Medium-sized Squirrel-cage 3-phase Induction Motor

21-F/DII Series

250 to 450 Frame Totally Enclosed Fan-coold Type
250 to 315 Drip Proof Type

Instruction Manual

TOSHIBA MITSUBISHI-ELECTRIC
INDUSTRIAL SYSTEMS CORPORATION

CONTENTS

1. INTRODUCTION

Congratulations on your purchase of the TMEIC 21-F Series 3-Phase Induction Motor. TMEIC has created this instruction manual to serve as a guide for important information including installation, operation, inspection, maintenance, and trouble-shooting the 21-F Series 3-Phase Induction Motor. Please read and understand the information contained in this manual before operating the motor. An utmost effort has been made to include all of the components and their relevant explanations.

TMEIC : TOSHIBA MITSUBISHI-ELECTRIC INDUSTRIAL SYSTEMS CORPORATION

NOTE

- Read the instruction manual before operating the motor.
- Save this manual for future reference.
- Deliver this instruction manual to the motor's end user.
- Include this manual when the motor is used in combination with a drive unit.
- This manual may not be reproduced by any means other than the purchaser's personal use without prior written consent of TMEIC.

2. SAFETY

SAFETY PRECAUTIONS

This instruction manual provides important information on the motor to ensure safe and correct operation by the operators involved with the transportation, installation, maintenance and inspection of the motor. These safety precautions were created to prevent injuries and prevent property damage. Familiarize yourself with the following symbols before reading the instruction manual.

[Symbol Explanation]

Safety symbol	Meaning
DANGER	A mistake during handling may result to serious or fatal injuries.
CAUTION	A mistake during handling may result to minor injuries or property damage.

[Symbol Explanation]

Safety symbol	Meaning
	Indicates **a prohibited action** (must never be conducted). The prohibited action is indicated with pictures or explanations near the symbol.
	Indicates **a mandatory action** (must always be conducted). The mandatory action is indicated with pictures or explanations near the symbol.
	Indicates **danger**. The danger is indicated with pictures or explanations near the symbol.
	Indicates **caution**. The caution is indicated with pictures or explanations near the symbol.

[Exemptions]

- TMEIC will not be held reliable for any damage that occurs due to fires, earthquakes, intentional or careless use, third party actions, other accidents, or use under any abnormal conditions.
- TMEIC will not be held reliable for any secondary damage (business profit losses, operation stops, etc.) caused by the use or disabled use of the motor.
- TMEIC will not be held reliable for any damage caused by installation, handling, operation, or modification not described in this instruction manual.
- TMEIC will not be held reliable for any damage that occurs due to incorrect operation when combined with any connected devices.

[Operator Qualifications]

- Only a qualified worker, who has received the designated training by a governmental agency or business operator according to local laws (Electric Facility Technology Standards, Occupational Safety and Sanitation Laws), may install operate or service the motor.
- Any work not regulated by law must be carried out under the instruction of a specialist skilled in motors and related work.

⚠ DANGER	
Prohibited	• Never modify the motor. Failure to observe this could lead to fire or electric shock. Always contact TMEIC for instructions when the motor must be modified.
	• Persons other than the operator must not approach the motor. Failure to observe this could lead to injuries or electric shock.
Contact Prohibited	• Never touch a rotating part or the electric circuit to which voltage is applied. Failure to observe this could lead to injury or electric shock.
Prohibited	• Do not use transporting devices that it is not suitable for the weight noted on the nameplate*. The motor could fall, causing injury or death. *Given in specifications (outline drawing or nameplate attached to the motor)
	• Do not attach a lifting wire to anything other than the stator's suspension hook. Do not suspend multiple motors. Always suspend the motors individually. The motor could fall, causing injury or death.
	• Never be positioned under a suspended load. The motor could fall, causing injury or death. When the operator must be positioned under the suspended load, always place the suspended load on a frame.
Mandatory	• Always suspend the lifting wire so that the lifting direction is vertical and the load is balanced. Incorrect suspension could cause the motor to fall, causing injury or death.
Prohibited	• Do not bend, pull, push in, or touch the power cable or motor lead wires. Failure to observe this could lead to electric shock or fire.
Mandatory	• Always use a suitable cable size for the power cable. Failure to observe this could lead to fire from overheating.
	• Accurately wire each cable so that single-phase operation does not take place. Incorrect wiring could lead to fire from overheating.
	• Install the motor in the working conditions (temperature, humidity, etc.) described in the specifications. Failure to observe this could lead to fire or electric shock. Confirm the working conditions in the specifications.
	• Always turn the power off before touching the motor's surface or the terminals. Working with live wires could lead to electric shock.
	• Always remove the key temporarily fixed to the spindle before starting trial operation. Failure to observe this could lead to injuries or electric shock.

DANGER	
Prohibited	• Do not approach the motor during the dielectric test. Always discharge the winding that has undergone the dielectric test before touching it. Failure to observe this could lead to electric shock.
Mandatory	• Always ground all windings to which the voltage is not applied during the dielectric test. Failure to ground these windings could lead to electric shock.
Mandatory	• Install a suitable protective relay, such as an earth (grounding) relay, on the power supply side, and ground the earth (grounding) terminal enclosed with the motor. Failure to ground these windings could lead to electric shock.
Prohibited	• Do not approach or touch the rotating parts during operation. Failure to observe this could lead to entanglement or injuries.
	• In the case of the motor with a brush, earth Brush (grounding Brush) should be replaced after the motor has stopped. Failure to observe this could lead to entanglement or injuries.
Mandatory	• Install a cover to prevent entanglement, springing and scattering at the coupling section connecting the motor with the driven machine. Failure to observe this could lead to injuries.
	• Always run the motor at the output, current, power voltage, frequency, rotating speed and operation time noted in the specifications, standards and rating plate, etc. Failure to observe this could lead to injuries or fires from motor damage or burning.
	• When using ventilation cooling, turn ON the power for the blower before turning the motor power ON.
	• Always turn the space heater ON when the motor has stopped. Failure to observe this could lead to overheating and fires.
	• Wear protective equipment such as long-sleeved work shirt, safety belt, protective goggles, etc., when installing, inspecting or servicing the motor. Failure to wear these items could lead to injuries or electric shocks.
Prohibited	• Do not run the motor when the protective devices or safety devices, including the lid and covers, are removed or stopped. Failure to observe this could lead to injuries or fires.
Mandatory	• Always confirm that all power connected to the motor is turned OFF before starting work. Failure to observe this could lead to electric shock.
	• Always wear a safety belt when carrying out work at heights exceeding 1.5 meters. There is a risk of falling.
	• Partition off the work area with ropes, etc., to prohibit the entry of unauthorized personal. Failure to observe this could lead to electric shock or entanglement.
	• Always carry out daily and periodical inspections. Failure to service and inspect the motor will inhibit the possibility of finding problems at an early stage, and could lead to fires or electric shock.

⚠ CAUTION	
Prohibited	• Do not place flammable objects near the motor. Failure to observe this could lead to ignition and fires.
Mandatory	• In the case of the motor with a fan cover, set distance from a fan cover to a wall to 200mm or more and don't bar an exhaust air. If distance is short, cooling will become insufficient, the motor could overheat and lead to burning.
	• Confirm that the motor rotation direction matches that indicated in the outline drawings or on the nameplate. If the rotation direction nameplate enclosed with the motor indicates only one direction, the motor cannot be rotated in reverse. If the motor rotates in reverse due to incorrect connections, the motor could overheat and burn.
	• It is performing dispose of the unwanted grease as much as possible at the time of the motor stop. When you process unavoidably at the time of operation, be careful of a solid of revolution and grease scattering. Failure to observe this could lead to entanglement or injuries.
	• Do not ride on the motor. There is a risk of falling.
	• Be careful not to stumble over the projection thing of the motor. Failure to observe this could lead to damage or injuries.
	• Do not touch the external surface of the motor directly during operation. It is high temperature, and failure to observe this could lead to burning oneself. Put a thick glove and touch.
	• Observe the following points when disassembling the bearings and using torches. • Remove all grease from the bearings. • Protect the bearings from the torch. • Limit the use of the torch to where there is no risk of starting fires. • Do not use the torch near general sources of fires such as heating appliances or cigarettes. Failure to observe this could lead to ignition.
	• If the motor is provided with a filter, periodically clean the filter. If the filter is clogged, the motor could overheat and lead to burning.
Prohibited	• Do not place foreign matters or rod-shaped items such as a stethoscope rod in the motor. When investigating vibration or acoustics with a stethoscope rod, do not place it in the rotating section. Failure to observe this could lead to damage or injuries.
	• After measuring the insulation, always discharge the motor before touching it. Failure to observe this could lead to electric shock.
Mandatory	• Always turn the switch OFF when a power failure occurs. Failure to observe this could lead to accidents if the power is suddenly restored.
Mandatory	• Always wear work gloves, etc., when touching the machined or pressed parts. Failure to wear gloves could lead to injuries if the sharp edges are touched.
	• Unless designated, always tighten the bolts, with the specified torque given in Table 2.1. Failure to tighten at the specified torque could cause the bolts to loosen and lead to damage, or overheating from a contact fault and lead to fires.
	• Always contact your TMEIC Representative for instructions before rewinding the coils. The insulators used for the coils, etc., could generate toxic gases depending on the thermal processing conditions.
	• Always contact a disposal specialist or contact your TMEIC Representative for instructions when disposing of this motor. Environmental damage could occur if the motor dose not handled by a disposal specialist.

[Confirmation of main body warning display label]

Confirm that the main body, warning label is attached at the designated position.
Contact your TMEIC representative if the label has been lost or if it is contaminated and/or hard to read.
(Including the designated labels.)

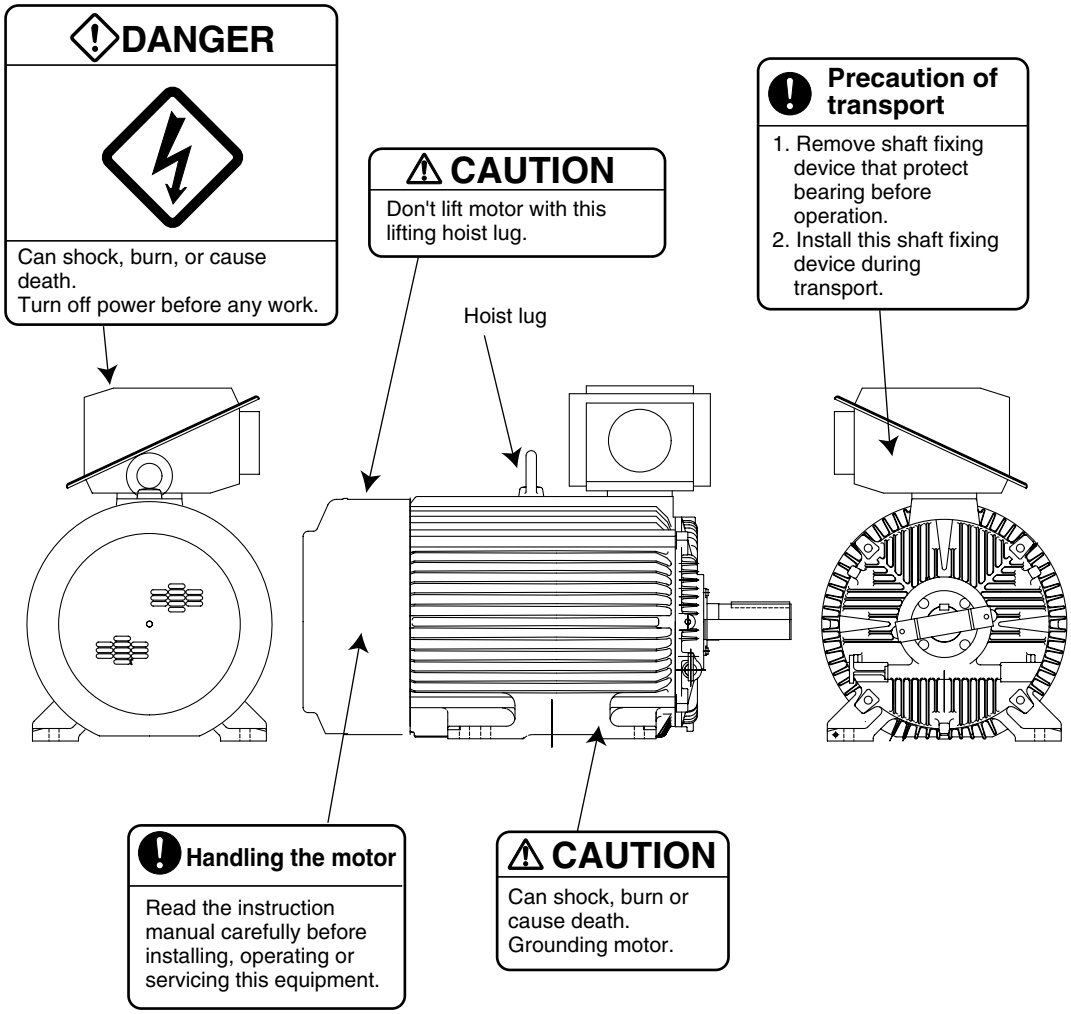


Figure 2.1 Warning display label installation positions and examples

Table 2.1 Specified torques for bolt tightening

Screw nominal	Reference value [N • m]	Tolerable range [N • m]
M2	0.206	0.177 ~ 0.235
M2.5	0.422	0.353 ~ 0.401
M3 x 0.5	0.716	0.608 ~ 0.824
(M3.5)	1.10	0.932 ~ 1.27
M4 x 0.7	1.65	1.39 ~ 1.89
M5 x 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

3. NAMEPLATE

The motor should conform to the specified standards along with the information on the rating nameplate. An example of a nameplate is shown in Figure 3.1.

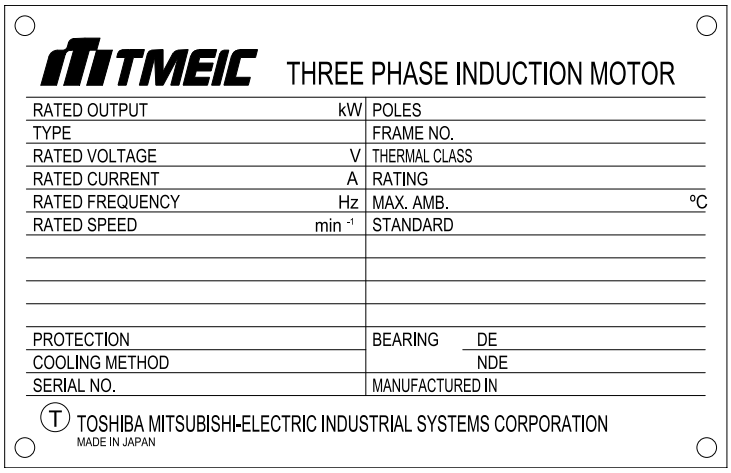


Figure 3.1 Typical Main Nameplate

Along with the rated nameplate other nameplates may be included on the motor. The connection diagram nameplate may be included inside of the terminal box. The following is an explanation of how to read the rating nameplate.

3.1 Form, Frame Number

The external characteristics are identified here.

3.2 Poles, Rated Speed, Rated Frequency

The (P) is the number of N, S poles in the stator coil. The f (Hz) is the line frequency. The N (min-1) is the synchronous speed of the motor.

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

The line frequency should correspond to the nameplate frequency. When using the motor at the rated load, the rotor should rotate at the rotational speed indicated on the nameplate.

3.3 Rated Output, Rated Voltage, Rated Current

The rated output of the motor is the largest continuous output (P) at the shaft end. The rated voltage on the nameplate is the line voltage of the motor. The rated current (A) shown on the nameplate is the current value when the motor is running at the rated voltage, current and load. The following is the formula used to calculate the shaft output, where pf is the motor power factor and η is the efficiency.

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

When using the motor, make sure the line voltage matches the rated voltage on the nameplate. Do not use the motor at the maximum output and current indicated on the nameplate.

3.4 Rating

The motor is guaranteed to have the rating shown on the nameplate. If this area is blank or “CONT” is written, then the motor is continuous. If a time is specified in this area, then the motor can only be used for the specified time. The motor will be able to restart after it has cooled down.

3.5 Maximum Ambient Temperature

If this area is blank the ambient temperature is 40°C or less and the altitude is 1000 m or less. If a value is written, then use these values as the maximum allowable value.

3.6 Thermal Class

The temperature rise limit is dependent on the measuring method used. Refer to the motor standard for the temperature rise limit.

3.7 Standard, Protection

The standard is based on the IEC Standard. The protection is written as IPXX, where the first “X” is the protection of body parts or foreign objects. The second “X” is the protection against water. For more details, refer to the IEC Standard.

3.8 Serial Number, Manufacture in

Each motor has its own individual manufacture number. The information regarding this motor is documented under this number. The manufacture year is the year the motor was manufactured.

4. CONSTRUCTION

Totally enclosed fan-cooled type

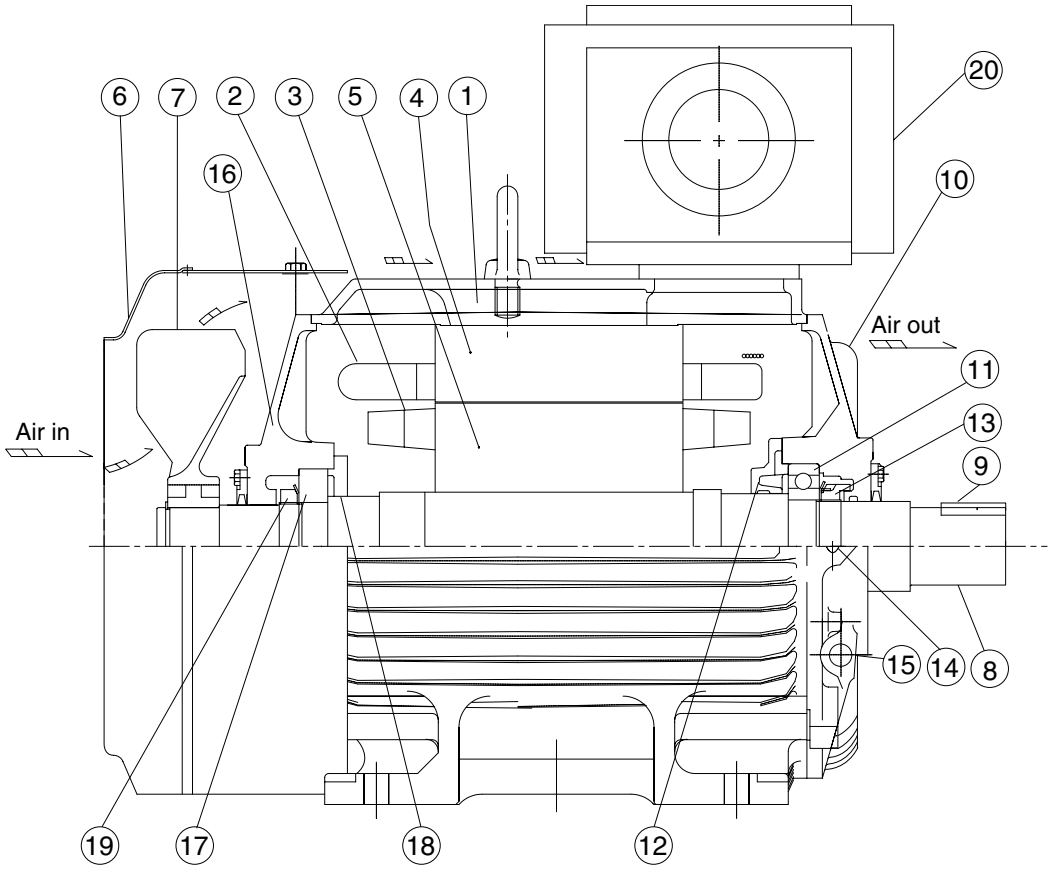


Figure 4.1 Section Drawing of Horizontal foot mount (Frame size 250S~280MD)

1	Frame
2	Stator coil
3	End ring
4	Stator core
5	Rotor core
6	Fan cover
7	External fan
8	Shaft
9	Shaft end key
10	Bearing bracket
11	Bearing
12	Bearing cover
13	Grease runner
14	Grease inlet
15	Grease outlet
16	Bearing bracket
17	Bearing
18	Bearing cover
19	Grease runner or bearing nut
20	Terminal box

Note: Parts number 18 and 19 are not attached when drive end is open bearing and non-drive end is shield bearing.

