge.  
Oil supply over the oil gauge level may result in oil leakage, and oil shortage may lead to excessive temperature rise.
- (3) Forced feed lubrication type  
Confirm that the orifice plate of bearing or flange type adjusting valve is fitted.  
After checking the lubricating system according to the piping diagram, circulate the specified lubricant. During check the oil flow, oil pressure and oil circulation through the oil site make sure that the piping has not trace of oil leakage.

## 6.6 Dielectric strength test

Measure the insulation resistance, and make sure that it is higher than the specified limit. Then conduct a dielectric strength test according to the following procedures.

The test voltage to be impressed should have an effective value specified below and should be free of harmonics. The test voltage should also be adjustable up to a specified value. To test the motor, increase the test voltage to a specified value at the rate of 1000V/sec. Keep the test voltage at that value for a specified period, and then reduce it to zero immediately.

(Caution: When impressing the test voltage, be sure to use a device capable of adjusting the test voltage. Never impress or cut off the full voltage directly by making use of a switch.) After the dielectric strength test has finished, be sure to discharge the tested winding. Never touch the windings until they have been discharged.

To carry out the dielectric strength test, connect together those terminals which are rated at the same voltage, and impress a specified test voltage between this connection and the ground. All other windings except those to be impressed with the voltage must be grounded.

When a specific phase or a part of a specific winding is subjected to a dielectric strength test, disconnect the ends of that phase or that part completely and connect the ends together. Impress a test voltage between the ends and the ground.

All other phases and windings should be grounded in advance. Since a high voltage is used in the dielectric strength test, take care to shield people from electric shock by keeping them away from the motor during the test.

For the rules concerning the dielectric strength test voltages, refer to the specific technical standards applicable.

Excerpts from the Technical Standards for Electrical Instruments.

Chapter 1; Section 3, "Insulation and Earthing of Distribution Line"

### Article 15

The generators, motors, synchronous condensers and other rotating machinery (exclusive of rotary converters) shall withstand for consecutive 10 minutes the test voltages specified below in relation to their maximum service voltage when applied between their windings and the ground.

The test voltage shall be 1.5 times as high as the maximum service voltage if the maximum service voltage is up to 7,000V.

(If the test voltage calculated as above is less than 500V, it shall be set at 500V.)

The test voltage shall be 1.25 times the maximum service voltage if the maximum service voltage is higher than 7,000V.

(If the test voltage calculated as above is less than 10,500V, it shall be set at 10,500V.)

Further, the foregoing dielectric strength test voltage apply to new motors, and when the dielectric strength test is being conducted after a regular inspection, etc., it is necessary to review the voltage value.





## 6.7 Others





Check for loosened bolts, nuts, dowel pins and connections. Unless otherwise designated, use the tightening torques listed in Table 4 when tightening bolts.






Table 4 Specified torques for bolt tightening

Screw nominal	Reference value Nm	Tolerable range Nm
M5 × 0.8	3.24	2.75 ~ 3.63
M6	5.49	4.71 ~ 6.37
M8	13.2	11.3 ~ 15.3
M10	26.5	22.6 ~ 30.4
M12	46.1	39.2 ~ 53.0
M16	110	93.2 ~ 127
M20	216	181 ~ 245
(M22)	284	245 ~ 333
M24	363	314 ~ 422
M30	735	628 ~ 843
M36	1280	1090 ~ 1470
M42	2050	1750 ~ 2350
M48	3090	2650 ~ 3520
M56	4950	4220 ~ 5680
M64	7350	6280 ~ 8420

## 7. Trial run

 <b>DANGER</b>	
	Do not operate with the cover of the terminal box detached. This may result in electric shock.
	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 operation, never touch or come near rotating parts. You may be caught in the mechanism and injured.

 <b>WARNING</b>	
	Do not operate after removing or disabling protective fixtures and safety equipment (including lids and covers). This may result in electric shock or injury.
	Do not allow anyone other than those handling the equipment to go close to the motor during operating. This may result in electric shock or injury.
	If a separate power source is used for ventilation and cooling equipment, that power has to be turned on before the motor operation. Failure to do this may result in overheating and lead to fire.





 <b>CAUTION</b>	
	If in doubt, switch off the drive immediately. Failure to do this may result in electric shock, injury, fire.
	Do not touch the external surface of the motor directly during operation. This may lead to the burn.
	Do not place flammable materials near the motor. They may ignite and burnout.
	Do not operate the motor without being short-circuited of the current transformer's secondary terminals. This may arise a high voltage between the terminals and damage the CT.




At first, after running the motor independently by disconnecting the intermediate shaft, etc. from the motor and confirming that there is no problem, connect it to its driven machines, and run together.

Whenever energizing the motor including a trial run, be sure to attach the cover to the terminal box.



- 1) Measure the supply voltage to check if the line voltages are balanced and are roughly in agreement with the rated motor voltages.
- 2) When starting the motor, keep the driven machine free from or at minimum possible load. Cut off the power source immediately after starting and perform the following inspection while it is rotating freely by inertia.
  - (1) Confirm that the motor is running in the rotating direction specified in the outline drawing or in the rotational arrow plate.
  - (2) Confirm that the bearing oil ring is turning normally.
  - (3) Confirm that there are no abnormal noises or vibration, or there is no smell insulating materials burning.
- 3) If there is no abnormalities under the above inspection, restart the motor and inspect the bearing temperature, vibration, end play and oil ring rotation.
- 4) Continue the no-load running until the bearing temperature reaches saturation. After confirming that there are no abnormalities, proceed to full-load operations.







8. Normal run

	
	Do not operate with the cover of the terminal box detached. This may result in electric shock.
	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 operation, never touch or come near rotating parts. You may be caught in the mechanism and injured.

	
	Do not operate after removing or disabling protective fixtures and safety equipment (including lids and covers). This may result in electric shock or injury.
	Do not allow anyone other than those handling the equipment to go close to the motor during operating. This may result in electric shock or injury.



	If a separate power source is used for ventilation and cooling equipment, that power has to be turned on before the motor operation. Failure to do this may result in overheating and lead to fire.
	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.

 <b>CAUTION</b>	
	If in doubt, switch off the drive immediately. Failure to do this may result in electric shock, injury, fire.
	Do not touch the external surface of the motor directly during operation. This may lead to the burn.
	Do not place flammable materials near the motor. They may ignite and burnout.
	Do not operate the motor without being short-circuited of the current transformer's secondary terminals. This may arise a high voltage between the terminals and damage the CT.
	For motors equipped with filters, clean the filter periodically. Filter clogging may result in overheating and burnout.

## 8.1 Starting



- (1) Confirm that the starting conditions have been established.
  - (a) Oil are lubricated to the bearings in the case of forced lubrication system.
  - (b) When a starting device is used, the circuit is set up to suit the starting conditions.
- (2) During the starting, check that the starting is normal.
  - (a) Starting current
  - (b) Starting time
- (3) In case of starting failure, follow the conditions of starting duty.  
For details, refer to the section "starting duty of motor".  
When the motor is restarted immediately after the power source was cut off, even if restarting is possible, the motor is likely to be damaged because of an abnormal starting current caused by the residual induced voltage. Therefore, wait for 10 sec to restart after the power source was cut off.




- (4) To restart after a long-term stop of two weeks or more, check the following.
  - (a) Insulation resistance measurement of the motor circuit.  
When it does not satisfy the values noted in section 10.3, dry with a space heater, etc., and restart after the insulation resistance has recovered.
  - (b) The oil level should be in the indicated line.
  - (c) Upon starting, the noise, vibration and oil ring turning condition should be as usual.
  - (d) Conduct the routine inspection of Table 5-1.
- (5) Starting abnormalities  
Check by Table 11. When the cause and conditions cannot be determined, contact us.

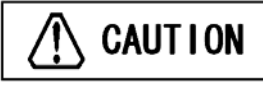


8.2 Running







During a run, check by Tables 5-1 and 5-2 to confirm that there are no abnormalities.

9. Maintenance

	
	Turn off the power before touching the motor surface or terminals. Conducting operations with live wires may result in electric shock.

	
	Connect the power cable according to the connection wiring diagram in the terminal box or the manual. Failure to do this may result in electric shock.
	Only qualified persons inspect around the brush mounted on the motor according to the manual. Failure to do this may result in electric shock or the mechanism.

