INSTRUCTION MANUAL

FOR

THREE PHASE LOW VOLTAGE INDUCTION MOTOR

HYUNDAI ELECTRIC

Contents

CHAPTER 1. General

1.1 Safety instructions

The electrical machines described here are parts of power installations for marine applications and are designed in accordance with the generally accepted engineering practice.

When improperly used, wrongly operated, insufficiently serviced, or in the case of non-permissible interventions, machines of this type may cause serious personal injury or material damage because of the electrical and mechanical conditions prevailing in operation.

The general criteria regarding adequate use (i. e. installation, connection, ambient and operating conditions) are specified by the standardized technical data given on the rating plate or in the ordering documents and must strictly be adhered to them.

It is assumed that the planning and executions of the mechanical and electrical installations, the transport, the erection and commissioning as well as the maintenance and repair work required during the installation, operation and maintenance be carried out or supervised by qualified personnel who are trained and authorized for this task. This refers both to the observance of the general erection and safety regulations for work on power installations, to the correct use of hoisting gear and tools and, if necessary, to the use of personal protective gear such as safety boots and the like.

These instructions do not purport to cover all details or variations in equipment, nor do provide for every possible contingency encountered in connection with installation, operation or maintenance.

In case of doubt we would recommend to ask for the assistance and services of the competent HYUNDAI service centers for installation, commissioning and servicing tasks.

1.2 Transport, storage

Individual machines must only be suspended in the main lifting lugs or recesses!

The hoisting gear used must be designed in accordance with the machine weight (see rating plate).

Use suitable rope guiding or spreading devices for machine with mounted accessories.

The lifting lugs are only suitable for lifting motors.

Therefore, the lifting lugs of motor should not be used for lifting complete machine sets if the motors are mounted on baseplates as a part of a machine set.

If a machine is not put into service immediately after arrival, store it in a dry, vibration-free room.

CHAPTER 2. Installation

2.1 Safety advice

Attention General safety instructions regarding the permissible use of the machines as well as the special knowledge required for carrying out work on power installations are given under CHAPTER 1. "General" which must exactly be observed as well as the special information given in the main instructions of the machine below.

2.2 Mounting

Temperatures exceeding 100℃ may arise under unfavourable operating conditions on the frame parts so that touching should be prevented or avoided in this case.

Temperature-sensitive parts such as normal cables or electronic components should not be in contact with or mounted to these hot parts.

In case of machines with coolant using the environment surrounding of the machine make sure that the cooling air has free access and can escape unobstructed.

Warm exhaust air must not be drawn in again.

Guarantee a strong support structure, align the machines carefully and accurately balance the elements to be fitted on the shaft to ensure smooth and vibration-free running. Place thin shims under the feet, if necessary, to prevent strain on the machines.

Minimize the number of shims, i. e. prefer on the less number of thick shims.

The featherkeys in the shaft extensions are locked prior to transport to prevent them from falling out.
The featherkey should be removed before the machine is started up.
If the shaft end of the machines faces upwards, ensure that water is prevented from entering the upper bearing.
Machines which, due to their type of construction, are fixed by their mounting feet to the wall should be supported from below by a base rail.
If a belt drive is used, install the machine in such a manner that it can be shifted on its base (e.g. on slide rails) to permit the correct belt tension to be adjusted.
Excessive belt tension may result in damage to the shaft and bearings.
Attention is invited to the measures necessary to prevent accidental touching of rotating parts (couplings, belt pulleys, etc.)

2.3 Connecting up

Examine the rating plate data to see that they agree with the power circuit to which the machine is to be connected. The supply cables should be matched to the rated current and plant-specific conditions (e. g. ambient temperature, method of cable installation etc.)Connect the supply-cable conductors in accordance with the connection diagram shown in the terminal box.
When lines R,S,T are connected to terminals U, V, W, respectively, the motor will rotate clockwise.
If the connections to any two terminals are crossed over, i.e. if lines R.S.T are connected to terminals V, U, W (or U, W, V or W, V, U) respectively, the motor will rotate anticlockwise.
The arrow plates of unidirectional machines indicate the direction of rotation and are fitted on the surface of fan cover.
- for clockwise rotation only :
- for anticlockwise rotation only :

Important : Temperature sensors should be so connected and controlled that, following response of the thermal protection system and subsequent cooling down of the drive, automatic restarting is made impossible to prevent any hazard and damage caused by inadvertent starting of the plant.
Before closing the terminal box, check to see that
- the conductor connections and, if applicable, the circuit connections have been made in conformity with the connection diagram pasted in the terminal box,
- the interior of the terminal box is clean and free from remainders of cable material,
- all terminal screws and the appropriate cable entry parts are firmly tightened (applies also to unused auxiliary terminals where these are provided),
- the minimum clearances in sir of at least 8 mm at 500 V, 10 mm at 660 V, are maintained, Remove all projecting wire ends!
- the connection leads are not subject to strain and the insulation cannot be damaged.
- unused entry openings are closed off.
- all seals and sealing surfaces are in perfect condition to ensure that the degree of protection is maintained. If sealing of the joints is affected by metal-to-metal joints only, the surfaces should be cleaned and thinly regreased,
- the entry glands fulfil all requirements e. g. concerning adaptation to lead diameter, type of protection and conditions of installation.

2.4 Terminal block connections

Tightening torques for electrical connections on the terminal block.

Frame size	Blot size	Torque(Nm)
Fr.90	M4	1.2~2.0
Fr.100~132	M5	2.0~~3.2
Fr.160~180	M6	3.0~5.0
Fr.200~225	M8	6.0~10
Fr.250~280	M12	16~25

- The tolerance of tightening torques is ±10%.
- Do not apply torque value more than the values above.
- torque may cause damage on terminal block and bolts.

2.5 Insulation testing

Before commissioning after long periods of storage or standstill the insulation resistance of the windings to the frame must be measured with DC voltage.
Do not discontinue measurement, before the final resistance value is indicated (this process may take up to 1 minute).
The limit values for minimum insulation resistance and for measuring voltage can be derived from the following table.

Descriptions	Rated Voltage < 600 v
Measuring voltage	500 V DC
Minimum insulation resistance with new, cleaned or repaired windings	$\frac{Un \times 3}{Pn + 1000}$ (M)

Where Un = Machine rated voltage (V)
Pn = Machine rated out put (kW)

If the insulation resistance value is in the region of the minimum value, damp and/or dirt can be the cause. If the insulation resistance value falls below this minimum figure, the cause must be established and the winding dried.
During operation the insulation resistance of the windings may decrease as a result of environmental and operating conditions.
If the measured insulation resistance value is above the minimum figure during operation, the machine can still operate further. When the measured value reaches or falls below this minimum value, however, either the windings must be dried, or the rotor must be removed and the windings thoroughly cleaned and dried. If the measured value approaches the minimum value, the resistance should subsequently be checked at appropriate short intervals.
Drying of winding shall be done by means of the following :

- Hot air or external heating method :
  Place a well ventilated sheet over the motor.
  The insulation should not be heated above 90℃ .
- Current method :
  With the rotor locked, apply a low voltage to allow a short-circuit current to flow in the winding.
  The winding is then dried by its own heat generation.
  Start at low current, increasing the current gradually until the temperature approaches 90℃ , then keep the current constant so that the insulation resistance reaches a constant value safely.

2.6 Commissioning

2.6.1 Preparation :

The following checks and tests should be performed after initial installation and subsequent.
overhauls :

- installation and operating conditions correspond to rating plate data.
- machine correctly installed and aligned.
- minimum insulation resistance satisfactory (also check after extended shutdowns),
- direction of rotation of the machine as specified,
- cooling air flow not obstructed,
- rotor revolves freely without touching,
- all fixing bolts, fastening devices and electrical connections tight,
- earthing connections with satisfactory conditions.
- bearing properly lubricated
- any auxiliary devices fitted (e. g. temperature monitoring instruments in windings and bearings, anticondensation heaters, etc.) properly connected and serviceable.

- all protective measures against contact with moving or live parts properly implemented.

The above list of operations cannot be complete, i. e. further checks may be necessary particularly regarding the specific plant conditions at site.

2.6.2 Starting up :

The following commissioning procedure is recommended after initial installation and subsequent overhauls.

- Start up the machine without load by closing the circuit breaker which should not be opened before the machine has run up to speed.
- Check the mechanical running for noises or vibrations at the bearings and bearing shields.
- If the machine does not run smoothly or if any abnormal noises are heard disconnect the machine and ascertain the cause of the defect as it runs down.
  If there is an improvement in its mechanical running immediately after disconnection the causes will be of magnetic or electrical nature. If not, the causes are mechanical, e.g. electrical machines or driven machine out of balance, or poor alignment of the machine set.
- If the mechanical running of the machine is satisfactory, observe operation of the machine for some minutes under no-load conditions.
- If the machine is running satisfactorily it should be brought onto load.
  Check the running smoothness and record the readings for voltage, current, and out put.
  If possible, also record the corresponding values from the driven machine.
- Monitor and record the temperatures of the bearings, windings, etc. until the steady state is reached.

2.6.3 Shutting down :

Confirm the load to be ready for the shutting down, open the circuit breaker and allow the drive to coast down without braking.
If the control of any auxiliary devices is not done automatically, switch off corresponding devices and, switch on the anti-condensation heaters.

CHAPTER. 3 Operation

3.1 Safety advice

Attention! Covers to prevent accidental contact with live or rotating parts, and those required for proper air guidance (and thus effective cooling) should not be opened during operation. Also refer to "4.1 Safety measures" under CHAPTER4. MAINTENANCE.

Caution! Any change in behavior may indicate that the machine is not functioning properly. If so, immediate action should be taken to find and eliminate the cause of the trouble to prevent future damage. Also refer to MAINTENANCE.

3.2 Starting up, shutting down

It is assumed that the procedures for starting up and shutting down are controlled by an automatically operating device.
Technical details as applicable may be seen in section "2.5 Commissioning", which stipulate a summary of measures necessary after installation inspections.

3.3 Prolonged shutdown periods

The following measures are normally required on shut-down machines which are ready for operation:

- Keep the machine dry by operating the anti-condensation heating.
- Operate the machine at regular intervals (about once a month) or at least turn the rotor.

Suitable corrosion protection, preservation, packing and drying measures are required before the machines are shutdown for a prolonged period of time.
At the end of prolonged shut-down periods, the measures described under "2.5 Commissioning" in the CHAPTER2 INSTALLATION must be performed as required depending on the duration of the shut-down period.

3.4 Trouble shooting

HYUNDAI designs and manufactures the motors to ensure high electrical and mechanical reliability.
However, some troubles may occur when using the motor over a long period.
In such case, find the cause as early as possible so as to minimize the trouble.

Trouble	Cause	Remedy
Failure or difficulty to	Mechanical restriction or overload.	Disconnect the motor from the load. Try to rotate by hand and if it is difficult the cause is a mechanical restriction. Disassemble and investigate. If the motor without the load can be started, check the load.
	Inter – turn or phase Short – circuit in Stator winding	Rewind the coil.
	Stator winding incorrectly connected	Check connection and reconnect.
	Low system voltage high frequency	Measure the motor terminal voltage and frequency. If it is different from specified, readjust.
	Fuse blown out	Renew
	Switch in poor contact	Readjust contact part or replace
	Connecting wire broken	Reconnect.
	Overcurrent relay operated.	Remove the cause and rest.
	Bearing binding	Renew
Overheating of bearing part	Too much grease in bearing	Remove excess of grease.
	Grease deteriorated or contaminated	Renew
	Strain applied from coupling	Improve alignment of machine.
	Ball bearing damaged	Renew
	Excessive belt tension	Reduce belt tension
	Misalignment	Realignment

Trouble	Cause		Remedy
Abnormal sound or abnormal vibration	Belt to tightened		Reduce belt tension
	Heat conducted from other part.		Investigate the cause for overheating of rotor or stator
	Abnormal speed	Inadequate Supply voltage Frequency	Check the terminal voltage, and adjust to the nominal voltage. Check and adjust the line frequency to the power
		Load variation	Check and adjust the machine.
		Excessive slipping	Check the rotor bar and the joint of short-circuit ring
	Air gap part in contact.		Renew bearing. Check for bending of shaft.
	Ingress of foreign matter		Remove foreign matter.
	Vibration or rotor	Loosened mounting bolt	Retighten.
		Misalignment of direct connected machines	Realignment.
		Unbalance	Rebalance
	Air gap in unbalance		Renew bearing with a spare part. Recenter bracket with frame.
	Magnetic sound	Bearing due to overload loosened Laminated core	Check and adjust load. Disassemble and repair.
	Abnormal sound from ball bearing	Collision of ball with retainer	Readjust or replace bearing.
		Grease deteriorated	Renew
	Ball surface damaged by electrolytic corrosion		Renew
	Ingress of foreign matter		Clean bearing and repack with fresh grease.
Overheating	Overload		Reduce load to or below rated value.
	High system voltage low frequency.		Adjust to the rated value.
	Cooling fan defective.		Disassemble and repair.
	Ventilating hole clogged.		Remove dust or dirt accumulation
	Friction between rotor and stator.		Renew bearing Readjust air gap uniformed.
	Coil grounded		Disassemble and repair coil.
Inundation			Disassemble and water wash to remove contaminant, then reassemble and dry. In the case of inundation by sea water, water wash and clean in hot water at 60℃ to 70℃ to remove salt, then reassemble and dry.