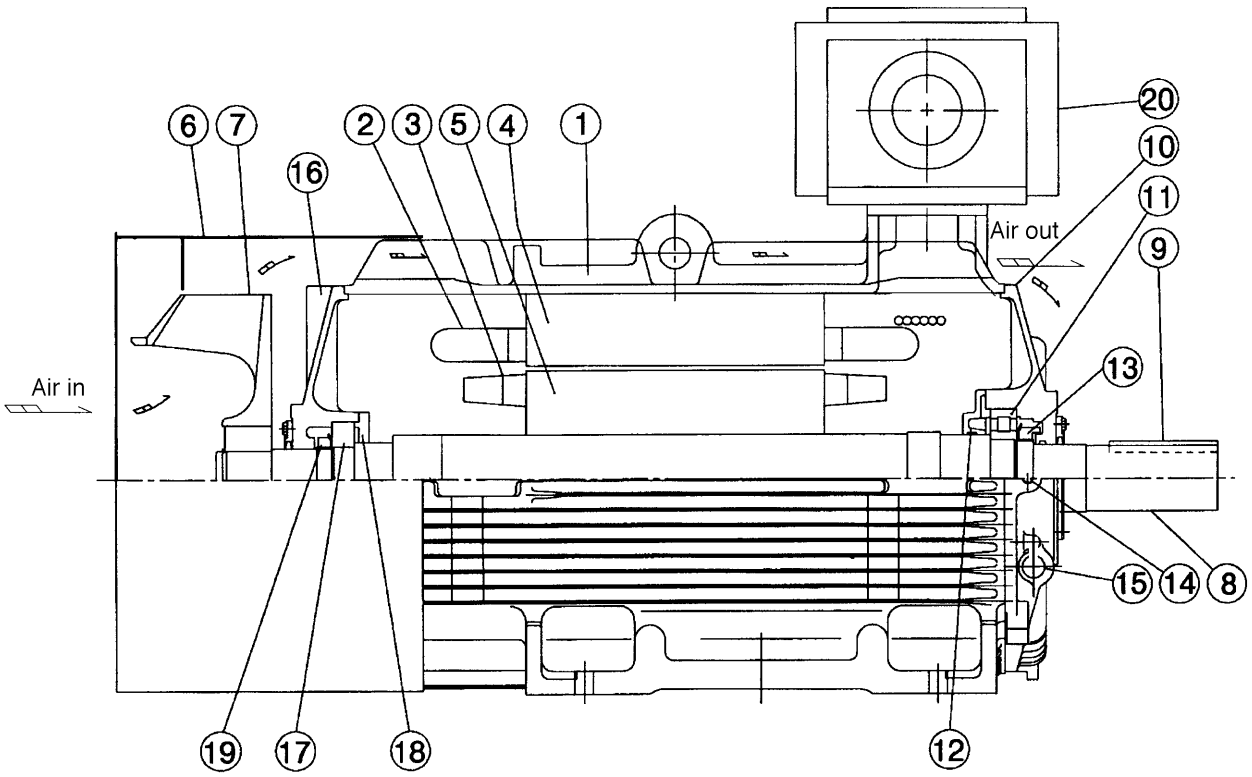


Figure 4.2 Section Drawing of Horizontal foot mount (Frame size 280L)

1	Frame
2	Stator coil
3	End ring
4	Stator core
5	Rotor core
6	Fan cover
7	External fan
8	Shaft
9	Shaft end key
10	Bearing bracket
11	Bearing
12	Bearing cover
13	Grease runner
14	Grease inlet
15	Grease outlet
16	Bearing bracket
17	Bearing
18	Bearing cover
19	Grease runner or bearing nut
20	Terminal box

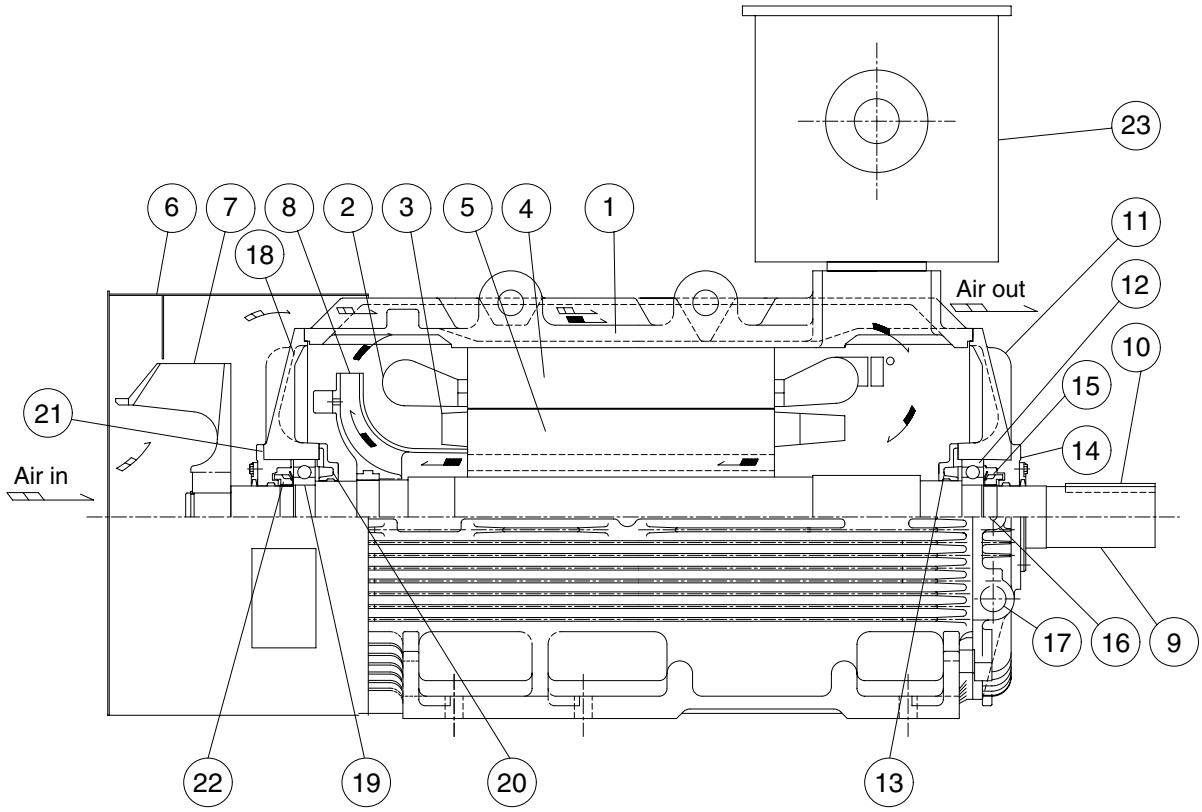


Figure 4.3 Section Drawing of Horizontal foot mount (Frame size 315H~450)

1	Frame
2	Stator coil
3	End ring
4	Stator core
5	Rotor core
6	Fan cover
7	External fan
8	Internal fan
9	Shaft
10	Shaft end key
11	Bearing bracket
12	Bearing
13	Internal bearing cover
14	External beating cover
15	Grease runner
16	Grease inlet
17	Grease outlet
18	Bearing bracket
19	Bearing
20	Internal bearing cover
21	External beating cover
22	Grease runner
23	Terminal box

Note: Parts number 11 and 14, 18 and 21 are the one part at frame size 315H.

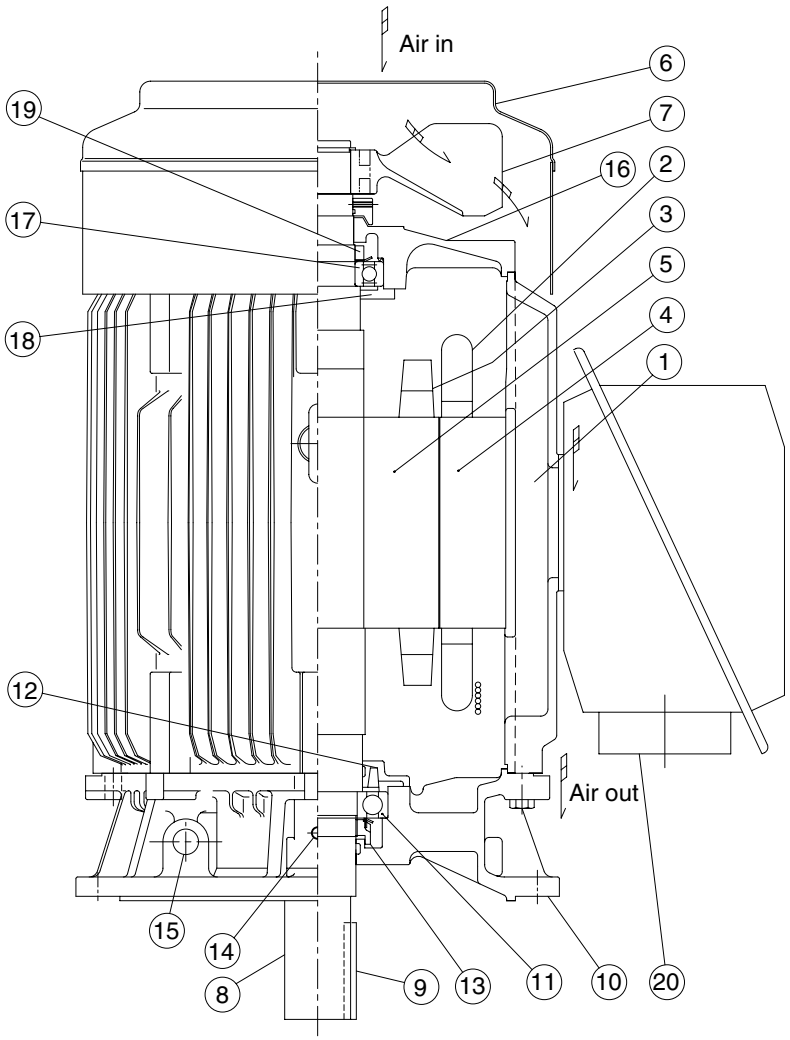


Figure 4.4 Section Drawing of Vertical flange mount (Frame size 250)

1	Frame
2	Stator coil
3	End ring
4	Stator core
5	Rotor core
6	Fan cover
7	External fan
8	Shaft
9	Shaft end key
10	Bearing bracket
11	Bearing
12	Bearing cover
13	Grease runner
14	Grease inlet
15	Grease outlet
16	Bearing bracket
17	Bearing
18	Bearing cover
19	Bearing nut
20	Terminal box

Note: Parts number 18 and 19 are not attached when drive end is open bearing and non-drive end is shield bearing.

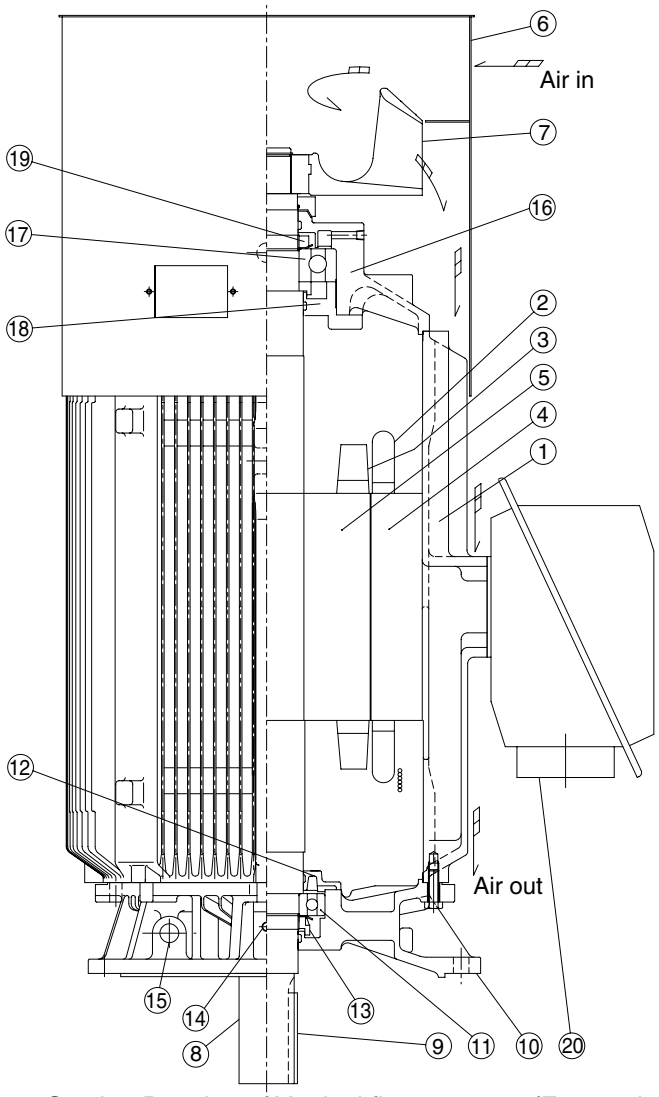


Figure 4.5 Section Drawing of Vertical flange mount (Frame size 280)

1	Frame
2	Stator coil
3	End ring
4	Stator core
5	Rotor core
6	Fan cover
7	External fan
8	Shaft
9	Shaft end key
10	Bearing bracket
11	Bearing
12	Bearing cover
13	Grease runner
14	Grease inlet
15	Grease outlet
16	Bearing bracket
17	Bearing
18	Bearing cover
19	Bearing nut
20	Terminal box

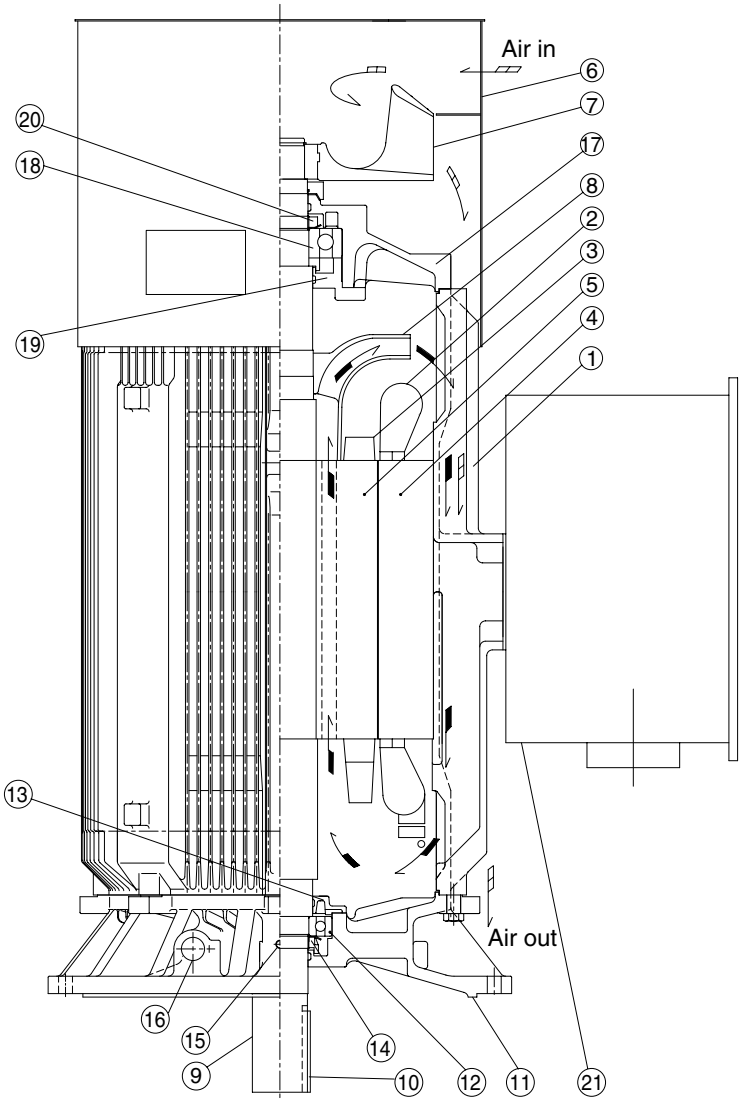


Figure 4.6 Section Drawing of Vertical flange mount (Frame size 315)

1	Frame
2	Stator coil
3	End ring
4	Stator core
5	Rotor core
6	Fan cover
7	External fan
8	Internal fan
9	Shaft
10	Shaft end key
11	Bearing bracket
12	Bearing
13	Bearing cover
14	Grease runner
15	Grease inlet
16	Grease outlet
17	Bearing bracket
18	Bearing
19	Bearing cover
20	Bearing nut
21	Terminal box

Drip proof type

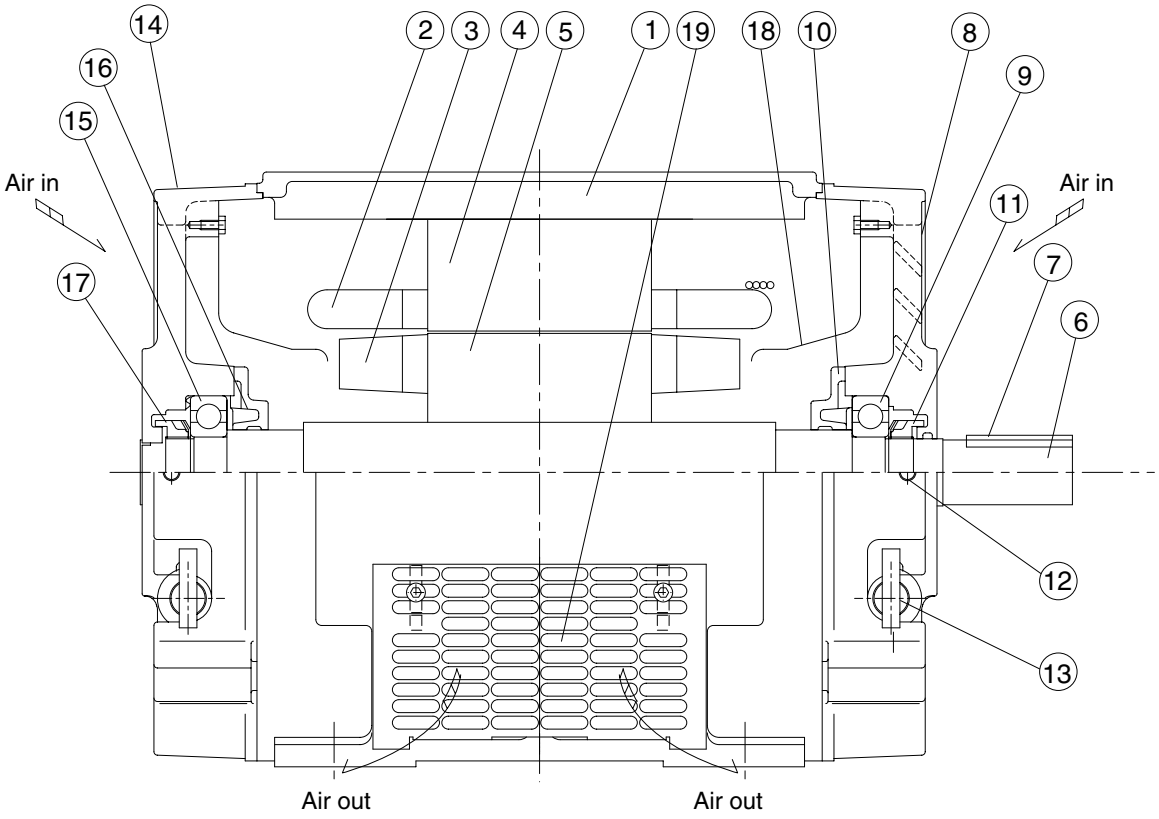


Figure 4.7 Section Drawing of Horizontal foot mount (Frame size 250S~315L)

1	Frame
2	Stator coil
3	End ring
4	Stator core
5	Rotor core
6	Shaft
7	Shaft end key
8	Bearing bracket
9	Bearing
10	Bearing cover
11	Grease runner
12	Grease inlet
13	Grease outlet
14	Bearing bracket
15	Bearing
16	Bearing cover
17	Grease runner or bearing nut
18	Fan guide
19	Cover

Note: Parts number 16 and 17 are not attached when drive end is open bearing and non-drive end is shield bearing. Parts number 19 is attached also on the frame upper part and bearing bracket.

5. TRANSPORT

The packaging has been designed to prevent damage to the motor during transportation. However, the packaging as well as the motor could have been damaged during transport. Use the following precautions when handling the motor.

(1) Always keep the worker's safety in mind when transporting the product. Handle the package carefully so that the product will not be damaged. The product is usually moved with equipment such as a crane, hoist or lifting wire. If the product must be handled by hand, do not allow any strong impacts to be applied.

(2) Suspend the product from the suspension bolts or fittings of the wood crate when provided. Avoid suspending the product from the wood crate. If the wood crate does not have any suspension bolts or fittings, suspend the product by place the lifting wire near the center of gravity.