	
	Please contact our company when you maintain the explosion-proof motor. It becomes impossible to keep the explosion-proof performance.
	The specified repair, maintenance, and overhaul must be carried out regularly by trained service person. Failure to do this may result in electric shock, injury and fire.

	Rope off the work area to prevent people other than work personnel from entering. Failure to do this may result in electric shock or becoming caught in the machinery.
	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.
	Do not place flammable materials near the motor. They may ignite and burnout.
	During and immediately after measuring, the terminals may in part carry dangerous voltages and must not be touched. This may result in electric shock.
	Do the regreasing or discharging in accordance with manual not to touch the rotating parts. Failure to do this may result in injured.
	Check the main terminal box periodically and check that there are not corrosion, deterioration of packing, etc. There is fears of the earth fault, the short-circuit, and the terminal box dispersion, etc.

The service life of motor is dependent largely upon maintenance. Record the data at regular intervals according to the following maintenance and inspection standard.

The data logging makes clear the trend of motor conditions to prevent troubles.

#### 9.1 Contents of inspection

The inspection of the motor may be divided into the following two groups according to their contents.

##### 9.1.1 Daily inspection

Inspect the motor by a visual check, sense of touch, sense of hearing, etc. on its external appearance.

##### 9.1.2 Regular inspection

- (1) Simplified inspection  
After dismounting the motor and its cover, inspect the coil end and the bearing metal especially. (About every 2 years)
- (2) Full-scale regular inspection  
By pulling out the rotor from the motor, check the internal parts minutely. In addition, regarding the auxiliary equipment such as lubricating devices. Check it according to the respective manuals, as same in the case of the motor.

#### 9.2 Interval of regular inspection

The basic idea for maintenance inspection is systematic monitoring. For this purpose, it is important to carry out the inspection continuously at proper intervals on necessary items.

The extent and interval of the regular inspection should be determined by taking

the operation environment, starting duty, the starting time, and characteristics important to the driven machine, into account.

- (1) Simplified inspection  
Simplified inspection should be performed between full-scale inspections, at your convenience.
- (2) Full-scale regular inspection
  - (a) Initial inspection  
1-2 years after starting operation is recommended  
There are cases where so-called initial failures are induced by causes such as the structural adaptation to the environment, entry of foreign objects during transportation or assembly at site, fit of structures, etc. The maintenance inspection that removes these initial failure factors at the proper time after starting operation is extremely effective for long-term trouble-free operation.
  - (b) Interval of regular inspections after the initial inspection  
About every 4 years after the initial inspection is recommended

### 9.3 Major inspection items

At the time of the daily inspection and regular inspection, the inspection should be carried out according to maintenance and inspection standards as shown in Table 5 to 8, including the following major inspection items.

- (1) Check for the looseness of stator coil wedges and stator coil end bound by strings  
The core slot part of the stator coil and the coil end part are prevented from looseness caused by the electromagnetic vibration acting on the coils by means of wedges and binding strings. The coil, wedges, spacers and binding strings, etc. are composed of insulators, and sometimes the wedges and binding strings become loose due to electromagnetic vibration during operation and the changing fit from the heat cycle. If these are left for a long period, insulator wear off and insulation may break down because the coils are caused to oscillate by the electromagnetic force and mechanical vibration. Therefore, it is necessary to inspect them at regular interval.
- (2) Check for the looseness, dislodgment of soldered parts and axial movement for rotor bars  
In the case of the squirrel cage type induction motor, fatigue progress on the rotor bars, the short-circuit rings and its soldered part because of thermal stress and electromagnetic force caused by inrush current at the starting time and centrifugal force caused by rotation act on them. When checking the rotor at the regular inspection, etc., there may be cases where the rotor bars are slackened, all of the rotor bars shifted in the axial direction, and the soldered parts between the rotor bars and the short-circuit ring are partially dislodged. If operation continues under this condition, cracks and breakage may develop in the rotor bar end part, the end part is expanded in the radial direction by the centrifugal force, thus causing damage to the stator coil and developing insulator breakdown. Therefore periodic inspection of these items is important.
- (3) Bearing  
The bearing periphery needs inspection for temperatures, abnormal noises, the scars on the journal surface due to vibrations, and foreign objects. In particular, the bearing periphery pay attention to (a) metal contacts and scars, (b) movement, deformation and abrasion of oil rings, (c) oil blackening or grease discoloring (d) oil level (e) oil leakage.

- (4) Dust adhering to the stator coil and ventilation duct space of the core  
 Dust adhering to the stator coil will worsen the thermal conduction, and dust adhering to ventilation duct space of the core will reduce the amount of cooling air. Both causes lead to increase of temperature rise.  
 In case dust adhesion is found, either determine the cleaning interval appropriate to the dust quantity or take countermeasures to prevent dust intrusion.
  
- (5) Checking the looseness of the stator core saddle plate stud and bolt fastening parts  
 The saddle plate which supports the stator core is fixed to the frame with studs and nuts (these are bolts if the machine is bipolar). Due to torque reactions and machine vibrations resulting from operation, the stud and bolt fastening parts may become loose. Leaving this unattended for a long time may cause the adjustment plate to fall off or the stator to move thus resulting coming in contact with the rotor. Therefore, it is necessary to periodically check the looseness of the stud and bolt fastening part and tighten the bolts more, as shown in Fig. 10 .

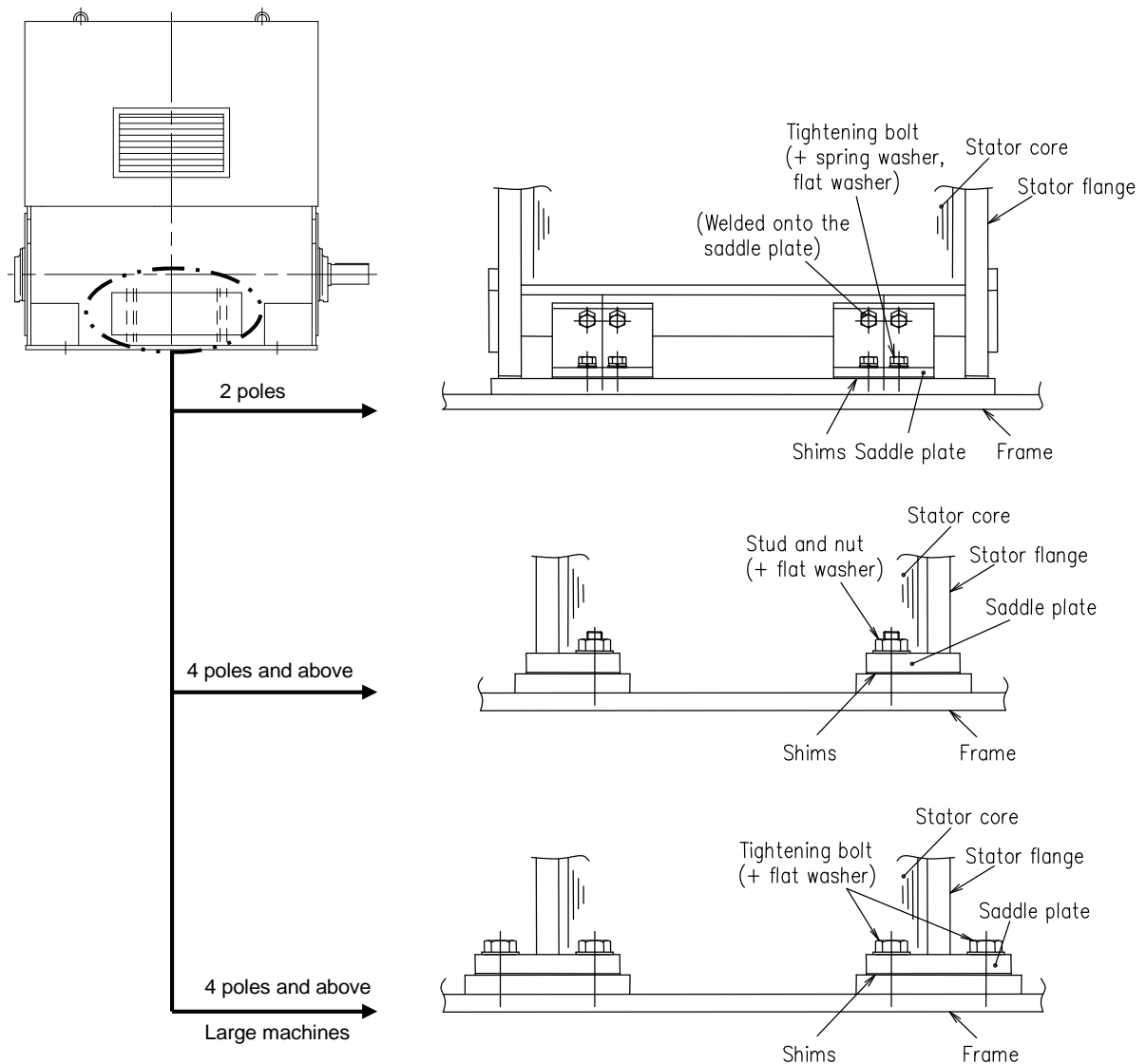


Fig. 10 Stator inner part fastening method

9.4 Test run after inspection

Execute the test run after the maintenance inspection according to the contents of item 6 and item 7.