CHAPTER4. Maintenance

4.1 Safety measures

As already pointed out under "1.1 Safety Instructions", the work required in power installations must only be carried by skilled personnel.
Attention! Before any work is started on the machines, particularly before covers are removed from live parts, make sure to see that the machine/plant has been correctly disconnected from the supply.
This applies both to the main circuits and to the auxiliary circuits and particularly to the anti-condensation heating circuits!
Please adhere to the following "safety rules".

- Isolate the equipment from the supply,
- Provide a safeguard to prevent unintentional reclosing,
- Verify safe isolation from the supply,
- Provide barriers or covers for adjacent live parts.

4.2 Periodic inspections

Careful maintenance and inspections are required to detect and clear any faults as early as possible before major damage can develop.
The effective / proper maintenance and inspection helps avert or minimize the undesirable problem.
Only general inspection intervals can be recommended because of the widely differing operating conditions. The inspection intervals must therefore be matched to the circumstances prevailing such as dirt deposits, number of starts,and loading etc.
In the case of faults or exceptional conditions representing electrical or mechanical overstressing of the machine, e.g. overload, short-circuit etc., the necessary inspections must be carried out at once.

Interval	Inspection	Inspection procedure	Corrective measure
Daily	Major motor in use	Check for vibration and sound, and the temperature of bearing etc. by touching by hand.	In abnormal vibration, sound or bearing heating is noted, investigate the cause and repair If over load or other abnormality is noted stop at once and remove the cause.
Weekly	Major motor not in use	Rotate the motor by hand and check for abnormality.	If abnormality is noted, investigate the cause and repair.
	Removal electric	Measure insulation resistance. Check ground connection	If insulation is deteriorated or ground connection is improper, investigate the cause and repair.
Monthly	Motor and starter	Measure insulation resistance.	If insulation is deteriorated investigate the cause and repair.
		Check stator and surface	Clean contaminated area.
		Check terminals for loosened connection.	Retighten loosened connection.
2~3 monthly	Motor noise	Check the bearing noise	Add grease to the bearing. If adding grease causes a bearing noise, replate it with a new bearing.
3-monthly	Electric circuit	Measure insulation resistance.	If the measurement is less than the minimum value given below dry or otherwise correct. 1 M ohm or greater

Interval	Inspection	Inspection procedure	Corrective measure
6-monthly	Apparatus associated with motor	Check operation of starter and accessory apparatus.	If operation is abnormal. Investigate the cause and repair. Repair defective or burnt part.
		Check contact part, terminal and connections.	If necessary, replace, Retighten loosened connection.
	Motor	Check for loosened bolt or nut in the base mounting part, joint cover mounting part, etc., and for correction.	Retighten loosened bolt or nut. Renew defective bolt or nut with a new one
Yearly	Motor	Measure air gap between stator and rotor. Check for abnormality in bearing part.	Renew defective bearing with a spare part. Clean shaft and bearing
	Spare part	(1) Check the number (2) Measure insulation resistance.	(1) Check with parts list. (2) If insulation is deteriorated. investigate the cause and dry or otherwise correct.

The above list cannot be complete, I, e, further checks may become necessary depending on the special plant conditions.
Any excessive deviations or change ascertained during the checks must be corrected immediately.

4.3 Maintenance and replacement of bearing

4.3.1 Re-greasing (not reguired for sealed type ball bearing)

Following grease should be used.

List of recommended grease brands.

MAKER'S NAME	GREASE BRAND
SHELL	Gadus S2 V100 2
EXXON MOBIL	MOBILUX NO.2
ESSO	BEACON NO.2
BP CASTROL	ENERGREASE LS2

4.3.2 Period of re-greasing.

Ball and roller bearing motors are shipped with sufficient grease for a long operating period. Relubrication intervals are consistent with the type of service shown in the following table.

Grease quantity and greasing interval

Bearing No.		Initial greasing quantity (gr)	Regreasing quantity (gr)	Greasing interval (monthly)					
				2 pole	4 pole	6 pole	8 pole	10 pole	12 pole
6206		15	10	4	6	6	6	6	6
6208		30	12	4	6	6	6	6	6
6211		80	12	4	6	6	6	6	6
6213		80	14	4	6	6	6	6	6
6307		30	12	4	6	6	6	6	6
6309		60	12	4	6	6	6	6	6
6310		80	17	4	6	6	6	6	6
6311		100	19	4	6	6	6	6	6
6312		100	20	4	6	6	6	6	6
6313		100	23	3	6	6	6	7	7
6314		150	26	2	6	6	6	7	7
6315		165	30	2	6	6	6	7	7
6316		180	33	2	6	6	6	7	7
6317		210	37	2	6	6	6	7	7
6318		240	41	–	6	6	6	7	7
6319		270	45	–	6	6	6	7	7
6320		245	74	–	6	6	6	7	7
6322		334	100	–	6	6	6	7	7
6324		434	130	–	6	6	6	7	7
6326		529	159	–	6	6	6	7	7
6226		203	61	–	6	6	6	7	7
7314DB		178	54	–	6	6	6	7	7
7316DB		256	76	–	6	6	6	7	7
7318DB		350	106	–	6	6	6	7	7
7320DB		490	148	–	6	6	6	7	7
7322DB		668	200	–	6	6	6	7	7
7324DB		868	260	–	6	6	6	7	7
7226DB		406	122	–	6	6	6	7	7
NU3□□	16	300	45	–	3	6	6	6	6
	17	325	45	–	3	6	6	6	6
	18	350	45	–	3	6	6	6	6
	19	375	45	–	3	6	6	6	6
	20	400	45	–	3	6	6	6	6

Note :
Special attention was foregiven for keeping the grease clean in order to achieve a maximum service life of the lubricant, and this is the reason that no discharge openings for used grease have been provided.(Excessive or too frequent lubrication may damage the motor)

4.3.3

The ball bearing requires replacement if it produces badly abnormal operation.
the procedure for bearing replacement is as given below.
After disassembling the motor by the procedure given later, remove the defective bearing from the rotor shaft by use of a bearing puller.
Anti-rust grease on the surface of the replacement bearing should be removed with a cloth. Install the new bearing on the rotor.
In doing this, be careful not to give shocks to the sealing plate, as the sealing plate may be deformed or dropped by the shock.
However, the bearings may desirably be used, it is unavoidable for them to be damaged by fatigue.
Nevertheless, an adequate operating method can retard the fatigue or can prevent failures due to other cause. Besides, should a damage take place, the cause should be examined in view of the appearance and character of the damaged part, and care must be taken not to allow the same trouble to be repeated.
It is very difficult to locate the cause of a trouble, which is usually attributable to a combination of several causes.
The following table shows common types of trouble and their causes.
Though simple, the table will serve as a rough guide to trouble investigation.

No.	Trouble	Phenomena	Probable cause
1	Noise	Low noise (rustle or rumble)	Dents formed on the race face owing to careless installation.
			Dents formed on the race face by external vibration while the fan is at rest.
		High-pitched noise	Too small clearance
		Intermittent noise	Foreign matter included
			Resonance due to careless assemble about the housing
2	Abnormal temperature		Insufficient clearance during operation.
			Overload
3	Crack	Axial crack on the inner or outer ring	Too tight fitting Uneven installing surface Housing deformation
		Circumferential crack on the inner or outerring	Uneven installing surface
			Extreme overload
		Irregular crack	Crack on the retainer or ball due to grease aging.
4	Indentation on the race face	Indentation of the pitch as the ball	Knock during installation
			Great blow struck on the bearing while the fan is at rest.
5	Retainer damaged		Grease aging
			Ball damaged
			Rivet damaged by vibration
6	Rust	Local spots on the race face	Corrosion by acid or moisture while the fan is at rest for a long time.
		Surface rust	Incomplete contact (Faulty fitting)

4.4 Dismantling and assembling

4.4.1 General information

Sectional views which are annexed provide useful information for the expert on the technical construction of normal machines.
Special models and variants may, however, differ in some technical details.
In case of problems, we would therefore always recommend to contact the works indicating the machine type and serial number.
The machines of vertical types of construction may be dismantled in a horizontal position.
Support the rotor when performing any work on the locating bearing when the machine is in the vertical position.
Below are the general procedures and items of caution for dismantling and assembling of motor.
Be sure to read them thoroughly before starting the dismantling and assembling

(1) Dismantle or assembly by one person is not only inefficient but is likely to cause fatal damage to the machine.
Hence, see to it that the job is carried out by two or more qualified personnel.
(2) Keep the place of dismantling in good order and well arranged to prevent mixing up of the parts and to improve the work efficiency.
(3) Cover the dismantled parts, particularly the important rotating parts such as bearing, etc., with vinyl or cloth to protect from dust.
(4) Before pulling out or inserting the rotor from or into the stator, fit their shaft centers so that the two may not come in contact. Take particular care so as not to scratch the winding coil, rotor bar, short-circuit ring, core, etc.
(5) Lay the rotor on a stand, and be sure to cover with vinyl or cloth, and wrap the bearing part of shaft with cloth for storage.

4.4.2 Dismantling

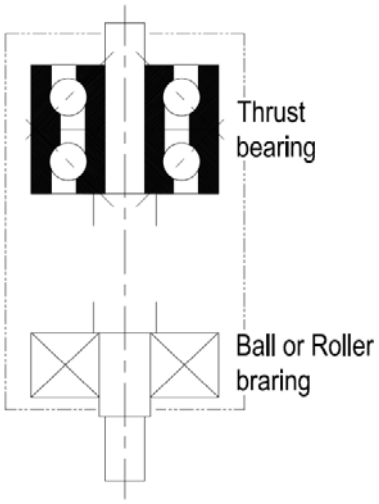
(1) Remove all external cable connected to the motor.
(2) Remove the direct coupling.
(3) Remove the bolts connecting the motor with auxiliary machine stand.
(4) Suspend the whole motor unit, and carry to the place of dismantling.
(5) In case of vertical type motor, lay the motor down horizontally.
(6) Pull out the coupling.
(7) In case of motor with open type bearing, remove the grease nipple.
(8) In case of motor with external fan, remove the external fan cover, and unscrew fan clamp before removing the external fan.
(9) Remove the end brackets on the coupling side and the opposite side.
When these brackets are removed, the rotor drops down to the level equivalent to the air gap, causing the rotor and stator to collide violently, and this may damage the core and winding coils, Hence, support both ends of the shaft with a crane or jack, or with hand (in case of motor with small capacity) before removing the end brackets.
(10) Pull out the rotor from the stator.

4.4.3 Assembling

(1) Carry out assembling "normally in the reverse order of dismantling.
Before assembling, thoroughly wipe off the dust, oil, etc. from the dismantling parts.
(2) Do not forget to replenish grease after installing the bearing.
(3) Remove the protectors used in each section before installing the parts, and after carrying out correct centering of direct coupling, make connection of electric circuits. This ends the assembling.
(4) On completion of assembling, check each section in accordance with the CHAPTER3. "Operation".

4.5 Thrust bearing installation

Thrust bearing consists of two angular contact ball bearings in the arrangement as shown in a diagram on left. This is called DB arrangement and bearing number on name plate is indicated with suffix DB. (Single angular contact ball bearing has suffix B only.)
DB arrangement is to be maintained as in diagram on left in case of reassembly of bearing or horizontal and vertical mounting change.



4.6 Maintenance for V-seal

The V-seal should be handled and maintained according to the below.
1) If there is influence from sunlight, UV exposure and ozone during the motors had been stored and used, the V-seal have been aged and damaged.
These effects can reduce the performance and lifetime of the V-seal.

2) To slow ozone aging, V-seal should be kept away from direct or reflected sunlight and electrical equipment that may generate ozone. Excessive heat build-up in the storage area and exposure to ozone can cause premature deterioration of the V-seal.

