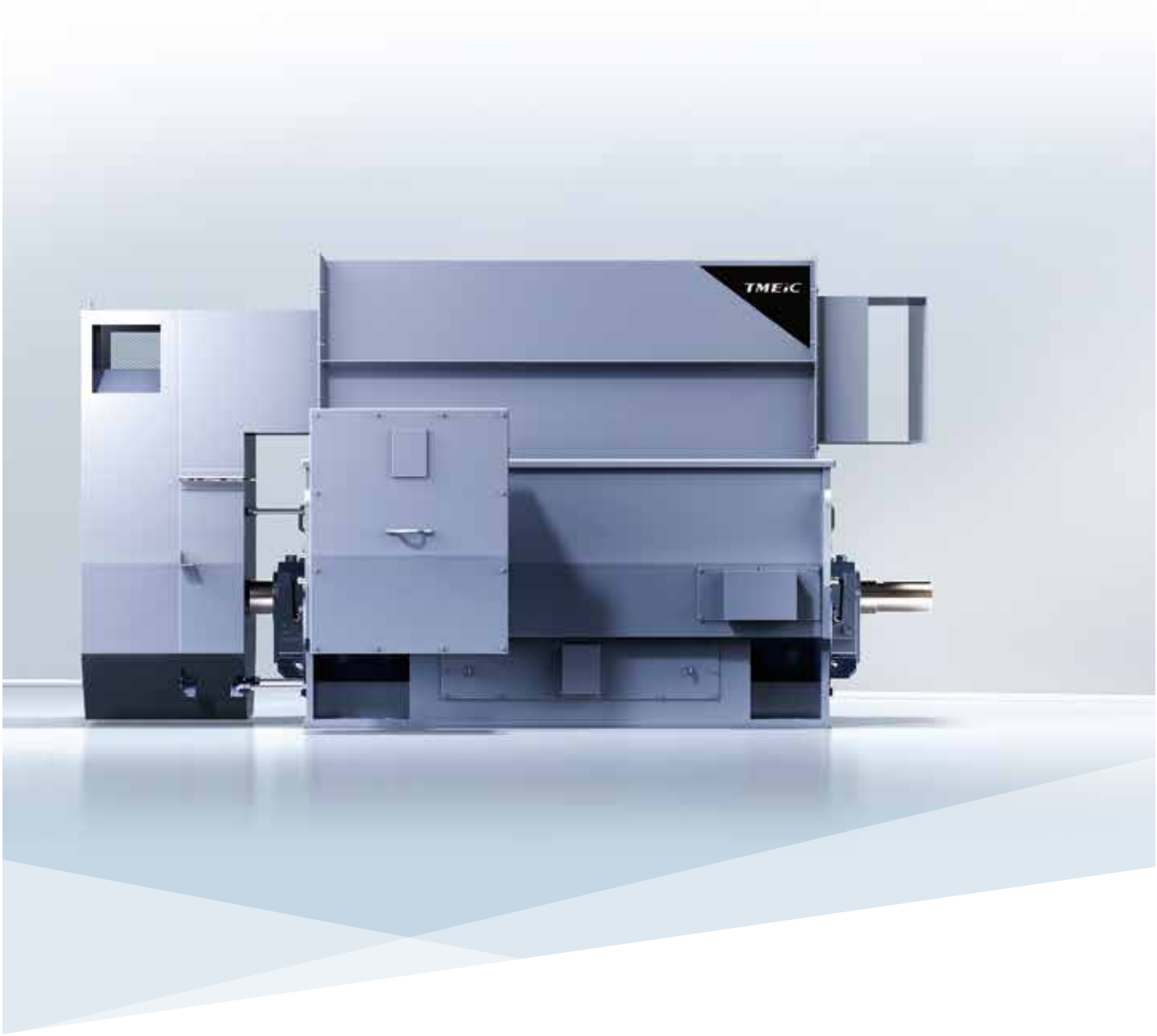
TMEiC
We drive industry

3-phase Induction Motor

TM21 Series

Instruction Manual



TMEIC Corporation

CONTENTS

Introduction

Thank you very much for purchasing our motor (or generator). This manual has been published to ensure safe and efficient use of the motor (generator). 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.

Although the part mainly indicated as a "motor" is in this manual, it can be read as a "generator", if you purchased an induction generator.

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.

- In addition to an instruction manual, be sure to read the caution labels and the instruction name plates attached on the motor (generator) body before use. Keep these labels and name plates in the good condition to be always able to read, and never peel or remove them. Please contact to our company when the labels or name plates become blurred or damaged.
- Keep this manual carefully after reading it, and use it suitably when the equipment is operated.
- Be sure to include this manual when coupling the motor (generator) with another machine and delivering it to the end user or reselling it to other user.

[Qualification of operating personnel]

- Only qualified persons are to install, operate, or service this motor according to all applicable codes and established safety practices.
- Please perform even the work which is not regulated legally under lead of the expert who understands a motor (generator) and is skilled.
- Please wear the defined protector (long sleeve working clothes, safety belt, helmet, safety shoes, glove) at the time of work.

[Indication and explanation of graphic symbol]

The important content is indicated on the product and in this manual, in order to prevent the harm to those who use, or other men, and damage of property and to use the product safely and correctly.

Please read the text and follow the items mentioned in this manual after understanding the following content (indication and graphic symbol) well.

Moreover, be sure to read the operation manual instruction of related apparatus and parts.

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.

Since **CAUTION** items also include the important content, please follow them.

In this manual, the following three kinds of graphic symbols are indicated to distinguish the meaning of "Warning," "Prohibited," or "Mandatory."

 : Warning

 : Prohibited action (one that must not be done)

 : Mandatory action (one that must be done)

Safety precautions (Continuation)

[About a disclaimer]

■ Our company does not take the liability to the damage produced by a fire, an earthquake, an action by the third party, other accidents, the intention or negligence by the user, misuse, and operation under unusual conditions.

■Our company does not take any liability about the collateral damage (loss of business advantage, interruption of business, etc.) produced from use or out of order of this product.

■Our company does not take any liability about installation, handling, or the damage produced by usage, which has not been explained in the manual.

■Our company does not take any liability about the damage produced by the combination of connection apparatus.

[Confirmation of caution labels]

Please confirm that the warning/caution labels are displayed on the designation part (refer to fig. 1-1 on page 10 or a submission drawing). If the label has been lost or hard to see by stain, please contact with our company.

 **DANGER**	
	■ The use of electrical equipment in hazardous locations is restricted. For these areas, an explosion-proof type motor (generator) should be used. - 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 power supply. - Conducting operations with live wires may result in electric shock.
	■ If a water cooler is used to cool the motor (generator), the cooling water shall be flow by specified temperature and flow rate. - Failure to do this may result in overheating and lead to fire.
	■Use lifting lugs (*) of frame when lifting a motor. - Using the lifting lugs of a cover of terminal boxes or a heat exchanger may result in falling of a motor and it may cause an injury. * Please refer to a "submission drawing" for details.
	■ Please use adequate handling equipment corresponding to the mass indicated in the submission drawing or name plate. - This 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 cause a motor to fall by damage or cut of the wire ropes, and this may results in injury.
	■Never enter the area directly beneath the motor while it is being hoisted. - You may be seriously injured if the motor should fall.
	■Motor should be lifted itself. - Failure to this may cause a motor to fall, resulting in injury.

Safety precautions (Continuation)

DANGER	
	■Be sure to remove the protective device for transportation before a trial run - Failure to do this may result in overheating of the motor or breakage of the device, and they may cause burnout or injury. - Depending on a motor, since the protective devices are attached not only on DE-side but also on NDE-side, please check and remove them before trial-run. - The device should be attached at the time of re-transportation of the motor.
	■The key which is temporary attached on a motor shaft should be removed before trial run. - Failure to this may cause scattering of a key, resulting in injury.
	■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.
	■When working at elevations of more than 1.5 meters, be sure to wear a safety belt. - If you fail to do this, you may fall and be injured.
	■Rope off the work area to prevent people other than work personnel from entering. - Failure to do this may result in people suffering electric shock or becoming caught in the machinery.
	■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.
	■Connect the earthing conductor to the earthing terminal of the motor. - Without grounding may result in electric shock.
	■Please attach a cover for involution prevention at the coupling part connected to a machine. - Without covering may result in injury.
	■Please check that the man approaches and is not in contact before a withstand voltage test and insulation resistance test. Provide an attention to nearby persons so that they don't approach and contact during the test. - Test voltage may result in electric shock.
	■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.
	■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. * Please refer to Table 6-6 (page 39) for details.

Safety precautions (Continuation)

DANGER	
	■After a withstand voltage test, ground windings to discharge. - Without discharging may result in electric shock.
	■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 place flammable materials near the motor. - They may ignite and burnout.
	■Shut down all power sources before starting periodic inspection. - Failure to do this may result in electric shock or injury. - In order to prevent the misoperation during work, hang an "operation prohibition" tag on the opened circuit breaker.
	■In the event of a power outage, be sure to set the power switch to the OFF position. - At the time of re-energizing, there is a possibility of electric shock or injury.
	■When using a source of flame with the bearing section dismantled, be careful of the following: ・Wipe away any lubricant from the bearings. ・Be sure to protect the bearing section from being heated. ・Use sources of flame only in places where there is no danger of fire. ・Do not use heaters, cigarettes or other general sources of flame near the bearing section. - Failure to do these may result in a fire.
	■For motors equipped with filters, clean the filter periodically. - Filter clogging may result in overheating and burnout.
	■Do not approach or touch to a rotating or live part at the visual inspection around brush. - This may result in electric shock or injury.

WARNING	
	■Only qualified persons are to carry out the transportation, installation, piping, wiring, operation, maintenance, and inspection. - 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.

Safety precautions (Continuation)

WARNING	
	■Do not use the motor (generator) except the motor (generator) specification. - This may result in electric shock, injury, or breakage.
	■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.
	■Do not put fingers or objects in the openings on 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 attempt to modify the motor. It doesn't assume the responsibility because it is outside the guarantee range of our company.

CAUTION	
	■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 motor with the inverter. - Failure to do this may result in overheating, damage of insulation or fire.
	■Do not put obstacles so that name plates may always be visible.
	■Do not detach the nameplate.
	■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.

Safety precautions (Continuation)

CAUTION	
	■Do not touch the external surface of the motor directly during operation. - This may lead to the burn.
	■Before rewinding coils, contact us and follow our instructions. - The insulation used on coils, etc. may generate toxic fumes during heating.
	■When the motor must be discarded, contact us and follow our instructions. - Heat treatment may generate toxic fumes

TMEIC THREE PHASE INDUCTION MOTOR

RATED OUTPUT		POLES	
TYPE		FRAME NO.	
RATED VOLTAGE	V	THERMAL CLASS	
RATED CURRENT	A	RATING	
RATED FREQUENCY	Hz	MAX. AMB.	℃
RATED SPEED	min^{-1}	STANDARD	
POWER FACTOR			
CONNECTION			
PROTECTION		BEARING DE	
COOLING METHOD		NDE	
SERIAL NO.		MANUFACTURED IN	

Ⓝ MADE IN JAPAN

TMEIC Corporation
NAGASAKI,852-8004 JAPAN

Rating nameplate

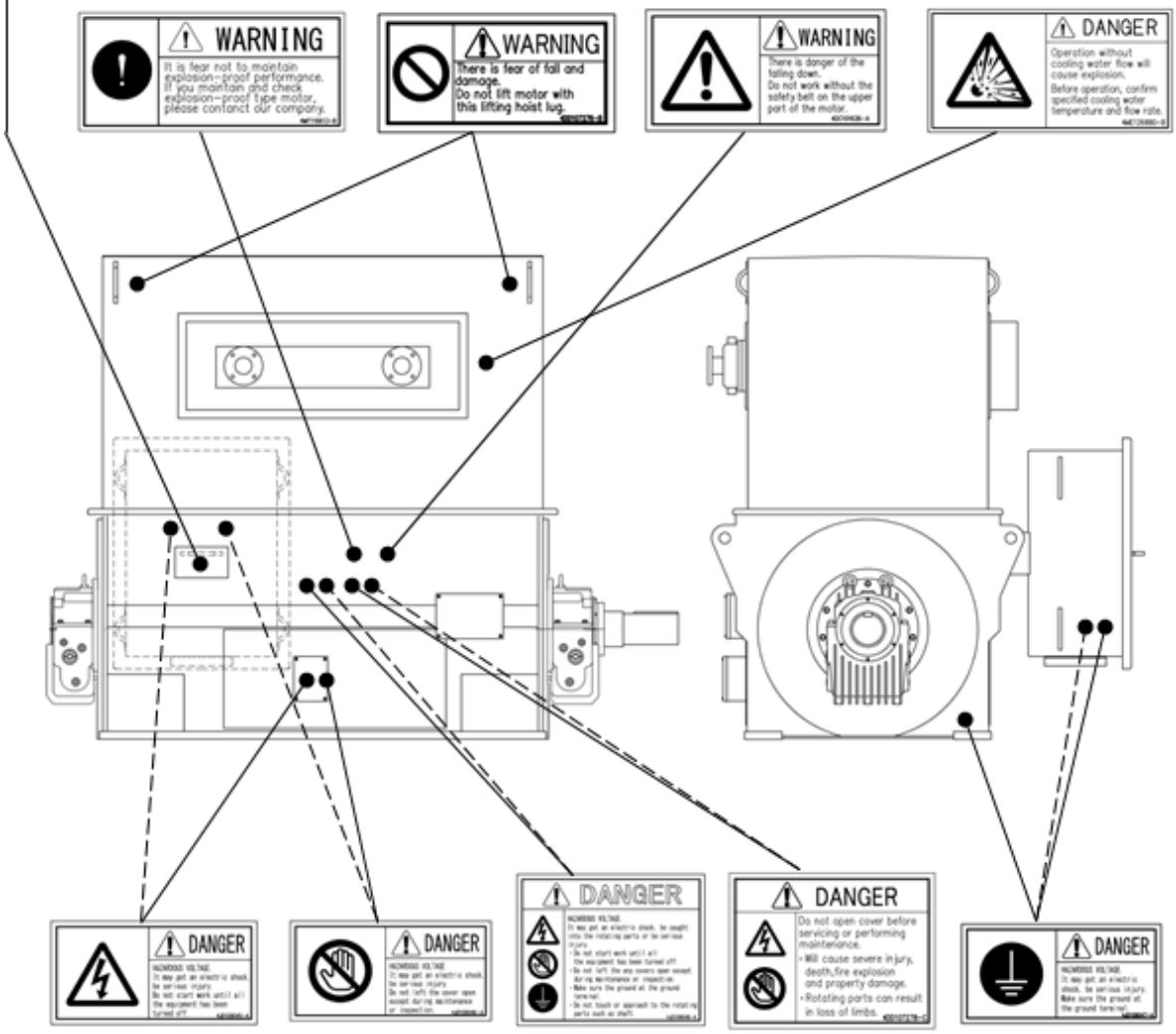


Fig.1-1 Position of name plates and warning labels (example)

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. 1-2.

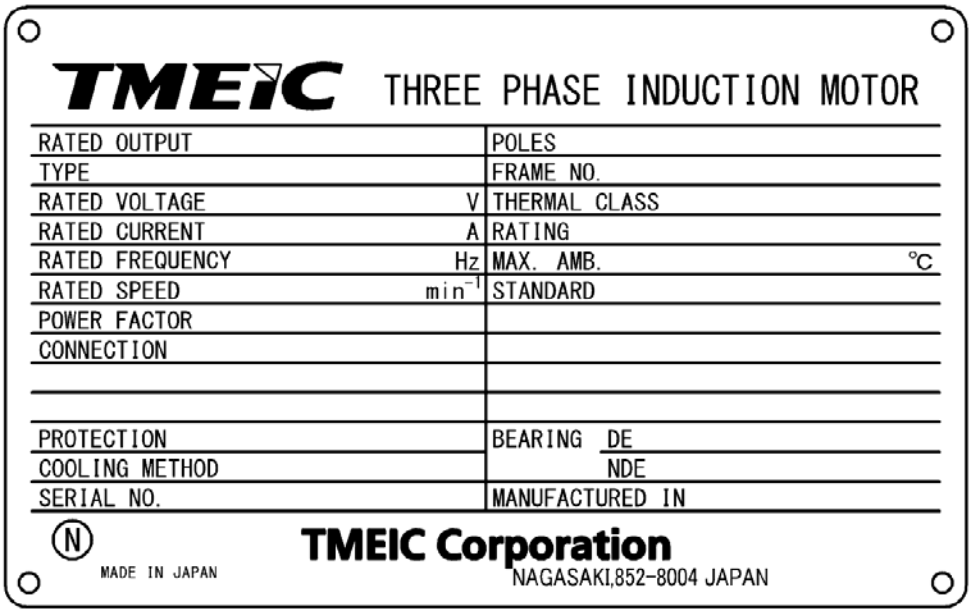


Fig. 1-2 Rating nameplate

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.

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

The power frequency in Hz is as f, the synchronous speed N (min^{-1}) of the motor becomes:
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 (η) are shown by %.

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

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 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.

1.5 Max. Amb., Altitude

When unspecified, operate the motor with an air inlet temperature of 40℃ 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.

1.6 Thermal class

This shows the insulation class.

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

1.7 Standard, Protection, Cooling method

The specified standard will be applied. Otherwise, our standard is IEC 60034-1.

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.

1.8 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. Use the check list shown in Appendix 1 at the time of acceptance.

(1) We have already provided a packing list or an invoice with your motor. Check the motor against the invoice.

(2) If there is breakage of packing, unpack immediately and investigate whether there are any abnormalities in the motor or other accessories. Take photos of the breakage, and inform to a carrier and our company.

(3) First unpack carefully. Check each component for shipping damage.

(4) Make sure that the output, voltage, frequency and model designation indicated on the rating nameplate comply with your ordering specifications.

(5) 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 drive end side bearing but also on the non-drive end side bearing, confirm certainly that the protective devices on the both bearings are removed before trial run.

(6) Check the entire motor carefully for damage, rust parts, fouled parts and intrusion of harmful objects. If there is a doubtful point during the inspection, please contact to our company immediately with the required information filled in Appendix 1

3. Storage

Notice
■In order to maintain quality, install a motor in the place which fulfills storage conditions. - Failure to this may result in performance degradation or damage.

(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. It is recommended that storage is performed at 10-50 degrees C of atmospheric temperatures, and 75% or less of humidity.

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.

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.

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 is not taken. 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. When the space heater is not attached, prevent a dewing by heating the inside of a motor by means of an electric light etc.

Antifriction bearings are filled with grease; however, since lubricant is not filled in sleeve bearings at transportation, the lubricant indicated in the outline drawing or the name plate shall be filled and the rotor shall be turned periodically to 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.

In order to prevent damage of bearing, be careful of a motor to receive neither a vibration nor a shock from a floor.

The cable penetrations in the terminal box should be covered with a cap or gummed tape.

(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 3-1 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 company 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.

Table 3-1 Styles of long-term storage and methods of quality preservation for motor assembly

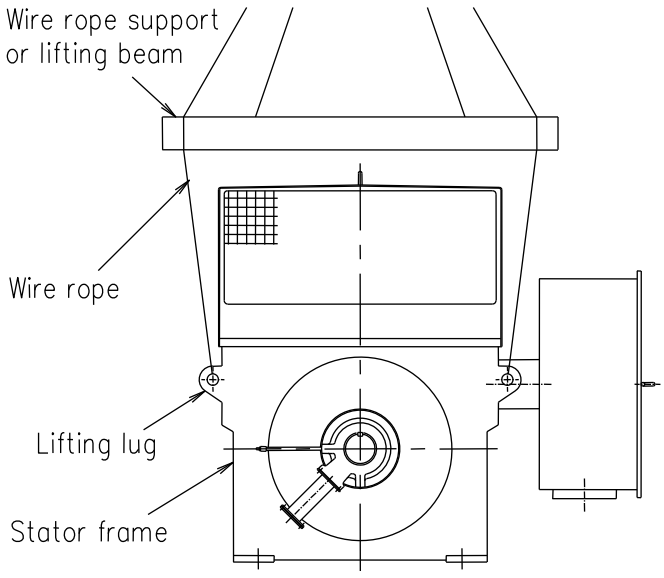
Item / Parts	Place of storage	Style of storage	Measure for quality preservation		Inspection method	Inspection cycle
			Protection from rust and moisture	Protection from deformation and damage		
Stator	Indoor	1) Wrap with a poly-ethylene sheet, and put on sleepers 2) Pack by sealing a desiccant in the poly-ethylene sheet. (silica-gel: 300 to 500 g/m^3)	1) Pretreat and apply an air-dry type coil varnish on the base mounting surface. 2) Pretreat and apply an 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. When it cannot be used, 0.3kg/m^3 of desiccants (silica gel) are enclosed inside the motor.	1) Put a canvas sheet over for protection from damage and rain and air borne contaminants . 2) Never stack 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 end and coupling, and check visually for rust. 4) Inspect the shaft journals every six months. 5) For antifriction bearings, turn the rotor every six months, and supply grease or replace grease completely.	Every 6 months
Rotor			1) Pretreat the shaft journal and oil slingers, and apply rust inhibitive oil.			
Bearing			1) For sleeve bearings: Pretreat the spherical surface and babbitt metal with rust preventive oil, or fill a volatile corrosion inhibitor (Ferro-Guard 1009 or equivalent) into the bearing housing at approximately 1% of the specified oil amount. 2) For antifriction bearings: Supply grease.			
Heat exchanger			Completely drain water accumulated in the cooler by air blow, wrap approximately 50 g (400 g/m3 for cooler capacity of 0.125 m3 or more) of vaporizable rust inhibitor (Copper-gard) in gauze or the like inside the cooler, and seal and store each flange section.	Protect the cooling fins to prevent damage.	Perform a visual inspection of the exterior.	Every 6 months

※ Before operation after a long term storage, take out all desiccants from the inside of a motor and drain a volatile corrosion inhibitor from a drain plug in order to return to the regular condition before a storage.