Table 5-1 Maintenance and inspection standard - Daily inspection (during motor operation)

Category	Inspection procedure			Requirements
	Subject of inspection	Inspection cycle	Method of inspection	
1. Power source	Voltage	Daily	Voltmeter	Limit: Within $\pm 10\%$ of rated values at rated frequency.
	Frequency	Daily	Frequency meter	Limit: Within $\pm 5\%$ of rated values Where the voltage and frequency change concurrently, the sum of the absolute values of their changing ratio shall be within 10%.
2. Running conditions	Vibration	Weekly	Sense of touch and vibrometer	Where the vibration is felt to increase over ordinary level, measure the value. Judge the vibration level according to section 10.4.1.
	Current	Daily	Ammeter	The current shall be less than the rated value, and shall be in order.
	Odor	Daily	Sense of smell	No burning smell.
	Noise	Daily	Sense of hearing and stethoscope	Check the noisy parts and use a stethoscope if necessary.
	Temperature (frame, bearing, coil)	Daily	Sense of touch, thermometer	No change in temperature rise from the values at the initial time.
	Cover and the like	Weekly	Visual inspection	No falling off and loosening of fixing bolts.
	Ladder and platform	Weekly	Visual inspection	No falling off and loosening of fixing bolts. No corrosion
3. Environment	Ambient temperature	Weekly	Thermometer	Within the standard values and normal
	Ventilation	Weekly	Visual check	No blockage in the ventilation grills, etc: The motor blower, if working, is normal.
4. Bearing	Temperature	Daily	Sense of touch, thermometer	When the temperature is sensed as abnormal, measure it with a thermometer.
4.1 Sleeve bearing				Temperature limits of self-cooled bearings: Up to 92°C, measured at the metal lower half (reading value)
	Oil level and oil leakage	Daily	Visual inspection	Be normal oil level.
	Oil pressure	Daily	Visual inspection	Be normal.
4.2 Anti-friction bearing	Oil ring	Daily	Visual inspection	Be rotating smoothly.
	Rotating noise	Daily	Sense of hearing, stethoscope	Be normal
	Temperature (includes oil slinger)	Daily	Sense of touch, thermometer	When the temperature is sensed as abnormal, measure it with a thermometer. Temperature limits (reading value): Up to 100°C, measured by embedded thermometer Up to 95°C, measured on surface of housing
	Grease fill-up	As specified	Grease gun	Refill as required.

Table 5-2 Maintenance inspection standard - Daily inspection (during motor operation)

Category	Inspection procedure			Requirements
	Subject of inspection	Inspection cycle	Method of inspection	
5. Cooler	Water leakage	Daily	Visual check	No leak
	Water pressure	Daily	Pressure gauge	Specified pressure
	Water flow	Daily	Flow sight	Flowing

Table 6 Maintenance inspection standard - Daily inspection (when the motor is stopped)

Category	Inspection procedure			Requirements
	Subject of inspection	Inspection cycle	Method of inspection	
1. Cooler	Check in detail the troubles recorded on the service log	Monthly	Service log	
2. Appearance	Damage and dirt on the frame and terminals	Monthly	Visual check	Clean and make repairs
	Cooling pipes, air duct and filter	Monthly	Visual check	Cleaning of found clogging
3. Bearing				
3.1 Sleeve bearing	Oil contamination	Monthly	Visual check	No sludge babbit metal chaffings or any other foreign objects
3.2 Anti-friction bearing	Discharged grease	Monthly	Drain port	No metallic powder or any other foreign objects, or contamination in grease
4. Earth brush (when attached)	The amount of brush wear	Monthly	Visual check	Check the amount of brush wear with reference to the following page, and exchange brushes according to the wear extent.



### Inspection and exchange of earth brush

The earthing brush may be attached near the bearing of a motor in order to prevent a harmful shaft current. Some structures of earthing brush attachment are shown below, and please check the amount of wear of a brush at the time of a motor stop. Brush exchange should make the position of illustration a standard and should carry it out a little early.

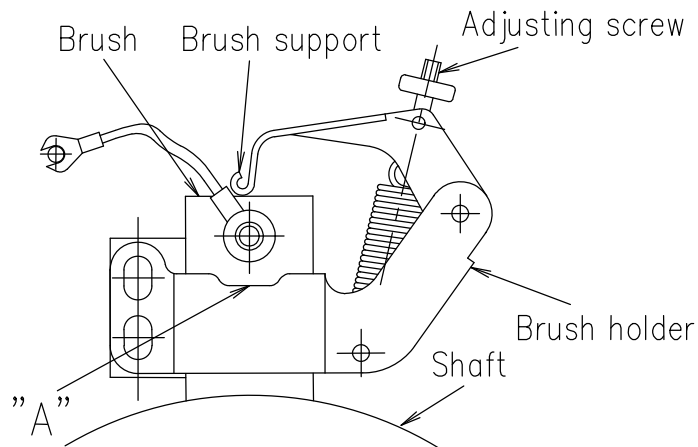
#### [Example #1]

1. When the top of a brush comes to the position of "A", exchange the brush for a new one.
2. If the wear extent of a brush is greater than 1mm per a month, adjust brush pressure within 18 to 22 kPa with adjusting screw.

#### Measuring method:

Put a thin paper between shaft and brush, and measure brush pressure to pull up the support of a brush holder with a spring scale.

The brush pressure measured by a spring scale should be about 1kg when the paper can be pulled out.



#### [Example #2]

This structure is a constant-pressure spring system.

Remove a brush at the time of a motor stop, and carry out a check of the amount of brush wear and cleaning.

When it wears out from the metal plate of a brush to about 10mm as shown in a figure, exchange the brush for a new one.

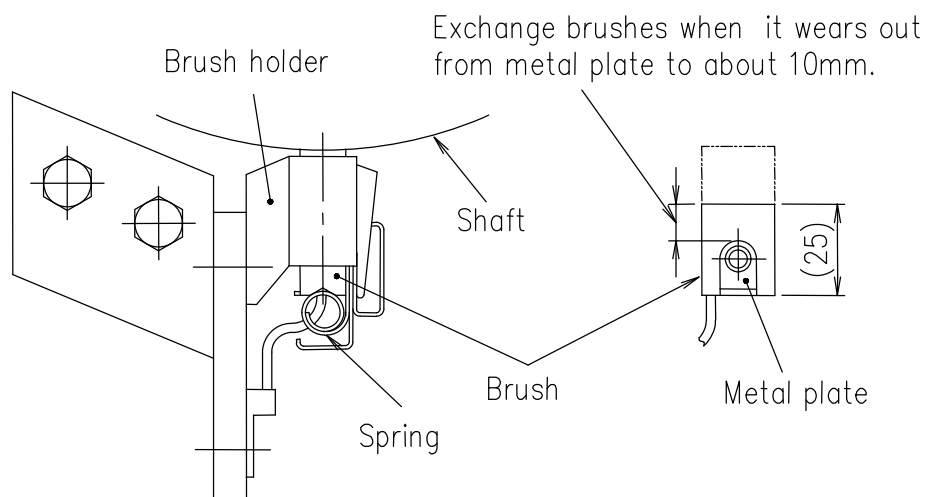


Table 7-1 Maintenance inspection standard - Regular inspection (Simplified inspection, field disassembly of the protective cover upper half and bearing housing upper half for inspection)