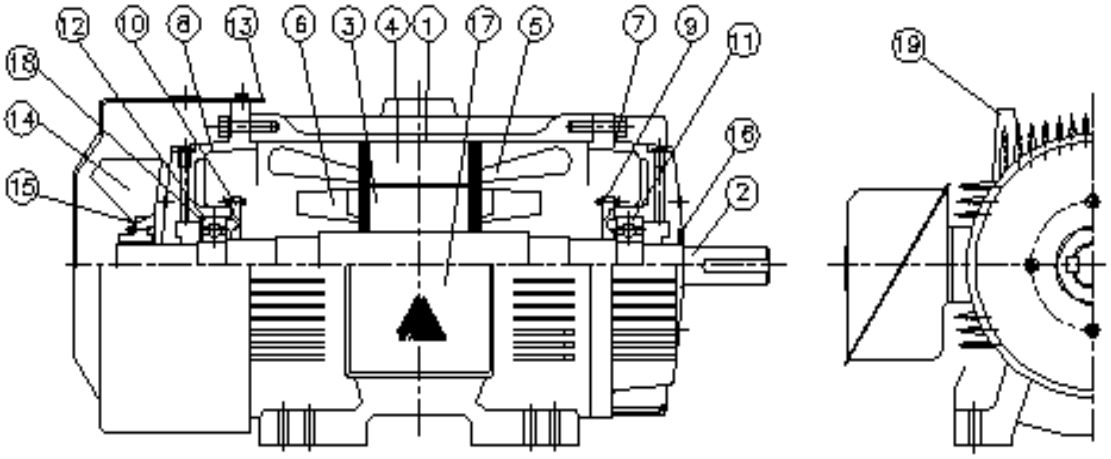
3) The condition of V-seal should be checked during the maintenance/repair period.
In case of V-seal, it should be replaced according to the condition because this is consumable part. It is difficult to define the lifetime of the V-seal because of various environmental factors, but HE are predicting a lifetime of about two years in general condition. If user want to maintain the lifetime and performance of V-seal a little longer, it is helpful to apply grease periodically on the surface of V-seal.

4.7 Spare parts

When ordering spare parts, please state the type and serial number as shown on the rating plate.
Example : Fan cover for type II ····· serial No. 9 ·····.
Commercial standard parts are available on the market by exactly indicating the type of construction,
the dimensions, the property class etc.

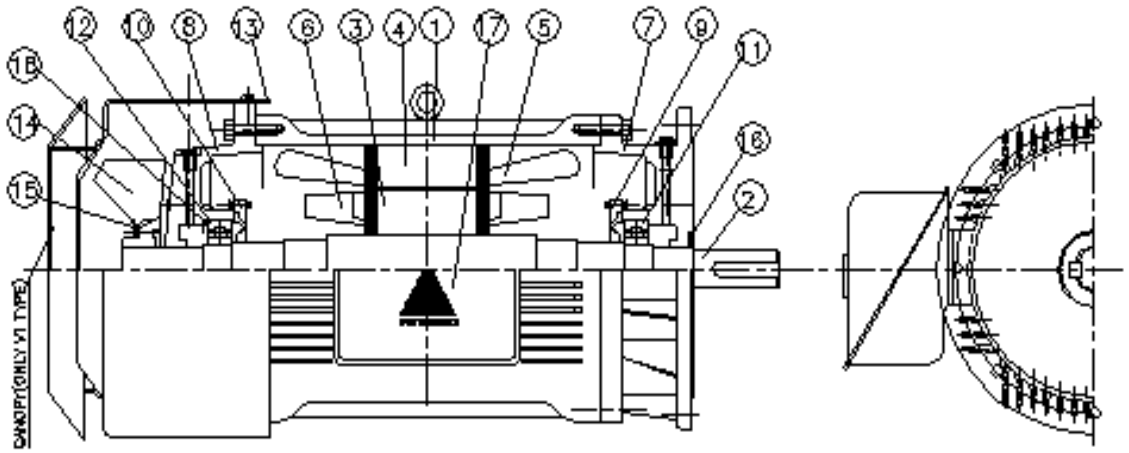
CHAPTER 5.

5.1Totally Enclosed Fan Cooled Induction Motor(Type:Horizontal Mounting)



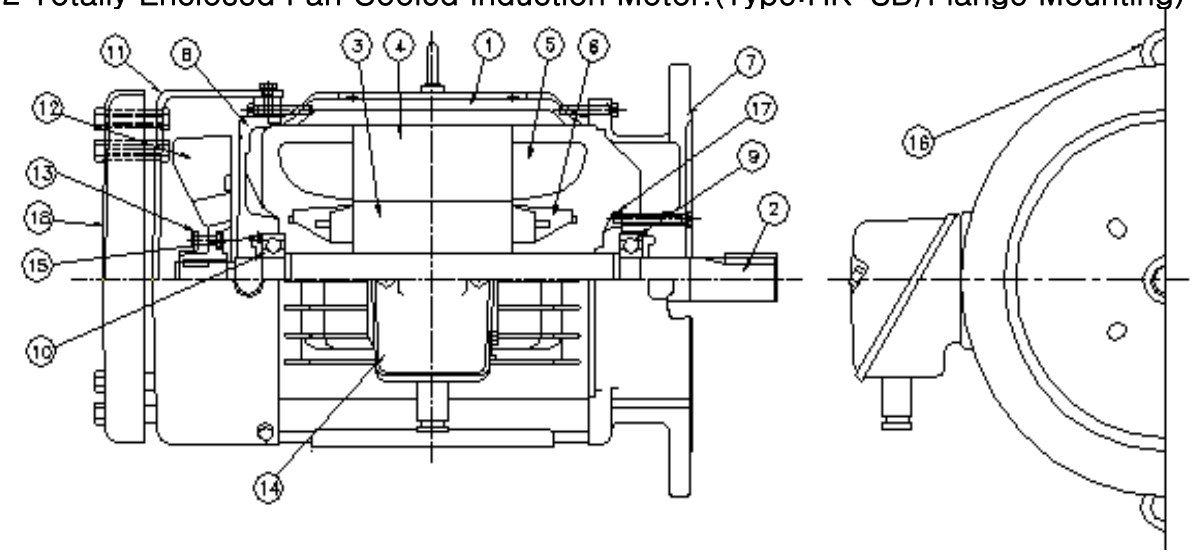
No.	Name of parts	Material	No.	Name of parts	Material
1	Frame	Cast Iron	11	Bearing(D.E)	Maker Standard
2	Shaft	Carbon Steel	12	Bearing(N-D.E)	Maker Standard
3	Rotor Core	Silicon Steel	13	Fan Cover	Mild Steel
4	Stator Core	Silicon Steel	14	Fan	Plastic
5	Stator Coil	Copper	15	Fan Clamp	Mild Steel
6	Bar & End Ring	Aluminum Casting	16	Slinger or V-ring	Rubber+Stainless Steel
7	Bracket(D.E)	Cast Iron	17	Terminal Box	Cast Iron
8	Bracket(N-D.E)	Cast Iron	18	Wave spring	Stainless Steel
9	Inn.Brg.Cap.(D.E)	Cast Iron	19	Lifting Lug	Cast Iron
10	Inn.Brg.Cap.(N-D.E)	Cast Iron			

Totally Enclosed Fan Cooled Induction Motor.(Type:Flange Mounting)



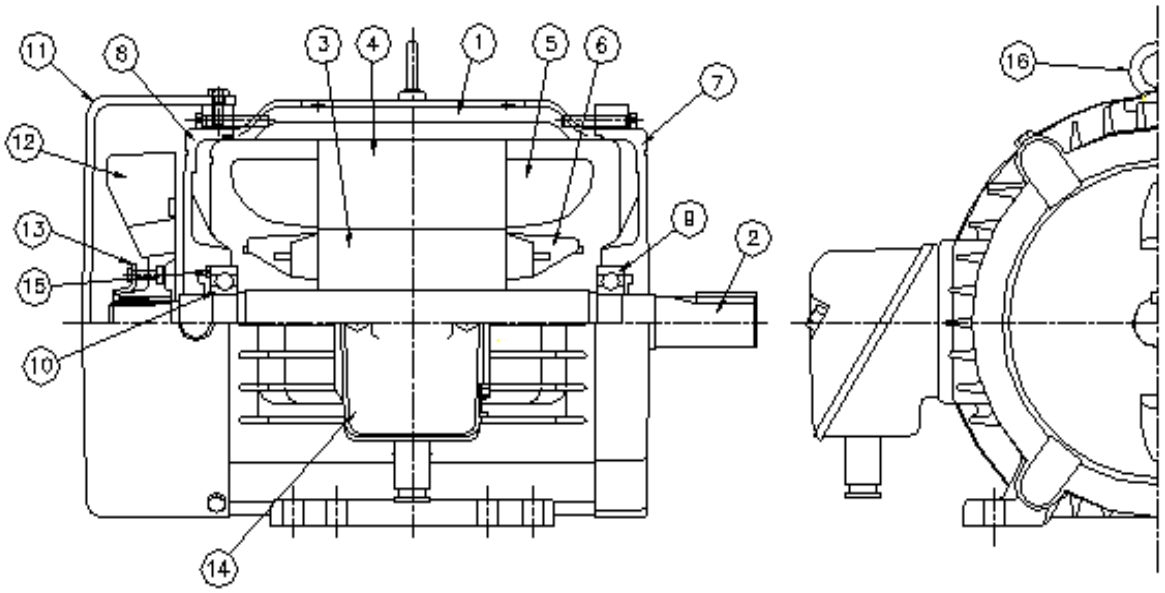
No.	Name of parts	Material	No.	Name of parts	Material
1	Frame	Cast Iron	10	Inn Brg.Cap(N-D.E)	Cast Iron
2	Shaft	Carbon Steel	11	Bearing(D.E)	Maker Standard
3	Rotor Core	Silicon Steel	12	Bearing(N-D.E)	Maker Standard
4	Stator Core	Silicon Steel	13	Fan Cover	Mild Steel
5	Stator Coil	Copper	14	Fan	Plastic
6	Bar & End Ring	Aluminum Casting	15	Fan Clamp	Mild Steel
7	Flange(D.E)	Cast Iron	16	Slinger or V-ring	Rubber+Stainless Steel
8	Bracket(N-D.E)	Cast Iron	17	Terminal Box	Cast Iron
9	Inn.Brg.Cap.(D.E)	Cast Iron	18	Wave spring	Stainless Steel

5.2 Totally Enclosed Fan Cooled Induction Motor.(Type:HK-SD/Flange Mounting)



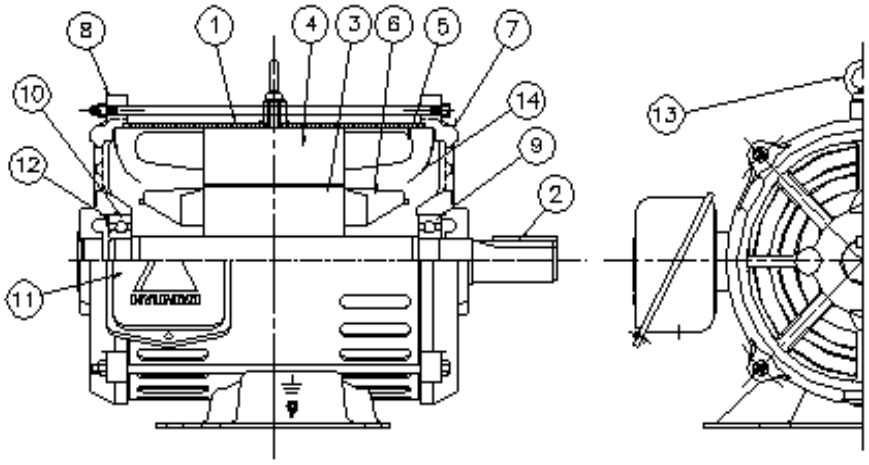
No.	Name of parts	Material	No.	Name of parts	Material
1	Frame	Cast Iron	10	Bearing(O.D.E)	High Carbon Steel
2	Shaft	Carbon Steel	11	Fan Cover	Mild Steel
3	Rotor Core	Semi Processed	12	Fan	Plastic
4	Stator Core	- Low Carbon Steel	13	Fan Clamp	Mild steel
5	Stator Coil	Copper	14	Conduit Box	Cast Iron
6	End Ring	Aluminum Casting	15	Wave Spring	Stainless Steel
7	End Shield(D.E.)	Cast Iron	16	Eye Bolt	Carbon Steel
8	End Shield(O.D.E.)	Cast Iron	17	Bearing Cap(D.E.)	Cast Iron
9	Bearing(D.E.)	High Carbon Steel	18	Drip Cover	Mild Steel

Totally Enclosed Fan Cooled Induction Motor.(Type:HK-SD/Horizontal Mounting)



No.	Name of parts	Material	No.	Name of parts	Material
1	Frame	Cast Iron	9	Bearing(O.D.E)	High Carbon Steel
2	Shaft	Carbon Steel	10	Bearing(O.D.E)	High Carbon Steel
3	Rotor Core	Semi Processed	11	Fan Cover	Mild Steel
4	Stator Core	- Low Carbon Steel	12	Fan	Plastic
5	Stator Coil	Copper	13	Fan Clamp	Mold steel
6	End Ring	Aluminum Casting	14	Conduit Box	Cast Iron
7	End Shield(D.E.)	Cast Iron	15	Wave Spring	Stainless Steel
8	End Shield(O.D.E.)	Cast Iron	16	Eye Bolt	Carbon Steel

5.3 Enclosed Ventilated Dripproof Induction Motor(Type:HK-DP)



No.	Name of parts	Material	No.	Name of parts	Material
1	Frame	Steel	10	Bearing(O.D.E)	High Carbon Steel
2	Shaft	Carbon Steel	11	Conduit Box	Cast Iron
3	Rotor Core	Semi Processed	12	Wave Spring	Stainless Steel
4	Stator Core	- Low Carbon Steel	13	Eye Bolt	Carbon Steel
5	Stator Coil	Copper	14	Baffle	Mild Steel
6	End Ring	Aluminum Casting			
7	End Shield(D.E.)	Cast Iron			
8	End Shield(O.D.E.)	Cast Iron			
9	Bearing(D.E.)	High Carbon Steel			

HYUNDAI ELECTRIC

INSTRUCTION MANUAL FOR THREE PHASE INDUCTION MOTORS

(Common items)

CONTENTS

1. FOREWORD

This instruction manual describes and provides instructions for installation, operation and maintenance of induction motors.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently, the matter should be referred to the nearest HYUNDAI HEAVY INDUSTRIES' business office.