4. Installation

4.1 Attention at motor transportation

WARNING	
	■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 hoist 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 by falling or overturning of the motor.
	■Hoist the motor alone. - You may be seriously injured if the motor should fall.
	■Do not attach wire ropes for hoisting to the locations other than the lifting lugs on the sides of the stator frame, and do not attempt to hoist more than one motor at a time.
	■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 (*). * Noted in specifications (outline drawing) or on nameplates attached to the motor itself. - This may cause the motor to fall, resulting in injury.
	■Make sure the load is applied vertically to wire ropes and that it is balanced during hoisting.



Example of motor lifting

4.1 Attention at motor transportation (Continuation)

WARNING	
	■Be sure to remove the transport protective device(s) before trial run. As there is case that the protective devices are not only attached on the drive end side bearing but also on the non-drive end side bearing, confirm certainly that the protective devices on the both bearings are removed before trial run. - Failure to do this may result in breakage or overheating and subsequent burnout and injury. ■Attach the protective device(s) in case of re-transport.
	■When working at elevations of more than 1.5 meters, be sure to wear a safety belt. - If you fail to do this, you may fall and be injured.
	■Rope off the work area to prevent people other than work personnel from entering. - Failure to do this may result in people suffering electric shock or becoming caught in the machinery.

Example of transportation cautions nameplate

4.2 Attention of installation place

WARNING	
	■Install the motor in a proper location that matches the operating conditions (*) noted in specifications. * Refer to the specifications in detail. - Failure to do this may result in fire or electric shock.

CAUTION	
	■Do not place flammable materials near the motor. - They may ignite and burnout.
	■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.
	■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 touch the key groove of the motor shaft end by bare-handed. - This may result in injury.
	■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.
	■Install the protection cover so as not to touch the rotation parts. - Failure to do this may result in injury.
	■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.
	■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.
	■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 there is no enough space, cooling will become insufficient, and the motor could overheat and lead to burning.

4.2 Attention of installation place (Continuation)

Notice	
■ Dry place ・ The place without the leakage of water from piping etc. ・ The place without falling of the condensed water from the roof which is made of the kind of glass or a metal ・ In case of installation on a floor, make a motor somewhat higher than a base plane to improve drainage.	■ Place with few dusts ・ Dusts may cause an insulation resistance depression of coils. ・ Dusts may cause of bearing accidents, such as deterioration of lube, wear of bearing metal, etc.
■ Well-ventilated cool place ・ Maintain an ambient temperature within 40 deg. C or name plate written temperature. ・ If an ambient or cooling medium temperature exceeds a specification value, the motor cannot be applied with the rated power	■ Easy place of a maintenance and inspection ・ The place which is easy to pull out a motor in consideration of disassembly and inspection of the future
■ The place without a toxic gas ・ The place with few corrosive gases and toxic gases ・ Avoid near the storage area of explosive gas and liquid.	■ The place where external vibration is not transmitted ・ Vibration of other machines should not be transmitted from a base, floor, etc.
■ The place with few voltage variations of a power source ・ The place where the voltage variation at operation and the voltage drop at starting is within the values which are determined in the specifications or the standard ・ Attach surge suppressors against an external surge by thunder and a switching surge by breaker operation.	■ The protective devices at a motor installation ・ When there is no requirement, the protective devices are not installed. ・ Depending upon the machine, it is recommended to install thermo sensors, such as thermistors and RTDs. ・ When protective devices need to be attached, please contact with our company.

4.3 Design and construction of foundation

For the design and construction of the foundation, 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 which are indicated in the submission document, but also it must endure the mechanical vibrations. Moreover, the natural frequency of the foundation should avoid resonance frequencies with the machine, such as the rotational speed frequency and electromagnetic frequency.

(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.

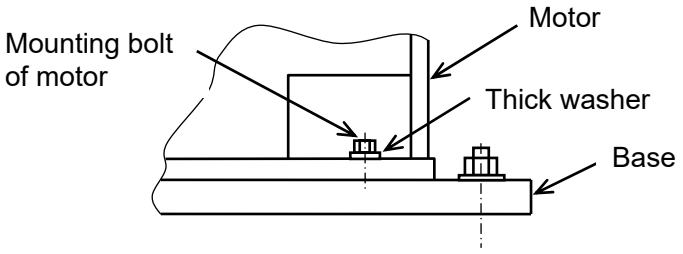
(6) The upper surface of the foundation should be finished as flat as possible in order to facilitate the motor installation.

(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.

4.4 Installation of motor

The motor base is a sole plate type or a common base type with a machine side. For the motor with sole plates, the motor should be temporarily installed on packers with sole plates. For the motor with a common base, the coupling is disconnected, and the base is installed. After a grouting is constructed, the motor should be set on the base with the machine, and centering is carried out.

At installing the motor to the base, tighten the bolts with thick washers.



(1) Temporary centering

Put the motor with sole plates on packers temporarily and carry out temporary centering based on the machine side

In this stage, the tolerance of the cylindrical surface shall be set up in approximately 0.05 mm and the tolerance of the length between each shaft end against normal dimension shall be in approximately ±0.5mm. In this case, adjust the liners on the packers.

When installing a vertical motor on a machine stand or base, remove a rust preventive agent of a lower bracket flange face and check that there are not rust and burr, and temporarily set the motor on the stand or base.

(2) Match of position

Confirm the match of position of piping and wiring.

4.5 Grouting

After the temporary centering, fill mortar into the lower part of the base, internal foundation bolt holes, etc., where total weight is applied to the base. The following things should be done at that time.

(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, piping, etc.

4.6 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. When the driven machine has already been installed on the common base etc., the installation of the motor should be carried out with the coupling of the driven machine as a reference.

When rotating a rotor of a motor with sleeve bearings, be sure to supply oil to journals to prevent damage of bearings.

Since the required shim length of each leg of a motor is indicated in the outline drawing, prepare the shims according to this. It may cause vibration if the shims are short.

(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 4-1, except when equipped with special thrust bearings or when requested from directly-coupled machines. Adjust the axial center of the stator by measuring the relative positions of the stator and rotor cores.

Table 4-1 End play tolerance of standard bearings

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

∗ End float is the summation of the end play of both sides

(2) As shown in Fig. 4-1, 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.

For vertical motor, a steady rest device is attached so that the shafts of a motor and machine may not swing within bearing, and parallelism and eccentricity are measured.

Generally, for measurement of the parallelism, the thickness gage or taper gage is used, whereas, for measurement of the eccentricity, a dial gage is attached 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 4-2 and 4-3)

Table 4-2 Recommended Alignment Values (Unit: mm)

Speed of rotation		Over 1500 min^{-1}	Over 1000 up to 1500 min^{-1}	Up to 1000 min^{-1}
Rigid coupling	Deviation 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

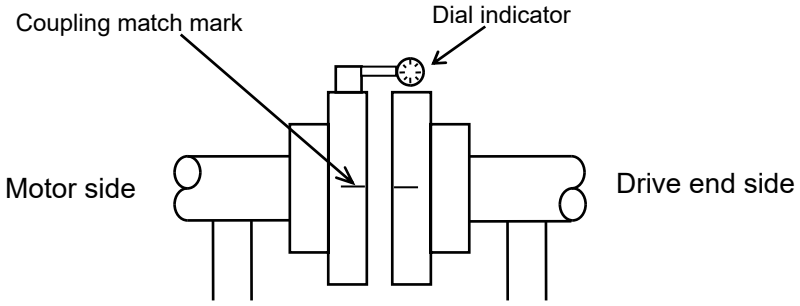


Fig. 4-1 Centering and alignment method with the coupling as a reference

Measurement of eccentricity

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

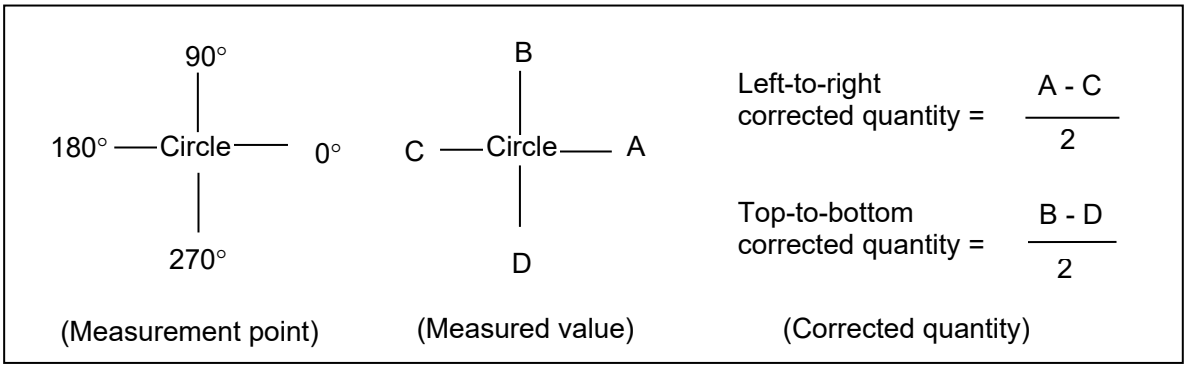


Fig. 4-2 Measurement of eccentricity

Note: The difference of the measured values of the sum of the right and left points (A+C) and the sum of the top and bottom points (B+D) in Fig. 4-2 must be less than 0.03mm. Most of the factors to which this difference becomes large are caused by the fixing failure of a dial gauge or the deflection of an attachment arm. Therefore, make correction of proper alignment.

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. Determine the corrected quantities as shown below.

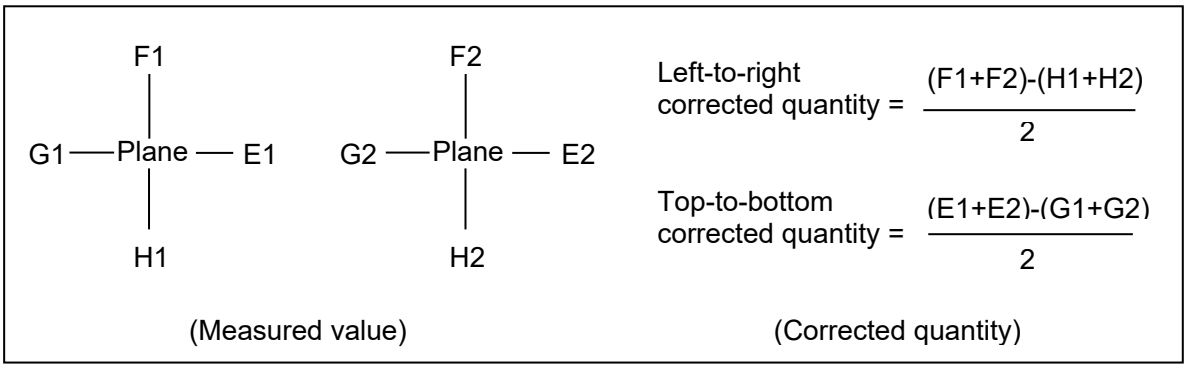


Fig. 4-3 Measurement of parallelism

Adjustment of alignment

The motor position is to be adjusted after the corrected values have been obtained from the measurement of the eccentricity and parallesm.

It is recommended that hot state alignment is carried out in consideration of the location of the shaft center when there is a temperature difference between the motor and directly coupled machine at load condition, since alignment is generally performed in cold state.

Note: The measurement of the alignment and the determination of the corrected value should be made after the motor foot and the foundation bolts of the base have been fully tightened.

For larger or higher speed machine, high-level technique is necessary for adjustment of the levelness at journals, the center position of two shafts at the coupling, the clearance between the coupling planes, etc., because of the rotor deflection or the relation of the critical speed and running speed. Therefore, technical assistance by our engineer or machine vender's expert is recommended for each case.

4.7 End play and burnout 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 to prevent the following phenomena;

(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, and the bearing may result in burnout.

(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. 4-4.

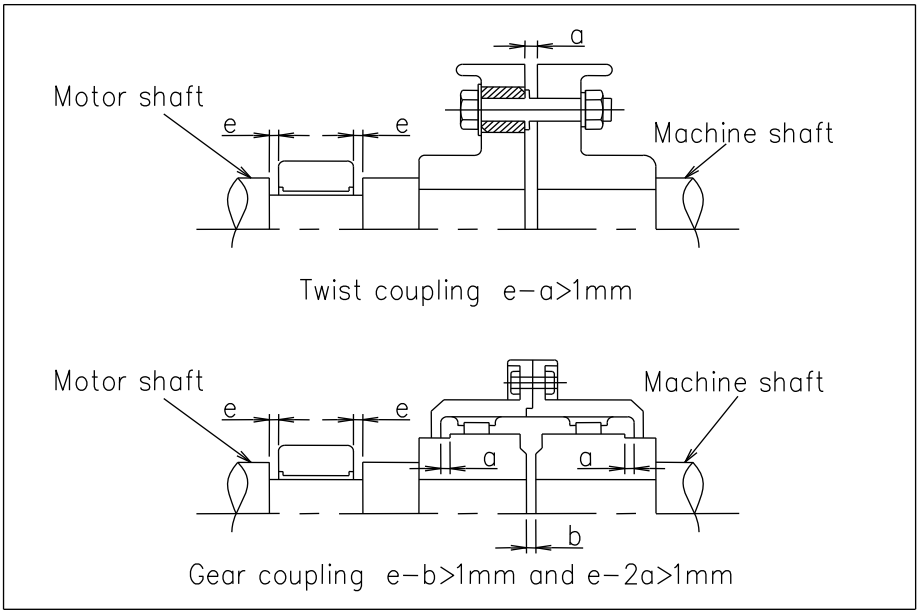


Fig. 4-4 Relation between the end-play of the bearing and the flexible coupling

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 the spigot part whether there are scars on it. If any, polish the surface gently with an abrasive stone.

4.8 Insulation for prevention of shaft current

Shaft insulation is applied to the motor for prevention of harmful shaft currents. Usually, the shaft is insulated on the non-drive end bearing as shown in Fig. 4-5. Thus, when selecting a double shaft-end motor, the non-drive end coupling should be insulated.

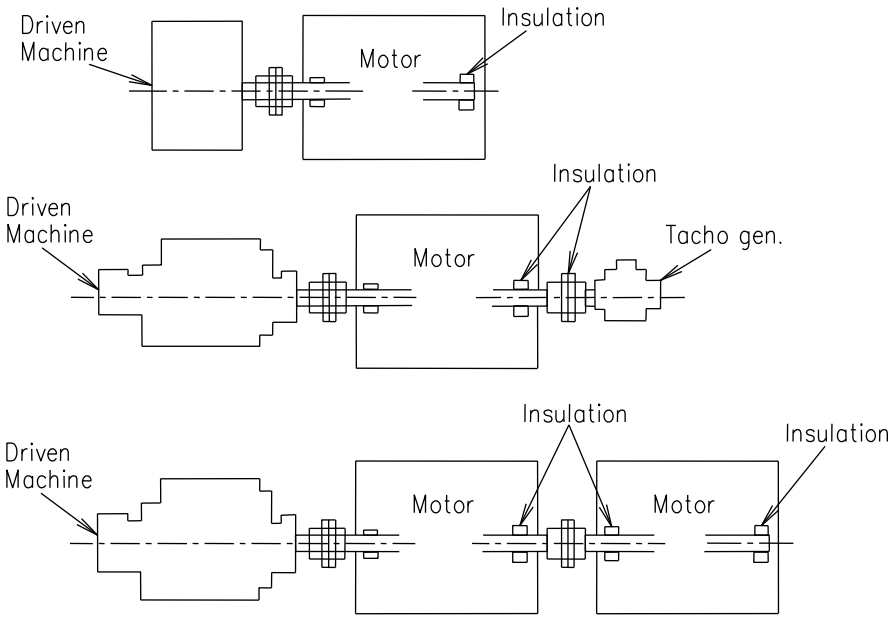


Fig. 4-5 Shaft insulation arrangement

4.9 Piping

When constructing piping from a motor to an oil tank, 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.

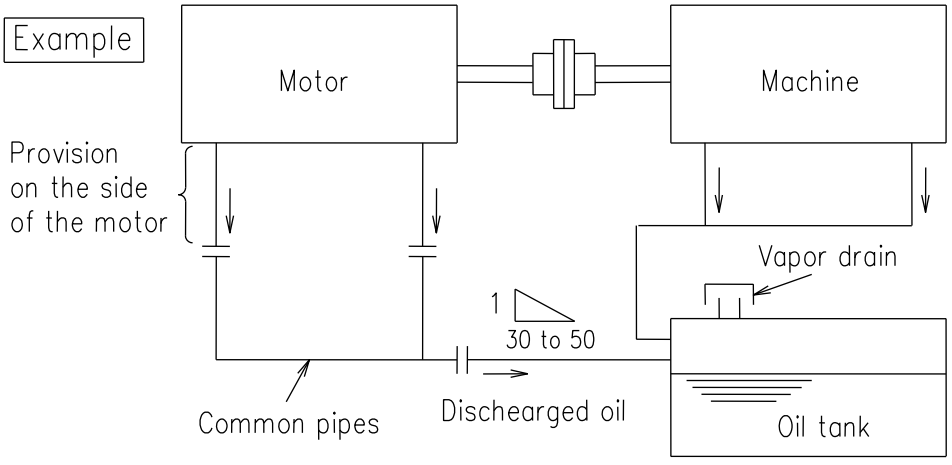
b) Establish the oil tank with a vapor drain, which is big enough to have either ① or ②, in order to decrease the inside pressure of the oil tank and of the pipes to a natural atmospheric pressure.

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

Record the installation results on the check sheet shown as Appendix 2.

5. Wiring

5.1 Attention at wiring

CAUTION	
	■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.

DANGER	
	■Connect the earthing conductor to the earthing terminal of the motor. - Without grounding 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. * Please refer to Table 6-6 (page 39) for details.

WARNING	
	■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.

5.2 Procedure of wiring

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. Since the temperature around the terminal box will be relatively high on motors that use a high-temperature insulation (insulation class ”F”), use high heat-resistance wiring cables and insulation tape around the terminal box.

5.3 Connection

Usually, a motor has three or six terminals and their leads are marked with L, V, W, etc. in the terminal box. When connecting the leads to the power cables (R, S, T, etc.) respectively, the motor rotates in the direction of the arrow mark shown on the motor frame.

If the connection name plate is attached, make a connection according to this.

5.4 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.

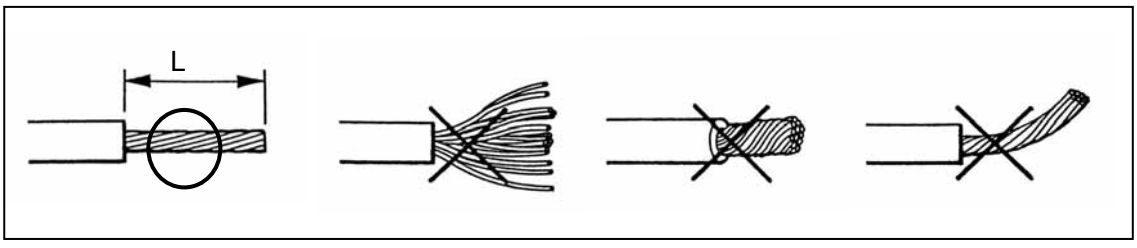
	Class	Grounding wire (mm^2)
1	1000kW or more～	100
2	750kW or more～1000kW	80
3	300kW or more～750kW	60
4	37kW or more～300kW	38

5.5 Terminal connection in auxiliary terminal boxes

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. In addition, use a driver that is smoothly inserted in the operating slot and of which a spring can be opened. (A terminal block may be damaged when a driver bigger than the operating slot is used by force. Be careful that the spring cannot be opened and a rated wire may not be inserted In case of too small driver.)

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

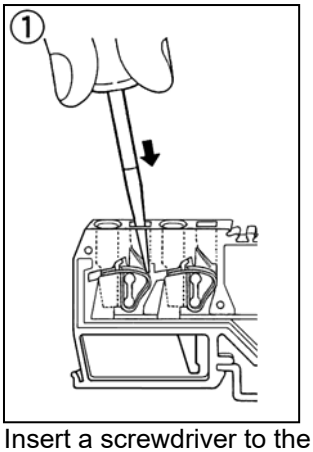
■ Stripping of Wire ○ Strip a conductor's stripped length related as drawings.