Category	Inspection procedure			Requirements
	Subject of inspection	Inspection cycle	Method of inspection	
1. Investigation	Check in operation log for abnormalities	2 years	Service log	Make repairs if necessary
2. Measurement	Coil insulation resistance	2 years	Megger	Desired values of stator coils $R \geq kV + 1 \text{ (M}\Omega\text{)}$ where R: minimum insulation resistance at 40°C kV: rated voltage (kV)
	Air gap	2 years	Gap gauge	$\frac{\text{Max, value} - \text{min, value}}{\text{Mean value}} \times 100 \leq 20\%$
3. Appearance	Pollution or worn painting on the frame	2 years	Visual check	Cleaning and repairs
	Terminals	2 years	Visual check	Repair if abnormal
	Filter	2 years	Visual check	Clean and repair (Replace when necessary)
	Bolt joints	2 years	Visual check	Freedom from looseness, dropping off and damage.
4. Stator	Core and coil	2 years	Visual check	Freedom from dust, oil, moisture and foreign objects.
	Core	2 years	Visual check	Freedom from unevenness, overheating, discoloring, damage, rust, etc.
	Core ends	2 years	Visual check	Freedom from tumble or protrusion of air duct spacers, loosened or damaged core sheets.
	Coil ends	2 years	Visual check	Freedom from deformations, damage and pollution
	Insulating materials	2 years	Visual check	Freedom from varnish spouting, void and tracking, etc.
	Wedge	2 years	Visual check	Freedom from loosening
	Coil supports	2 years	Visual check	Freedom from shifting, getting out and loosening
	Air deflector	2 years	Knocking sound Visual check	Freedom from loosening and cracks
5. Rotor	Core	2 years	Visual check	Freedom from rust, loosening, dust, oil, moisture, other foreign objects, overheating, discoloring and damage
	Connection of rotor bars and end ring	2 years	Visual check	Freedom from cracks and bar shifting

Table 7-2 Maintenance inspection standard - Regular inspection (Simplified inspection, field disassembly of the protective cover upper half and bearing housing upper half for inspection)

Category	Inspection procedure			Requirements
	Subject of inspection	Inspection cycle	Method of inspection	
6. Bearing				
6.1 Sleeve bearing	Metal Contact	2 years	(Overhaul inspection of bearing) Visual check (magnifying glass)	Lower metal to be in good working order Upper metal to be free from contact marks
	Metal adhesion	2 years	Color check	50% or more
	Metal clearance	2 years	Micrometer	Refer to sleeve bearing instruction manual
	Oil slinger	2 years	Thickness gauge	Within limit
	Oil ring	2 years	Visual check	Freedom from deformation and serious wear: freedom from loosened setscrew
	Oil	2 years	Visual check	Freedom from dirt, deterioration and foreign objects
	End play	2 years	Thickness gauge Scale	Within limit Refer to Sect. 4.2 Table 2.
6.2 Anti-friction bearing	Grease con-termination	2 years	Visual check	Grease replacement
7. Instruments	Dirt, damage	2 years	Visual check	Freedom from dust, oil, moisture, foreign objects and damage
8. Coupling	Deviation of degree of eccentricity and parallelism	As required	Dial gauge	Within tolerances, Refer to Sect. 4.2.
	Centering	As required	Dial gauge	Within tolerances, Refer to Sect. 4.2.
	Direct coupling	As required	Visual check	Freedom from the loosening of the bolts and nuts.
	Damage	As required	Visual check  (color check if required)	Freedom from damage and breakage of key way  No abnormal wear on tooth surface of the gear coupling.
9. Operation on load	Abnormal noise, vibration abnormal odor	2 years	Sense of hearing Sense of touch Sense of smell	No abnormality
	Rotational direction	2 years	Visual check	Normal rotational direction
10. Shaft current	Protective device	2 years	Visual check Tester	After cleaning, measure insulation resistance : 0.5M $\Omega$ or more at single motor when disassembled

Table 8-1 Maintenance inspection standard - Regular inspection  
(Full-scale regular inspection by drawing out the rotor)

\* Cycle 4 years shows the intervals from the initial inspection. The initial inspection shall be 1-2 years from the start of operation (Refer to Sect. 9.2)

Category	Inspection procedure			Requirements
	Subject of inspection	Inspection cycle	Method of inspection	
1. Investigation	Check the operation log for abnormalities	4 years	Service log	Make repairs if necessary
2. Measurement	Shaft level		Level meter	Measure the level at both journals, and make sure that the difference is within 0.05 mm/m.
	Coil insulation resistance	4 years	Megger	More than specified values Refer to Table 7.
	Space heater insulation resistance	4 years	Megger	More than 1k $\Omega$ with a 500V megger
3. Appearance	Air gap	4 years	Gap gauge	Refer to Table 7
	Pollution or worn painting on the frame	4 years	Visual check	Cleaning and repairs
	Filter	4 years	Visual check	Clean and repair (Replace when necessary)
4. Stator	Bolt joints	4 years	Visual check	Freedom from looseness, dropping off and damage.
	Core and coil	4 years	Visual check	Freedom from dust, oil, moisture and foreign objects.
	Core	4 years	Visual check	Freedom from unevenness, overheating, discoloring, damage, loosening, rust, etc.
	Core ends	4 years	Visual check	Freedom from tumble or protrusion of air duct spacers, loosened or damaged core sheets.
	Air ducts	4 years	Visual check	Freedom from clogging
	Coil ends	4 years	Visual check	Freedom from deformations, damage and pollution
	Insulating materials	4 years	Visual check	Freedom from varnish spouting, void and tracking, etc.
	Coil supports	4 years	Visual check	Freedom from shifting, getting out and loosening.
	Wedge	4 years	Hammering	Freedom from withering, loosening and falling off.
	Coil binding strings	4 years	Visual check	Freedom from shifting, loosening, discoloring and deterioration.
	Lead cable and terminals	4 years	Sense of touch Visual check	Freedom from damage, deterioration and deformation of terminals. Freedom from dust, oil, moisture and adhering foreign objects.
	Air deflector	4 years	Visual check	No abnormality in the welded part. No loosened bolts.
	Space heater	4 years	Visual check	Freedom from loosened fastener parts, dust, oil, moisture and adhering foreign objects.
5. Rotor	Core	4 years	Visual check	Freedom from rust, loosening, dust, oil, moisture, other foreign objects, overheating, discoloring and damage

Table 8-2 Maintenance inspection standard - Regular inspection  
(Full-scale regular inspection by drawing out the rotor)

Category	Inspection procedure			Requirements	
	Subject of inspection	Inspection cycle	Method of inspection		
6. Bearing	Joint of rotor bars and end ring	* 4 years	Visual check Color check	Freedom from cracks. Dislocation of silver solder shall be less than 50% for each side of joint surface. No bar shifting.	
	Rotor bar	4 years	Hammering	Freedom from loosening.	
	Fan	4 years	Visual check	Freedom from fan blade deformation.	
	Balance weight	4 years	Hammering	Freedom from loosening.	
	Shaft journal		Visual check Sense of touch	Freedom from scars, knock marks, pressing marks.	
	6.1 Sleeve bearing	Metal contact	Yearly	(Overhaul inspection of bearing) Visual check (magnifying glass)	Lower metal to be in good working order Upper metal to be free from contact marks
		Metal adhesion	Yearly	Color check	More than 50%
		Metal clearance	Yearly	Micrometer	Refer to sleeve bearing instruction manual.
		Oil slinger	Yearly	Thickness gauge	Within limit
		Oil ring	Yearly	Visual check	Freedom from deformation and serious wear: freedom from loosened setscrews
		Oil	Yearly	Visual check	Freedom from dirt, deterioration and foreign objects
		End play	Yearly	Thickness gauge Scale	Refer to Sect. 4.2 , Table 2
6.2 Anti-friction bearing	Grease con-termination	Yearly	Visual check	Grease replacement	
7. Instruments	Correction	* 4 years	Comparison with standard	Within standard values.	
8. Coupling	Deviation of degree of eccentricity and parallelism	As required	Dial gauge	Refer to Sect. 4.2.	
	Centering	As required	Dial gauge	Refer to Sect. 4.2.	
	Direct coupling	As required	Visual check	Freedom from the loosening of the bolts and nuts.	
	Damage	As required	Visual check	Freedom from damage and breakage of key way	
9. Operation on load	Abnormal noise, vibration abnormal odor	Yearly	(color check if required) Sense of hearing, touch, and smell	No abnormal wear on tooth surface of the gear coupling. No abnormalities	
	Rotational direction	Yearly	Visual check	Normal rotational direction	
10. Cooler	Inside inspection	* 4 years	Visual check	Freedom from abnormal corrosion and pinholes.	
11. Piping	Hydraulic test	4 years	Hydraulic test	Freedom from leakage and deformation.	
	Damage	4 years	Visual check	Freedom from loosened fastenings, water leakage, oil leakage and corrosion.	
12. Shaft current	Protective device	Yearly	Visual check Tester	After cleaning, measure insulation resistance : 0.5MΩ or more at single motor when disassembled	