NOTE

For service shop requirements, you are referred to ;

ELECTRIC MOTOR MANUFACTURE DEP'T
INDUSTRIAL & POWER SYSTEM DIVISION.
HYUNDAI HEAVEY INDUSTRIES CO., LTD

Postal office : 1, CHEONHA-DONG, DONG-KU, ULSAN, KOREA
Telephone : 82-52-230-6671,72
Fax : 82-52-230-6996

2. RECEIVING, HANDLING AND STORAGE

2.1 RECEIVING

Each shipment should be carefully examined upon arrival. If the packing should be found damaged, unpacking should be made immediately to check whether or not the motor and its fitting are good condition, and any damage to contents should be photographed and reported to the carrier and to the nearest HYUNDAI HEAVY INDUSTRIES' business office.

All of large motors are equipped with a locking device which functions to protect the bearing from damage due to the movement of the rotor in transit. Do not remove this device until transport is complete and coupling is ready to be fitted.

2.2 HANDLING

In order to handling after it is unpacked, the motors are always required the chain hoist, wire ropes and other handling equipment. When hoisting the motor, the wire ropes should be attached to the lifting holes on side of the motor frame, and should be put in a hard rubber, thick cloth, etc. between the external covers for protective purpose.
At that time, the motor is slowly and carefully raised and moved to the intended position.

> **CAUTION**: The unpacking works and handling the motor should have been the attention during unpacking as following points.
> -. Anti-corrosive agent which is applied to the coupling shaft ends should be removed right before motor starting.
> -. The motors should be checked the coupling or shaft ends to ascertain whether or not they are in abnormal condition.

2.3 STORAGE

If the motors are not put into service at time of delivery, it should be stored as follow conditions.

Outdoor Storage Is Not Recommended.
Because variations in temperature and humidity can cause condensation, resulting in corrosion of metal parts and possibly in insulation failure. Therefore, the following covers the minimum acceptable storage arrangements, in an unheated but protected environment.
It is preferable to use a heated facility, which would simplify meeting these conditions.
When outdoor storage can not be avoided, contact HHI for specific instruction to minimize damage, giving full particulars of the circumstance.

Storage Facility Requirements.
The storage facility must provide protection from contact
with rain, hail, snow blowing sand or dirt, accumulations of ground water, corrosive fumes and infestation by vermin or insects.
There should not be continuous nor severe intermittent floor vibration. There should be power service for the space heaters and illumination. There should be fire detection and fire-fighting plan. The motors must not be stored where it is liable to accidental damage, or exposed to weld spatter, exhaust fumes or dirt and stones kicked up by passing vehicles.
If necessary, guards or separating walls to provide adequate protection. Avoid storage in an atmosphere containing corrosive gases, particularly chlorine, sulphur dioxide and nitrous oxides.

Temperature Control.
Whenever the motor temperature is equal to and below room temperature, water vapor can condense on and within it to promote rapid deterioration.
Prevent this by energizing the space heaters to keep the motor temperature above room temperature by at least 3 ℃. However, during periods of extreme cold or rapid temperature drops, the space heaters may not be adequate to maintain this differential and supplementary heating may be required.

> **CAUTION** : If the motor is boxed or covered in any way when the space heaters are energized, there should be thermostatics control and sufficient surveillance to detect an over-temperature condition quickly. Ensure that temporary packaging does not contact the space heaters.
> When windings of motor are uninjured and their insulation resistance to ground is well above the minimum of rated voltage(KV) plus 1 megaohms when corrected to 40 C according to IEEE 43 or as below Fig.1 , low temperature is not a problem.
> However, if the resistance drops, the windings can be permanently damaged by freezing. Therefore, the motor temperature should be kept above the freezing point.

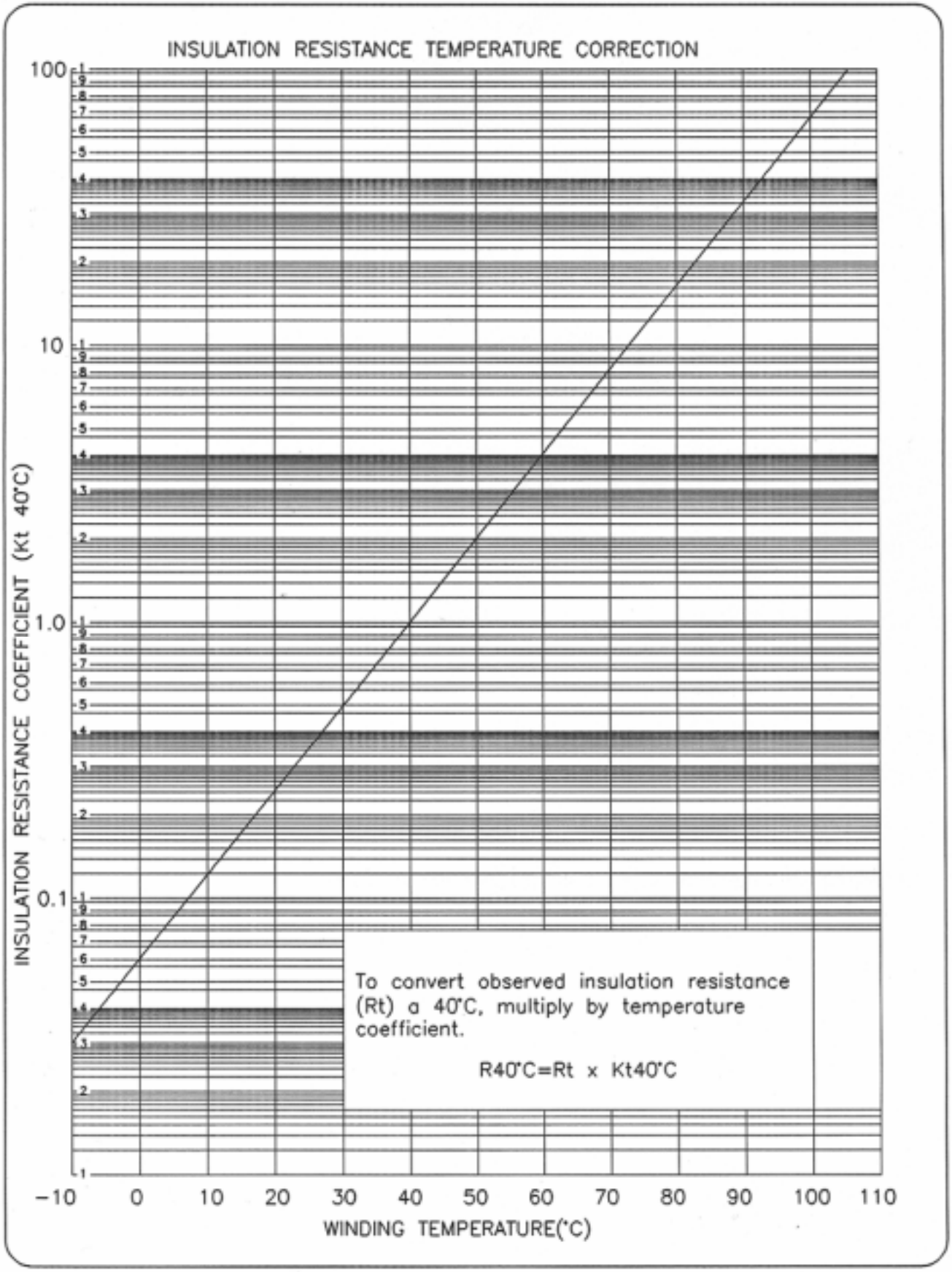
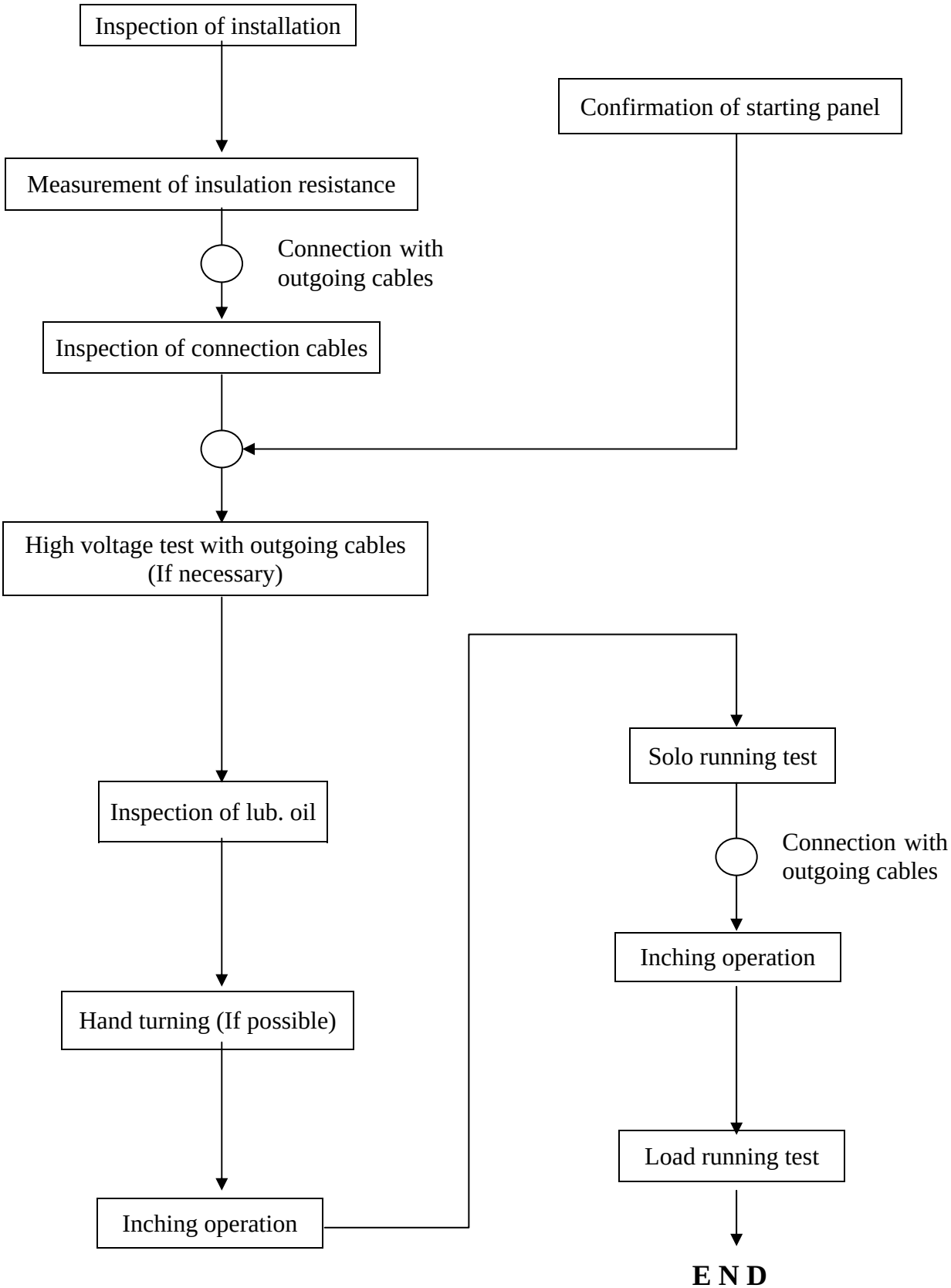


Fig.1 Insulation Resistance Temperature Correction

3. INSPECTION & TEST for INITIAL START UP ON SITE

Generally, inspection and text of motors are performed as following chart for initial start up on site.