(3) When suspending the product from a crane, attach the lifting wire to the suspension bolts or fittings on the side or the top of the motor. Always lift the motor slowly. If the motor has a specific suspension instruction plate, follow the given instructions.

(4) The motor must be stored inside during transportation. If the motor must be stored outside, protect the product from rain. Refer to section 7 (Storage) for prolonged storage instructions.

(5) If any damage is observed on the package, open the package immediately. Carefully check for any abnormalities on the product. If there are any abnormalities, contact your TMEIC Representative.

(6) The shaft is locked to prevent the bearings from being damaged during transportation. Do not remove this locking plate until the motor has been installed, connected to the load and the trial operation preparations are completed.

(7) When repackaging and transporting the finished product after the motor has been connected to the machine, observe the following:

1) NEVER suspend the entire machine by the motor's suspension bolts or fittings. The strength of the motor's suspension bolts or fittings are determined according to only the motor weight. If the entire machine weight is applied, the bolts or fittings could fail and cause serious injury or even death.
2) Lock the shaft on motors to prevent damage during transportation.
3) If the motor is disassembled from the unit and transported as a single part, apply rust-preventing oil or grease to the shaft, feet soles and flange surfaces to prevent rusting.

6. RECEIVING

The 21-F series motor undergoes numerous electrical and mechanical tests and inspections before being shipped from the facility. When accepting the motor, confirm that the package and product have not been damaged during transportation. If any damage is observed, open the product immediately. Carefully check for any abnormalities on the motor and accessories. If there is anything suspicious, contact your nearest TMEIC Representative. When making any inquiries regarding the motor, always indicate the serial number located on the nameplate. Do not remove the locking plate on motors that have a locked shaft (motors using cylindrical roller bearing, etc.) until the motor has been installed, connected to the load or the trial operation preparations are completed.

7. STORAGE

Long term storage may be required between the following periods.

(1) Machine Manufacturer ..... Shipping Date
(2) Arrival at Site ..... Installation
(3) Installation ..... Trial Operation
(4) Trial Operation ..... Actual Operation

(Includes halted operation due to adjustments at the plant)

For long term storage of a motor during these periods, special storage methods must be made to maintain the motor's quality and functions. The windings and bearings of the motor are especially susceptible to dust. Moreover, the machined surfaces must be protected against rust. The following three points should be taken into consideration when preparing for long term storage.

(1) Prevent rain, dust, foreign matter, etc from entering the motor
(2) Prevent water, condensation, etc on the winding insulation which will decrease the resistance drop
(3) Prevent rust from forming inside and outside the motor.

7.1 Storage period from the machine manufacturer delivery date to shipping date.

(1) Conduct the following items from the time the machine is delivered to when it is assembled to the machine. Inspect the motor's appearance when it is delivered. Check for any abnormalities including motor damage and contamination. Repair any damage to the protective sheets.
   (a) Store the motor inside. Avoid places with high humidity levels. Raise the motor off the ground by placing the motor on blocks.
   (b) Protect the motor from rainwater, water puddles and external damage.
   (c) If the motor must be stored near work being conducted, use appropriate protection. Select a place where the motor will not be subject to welding sparks, tools or materials falling on the motor. Never place objects on the motor or use the motor as a footstep for other work.
   (d) When the motor is stored for a long period, the winding could absorb moisture causing the insulation resistance to de crease. Measure and record the winding insulation resistance when the motor is delivered and periodically measure the winding insulation resistance while it is being stored (approximately once a month). Confirm that the resistance is 1/10 or more than the previous measurement and that the resistance is greater than [rated voltage (kV)+1] (MO). If the insulation resistance falls below the given values, follow the steps in section 18.2(3) to dry the winding. Once completed, protect the motor from further moisture absorption.
(2) After the motor is attached to the driven machine and the trial operation is conducted, protect the motor against humidity and dust.
(3) Once the trial operation is completed, cover the cable openings on the terminal box by attaching covers, applying tape, etc.
(4) If the motor is removed from the driven machine and stored, cover and seal the entire motor with a protective sheets. Place desiccate packages inside the protective sheets. (Use approximately 500g of desiccate packages for every 1-m3.)

7.2 Storage period after arriving at the field until installation

There are many different cases such as machine and facility type to take into consideration. Therefore this section as well as section 7.3 (Storage period after field installation until trial operation) should be conducted in the same manner.
(1) Follow section 7.1 (1).
(2) The motor must be stored in the transportation package until installed. If the motor will be stored for an extended period of time before installation, implement section 7.3 (Storage period after installation until trial operation).

7.3 Storage period after field installation until trial operation

(1) Install the motor after any welding, grinding, concrete pouring and so forth has been conducted in the installation area. Protect the motor from these conditions.
(2) After installing the motor, cover the motor with protective sheets to protect the motor from contaminates.
(3) Use rust-preventing measures on the bearings and shaft end. About once a month manually rotate the shaft. Always reinstall the removed transportation fittings after rotating the shaft.
(4) Apply rust-preventing oil or grease on the exposed-machined surfaces of the motor including the shaft end, shaft coupling, flange surface and feet soles.
(5) If the motor has a space heater, we recommend turning ON the space heater during storage. If the motor does not have a space heater, place desiccate packages inside the protective sheets.
(6) After connecting the cables, seal the cable openings on the terminal box by using a sealing agent, tape, etc to prevent outside air into the terminal box.
(7) Protect the motor from any welding sparks or damage that may occur from falling objects, etc.
(8) Measure and record the winding insulation resistance about once a month to confirm that the resistance has not dropped. Follow the steps in section 18.2(3) to dry the winding if one of the following occurs: the insulation resistance value of the winding is 1/10 or more than the previous measurement value and that the insulation resistance is greater than or equal to [rated voltage (kV)+1] (MΩ). Once completed, prevent the motor from further moisture absorption.
(9) Cover the entire motor with protective sheets, and seal the ventilation ports and bearing areas.

7.4 Confirmation Before Trial Operation

(1) Remove all of the protective sheets used to protect the motor against rust, dust and damage. Also remove all of the transportation fittings or other parts. Before operating the motor, make sure the motor is in operating condition.
(2) Measure the insulation resistance of the winding to confirm that it has not dropped.
(3) Before starting the trial operation, supply the required amount of grease according to the grease nameplate.

7.5 Storage Period After Trial Operation Until Actual Operation (Including Halts Due to Operation Adjustments)

Store the motor in the following manner after it has been prepared for operation, including the solo run.

(1) Operate the motor more than once a month to prevent rust from forming.
(2) Periodically supply or replace the required amount of grease according to the grease nameplate.
(3) When the motor is not in use or has intermittently stopped, store the motor in the same manner as explained in section 7.3 (Storage period after field installation until trial operation).
(4) Service and inspect the motor when the motor is running continuously by following the instruction manual. Periodically check the motor for abnormalities such as vibration, noise and temperature.

8. UNPACKING

Carefully handle the product during unpacking and subsequent work by observing the following.

(1) Do NOT drop any nails, bolts or small metal chips into the motor while unpacking.
(2) Do NOT remove the rust-preventing agent from the coupling or shaft end until initial use.
(3) After unpacking the product, inspect the coupling and shaft end for any abnormalities.

9. INSTALLATION

9.1 Installation Area

Observe the following maintenance conditions when installing the motor.

9.1.1 Environment Precautions

(1) Select a dry area
The motor should not be subjected to water from leaking pipes, humid air or other sources of moisture.

(2) Select a well-ventilated area
Avoid installing the motor in poorly ventilated areas or where there are many machines in a confined area. The temperature could rise in these areas thus adversely affecting the motor.

(3) Select a cool area
The motor is greatly influenced by the ambient temperature. Operate the motor in an ambient temperature between -20°C and +40°C. The motor cannot be used when the ambient temperature is lower than -20°C or higher than 40°C.

(4) Select a clean area with a low dust level and the demand of cleaning
The cooling of the motor will decrease in areas where there is a high dust level thus causing the bearing or shaft to wear. Do not allow dust to build up on the motor. Clean so that dust do not pile up the motor.
In the case of the motor with a air filter, clean the filter periodicaly. If a filter is got blocked, cooling will become insufficient, failure to observe this could lead to burning.
If dust enters a protection–type motor, the winding insulation resistance could drop causing overheating. And in the case of the motor with a space heater, failure to observe this could lead to burning.

(5) Select distance from a fan cover to a wall
In the case of the motor with a fan cover, set distance from a fan cover to a wall to 200mm or more and don't bar an exhaust air. If distance is short, cooling will become insufficient, the motor could overheat and lead to burning.

(6) Select an area with no toxic gases
Protect the motor from any rust or corrosion. Acidic gases, such as chlorine and sulfur dioxide, can corrode iron and also damage the winding. Protect the motor from the exhaust of neighboring machines. If iron fragments, coal dust, cement or ground dust can enter the cooling air, make improvements by mounting a filter or changing the air intake direction. If any adjustments are made, make sure to maintain the same cooling air volume.

(7) Select an area where maintenance and inspections can easily be made
Select an area where the motor can be pulled out easily for inspections and disassembly.

(8) Select an area with no toxic or corrosive gases
Avoid installing the motor near storage areas for explosive gasses or fluids.

(9) Select an area that is not subjected to external vibration
The motor should not have external vibrations conveyed from the foundations of other machines.

(10) Select an area with little power voltage fluctuation
- Select an area where the voltage fluctuations during operation or voltage drop during startup is within the values in the specifications or standards.
- Install a protective device against external surges caused by lightning or switching surges caused by breaker operation.

9.1.2 Maintenance Precautions

Install the motor in an area where it can be approached easily for daily maintenance including inspections, grease replenishment and cleaning. The motor should also be able to be removed for period inspections, maintenance and repairs.

9.1.3 Outdoor Installation

Only use an outdoor-type motor when installing a motor outside. The outdoor-type motor is designed for a set installation direction (for example, the shaft end facing downward). If the motor will be installed in a different direction contact your nearest TMEIC Representative. The motor must be designed and manufactured to match the required installation direction. For example, motors with the drain hole located on the bearing bracket must be installed with the drain hole facing downward. If this is not observed, water will enter the motor.

9.2 Installation Foundation

If the installation method is done incorrectly, abnormal vibrations or noise could occur, leading to fires or motor damage. If the foundation is not solid, the machine or motor vibration could increase and could cause the installation position to move or the foundation could shift leading to bearing or shaft damage. The installation methods must be carefully considered and implemented.

(1) Installation on the foundation

The foundation should be made of solid concrete with the foundation bolts directly embedded into the concrete.

(2) Installation on driven machine

When installing the motor directly on the driven machine, confirm the machine's structure and strength. The machine structure must be able to withstand the load. If the structure can withstand the load, attach the motor securely to the structure so that the bolts will not loosen.

(3) Installation on wall or column

If the motor must be installed on a wall or support column, the structure, strength and other characteristics must be carefully investigated. Securely fix the motor by using angles, channels, and other suitable equipment. Install the motor so that there will be no problems during maintenance or inspection.

9.3 Precautions for Installation

Install a protective cover over the shaft extension and coupling. This will prevent objects or people from coming in contact with the shaft, coupling, belt or pulley of the motor and driven machine.

9.4 Coupling with driven machine

(1) Direct Couple

It is important to correctly align the motor to prevent unnecessary shaft stress, vibration, bearing wear, coupling wear, and so forth. Follow the coupling manufacturer alignment instructions if they are provided.

Using the driven machine as reference, the driven machine and motor are aligned by adjusting the motor. However the driven machine can also by adjusted using the motor as reference if the motor cannot be adjusted. The unit is considered aligned when the center of the motor shaft and the driven machine's coupling are aligned. Parallelism and eccentricity is measured at the coupling of the driven machine. A thickness gauge or taper gauge is used to measure the parallelism. To measure the eccentricity, a dial gauge is placed on one coupling and the dial gauge is read when both shafts are rotated to 0°, 90°, 180° and 270° (refer to Figure 9.3). The alignment accuracy must be 0.025mm or less for both parallel and eccentricity.

The tolerance for the coupling alignment is as follows: if the motor has a large radial load, keep the coupling alignment value less than 0.025mm of the target coupling tolerance.

Note: Verify that the motor or foundation bolts are tightened when measuring the alignment and determining the correction.

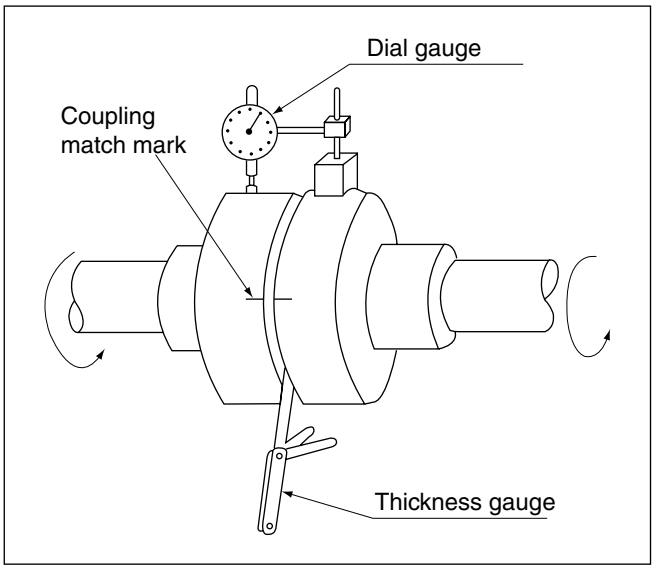
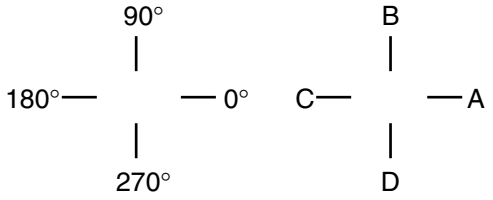


Fig. 9.1 Alignment procedures

(A) Measuring eccentricity

Rotate both shafts while measuring and recording the dial gauge reading at four places shown below. Use the following expressions to obtain the correction.



(Measurement points) (Measurement values)

$$\text{Left/right correction amount} = \frac{A - C}{2}$$

$$\text{Top/bottom correction amount} = \frac{B - D}{2}$$

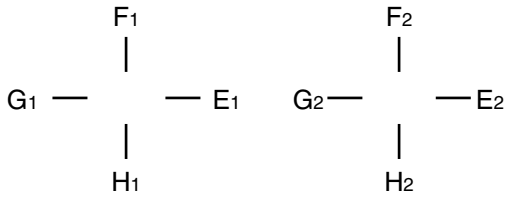
(Correction amount)

Figure 9.2 Measure the eccentricity

Note: For Figure 9.3 measurement values, the difference of the left/right total (A+C) and the top/bottom to tal (B+D) must be within 0.025mm. If this difference is larger than 0.025 mm, either the dial gauge is improperly fixed or the dial gauge arm is too weak.

(B) Measuring parallel

At the same positions for the eccentricity measurement, measure and record the E1, F1, G1 and H1 values with a thickness gauge or other measuring device. Next, rotate both shafts 180°. Measure and record the E2, F2, G2 and H2 values. Use the following expressions to obtain the correction.



(Measurement values)

$$\text{Left/right correction amount} = \frac{(F_1 + F_2) - (H_1 + H_2)}{2}$$

$$\text{Top/bottom correction amount} = \frac{(E_1 + E_2) - (G_1 + G_2)}{2}$$

(Correction amount)

Figure 9.3 Measure parallelism

(C) Correcting alignment

After calculating the correction amounts for both the eccentricity and parallelism, adjust the motor position.

(D) Special notes for alignment

(a) Aligning machines that have different operating temperatures

Generally, the driven machine and motor are aligned at cold state. The driven machine temperature could rise during operation causing a temperature difference with the coupled motor bearing. Thus leading to vibrations or fluctuations in the bearing. The best method to resolve this problem is to align the driven machine and motor at running temperature. First couple and run the motor after it is initially aligned at cold state. Once at steady state temperature, stop the machine and check the alignment. We recommend using the steady state alignment method.

(b) Aligning a sleeve bearing machine to a rolling bearing machine

If one machine uses sleeve bearings and the other machine uses rolling bearings, the center position of the shaft supported by the sleeve bearings will be offset due to the oil layer formed during rotation. Therefore this offset must be taken into consideration during when aligning the machines without the formed oil layer.

(2) V-Belt Drive

When a belt drive is used for connecting the motor to the driven machine, the belt selection and tension can cause excessive force on the shaft end and bearings if done incorrectly. This can lead to a shorter bearing life or even damage to the bearing. Therefore, observe the following points.

The motor V-Pulley and V-belt applications are shown in Table 9.1. If the pulley diameter is small, the belt conveyance capacity will drop causing an excessive shaft load. This may lead to shaft or bearing damage. Contact your nearest TMEIC representative if the pulley diameter is smaller than the values given in Table 9.1, if the number of belts has increased or if the distance from the motor shaft to the load point has increased.

1) Installing the V-Pulley

Use an arm-type V-pulley to prevent the motor's cooling air from being obstructed. If a flat-type V-pulley is used, create a large ventilation hole. When installing the V-pulley on the motor, align the V-pulley rim edge with the motor shaft step, as shown in Figure 9.4. This will allow the applied load to be reduced.

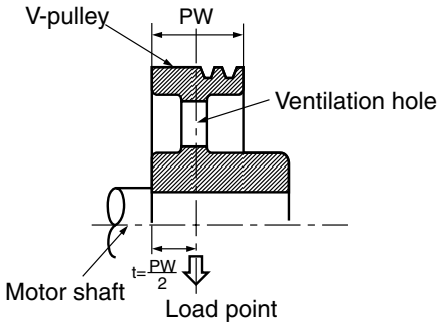


Fig. 9.4 Installing method of the V-Pulley

2) V-belt tensioning method

(A) The load points (pulley center) for the motor belt are shown in Table 9.1. Adjust the motor pulley and driven pulley positions as shown in Figure 9.5. The shaft, bearings and belts could all be damaged if the belt or pulleys are inclined.

Table 9.1

Output	4-pole							6-pole							8-pole							Remarks
	V-pulley dimensions mm		Belt		Belt load point	Belt slack weight Td (N/qty.)		V-pulley dimensions mm		Belt		Belt load point	Belt slack weight Td (N/qty.)		V-pulley dimensions mm		Belt		Belt load point	Belt slack weight Td (N/qty.)		
kW	Nominal diameter (Minimum value)	Rim width (Maximum value)	Type	No. of belts	mm	Tension for new belt	Tension when reattaching belt	Nominal diameter (Minimum value)	Rim width (Maximum value)	Type	No. of belts	mm	Tension for new belt	Tension when reattaching belt	Nominal diameter (Minimum value)	Rim width (Maximum value)	Type	No. of belts	mm	Tension for new belt	Tension when reattaching belt	
37	224	161.5	C	6	80.8	40~46	31~40	265	161.5	C	6	80.8	45~52	35~45	280	187	C	7	93.5	46~53	36~46	
45	265	161.5	C	6	80.8	44~51	34~44	280	187	C	7	93.5	45~52	35~45	315	187	C	7	93.5	51~58	39~51	
55	265	187	C	7	93.5	46~53	36~46	300	212.5	C	8	106.3	46~53	36~46	355	196	D	5	98	81~93	63~81	Standard V-belt
75	315	212.5	C	8	106.3	51~59	39~51	355	233	D	6	116.5	78~90	61~78	400	233	D	6	116.5	84~97	66~84	
90	—	—	—	—	—	—	—	400	233	D	6	116.5	86~100	68~86	450	233	D	6	116.5	92~106	72~92	
110	—	—	—	—	—	—	—	400	270	D	7	135	89~103	70~89	450	270	D	7	133	95~110	74~95	
132	—	—	—	—	—	—	—	475	270	D	7	135	99~114	77~99	450	344	D	9	172	90~104	71~90	
37	200	77.9	5V	4	39	58~67	45~58	224	77.9	5V	4	39	74~84	57~74	250	95.4	5V	5	47.7	70~80	55~70	
45	224	77.9	5V	4	39	63~73	49~63	224	95.4	5V	5	47.7	72~82	56~72	250	112.9	5V	6	56.5	71~81	55~71	
55	224	95.4	5V	5	47.7	62~71	48~62	250	112.9	5V	6	56.5	67~76	52~67	280	112.9	5V	6	56.5	77~88	60~77	
75	250	112.9	5V	6	56.5	64~74	50~64	315	112.9	5V	6	56.5	73~83	57~73	355	112.9	5V	6	56.5	83~96	65~83	Thin V-belt
90	280	112.9	5V	6	56.5	70~79	54~70	355	112.9	5V	6	56.5	78~89	61~78	355	123.8	8V	4	62	154~176	120~154	
110	—	—	—	—	—	—	—	355	123.8	8V	4	61.9	147~170	115~147	400	123.8	8V	4	62	168~192	130~168	
132	—	—	—	—	—	—	—	400	123.8	8V	4	61.9	159~182	123~159	450	123.8	8V	4	62	179~206	139~179	

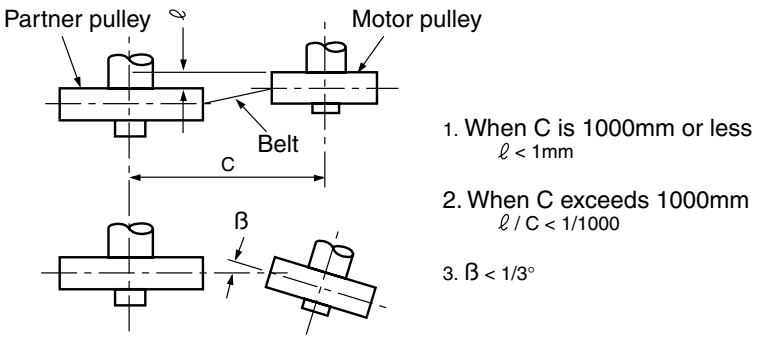


Figure 9.5 V-belt adjust method

(B) The belt and pulley contact angle F should be larger than 140°.