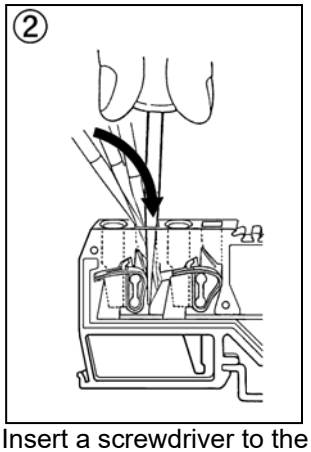
Conductor's stripped length (Std)

For space heaters (WAGO 282) : 12 to 13 mm
(WAGO 2004) : 11 to 13 mm
For RTD's etc. (WAGO 870) : 6 to 7 mm
(WAGO 2001) : 11 to 13 mm

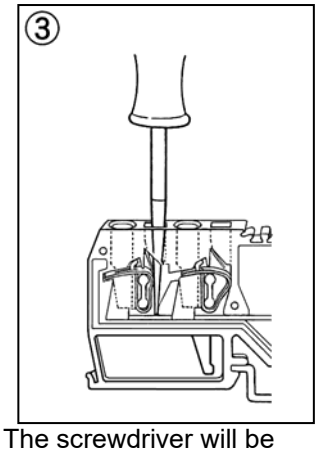
■ Connecting ○ Follow the instructions below.



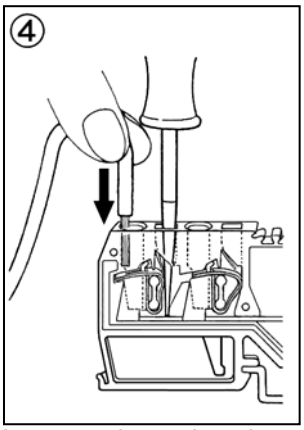
① Insert a screwdriver to the operating slot (square hole) obliquely



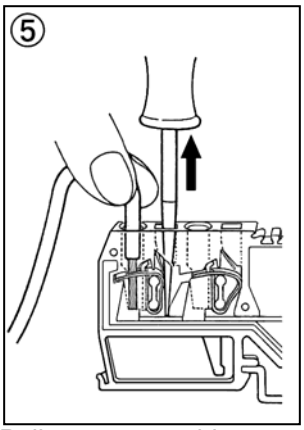
② Insert a screwdriver to the inside of the terminal block.



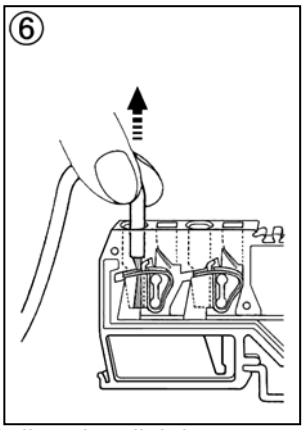
③ The screwdriver will be fixed when operated correctly.



④ Insert a wire to the wire hole (round hole).



⑤ Pull out a screwdriver from the operating slot with holding a wire.



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

■ Removal ○ By inserting a screwdriver and opening a spring in the same way with connecting, a wire can be pulled out.

5.6 Precaution at inverter drive

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.)

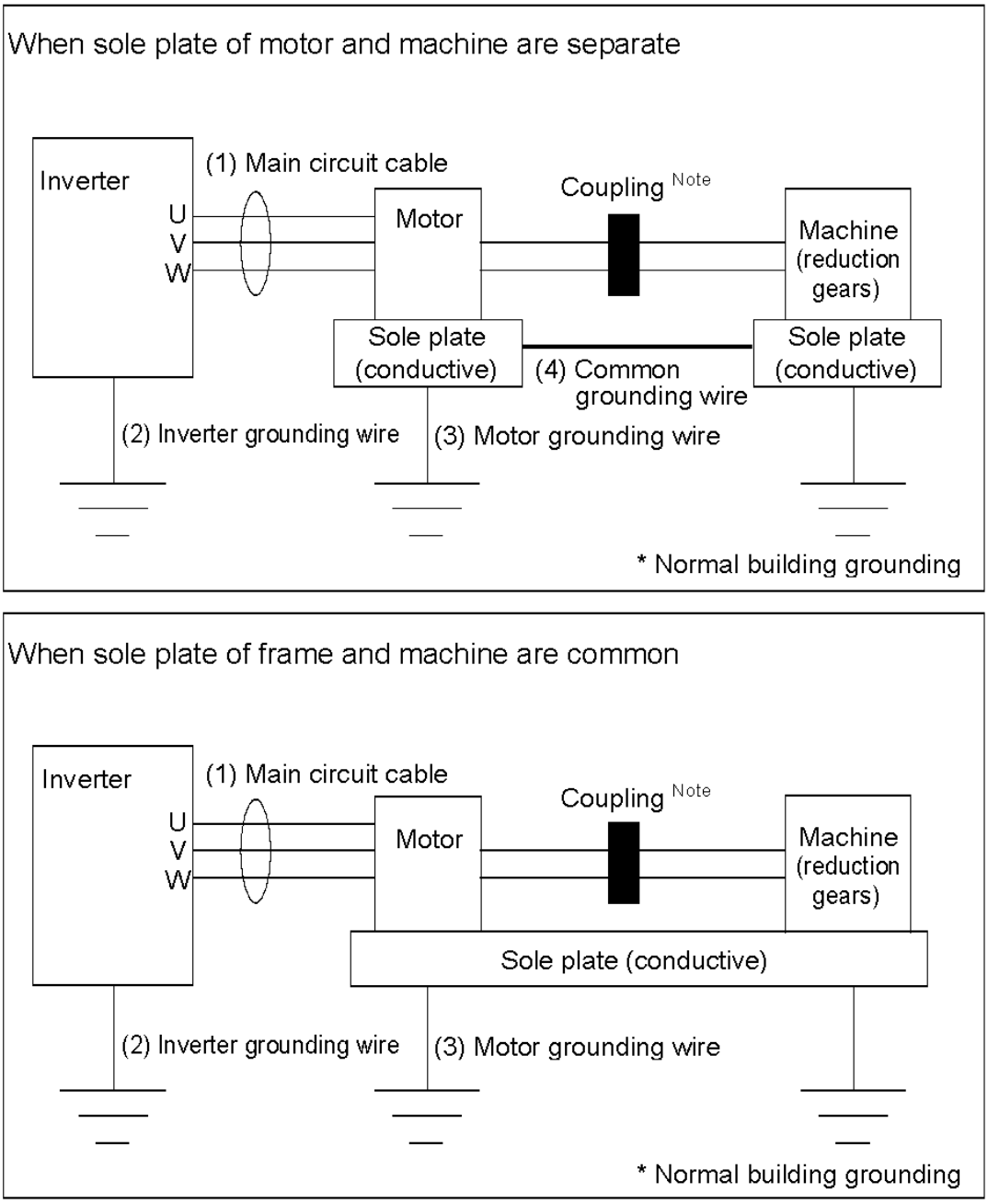


Fig. 5-1 Grounding wire connection

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

a) Function

When driving a motor by an inverter, shaft voltage occurs between the shaft and earth (ground) due to electrostatic induction. This voltage is depending upon the motor and inverter capacitance. When this voltage is large, bearing failure may occur due to the shaft current passing through the bearing. To prevent the shaft current, an earth brush (grounding brush) is installed for an inverter-driven motor, and the shaft current will not pass through the brush to the bearing bracket (ground). Pay attention because the brush is subject to spark.

b) Attachment procedure

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.

c) Maintenance procedure

Since the brush wear varies due to a running period and environmental conditions, check the brush once every 1-2 month. Replace the brush according to the earth brush maintenance nameplate attached to the motor frame.

The following is an example of installation construction of an earth brush.

［Installation Instructions］

This structure is an example of a constant-pressure loading spring type. Assemble in the order shown in Figure 5-2 (1) to (4).

(1) Set the brush in the brush holder and attach the lead wire to the screw of the brush holder.
(2) Spread the tip of the spring slightly and attach it to the brush holder while hooking it to the brush holder.
(3) Push the spring downward.
(4) Attach the spring by hooking the protruding part of the spring into the hole of the brush holder.

After removing a brush at motor stop, check the brush abrasion loss and clean up.

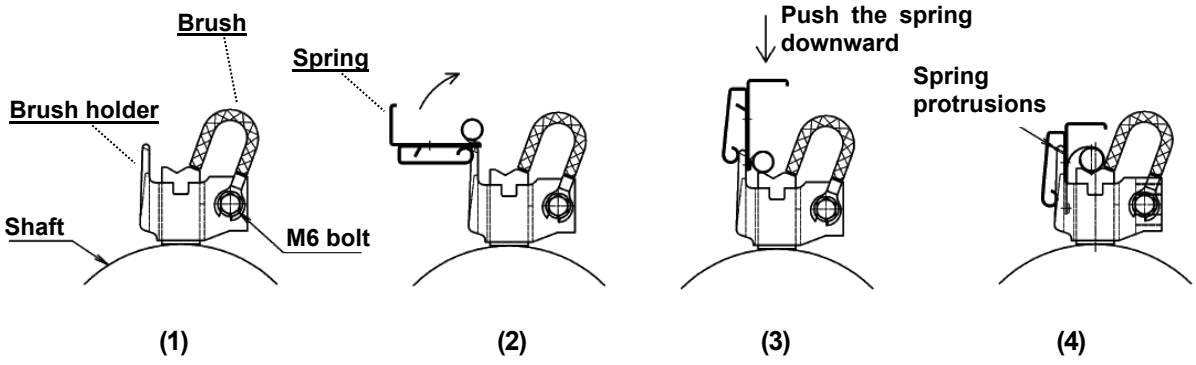


Fig. 5-2 Earth Brush Installation Instructions

6. Preparations and inspections before trial run

The motor has passed strict factory tests, but it is considered that there is influence by accidents during transportation or at the time of long-term storage. Thus, recheck the following items.

Use the check sheet shown in Appendix 3 for preparations and inspections before the trial run

6.1 Measurement of insulation resistance

CAUTION	
	■Do not touch the terminals during the measurement of insulation resistance. - This may result in electric shock.

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 14.3 “Insulation resistance” in Page 83.

6.2 Inspection of wiring

CAUTION	
	■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.

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.

6.3 Inspection of grounding wires

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

6.4 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 antifriction bearings are lubricated by grease or oil, and the sleeve bearings are lubricated by oil rings. When the rust preventive agent is enclosed in the bearing housings of oil-lubricated motor, lube oil is poured in after discharging it from the drain plug. Use the grease or oil specified in the nameplate or outline drawing. Refer to our recommended lubricants shown in section 6.5.

(1) Natural cooling type (antifriction 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 and antifriction bearing of vertical motor)
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 no trace of oil leakage.

(4) Water cooled type (antifriction bearing of vertical motor)
When thrust is large for a vertical motor, an oil cooler is installed into an oil reservoir to cool the lube by water.
Fill the lube in the oil reservoir up to the level specified with the oil gauge. Excess of lube supply will cause an oil leakage, and shortage of lube will cause the increase of temperature rise.

6.5 Lubricant

(1) Lubrication oil (turbine oil)
Use inhibited turbine oil as lubricant for sleeve bearings or a part of antifriction bearing of a vertical motor. Make sure that the lubricant of the type specified in name plate and outline drawing is used.

Gas turbine oil	
Grade2 oil	ISO VG32
Grade2 oil	ISO VG46
Grade2 oil	ISO VG68

Table 6-1 shows oil characteristics at 40℃, our recommend oil is listed as table 6-2.
Basically we will recommend “Mobil SHC600 series” made in Exxon Mobil.

Table 6-1 Oil characteristics

	ISO VG32	ISO VG46	ISO VG68
Kinematic viscosity [cSt]	28.8～35.2	41.4～50.6	61.2～74.8

Table 6-2 Commercial lubricants

	Brand name		
Manufacturer	GAS Turbine Oil ISO VG32	GAS Turbine Oil ISO VG46	GAS Turbine Oil ISO VG68
Mobil	Mobil SHC 624, 824	Mobil SHC 625, 825	Mobil SHC 626
SHELL	Turbo oil GT32	Turbo oil GT46	
ENEOS	FBK Turbine Oil GT32		
COSMO	Cosmo Turbine Super GT32		
IDEMITSU	Daphne Super Turbine Oil MG, FX	Daphne Super Turbine Oil HT46	Daphne Super Turbine Oil HT68
Manufacturer	Turbine Oil ISO VG32	Turbine Oil ISO VG46	Turbine Oil ISO VG68
Mobil	Mobil DTE Light Mobil DTE 732	Mobil DTE Medium Mobil DTE 746	Mobil DTE Heavy Medium Mobil DTE 768
SHELL	Turbo Oil T32	Turbo Oil T46	Turbo Oil T68
ENEOS	FBK Turbine 32 RIX Turbine 32	FBK Turbine 46 RIX Turbine 46	FBK Turbine 68 RIX Turbine 68
COSMO	Cosmo Turbine Super 32	Cosmo Turbine Super 46	Cosmo Turbine Super 68
IDEMITSU	Daphne Turbine Oil 32	Daphne Turbine Oil 46	Daphne Turbine Oil 68

Note: Due to merging, etc. of oil companies, brand names may be integrated/rearranged or changed. Therefore, for more details, contact the relevant oil companies.

Notice

■Avoid a mixture of different type of lube
- This may result in reduction of lube life remarkably.

■When changed into different type of lube, filled it after washing out a former lube.

Recommended change interval of the lube for the self-cooling sleeve bearing is indicated on the tables 6-3 and 6-4 according to the brand name. Refer to the section 9.3 (5)-2 "yearly maintenance" for exchange of lube.

Since the change interval of the lube is ruled by the continuity of a surrounding environmental condition used, such as the ambient temperature, a cleanness degree, operation condition, the severity degrees, etc., manage with the following change intervals of the lube as a reference.

Table 6-3 Oil change interval of self-cooled type
(Recommended lube for change interval of one year*)

Manufacture	Recommended brand
Mobil	Mobil DTE 732, 746, 768 Mobil SHC 624, 625, 626, 824, 825
SHELL	Shell Turbo oil GT
ENEOS	FBK Turbine GT32 RIX Turbine
COSMO	Cosmo Turbine Super GT32
IDEMITSU	Daphne Super Turbine Oil FX, MG, HT46, HT68

Table 6-4 Oil change interval of self-cooled type
(Recommended lube for change interval of 1-2 years*)

Manufacture	Recommended brand
Mobil	Mobil SHC 624, 625, 626, 824, 825
ENEOS	FBK turbine GT32
COSMO	Cosmo turbine super GT32

* Note) The oil brand name may change. So contact oil vendor for detail information.

(2) Grease

(2)-1 Selection of grease

a) Recommended grease

Use the grease that is indicated on the bearing nameplate, which is attached near the rating nameplate of the motor and includes the content of a bearing maintenance and the grease name. Our standard grease is as follows.

Manufacture	Brand name	Soap base
Kyodo Yushi	·Raremax Super	Polyurea
SKF	·LGHP 2	Polyurea

The following types of grease can be recommended particularly for use in motors. Please contact us if you are considering the use of other types of grease.

Table 6-5 The marketed grease list

Manufacture	Brand name (Soap base)
SKF	・LGHP2 (Urea base)
Mobil	・BEACON325（Lithium base for low temperature) ・Mobilith SHC100 (Lithium complex base) ・Unirex N2 (Lithium complex base) ・Polyrex EM (Urea base)
Shell	・Shell Gadus S2 V100 2 (Lithium base) ・Shell Stamina Grease RL2 (Urea base)
ENEOS	・Multinoc SDX (Lithium base + special sodium) ・Multinoc Deluxe No.1 (Lithium base + special sodium) ・Multinoc No.1, No.2 (Lithium base) ・Multinoc Urea No.2 (Urea base)
Cosmo	・New Dynamax No.2 (Lithium base) ・Cosmo Wide Grease WR (Lithium base + special sodium)
Kyodo Yushi	・Multemp SRL, SRH (Lithium base) ・Unilube No.2 (Lithium base) ・Raremax Super (Urea base)

b）Selection criteria according to the purposes

- For use in a high speed bearing, use grease with high pressure resistance.
  Choose a high consistency type concerning noise, and a low consistency type in terms of stirring loss. Generally, No.1 or No.2 grease is used.
- For low speed and high load service, use grease with high pressure resistance and low consistency.
- For long-period oil less service, use grease containing antioxidant and that is high in restorability (the property to return to the previous state while the bearing is stopped).
- For a high temperature bearing in particular, grease with a nonmetallic soap base (nonsoap) may be used.
- For damp places, use a water resistant type.
- For the standard motor of this series, urea soap based grease is used.
  The grease must be selected basically according to the conditions mentioned above, but other grease may also be used. However, do not mix different greases.
  When changing the grease, completely wash away the old grease, and supply new grease. However, in the case of similar soap base (Li + Na) grease to Li soap base grease, a slightly larger volume may be required to force out the old grease.
- The following greases are used for heat resistant, water resistant, or cold resistant requirements.

Heat resistant (up to 150℃)	Heat resistant silicone grease (not suitable for high-speed rotating bearings)
Water resistant, chemical resistant (other than caustic soda)	Silicone grease (not suitable for high-speed rotating bearings)
Cold resistant (up to -60℃)	cold resistant silicone grease (not suitable for high-speed rotating bearings)

Notice
■During operation, the bearing temperature will generally be several degrees higher than the measured temperature of the bearing housing. - Be sure to select a grease with temperature specifications that enable it to handle this higher bearing temperature.

(2)-2 Grease up

Since the grease will deteriorate with use, and lose lubrication function, the bearings must be replenished with grease periodically, according to the bearing nameplate attached on the motor. The grease-up interval should be within 1 year or 3000 running hours.

Notice
(1) When starting to run the motor after purchasing, of after 2 months or longer stoppage, be sure to add grease immediately after starting. (2) After starting operation, add grease in the quantity and at the interval indicated on the bearing caution plate on the motor. (3) While injecting grease, keep the motor running or turn it by hand, with the grease drain port open. (4) “Initial quantity” is the quantity for filling the bearing after disassembly cleaning. (5) “Regrease quantity” is the quantity to be injected at each “refill interval”. (6) Do not think of adding more quantity so as to extend refill interval. (7) On the basis of the refill interval indicated on the caution plate, calculate the equivalent interval days, assuming 24-hour daily operation, and inject grease accordingly. This will extend bearing life and keep the bearing running in good condition. When the motor is irregularly operated, e.g., running 12 hours a day, then, 8 hours or 3 hours a day, calculate the refill interval assuming daily 12-hour operation to maintain good lubrication conditions. (8) Since a 4-pole or a 6-pole motor tends to develop failures such as abnormal noise, abnormal wear and bearing burning at high probability, when the specified grease injection after the installation of the motor, after 2 months or longer stoppage, or at the specified period under operation is neglected, rigorous maintenance (greasing) is particularly important with these bearings. (9) Excess grease causes bearing overheating, prolonged high temperature, or grease leakage, and too little grease causes local lack of grease in the bearing and consequential burning. Therefore, be sure to keep the specified add quantity.

(2)-3 Grease discharge

When the outside oil shield is filled with grease, the stirring resistance creates heat to overheat the bearing or forces out grease. When adding grease, remove the grease drain cover and positively discharge grease and positively discharge grease.

6.6 Withstand voltage test

CAUTION	
	■Please check that the man approaches and is not in contact before a withstand voltage test and insulation resistance test. Provide an attention to nearby persons so that they don't approach and contact during the test. - Test voltage may result in electric shock.
	■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 a withstand voltage test, ground windings to discharge. - Without discharging may result in electric shock.

If a withstand voltage test is carried out before a trial run, measure the insulation resistance, and make sure that it is higher than the specified limit.

Refer to IEC 60034-1 Chapter 9.2 and NEMA MG-1 Part-3 about the test voltage and the test procedure.

After the withstand voltage test has finished, be sure to discharge the tested winding. Never touch the windings until they have been discharged. To carry out the withstand voltage 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 withstand voltage 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.

6.7 Others

DANGER	
	■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. * Please refer to Table 6-6 (page 39) for details.

CAUTION	
	■The key which is temporary attached on a motor shaft should be removed before trial run. - Failure to this may cause scattering of a key, resulting in injury.

Check for loosened bolts, nuts, dowel pins and connections. Unless otherwise designated, use the tightening torques listed in Table 6-6 when tightening bolts.

Table 6-6 Specified torques for bolt tightening (in case of strength class 4.8)

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. Implementation of trial run

DANGER	
	■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 place flammable materials near the motor during operation. - They may ignite and burnout.

WARNING	
	■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.

CAUTION	
	■If in doubt, switch off the drive immediately. - Failure to do this may result in electric shock, injury, fire.
	■Do not touch neither a hand nor the body to the external surface of the motor directly because it becomes high temperature during operation. - This may lead to the burn.
	■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.

Notice
■Check that the magnetic center gauge matches to the reference line of the rotor at starting of motor solo run. - To overlook it may result in damage of the machine, such as a bearing burning.

At first, perform a motor solo run by disconnecting the intermediate shaft, etc. from the motor, and confirm that there is no problem. Then, connect the motor 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. The following inspections and confirmations should be carried out before operation.

Use the check sheet shown in Appendix 4 to record at a trial run.

7.1 Solo run tests

(1) Measure the supply voltage to check if the line voltages are balanced and are roughly in agreement with the rated motor voltages.

(2) Check that the oil level of bearing is within the indicated position.

(3) When starting a motor at first, cut off the power source immediately after starting, and perform the following inspection while it is rotating freely by inertia.

a) Confirm that the motor is running in the rotating direction specified in the outline drawing or in the rotational arrow plate.

b) Confirm that the bearing oil ring is turning normally.

c) Confirm that there are no abnormal noises or vibration, or there is no smell insulating materials burning.