3.1 INSTALLATION

GENERAL

Ensure that the motor enclosure is suitable for its environment, that the ambient temperature is less than specification of operating the motor at all times and that all bearings are lubricated before operating the motor.

FOUNDATION

Motors should be mounted on a solid and rigid foundations to ensure proper vibration and free operation. The desirable foundation and anchor bolt design will;

-. accommodate at least the maximum static and dynamic foundation loads indicated on the motor outline dimension drawings.

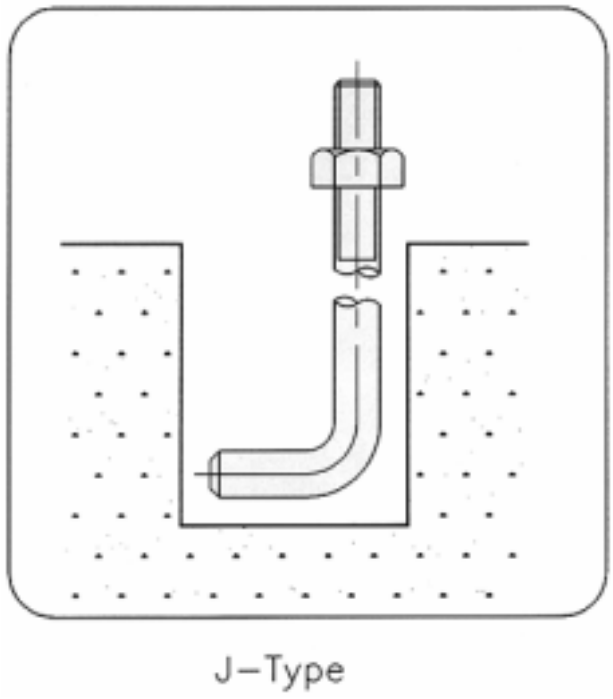
-. have sufficient rigidity to maintain acceptable alignment after the application of load.

-. be free of natural frequencies which are likely to be excited during normal operation. (This could result in vibration problems on the motor.)

In some cases where precision is required, a study of these factors should be conducted to determine the natural frequencies of the motor support.

FOUNDATION BOLT

There are some different methods of installing the foundation bolt as shown in Fig.2. The methods depend on the capacity and construction of the motor.



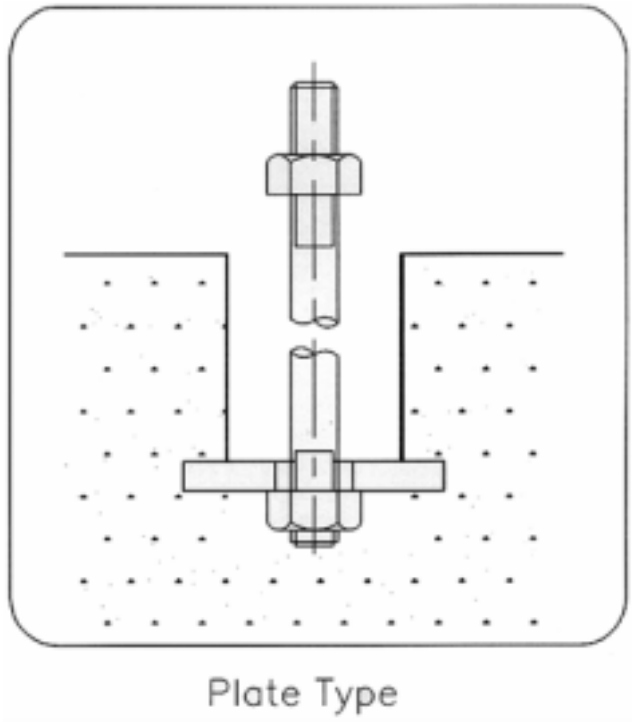


Fig.2 Type of Foundation Bolt

MOUNTING.

After remove the packaging from the skidding of the motor; remove the polyethylene shroud; remove the motor from the skidding, the motors should be mounted on a flat surface and packed out with shims (shim allowance generally 2 -3 mm thick). The shims should support the maximum length of each motor foot. It is preferable to use corrosion resistance shims such as brass or stainless steel, otherwise "shims swell" due to corrosion resistance may be detrimental to good alignment. Care should be taken not to distort the frame during " bolting down".

REMOVE THE LOCKING DEVICE OF LARGE MOTORS.

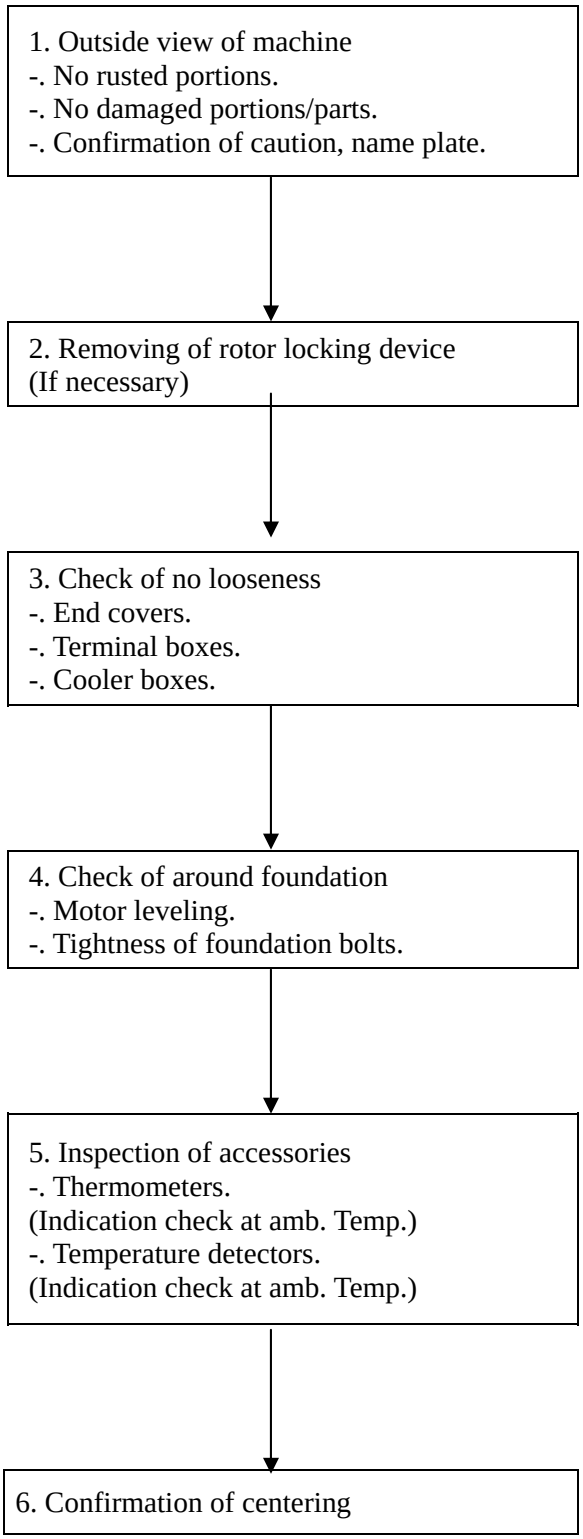
All of large motors are equipped with the device for preventing the shaft from movement in order to protect the rolling face of bearing from damages due to vibration in transit.

This locking device is fitted on the drive side or on the non drive side. Before connecting motor to a machine, the fitting bolts should be loosened, and the fitting device should be taken off.

3.2 INSPECTION OF INSTALLATION

After installation, check should be made for looseness of bolts and nuts on the terminal boxes, cooler boxes and so on. At that time, the foundation and centering of the motors should be checked. These items are normally checked and reviewed on the erection records.

Check list for inspection of installation



3.3 MEASUREMENT OF INSULATION RESISTANCE.

3.3.1 One Minute Test.

If the motors were stored in very damp surroundings for a prolonged period, the insulation resistance of windings to frame should be measured at DC power for 1 minute with a low energy source device (eg Megger).

In case of high voltage circuit, that is 600 V and above, is measured by 1000 V megger, and low voltage circuit, less than 600 V, is measured by 500 V megger. Insulation resistance of winding for the high voltage motor will be converted to 40℃ based values by IEEE 43.

The criteria of its value are (kv + 1) Megaohm at 40℃ for winding, and 1 Megaohm for space heater in accordance with international standard (IEEE 43, JEC 37 etc.). If the insulation resistance has been reduced as a result of extreme condition (eg penetration of water) and has a value less than the criteria value, the windings must be dried before connection to supply voltage and operation.

3.3.2 Polarization Index.

In case of high voltage circuit, that is 600 V and above, provided insulation resistance is within the acceptable limits, then a polarization index can be performed.

On windings apply to DC power in accordance with IEEE 43 between windings and ground; when the stator coil is tested, the rotor coil and R.T.D leads are to be earthed.

The insulation resistance at one (1) minutes should be recorded and the insulation resistance at ten (10) minutes should be recorded.

The polarization index is the insulation resistance index at 10 minute divided by the insulation resistance index at 1 minutes. This index should be greater than 1.

If the polarization index is less than 1, the HHI's service center should be contacted. The windings may need to be dried before operation.

3.3.3 High Voltage Test.

This test is intended for detecting the weak points of winding for high voltage machine. The dielectric test is carried out before the operating the motor, on windings apply to specified voltage for one(1) minute between the windings and ground.

★ Supply voltage : 2E+1000 for the line for above 1000 V

E means rated voltage or secondary induction voltage in case of the wound rotor ; AC power condition.
If AC power is not supplied, apply DC power instead of the power frequency voltage specified above. The DC voltage level is at least 1.7times of AC high voltage test voltage.

CAUTION ; Cautions in testing as follows
-. In case of the wound rotor type, the slip ring and brush support part of the motor are to be throughly cleaned; and dust and moisture are to be completely removed before the high voltage test is started.
-. When the stator coil is tested, the rotor coil and RTD leads are to be earthed.
-. Electricity is to be discharged without fail after the high voltage test has been finished.

3.4 INSPECTION OF LUBRICATION OIL

Before the initial running test, inspection of lubrication oil is very important, that is, confirmation of no oil leakage and proper oil level. Refer to bearing maintenance manual.

3.5 MANUAL ROTATION

If possible, rotate the rotor by manual means to ensure that it is free to move without rubbing or scraping and to lubricate the bearing surfaces. A minimum of 10 revolutions is recommended.

3.6 CONNECTING TO POWER AND GROUNDING

Examine the nameplate data to make sure the correct power supply. Also check the heater power where applicable. Check all connections to ensure that they have not come loose during transport. Make certain that the correct cable size has been selected and connect to phase rotation as shown in motor terminal box. The motor and control wiring, overload protection and grounding should be done in accordance with the National Electrical Code and local requirements.
In case of the wound rotor, check brushes are "free" in the holder and pressure of brush is working correctly. Ensure that slipring surface is clean and free from contamination. Avoid "finger print" marks on ring surface. To maintain the proper degree of protection, make sure all gaskets and cover plates are properly fixed and sealed. Any unused entry holes should be plugged.

WARNING :
-.Ensure that the motor starter (supplied by others) is open.
-.Make the connections as the required rotation.
-.Drill the cable entry plate (at bottom of box) to suit your power cable and its fitting.
-.Connect the station ground to one of the ground pads provided on the stator frame.

3.7 SOLO RUN TEST

Before coupling with the load machine, the motor is normally carried out solo running test.
At initial starting, the motor is inching operated for approx. 1-2 sec.
At that time, inspection of rotation, abnormal noise, and lubrication condition are checked during the idling. If these items have any problem, the supplied power shall be taken off and checked and reported in detail..
The motor is then restarted. The motor is run during 1 - 2 hrs. and vibration amplitude on the bearing housing and bearing temperature are measured and recorded.

3.8 ALIGNMENT

The correct alignment of machinery is very important for reducing the stress and vibration of the shaft and the wear of the bearing and coupling. In case that instructions are given by a coupling maker, it is recommended that the instructions be followed to.

Flexible Coupling

The flexible coupling set forth herein means the one which is driven through the rubber brush or the leather brush, including the gear coupling. In aligning the motor equipped with the sleeve bearing, an attention is to be paid to the end play of the motor bearing and to the position of the coupling. Center of the motor bearing end play is indicated by the end play indicator. The bearing end play can be equally divided by setting the end play indicator to the standard line of the shaft as shown in Fig.3.