(C) When attaching a new belt, always shorten the distance between the pulleys. Attach the belt onto the pulley before reapplying the tension. If the belt has too much tension, the bearings could get damaged. If the belt has too little tension, the belt could slip and be dislocated or damaged. Adjust the belt to where it does not slip. When using a V-belt type pulley, adjust the distance between the shafts using the following method: The slack load (Td) given in Table 9.1 should create a slack amount (d) of 1.6mm per 100mm of the distance (t) between the V-pulley contacts. (For example, = 1.6 x 1000/100 = 16mm for t = 1000mm.) Always adjust the tension when the belt is replaced. A new belt could stretch within the first two to eight hours. Always apply tension to the belt at the slack load (Td) when reattaching a belt given in Table 9.1. When using an old belt, apply tension to the belt at the slack load (Td). When using two or more V-belts, always use the same type belt from the same company to maintain matched sets.

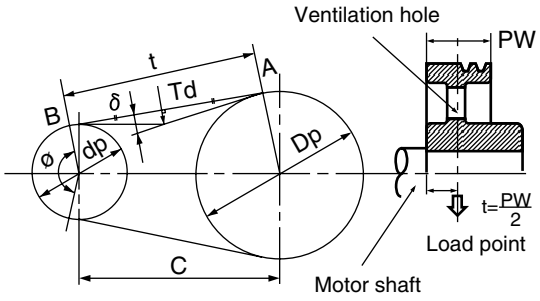


Figure 9.6 Checking the various tensions

C: Distance between shafts (mm)

Ø: Contact angle (°)

Dp, dp: Pulley pitch diameter (mm)

Td: Slack load (kg/qty.)

PW: Rim width (mm)

PW / 2: Load point (mm)

t: Distance between V-pulley contacts (mm) = $\sqrt{C^2 - \left(\frac{Dp - dp}{2}\right)^2}$

δ: Slack amount (mm) = 1.6 x t / 100

(D) Change the belt tension by moving the adjustment bolt on the slide base. Lightly tighten the mounting bolts to where there is no play between the motor and slide base.

(E) Move the motor in parallel to the driven machine with the adjustment bolts.

(F) Set the motor in place with the mounting bolts. After fixing the motor, loosen the adjustment bolt, and then re-tighten the mounting bolt. After completed, re-tighten the adjustment bolt before starting operation.

(G) Pulley diameter: If one pulley is replaced due to rusting or wear, or if the dimensions of the pulley set change from the initial dimensions due to design changes (when the pulley diameter must be decreased or the pulley width length ened), the shaft strength and bearing life could be affected. Contact your TMEIC Representative if this occurs.

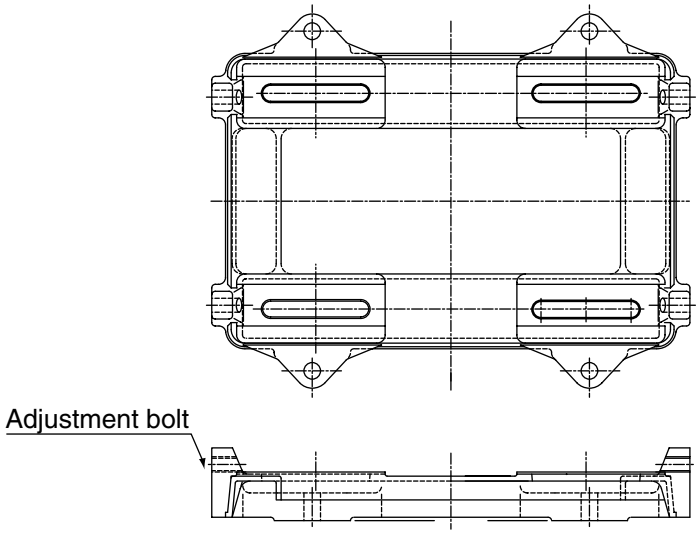


Figure 9.7 Slide base (Frame No. 250S to 280L)

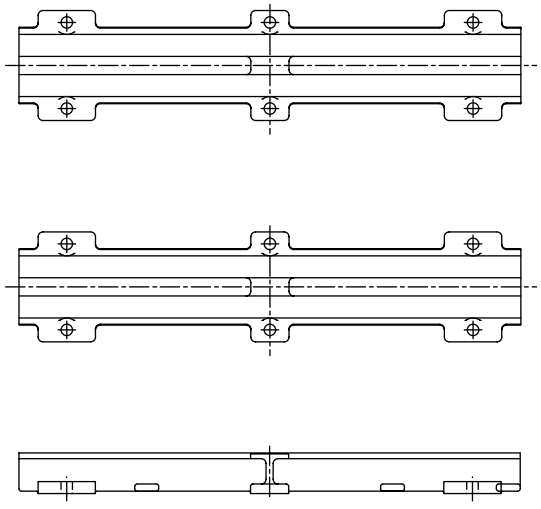


Figure 9.8 Slide rail (Frame No. 315H~400H)

Note: When connecting the slide base to the common frame make sure that the feet soles of the slide base completely contacts the frame.

(3) Gear drive

Connect the motor shaft parallel to the gear drive shaft on the driven machine. When using a vertical type motor, avoid applying a thrust load that exceeds the shaft coupling, pulley or gear weight. If an excessive thrust load is applied to the motor shaft, the motor bearing life could be reduced or the bearings could be damaged.

10. CONNECTION

10.1 Preliminary inspection before connecting

10.1.1 Measure the winding insulation resistance

Use a 500V insulation resistance tester for a low voltage motor (less than 600V). Use a 1000 V insulation resistance tester for a high voltage motor (more than 600V). Refer to section 17.2 (2) 3 for more details on the insulation resistance values.

10.1.2 About direction change of the terminal box

When changing direction of the terminal box,

(1) Be sure to confirm that it is in the state of a power supply OFF before a work start.

(2) The lead length of the motor is adjusted at the time of shipment our company, rotate only the terminal box as much as possible.

(3) Bolts, seal should be restored in the state before direction change.

(4) When changing direction of the packing, the motor lead, contact the service man of our company or the motor service shop.

However, when the above-mentioned works is carried out at the customer, check that trouble does not arise in operation of the motor with modification.

10.1.3 Dielectric test

⚠ DANGER	
Prohibited	• Do not approach the motor during the dielectric test. Always discharge the winding that has undergone the dielectric test before touching it. Failure to observe this could lead to electric shock.
Mandatory	• Always ground all windings to which the voltage is not applied during the dielectric test. Failure to ground these windings could lead to electric shock if there is a current leakage.

Before conducting the dielectric test, measure the insulation resistance of the winding to confirm that it is larger than the specified value. Always observe the following.

- Use the values specified below for the test voltage. The voltage should be increased to the required voltage without containing high harmonics.
- Raise the applied voltage at a rate of 1000V/s. After maintaining the specified voltage at the specified time, immediately return the voltage to zero. Use equipment that can vary the voltage. Do NOT apply the entire voltage at once.
- Tie the terminals with the same rated voltage, and apply the specified voltage across the bundled terminals and ground.
- When carrying out the dielectric test for one phase or one section of the winding, isolate the other phases or section ends. Tie each terminal together and apply a voltage across the terminal and ground. Ground all other phases and windings when conducting the test.

Recommended dielectric test voltage

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

1.5-times maximum applicable voltage. (If the test voltage is less than 500 volts, 500 volts shall be applied.)

10.2 Connecting the motor

10.2.1 Connection methods

The connection methods for the general 3-phase motor are shown in Figure 10.1.
These are called Y (star) connection, Δ (delta) connection, or 2//Y (two-parallel star) connection, etc.
Note that there are other special methods of connection.

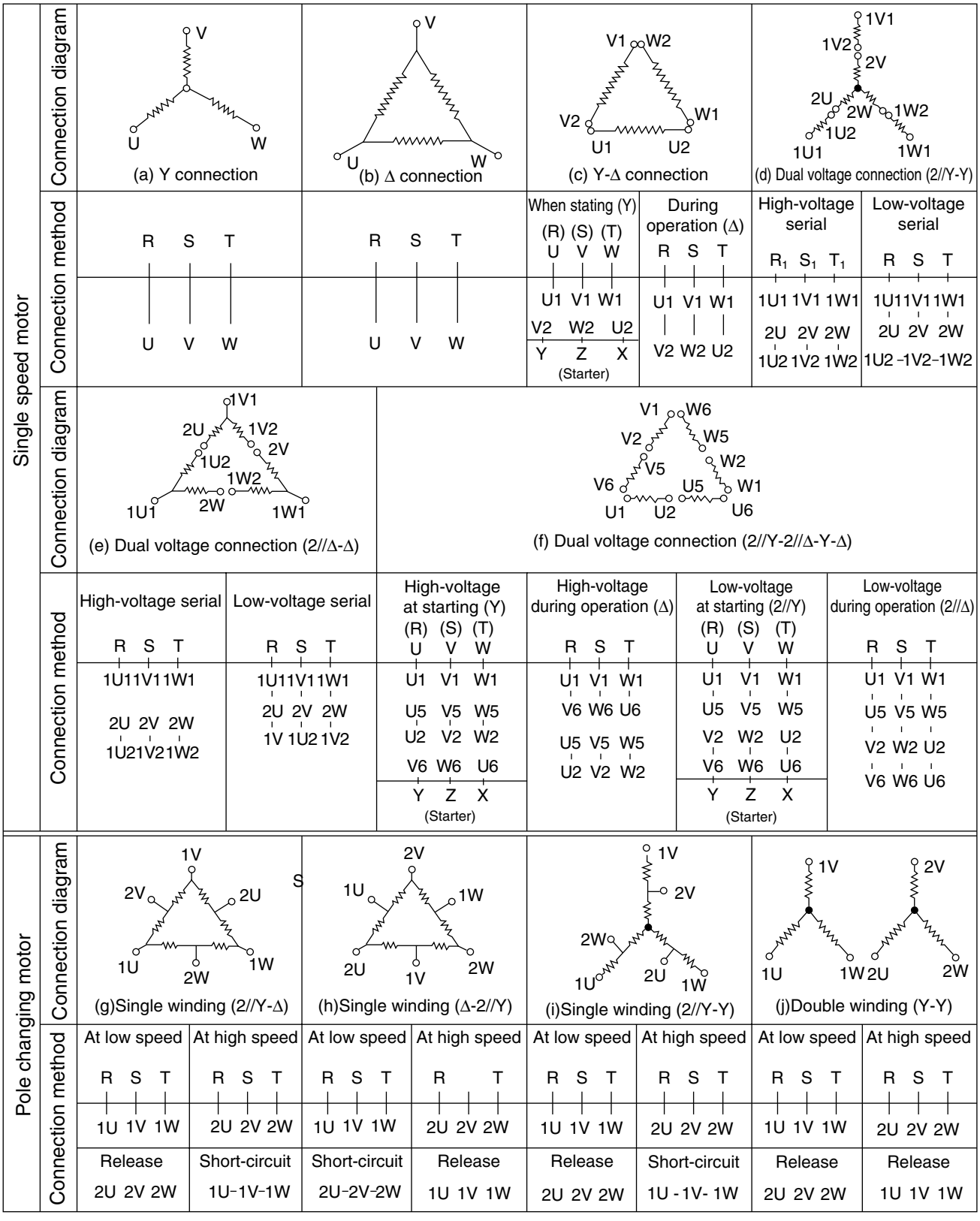


Figure 10.1 Connection diagram and connection method

11. WIRING

11.1 Wiring procedures

Always use proper wiring equipment. Follow the Electric Facility Technology Standards and any other applicable standard. If the wiring distance is long, the voltage drop could increase and cause problems when starting the motor. Therefore keep the wire length as short as possible or adjust the applied voltage for the voltage drop.
The motor insulation type is shown on the nameplate. The temperature around the terminal box will be relatively high on motors that use a high-temperature insulation (insulation class “F”). Therefore use high heat-resistance wiring cables and insulation tape around the terminal box.
Be careful of the lead not to pull out from the inside of the motor, or not to push into the inside of the motor at the time of lead connection.

11.2 Grounding (Earth)

The motor insulation acts both as an insulator as well as an inductor. Therefore a capacitance is formed between the insulation and the ground. If the motor is not grounded, 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.

11.3 Precautions for driving inverter

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

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

(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.)
(5) Earth Brush (Grounding Brush)
    1) Function
    When an inverter drives the motor, shaft voltage occurs between the shaft and earth (ground) due to electrostatic induction. This voltage is different than the motor and inverter capacitance. When this voltage is large, bearing failure will occur due to the shaft current passing through the bearing. TMEIC installs an earth brush (grounding brush) to prevent shaft current. The current will pass through the brush to the bearing bracket (ground), thus protecting the bearing. The brush is subject to spark, therefore take caution.
    2) attachment
    The brush is commonly attached on the drive end bearing bracket. Replace the brush after the power supply has been turned off, under the motor stop.
    3) Maintenance
    Brush wear varies due to running speed and environmental conditions. Check the brush once every **1-2** month.
    Figure 11.1 shows the earth brush maintenance nameplate. Replace the brush before it reaches the indicated limit.
    4) Replacement
    If you change the brush, contact your nearest TMEIC Representative for more details.
    A brush performance is influenced.

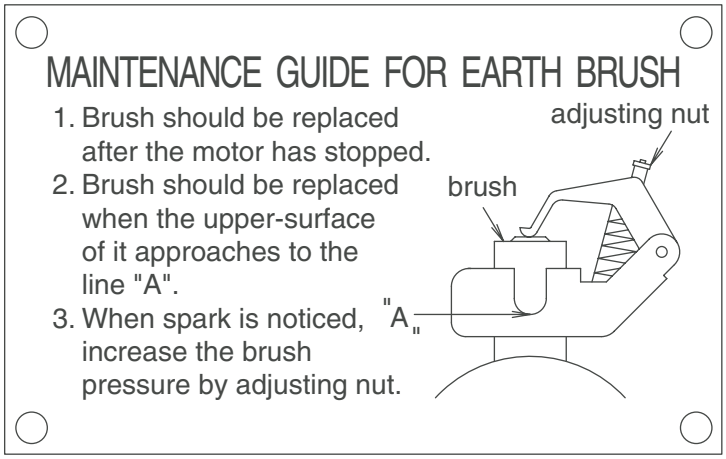


Fig. 11.1 Shaft earth brush inspection methods

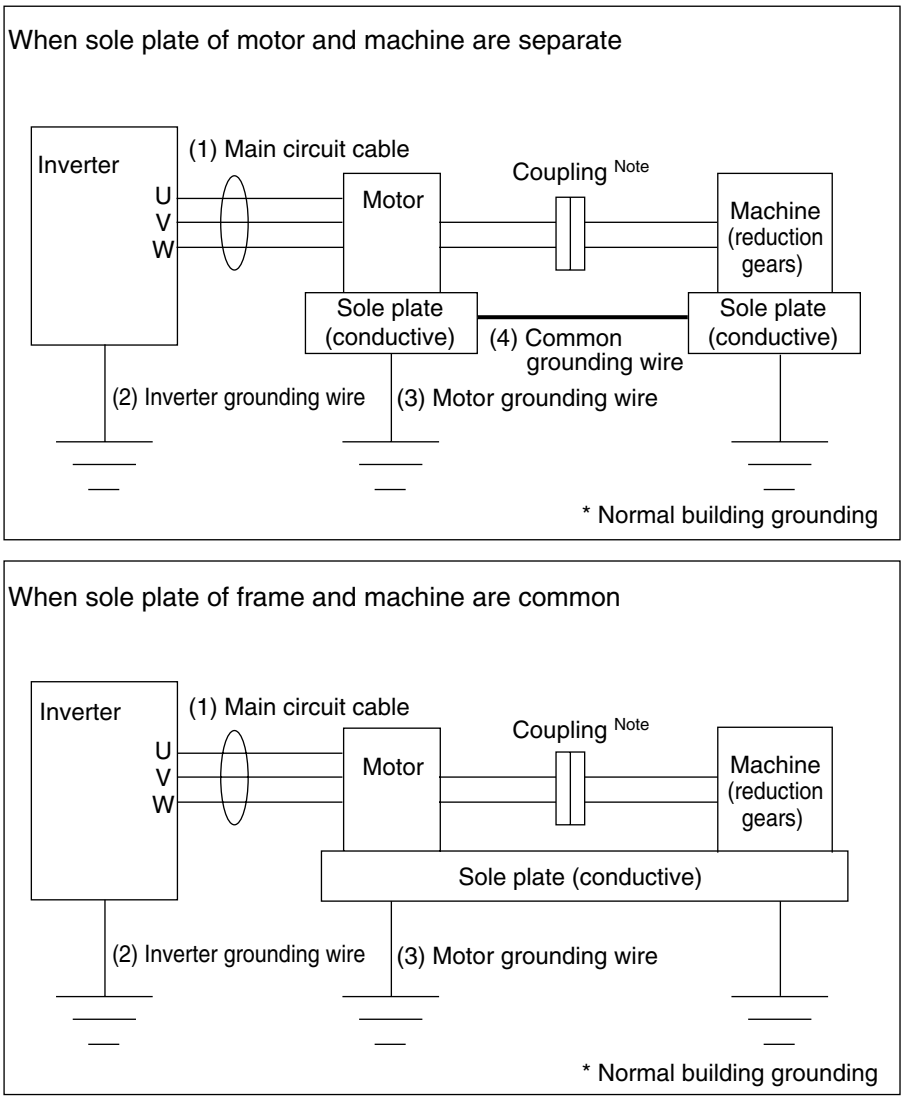


Figure 11.2 Grounding wire connection

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

11.4 Precautions for Y-Δ starting

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

(1) When selecting the Y-Δ starting device, select a device that uses a magnetic switch on the primary side to prevent the voltage from being applied to the motor winding when the motor has stopped.
(2) If there is no magnetic switch on the primary side, always open the switch on the power source side when the motor has stopped.
(3) When using high-voltage Y-Δ starting, install a protective device to suppress the switching surge when turning ON and OFF the motor (especially a vacuum switch).

12. PRECAUTIONS FOR INITIAL STARTING

Allow only the motor to rotate by not connecting the motor to the coupling. Make sure the terminal box cover is connected when the power is applied. Use the following steps when starting the motor for the first time.

(1) Check the voltage, frequency and phase (refer to the values given on the nameplate).
(2) Make sure the leads are correctly connected. Confirm the tightening state at each connection section and insulation.
(3) Confirm that the shaft locking plate was removed, if used during transportation.
(4) Replenish the grease according to the time period and amount indicated on the nameplate (in order to prevent the poor lubricous and abnormal noise by the shortage of grease).
(5) Confirm that there is sufficient clearance between the motor's fixed sections and rotation sections. If possible, try rotating the rotor to check for abnormal noise or vibration. If any abnormality is found, inspect the inside of the motor (coil ends, fan, air gap clearance, etc).
(6) Start the motor, then immediately stop the motor, allowing the inertia of the rotor to rotate the shaft and check the following items.
    1) Is the shaft rotating in the correct direction?
    2) Are there abnormal noises coming from bearing?
    3) Is the motor producing any abnormal noise?
    4) Is there any abnormal smell coming from the motor?
       When a new motor and driven machine are started for the first time, sometimes the heating of the new varnish causes a temporary smell to come from the motor windings.
    5) Is the installation of the motor and coupling correct?
(7) After checking the items in step (6), turn the motor on. Check the following items after the motor has reached steady state operation.
    1) Are the three phases of the current balanced and without pulsation?
    2) Is there any noise? Is there any vibration?
    3) Is the bearing temperature at steady state?
(8) If the above (7) are all acceptable, the motor can be connected to the driven machine and operation can start.