(4) If there is no abnormalities under the above inspection, restart the motor and inspect the bearing temperature, vibration, end play and oil ring rotation.

(5) When performing a motor solo run again, check that the shaft is in a center gauge. If the shaft has shifted, the motor should go into operation after the shaft is set by the center gauge.

(6) In case of the motor with antifriction bearings, supply the replenishment amount of the grease which is indicated on the bearing name plate during the trial run.

7.2 Direct coupled tests

(1) When starting a motor after being coupled with a machine, it shall be no-load, and cut off the power source immediately after starting. While it is rotating freely by inertia, the following items should be checked.

a) Confirm that the bearing oil ring is turning normally.

b) Confirm that there are no abnormal noises or vibration, or there is no smell insulating materials burning.

(2) If there is no abnormalities under the above inspection, restart the motor and inspect the bearing temperature, vibration, end play and oil ring rotation.

(3) 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 operation

DANGER	
	■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 place flammable materials near the motor during operation. - They may ignite and burnout.

WARNING	
	■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.
	■At the power failure, switch off the power supply surely - Failure to do this may result in injury.

CAUTION	
	■If in doubt, switch off the drive immediately. - Failure to do this may result in electric shock, injury, fire.
	■Do not touch neither a hand nor the body to the external surface of the motor directly because it becomes high temperature during operation. - This may lead to the burn.
	■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 At starting

(1) Confirm that the starting conditions have been established.
  a）Oil is 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 following starting conditions are normal.
  a）Starting current
  b）Starting time

(3) In case of starting failure, follow the conditions of starting duty.

Notice
■Wait for 10 sec to restart after the power source is cut off and the motor stops completely. - 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. For details, refer to Section 14.1 “starting duty of motor” (page 81).

(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 14.3, 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 9-2 (page 56).

(5) Starting abnormalities
  Check by Table 10-1 (page 62) and Table 10-2 (page 63). When the cause and conditions cannot be determined, contact us.

8.2 At running

During operation, check by Table 9-2 (page 56) and Table 9-3 (page 57) to confirm that there are no abnormalities.

9. Maintenance

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.

Use the sheet for the operation record shown in Appendix 5.

DANGER	
	■ 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. - In order to prevent the misoperation during work, hang an "operation prohibition" tag on the opened circuit breaker.
	■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. * Please refer to Table 6-6 (page 39) for details.

WARNING	
	■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.

CAUTION	
	■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.
	■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.

9. Maintenance (Continuation)

CAUTION	
	■When using a source of flame with the bearing section dismantled, be careful of the following: ・Wipe away any lubricant from the bearings. ・Be sure to protect the bearing section from being heated. ・Use sources of flame only in places where there is no danger of fire. ・Do not use heaters, cigarettes or other general sources of flame near the bearing section. - Failure to do these may result in fire.
	■Do not place flammable materials near the motor. - They may ignite and burnout.
	■During and immediately after measuring the insulation resistance, 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 injury.
	■For motors equipped with filters, clean the filter periodically. - Filter clogging may result in overheating and burnout.
	■Do not approach or touch to a rotating or live part at the visual inspection around brush. - This may result in electric shock or injury.

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 Periodic inspection

(1) Simplified inspection
After dismounting the motor and its cover, inspect the coil end and the bearing metal especially.

(2) Precise inspection
Remove the rotor from the motor, and inspect detail minutely.

In addition to a motor, perform a periodical maintenance to auxiliary machinery, such as a lubricating device, based on each manual.

9.2 Interval of periodic 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 periodic inspection should be determined by taking the operation environment, starting duty, the starting time, and importance to the driven machine, into account.

(1) Simplified inspection
Simplified inspection should be performed between precise inspections, at your convenience. (Every two years)

(2) Precise 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) Overhaul after the initial inspection
About every 4 years after the initial inspection is recommended.

Refer to Section 13 “Instruction of disassembly and reassembly” (page 66-88) for the procedure of the disassembly and reassembly of a motor.

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 9-2 to 9-8 (page 56 to 61), 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) 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.

(3) 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.

(4) 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) for frame 710 and more motors. 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.

(5) Sleeve bearing

The sleeve bearings must be maintained and checked on proper schedules adapted to the operation conditions of the machine. Refer to Section 6.5 "Lubricant" for an exchange of lube.

(5)-1 Daily maintenance

a) Bearing temperature

Abnormal bearing temperature can be detected through the comparison of the accumulated records of daily data, and for this reason, daily operation data records are important.

The bearing temperature is measured by any following methods:

i) Use of a dial thermometer, thermocouple, R.T.D. or other accessory instruments.

ii) Use of a bar thermometer.

A bar thermometer is inserted into the measuring hole of the bearing housing as shown in Fig. 9-1. (This hole is normally plugged, but the plug is removable to allow the installation of a dial thermometer or the like instrument.)

When installing instruments into this hole, contact us to prevent oil leakage.

iii) With forced feed lubrication type bearings, the bearing temperature may be known from the temperature of the outlet oil, in addition to the methods (i) and (ii). Regardless of the method, when abnormal bearing temperature is detected, the bearing must be inspected immediately.

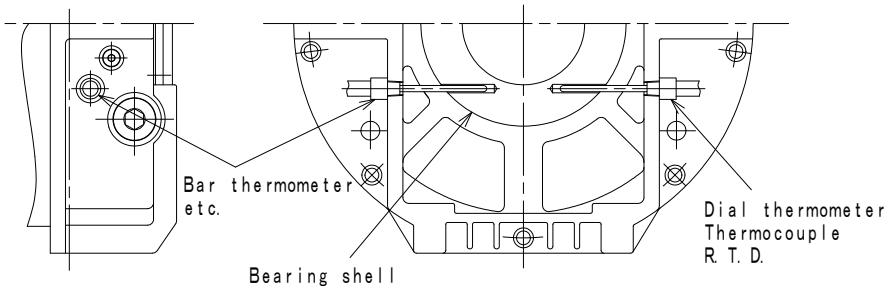


Fig. 9-1 Measuring holes for bearing temperature

Since oil viscosity decreases in winter or cold regions, the bearing temperature may rise. In this case, replace the lubricant with one having better low-temperature characteristics, or, in the case of a forced feed lubricant type, it is recommended that a heater is installed in the oil tank to maintain the oil at an optimum temperature.

b) Oil quantity

i) Self cooled type

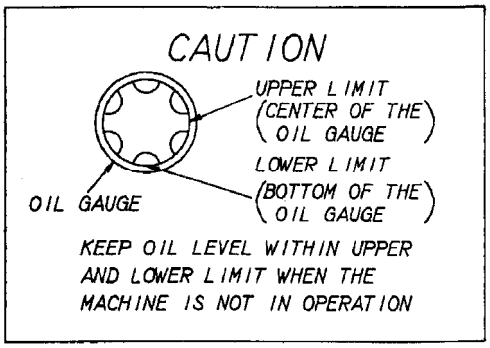
DANGER

■A supply and exchange of lube shall be done after stopping a motor.
- Failure to do this may result in fire.

Notice

■Confirm that the oil level is kept within the indicated location of the oil level gage.

・Refer to the label for oil level which is attached on the motor.



・Excessive oil supply causes leakage.

・Shortage of oil supply leads to excessive temperature rise, and the bearing metal may burn.

Remove the upper plug (see Fig. 13-1 in page 67), and fill lubricant specified in the outline drawing. The mark on the motor oil level gauge indicates the proper oil level with the machine still. While operating the machine, the oil level may vary slightly.

ii) Forced feed lubrication type

Notice

■Confirm that the feed oil pressure is correct with the pressure gauge, and the oil outlet flow is correct with the oil sight gauge.

・Excessive oil supply causes leakage.

・Shortage of oil supply leads to excessive temperature rise, and the bearing metal may burn.

■Be sure to install the outlet oil piping at a down-grade of 1/30 to 1/50 in the oil return direction.

Be sure to flush the piping interior and the circulation devices before starting operation. Do not flow the flushing oil into the bearing, because it contains the foreign matter that was present in the piping. For details, refer to Section 4.9 “Piping”.

c) Oil ring

Check the oil ring rotation by seeing directly from the sight glass or by using the mirror.

d) Oil leakage

Check the bearing, piping and oil feeder, etc. for the absence of oil leaking.

Since the oil seal at the shaft penetration part is a contacted type (floating) seal, the lubrication oil may ooze from the clearance and drip down to the lower part of the bearing housing, even in a normal condition.

e) Long term shutdown

When the motor is left off duty for a long time, or stored as a stand-by unit, be sure to turn the rotor while supplying oil on the journal once in two weeks to prevent rusting in the journal.

(5)-2 Yearly maintenance

a) Checking bearing

Remove the bearing housing upper half, and check the contact pattern on the bearing metal surface for uniform contact, and check the journal for surface damage.

b) Checking oil ring

Check the oil ring for abnormal side wear, for deformation and for loose joint screws.

c) Changing lubricant

DANGER	
	■Do not place flammable materials near the motor. - They may ignite and burnout.
	■When using a source of flame with the bearing section dismantled, be careful of the following: ・Wipe away any lubricant from the bearings. ・Be sure to protect the bearing section from being heated. ・Use sources of flame only in places where there is no danger of fire. ・Do not use heaters, cigarettes or other general sources of flame near the bearing section. - Failure to do these may result in fire.
	■A supply and exchange of lube shall be done after stopping a motor. - Failure to do this may result in fire.

Change interval of the lubricant oil is variable, depending on such conditions as the ambient temperature, ambient cleanliness level, operation condition, the severity degrees, etc. Refer to Section 6.5 "Lubricant" for the details.

(5)-3 Maintenance and inspection at periodical overhauling

The motor should be disassembled, and check all the parts at periodic inspection. For the sleeve bearing, inspect it in the same way as in the above Section 9.3 (5)-2 "Yearly maintenance", and also executes the following:

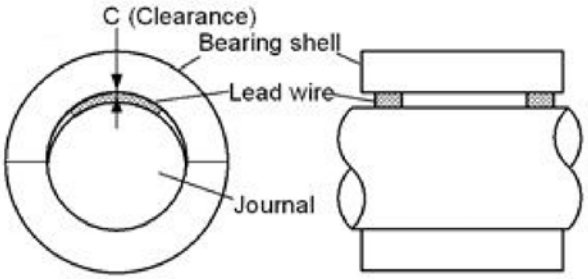
a) Measuring bearing clearance

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

i) Insert a lead wire between the journal and the bearing shell bore before removing the bearing shell lower half, and then cover the bearing sell upper half in place.
ii) Clamp the bearing housing halves together.
iii) The thickness of the pinched and flattened lead wire, as measured with a micrometer, is the bearing clearance.
In this procedure, use a lead wire of diameter which is larger than the clearance approximately by 5/100 to 10/100 mm.
Evaluate the clearance by the following equation, and if the clearance exceeds the calculated value, bearing metal must be exchanged.

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

where [C = clearance (mm), d = Journal OD (mm)]



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

c）Repair
Bearing problems should be handled as shown in Table 9-1. Execute the respective repair.

Table 9-1 Repair

Trouble, etc.	Countermeasure
Cleaning	Thoroughly clean the oil grooves, oil outlet holes, thermometer insertion holes, and the oil inlet/outlet for a forced feed type, with clean detergent. Finally, dry the bearing with soft and lint-free cloth, or with air blow.
Uneven contact with journal	Careful observation of the white metal surface reveals the contact pattern. When a locally concentrated contact pattern is observed, examine whether the motor coupling condition is correct, etc. and if the bearing itself is the cause, scrape off the metal from the surface area where the contact pattern is concentrated, to obtain uniform contact. In this procedure, check the contact by applying red oxide of lead thinly to the journal, and take care not to remove too much babbitt metal at once, and remove only the required minimum.
The thrust surface is partially in contact, or abnormally worn	Check whether the bearing has not been assembled in the wrong orientation, the motor itself has been leveled well, the end play is proper, or other external conditions are in order. When the cause is in the bearing itself, correct the metal surface by scraper, as above.
Eccentricity of the oil ring	Correct it by turning on a lathe.
Loosening of the oil ring joint screws	Carefully check the screw tightness at inspection. If the screw has loosen, use a screw of larger size, and re-cut the internal thread with a larger tap.
The metal surface shows minor scratches or small dents	Smooth the surface with a scraper, and when the scratches or dents are too deep, carefully remove the burr and smooth the bearing metal edges. Take care not to remove too much babbitt metal at once, and remove only the required minimum.
Electrolytic erosion is found	Check the insulation between the bearing shell and the bearing housing, and that of the thermometer, to completely shut off the shaft current. Repair the babbitt metal surface with a scraper.
Bearing has seized or flaked	Replace the bearing metal.
Journal surface has rusted	Polish the surface with oil-soaked hemp rope using chromium oxide powder. When the rust is excessive, use an emery paper.

(6) Antifriction bearing

The Antifriction bearings must be maintained and checked on proper schedules adapted to the operation conditions of the machine. Refer to Section 6.5 "Lubricant" for a supply and an exchange of a grease

(6)-1 Daily maintenance

Notice
■When opening the bearing drain cover, take great care not to allow the entry of dust or iron powder, etc. to prevent damage to the bearing.
■Also take care not to allow foreign matter entry when storing grease for refill or injecting grease with a grease gun.
■Unless some sign of fault is evident, the bearing should not be opened.

a）Bearing noise during operation

Defects in rolling bearings can most conveniently be detected by their running noise. Listen to carefully to the bearing noise with a stethoscopic rod. Typical bearing noise types are as follows:

i) Squeak

The tone is like squeaking metallic materials and it is generated in the case of bad lubrication condition or adhesion condition, or excess radial bearing clearance. They generate more frequent in winter, and tend to temporarily disappear of faint when grease is added. It has been confirmed that bearing temperature does not rise and there is no problem for bearing or grease life when the noise is judged to squeak noise.

ii) Sliding noise

Sliding noise causes from the minor irregularity on the raceway surface of the outer ring or on the rolling element's surface. As long as it is simple and soft noise, it is harmless.

iii) Knocking noise

Knocking vibration noise is produced when the radial bearing clearance is excessive, or the outer ring is installed in misalignment.

iv) Muddy noise

Intermittent muddy noise indicates the presence of dust or magnetized metal particles in the bearing. Continuous muddy noise indicates early flaking on the rolling elements or raceway surfaces, or electrolytic erosion. It occurs at high speeds.

v) Buzzing noise

① Reverberating vibration noise resulting from abnormal deformation in the bearing housing by the rotor weight occurs when its amplified deformation is conducted to the outer ring of the bearing.

② When the grease lubrication effect is faulty, the rolling elements locally slip relative to the raceway surfaces of the inner and outer rings, and produce roaring noise.

③ When the shaft is eccentric or not accurately square, vibration and squeaking roar are produced.

This noise is especially loud with roller bearings. At low speeds, the noise is loud, and at high speeds, fine high-frequency noise is produced.

vi) Roller dropped out noise, ball dropped out noise

These dropped out noises are produced when the bearing is subject only to radial load at low speed. When the rolling elements leave the loaded position and enter the unloaded position, they become free to move, and drop under gravity to collide with the cage or the raceway, producing noise.

b）Bearing temperature

Rolling bearings may not be in abnormal conditions even when the temperature is high, and individual study is required to evaluate their conditions. When grease with low cone penetration is used in a high speed bearing, the bearing temperature rises, but this is because of the intensive stirring of the grease, and as long as the temperature is within the allowable range of the grease, no special measure is required. However, temperature rise in a manner significantly different from normal can be an indication of some faults such as excess grease, deteriorated grease and flaking, so that daily recording of the bearing temperature is necessary.

The temperature of rolling bearings can be measured with a dial thermometer, a thermocouple, or a R.T.D, but a bar thermometer attached to the bearing housing with a putty is also satisfactory.

Daily monitoring and recording of the temperature will enable the detection of bearing faults.

c）Grease leakage

Inspect the bearing area for grease leakage.

d）Bearing vibration

Daily recording of the vibration on bearings can discover abnormal vibration. Faults such as flaking, abrasion, denting, galling, breaking and electrolytic erosion produce loud noise, heating and vibration, and demand bearing replacement, but when proper measures are taken at the early stage of faults, accidents are avoided.

The following are representative diagnostic guidelines:

i) When vibration and noise increase in relatively short time, the load condition should be checked.
   - ④ Excessive load such as belt tension
   - ⑤ Excessive thrust load due to the heat expansion of motor or the directly coupled machine.
   - ⑥ Excessive thrust load due to the inadequacy in direct coupling, etc.
   - ⑦ Excessive radial load to distorted foundation or introduced in the course of installation.

ii) With a ball bearing, axial vibration in an abnormally high frequency is observed sometimes. This is a resonance of the natural frequency of the vibration system consisting of the mass of the bearing outer ring and the axial elasticity of the rolling elements with the random waving. In this case, vibration occurs and fades very irregularly. Occasionally, the bearing area of the bearing housing produces abnormal beat resonance. In this case, the following counter measures must be taken:
   - ① Replacing the bearing
   - ② Applying some preload to the thrust direction of the outer ring.
   - ③ Changing the grease with one of better lubrication effect

(6)-2 Yearly maintenance

a) Grease change or grease-up

Bearing grease has definite service life, and after its life, it deteriorates and decreases. If the motor is run with the bearing filled with deteriorated grease, the bearing becomes heated and eventually burns. Replace the old grease with new grease. The grease change or replenish intervals are given on the bearing name plate. Add grease during operation as follows:

i) Clean the area around grease filler by wiping to remove dirt.
ii) By injecting grease into grease filler with a grease gun, the old grease is pushed out of the drain port.
iii) When the injection volume according to the bearing nameplate has been injected, stop injecting, and let the motor run a while, with the cover of the grease drain port open to allow excess grease to flow out.
iv) If the drain cover is closed without discharging the excess grease, the bearing may heat abnormally. When no more grease is discharging, close the drain cover.

(6)-3 Maintenance at periodical overhaul

In the course of the periodical overhauling, various parts of the motor are checked, and as far as the bearing is concerned, the check is the same as the “yearly maintenance”, with the addition of the following.

DANGER
■Shut down all power sources before starting periodic inspection. - Failure to do this may result in electric shock or injury. - In order to prevent the misoperation during work, hang an "operation prohibition" tag on the opened circuit breaker.

a) Cautions at removing bearings

When removing the bearing, pay attention to the following cautions:

i) When a bearing is removed, be sure to install a new bearing, without re-using the removed bearing.
ii) Carefully wash and clean the area around the bearing, including the shaft, the bearing housing and the oil shield, and carefully keep the interior of the grease feed pipe clean.
iii) When disassembling and reassembling the motor, be careful in handling the insulation for blocking shaft current, inserted in the non-drive end side bearing housing. Take care also not to allow current conducting dust to deposit in this area. For the exact location of the insulation, refer to Fig. 13-12, the bearing structural drawing. Where a bearing thermometer is installed, the element is also insulated, and due caution is required in handling it.

b) Measuring insulation resistance

To evaluate the shaft current blocking insulation, measure its insulation resistance in the course of trial run after reassembling the motor, with a 500V megger. At least 0.5MΩ at the time of motor disassembly shall be acceptable.

(6)-4 Long-period out of operation and storage

Motors left out of operation for a long period of time, or stand-by motors should be greased once in 6 months while turning.

Spare bearings must be coated with rust-preventive oil, oil-resistively packed, sealed in a case, and stored in a dust-free, cool and moisture-free place. Large bearings should be placed on a flat shelf.

9.4 Commissioning after inspection

Execute the test run after the maintenance inspection according to the contents of Section 6 ”Preparations and inspections before trial run” (page 32 to 39) and Section 7 “Implementation of trial run” (page 40 to 41).

Table 9-2 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: Inside of zone B in Fig. 14-1
	Frequency	Daily	Frequency meter	Limit: Inside of zone B in Fig. 14-1
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 value according to Section 14.4.1
	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,bear-ing,coil)	Daily	Sense of touch, thermometer	No change in temperature rise from the values at the initial time.
	Cover etc.	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. Environ-ment	Ambient temperature	Weekly	Thermo-meter	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				
4.1 Sleeve bearing	Temperature	Daily	Sense of touch, thermometer	When the temperature is sensed as abnormal, measure it with a thermometer. Temperature limit: 95℃ (reading value)
	Oil level and oil leakage	Daily	Visual inspection	Be normal oil level.
	Oil pressure	Daily	Visual inspection	Be normal.
	Oil rings	Daily	Visual inspection	Be rotating smoothly.
4.2 Antifriction bearing	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℃, measured by embedded sensor Up to 95℃, measured on surface of housing
	Grease up	As specified	Grease gun	Refill as required.

Table 9-3 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 Flow meter	Flowing Be regular flow rate

Table 9-4 Maintenance inspection standard - Daily inspection (when the motor is stopped)

Category	Inspection procedure			Requirements
	Subject of inspection	Inspection cycle	Method of inspection	
1. Investigation	Check failures in operation log	Monthly	Service log	No abnormality
2. Appearance	Damage and dirt on the frame and terminals	Monthly	Visual check	Clean and make repairs
	Cooler tubes, air ducts, and filters	Monthly	Visual check	Cleaning of found clogging
3. Bearing				
3.1 Sleeve bearing	Oil contamination	Monthly	Visual check	No sludge babbitt metal chaffings or any other foreign objects
3.2antifriction bearing	Discharged grease	Monthly	Visual check Analysis	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 Section 5.6(5) (page 31), and exchange brushes according to the wear extent.