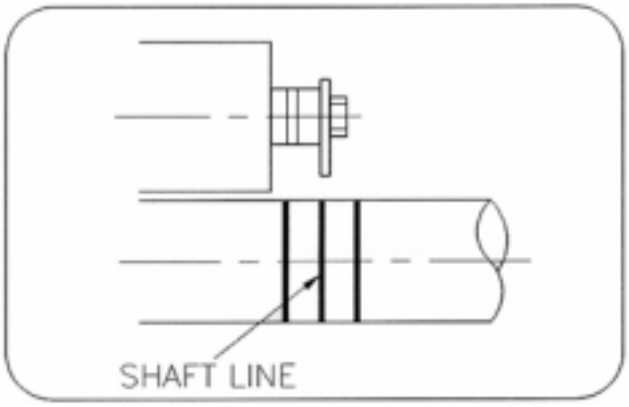


Fig.3 End Play Indicator

CAUTION : In the case that the coupling is used, it is liable to be considered that the rotor can be easily moved in the axial direction. In actual fact, however, it hardly slides in the axial direction at the coupling as torque grows greater. When by some reason the rotor has undergone some axial movement, and the coupling does not provide enough slip to allow the rotor to return to the magnetic center of the motor, it will continue to operate with the bearing end in contact with the shoulder of the journal.

Rigid Coupling

In case of the sleeve bearing, when both flanges are connected to each other, the end play indicator is referred to install the flexible coupling in order to determine the position of the motor.

Alignment

Alignment is made to bring the shaft centers of the motor and machine combined with it into the same line; the parallel and eccentricity are measured through the coupling. Generally a thickness gauge or a taper gauge is used in measuring the parallel, and in measuring the eccentricity, a dial gauge is to be fitted to the coupling on one side; the both shafts are to be turned by
0 deg, 90deg, 180deg and 270 deg; and the dial gauge reading is to be taken at the four points as shown Fig.4. The alignment accuracy is to be generally 0.025mm or less(both plate and circle).

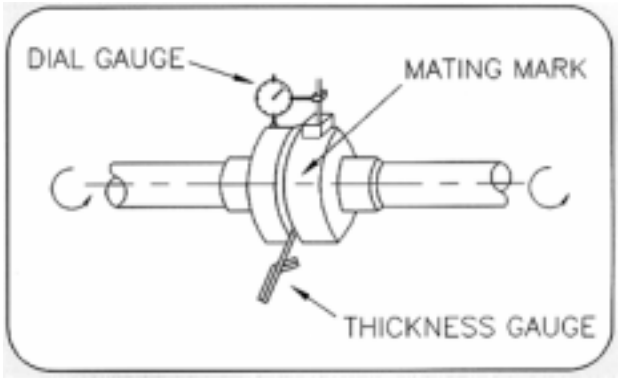
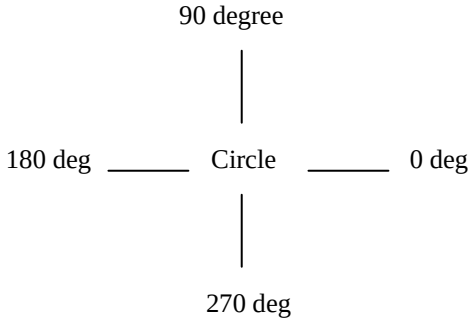


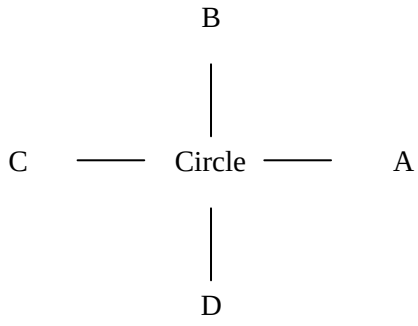
Fig.4 Procedure for Alignment

Measurement of Eccentricity

The both shafts are to be simultaneously turned; the values shall be obtained from the measurement made at four points by means of a dial gauge and are to be recorded ; and the corrected value is to be obtained in the following manners.



(Measuring Point)



(Measured Value)

$$\text{Corrected value of left and right} = \frac{A - C}{2}$$

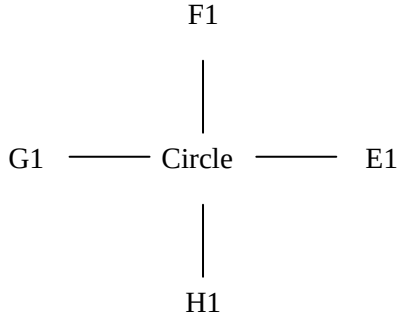
$$\text{Corrected value of top and bottem} = \frac{B - D}{2}$$

(Corrected Value)

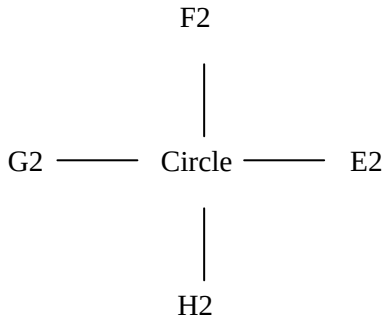
CAUTION ; The difference between the total of the measured values at the left and right points (A-C) and the total of the measured values at the top and bottom points (B- D) should not exceed 0.03mm. Greater difference, if any, may be caused by the improper fitting of the dial gauge and the erection of the fitting arm.

Measurement of parallelism

The values at the four points of E1, F1, G1 and H1 are to be corrected after measurement made by means of a thickness gauge at the position where the both shaft were connected to each other at the time of eccentricity measurement; and measurements are to be made again at the points of E2,F2,
G2 and H2 after turning the both shafts.



(Measured Value)



(Measured Value)

Corrected value of left and right =

$$= \frac{(F1 + F2) - (H1 + H2)}{2}$$

Corrected value of top and bottom =

$$= \frac{(E1 + E2) - (G1 + G2)}{2}$$

(Measured Value)

Belt Connection.

If it is intended that the motor will be direct coupled through a flexible coupling to a machine, no check for minimum sprocket diameter will be necessary. However, if a chain, gear, V-belt, or flat belt drive is used on the output shaft a check should be made.

Direction of belt tension.

In case of the motor with the roller bearing, the belt tension may be applied in the horizontal or the vertical direction. In case of the motor with the sleeve bearing, the belt tension should be applied in the horizontal direction only.

Alignment of belted drives.

Aligning a belted drive is much simpler than aligning a direct coupling drive. To check alignment, place a straight edge across the faces of the drive and driven sheaves. If properly aligned, the straight edge will contact both sheave faces squarely.

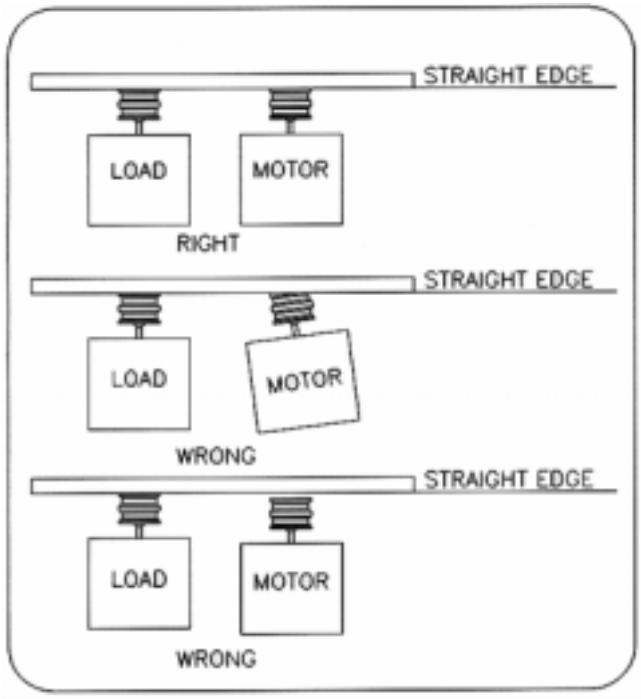


Fig.5 Alignment of Belt Drive

Belt tension.

The V-belt is to be stretched in the following way. There is calculated deflection force to be applied perpendicular to the belt at the center of the belt span as shown in Fig. 6

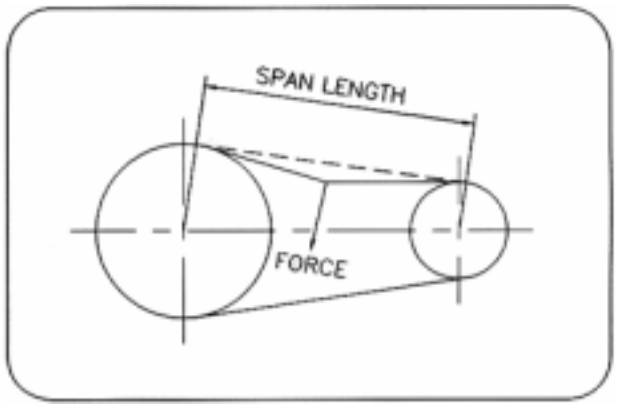


Fig.6 Belt Tension

The drive is properly tensioned when the deflection of the belt caused by the deflection force is equal to 1.6mm for span length of 100mm. If the deflection forces higher than normal values, this will result in reduced belt life, reduced bearing life and could cause shaft failure.

Coupling Balance

The coupling should be dynamically balanced to G2.5 or better. The motor is dynamically balanced with a half key fitted, therefore, the proposed coupling should be balanced accordingly, and the correct key profile fitted.

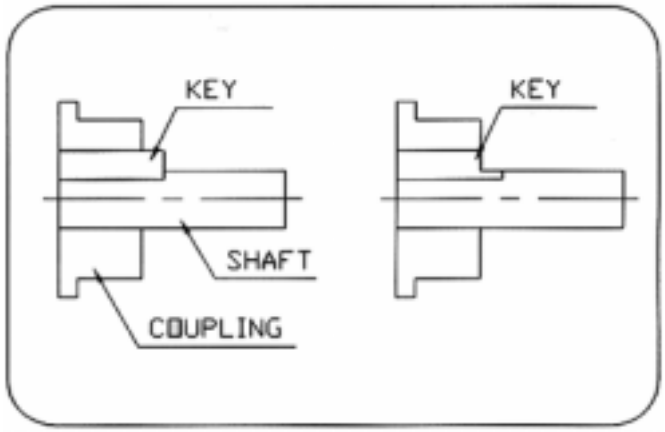


Fig.7 Coupling Balance

Frame Distortion Test.

In addition to ensure the proper alignment of the coupling, care should be taken to ensure that the motor frame is not distorted during alignment.

To confirm that distortion has not occurred, we recommend the following procedure be adopted ;

1) Align the motor within tolerances as required by section "alignment".
2) Apply a dial gauge between the motor frame adjacent to one mounting foot and the foundation, and set indicator for zero.
3) Loosen hold down bolt and record movement of dial gauge measurement.
4) Re-torque hold down bolt.
4) Repeat steps 1- 4 for all hold down bolts, one at a time.

3.9 TEST RUN OF MOTOR.

After coupling with the load machine, the motor is inching operated at first.

When both motor and load machine show no abnormality, the motor is restarted with minimum load. At that time, the current, supplied voltage are checked and recorded. While the motor is running continuously, the motor vibration on the bearing housing are controlled by the curve of Fig.8.

4. INSPECTION AND MAINTENANCE SCHEDULE

The following maintenance and inspection schedules cover the necessary steps for inspection of the motors.
Since the conditions under which the motors is required to operate may differ considerably, the maintenance and inspection schedules can only be recommended the intervals at which at least first inspection should be carried out if operating conditions are normal. On the basis of the experience gained with the plant, the inspection intervals should therefore be selected to meet such conditions as contamination, frequency of start-ups load etc.