13. OPERATION MANAGEMENT STANDARDS

13.1 Number of starts

If the motor is started frequently, the windings could burn or the rotor bar could damage. Therefore, the number of starts the motor makes should be limited. When using the motor under special circumstances such as driving a heavy inertia load, the number of starts is limited based on the caution plate (attached below main nameplate).

THIS MOTOR IS DESIGNED FOR
THE STARTING CONDITIONS SHOWN BELOW.

1. THE MOTOR INITIALLY AT AMBIENT TEMPERATURE CAN BE STARTED TWICE SUCCESSIVELY.
2. THE MOTOR AT OPERATING TEMPERATURE CAN BE IMMEDIATELY STARTED ONCE AFTER THE CONTINUOUS OPERATION.
3. IF ADDITIONAL STARTS ARE REQUIRED,
   (1) THE NEXT STARTING IS TO BE MADE AFTER 60 MINUTES, IF THE MOTOR IS CONTINUOUSLY OPERATED,
   OR (2) IT MUST BE MADE AFTER 90 MINUTES,IF THE MOTOR IS KEPT UNENERGIZED.
4. TWO SUCCESSIVE JOGGING STARTS ARE REGARDED AS ONE NORMAL START (BRINGING THE MOTOR FROM THE REST TO FULL SPEED.)

Figure 13.1 Caution Plate (Example)

Unless the motor is specially designated, observe the following items.

- The motor can be started twice from cold state. The required cooling time is 10 hours.
- The motor can be started once after a loaded operation.
- The motor can be started after the following operations:

  Load operation for 60 minutes or more
  No-load operation for 30 minutes or more
  Stopping for 90 minutes or more

  Two short operations are equivalent to one start up of the motor.

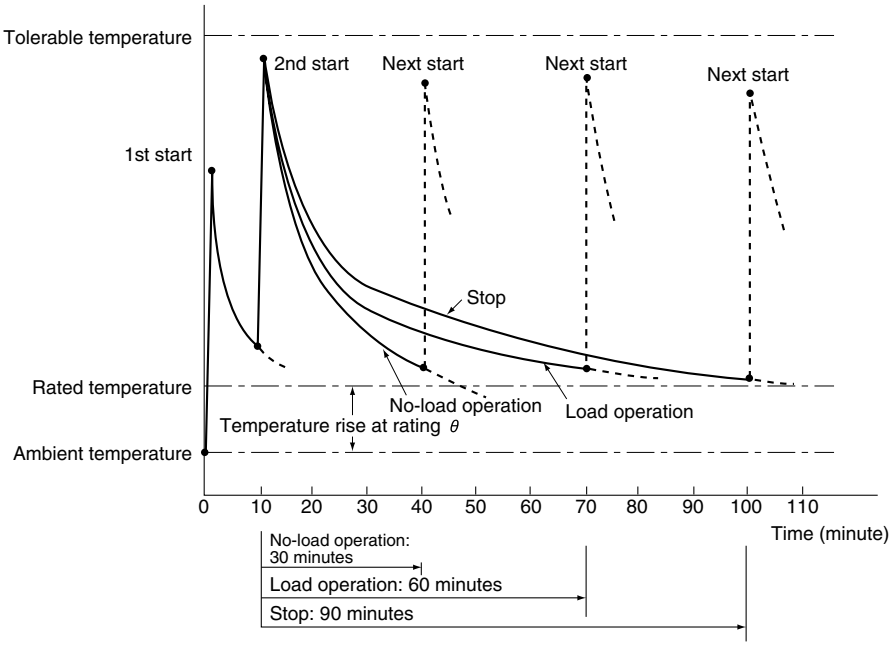


Figure 13.2 Temperature rise of the motor under start up

During the trial operation, the motor must be successively started several times to adjust the control unit. However, the number of starts should be limited to prolong the motor life.

If starting/stopping is frequent due to operation designs, use the following table for the number of starts per year. The 21-F series standard motors are considered “Normal”. Contact your nearest TMEIC Representative if the start/stop frequency falls within the “Heave” or “Extra Heavy” ranks. The “Extra Heavy” rank requires a motor designed for many starts.

Rank	Number of starts (per year)
Normal	1000 times or less
Heavy	3000 times or less
Extra Heavy	More than 3000 times

13.2 Thermal classification and temperature rise limits

The thermal classification of general-purpose motor insulation and the temperature rise limits for each section are shown in Table 13.2.

Table 13.2 Temperature rise limits

Unit: K

Item	Part of machine	Thermal classification														
		A			E			B			F			H		
		Thermometer method	Resistance method	Embedded temperature detector method	Thermometer method	Resistance method	Embedded temperature detector method	Thermometer method	Resistance method	Embedded temperature detector method	Thermometer method	Resistance method	Embedded temperature detector method	Thermometer method	Resistance method	Embedded temperature detector method
1 (a)	AC windings of machines having outputs of 5,000 kW (or kVA) or more.	–	60	65	–	75	80	–	80	85	–	100	105	–	125	130
(b)	AC windings of machines having outputs above 200 kW (or kVA), but less than 5,000 kW (or kV).	–	60	65	–	75	80	–	80	90	–	105	110	–	125	130
(c)	AC windings of machines having outputs of 200 kW (or kVA) or less, other than those in items 1(d) or 1(e).	(1)	60	–	(1)	75	–	(1)	80	–	(1)	105	–	(1)	125	–
(d)	AC windings of machines having rated outputs of less than 600 W (or VA).	(1)	65	–	(1)	75	–	(1)	85	–	(1)	110	–	(1)	130	–
(e)	AC windings which are self-cooled without a fan (IC 40) and/or with encapsulated windings.	–	65	–	–	75	–	–	85	–	–	110	–	–	130	–
2	Insulated rotor winding	–	60	–	–	75	–	–	80	–	–	105	–	–	125	–
3	Squirrel-cage winding	The temperature rise at this section must not adversely affect the other insulations at the section or adjacent materials in any case.														
4	Rectifier, slip ring, brush and brush adjuster	The temperature rise at these sections must not adversely affect the other insulations at the section or adjacent materials in any case.														
5	Iron core and all structural components regardless of contact with insulators (excluding bearings)	The temperature rise at this section must not adversely affect the other insulations at the section or adjacent materials in any case.														

Note: 1) It is best if the manufacturer and customer decide on the temperature measuring method.
2) When the rating is less than 200 kW the temperature rise of the insulation classes A, E, B, and F can be 5K over the resistance measurement method using the super imposing test method.

13.3 Vibration

13.3.1 Acceptable vibration during operation

When the load machine is driven, it can be affected by the accuracy of the coupling with the load machine or the vibration that occurs from the load machine. In addition, the vibration could change according to the condition of the foundation or base. Less vibration is desired however there could be a small difference in vibration levels according to the motor rotation speed or installation conditions. The vibration range that does not obstruct operations is shown in Figure 13.3. The vibration impact acceleration for a standard motor is 5m/s^2 or less. Therefore, if higher vibration acceleration could be applied to the motor in applications for presses, etc. contact your nearest TMEIC Representative. The vibration velocity severity is shown in Figure 13.3. The amplitude and vibration velocity is the maximum value of the bearing housing. The motor's vibration is tested to conform to the customer's specification before shipment. However if the alignment is not within tolerance or the driven machine has a large vibration it will affect the performance of the motor. If this occurs, readjust the alignment of the motor or reduce the vibration of the load machine. The motor vibration is adjusted to an acceptable level before shipment, however the actual foundation and base can change the total system's vibration sensitivity and increase the motor's vibration. If this occurs, sometimes the total system, including the motor, is in resonance. Therefore reconfirm the foundation and base conditions to reduce the vibration sensitivity.

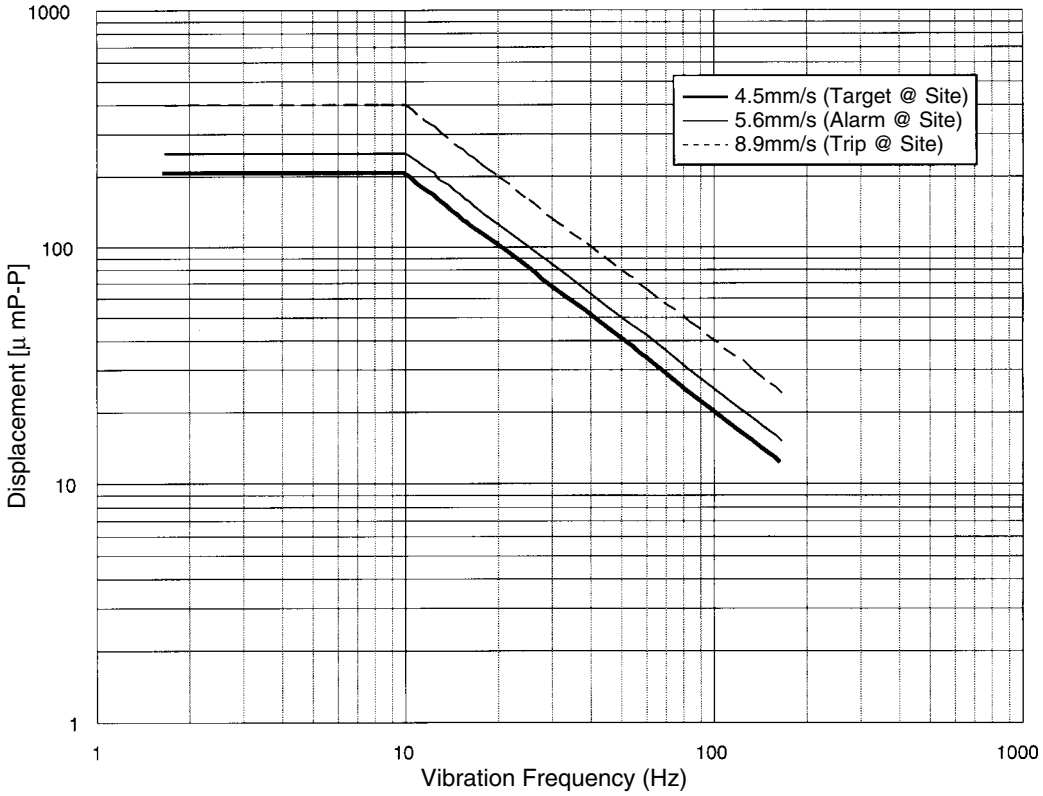


Figure 13.3 Acceptable vibration limits

Note: 1) Rotating Frequency (Hz) = Rotational Speed (min^{-1}) / 60
2) Vibration Frequency is the actual maximum vibration amplitude. The rotational frequency and vibration frequency do not correspond with each other.

13.3.2 Vibration when stopped

If vibration is applied to the motor while it has stopped, the bearings and windings could be affected. Fretting could occur in the bearings and develop into abnormal bearing noise or damage; therefore special attention is required.

If the motor is installed on an inadequate foundation or floor, vibration from other operating motors or machines can transfer their vibration to the motor as shown in Figure 13.4. In this case, relatively small vibration will occur on the race surface of the rolling elements, thus causing wear. This is called fretting. If fretting occurs, Brinell pressure marks (local dimples) will form on the bearing inner or outer race surface, and may obstruct the bearing's rotation. The following measures should be taken in this case.

(1) The shaft must be constantly rotated.
(2) The motor must be fixed so that the vibration does not occur on the race surface of the bearing's rolling elements. For example, insert a wood wedge between the shaft coupling and bearing bracket, or both sections must be pressed together with adjustment bolts.
(3) If the vibration is not very large, two or more motors can be alternately operated at an interval of several days. In other words, it is necessary to prevent damage to the balls or rollers and inner ring or outer ring.
(4) The vibration of adjacent operating machines must be reduced.
(5) The foundation or floor structure must be modified to reduce the vibration applied to the stopped motor.

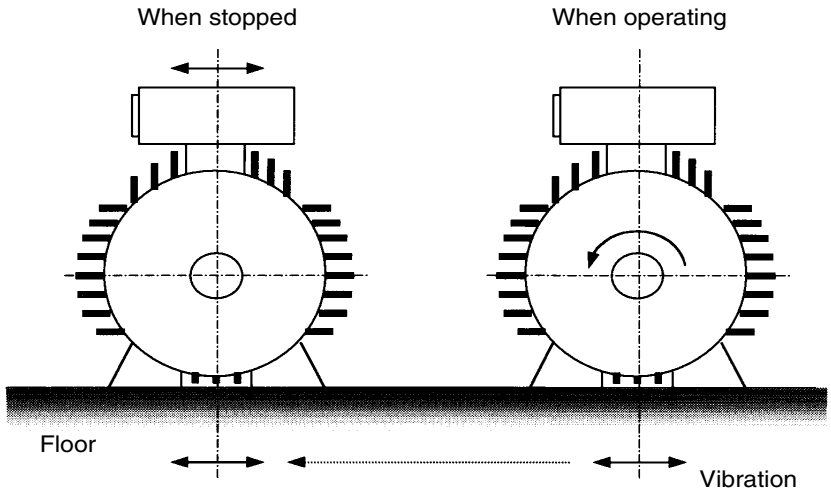


Figure 13.4 Vibration when motor is stopped

14. REMOVAL

Always confirm that the power is shut off before working on the motor.

14.1 Confirming the inside of the terminal box and removing the connections

Open the terminal box, and visually check the parts. Correct any abnormalities found when the motor is reassembled.
The following items must be inspected.

(1) Presence of damage or deterioration on the bolts or lead wires
(2) Presence of water damage or rust inside the box
(3) Connection state of bolts and terminals (loosened, deformation, thermal traces, size compatibility)
(4) Disconnect each wire and confirm that each phase is color-coded. This will ensure the correct wiring when the motor is reassembled.
(5) Protect the disconnected cable terminals with tape.
(6) Tie the U, V, W phase windings together. Measure the insulation resistance between the windings and ground. For low-voltage motors, use a 500V-insulation resistance gauge. For high-voltage motors, use a 1000V-insulation resistance gauge. Confirm that the resistance value is 1/10 or more of the previous measurement value and that the resistance value is [rated voltage (kV)+1] (MΩ) or more.

14.2 Separating the shaft coupling

Before separating the shaft coupling, check for any abnormalities including bolt looseness and dislocated washers. Measure and record the shaft deflection. When separating the shaft coupling of a vertical motor, set the motor so that the load side pump impellers, etc do not fall off.

14.3 Removing, changing the direction or transferring the motor

Remove the mounting bolts. If there is sufficient space for disassembling the motor at the site, suspend the motor with a crane and rotate the motor for ease of disassemble. Make sure the motor shaft is horizontal. If there is not sufficient space for disassemble, move the motor to a place where it can be disassembled. Before disassembling the motor, mark the alignment on the frame-bearing bracket, bearing bracket-bearing cover, and fan cover-bearing bracket surfaces.

15. DISASSEMBLY

Use a crane, lifting wire and standard tools when disassembling the motor.

15.1 Removing the covers

First, remove the grease pipe. Then remove the fan cover.

15.2 Removing the coupling, pulley, fan, etc.

Remove the snap ring or fixing screws before removing the external fan. If the part has a tight fitting, apply heat to the boss area before removing the parts from the shaft. Remove the shaft coupling, pulley or fan connected to the shaft end. Remove the part using a puller while protecting the shaft and key from being damaged.

15.3 Removing the accessories around the bearings

(1) Remove the bolts of the inner bearing cover (when used). If the motor uses an outer bearing cover, remove the outer bearing cover using the bearing bracket.
(2) Remove any protective plates, seals or any other part that will prevent the removal of the bearing bracket. When removing the part try not to damage the shaft, key or bearing-bracket machined surfaces.

15.4 Removing the bearing-bracket

(1) Support the non-drive end with a jack or support frame, and slightly raise the bearing bracket.
(2) Remove the bolts and separate the bearing bracket from the frame.
(3) Carefully set the rotor on the inner diameter of the stator.
(4) Suspend and remove the bearing bracket as shown in Figure 15.1.

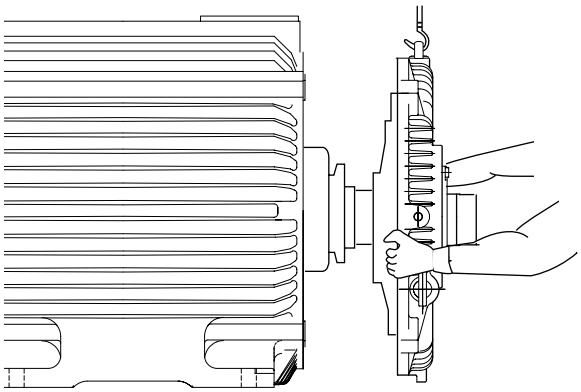


Figure 15.1 Removing the bearing bracket

15.5 Pulling off the rotor

Suspend the rotor horizontally using an L-shaped rotor inserting tool and carefully remove it. The rotor can also be removed by mounting a long pipe on both shaft ends and suspending the ends with two cranes as shown in Figure 15.2. In this case, wrap a clear sheet around the rotor so that the core and windings are not damaged. Protect the bearings with rags to prevent foreign matter from entering the bearing.

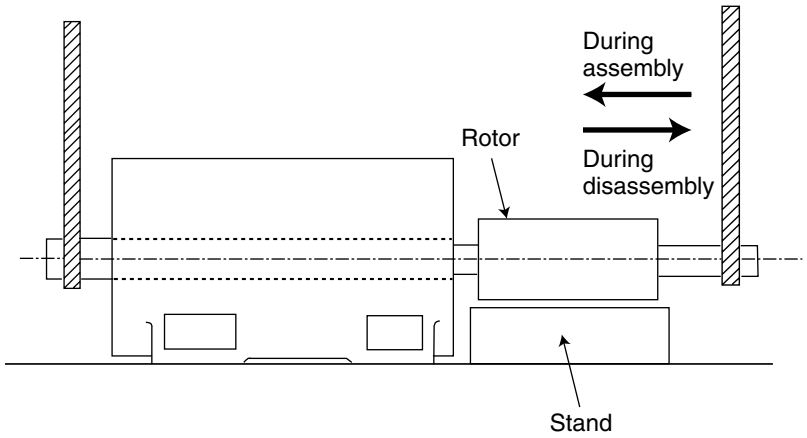


Figure 15.2 Pulling out and inserting the rotor

15.6 Removing the bearings

If the bearings are forcibly removed with a hammer or pried off, problems can arise such as shaft bending. Remove the bearings with care.

(1) Removing the grease runner and bearing nuts.

If a grease runner or bearing nut is installed, lift the washer stopper and remove the grease runner or bearing nut and washer. In case of without a washer, the stopper is a setscrew. Remove the grease runner or bearing nut after removing the setscrew.

(2) Removing the bearings

Remove the bearings using a puller as shown in Figure 15.3. The hooks should be applied to the bearing inner or outer ring. Turn the wrench slowly to remove the bearings. For a motor with an inner-bearing cap, remove the bearing by applying the hooks to the inner-bearing cap as shown in Figure 15.4.

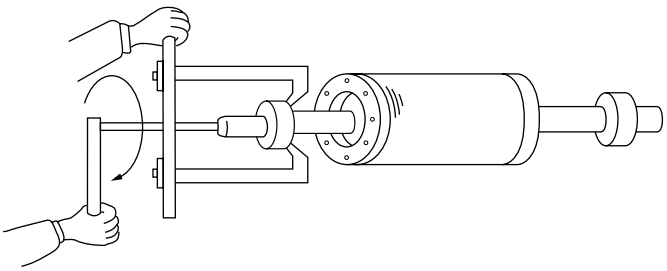


Figure 15.3 Removing with a puller (Part 1)

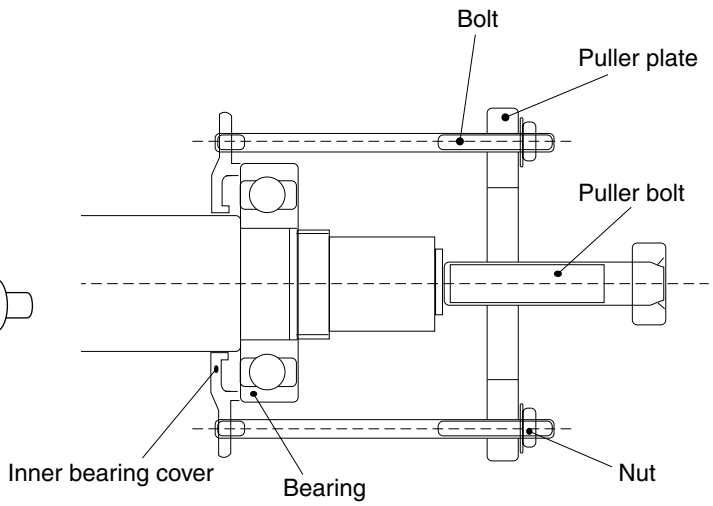


Figure 15.4 Removing with a puller (Part 2)

16. ASSEMBLY

Prepare a crane, lifting wire and standard tools for assembling the motor.