Table 9-5 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 abnormalities in operation log	2 years	Service log	Make repairs if necessary
2. Measurement	Insulation resistance of coils	2 years	Megger	1000V or more : More than 100 [MΩ] Less than 1000V : More than 5 [MΩ]
	Air gap	2 years	Gap gauge	$\frac{\text{Max, value} - \text{min, value}}{\text{Mean value}} \times 100 \leq 20\%$
	Fan clearance	2 years	Gap gauge	Min 5mm
3. Appearance	Dirt or painting on the frame	2 years	Visual check	Cleaning and repairs
	Terminals	2 years	Visual check	Repair if abnormal
	Filters	2 years	Visual check	Clean and repair (Replace when necessary)
	Bolt joints	2 years	Visual check	No loosening, falling off and damage
	Motor foundations	2 years	Visual check	No indentations or cracks
4. Stator	Cores and coils	2 years	Visual check	No dust, oil, moisture and foreign objects
	Cores	2 years	Visual check	No unevenness, overheating, discoloring, damage, rust, etc.
	Core ends	2 years	Visual check	No tumble or protrusion of air duct pieces, loosening or damage of core sheets
	Coil ends	2 years	Visual check	No deformations, damage and dirt
	Insulating materials	2 years	Visual check	No varnish spouting, void and tracking, etc.
	Wedges	2 years	Visual check	No loosening
	Coil supports	2 years	Visual check	No shifting, getting out and loosening
	Air deflectors	2 years	Knocking sound Visual check	No loosening and cracks
5. Rotor	Cores	2 years	Visual check	No rust, loosening, dust, oil, moisture, other foreign objects, overheating, discoloring and damage
	Connection of rotor bars and end rings	2 years	Visual check	No cracks and bar shifting

Table 9-6 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 of bearing)	Lower metal to be in good working order
			Visual check (magnifying glass)	Upper metal to be free from contact marks
	Metal adhesion	2 years	Color check (PI)	50% or more
	Metal clearance	2 years	Micrometer	Refer to Section 9.3(5)-3a)
	Oil slingers	2 years	Thickness gauge	Within limit
	Oil rings	2 years	Visual check	No deformation and serious wear No loosened setscrew
	Oil	2 years	Visual check	No dirt, deterioration and foreign objects
	End play	2 years	Thickness gauge	Within limit
			Scale	Refer to Section 4.6 Table 4-1
6.2 Antifriction bearing	Grease con-termination	2 years	Visual check	No dirt, deterioration and foreign objects Replace of grease
7. Instruments	Dirt, damage	2 years	Visual check	No dust, oil, moisture, foreign objects and damage
8. Coupling	Deviation of eccentricity and parallelism	As required	Dial gauge	Within tolerances Refer to Section 4.6
	Centering	As required	Dial gauge	Within tolerances Refer to Section 4.6
	Direct coupling	As required	Visual check	No loosened bolts and nuts.
	Damage	As required	Visual check	No damage and breakage of key way
			(Color check if required)	No abnormal wear on tooth surface of the gear coupling.
9. Operation on load	Abnormal noise, vibration abnormal odor	As required	Sense of hearing, touch, and smell	No abnormality
	Rotational direction	As required	Visual check	Normal rotational direction
10.Heat exchanger (CACA cooler)	Crack or corrosion of pipe	As required	Visual check	No crack or corrosion When crack or corrosion is found, replace the heat exchanger.
11.Shaft current	Protective device	2 years	Visual check Tester	After cleaning, measure insulation resistance: 0.5MΩ or more (at motor itself when disassembled)

Table 9-7 Maintenance inspection standard - Regular inspection (Overhaul with rotor removal)

* 4-year-cycle shows the interval from the initial inspection. The initial inspection shall be 1-2 years from the start of operation (Refer to Section 9.1)

Category	Inspection procedure			Requirements
	Subject of inspection	Inspection cycle	Method of inspection	
1. Investigation	Check abnormalities in operation log	4 years (*)	Service log	Make repairs if necessary
2. Measurement	Shaft level	4 years (*)	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 9-5
	Space heater insulation resistance	4 years (*)	Megger	More than 1kΩ with a 500V megger
	Air gap	4 years (*)	Gap gauge	Refer to Table 9-5
	Fan clearance	4 years (*)	Gap gauge	Min 5mm
3. Appearance	Dirt or painting on the frame	4 years (*)	Visual check	Cleaning and repairs
	Filters	4 years (*)	Visual check	Clean and repair (Replace when necessary)
	Bolt joints	4 years (*)	Visual check	No loosening, falling off and damage
	Motor foundations	4 years (*)	Visual check	No indentations or cracks
4. Stator	Cores and coils	4 years (*)	Visual check	No dust, oil, moisture and foreign objects
	Cores	4 years (*)	Visual check	No unevenness, overheating, discoloring, damage, rust, etc.
	Core ends	4 years (*)	Visual check	No tumble or protrusion of air duct pieces, loosening or damage of core sheets
	Air ducts	4 years (*)	Visual check	No clogging
	Coil ends	4 years (*)	Visual check	No deformations, damage and dirt
	Insulating materials	4 years (*)	Visual check	No varnish spouting, void and tracking, etc.
	Coil supports	4 years (*)	Visual check	No shifting, getting out and loosening
	Wedges	4 years (*)	Hammering	No withering, loosening and falling off
	Coil binding strings	4 years (*)	Visual check Sense of touch	No shifting, loosening, discoloring and deterioration
	Lead cable and terminals	4 years (*)	Visual check	No damage, deterioration and deformation of terminals No dust, oil, moisture and adhering of foreign objects
	Air deflectors	4 years (*)	Visual check	No abnormality in the welded part No loosened bolts
	Space heaters	4 years (*)	Visual check	No loosened fastener parts, dust, oil, moisture and adhering of foreign objects.
5. Rotor	Cores	4 years (*)	Visual check	No rust, loosening, dust, oil, moisture, other foreign objects, overheating, discoloring and damage
	Joint of rotor bars and end rings	4 years (*)	Visual check Color check	No cracks. Dislocation of silver solder shall be less than 50% for each side of joint surface. No bar shifting
	Rotor bars	4 years (*)	Hammering	No loosening.
	Fans	4 years (*)	Visual check	No deformation of fan blades
	Balance weights	4 years (*)	Hammering	No loosening
	Shaft journal	4 years (*)	Visual check Sense of touch	No scars, knock marks, and pressing marks

Table 9-8 Maintenance inspection standard - Regular inspection (Overhaul with rotor removal)

* 4-year-cycle shows the interval from the initial inspection. The initial inspection shall be 1-2 years from the start of operation (Refer to Section 9.1)

Category	Inspection procedure			Requirements
	Subject of inspection	Inspection cycle	Method of inspection	
6. Bearing				
6.1 Sleeve bearing	Metal contact	2 years	(Overhaul 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	More than 50%
	Metal clearance	2 years	Micrometer	Refer to Section 9.3(5)-3a)
	Oil slingers	2 years	Thickness gauge	Within limit
	Oil rings	2 years	Visual check	No deformation and serious wear No loosened setscrews
	Oil	2 years	Visual check	No dirt, deterioration and foreign objects
	End play	2 years	Thickness gauge, Scale	Refer to Section 4.6, Table 4-1
6.2 Antifriction bearing	Grease con-termination	2 years	Visual check	Grease replacement
7. Instruments	Correction	4 years (*)	Comparison with standard	Within standard values
8. Coupling	Deviation of eccentricity and parallelism	As required	Dial gauge	Refer to Section 4.6
	Centering	As required	Dial gauge	Refer to Section 4.6
	Direct coupling	As required	Visual check	No loosened bolts and nuts.
	Damage	As required	Visual check (Color check if required)	No damage and breakage of key way No abnormal wear on tooth surface of the gear coupling.
9. Operation on load	Abnormal noise, vibration, and abnormal smell	As required	Sense of hearing, touch, and smell	No abnormalities
	Rotational direction	As required	Visual check	Normal rotational direction
10.Cooler (CACW cooler)	Inside inspection	4 years (*)	Visual check	No abnormal corrosion and pinholes.
	Hydraulic test	4 years (*)	Hydraulic test	No leakage and deformation.
(CACA cooler)	Inspection of pipe	4 years (*)	Visual check	No crack or corrosion When crack or corrosion is found, replace the heat exchanger.
11.Piping	Damage	4 years (*)	Visual check	Freedom from loosened fastenings, water leakage, oil leakage and corrosion.
12.Shaft current	Protective device	2 years	Visual check Tester	After cleaning, measure insulation resistance: 0.5MΩ or more (at motor itself when disassembled)

10. Troubleshooting

Table 10-1 shows the various troubles, their causes and countermeasures.
If you consider the troubles serious, immediately contact us.

Table 10-1 Troubleshooting

Trouble	Cause		Countermeasure
1. The motor will not start. Even when the main switch is turned on, no sound is heard.	The starting conditions have not yet been prepared.	Some interlocks have not yet been released.	Check for wrong wires and contacts on the circuit.
	The circuit from power source to motor main terminals is wrong.	No voltage is supplied to the starter.	
		Starting contactor is wrong.	
		The fuses of two-phases are melted.	Exchange melted fuses.
	The stator winding of the motor is broken.		Check the main terminal. Repair the detective stator winding.
2. The motor generates abnormal noise without starting up.	The motor condition remains one phase	One phase fuse is melted.	Check for wrong wires and contacts on the circuit.
		One-phase of starter circuit is wrong.	
		Starting contactor is wrong.	
	Mechanical lock.	The driven machine is locked.	Check the driven machine and coupling, and consider proper countermeasures.
		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	
	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.
4. Abnormal noise and vibration	One-line fault; unbalanced voltage	Wire in circuit is broken.	Check each line to locate defective points.
		The fuse is melted.	
		Contact is wrong.	
	Mechanical abnormalities of motor	Unbalanced rotor	Overhaul inspection
		Slackened core laminations	
		Cracked end ring, ruptured bar	Overhaul inspection
		Slackened core laminations	Overhaul inspection
		Unbalance or contact of air gap	Overhaul inspection
		Intrusion of foreign objects	Overhaul inspection
		Bending or cracking of shaft	Overhaul inspection
	Oscillating in the driven machine	Vibration of the driven machine	Disconnect the coupled machine, and check for the causes.
	Misalignment	Bending of shaft	
		Slackened coupling	Tighten up the coupling bolts.
		Improper connection with foundation	Make repairs

Table 10-2 Troubleshooting

Trouble	Cause		Countermeasure
5. Excessive temperature rise and smoking	Abnormalities in the power source	Unbalanced voltage, one-line fault, wrong voltage or frequency, or voltage drop	Check the power source and starter for abnormalities.
	Overload	Overload caused by the fault of the driven machine	Disconnect the motor, and check for troubles.
		Excessive start and stop or excessive reverse running.	Review the selection of motor.
	Poor cooling	Clogged filter or intrusion of foreign objects into the ventilation grille.	Cleaning
	Defective windings	Stator windings are shorted or earthed.	Repair windings.
	Mechanical fault	The metal contact in air gap	Same as item 2
		Overheat of bearing caused by bad directed coupling such as excessive belt tension, misalignment, etc.	
6. Seizure of sleeve bearing	Shortage of lubricant	Fault of rotation caused by deformation or abrasion of oil ring	Exchange or repair of oil ring.
		Shortage of supply oil quantity	Supply of oil
		Oil leakage	Check for the causes
		Oil circulation pump failure, blocked oil piping, or oil leak	Disassembly investigation and correct
	Defective lubricant	Change in quality or deterioration	Check color and acid value.
			Oil exchange
		Unsuitable oil viscosity	Oil exchange
		Mixture of water or foreign substances (metal sludge or dust)	Study contamination route.
			Oil exchange
	Failure of bearing metal contact	Excessive bearing clearance	Exchange the bearing
		Defective contact of bearing caused by abrasion or vibration, etc.	Correct
	Defective bearing insulation	Contamination, water, wet by oil, or defective pipe insulation	Clean and check insulation resistance.
	Excessive vibration or abnormal thrust	Misalignment of direct coupling or installation, shaft bending, or impact from machine side	Correct alignment Check load machine
7. Defect of grease lubricated antifriction bearing	Pronounced retainer sound	Vibration of the retainer, wear, or shortage of grease	Replenish the grease. If the sound recurs, replace the bearing.
	Squeak sound (No problem and no effect on bearing life unless the sound is so large as to cause vibration)	Lack of grease	Replenish the grease.
		Defective lubrication	Change the grease type to soft and good oily one
		Excessive radial clearance	Replace the bearing with having smaller clearance.
	Flaw sound	Scratches on the raceway surface or rolling elements	Replenish the grease. Replace the bearing.
	Dust sound	Mixture of dust or magnetized iron powder	Clean or replace the bearing.
	Howling or resonant sound	Defective lubrication, misalignment of shaft center, or improper perpendicularly	Change to good oily grease. Correct for optimal preload or fit.

Table 10-3 Troubleshooting

Trouble	Cause		Countermeasure
7. Defect of grease lubricated antifriction bearing	Increase of vibration	Scratched or worn bearing, or mixture of foreign substances	Replace the bearing.
		Shortage of grease	Replenish the grease.
		Defective lubrication by deterioration	(Inject a new grease and discharge an old grease)
		Improperly mounted bearing	Disassembly and reassembly
	Increase of temperature rise (The temporary temperature rise following injection is not a problem)	Scratched bearing or mixture of dust	Replace the bearing.
		Shortage of grease	Replenish the grease.
		Defective lubrication by deterioration	(Inject a new grease and discharge an old grease)
		Overgrease	Inject the grease with discharge port open while running the machine.
		Improperly mounted bearing	Correct the mounting.
		Excessive bearing load	Remove the cause of the excessive bearing load
		Overload	Remove the overload
	Flaking (Local peeling of metallic surface)	Excessive thrust loads	Examine thrust loads
		Improperly adjusted assembly	Adjust the preload at mounting properly
		Misaligned bearing centers or inclined bearing installation	Perform assembly properly. Replace it to a bearing with larger clearance.
		Scratches caused by excessive force at assembly	Be careful at assembly. Confirm mounting dimensions
		Foreign matter caught in fit surfaces	Clean or correct the fit surface of the shaft and housing
		Local deformation by the scratches	
		Improper bearing clearance	Replace the bearing.
		Defective lubrication	Replenish the grease.
		Rusting	Cleaning Be careful at assembly.
	Cracked rolling elements and raceway surface	Abnormal impact while there is excessive bearing clearance	Replace the bearing. Be careful at assembly.
		Jammed by contaminants at mounting	
		Wear by loose fit tolerance	
		Slide on the end face due to loosely tightened retainer	
	Chipped rib of bearing inner ring	Hit at mounting the bearing	Replace the bearing. Be careful at assembly.
	Bruises of the rolling element pitch	Excessive force to the rolling element at mounting	Replace the bearing. Be careful at assembly.
	Spotted bruises	Entering a foreign matter into bearing unit at standstill	Be free from contaminants
	Wear of the rolling element pitch	Vibration during transport	Replace the bearing.
		External vibration transmitted from the soft base	Make stiff base. Minimize external vibration.
	Abnormal wear	Mixture of foreign substances, rust, or shortage or deterioration of lubricants	Replace the bearing. Improve the environment. Enhance the seals. Adopt adequate lubricant.
	Creep	Improper fit, vibration, or impact loads	Replace the bearing or repair properly. Check the loads.

Table 10-4 Troubleshooting

Trouble	Cause		Countermeasure
7. Defect of grease lubricated antifriction bearing	Contact corrosion	Defective correction at the fit parts	Replace the bearing or repair properly.
		Elastic deformation due to excessively large loads	Check the loads.
	Electrolytic corrosion	Shaft current	Replace the bearing. Clean the shaft current preventive insulation.
	Damaged cage	Defective cage	Replace the bearing.
		Defective lubrication	Inject a suitable lubricant into the cage riding clearance.
		Damage at mounting	
8. Defect of oil lubricated antifriction bearing	High temperature	Shortage of oil supply	Check the oil level. Fill with oil.
		Defective lubricant, inappropriate oil type, or deterioration	Replace the lubricant. Change the oil type.
		High room (water) temperature	Reduce the temperature
		Mixture of foreign substances	Check the route where the foreign substances penetrate.
8. Irregular detection of ammeter	Early indication of the above trouble	Winding fault, bearing seizure, breaking of wire, contact failure, etc.	

11. Replacement parts

Confirm that the renewal parts suits the original specification. Please contact us if there is an unclear point.

CAUTION	
	■Before rewinding coils, contact us and follow our instructions. - The insulation used on coils, etc. may generate toxic fumes during heating.

Notice
■Use an equivalent device, when renewing accessories, such as a dial thermometer, thermocouple, etc., with which the bearing is equipped. Especially, since there is a case where an insulation tube is inserted to a temperature sensing element in order to prevent damage of the bearing from the shaft current, be sure to equip with the insulation tube in that case.

12. Disposal

When discarding a motor, we recommend asking to a special disposal company. Notify the following notes to them in that case.

CAUTION	
	■When the motor must be discarded, contact us and follow our instructions. - By heating, toxic fumes may be generated.
	■When the motor must be discarded, it should be treated as a general industrial waste.

13. Instruction of disassembly and reassembly

13.1 Horizontal motor with sleeve bearings

The disassembling and reassembling procedures of bracket type bearings may vary slightly according to the motor types, but typically they are executed as described below.

13.1.1 Preparation for disassembly

(1) Thoroughly study the structure of the machine to be disassembled.
   a) Make preparation for the disassembly procedure.
   b) Prepare disassembly tools.

(2) Carefully select the area for disassembly.
   a) Avoid dusty areas.
   b) Be careful of the weather when disassembling outdoor machines, and if necessary, bring them indoors.

(3) Carefully clean the area around the bearings, including the shaft and the bearing housing.

13.1.2 Bearing disassembly procedure

(1) Removing accessories
   a) Remove the dial thermometer, thermocouple or other bearing temperature measuring devices.
   b) Drain the lubricant from the bearing housing through the drain port by removing the plug.
   c) Disconnect the oil feed pipe, if connected.

(2) Removing bearing housing upper half (see Fig. 13-1, 13-2)
   a) Remove clamping bolts ③ for bearing housing upper half ① and bearing upper half cover ②, and take off upper half cover ②.
   b) Remove clamping bolts ⑤ for bearing housing upper half ① and bearing housing lower half ④.
   c) Lift the bearing housing upper half ① carefully and slowly, taking care to avoid fouling other components, and remove it. Especially, to prevent damage to the floating seals during disassembly, when lifting the bearing housing upper half ①, keep the bottom surface horizontal at all times. Since the non-drive end side bearing is normally provided with an insulator to prevent shaft current, pay attention to it during disassembly and reassembly. In addition, take care to keep this area free from contamination by foreign matter that may allow current at all times.