## 10. Basic knowledge for maintenance and inspection

## 10.1 Starting duty

The standard allowable starting duty for each squirrel-cage induction motor is specified to enable the concerned motor to start rotation twice consecutively under the state in which the motor is cooled to the ambient temperature or enable it to start rotation once after operation at the rated load.

When the motor starts, it receives a high level of thermal and mechanical stress as a result of starting currents and electromagnetic vibrations. Therefore, frequently repeated starts/stops are undesirable for its service life. Therefore, if a frequency of at least four starts per day is planned, it is necessary to use a motor for frequent starts.

## 10.2 Limit of temperature rise

In case the reference ambient temperature is 40°C, the limits of temperature rise standardized in JEC-2137 become as shown in the following Table 9 (Since the value may vary for other standards, refer to the specific standard applicable for details.)

Table 9 Limits of temperature rise of air-cooled induction machines  
(JEC-2137 supplement 1:2009-5) (Unit K)

Item	Induction machine part	Thermal class A			Thermal class E			Thermal class B			Thermal class F			Thermal class H		
		Method of temperature measurement Th : Thermometer method R : Resistance method ETD : Embedded temperature detector method														
		Th	R	ETD	Th	R	ETD	Th	R	ETD	Th	R	ETD	Th	R	ETD
1	Stator windings															
	a. Output: 500kW or more	-	60	65	-	75	80	-	80	85	-	100	110	-	125	130
	b. Output: In excess of 200kW; less than 500	-	60	65	-	75	80	-	80	90	(1)	105	115	-	125	135
	c. Output: No more than 200kW and other than d and e(2)	(1)	60	-	(1)	75	-	(1)	80	-	(1)	105	-	(1)	125	-
	d. Output: Less than 600W	(1)	65	-	(1)	75	-	(1)	85	-	(1)	110	-	(1)	130	-
	e. Self-cooled mold type without cooling fans(2)	-	65	-	-	75	-	-	85	-	-	110	-	-	130	-
2	Insulated rotor winding	50	60	-	65	75	-	70	80	-	85	105	-	105	125	-
3	Squirrel-cage winding	The temperature of this part must not have harmful impacts on its insulating materials and neighbouring materials.														
4	Commutator, slip-ring, brush															
5	Coils and all structure components (excluding bearings) regardless of contacts with winding															

Notes 1: If agreed upon between the manufacturer and the purchaser, the decision can be made in accordance with the thermometer method.

2: When applying the overlay equivalent load method is applied to the winding of the induction machine whose heat-resistance classes are A, E, B and F and ratings are no more than 200kW, it is all right to exceed the temperature increase limit of the resistance method by 5K only.

The insulation degradation for the winding of the induction machine is mainly caused by heat and local discharge.

As other deteriorating factors, mechanical fatigue, pollution, and absorption of moisture should be considered.

The windings cause early insulation degradation and the motor life is proportionately shortened when the motor temperature rise remains higher than the limit of temperature rise allowable by fouling of the air duct.

### 10.3 Insulation resistance

The insulation resistance is an important value for checking the reliability of the insulation.

The insulation resistance changes depending on the motor output, voltage, speed, insulation class, temperature, moisture, degree of pollution on insulator surface, test voltage, and duration of test voltage applied, etc. Thus, it is very difficult to judge from the insulation resistance only whether the reliability of the motor is high or not. There are no clear standards concerning what the insulation resistance should be.

However, we have set the following values as reference.

$$R \geq kV + 1 \quad (M\Omega)$$

where,

R: minimum insulation resistance at 40°C

kV: rated voltage (kV)

The measurement of the insulation resistance should be carried out at the motor terminals for the stator winding and rotor winding.

For the stator windings, use a 500V megger when the rated voltage is less than 600V, and use a 1,000V megger when it is 600V or over.

Further, the value after the voltage is applied for one minute should be used as the measured insulation resistance. At this time, it is also important to record the measured winding temperature.

As reference, the insulation resistance secured in our factory is generally as follows.

Stator winding    More than 300MΩ

### 10.4 Vibration

Each motor is sufficiently balanced in our factory. But vibration may increase, when directly coupled with the driven machine, under the influences of insufficient coupling accuracy, vibration caused by the driven machine or the installed condition on the foundation or base.

Excessive vibration possibly incurs fatigue failure of the shaft, bearings, core, windings, etc., and may cause insulation trouble, destruction of the foundation, etc. It is very important, therefore, to maintain and monitor each motor so that its vibration is kept within allowable range.

#### 10.4.1 Allowable values of vibration

JEC-2137 defines that "the rated voltage and the rated frequency are used to perform no-load operations and the vibration speed at this time is measured." Our company defines the goal value of the vibration speed on the on-site bearing bracket as follows:

Vibration speed goal value: No more than 4.5 mm/s r.m.s.  
(On a single motor unit at site)

Conventionally, this is evaluated with the vibration amplitude value. One of the most famous comprehensive surveys of the allowable values of general machine vibration is VDI2056 complied by the VDI Vibration Expert Committee of Germany. ISO also shows how to measure and evaluate the allowable value of vibration in terms of the vibration severity.

These allowable values are, as it were experientially recommended value of vibration, variable with the installed condition.

Shown in Fig. 11 are allowable values of vibration that we recommend. Fig. 11 shows allowable values of vibration measured per frequency spectrum, and when the vibration exceeded the corresponding value indicated by the S line which represents the standard level to require some measures against vibration for long use, a suitable countermeasure must be taken in accordance with the result of investigation into the cause of the vibration increase.

#### 10.4.2 Causes of vibration

The following cases must be taken into consideration as the cause of vibration.

##### (1) Mechanical vibration

###### (a) Vibration with constant amplitude

The following cases, when the amplitude doesn't change at any time under the constant speed and voltage, are taken into consideration.

###### (a-I) The frequency is number of revolution

###### (i) Vibration caused by unbalance

- Bad installation .... Imperfect or improper connection with foundation.
- Bad direct coupling with machine .... Insufficient straightness of coupling.
- Misalignment .... Eccentricity of mutually coupled shafts.
- Vibration increased gradually by unbalance in weight .... Sticking of dust upon core and fan etc; withering of insulator.
- Shortage or reduction of the inadequate or impaired fit between rotor core and shaft.

###### (ii) Bending trouble of shaft

###### (iii) Insufficient rigidity or resonance of structural members

Resonance with structural members or excessive vibration due to poorly installed foundation.

###### (iv) Metallic contact with stationary parts (bearing, etc.)

The direction of whip is opposite to the rotating direction.