16.1 Installing the bearings

Before inserting the bearings, wipe clean the bearing's inner surface and remove any damage or protrusions. Confirm the fitting section dimensions of the bearing housing and tolerances that are as shown in section 17.2 (3) 3). Replace the bearings. If the motor uses an inner bearing cover, insert the cover before the bearing. Install the bearings using the following method.

(1) Installing the bearings

1) Installing sealed bearings

Sealed bearings are installed by either heating or pressing. When heating the bearing, use a low-frequency induction heater (bearing heater). Measure the temperature of the bearing's inner ring. Make sure that the temperature does not exceed 80°C. When pressing the bearing, apply oil to the inner diameter of the bearing and fitted shaft surface. Align the bearing squarely. Place a mounting tool on the inner ring, and carefully insert the bearing using a press. If a press is not available, carefully tap the mounting tool to insert the bearing. When tapping the mounting tool, do not pry the bearing or make contact with the bearing retainer, seal or outer ring.

2) Installing open-type ball bearings or cylindrical roller bearings

Insert the inner bearing cover before installing the bearing. Measure the temperature of the bearing's inner ring when heating the bearings with a low-frequency induction heater (bearing heater). When heating the bearing in grease, set the bearing in clean grease for 30 minutes, and heat to approximately 100°C. Make sure that the temperature does not exceed 120°C. Next, insert the heated bearing onto the shaft. Do not move the bearing until it has cooled down. Moving the bearing or assembling the bracket while still hot can cause twisting.

(2) Installing the grease runner and bearing nut

Install the grease runner or bearing nut with the washer. Cool the bearings to room temperature. Once at room temperature, tighten the grease runner or bearing nut as shown in Figure 16.1, and set the bearing with the washer. In case of without a washer, the stopper is a setscrew. Install the grease runner or bearing nut with the setscrew which applied the locktight.

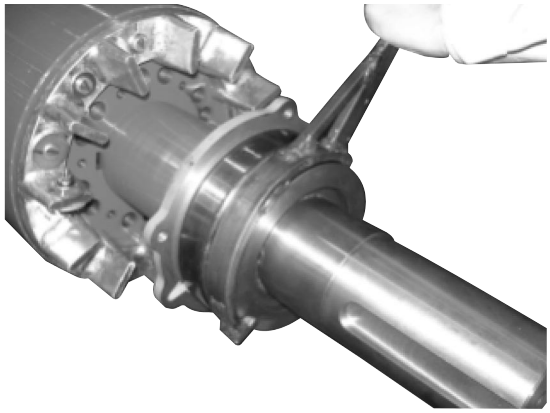


Figure 16.1 Tightening the grease runner and bearing nut

(3) Inserting lubrication grease

Insert grease into the rolling element section of the bearing. Insert grease into about half of the inner bearing cover housing. Follow the grease type and quantity indicated on the grease plate attached to the motor. When using cylindrical roller bearings, apply grease to the bearing outer and inner ring before assembling the bearing together.

16.2 Inserting the rotor

Suspend the rotor horizontally using an L-shaped rotor installing tool and carefully insert it. The rotor can also be inserted by mounting a long pipe on both shaft ends and suspending the ends with two cranes as shown in Figure 15.2. In this case, wrap a clear sheet around the rotor so that the iron core and windings are not damaged. Protect the bearings with rags to prevent foreign matter from entering the bearing.

16.3 Assembling the bracket

Confirm the fitting tolerance between the bearing bracket and bearings shown in section 17.2(3)3). Assembly of the bearing bracket is using the following method.

(1) Assembling the drive end bearing bracket
   (a) Suspend the bearing bracket by a crane.
   (b) Fit the bearing bracket with the bearings. If there is an inner bearing cover, use the guide bolt to align the position of the inner bearing cover, bearing bracket and grease supply port. Next replace the guide bolt with a bolt.
   (c) Apply a sealant to the frame and bearing bracket contact surface. If there is an outer bearing cover, apply the sealant between the bearing bracket and cover.
   (d) Assemble the bearing bracket to the frame.
   (e) Tighten the bolts symmetrical.

(2) Assembly of non-drive end bracket
   (a) Suspend the bearing bracket by a crane.
   (b) Apply a sealant to the frame and bearing bracket contact surface. If there is an outer bearing cover, apply the sealant between the bearing bracket and cover.
   (c) With a medium or large-sized motor, support the non-drive end shaft end with a jack or suspension wire. Carefully raise the rotor and assemble the bearing bracket to the frame. Align the grease supply port position using the guide bolt.
   (d) Tighten the bolts symmetrical.

   CAUTION: The pre-load spring may be inserted in the housing of a bearing bracket. Assemble without fail.

16.4 Assembling the accessories around the bearings

Assemble the parts that were removed during disassembly. If any of the parts have deteriorated or been damaged, replace them with new parts. Apply rust-preventing agent or sealant, where necessary.

16.5 Assembling the shaft coupling, pulley, fan, etc.

Assemble the shaft coupling, pulley, fan etc. to the shaft. If the part has a tight fitting, heat the boss area before installing the parts onto the shaft. When fixing the boss to the shaft with lock screws, always apply locking sealant to the screws and tighten.

16.6 Installing the covers

Align the match marks, and assemble the covers such as the fan cover.

17. MAINTENANCE AND INSPECTION

The main purpose of motor maintenance is to prevent unforeseen accidents. By finding and removing the faulty areas through regular maintenance can prevent unforeseen accidents. The data obtained during inspection should be recorded and saved.

17.1 Daily inspections

Daily inspections are conducted to check the condition of the motor before and during operation. Disassembly is not required for the inspections. The daily inspection items detail given in Table 17.1.

Table17.1 Daily inspections

Inspection target	Inspection procedures		Judgment standards	Remedies, etc.
	Inspection item	Inspection method		
Power state	Voltage fluctuation	Check with voltmeter	The value should be within ±2 to 3% of the rated value. Fluctuation of the working voltage should be within ±10% of the standards, and is expressed as "should not obstruct practical operation". Note that this does not ensure the motor's performance life. The voltage unbalance must be within 1%.	Recover to normal state.
	Current	Check with ammeter	The current must be less than the rated value, and must not deflect at a cycle.	Recover to normal state.
Environment	Ambient temperature	Check with thermometer	The value must be less than that indicated on the nameplate. (If not indicated, -20°C to +40°C)	Set to within standard value.
	Ventilation state	Visual check	The intake/outtake holes must not be obstructed.	Remove any obstacles.
Appearance	Stator frame contamination, Shaft penetration section contamination	Visual check	There must be no remarkable changes compared to normal operation.	Clean if heavily contaminated.
Operation status	Vibration	Touch check, check with vibration meter	Must be no differing vibration or increased amplitude compared to normal state.	If the tolerable value is exceeded, stop operation, and remove cause.
	Odors	Smell check	Must be no burning smell.	Stop operation, and remove cause.
	Abnormal noise	Listen check, check with stethoscope	Must be no acoustics or increased noise level compared to normal state.	If operation is obstructed, stop and remove cause.
	Stator frame temperature	Touch check, check with thermometer	Must be no abnormal rise compared to normal operation temperature.	Recover to normal state.
Bearing periphery	Bearing noise	Listen check, check with stethoscope	Must be no acoustics or increased noise level compared to normal state.	Replenish the grease. If the problem is not resolved, replace the bearings.
	Vibration	Touch check, check with vibration meter	Must be no abnormal vibration.	
	Bearing temperature	Touch check, check with thermometer	Must be no abnormal rise compared to normal operation temperature.	
	Grease	Visual check	Must be no leaks.	Remove the cause, and recover to normal state.

17.2 Inspection periods

Inspection periods are conducted with some motor disassembly to examine the areas that wear easily. The periodic inspection should be conducted about once every two months. Follow the details given in Table 17.2.

Table17.2 Periodical inspection

Inspection target	Inspection procedures		Judgment standards	Remedies, etc.
	Inspection item	Inspection method		
Daily inspection status	Study the records	Visual check		Use as reference for periodical inspections.
Installation status	Installation bolts, legs, tightening bolts, etc.	Visual check	Must be no loosening	Tighten
Grounding	Stator frame and terminal box	Visual check	Must be no grounded	Recover to normal state.
Painting	Peeling, rust	Visual check	Must be no damage, discoloration, peeling or rust	Apply rust-preventing agent. Repaint
Insulation resistance	Between stator winding and grounding	Check with insulation resistance meter	Measure with a 500V insulation resistance gauge for a low-voltage motor (with a 1000V insulation resistance gauge for a high-voltage motor). Confirm that the value is 1/10 or more of the previous measurement value, and is [rated voltage (kV)+1] (MΩ) or more.	Dry stator winding. If state is not recovered, repair.
Coupling state	Core deviation	Follow section 9.4 (Coupling with machine)	Follow section 9.4 (Coupling with machine)	Readjust the coupling center.
1. Shaft coupling	Sunk key	Visual check	Must be no damage or deformation	Replace
	Shaft coupling with no key	Visual check	Match marks must not be loose	Recover to normal state.
	Tightening reamer bolt	Visual check	Must not be loose	Tighten
2. V-belt	Pulley alignment	Check with ruler	Follow section 9.4 (Coupling with machine)	Readjust
	Tension	Follow section 9.4 (Coupling with machine)	Follow section 9.4 (Coupling with machine)	
	Wear		Must be few wear	Replace
Open-type bearings	Waste grease color, foreign matter, hardness	Visual, touch check	Must be no life deterioration or abnormal discoloration caused by entry of wear chips, air or water Grease must not be old and hard due to insufficient injection	Replace grease, replenish grease during operation. Remove grease from discharge port.
Terminal box	Connection sections	Visual check	Must be no loosening at connection section Must have sufficient insulation	Tighten Insulate
	Inner inspection	Visual check	Must be no dust or water, etc., inside Must be no rust	Clean
	Packing	Visual check	Must not be deteriorated, damaged or deformed	Replace

(1) Stator

The motor can operate for a long time through daily inspections and monitoring. However if any problems are found during operation or any questions arise from the records, the motor must be disassembled, inspected and repaired to ensure long-term operation.

The inspection periods are classified according to the degree the motor is disassembled. The normal inspection consisting of disassembling and inspecting the bearing should be conducted once every two years. The detailed inspection consisting of inspecting the rotor in detail should be conducted once every four years.

The inspection areas, items and judgment standards are given in the following tables. If minor abnormalities are found through the inspections, service and repair the area at the site. If the abnormal condition cannot be repaired at the site or if the motor operation and functions could be adversely affected, immediately contact your nearest TMEIC Representative.

Table 17.3 Periodical inspection (Stator)

○: Enforce, ⊗: Enforce within inspection range, ×: Do not enforce

Inspection place	Inspection item	Inspection item/cycle: Precision inspection (once every four years)	Inspection item/cycle: Normal inspection (once every two years)	Inspection method, cautions	Judgment standards, etc.
Stator	1. Pre-disassembly inspection				
	(1) Motor appearance inspection	○	○	Visually check for the presence of rust on the exposed sections, peeling of paint, oil (grease) leeks, and damage of any accessories such as the oil level gauge, etc.	Must be no remarkable contamination or deformation. Replace the oil level gauge if cracked. Wipe off any adhered oil.
	(2) Insulation resistance measurement: Stator winding Space heater	○	○	Use 1000V megger for high voltages (600V or more), and 500V megger for low voltages. Record the temperature, weather and machine temperature when measuring. Always ground after measuring the insulation resistance.	High voltage: (kV+1) MΩ or more Low voltage: 1MΩ or more Confirm that the value has not dropped from the conventional value. Refer to section 17.2(2)3) for details.
	(3) Lead wires and terminal damage, deformation, discoloration	○	○	Visual check. Check for presence of strand breakage at terminal crimp section.	Replace terminal if there is any remarkable deformation or discoloration. Replace lead wire if cracked.
	(4) Measurement of stator and rotor clearance (air gap)	○	○	Use taper gauge.	$\frac{\text{Maximum value - minimum value}}{\text{Average measurement value}} \times 100 \leqq 20\%$
	2. Disassembly inspection				
	(1) Presence of coil damage, deformation or cracking (coil and coil end connection section) Contamination and clogging inspection	○	○	Visual check Use a mirror to inspect the inside and back. Do not use metal brushes or spatulas, etc.	If the surface or red varnish has peeled, clean, repair and dry. Clean off any contamination or clogging. Contact the maker if cracking or damage to the insulator (inside) is found.
	(2) Presence of coil end spacer, throttle cord loosening or breakage	○	○	Visual, touch check (same as above)	Repair any cracks on the spacer. Repair any loosening or breakage of the throttle cord. Contact the maker if the range of cracks or loosening is generally large.

○: Enforce, ⊗: Enforce within inspection range, ×: Do not enforce

Inspection place	Inspection item	Inspection item/cycle		Inspection method, cautions	Judgment standards, etc.
		Precision inspection (once every four years)	Normal inspection (once every two years)		
Stator	(3) Core, clamper, duct piece rusting, damage, loosening, contamination (clogging)	○	×	Visual, mirror, touch check	Blow off any contamination or clogging with compressed air. Vacuum off or wipe off with a cotton cloth any dirt.
	(4) Wedge (insulation wedge) loosening and damage	○	×	Visual, touch check	Repair slight loosening (use adhesive) Contact the maker if there is general loosening, cracks or burning.
	(5) Diagnosis of insulation deterioration	○	×	DC absorption, tanδ , etc., test	Refer to section 16.2(2)6) for details on these diagnoses.
	(6) Measurement of resistance temperature sensor (thermo-winding) resistance	○	○	Use tester or bridge, etc. Inspect for dislocated or broken wires.	Follow JIS Standards.
	(7) Presence of abnormal contact with rotor	○	×	Visual check	Must be no remarkable contact marks.
	(8) Ventilation cover, etc., rust, damage, paint peeling, soundproofing material deterioration or dislocation	○	×	Visual, touch check	Repair slight errors. If soundproofing material is deteriorated (especially the foam), replace.
	(9) Space heater inspection	○	○	Visually check for corrosion, terminal and wire contamination, dislocation, deformation and wire strand breakage. Measure heater strand resistance with tester.	Equal to or ±10% or less of resistance value calculated from voltage and wattage.
	(10) Tightening section tightening state	○	○	Check with spanner or tap with test hammer.	Must be no loosening or play.

(2) Windings and Insulation

1) Inspection and Maintenance

Make sure the motor's winding insulation is not contaminated and is always kept dry. The motor is designed so that ventilation routes, protective covers and so forth are placed at suitable positions to limit the contamination of the insulation. It may be necessary to heat the motor with a space heater while it is stopped to prevent moisture from condensing on the windings.

2) Winding Cleaning

It is important to keep the windings clean at all times. Dust and foreign matter, such as carbon, copper, mica tape fragments, could block the air ducts and lower the airflow rate through the stator. This can make heat dissipation difficult and cause the motor to overheat locally or overall. If condensed water or grease are allowed to form a conductive paste or the accumulated dust is conductive, the windings could short-circuit or ground fault. Abrasive dust can damage the winding. Although grease itself is not harmful, it can cause other contaminants to adhere to the windings.

(A) Clean by wiping the windings with a cloth. Cleaning the motor within arm length is an effective method for removing dust and foreign matter lightly adhered to the motor. Wipe the surface with a clean dry cloth. Do not allow lint to adhere to the surface.

(B) Clean by blowing compressed air: Blowing compressed air in areas out of arm length is effective for removing dust or foreign matter lightly adhered to the motor. Use dry clean compressed air set to a pressure approximately 0.3 to 0.4MPa. Before blowing the compressed air on the windings, let out any water that has accumulated in the air pipe or hose. If abrasive particles in the compressed air get under the insulation tape, the windings could damage. Always have both ends of the motor open to create a large opening for the air and dirt to escape. If the blown dirt is not removed from the motor properly, the cleaning will not be effective.

(C) Clean by vacuuming. Vacuuming is effective for removing dust or lightly adhered contamination. With this method, the dust is not propelled into the motor as with the compressed air, and the neighboring machines will not be affected. This method is recommended for removing sand and iron chips.

(D) Clean with solvents. Solvents effectively remove solids and solidified matter from the winding surface. This is particularly effective for removing grease and solidified matter consisting of grease, carbon and dust. After using the solvent, remove the solvent with a clean cloth.

Note: When using solvents use proper safety methods to prevent fires, explosions or poisoning.

Other effective methods of cleaning include steam cleaning and desalting. Contact your TMEIC Representative for further information.

3) Insulation Resistance Measurement

Insulation resistance refers to the winding's DC resistance. The resistance occurs due to the leaking current that passes in the winding and on the winding surface. The winding resistance may drop due to insulation deterioration, mechanical damage of the winding, dust adherence or a rise in ambient temperature. The measured winding insulation resistance value will fall as the test voltage increases and as the applied test voltage time shortens. The winding insulation resistance is an effective means for judging the insulation condition. Therefore, periodically measure the resistance when the motor has stopped. Record the measuring instrument type, winding temperature, ambient temperature, relative humidity and other states such as standstill time after stopping. If the winding is contaminated, clean the windings using the previously described procedures. Record the new winding insulation resistance.

The winding insulation resistance can be measured with an insulation resistance tester or electron tube tester. A 500V test voltage is recommended for low voltage motors and a 1000V test voltage for high voltage motors.

When using an insulation resistance tester, apply the voltage for one minute, then measure the resistance.

When using an electron tube tester, apply the voltage for 10 minutes, then measure the resistance.

Record the winding insulation resistance at 30-second, 1-minute and 10-minute intervals. The winding insulation resistance will change with the charged current, absorbed current and according to the application time. Therefore the time must be recorded.

The temperature and humidity can affect the winding insulation resistance. Salt will affect the winding insulation resistance and cause the resistance to fluctuate. If this occurs, contact your nearest TMEIC representative.

The winding insulation resistance tolerance will change according to motor type, rating and frame number. Therefore cannot be indicated as a set value. However, the following JEC Standard expressions can be used as a guideline for the winding insulation resistance. A safe minimum value for daily maintenance, R = rated voltage (kV)+1 [MΩ] at room temperature.

If R = minimum tolerable insulation resistance of winding (MΩ) at 40℃, then

$$R \geqq \frac{E+1/3N}{P+2000} + 0.5$$

E = Rated voltage (V)

P = Rated output (kW)

N = Rotation speed per minute (min^{-1})

4) Preventing a drop in resistance

The windings should always remain clean and dry. Dust adhered to the surface of the windings will prevent heat dissipation, depending on the type of dust could cause insulation deterioration. Water can enter the motor through the external lead connections, winding cracks, etc and cause the winding insulation resistance to drop. Careful daily cleaning and prevention of moisture absorption will prevent the resistance from dropping.

A) Install a space heater: When the motor is in operation the humidity inside the motor is low. However, moisture can accumulate while the motor has stopped. To prevent moisture from forming, turn ON a space heater when stopping the motor. Maintain a temperature inside the motor 3 to 5K higher than the ambient temperature.

B) Install light bulbs. If a space heater is not available, several 100 to 50W incandescent light bulbs can also be used.

5) Drying

If the winding has absorbed moisture and the winding insulation resistance is low, always clean the winding before drying it. There are several ways to dry the windings including using a space heater, hot air or with current. However, the winding should not be dried using a current if the insulation resistance is 0.05MΩ or less. When using any of these methods, make sure that the temperature does not rise more than 10K per hour. Moreover, the temperature should not exceed 75C°-85°C (this temperature is the overall temperature of the winding). When drying the windings, measure the winding insulation resistance at set time intervals. The winding is considered completely dried when it has been dried for 24 hours or longer after the winding insulation resistance value reaches a set value.

The winding insulation resistance trends caused by drying the windings are shown in Figure 17.1. A simple change in compensation of the winding insulation resistance with respect to the temperature can increase the winding insulation resistance two-times for every 10 to 15K drop of temperature. The temperature compensation curve is shown in Figure 17.2.