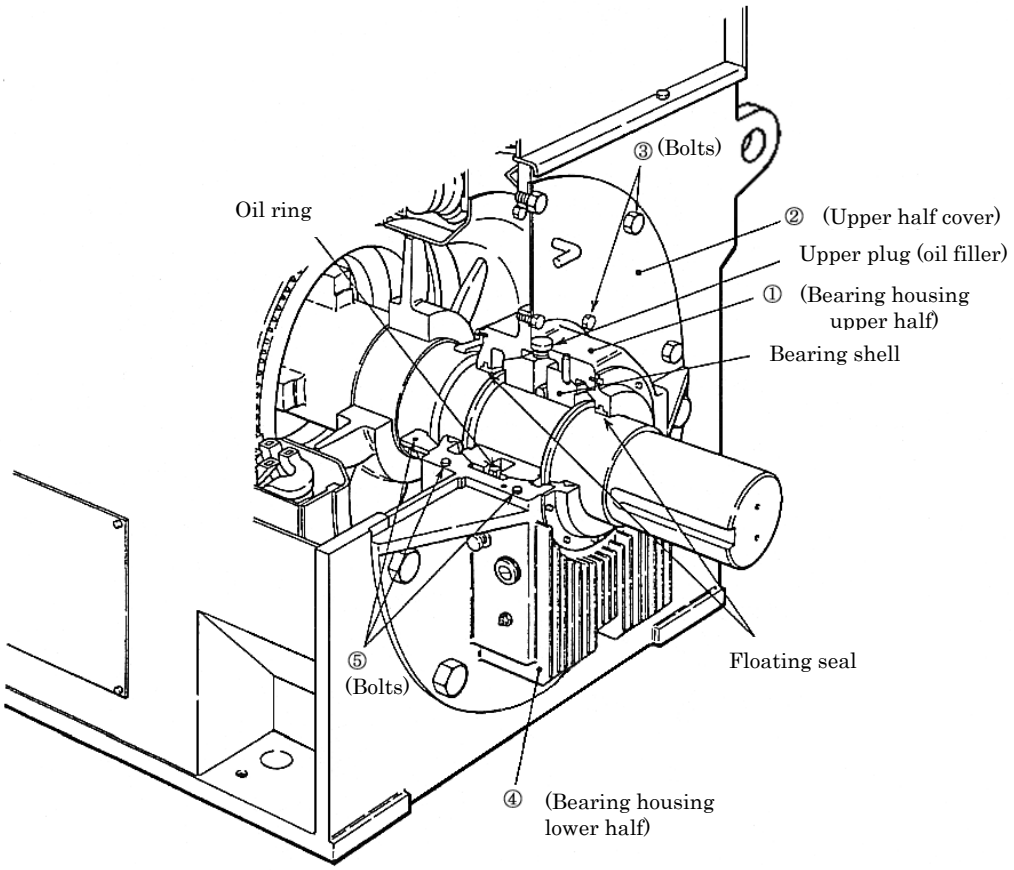


Fig. 13-1

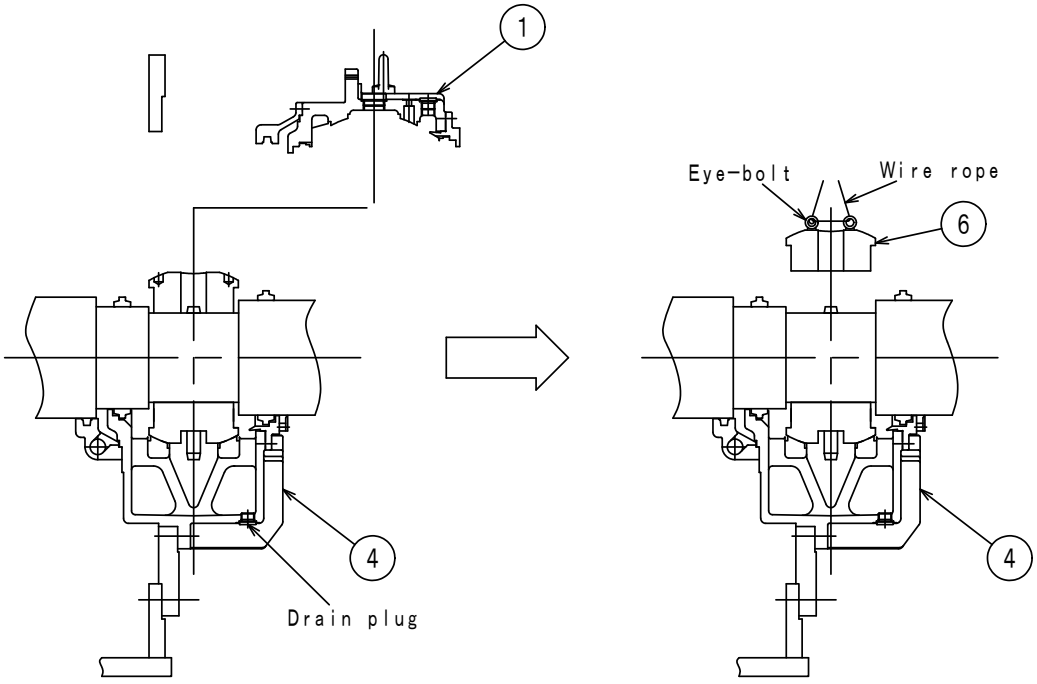


Fig. 13-2

Fig. 13-3

(3) Disassembly of bearing shell upper half (see Fig. 13-3)

a) Screw eye-bolts into bearing shell upper half ⑥.

b) Pass wire rope through the eye-bolts and lift the bearing shell upper half vertically. Take care not to damage the metal while removing the bearing shell, and be sure to place the removed bearing shell on protective wood blocks, not directly on the floor.

c) Move the bearing shell slowly, and absolutely avoid crash drop.

(4) Disassembly of oil ring (see Fig. 13-4)

a) Rotating the joint to the top, and then remove the joining screws from oil ring ⑦.

b) Take out oil ring ⑦ from the journal.

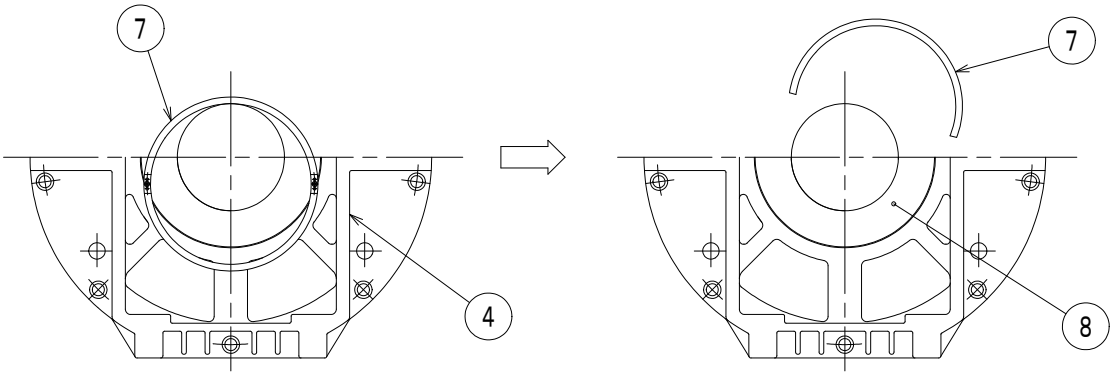


Fig. 13-4

(5) Disassembly of floating seal (see Fig. 13-5)

a) Unlock garter spring ⑨, and take out upper half ⑩ of floating seal.

b) Rotate floating seal lower half ⑪to the top position, and remove it.
When taking out the floating seals, pay attention to prevent damage.

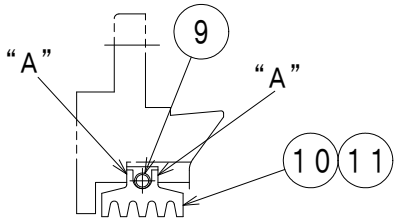


Fig. 13-5

(6) Disassembly of bearing shell lower half (see Fig. 13-6, 7, 8)

Synchronize the disassembly procedures on both the drive end and non-drive end sides.

a) Lift up the rotor within the limit that can remove bearing shell lower half ⑧. In this procedures, take care to avoid the contact of the air gap between the rotor and the stator. The allowable lifting limit is 0.5 mm.

Example of rotor lifting method

i) Jacking up the drive end side coupling.

ii) Lift the shaft end of the non-drive end side with a fine-adjustable chain block, applying wire rope to the shaft end over a protection sheet.

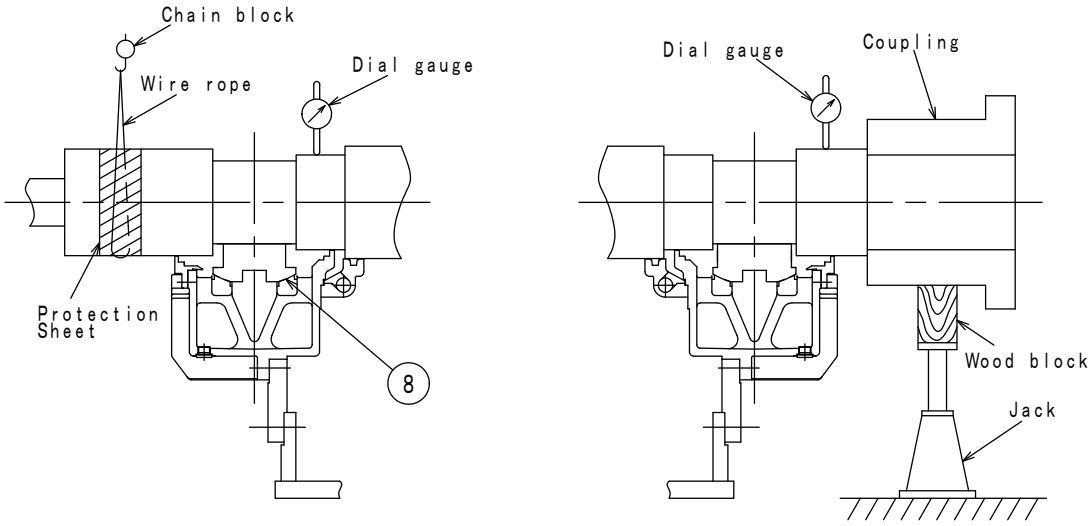


Fig. 13-6

As the other method, there is the case that the non-drive end side also be jacked up as shown in i), or when the shaft is not extended, there is the case that a pipe is inserted into the shaft end and this pipe is lifted with a wire rope (see Fig. 13-7).

iii) This work must be executed with utmost care and attention, and must be entrusted by skilled workers.

b) During lifting the rotor, rotate bearing shell lower half ⑧ to the top position of the shaft journal.

c) Screw eye-bolts into bearing shell lower half ⑧, and take it out by lifting (see Fig. 13-8). Take utmost care in this procedure as same in the case of the bearing shell upper half.

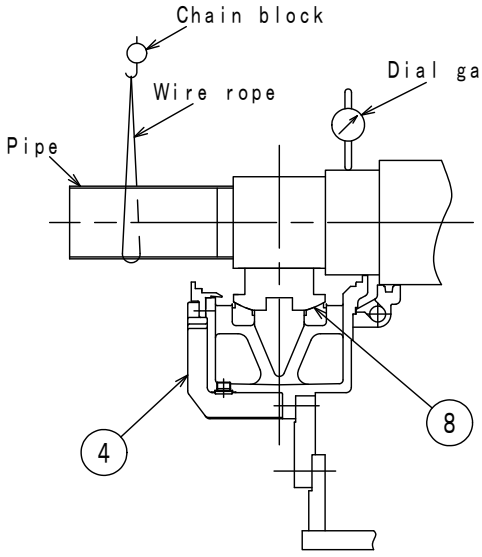


Fig. 13-7

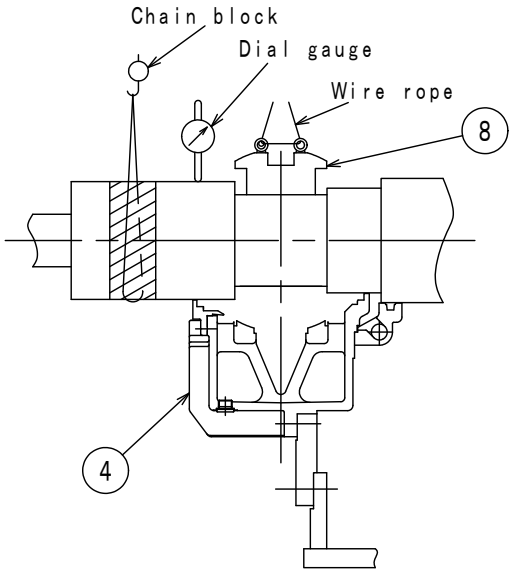


Fig. 13-8

(7) Disassembly of bearing housing lower half (see Fig. 13-9)

The bearing housing lower half is disassembled only when the rotor is pulled out.

a) Remove the fastening bolts for seal carrier ⑫ on the drive end side and on the non-drive end side.

b) Set up eye-bolts into the screw holes of the lower half fastening the upper half and the lower half of the bearing housing, and hold the bearing housing by passing wire rope through the eyes, paying attention to the center of gravity location.

c) Remove the bolts that are fastening the housing lower half to the stator frame.

d) Lower or remove the bearing housing lower half not to prevent the rotor pulling-out. In general, since the rotor is pulled out to the opposite load side, lower the bearing housing lower half on the load side only enough to clear the coupling (the coupling flange outer diameter must be smaller than the stator core bore), and remove the bearing housing lower half on the opposite side to prevent damage to the collector, etc.

e) Carefully lower the rotor by loosening the jack and the wire rope, and place the rotor on the stator core. In this procedure, lower the jack and the wire rope on both the load side and the opposite side simultaneously so as to avoid partial contact and impact to the core surface.

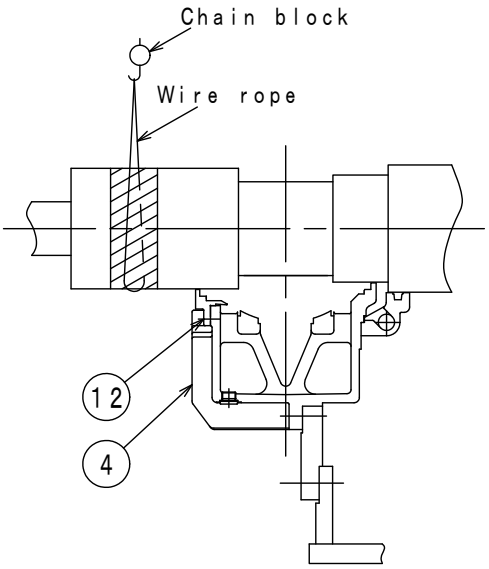


Fig. 13-9

13.1.3 Reassembly procedure

When reassembling the bearings, clean the all disassembled parts, and carefully avoid leaving any parts unassembled.

(1) Reassembly of bearing housing lower half

a) Lift the rotor up 0.5 mm max., paying attention to the clearance of the air gap, as same in the case of the bearing housing lower half disassembly (Section 13.1.2(6)).

b) Locate the bearing housing lower half to its exact position, and fasten it to the stator frame. Remove the wire rope from the bearing housing.

(2) Reassembly of bearing shell lower half

a) Wash the shaft with benzine or kerosine, and blow thoroughly with compressed air.

b) Apply bearing lubricant to the shaft.

c) Apply lubricant to the babbitt metal surface of the bearing shell lower half, and slide the shell to its position underneath the shaft.

d) Align the mating surface of the bearing housing lower half with the mating surface of the bearing shell lower half using a stretch.

e) Checking magnetic center gauge

Confirm that magnetic center gauge ⑬ mounted to the bearing housing lower half on the drive end side is matched with the red reference line indicated on the shaft(see Fig. 13-10).

f) Carefully lower the floating rotor and support it by the bearing shell lower half.

g) Install the seal carrier that has been removed in Section 13.1.2(7), and make sure that their clearance with the shaft is correct by measuring with a thickness gauge.

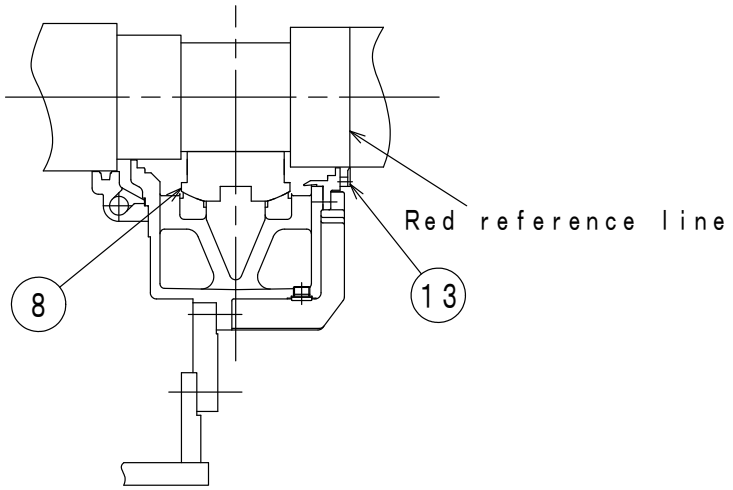


Fig. 13-10

(3) Reassembly of oil ring

Reassemble the two halves of the oil ring carefully avoiding wrong pairing. If wrong halves are assembled together, they don't fit well or may be elliptic, resulting in improper rotation. The joint of the rings should be within the surface of the ring sides.

(4) Reassembly of bearing shell upper half

a) Screw eye-bolts into the bearing shell upper halves, and slinging them vertically with wire rope, reassemble them with the bearing shell lower halves. Align the match marks on the upper and lower bearing shell halves.

b) Thoroughly check that all the parts such as the anti-rotation pin are assembled in the bearing housing.

c) Check that not foreign objects such as tools and bolts are left in the bearing housing.

d) Be sure to apply oil seal to the mating surfaces of the housing to prevent oil leakage.

(5) Reassembly of floating seal

a) Apply un-hardening compound (like ThreeBond 1121) or grease thinly on the peripheral side faces ("A" in Fig. 13-5) of the floating seal, and apply lubrication oil thinly on the bore of the floating seal.

b) Insert the floating seal lower half (with an oil drain hole) into the seal carrier and lower half by turning it. Make sure that the drain hole is facing inside the oil sump.

c) Install the floating seal upper half. Wound the garter spring around the floating seal, and lock it. Carefully align the upper and the lower halves of the floating seal to make their surfaces flush. After assembling, make sure it is free from jamming to be caused from deformation by turning it.

d) During reassembling the seal carrier upper half, confirm that the anti-rotation pin of the seal is properly secured in its groove.

(6) Reassembly of bearing housing upper half

Notice
■In case of outdoor use, a sealing compound is applied to the machined connecting face.

Reassemble the bearing housing upper half by the reversing procedure as shown in Section 13.1.2(2).

a) Install the dial thermometer, thermocouple or other bearing thermometer. In this case, appointed lube is poured into the measuring hole of the bearing.

b) For a forced lubrication type bearing, reassemble the oil inlet and outlet piping. Fill lubricant up to the level indicated on the oil level gauge for self-cooled sleeve bearing.

c) Confirm that the air gap is uniform around the entire circumference.

d) For an outdoor type motor, coat sealant to the hatching part as shown in Fig. 13-11.
With an outdoor type motor, be sure to coat sealant on the periphery areas shown in Fig. 13, whenever disassembling.
Since the motor is already sealed with a sealant in all the required parts before shipping, the received new motor does not need disassembling and coating with a sealant to the machined surface between the lower bracket and the lower bearing housing and between the stator frame and the lower bracket.

* Use the sealant of Three Bond 1208D or equivalent.

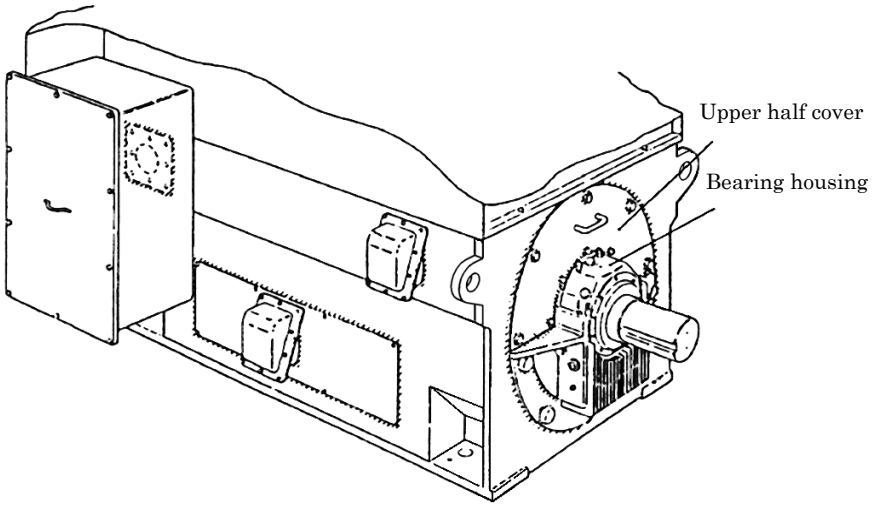
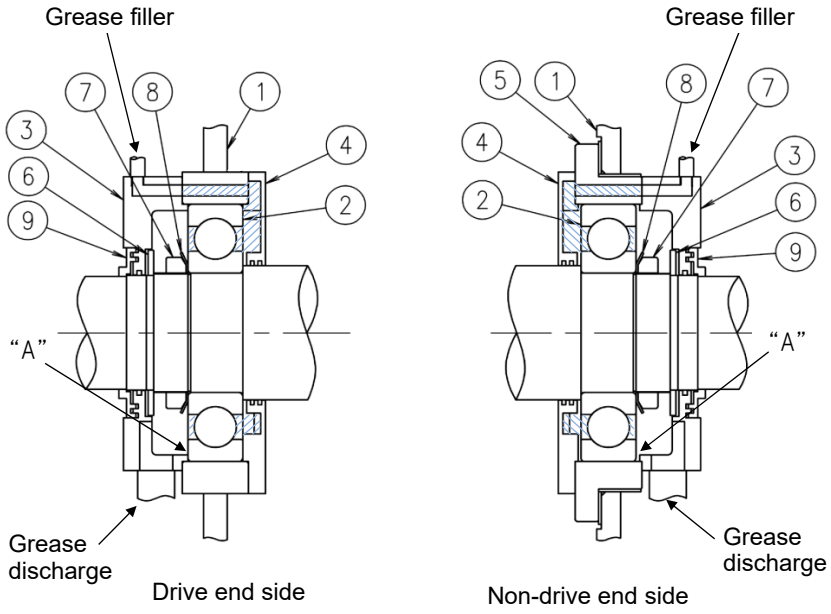


Fig. 13-11 Sealant coating area

13.2 Horizontal motor with antifriction bearing

Construction of antifriction bearings of a horizontal motor is shown in Fig. 13-12. Disassemble and reassemble the antifriction bearings as follows.



No.	Part name
1	Bearing bracket
2	Antifriction bearing
3	Outside slinger
4	Inside slinger
5	Insulated bearing support
6	Grease valve
7	Lock nut
8	Lock washer
9	Labyrinth seal

Fig. 13-12 Grease lubricated antifriction bearing structure

13.2.1 Disassembly procedure

(1) Disconnect the load machine from the motor.

(2) Remove the thermometer and other accessories.

(3) Remove the coupling.

(4) Remove the parts in the bearing area, referring to Fig. 13-12.
Take care not to damage the parts during removing.

(5) Remove the bearing using a puller as shown in Fig. 13-13 or commercial rolling bearing puller. When pulling, heat the inner ring.