###### (v) Unbalance of air gap caused by eccentricity of rotor

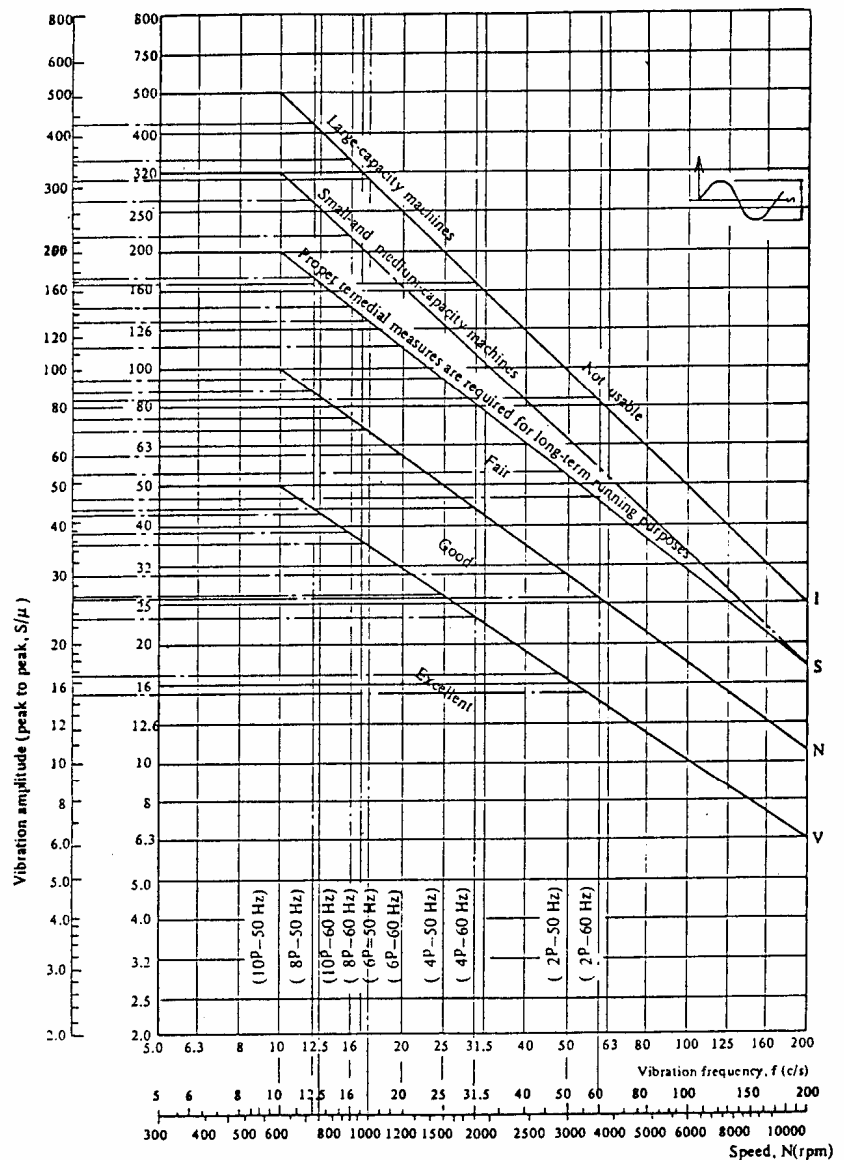
The vibration is increased by electromagnetic force whenever voltage is induced.



Peak to peak values (Unit  $\mu\text{m} = \frac{1}{1000}\text{mm}$ )

Allowable value of Vibration (Overall)	Number of Poles	2P	4P	6P	8P or over
	Frequency				
Single motor	50 Hz	20	30	30	40
	60 Hz	20	25	30	40
Rated load operation after directly coupled	50 Hz	30	50	50	50
	60 Hz	26	43	50	50

Allowable value  
of Vibration  
(by frequency  
spectrum)



- Notes 1. The measuring location shall be on the top of the bearing housing.
2. Each value indicates one after directly coupled.
3. The vibration frequencies show the maximum amplitudes of the actually measured vibration; be aware that they do not necessarily agree with the synchronous frequency on the motor.

Fig. 11 Allowable vibration frequency spectrum value

- (a-II) The frequency is twice of the synchronous one
    - (i) Bearing is deformed elliptically.
    - (ii) The fit between rotor core and shaft is insufficient in a specific direction.
  
  - (b) Vibration with changeable amplitudes
 

The following cases, when the amplitude change with time under the constant speed and voltage, are taken into consideration.

    - (b-I) The frequency is the same as the synchronous one
 

Bending trouble of shaft caused by heat distortion  
The countermeasure, as it is complex phenomena with vibration caused under the influence of thermal factor, is very difficult.  
It is very important to classify the causes and characteristics systematically.  
Bending troubles of shaft caused by heat are as the following.

      - (i) Bending trouble of shaft caused by thermal expansion of rotor conductors.
      - (ii) Labyrinth seal is contact lightly with the shaft, or bearing is contact in a specific direction.  
In the case of vibration caused by thermal factor, the vibration phase often changes. Especially, the change of the phase, in case of the above (ii), become periodically.
    - (b-II) The frequency is not related to the synchronous one.
      - (i) Oil whip
 

Oil whip caused under the influence of oil film in the bearing becomes a large vibration. The whirling speed is nearly equal to the critical speed of shaft, and the whirling direction agrees with the rotation one.  
The vibration is generated when the rotational speed reaches twice or more as high as the critical speed.  
Oil whip is generated easily in proportion to the smaller eccentricity of the bearing.
      - (ii) Oil whirl
 

Although the above oil whip causes a large vibration, there is, on the other hand, a phenomenon that vibrates at 1/2 frequency of the shaft speed even if the shaft rotates at low speed.  
This is called oil whirl. Like oil whip, the whirling direction agrees with the rotational one, and it is generated easily in proportion to the smaller eccentricity of the bearing.
- (2) Electrical vibration  
This vibration occurs as a result of mechanical resonance caused by electromagnetic force.
- (a) The frequency is twice of source one
 

The vibration is caused by unbalance of air gap, unbalance of source voltage, unbalance of stator winding, or looseness of stator core, etc.
  - (b) The frequency is multiples of source one
 

It is vibration by deforming force on radical direction of the stator core generated as the result of a bat slot combination.
  - (c) The frequency is twice of slip one
 

It is vibration by magnetic unbalance generated as the result of unbalance of air gap on 2 pole motor, looseness of rotor core, or break of rotor bar.
  - (d) Beat
 

It is vibration with beat caused by twice source frequency as the result of unbalanced air gap coinciding with the frequency which is the number of poles times slip (example: twice slip frequency in 2 poles machines).

### 10.4.3 Investigating the causes of increased vibration

The causes of increased vibration must be investigated systematically. Generally, the investigation should be carried out in the following procedure.

- (a) Classify the causes into electrical and mechanical ones. Turn off the power source, and investigate how the vibration changes. If the vibration is ascribable to electrical causes, it will disappear.
- (b) Check whether the vibration is due to the driven machine. Disconnect the driven machine, and check the motor alone.
- (c) Measure the change of vibration frequency, amplitude and phase.
- (d) Check whether the amplitude changes with time.
- (e) Check the alteration of the amplitude when the rotational speed changes, to judge whether the vibration is caused as the result of resonance or not.
- (f) Check the vibration with reference to the alteration of lubricant temperature, temperature of motor inside, bearing temperature, etc. and also check the shaft behavior.
- (g) Arrange the data to analyze the cause of vibration.

### 10.5 Noise

Typical causes of motor noise generation are described in the following Fig. 12.