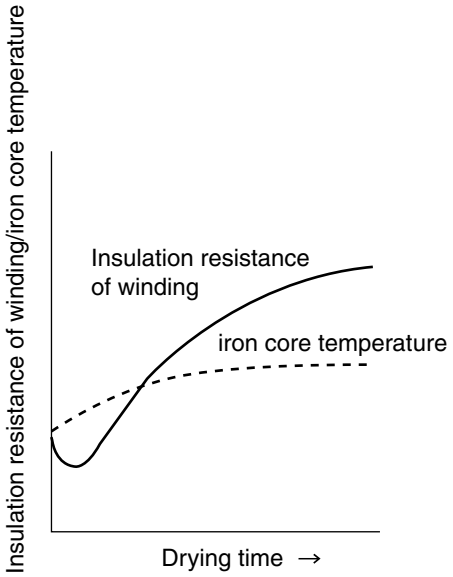


Figure 17.1 Changes in insulation resistance of winding

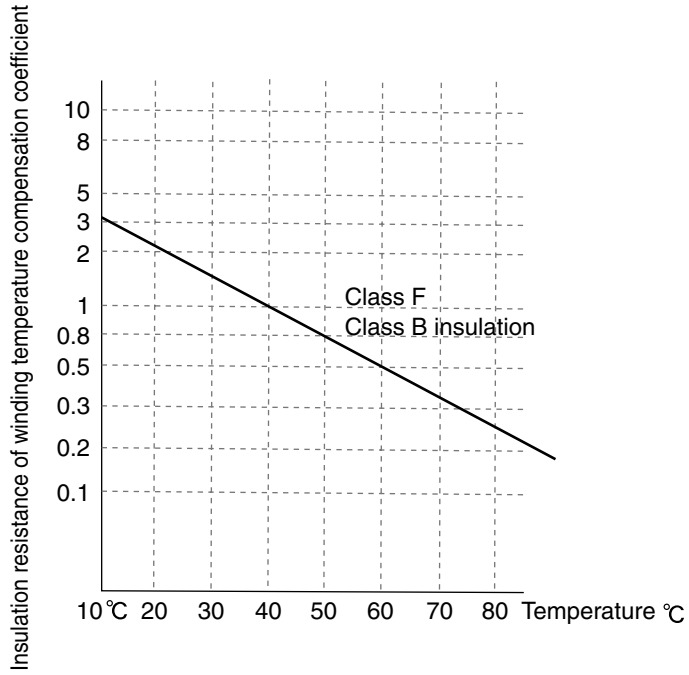


Figure 17.2 Temperature compensation curve

(3) Rolling bearing

The motor can operate for a long time through daily inspections and monitoring. However if any problems are found during operation or any questions arise from the records, the motor must be disassembled, inspected and repaired to ensure long-term operation.

The inspection periods are classified according to the degree of disassembly. The normal inspection consisting of disassembling and inspecting the bearing should be conducted once every two years. The detailed inspection consisting of inspecting the rotor in detail should be conducted once every four years.

The inspection areas, items and judgment standards are given in the following tables. If minor abnormalities are found through the inspections, service and repair the area at the site. If the abnormal condition cannot be repaired at the site or if the motor operation and functions could be adversely affected, immediately contact your nearest TMEIC Representative.

1) Bearing construction
Horizontal Mount Type

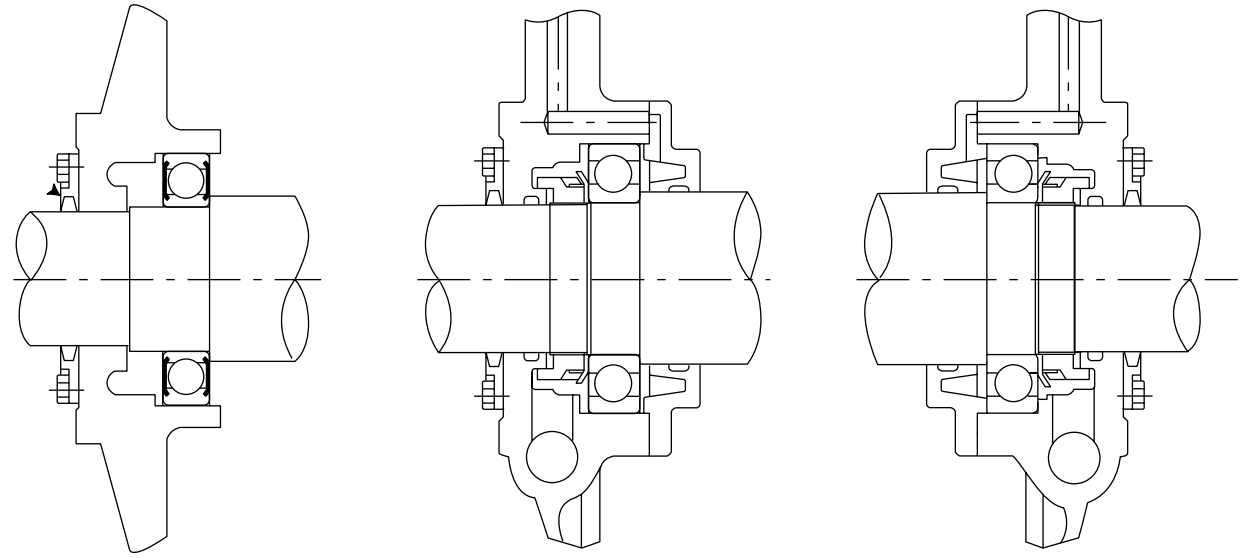


Figure 17.3 Bearing construction grease lubrication type
(Frame size 250S to 315H, Direct coupled)

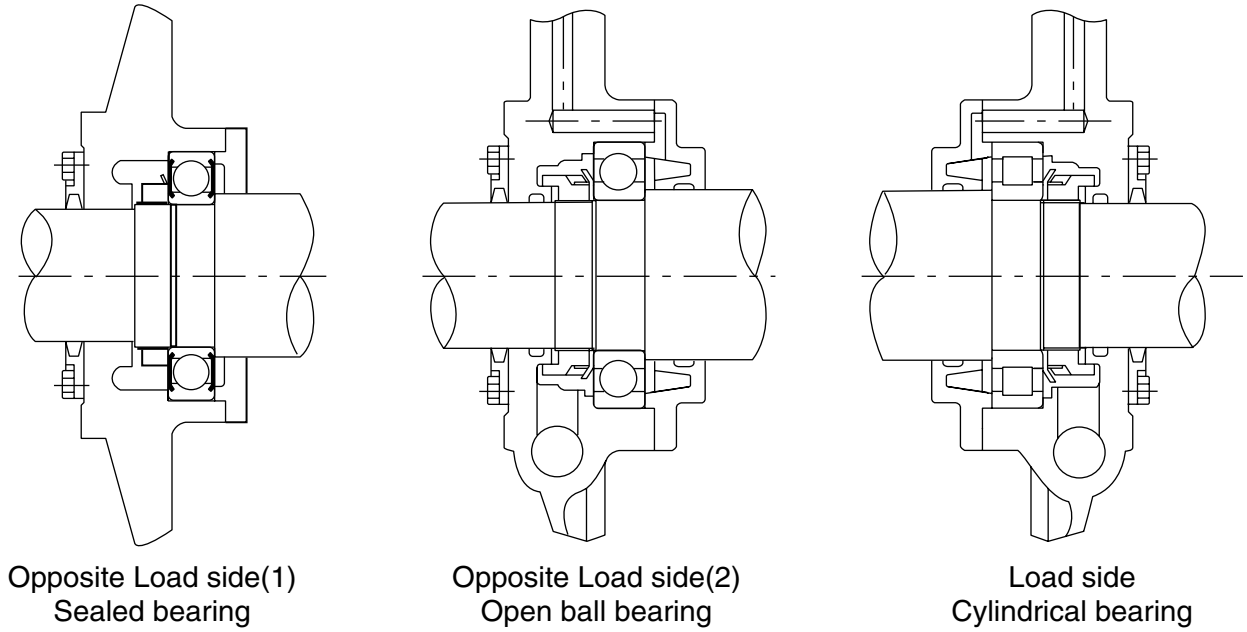


Figure 17.4 Bearing construction grease lubrication type
(Frame size 250S to 315H, Belt drive)

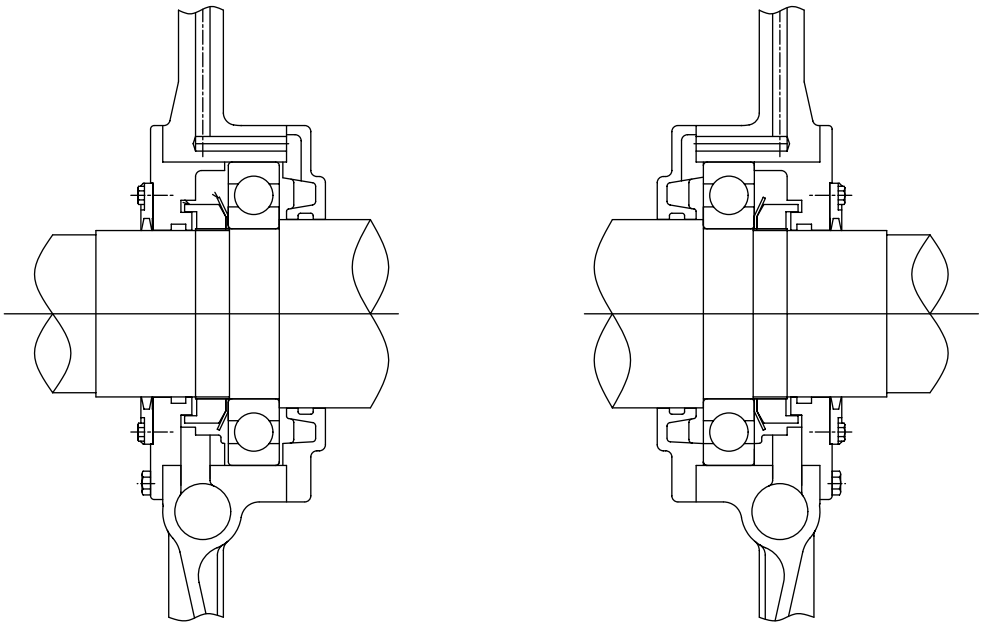


Figure 17.5 Bearing construction grease lubrication type
(Frame size 355H to 450, Direct coupled)

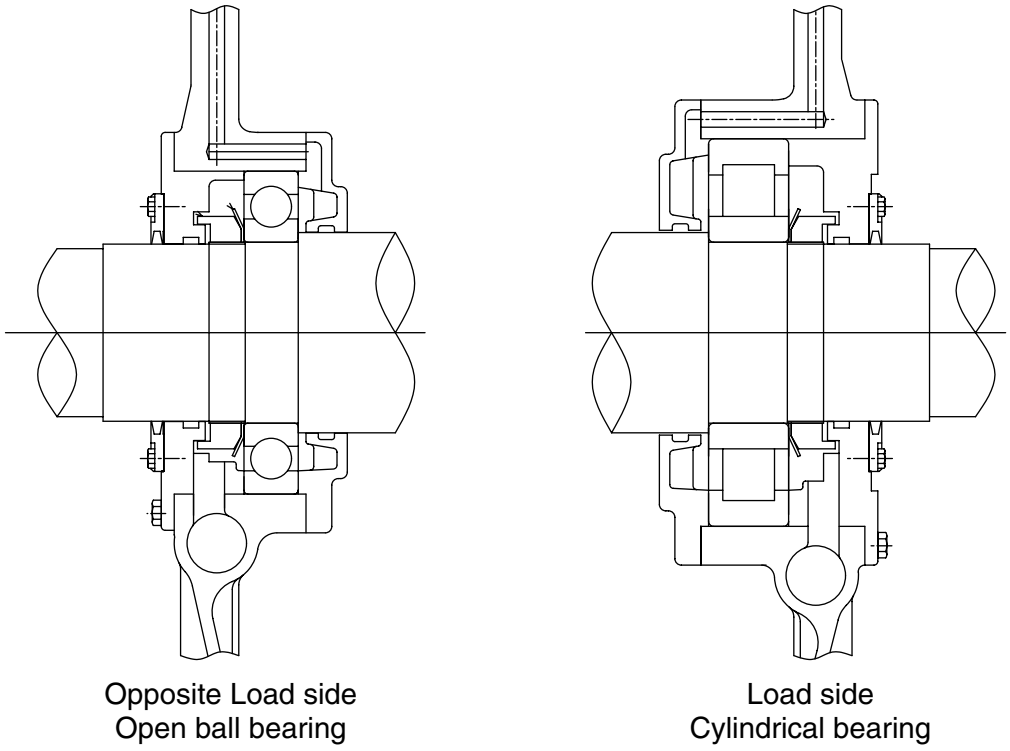
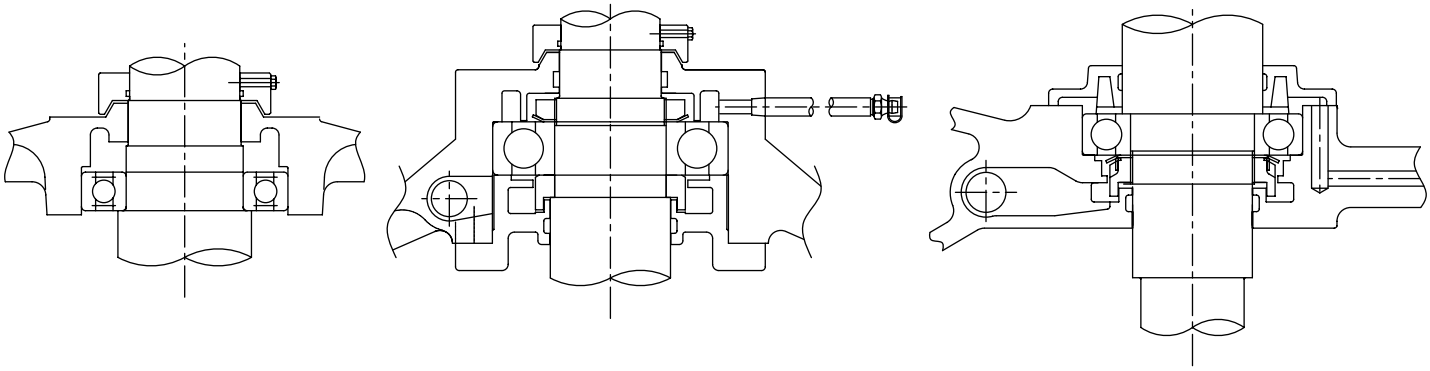


Figure 17.6 Bearing construction grease lubrication type
(Frame size 355H to 450, Belt drive)

Vertical Mount type



Opposite Load side(1)
Sealed bearing

Opposite Load side(2)
Open ball bearing

Load side
Cylindrical bearing

Figure 17.7 Bearing construction grease lubrication type
(Frame size 250S to 315H, Direct coupled)

Periodical inspections

○: Enforce, ⊗: Enforce within inspection range, ×: Do not enforce

Inspection place	Inspection item	Inspection item/cycle		Inspection method, cautions	Judgment standards, etc.
		Precision inspection (once every four years)	Normal inspection (once every two years)		
Bearings (rolling bearings)	(A) Grease (grease, oil) deterioration, discoloration	○	○	Visual check Caution against: Entry of foreign matter such as water and dust Entry of wear chips from retainer material	If greatly discolored or contaminated, investigate the cause and take measures.
	(B) Bearing nut and washer damage, deformation, rusting	○	○	Visual, touch check Special caution against: Bearing nut peripheral groove deformation Inner diameter screw crushing Washer claw damage (cracking)	If the washer lip or claws are damaged (cracked), replace. If the bearing nut grooves are deformed, determined whether they can withstand reuse, and replace if necessary.
	(C) Grease runner, rusting	○	○	Visual, touch check Special caution against: Abnormal contact marks on outer diameter section Cracking of blades	Replace if damaged.
	(D) Bearing wear, discoloration, rusting	○	○	Visual, touch check Especially check inner and outer rings and rolling surface Use the daily inspection baring temperature, abnormal noise and vibration records as reference.	If fretting marks, peeling (flaking) or electric corrosion smearing, galling, etc., are observed, investigate the cause and take appropriate measures.
	(E) State of fitting with bearing inner and outer rings (Rust, damage, changes in fitting dimensions)	○	○	Visual check, check with micrometer	Refer to section 16.2(3) 3) and 4) for details on the tolerable dimensions and repair methods.
	(F) Bearing housing and terminal cover internal rusting, damage, discoloration (Inspect oil tank if oil lubrication is used)	○	○	Visual, touch check Caution against clogging at the oil supply and drain ports (holes), and contact and discoloration on inner diameter	Service and repair minor damage and rusting, etc. If damaged, replace.
	(G) Oil supply/drain pipe damage, clogging, tightening state	○	○	Visual, touch check, check with pipe wrench	Replace if major damage is found. Wipe off any oil and reinstall pipe.

Periodical inspections

○: Enforce, ⊗: Enforce within inspection range, ×: Do not enforce

Inspection place	Inspection item	Inspection item/cycle		Inspection method, cautions	Judgment standards, etc.
		Precision inspection (once every four years)	Normal inspection (once every two years)		
Bearings (rolling bearings)	(H) Oil runner (screw pump) damage Pollution, hole clogging (For lubrication oil, vertical machine)	○	○	Visual, touch check	Judge whether to repair or replace according to the runner pump action (function to circulate oil).
	(I) Confirmation of bearing tightening state	○	○	Confirm that the bearing nut and washer tightening is not insufficient after replacing the bearings. When using a double combination (angular type bearing), confirm the phase marks.	Tighten again if incorrectly tightened.

2) Fitting the bearings

The following bearing dimensions apply to the fit between both the shaft and the bearing bracket. (Table 17.6,17.7) When replacing the bearings, measure the related dimensions of the shaft and bearing bracket. Compare these dimensions to the values in the table. If the fit is too loose or too tight the bearings could damage and shorten the bearing life.

(A) Visual check
- Check that there is no damage on the fitting surface
- Check that there is no rust
- Check that there are not traces of slipping and rotation on the fitting surface

(B) Dimension measurement
- Measure the outer diameter of the shaft at the fitting section or the inner diameter of the housing (bracket or shaft case) with a micrometer, and confirm that the values are within the tolerable values shown below.

3) Dimension tolerance at the bearing fitted sections (unit: mm)

Table 17.6 Tolerable difference of shaft outer diameter

	Ball bearings	Cylindrical roller bearings	Angular contact ball bearings
φ55 ~ φ80	+0.002 ~ +0.015 (JIS k5)	+0.011 ~ +0.024 (JIS m5)	+0.006 ~ -0.007 (JIS j5)
φ85 ~ φ100	+0.003 ~ +0.018 (JIS k5)	+0.013 ~ +0.028 (JIS m5)	+0.006 ~ -0.009 (JIS j5)
φ110 ~ φ120	+0.013 ~ +0.028 (JIS m5)	+0.013 ~ +0.028 (JIS m5)	+0.006 ~ -0.009 (JIS j5)
φ130 ~ φ140	+0.015 ~ +0.033 (JIS m5)	+0.015 ~ +0.033 (JIS m5)	+0.007 ~ -0.011 (JIS j5)
φ150 ~ φ180	——	+0.027~+0.052 (JIS n6)	——

Note: This applies to the drive end bearings that receive the external (belt) load. This is m5 for all other cases.

Table 17.7 Bearing bracket housing inner diaeter tolerance

Dimensions	Ball bearing tolerance	Cylindrical roller bearing tolerance
φ130 ~ φ180	0 ~ +0.025 (H6)	-0.007 ~ +0.018 (J6)
φ190 ~ φ250	0 ~ +0.029 (H6)	-0.007 ~ +0.022 (J6)
φ260 ~ φ300	——	-0.007 ~ +0.025 (J6)
φ320 ~ φ340	——	-0.007 ~ +0.029 (J6)

Note: If the housing inner diameter tolerance is 0.010 or more larger than the above values, repair the housing inner diameter with the methods given in section 4) below.

4) Repair methods

Shaft and housing (bearing bracket) inner diameter repair methods: A) Chrome plate the surfaces. B) Spray melted metal. C) Heat shrink a ring into the housing and machine. Refer to Figure 17.8 for chrome plating. For more details, contact TMEIC.