Interval			Inspection and maintenance work	Machine part
A	B	C		
A : Daily Inspection B : First Inspection ; Not later than 6 Months. C : Following inspection ; Not later than two(2) years (when required, dismantling the machine)				
○			Check the machine for irregular noise and excessive vibration (fig 8)	
○			Where possible measure and record the bearing temperature	
			Re-lubricant the grease lub. Bearing Oil-lub bearing : Change the oil. Clean and inspect the bearings. For the intervals of maintenance work, see the lubrication instruction plate on the machine.	
	○	○	Check the shaft sealing rubber ring for deterioration	

Intervals			Inspection and maintenance work	Machine parts
A	B	C		
O			Where possible, measure the bearing temperature, oil pressure and flow rate	Sleeve(Whitemetal) bearing
O			Check that the oil-rings are operating correctly.	
O			Check the oil flow, oil level and oil leak.	
	O	O	Check the contamination of lub. oil and change the lub. oil	
	O	O	Carry out the following oil change with (normal amb. temp.) Self oil lub. : 5000-8000 operating hours Forced feed oil lub. : 15000-20000 operating hours.	
		O	Check the axial play	
	O	O	Check the shaft sealing for deterioration	
		O	Inspect the bearing surface	
	O	O	Clean and inspect the bearing insulation and insulation of the pipe.	
	O	O	Check the system, connections and piping for leaks	Forced feed oil lub. System
	O	O	Check the oil level	
	O	O	Clean and inspect the oil filters and oil coolers	
	O	O	Check the enclosure is not clogging (blocking) the machine ventilation	Enclosure
	O	O	Check the gaskets for deterioration.	
	O	O	Check the enclosure for deform and damage	
		O	Check the noise-suppression material for damage.	
	O	O	Check and clean the external cooling air paths.	
		O	Drain the drain plug, when provided.	
	O	O	Replace and clean the air filter, when provided	
	O	O	Check the clearances to rotating parts.	
	O	O	Check the enclosure for corrosion.	
		O	Check earthing (grounding) terminals.	

Intervals			Inspection and maintenance work	Machine parts
A	B	C		
	O	O	Check the enclosure including external cabling conduit connection for ingress of water or dust.	Junction(terminal) box, terminals
		O	With loose leads: Check the cable connections are properly insulated.	
		O	Check connection for good contact.	
		O	Check terminal insulators for damage.	
O			Measure and record the winding temperature detectors, when provided.	Stator winding
	O	O	Check and record the insulation resistance of windings.	
	O	O	Clean the windings, as far as possible.	
		O	For totally enclosed machines, clean the winding if required.	
		O	For the wound rotor machine with continuous sliding brushes and open enclosure machine; Clean entire winding, cooling air paths including the corepacks - airduct.	
		O	Check the slot wedge for tight fit.	
		O	Check condition of winding insulation, including end connections.	
		O	Check winding, bracing for tightness.	
	O	O	Clean the winding, as far as possible.	Squirrel-cage rotor
		O	For totally enclosed machine, clean entire winding if required.	
		O	For the open enclosed machine: Clean entire winding, cooling air paths including the corepacks-airduct.	
		O	Check cage bars and end rings for fractures and loose soldered connection.	
		O	Check cage for axial displacement.	
		O	Check end rings and support rings and the associated locking elements for tightfit.	

Intervals			Inspection and maintenance work	Machine parts
A	B	C		
	O	O	Check and record the insulation resistance of windings.	Wound rotor Winding
	O	O	Clean the winding, as far as possible.	
		O	For totally enclosed machines, clean the winding if required.	
		O	For the machine with continuous sliding brushes or open enclosure machines; Clean entire winding, cooling air paths including the corepacks-airduct.	
		O	Check the slot wedge for tight fits.	
	O	O	Check the winding-end for deposits of oil and carbon dust.	
		O	Check the banding for tightness, and check for any loose soldered joints.	
		O	Check bracings and wedges of winding end, and ring circuits for tight.	
		O	Check leads of stator winding, slipring leads f wound rotor machine and their locking lements for tight.	Leads on stator and rotor
O			Vent the cooler while in operation(monthly)	Water air cooler (heat exchanger)
O			Where possible, measure and record the water temperature.	
	O	O	Check the cooler, connection and piping for leak.	
	O	O	Check and clean the cooler.	
	O	O	Inspect the corrosion protection (when provided)	
O			Compare brush noise, sparking and contact marking with conditions found in previous inspection(monthly)	Slip ring, Brushes
	O	O	Check the brush length and replace as necessary	
	O	O	Check the brushes can move freely in the brush holders.	
	O	O	Check the pigtail(connection) leads for discoloration and damage.	
	O	O	Take out and clean the air filter	

Intervals			Inspection and maintenance work	Machine parts
A	B	C		
	O	O	Inspect contact surfaces; They should be bright, free from rubbing or threading and have a uniform skin.	Slip ring, Brushes (cont'd)
	O	O	Remove deposits of carbon dust from the slipring chamber, slip ring and brush holders.	
		O	Check the holder for damage.	
		O	Check the tight fitness of slip ring, including separators and fixing studs.	
	O	O	For arm type brush holder, check brushes for tight screwed.	
O			Avoid continuously sliding the brushes.	Brush lifting Mechanism
O			Avoid continuously rotate the thrust roller.	
	O	O	Check the mechanism, including the sliding surface of the shaft to short-circuit ring are free form dust.	
	O	O	Check the abnormality of thrust roller and limit switch.	
	O	O	Check the sliding surface of short-circuit ring for corrosion.	
		O	Check setting of short-circuit ring to shaft.	
	O	O	For arm type brush holders, check brushers for tight screwed.	
	O	O	Re-lub. the reduction gear assembly.	
	O	O	Check the manually operated gear unit for damage.	
O			Axial rotor placement should be kept by indication the shaft on its magnetic center.	Shaft and coupling
	O	O	Check and adjust the belt tension.	
	O	O	Check the external and internal fan for damage or corrosion.	
		O	Check rotor alignment.	
		O	Check the balancing weight for tight fit.	
		O	Check all coupling bolts and locking element for tight fit	
		O	Check the oil leakage of gear coupling.	
		O	Check the shaft keys for tight fit.	

Intervals			Inspection and maintenance work	Machine parts
A	B	C		
		O	Check the monitoring instruments and contact device for proper function.	Monitoring instruments.
	O	O	Check the brush length and replace as necessary.	Ground brush
		O	Check the holder for damage.	

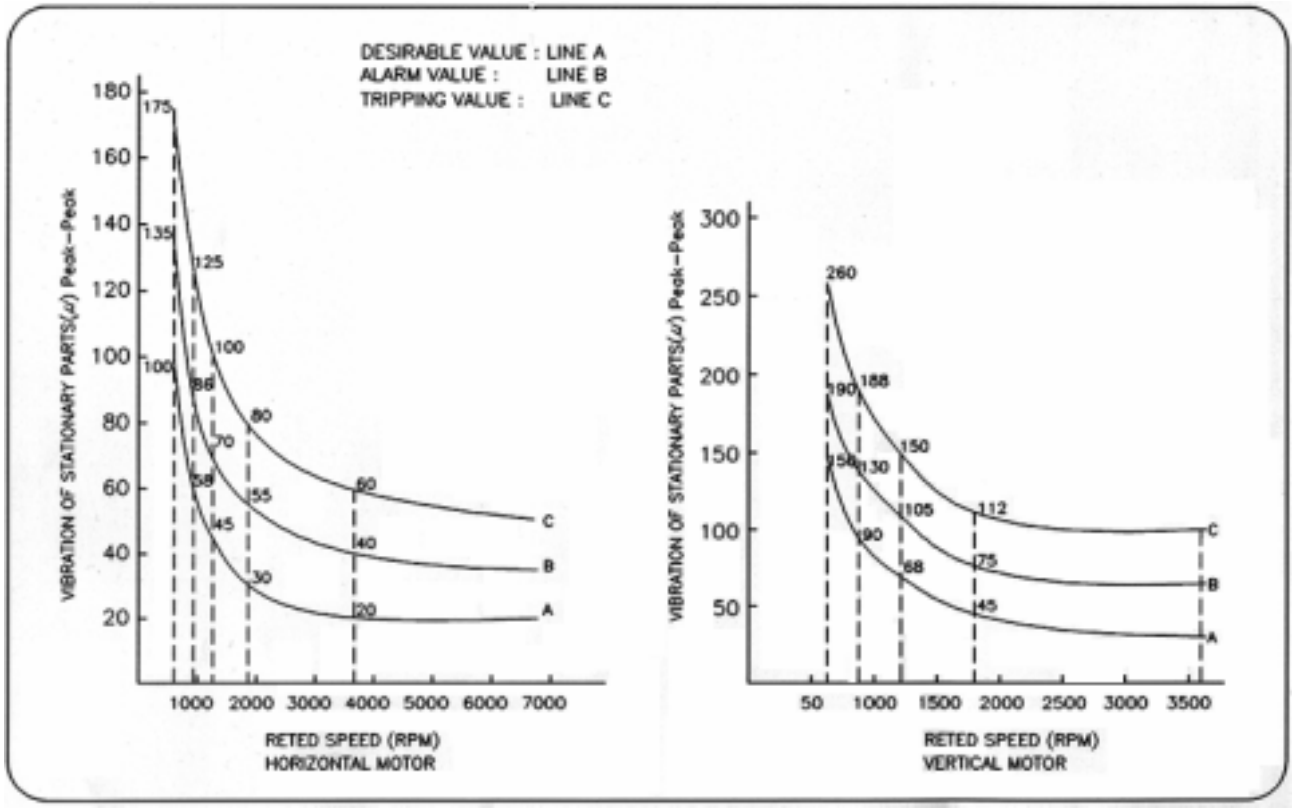


Fig. Values of Vibration

5. MAINTENANCE OF WINDINGS

5.1 GENERAL

It is important in keeping the machines in good conditions to perform periodical maintenance to prevent the insulation form being damaged by moisture, dirt and other foreign matter.

If the machines has been operated under higher humidity conditions, not used for a long time, or subjected to sudden changes of ambient temperature, the insulation may have absorbed considerable moisture, causing deterioration of the insulation.

Other causes of insulation breakdown include operation of the machines at an overcurrent exceeding the rated current, use under an ambient temperature exceeding the specified values as may be possible with a heated air blower which directly radiates heat over the machines, and overheated windings resulting from dust accumulating on the core packs and coil ends. All of the above items impair insulation and reduce the life of the machine.

5.2 CLEANING OF COILS

The method selected will depend on the type of machines, type of insulation, kind of dirt, and other condition and circumstances.

Cleaning by wiping with cloth.

Wiping cloths can be used for cleaning when the machine is small, the surfaces to be cleaned accessible, and the dirt to be removed is dry.
Waste should not be used as lint will adhere to the insulation and increase the collection of dirt, moisture, and oil. This is particularly objectionable on high voltage insulation as it tends to cause concentration of Corona.

Cleaning by means of compressed air.

Compressed air, blowing out dirt with a jet of air, is usually effective especially where dirt has collected in places that cannot be reached with a wiping cloth. Cleaning can be done more quickly with compressed air than a with wiping cloth. especially on the large machines. If blowing with compressed air results in simply transferring dirt from one place to another on the machine, little is accomplished.

There are a number of precautions to be observed when using compressed air; Air being blown should be dry, especially if blowing with against insulation. Moisture condenses and accumulates in air lines and hoses.
Care should be taken to assure this has been completely dried out before using the compressed air on insulation.
Compressed air should never be more than 3 4Kg/cm2 pressure. Higher pressures can damage insulation and force dirt under loosened tape.
Care should be taken not to blow loosened dirt into inner recesses where it will be difficult to remove and where it might obstruct ventilating ducts.

WARNING : Wear goggles when blowing dirt out with compressed air and be careful not to direct the air jet toward others. Failure to heed this warning can be result in injury to the eyes.

Cleaning by means of solvents.

Solvents are usually required to remove grease and oil dirt. A lint-free cloth wet with solvent may be dipped in the fluid.
Petroleum distillates are the only solvents recommended for cleaning electrical apparatus. These solvents, classed as Safety-Type Solvents, have a flash point above 37.8 deg and are available from most oil companies and other supply sources under various trade names;
-.Mineral spirits, cleaner's naphtha, and similar products with a flash point above 37.8 deg.
-.Gasoline, naphtha, and similar grades must not be used for cleaning. They are highly volatile and present a great fire hazard.

WARNING : Avoid prolonged or repeated contact with petroleum distillates or breathing their vapors. These solvents can cause severe skin irritation, are toxic, and are readily absorbed into the system. Failure to heed this warning can cause severe personal injury or death.
Do not use carbon tetrachloride or mixtures containing carbon tetrachloride for cleaning purposes. Carbon tetrachloride and its fumes are highly toxic. Failure to heed this warning can result in serious illness or death.
Avoid excessive contact with cleaning solvents and breathing of their vapors. Some solvents are extremely toxic and readily absorbed into the system.

5.3 USE OF SPACE HEATERS

When the motor is operating, its interior is not humid, and in dry condition, but absorbs humidity at rest.
In order to prevent absorption of humidity, the space heater installed inside frame is to be immediately energized after the motor comes to stop, and
the temperature inside of the motor is to be controlled 3 to 5 deg higher than the ambient temperature.
If no space heater, it is considered that the 100 - 150 W incandescent lamp may be used.