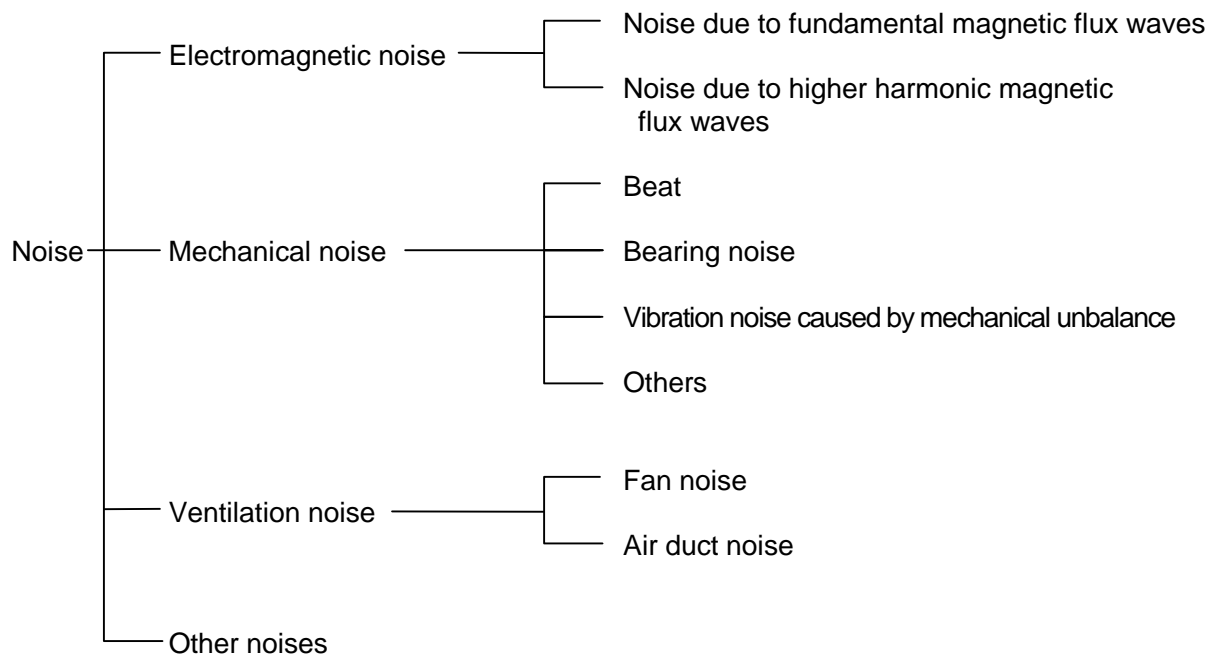


Fig. 12. Typical causes of noise generation

(1) Electromagnetic noise

Electromagnetic noise is caused when magnetic flux in the air gap between the stator and rotor is transmitted to the stator core, frame, or rotor. Electromagnetic noise is easily discriminable from noise caused by mechanical force since it immediately stops when the power supply to the motor was disconnected.

(a) Noise caused by fundamental waves of magnetic flux

Electromagnetic noise comprises noise whose frequency is twice as high as the supply frequency. This noise is amplified when the air gap length, magnetic circuit or primary voltage becomes unbalanced. Thus, when this noise becomes excessive, it is necessary to check the air gap, etc.

(b) Noise caused by higher harmonics of magnetic flux

Main causes of this noise are the force based on higher harmonics of magnetic flux ascribed to slot combination. Usually, this noise frequency is 1,000Hz or more.

(c) Beat

This noise is caused by the unbalance on the secondary resistor, or the eccentricity or deformation of the rotor. The frequency is twice as high as the slip frequency. When this noise is caused, it is necessary to check the rotor.

(2) Mechanical noise

Mechanical noise are classified into bearing noise and stator resonance noise.

(a) Bearing noise

Bearings are generally classified into sleeve bearing and anti-friction bearing.

Noise isn't caused by the sleeve bearing unless it has a large gap in the radial direction.

Noise caused by the anti-friction bearing is complex. Main causes of anti-friction bearing noise are shown in Fig. 13.

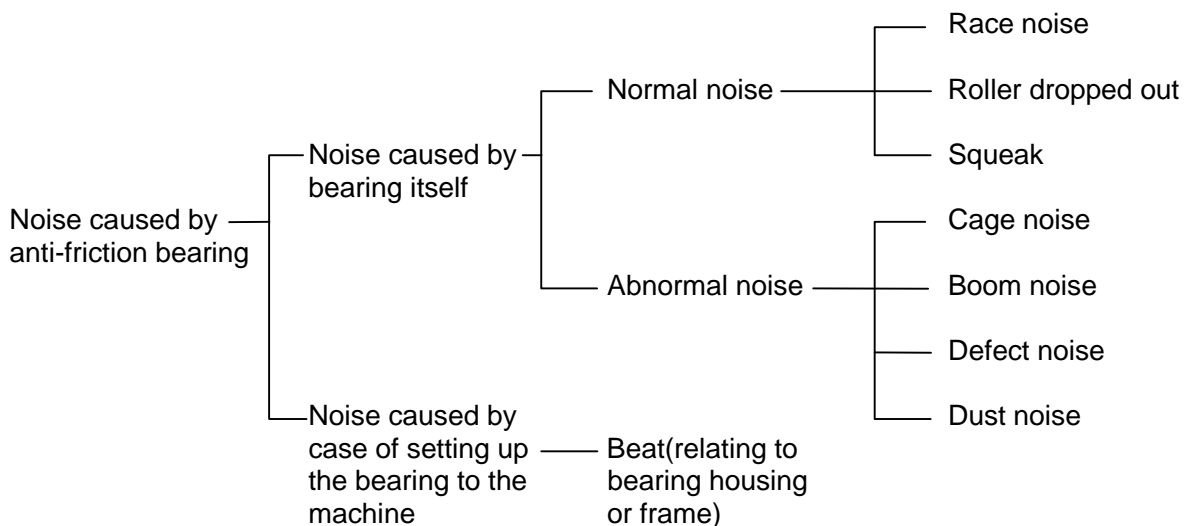


Fig. 13. Noise caused by anti-friction bearing

Of these, race noise (basic noise having the frequency of 1,000Hz or more), roller dropped out noise and squeak are classified as normal. The remainder are referred to as abnormal. Typical of abnormal noises is defect noise.

Defect noise is caused by defects on the raceways or rolling elements. The noise frequency becomes higher in proportion to the motor speed or the number of rolling elements.

It is necessary to replace the bearing if defect noise is found.

(b) Vibration noise caused by mechanical unbalance

If the balance of the rotor was disturbed, the motor generates vibration noise at the equivalent frequency to the number of revolutions because of excessive force acting on the bearing.

The frequency caused by this phenomenon is generally low; thus, it is no problem as the motor noise.

(3) Ventilation noise

Ventilation noise usually has a uniform spectrum over a wide frequency range, and it also contains unique frequencies concerned with the number of fan blades, the number of ducts, etc.

(a) Fan noise

Fan noise is governed by the shape and speed of the fan. Generally, fan noise becomes larger as the speed and size of the fan becomes higher and larger.

(i) Noise caused by rotation of fan

This noise is caused as the fan blades give the impact by pressure on air periodically. The fundamental frequency is equal to the product given by multiply the number of blades by the speed.

(ii) Vortex noise caused by fan blades

There is a pressure gradient across the fan blades, and the air flow makes a vortex. The noise caused by vortices usually has a uniform spectrum over a wide frequency range.

(b) Duct noise

When the stator and rotor have air ducts in the radial directions, the relative movement of the stator and rotor slots in the circumferential direction generates compressional waves at the inlet and outlet of the air duct, causing the so-called siren effect.

This frequency is usually high, and its fundamental frequency is equal to product given by multiply the number of ducts by the speed.

## 10.6 Influences of power source fluctuation

JIS, JEC, and IEC show the following (1) and (2) for the influences of fluctuating power source. Therefore, it is no problem, in practice, to use the motor within this range. Influences of fluctuations on motor characteristics are shown in Table 10.

(1) Voltage variation

Induction motors, except those with special requirements for starting characteristic or breakdown torque, shall operate without any practical difficulty at the rated output, even if the terminal voltage varies within  $\pm 10\%$  of the rated value at the rated frequency.

(2) Frequency variation

Induction motors shall be operated without any practical difficulty at the rated output, even if the frequency of the power source varies within  $\pm 5\%$  of the rated value.

And, even if the voltage and frequency of the power source vary simultaneously, the motor shall operate without any practical difficulty at the rated output, as long as the variations of voltage and frequency remain within  $\pm 10\%$  and  $\pm 5\%$  of the rated values respectively and the sum of the absolute percentage values in each variation does not exceed 10%.

Table 10. Influences of characteristics on motor with regard to the fluctuations

Starting and maximum torque	Synchronous speed	% slip	Full-load speed	Full-load current	Starting current	Temperature rise at full load	Magnetic noise Particularly no-load condition
-----------------------------	-------------------	--------	-----------------	-------------------	------------------	-------------------------------	--

Voltage change

110% voltage	(+)21%	unchanged	(-)17%	(+)0.4%	(-)7%	(+)10 to 20%	(-)3 to 4%	(+) slight
Relation with voltage	(voltage) <sup>2</sup>	constant	$\frac{1}{(\text{voltage})^2}$	—	—	(voltage)	—	—
90% voltage	(-)19%	unchanged	(+)23%	(-)0.5%	(+)11%	(-)10 to 12%	(+)10 to 15%	(+) slight

Frequency change

105% frequency	(-)10%	(+)5%	practically no change	(+)5%	(-) slight	(-)5 to 6%	(-) slight	(+) slight
Relation with frequency	$\frac{1}{(\text{frequency})}$	(frequency)	—	—	—	$\frac{1}{(\text{frequency})}$	—	—
95% frequency	(+)10%	(-)5%	practically no change	(-)5%	(+) slight	(+)6 to 7%	(+) slight	(+) slight

Note: (+) denotes increase, and (-) decrease

## 10.7 Influences of unbalanced voltage of the power source

## (1) Definition of the voltage unbalance ratio

Generally, the voltage and current unbalance ratio are expressed as follows.