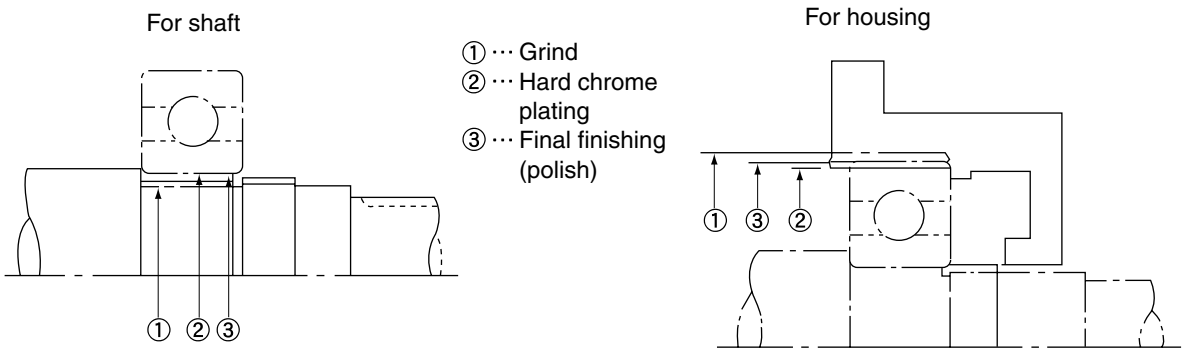


Figure 17.8 Hard chrome plating methods

5) Recommended grease

TMEIC uses Multinock SDX (Nippon Oil Corporation) or Alvania S2 or RL2 (Showa Shell Sekiyu K.K.) as the standard grease. Unless designated otherwise, Multinock SDX or Alvania S2 or RL2 type grease is used in the bearings. Multinock SDX or Alvania S2 or RL2 is also the type of grease used in the sealed bearings. Therefore when ordering a replacement bearing, designate the bearing type and the grease type.

6) Grease replacement standards

Table 17.8 Grease on the market

Manufacturer	Remarks			Brand	Thickener soap	Working temperature (reference) (°C)
	General purpose	Low temp.	Wide range temp.			
Nippon Oil Corporation			○	Multinock SDX	Li + Na	-40 ~ +135
			○	Multinock DX 1	Li + Na	-10 ~ +135
			○	Multinock DX 2	Li + Na	-10 ~ +135
			○	Multinock Urea	Urea	-45 ~ +140
	○			Multinock 1	Li	-20 ~ +120
	○			Multinock 2	Li	-20 ~ +120
IDEMITSU KOSAN CO. LTD.	○			Daphne Eponex 2	Li	-40 ~ +130
Showa Shell Sekiyu K.K.			○	DOLIUM R	Urea	-20 ~ +150
	○			ALVANIA S2 or RL2	Li	-20 ~ +120
KYODO YUSHI			○	MULTEMP SRL	Li	-40 ~ +150
			○	MULTEMP SRH	Li	-40 ~ +150
	○			MULTEMP PS 2	Li	-50 ~ +120
	○			UNILUBE 2	Li	-20 ~ +130
ESSO		○		BEACON 325	Li	-60 ~ +120
	○			LISTAN (BEACON) 2	Li	-20 ~ +100
COSMO OIL	○			DINAMAX 2	Li	-30 ~ +130
			○	WIDEGREASE WR 3	Na	-40 ~ +140
MOBIL OIL CO.	○			MOBILUX 2	Li	-20 ~ +120
DOW CORNING		○	○	SH 44M (SILICONE)	Li + Si	-40 ~ +180
Chebron			○	BRB 2	Urea	-30 ~ +180

7) Grease Replenishment

Grease replenishment interval is dependent on the grease type, temperature, environment, etc. Therefore refer to the grease nameplate for the interval and grease amount.

18. FAILURE DIAGNOSIS AND THE MEASURE

Various kinds of failure, its cause, and measures are listed to Table 18.1.
When you judge it as big failure, contact your TMEIC representative immediately.

Table 18.1 Failure and its disposal

	Failure state	Cause		Measure
1.	The motor does not rotate. No noise is heard.	Starting conditions are imperfect. Poor circuit from a power supply to the motor terminal Disconnection of stator winding	Each interrock release state is faulty. No voltage to a starter coil Poor contact of a startier Two fuse are broken. Failure of over current relay(OCR)	Follow a circuit and investigate wiring and contact. Replace the fuse. Investigate the terminal. Repair the stator coil.
2.	The motor does not rotate. An abnormal noise is heard.	One phase is open causing a single phase state. The motor is locked(bearing damage, etc) Disconnection of stator winding	Starter's one phase is open Poor contact of a startier A load machine is locked. Poor connection(excessive belt tense, poor alignment, etc) The bearing is locked. Gap contact by bearing damage Disconnection of one phase	Follow a circuit and investigate wiring and contact. Investigate a machine and a connection state. Repair the stator coil.
3.	The protection device functions.	Failure of starter The short circuit or earthing of rotor winding The motor is locked(bearing damage, etc) Incorrect setting value of a protection device	Insulated degradation by overheating, vibration, shock,etc. It is the same as the 2nd clause.	Repair the rotor coil. Investigate a machine and a connection state.
4.	An abnormal noise is heard. The vibration is large.	One phase is open causing a single phase state. The abnormalities in voltage Vibration from a load side Poor connection Jarring noise	Disconnection of a circuit, broken. fuse, poor contact unbalanced rotor, cutting of a rotor bar An uneven gap, contact Foreign substance invasion, a shaft bend, crevice Vibration from a load machine. A shaft bend The coupling is fauly.	Follow a circuit and investigate wiring and contact. Decomposition investigation Separate the motor from the load machine. And investigate vibration. Center the shaft. With no problem in use
5.	Temperature rises abnormaly and smoke emits.	The power supply is faulty. Overload The cooling ventilation is blocked. The stator coil is faulty. Mechanical incongruity	Non-balanced voltage, a single phase state, incorrect voltage, freqency, voltage drop, bad condition of a load machine A frequent starting stop and reversible operation The blockade of a ventilation way (Blocked filter, The foreign substance of a fresh air inlet, etc) The short circuit or earthing of stator winding The rotor core is contacting the stator core. Heating of bearing by connection(excessive belt tense, poor alignment, etc)	Investigate a power supply and a starter. Separate the motor from the load machine. And investigate an no-load current. Reinvestigate selection of the motor. Clean. Repair the stator coil. It is the same as the 2nd clause.
6.	Bearing is bad condition.	A bad condition is discovered by noise, vibration, or temperature. Since there are many bad conditions resulting from grease, when sound is high, it is good to pour in grease first and to observe a situation.	Roller(ball, roller)or track surface flaking, presure marks on handling, insufficient grease, over grease, poor quality, entry of foreign matter such as dirt, metal powder, bearing cage damage, incorrect handling during assembly, excessive external load, too little crevice	Wash and investigate the bearing and when poor, it replaces. Adjust the grease amount, Use correct grease. Wash the bearing. Replace bearing. Reassemble and adjust coupling. Review motor rating.
7.	The ammeter sways.	The initial signs of the above mentioned failure	Stator coil failure, bearing's seizure, disconnect starting, poor contact cutting of a rotor bar, etc. The load varies.	

19. PART EXPLANATION

19.1 Rolling Bearings

The main types of bearings used for general-purpose motors include deep-groove ball bearings and cylindrical roller bearings.

(1) Deep-groove ball bearings

Deep-groove ball bearings are most commonly used. Deep arc-shaped grooves are formed on the path of both the inner and outer ring of the bearing. These bearings are suitable for high-speed rotation as they can withstand radial load, bi-directional thrust loads and a combination of these loads. Using this simple structure, it is easier to manufacture bearings with a higher accuracy than other types of bearings. This type of bearing includes the open-type bearing and the sealed bearing with grease. Generally a pressed cage is used for the deep-groove ball bearings, and a machined cage is used for large-sized bearings or high-speed rotation applications.

1) Open-type ball bearing (Figure 19.1)

The open-type ball bearing does not have a seal to protect the bearing from external foreign matter or to prevent grease from leaking. Therefore bearing covers are be provided on the motor to prevent this from happening. The grease can be replaced easily, therefore this type of bearing has a long life.

2) Sealed bearing (Figure 19.2)

The main dimensions for a sealed bearing are the same as an open-type ball bearing. A sealed bearing is a deep-groove ball bearing that has a meshed sealed plate to prevent grease from leaking and protects the bearing from external foreign matter. The types of sealed bearing used are the ZZ type bearing with a plate installed on both sides and the Z type bearing with a plate installed on one side. These are non-contact type so the friction torque is small.

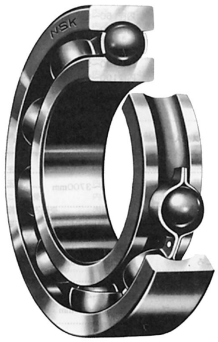


Figure 19.1 Open-type ball bearing

Figure 19.2 Sealed bearing

(2) Cylindrical roller bearing (Figure 19.3)

With the cylindrical roller bearing, the roller and path linearly contact providing a large radial load performance and making this bearing structurally suitable for high-speed rotation. The bearing that does not have a guide flange (NU type, N type) on the inner ring or outer ring cannot withstand any thrust load.

This type of bearing is most suitable for the free side bearing. The cylindrical roller bearing can be separated. Therefore the inner and outer ring can be separated with relative ease when interference fits are required. The roller bearing usually uses a pressed cage and a machined cage is used for large sized bearings or high-speed rotation applications.

Figure 19.3 Cylindrical roller bearing

(3) Bearing's radial internal clearance

The bearing's radial internal clearance is very important because it directly affects the bearing's life, noise and vibration. Therefore when purchasing new bearings, confirm the bearing number (for example, 6310, NU314) and seal symbol (ZZ) to correctly indicate the required type of bearing. Normal clearances are used with general-purpose industrial bearings. However, sometimes motors use bearings with special clearances to suppress noise and vibration. This clearance is indicated with symbols such as CM, C3, or in some cases C4. Indicate the CM, C3 or C4 internal clearance symbol when placing an order (for example, 6310ZZCM, 6310ZZC3).

The relation of each clearance is shown in Table 19.1 and Table 19.2.

Table 19.1 Deep-groove ball bearing's radial internal clearance

Unit: μm

Nominal dimensions of bearing inner diameter(mm)		Radial internal clearance							
		CM		Normal (CN)		C3		C4	
More than	less than	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
30	40	9	17	6	20	15	33	28	46
40	50	9	17	6	23	18	36	30	51
50	65	12	22	8	28	23	43	38	61
65	80	12	22	10	30	25	51	46	71
80	100	18	30	12	36	30	58	53	84
100	120	18	30	15	41	36	66	61	97
120	140	24	38	18	48	41	81	71	114

Table 19.2 Cylindrical roller bearing's radial internal clearance (non-compatible cylinder holes)

Unit: μm

Nominal dimensions of bearing inner diameter(mm)		Radial internal clearance					
		CM		Normal		C3	
More than	less than	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
65	81	30	45	40	60	70	90
80	100	35	55	45	70	80	105
100	120	35	60	50	80	95	120
120	140	40	65	60	90	105	135
140	160	50	80	65	100	115	150

Remarks:
Use cylindrical roller bearings for which squeak-resistance measures have been taken.
If the radial internal clearance is large, squeaking could occur, but the bearing performance will not be affected.

(4) Grease replacement amount and replacement period for open-type bearings

By accurately replacing the grease, open-type bearings can be used for a long time.

The aged deterioration of the grease's lubrication performance is affected mainly by the grease type, bearing size, bearing type, operating speed, operating condition and atmosphere (dust, humidity).

The grease wear over time is very minor, however special care must be taken to the lubrication to prevent severe wear or bearing problems. Always use the type of grease indicated on the grease plate. When the use of a different type of grease cannot be avoided, follow section 1) below.

Table 19.3 Possibility of combining different types of grease

Soap base	Ca	Na	Al	Ba	Li
Ca	○	△	△	×	△
Na	△	○	△	×	×
Al	△	△	○	×	×
Ba	×	×	×	○	×
Li	△	×	×	×	○

○: This will vary depending on the properties of the greases, but as the soap base is the same, the effect is relatively small, and combination is possible.
△: Changes separate from the properties of the greases may occur.
×: Remarkable changes will occur, so combination is not possible.

1) Recommended grease

TMEIC uses Multinock SDX (Nippon Oil Corporation) or Alvania S2 or RL2 (Showa Shell Sekiyu K.K.) as the standard grease. Unless designated otherwise, Multinock SDX or Alvania S2 or RL2 type grease is used in the bearings. Multinock SDX or Alvania S2 or RL2 is also the type of grease used in the sealed bearings. Therefore when ordering a replacement bearing, designate the bearing type and the grease type.

2) Application of different types of grease

When using grease other than that indicated on the grease plate attached to the motor, the grease life (replacement period) may be shortened.

3) Combination of different types of grease

As a general rule, avoid combining different types of grease. Caution is required because the properties of the grease could change due to the combination. The main properties are easily affected by combining two different types of grease. The dropping point, consistency, mechanical stability and leaking properties can all change. Generally, combining grease with the same soap base has little effect. However, combining grease with different soap bases will have a large effect on the properties. This relation is shown in Table 19.3. Before using the grease indicated with △ or × mark in the table, the motor must be disassembled and cleaned before the grease is refilled. If the specified grease is not used the grease life will be shortened.

4) Grease replenishment methods

A grease nameplate is attached to the motor. Follow the values given on the nameplate for the initial filling amount, when disassembling and reassembling the motor, and for the replacement amount and replacement period. When reinserting the grease remover, pay attention to the position of the tool. When using a horizontal motor, the remover is located below the shaft, therefore the arrow will face upward. If the tool was attached with a screw, tighten a screw at the time of a re-assembly. If the tool was attached without a screw, since seal is carried out with packing, insert firmly and fix certainly.

Caution:
It is performing dispose of the unwanted grease as much as possible at the time of the motor stop.
When you process unavoidably at the time of operation, be careful of a solid of revolution and grease scattering.
The point which are careful of drive end ····· Coupling or a pulley is close to grease inlet, outlet.
Non-drive end ····· In the case of the motor with a external fan, fan is close to grease outlet. Scattering of grease.

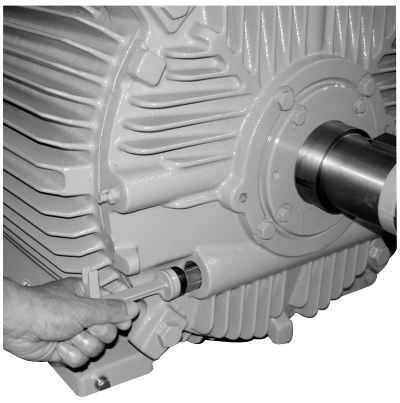


Figure 19.4 The grease remover

(A) Always remove the unwanted grease before replacing it with new grease.

(B) First, remove the grease remover (Figure 19.4).
Dispose of the unwanted grease using the grease remover. Oil may collect around the tool. It is unnecessary, used oil.
Lubricous function is not with probrem. Before reinsert, wipe oil and clean it.

(C) Reinsert the grease remover, and add the specified amount of grease to the grease nipple. After the grease is added, the remover does not need to be removed until the grease is replaced. Add the grease when the motor is in operation.

(D) If too much grease is added, the bearings could overheat or grease could leak between the bearing cover and shaft.
Always supply the specified amount.

5) Recommended replacement cycle for roller bearings

The roller bearing replacement cycle is indicated in Table 19.4. Use this as a guideline when replacing roller bearings. Contact your nearest TMEIC Representative for more details.

Table 19.4 Recommended replacement cycle for bearings

Condition	Pole	Bearing type	Recommended bearing replacement cycle
Direct couple or no load is applied from machine side	2 poles	Open-type bearings	3 years
	4 poles or over		5 years (3years for vertical)
		Sealed bearings	5 years (3years for vertical)
Belt drive or load is applied from machine side	4 poles or over	——	3 years

19.2 Stator winding and insulation

The stator thermal classification and insulation are the most important elements of the motor. To use the motor for a long time, the windings and insulation must be properly serviced and inspected.

(1) Thermal classification and temperature rise limits

The general-purpose motor insulation thermal classification and temperature rise limits for each section are shown in Table 13.1.

(2) Working environment and insulation life

The working environment, such as those shown in Table 19.5, greatly affects the motor's insulation life. Therefore use a motor that matches each working environment.

Table 19.5 Working environment and effect on insulation life

Working environment	Effect on insulation life	Examples of countermeasures
High temperature	The effect is great in that the insulation life will be halved by a 10°C temperature rise.	If the ambient temperature exceeds 40°C, use a motor for high-temperature purposes. (JIS C4004)
Low temperature	If the temperature drops below the normal working temperature, stress will be applied on the insulation, and the insulation performance could drop due to peeling or cracking.	If the ambient temperature is less than -20°C, use a motor for low-temperature purposes. (JIS C4004)
High humidity	When the humidity increases, the insulation resistance of winding will drop. If salt or dust, etc., adhere, these will function as electrolytes and cause a remarkable drop.	Use a moisture-proof motor (JIS C4004)
High water levels	If there are high levels of water, the water could enter the motor from outside causing the insulation resistance of winding to drop in the same manner as when the humidity is high.	Use an outdoor-type motor Use a water-proof motor (JIS C4004)
High dust levels	In an environment with high levels of dust, the dust could accumulate in the motor or around the frame causing the heat dissipation effect to drop. In addition, the dust, moisture or water could combine and lower the insulation life.	Use a dust-proof motor (JIS C4004)
Presence of chemicals, toxic gases or high levels of salt	The insulation could deteriorate due to acids, alkalies or corrosive gases.	Use a corrosion-proof motor (JEMA Technical Material No. 118)
Presence of explosive gases	The insulation resistance of winding could drop due to an increase in moisture. If salt or dust, etc., adhere, these will function as electrolytes and cause a remarkable drop.	Use an explosion-proof motor (JIS C 0903 JEM 1201)

Note: The values in parentheses in the examples of measures are reference standards and technical data.

(3) Drying the stator winding

The windings may experience electrical trouble from moisture that adhered to the surface or that has penetrated the insulation. If the winding insulation resistance has dropped due to moisture (when the resistance is 1/10 or less than the previous measurement or the resistance is less than the rated voltage (kV)+1 [MΩ]) always dry the windings according to the methods given in Table 19.6 before starting operation.

Changes in the winding insulation resistance during drying: The winding insulation resistance value will drop once the temperature of the motor rises when the drying begins. After reaching a minimum value, it will abruptly rise. The resistance will then level out as the winding dries.

Table 19.6 Drying the stator winding

Drying process name	Details
Drying with heating dryer	A heating dryer is an easy to use drying facility. Make sure that the temperature does not rise too high. The upper limit of the temperature is the maximum tolerable value determined according to the motor insulation class. (Class E: 120°C, Class B: 130°C, Class F: 155°C)
Drying with electric heat	An electric heating appliance or infrared lamp are effective heat sources commonly used to heat the motor at the site. Take care not to heat locally by directly radiating heat onto the insulator surface, etc.
Drying by energizing	If a low voltage is applied from an external power supplu onto the motor's lead wires, and a cuurent is passed directly to the windings, the insulator can be dried.

Precautions for drying

1. Gradually heat the insulator. Do not heat suddenly.
2. Circulate dry air with a sufficient air volume.
3. Intermittently heat.
4. Monitor the temperature while drying. (Generally between 100°C and 120°C)
5. Take special care to protect the accessories such as the packing and sealing material from the heat.

(4) Precautions for stator winding

In addition to taking measures against temperature and humidity, the following precautions must be made to the stator windings to ensure long-term use of the motor.

1) Prohibit constant voltage application

When using the Y-Δ starting method, the neutral point of the motor windings may be released while the motor has stopped and the power voltage may be applied on the other end of the winding. In this case, voltage will constantly be applied on the motor windings. In an environment with humidity and dust, this can lead to sudden insulation deterioration. Thus, make sure that the voltage is not applied on the windings while the motor is stopped.

2) Prevent applied surge voltages

If a sudden surge voltage is applied to the stator windings, a dielectric breakdown could occur. This can occur easily if the power voltage is suddenly switched. With a low-voltage motor (rated voltage 440V or less), make sure that the surge voltage peak value does not exceed 850V. An inverter driven motor has reinforced insulated parts, therefore the peak value should not exceed 1250V. Even with reinforced insulated parts, if the surge voltage peak value exceeds 1250V install a surge suppression filter.

(5) Main types of stator winding trouble (Table 19.7)

Table19.7 Main types of stator winding trouble

Trouble symptom		Cause
Burning	Front discoloration	Locked state, overload, overcurrent obstructing cooling
	Discoloration of one or two phases greater than other phases	Single-phase lock or single-phase operation
Short-circuit	Inter-layer short-circuit	Environmental causes ┌ Temperature, humidity, dust, chemicals, gas, salt, └ oil, mold, radiation, etc.
	Inter-phase short-circuit	Electrical causes ┌ Electrical stress, constant voltage application, └ surge voltage application, etc.
	Ground fault	Mechanical causes ┌ Mechaninal stress, vibration └ impact, heat cycle, etc.

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