13.2.2 Reassembly procedure

(1) Preparation

a) Clean the reassembly area, bench, tools, etc. and hands, and prepare clean and lint-free cloth.

b) Check the fit surfaces of the shaft and the bearing housing for damage, rust, etc., chamfer the edge of the fit surface slightly, remove metal powder, dust, etc. completely, clean in benzene, and dry them.

c) When using a new bearing, unpack it only immediately before assembling, and install without washing.

d) Check the fit part dimensions for correct interference.

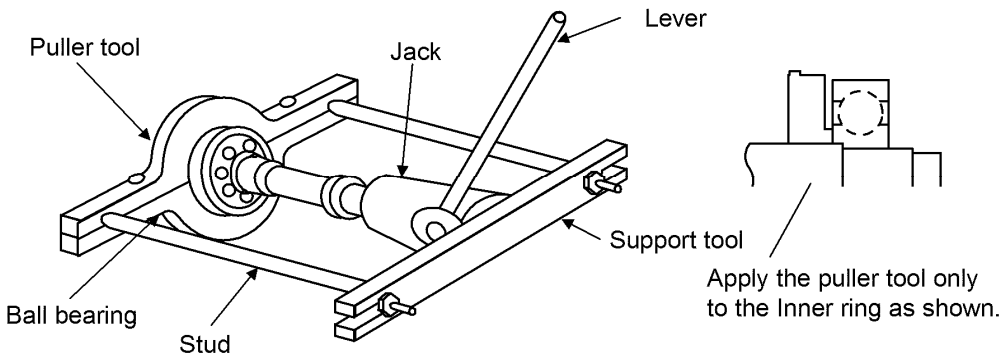


Fig. 13-13 Example of bearing pulling

(2) Insertion

Mount the bearing squarely with the side of engraved bearing number facing out, as follows:

Notice
■In shrinkage fitting, uniform heating is important.
■Never use a torch burner for heating.

Heat the bearing in oil at a temperature below 120℃. Since the bearing steel starts to get tempered at 150℃, take care not to heat the oil above 120℃. Take great care to keep the oil clean free from foreign matter by filtering. Where drying oven is available, heat the bearing sealed in a can, placing the can in the oven maintained at 100 to 120℃. After mounting the heated bearing on the shaft, finger-tighten the clamping nut, let the bearing cool to the room temperature, and then firmly tighten the nut at the room temperature.

13.2.3 Replacement of bearings

When replacing the bearings, keep the following cautions:

(1) Make sure that the types of replacing bearings are same as the ones in the bearing nameplate.

(2) In mounting a bearing, always tightly fit to the shaft, and loosely fit to the housing, to avoid rolling member pressure concentration on small areas of the raceway, and to allow thermal expansion sliding. Too tight fit induces undue force in the raceway, and compression of the rolling elements may cause excessive wear and early destruction. Too slack fit causes slip under load, leading to erosion, loss of bearing function, and excessive short bearing life.

The fit classes for ordinary radial rolling bearings are as follows:

a) Fit between bearing and bearing housing (Inner ring turning)

Bore tolerance of the bearing bracket or insulated bearing support·····H6

Bearing OD tolerance·····Medium; See bearing maker's catalog.

b) Fit between bearing and shaft (Inner ring turning)

Bearing bore tolerance·····Medium; See bearing maker's catalog.

Shaft OD tolerance·····k5

(3) After mounting a bearing, make sure that the nut locking washer tongue is firmly folded, and the washer is free from cracks.

(4) After checking, cover the bearing area with clean paper or cloth to prevent dust entry.

(5) Make sure the inner and outer bearing covers are tightly closed without space for dust entry.

(6) Turn the rotor slowly to check for abnormal noise.

(7) Grease injection

Fill the hatched area in Fig. 13-12 with grease. The space to be filled with grease includes the supply sector of the inside oil shield, 2/3 of the other sector, the feed route from the grease nipple, the bearing interior, and portion “A” in the drain area.

When reassembling the bearing after disassembling for periodical overhauling and replacing:

a) Fill the bearing side of inside oil shield ④, and the inside of rolling bearing ② with grease

b) Reassemble the bearing area

c) Apply grease to portion “A”

d) Install grease valve ⑥ and outside oil shield ③

The initial grease quantity is given on the bearing name plate. In injecting grease, take care not to allow foreign matter entry, and not to overfill to avoid heating.

(8) For an outdoor motor, apply sealant after assembling the bearing area, as shown in Fig. 13-14.

In case of an outdoor type motor, after disassembling for periodical overhauling, be sure to coat sealant on the peripheral areas shown in Fig. 13-14.

(Sealant coating areas are indicated by hatching.)

Since the motor is already sealed with sealant in all the required parts before shipping, the received new motor does not need disassembling and coating with a sealant.

* Use the sealant of Three Bond 1208D or equivalent.

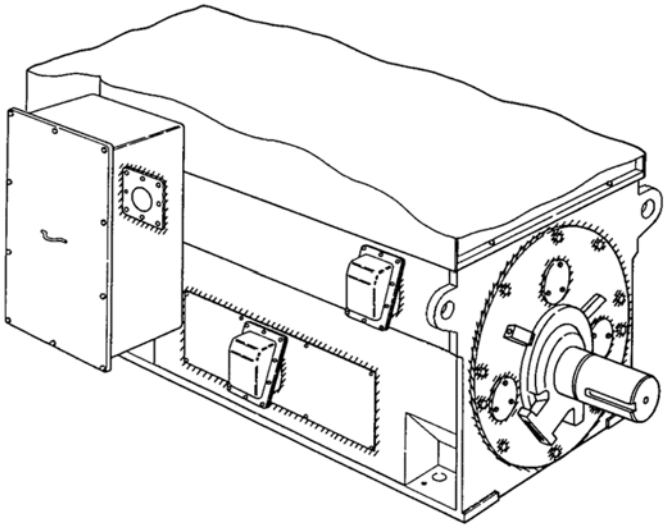


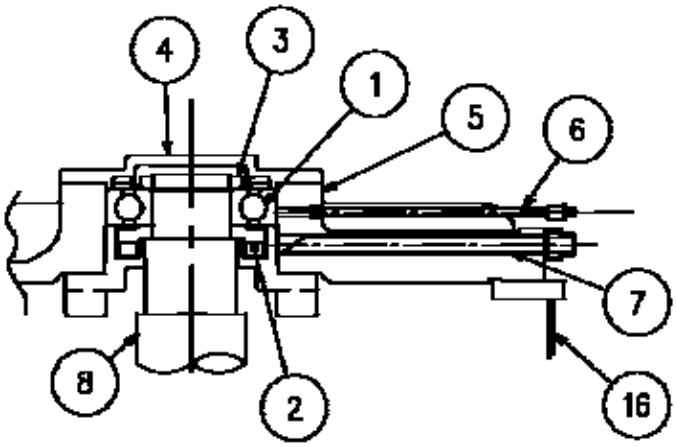
Fig.13-14 Sealant coating areas

Notice

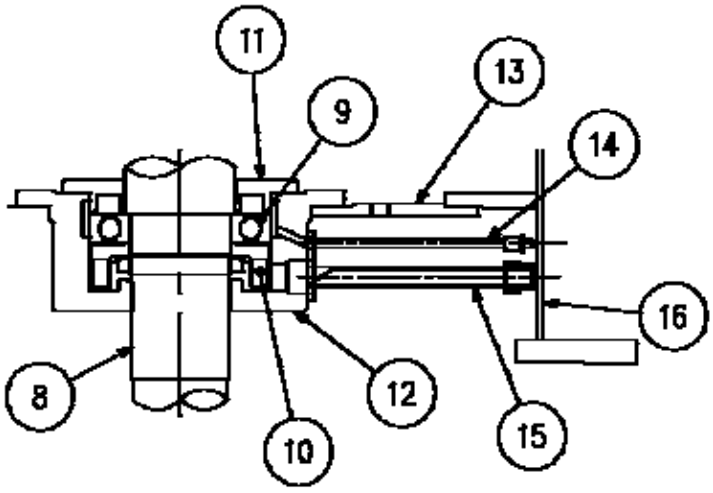
■Use an equivalent device, when renewing accessories, such as a dial thermometer, thermocouple, etc., with which the bearing is equipped. Especially, since there is a case where an insulation tube is inserted to a temperature sensing element in order to prevent damage of the bearing from the shaft current, be sure to equip with the insulation tube in that case.

13.3 Vertical motor with angular ball bearing

Disassembling and reassembling of a vertical motor with angular ball bearing at upper side should be as follows. Construction of bearings is shown in Fig. 13-15.



Upper bearing



Lower bearing

No.	Name
1	Angular ball bearing
2	Grease runner
3	Ring nut
4	Bearing cover
5	Upper bracket
6	Grease feed pipe
7	Grease discharge pipe
8	Shaft
9	Ball bearing
10	Grease runner
11	Bearing cover
12	Bearing housing
13	Lower bracket
14	Grease feed pipe
15	Grease discharge pipe
16	Frame

Fig. 13-15 Bearing construction

13.3.1 Disassembly procedure

(1) Uncouple the motor from the driven machine, and disconnect the power cable. Drain the lubricant for an oil bath type bearing.

(2) Remove the accessories such as a temperature detector.

(3) Remove the fan cover in case of TEAAC motor, and remove the air duct.

(4) Move the motor to the disassembly area and set on side.

(5) Remove the coupling in case of TEAAC motor, and remove the external fan.

(6) Remove the upper and lower brackets.

(7) Remove the upper bearing cover and lower bearing housing.

(8) Remove the upper ring nut and lower grease runner.

(9) Remove the bearing using a puller as shown in Fig. 13-13 or commercial rolling bearing puller. When pulling, heat the inner ring.

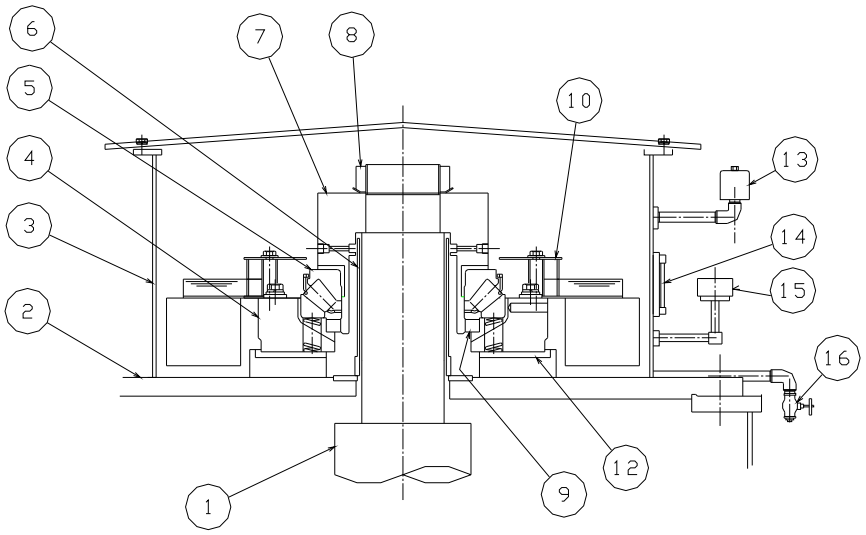
13.3.2 Reassembly procedure

Reassembly of the motor is accomplished by reversing the disassembly steps in Section 13.3.1. Refer to Section 13.2.2 and 13.2.3 for exchanging and reassembling the bearings. In case where the upper bearing is oil bath type, filling a grease to the bearing is unnecessary.

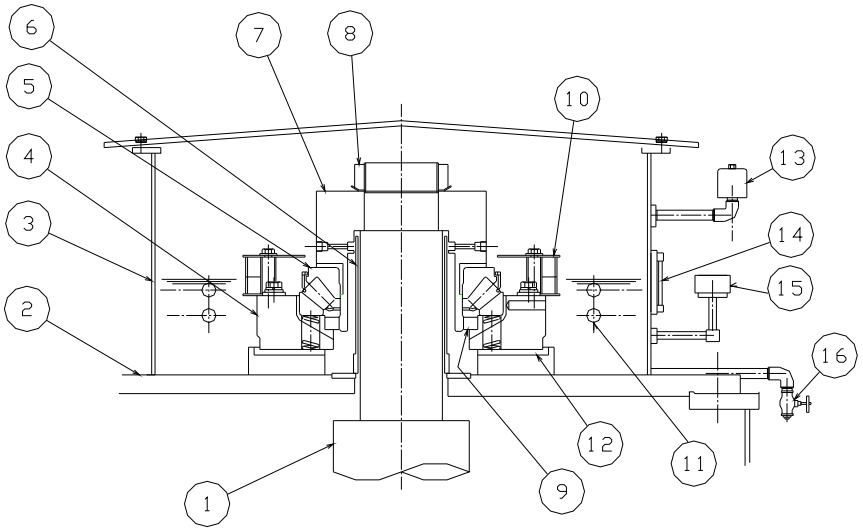
13.4 Vertical motor with spherical roller bearing

Disassembling and reassembling of a vertical motor with spherical roller bearing at upper side should be as follows. Construction of bearings is shown in Fig. 13-16. Since the lower bearing construction is the same as Fig. 13-15, refer to Section 13.3.

Self cooled



Water cooled



No.	Name	No.	Name
1	Shaft	9	Guide bearing
2	Upper bracket	10	Oil scattering prevention cover
3	Oil reservoir	11	Water cooling pipe
4	Bearing seating	12	Bearing insulation
5	Spherical roller bearing	13	Air breather
6	Oil weir	14	Oil level gauge
7	Upper runner	15	Overflow plug
8	Ring nut	16	Oil drainage valve

Fig. 13-16 Bearing construction

13.4.1 Disassemble procedure

(1) Uncouple the motor from the driven machine, and disconnect the cables for the power supply and the instruments.

(2) In case of a water cooled type, drain the water in the piping and disconnect the piping.

(3) Discharge the lubricant.

(4) Remove the accessories such as a temperature detector.

(5) Move the motor to the disassembly area and set on a maintenance stand.

(6) Support the shaft end by jack.

(7) Remove the lid of the oil reservoir.

(8) Remove the ring nut for the upper runner.

(9) Remove the oil scattering protection cover.

(10) Heat the upper runner and remove it.

(11) Remove the upper bracket.

(12) Pull out the rotor from the stator using a lifting tool and lay it on another place.

(13) Remove the lower bearing housing.

(14) Remove the grease runner.

(15) Remove the bearing using a puller as shown in Fig. 13-13 or commercial rolling bearing puller. When pulling, heat the inner ring.

(16) Heat the inner ring of the spherical roller bearing and remove the bearing from the upper runner. Remove the bearing outer ring from the upper bearing seating.

13.4.2 Reassembly procedure

Reassembly of the motor is accomplished by reversing the disassembly steps in Section 13.4.1. Refer to Section 13.2.2 and 13.2.3 for exchanging and reassembling the bearings. Since the upper bearing is oil lubricated type, filling a grease to the bearing is unnecessary.

14. Supplementary knowledge for maintenance inspection

14.1 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, if a frequency of at least four starts per day is planned, it is necessary to use a motor for frequent starts.

14.2 Temperature rise limit

14.2.1 Allowable temperature rise

In case the reference ambient temperature is 40℃, the limits of temperature rise standardized in IEC60034-1:2010 become as shown in the following Table 14-1. (Since the value may vary for other standards, refer to the specific standard applicable for details.)

Table 14-1 Limits of temperature rise of air-cooled induction machines (IEC60034-1：2010)（Unit: K）

Item	Part of induction machine	Thermal class 130(B)			Thermal class 155(F)			Thermal class 180(H)		
		Thermometer	Resistance	ETD	Thermometer	Resistance	ETD	Thermometer	Resistance	ETD
1	Stator windings									
	a. 5000kW or more	—	80	85(1)	—	105	110(1)	—	125	130(1)
	b. 200kW < Output < 5000kW	—	80	90(1)	—	105	115(1)	—	125	135(1)
	c. 200kW or less, except d, e (2)	—	80	—	—	105	—	—	125	—
	d. Less than 600W (2)	—	85	—	—	110	—	—	130	—
	e. Self-cooled w/o fan (2)	—	85	—	—	110	—	—	130	—
2	Magnetic cores and all structural components (other than bearings) whether or not in contact with insulation	The temperature rise or the temperature shall not be detrimental to the insulation of that part or to any other part adjacent to it.								

Notes (1) For adjustment for high voltage windings: See item 4 of Table 9 in IEC60034-1:2010.

(2) With the application of the supersosition test method of windings of machines rated at 200kW or less with thermal classes 130(B) and 155(F), the limits of temperature rise given for the resistance method may be exceeded by 5K.

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.

14.2.2 Recommended setting values of temperature

Our recommended temperature settings of alarm etc. are listed in Table 14-2 for reference.

Table 14-2 Recommended setting values of temperature (Unit: ℃)

Measured points and conditions			Alarm	Trip
Stator windings	5000kW or more	B rise	125	135
		F rise	150	160
	Less than 5000kW	B rise	130	140
		F rise	155	160
Bearings	Sleeve bearing		95	100
	Antifriction bearing		100	105

However, the maximum temperature at operation may be much less than the recommended value of Table 14-2 due to a surrounding environment, a service condition, etc. In such a case, in order to find the abnormalities of a motor at an early stage, consider the alarm value to be set up in approximately the highest operating temperature +10℃. In addition, it is also important to check by trend management that there is no unusual temperature change, and when abnormalities are observed, plan the precision inspection as early as possible.

14.3 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.

Stator Winding

・1000V or more : More than 100 [MΩ]

・Less than 1000V : More than 5 [MΩ]

Space heater

More than 1 [MΩ]

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 600V or less, and use a 1,000V megger when it exceeds 600V.

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 300 [MΩ]

14.4 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.

14.4.1 Allowable vibration values

IEC60034-14 defines that "the rated voltage and the rated frequency are used to perform no-load operations and the vibration velocity at this time is measured." Moreover, ISO 10816-3 defines the vibration control value at site. Based on these, we recommend the values in Table 14-3 as a control value of the vibration velocity on the bearing housing at site.

Table 14-3 Recommended control values of vibration velocity on a bearing housing (on a massive foundation)

	Recommended control value
Target value	4.5 [mm/s r.m.s.]
Alarm value	5.6 [mm/s r.m.s.]
Trip value	8.9 [mm/s r.m.s.]

On the other hand, a vibration amplitude is conventionally used in many cases, and the recommended values of the vibration amplitude are shown in Table 14-4.

Table 14-4 Recommended control values of vibration amplitude on a bearing housing (on a massive foundation) (Unit: μm(p-p))

		Frequency	Mounting	2P	4P	6P or more
Target value	Motor solo run	50 Hz	Horizontal	20	25	30
			Vertical	25	30	35
		60 Hz	Horizontal	20	25	30
			Vertical	25	30	35
	At rated load operation after coupling with a driven machine	50 Hz	Horizontal	30	50	50
			Vertical	35	55	55
		60 Hz	Horizontal	26	42	50
			Vertical	30	45	55
Alarm value	At rated load operation after coupling with a driven machine	50 Hz	Horizontal	37	62	62
			Vertical	43	68	68
		60 Hz	Horizontal	32	52	62
			Vertical	37	56	68

These allowable values are target or recommended values of vibration based on experience, and they are variable depending on the installed condition. When the vibration exceeds the recommended alarm value, investigate the cause of vibration and take a suitable countermeasure, referring to Sections 14.4.2 and 14.4.3

14.4.2 Cause of vibration

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

(1) Mechanical vibration

(1)-1 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) Frequency of the rotational speed

i) Unbalance

- Unbalance
  - Bad installation ..... Imperfect or improper connection with foundation
  - Bad coupling ..... Bad parallelism, perpendicularity, etc. of coupling
  - Misalignment ..... Bad eccentricity of shaft level
  - Secular change of rotor unbalance ..... Sticking of dust upon core, fan, etc. Movement of parts
  - Shortage or reduction fit between rotor core and shaft

ii) Bending 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 (such as 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

b) Frequency of twice the rotational speed
i) Bearing is deformed elliptically
ii) The fit between rotor core and shaft is insufficient in a specific direction

(1)-2 Vibration with changeable amplitude
The following cases, when the amplitude change with time under the constant speed and voltage, are taken into consideration.

a) Frequency of the rotational speed
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 heating are as follows:
i) Bending of shaft caused by thermal expansion of rotor conductors
ii) In the case of vibration caused by thermal factor when labyrinth seal is contact lightly with the shaft or bearing is contact in a specific direction, the vibration phase often changes. Especially, the change of the phase, in case of the latter, becomes periodically.

b) Frequency not related to the rotational speed
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 the rotor, 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) Twice of the power supply frequency
The vibration is caused by unbalance of air gap, unbalance of source voltage, unbalance of stator winding, or looseness of stator core, etc.

b) Multiples of the power supply frequency
It is caused by deforming force on radical direction of the stator core generated as the result of a bad slot combination.

c) Twice of the slip frequency
It is caused 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 (sound)
A beat coinciding with the frequency, which is the number of poles times slip (example: twice of slip frequency in 2 pole motor), may occur as the result of unbalanced air gap and the slip.

14.4.3 Investigating the causes of increased vibration

A vibration investigation of possible cause needs to carry out with insight systematically. Generally, the investigation should be carried out in the following procedure.

(1) 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.

(2) Check whether the vibration is due to the driven machine.
Disconnect the driven machine, and check the motor alone.