Voltage unbalance ratio =

$$\frac{\text{Negative phase sequence voltage}}{\text{Positive phase sequence voltage}} \times 100 (\%)$$

Current unbalance ratio =

$$\frac{\text{Negative phase sequence current}}{\text{Positive phase sequence current}} \times 100 (\%)$$

## (2) Influences of unbalanced voltage of the power source

- (a) When the motor is operated with unbalanced voltage, the current for each phase will be shown in Fig. 14. With unbalanced voltage, the input will increase while the output, torque and efficiency will decrease. As is obvious from Fig. 14, the phase carrying the larger current may be overheated extremely, namely, the life of its winding will be short, and at the same time the power cost will be high as the result of increased loss. In addition, if the unbalanced voltage is large, there is danger of increasing the vibration or noise.
- (b) An extreme case of unbalanced voltage is one line fault. In this case, the full-load slip rises to about twice against the value under three-phase-running, and the line current rises to more than  $\sqrt{3}$  times against the value under three phases running. Avoid running the motor for long periods under such a condition, because the winding may burn out.

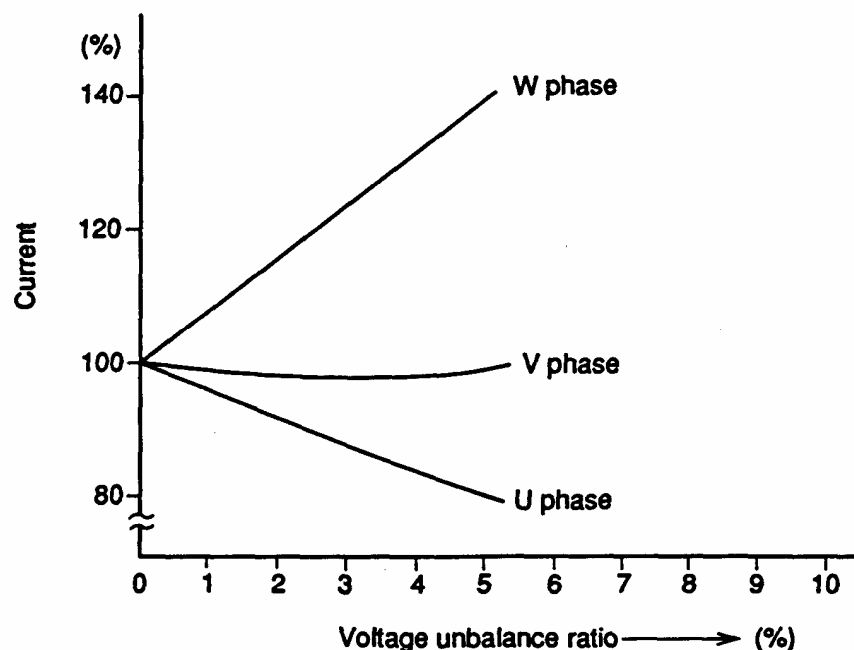


Fig. 14 Each phase current affected by unbalanced voltage (example)

## 11. Troubleshooting

Table 11 shows the various troubles, their causes and counter-measures.  
If you consider the troubles serious, immediately contact us.

Table 11-1 Troubleshooting

Trouble	Cause		Countermeasure
1. The motor will not start. Even when the main switch is turned on, the motor remains non-rotated.	The starting conditions have not yet been prepared. The circuit from power source to motor main terminals is wrong.	Some interlocks have not yet been released. No voltage is supplied to the starter; starting contractor is wrong. The fuses of two-phases are blown.	Check for wrong wires and contacts on the circuit.
	The stator winding of the motor is broken.		Exchange blown fuses. Check the main terminal. Repair the defective stator winding.
2. The motor generates abnormal noise without starting up.	The motor condition remains one phase	One phase fuse is blown. One-phase of starter circuit is wrong. Starting contractor is wrong.	Check for wrong wires and contacts on the circuit.
	Mechanical lock.	The driven machine is locked. The coupling connection is wrong (belting too tight: misalignment; installation error, etc.) Bearing is melted. The metal contact in air gap due to bearing melting	Check the driven machine and coupling and consider proper countermeasures.
	The stator winding of the motor is broken.	One-phase is broken.	Repair the defective stator winding.
3. The protective relay trips when main switch is turned on.	Starter failure. Rotor winding is shorted or earthed.	Deterioration of insulation caused by overheat, vibration, shocks, etc.	Repair the defective stator winding.
	Mechanical lock. Improper setting of protective relay.	Same as item 2 above	Correct the relay setting.



Table 11-2 Troubleshooting

Trouble	Cause		Countermeasure
4. Abnormal noise and vibration	One-line fault; unbalanced voltage	Wire in circuit is broken. The fuse is blown. Contact is wrong.	Check each line to locate defective points.
		Mechanical abnormalities of motor	Unbalanced rotor Cracked end ring; ruptured bar
	Slackened core laminations		Overhaul inspection
	Unbalance or contact of air gap		Overhaul inspection
	Intrusion of foreign objects		Overhaul inspection
	Bending or cracking trouble of shaft		Overhaul inspection
	Oscillating in the driven machine		Vibration of the driven machine
		Misalignment	Bending trouble of shaft
	Slackened coupling		Tighten up the coupling bolts.
	Improper connection with foundation		Make repairs.
5. Excessive temperature rise and smoking	Abnormalities in the power source	Unbalanced voltage one-line fault; wrong voltage or frequency; voltage drop	Check the power source and starter for abnormalities.
		Overload	Overload caused by the fault of the driven machine
	Poor cooling		Excessive start and stop; excessive reverse running.
		Clogged filter; intrusion of foreign objects into the ventilation grille.	Cleaning

Table 11-3 Troubleshooting

Trouble	Cause		Countermeasure
6. Seizure of sleeve bearing (For details, refer to the bearing manual.)	Defective winding	Stator winding is shorted or earthed.	Repair winding.
	Mechanical fault	The metal contact in air gap. Overheat of bearing caused by bad directed coupling (Excessive belt tension, misalignment, etc.)	Same as item 2
	Shortage of lubricant	Fault of rotation caused by deformation or abrasion of oil ring; Shortage of oil quantity; Oil leakage.	Exchange or repair of oil ring
		Defective contact of bearing caused by abrasion or vibration etc.	Overhaul inspection
7. Defect of grease lubricated anti-friction bearing For details, refer to the bearing manual.)	The defect identified by noise, vibration and temperature. In many cases, the trouble is concerned with grease. If the noise is excessive, charge grease.	Defective lubricant	Oil exchange
		Fatigue galling of raceways and rolling elements; Depressions and other defects imparted upon the raceways and rolling elements caused by poor handling.	Wash the bearing and check for defects. If the bearing is found defective, replace it with a new one.
		Shortage or excessive charge of grease.	Supply a specified quantity with grease of specified brand.
		Change in quality of grease or wrong brand	Wash the bearing.
		Mixture of dust and metal sludge.	Bearing exchange
8. Irregular deflection of ammeter	Early indication of the above trouble	Deformation or damage of retainer in bearing; Improper mounting of bearing; Excessive thrust load; Too small clearance.	Correct the bearing setting. Correct the alignment. Check the driven machine.
		Winding fault; bearing seizure; faulty connections or breaking of wire; contact fault; etc.	

**CAUTION**

When the motor must be discarded, have this done by a specialist disposal firm, or contact a Toshiba Mitsubishi – Electric Industrial Systems Corporation customer service representative.

Failure to do this may result in damage to the environment.



Before rewinding coils, contact a Toshiba Mitsubishi – Electric Industrial Systems Corporation customer service representative and follow his or her instructions.

The insulation used on coils, etc. may generate toxic fumes during heating.



Toshiba Mitsubishi - Electric Industrial Systems Corporation