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

(4) Check whether the amplitude changes with time.

(5) 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.

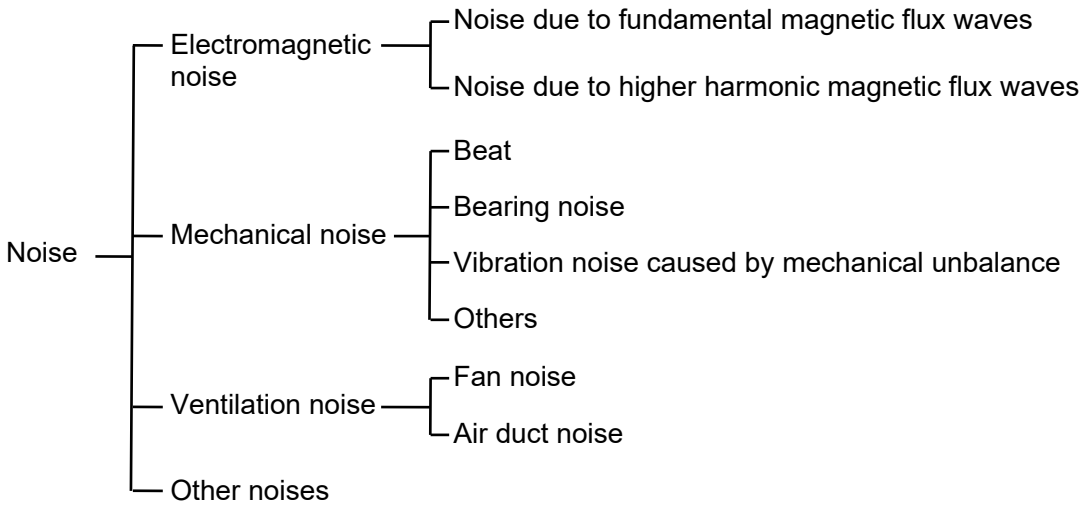
(6) Check the vibration with reference to the alteration of lubricant temperature, temperature of motor inside, bearing temperature, etc. and also check the shaft behavior.

(7) Arrange the data to analyze the cause of vibration.

14.5 Noise

Typical causes of motor noise generation are described in the following Table 14-5.

Table 14-5 Classification of noise



(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 sound

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

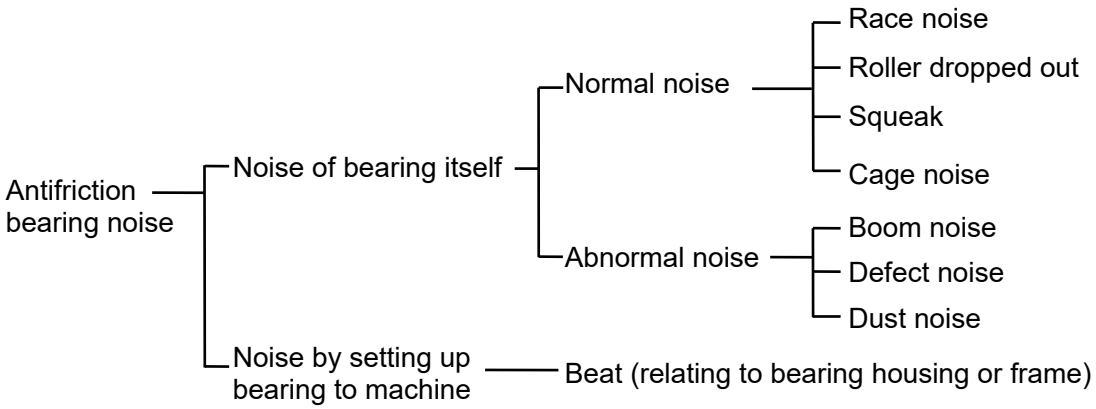
Mechanical noises are classified into bearing noise and stator resonance noise.

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 radical direction.

Noise caused by the anti-friction bearing is complex. Main causes of anti-friction bearing noise are shown in Table 14-6.

Table 14-6 Causes of antifriction bearing noise



Among these, race noise (basic noise having the frequency of 1,000Hz or more), roller dropped out noise and squeak are classified as normal. The remainders 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 in 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

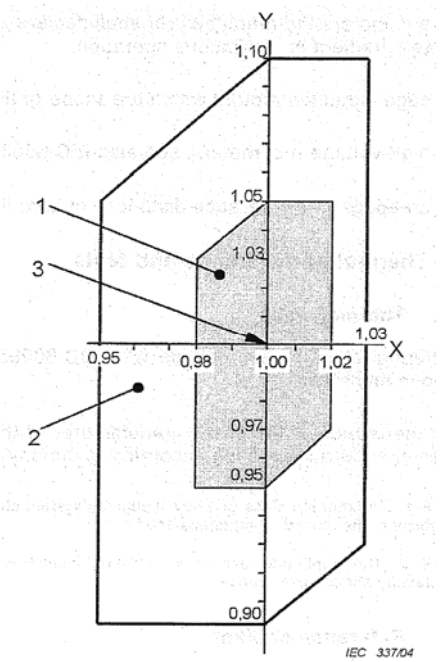
There is a pressure gradient across the fan blades, and the air flow makes a vortex. The noise caused by vortices usually has a uniform spectrum over a wide frequency range.

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.

14.6 Influence of power supply variation

IEC 60034-1 describes about a voltage and frequency that a machine shall be capable of performing its primary function (rated torque) continuously within zone A in Fig.14, and shall be capable of performing its primary function within zone B but may exhibit greater deviations than zone A. Although deviation of a temperature rise or performances is permitted except a rating point, it is no problem, in practice, to use the motor within these ranges. Influences of fluctuations on motor characteristics are shown in Table 14-7.



X-axis Frequency [p.u.]

Y-axis Voltage [p.u.]

1 Zone A

2 Zone B (Outside zone A)

3 Rating point

Fig. 14-1 Voltage and frequency limits for motors

Table 14-7 Example of influences of characteristics on motor with regard to the fluctuations

	Locked rotor and max. torque	Synchro-nous speed	% slip	Full load speed	Full load current	Locked rotor current	Temp. rise at full load	Magnetic noise at no load
For voltage variation								
110% voltage	(+)21%	Unchanged	(-)17%	(+)0.4%	(-)7%	(+)10 ～20%	(-)3 ～4%	(+) slightly
Function of voltage	$(\text{Voltage})^2$	Constant	$\frac{1}{(\text{Voltage})^2}$	—	—	(Voltage)	—	—
90% voltage	(-)19%	Unchanged	(+)23%	(-)0.5%	(+)11%	(-)10 ～12%	(+)10 ～15%	(-) slightly
For frequency variation								
105% frequency	(-)5%	(+)5%	Practically unchanged	(+)5%	(-) slightly	(-)5 ～6%	(-) slightly	(-) slightly
Function of frequency	$\frac{1}{(\text{Frequency})}$	(Frequency)	—	—	—	$\frac{1}{(\text{Frequency})}$	—	—
95% frequency	(+)5%	(−)5%	Practically unchanged	(−)5%	(+) slightly	(+)6 ～7%	(+) slightly	(+) slightly

14.7 Influence of unbalanced voltage in power source

(1) Definition of the voltage unbalance ratio

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

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

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

(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. 14-2. With unbalanced voltage, the input will increase while the output, torque and efficiency will decrease.
As is obvious from Fig. 14-2, 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.

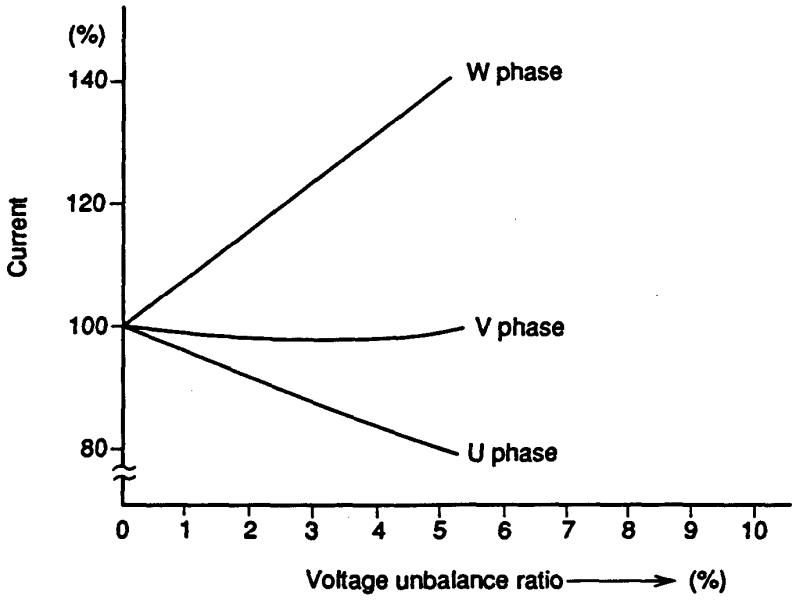


Fig. 14-2 Each phase current affected by unbalanced voltage (example)

Appendix 1　Conditions at acceptance

Date　:
Company　:
Name　:
Contact to　:

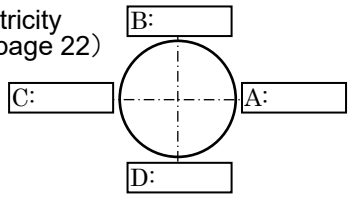
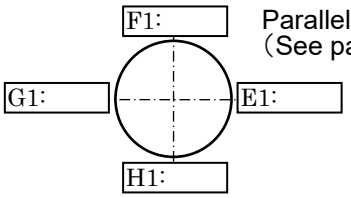
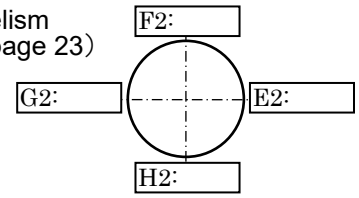
Rating of the motor (generator)	kW　P　V　Hz
Serial No. (in rating nameplate)	
Received date	
Date of acceptance inspection	
Package condition	Wooden crate　Awning sheet　Other(　)
Existence of damage	Yes (Package　Body　Spare parts　Tools　Other)　/ No
If there is damage,	With photos / Without photo
Carrier	
Contact to carrier	Done / Not yet
Contact to shipping agency	Done / Not yet
Contact to insurance company	Done / Not yet
Condition of damage (in detail)	
Other points being noticed	

Appendix 2 Check sheet for installation

Ratings of the motor (generator) kW(kVA) P V Hz Date

Serial No. (in rating nameplate) Inspector

No.	Item	Description	Criteria	Result
1	Place of installation			
	1)Circulation path of exhaust air	Installation space, Direction of exhaust port	Exhaust air does not flow to inlet. No ventilation obstruction	
	2)Disassembly and reassembly space	Disassembly and reassembly place, and carrying-out route	Reservation of workspace, and carrying-out route	
	3)Use of crane	Existence of crane or beam	Installation and carrying-out is possible	
	4)Environment of installation	Existence of gas, moisture, water, and foreign substance	Environment shall be matched to specification	
2	Foundation			
	1)Foundation bolt	Height, slope, and pitch	Installation of base is available. Dimension check with outline drawing.	
	2)Stiffness	Stiffness of foundation, and natural frequency	To withstand static and dynamic load To detune natural frequency	
3	Installation			
	1)Level of base	Level of axial and perpendicular direction	Within 0.05mm/1m	
	2)Position of foundation bolt hole	Relation between bolts and position of base hole	Bolts shall not contact to holes	
	3)Liner margin	Adjustment margin by liners	2mm and above	
	4)Position of wiring and piping	Direction and position of wiring and piping	Check with outline drawing	
	5)Transport protective device	Removal of transport protective device. Supply oil to journal	Check if there is abnormal sound during hand turning	
	6)Temporary centering	Parallelism and eccentricity	Within ±0.5mm	
4	Grouting			
	1)Grouting margin and area	Grouting margin	Check if the grouting under sole plate is enough.	
	2)Foundation bolt	Tightness of bolts	To be tighten them after grouting	
5	Alignment			
	1)Runout of coupling	Deviation of eccentricity	Within the values in Table 4-2	
	2)Alignment of axial direction	Movement of axial direction (for sleeve bearing)	No contact of shaft to side of bearing metal	
	3)Alignment of eccentricity and parallelism	Deviation of eccentricity and parallelism	Within the values in Table 4-2	
	4)Soft feet	Clearance when loosening each mounting bolt	Within 0.1mm	
	5)Liner margin	Liner adjusting margin	2mm and over	
	6)Fastening of bolt	Confirmation of attached thick washer Confirmation of tightening torque	Check that thick washer is used. Tightening torque:_____Nm	
	7)Counter mark of coupling	Confirmation of counter mark	Counter mark shall be matched.	

No.	Item	Description	Criteria	Result
6	Piping			
	1)Connection of oil feed and outlet pipe flange	Deviation of face and center	No oil leakage from matching face	
	2)Slope of oil outlet pipe	Check of slope	1/30～1/50	
	3)Arrangement of oil outlet pipe	Confirmation of drainage oil flow by sight flow	Drainage oil shall flow smoothly.	
	Record of alignment Eccentricity （See page 22）   Parallelism （See page 23）  		

Appendix 3　Check sheet before trial run

Ratings of the motor (generator)　　kW(kVA)　P　　V　Hz　　Date

Serial No. (in rating nameplate)　　Inspector

No.	Item	Description	Criteria	Result
1	Check of power source			
	1)Voltage	Check of voltage:_____V Voltage variation:_____V～_____V	Check with name plate Within zone B in Fig. 14-1	
	2)Frequency	Frequency variation:____Hz～___Hz	Within zone B in Fig. 14-1	
	3)Power source for space heater	___Φ　____V　___Hz	Check with name plate	
2	Measurement of insulation resistance	According to Sec. 14.3 Amb. temp.:____℃, Relative humidity:____%RH, Weather:_____		
	1)Stator winding	_____MΩ　@1000VDC - 1 min. Winding temp.:_____℃	1000V or more：More than 100 [MΩ], Less than 1000V：More than 5 [MΩ]	
	2)Space heater	_____MΩ　@500VDC - 1 min.	1 MΩ and over	
3	Inspection of wiring			
	1)Check of wiring	Connected terminal marking	Check with outline drawing	
	2)Check of condition of terminal bundle	Not fastened or loosened terminal Connection of CT secondary terminal	No abnormal fastening Connection of CT secondary terminal with instrument, or short circuit	
	3)Inspection of grounding conductor	Check of connection of grounding conductor	Check with outline drawing or level	
4	Inspection of bearing			
	1)Antifriction bearing	Check of grease leakage	No grease leakage	
		Preparation of replenishment grease Grease type: (Manufacturer:　　)	Confirmation of grease Don't mix different greases	
	2)Sleeve bearing	When rust preventive agent is enclosed in the bearing housing, discharge it from the drain plug.	No rust preventive agent in the housing	
		Supply lubricant oil (for self-lub) Oil type: (Manufacturer:　　)	Check with outline drawing or name plate Within indicated level of the oil level gauge	
		Check of oil leakage	No oil leakage	
		Confirmation of setting of orifice (for forced lub)	Check with outline drawing	
		Check of lubricant oil (for forded-lub) Oil type: (Manufacturer:　　) Supplied oil pressure:_____MPa	Check with outline drawing or name plate	
		Check of discharged oil flow by flow sight	Discharged oil shall flows smoothly.	
	3)Oil bath type antifriction bearing	When rust preventive agent is enclosed in the oil reservoir, discharge it from drainage valve.	No rust preventive agent in the reservoir	
		Supply lubricant oil Oil type: (Manufacturer:　　)	Check with outline drawing or name plate Within indicated level of the oil level gauge	
		Check of oil leakage	No oil leakage	
		Check of cooling water (for water cooled) _____MPa, _____L/min, ____℃	Check with outline drawing or name plate	

No.	Item	Description	Criteria	Result
5	Heat exchanger (CACW)			
	1)Check of flange connection part	Check of looseness of fastening bolt Check of water leakage	No looseness of bolt No water leakage	
	2)Confirmation of cooling water	_____MPa, _____L/min, ____℃	Check with outline drawing or name plate	
6	Others	※Check by instant power source ON		
	1)Confirmation of rotational direction	Direction of rotation: CW / CCW (viewed from drive end side)	Check with outline drawing	
	2)Check of abnormal sound	Check of abnormal sound at bearing or inside of motor	No abnormal sound such as contact noise	
	3)Check of abnormal heat	Check of abnormal smell	No abnormal smell	
	4)Oil ring (for sleeve bearing)	Check of oil ring rotation	Oil ring shall rotate smoothly.	

Appendix 4 Check sheet at trial run

Ratings of the motor (generator) kW(kVA) P V Hz

Serial No. (in rating nameplate)

No.	Item	Description	Criteria	Result
1	Motor solo run test	Date:_____ , Inspector:_____, Amb. temp.:____℃ Relative humidity:____%RH, Weather:_____, Water temp.:____℃		
	1)Center gauge (for sleeve bearing)	Check of position of center gauge	Start the motor after matching the rotor to the center gauge.	
	2)Power source	Check of three phase voltage balance	Three phase voltage shall be balanced.	
		Check of current pulsation	No current pulsation	
	3)Grease	Supply grease at rotation	Grease-up acc. to name plate	
	4)Abnormal sound	Check of abnormal sound at bearing or inside of motor	No abnormal sound such as contact noise	
	5)Vibration	Unit: mm/s(rms) or μm(p-p) DE bearing H/V: _____/_____ NDE bearing H/V: _____/_____	Refer to Section 14.4.1	
	6)Temperature	Stator winding:____℃ DE/NDE bearing:____℃/____℃	Refer to Section 14.2.2	
2	Coupled test (at no load)	Date:_____ , Inspector:_____, Amb. temp.:____℃ Relative humidity:____%RH, Weather:_____, Water temp.:____℃		
	1)Center gauge (for sleeve bearing)	Check of position of center gauge	To be rotated at center gauge position	
	2)Oil ring (for sleeve bearing)	Check of oil ring rotation	Oil ring shall rotate smoothly.	
	3)Check of abnormal sound	Check of abnormal sound at bearing or inside of motor	No abnormal sound such as contact noise	
	4)Vibration	Unit: mm/s(rms) or μm(p-p) DE bearing H/V: _____/_____ NDE bearing H/V: _____/_____	Refer to Section 14.4.1	
	5)Temperature	Stator winding:____℃ DE/NDE bearing:____℃/____℃	Refer to Section 14.2.2	
3	Coupled test (on load)	Date:_____ , Inspector:_____, Amb. temp.:____℃ Relative humidity:____%RH, Weather:_____, Water temp.:____℃		
	1)Staring	Starting time:_____s (at____V)	Check with outline drawing	
	2)Abnormal sound	Check of abnormal sound at bearing or inside of motor	No abnormal sound such as contact noise	
	3)Check of abnormal heat	Check of abnormal smell	No abnormal smell	
	4)Oil ring (for sleeve bearing)	Check of oil ring rotation	Oil ring shall rotate smoothly.	
	5)Lubricant oil	Check of oil level (for self-cooled sleeve bearing)	Within indicated level of the oil level gauge	
		Check of discharged oil flow by flow sight	Discharged oil shall flows smoothly.	
	6)Vibration	Unit: mm/s(rms) or μm(p-p) DE bearing H/V: _____/_____ NDE bearing H/V: _____/_____	Refer to Section 14.4.1	
	7)Temperature	Stator winding:____℃ DE/NDE bearing:____℃/____℃	Refer to Section 14.2.2	
4	Notice			

Appendix 5 Records during operation

Ratings of the motor (generator) kW(kVA) P V Hz

Serial No. (in rating nameplate) Inspector

※For a periodical log, fill in this form by using copy of this sheet.

No.	Item	Record			
1	Power source	Voltage:______V, Frequency:_____Hz			
2	Utility	Water cooled	Water q'ty:_____L/min, Pressure:_____MPa		
		Forced lub	Oil q'ty:______L/min		
3	Exchange or replenishment records of lubricant				
	Date	Lubricant type (manufacturer)	Exchange or replenishment	Q'ty of supply ［L or g］	
				DE:________/ NDE:________	
				DE:________/ NDE:________	
				DE:________/ NDE:________	
				DE:________/ NDE:________	
				DE:________/ NDE:________	

No.	Date	Amb. temp. [℃]	(Water cooled) Water temp. [℃]	(Forced lub) Oil temp. [℃]	Winding temp. [℃]	Bearing temp. DE/NDE [℃]	Bearing vibration DE/NDE [mm/s(rms) or μm(p-p)]
4	Operation records						
						_____ / _____	H: _____ / _____ V: _____ / _____
						_____ / _____	H: _____ / _____ V: _____ / _____
						_____ / _____	H: _____ / _____ V: _____ / _____
						_____ / _____	H: _____ / _____ V: _____ / _____
						_____ / _____	H: _____ / _____ V: _____ / _____
						_____ / _____	H: _____ / _____ V: _____ / _____
						_____ / _____	H: _____ / _____ V: _____ / _____
						_____ / _____	H: _____ / _____ V: _____ / _____
						_____ / _____	H: _____ / _____ V: _____ / _____
						_____ / _____	H: _____ / _____ V: _____ / _____
5	Notices (Abnormal noise, oil leakage, water leakage, abnormal smell, ventilation, etc.)						

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