5.4 DRYING INSULATION

Should the insulation resistance for the winding have poor insulation resistance due to the ingress of moisture, then the windings must be dried to improve the insulation resistance to the minimum specified value before the application of insulation resistance. The preferred method of drying windings is the external heat method. The alternative is the internal heat method.

1) The external heat method.

*. Temperature controlled oven.
The best method is to dismantle the motor (including bearing) and place the motor in a temperature controlled oven at between 110 deg max. for 8 - 10 hours depending on oven efficiency to remove moisture.
*. The alternative external heat method is to remove endshields and covers, connect the anti-condensation heaters, fit additional "black heat" resistance in and around the motor.
Additional resistance heaters should be controlled by a temperature controller with a probe adjacent to the winding at the top of the motor. The temperature should be set for 100 deg to 120 deg. The drying process will take approximately 10 - 16 hours once the correct temperature is achieved.

< **Key Points to Remember.**>

1. Heaters must be the "black heat" type otherwise the insulation might be burnt.
2. The motor may need to be covered by some thermal insulation to retain the heat.
3. A vent opening should be placed in the tip of the thermal insulation tent for the evaporated moisture to escape.
4. Sufficient space should be allowed between the heaters and any winding insulation so as not to generate local excess heating of the winding insulation.

2) The internal heat method

With this method, the heat is applied by passing current through the windings to generate heat. Extreme caution should be exercised using this method so that you do not damage the internal insulation before the windings are up to optimal temperature.

WARNING : This method should only be used if all winding resistance is greater than 1 Meg ohm.

< **Key Points to Remember.**>

1. Remove brushes and short the ring together with a copper link in case of a slip ring motor(wound rotor)
2. Connect an AC supply voltage to the stator windings. The applied voltage should be approximately 12 %. In this case that the stator nominal voltage is 3300 volts and since 415 V AC represents 415/3300 x 100 = 12.5%, this will be a convenient supply voltage, In this case that the current taken from the supply would be typically 70% of the full load rated current.
3. The power supply should be controlled with a temperature controller operating from the internally connected RTDs supplied by the motor manufacturer.
4. The shaft should be locked tp prevent rotation.
5. Set the temperature controller for 110 deg maximum.
6. Drying will take approx. 8 -12 hours once the windings have reached 100 deg. The windings should take 6 -8 hours to heat up to 110 deg.

Determination of dried insulation

During the drying process the insulation resistance should be checked with a 500 Volt(low voltage machine) or 1000 Volt(only high voltage machine) DC low energy source meter(eg, megger) and then recorded after 1 minute.
This process should be repeated every hour until the results show the winding is dry.

Once the winding is completely dry, the insulation resistance will stabilize. After the windings cool down the insulation value should increase.

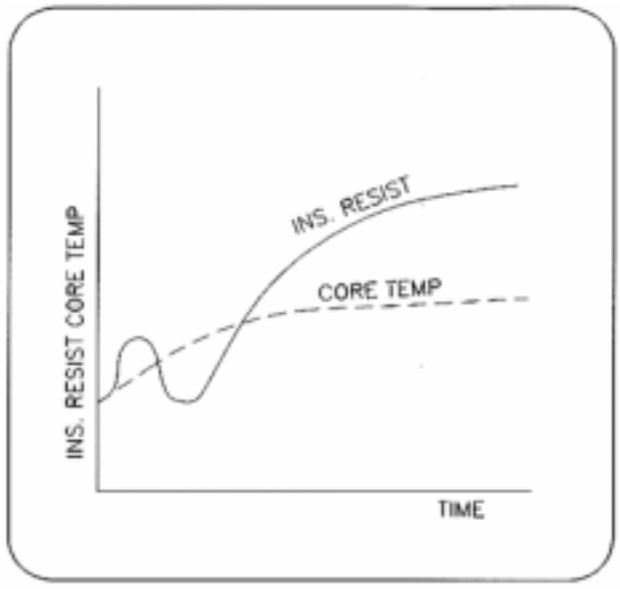


Fig.9 Change in Insulation Resistance

Notes on drying insulation.

1) A temperature controlled oven should be used if the windings have been completely immersed in water.
2) Should the windings contain contamination, the windings should be properly cleaned before attempting to dry windings. Contact your factory representative for further advice.
3) All processes for drying of insulation are specified processes and should be performed under the supervision of qualified personnel. Failure to observe proper procedures may result in permanent damage to the insulation or winding system. For further advice contact your factory representative.

6. MAINTENANCE OF SLIPRINGS, BRUSHES & BRUSH HOLDERS.

6.1 SLIPRINGS

Good Conditions

The slipring must run true to the centre of rotation. The maximum permissible TIR(Total Indicator Runout) must be no greater than 0.02mm. If the TIR is greater than this, the sliprings must be machined true. The surface of the sliprings must be a smooth finish. The slipring will normally show a running band under the brush contact area. This can be from light straw in colour to dark brown (almost black). The most normal colour is "light brown" . The surface should be consistent in colour around the periphery and across the brush track. Sparking should not be evident during operation and the rings should be dry with no signs of contamination.

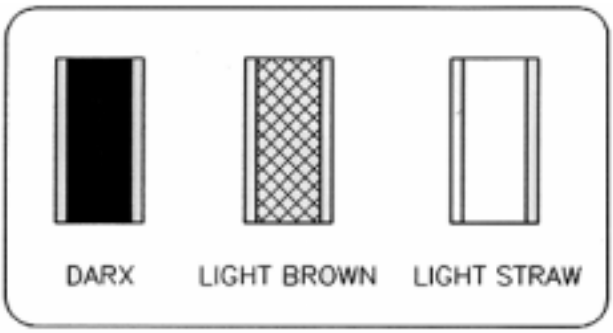


Fig.10 Examples of Good Condition

The Brush Running Band is a film on the ring basically consisting of copper oxide and carbon. This film occurs naturally during normal operating and it is essential for good brush and ring condition. Do no try to remove it. The film is easily maintained by ensuring the area is free from contamination and the machine is properly loaded.

Poor Conditions

Poor ring condition can be caused by several conditions. The common causes of poor ring conditions are ;

a) Brush loading is not optimum.Correction : See Section "Optimizing Brush Wear".

b) Contamination : Such as oil, salt air, H2S or silicone vapours (even from silastic) may destroy the film build up on the rings.
Correction : The contamination should be removed and a new set of brushes fitted and bedded in. It is preferred that sliprings be cleaned with a dry lint-free cloth. If required, some "non residue/non-corrosive" electrical cleaning solvent could be used.

> **WARNING** ; Electrical solvent, if inhaled or absorbed through the skin, can be dangerous to your health. Please refer to the manufacture safety information for proper advice.

c) Corrosion of brush rings. This condition may occur if the motor has been at standstill for a long time (eg, after extended storage).
Correction ; This should be removed by using a fine "commutator" stone available from most service shops or brush suppliers. Rotate the motor either with a small pony motor or run the motor on no load and uncoupled with the sliprings short circuited after accelerating to full speed (do not start without rotor resistance starter).

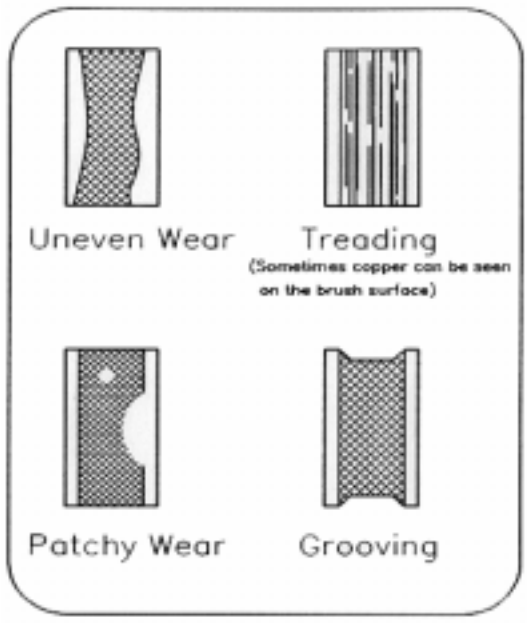
> **WARNING** ; Although no voltage is present across the rings during this operation you should ;
> -. ensure the rings cannot open circuit, therwise high voltages could be present.
> -. follow electrical safety rules.
> -. this procedure only be performed by qualified and experienced personnel

d) Threading. If threading occurs, brush optimization should be corrected first.

① Light threading can be corrected the same way as "corrosion".

② Heavy threading should be corrected by machining the sliprings.

e) Out of round rings. This must be corrected by machining the sliprings.



Fig,11 Examples of Poor Condition

Machining sliprings.

Method 1 - Preferred :
Dismantle the motor and remove bearings. Place the rotor in a lathe, centre bearing journals true and machine sliprings.

Method 2 - Alternative :
The rings be removed from the shaft with a puller which can be attached to the hub of the slipring assembly. Access to the rings can be gained by removing the drive end endshield and carefully disconnecting the rotor leads. After the rings have been removed they can be machined in a lathe.

Method 3 - Alternative :
Some motor repair shops offer on site machining. This is not a preferred method, but may be required for emergency repair. If on site machining is performed, the following precautions should be adhered to ;

i) replace brushes after machining operation is complete.
ii) all ring swarth to be removed from slipring enclosure.
iii) this operation should only be performed by experienced personnel.

After machining, the rings should be kept clean and free from finger prints until ring film has developed during operation.

6.2 BRUSH AND BRUSH HOLDERS

General.
The brushes must make good contact with the slipring surface. To ensure this, they must move freely within the brush holder and pressure lever must apply the correct pressure. The brush holder assembly is fixed. To replace brushes, unclip the pressure level and undo the "pigtail" from the holder assembly.

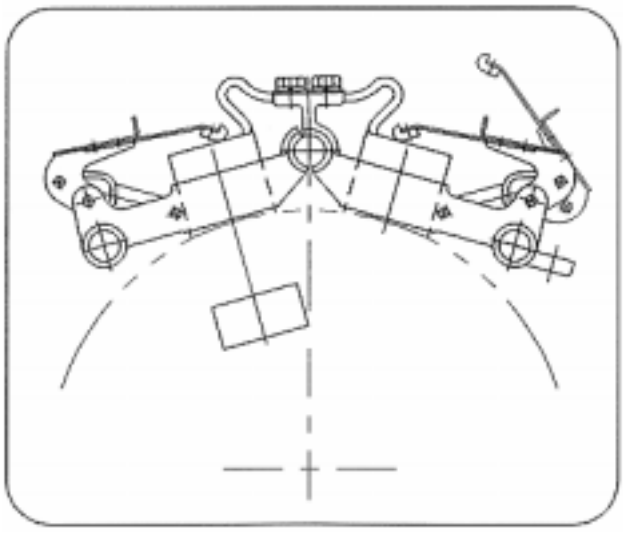


Fig.12 Brush Holder Assembly

If satisfactory brush life has been obtained, replace the brushes with the same grade as the original. Always make sure brushes are bedded in after replacement.

It may be possible that brushes wear out quickly. A common cause for this is a light load or brushes not making proper contact with the rings. In this case consult Section " Brush Optimization" or your carbon brush supplier.

If brush holders need replacing, the brush assembly may be removed by taking off the drive end endshield. The brushes are to be changed when they have work down to about 1/3 of their original length. The wear is not the same for all brushes. It is important to keep the brush housing clean and grease from excess carbon dust. Clean out housing periodically, using vacuum cleaner and clean, dry compressed air(max. 4 bar) where possible.

WARNING ; Cleaning while operating is not recommended, except in case of experienced operators. High velocity compressed air can lift brushes or short pigtails together.

Bedding Brushes

When new brushes are fitted they should be bedded in. If the sliprings wear, the diameter can vary, so the diameters of the brush face and the diameter of the rings may not be exactly the same. So, in all cases, brushes should be bedded in.

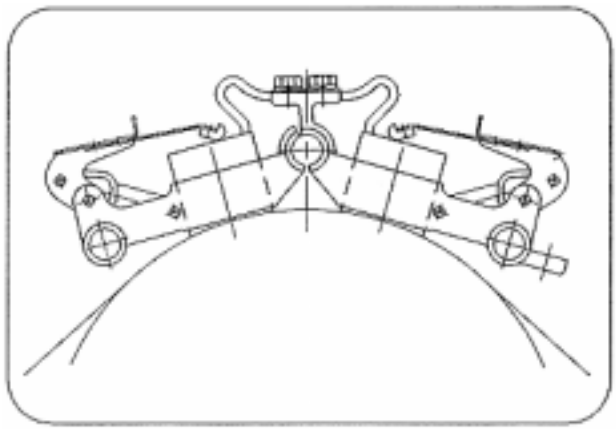


Fig. 13 'Bedding' Brushes In

Some abrasive sand paper should be placed around the slipring and the brush fitted in the holder with the tensator in place. The abrasive is drawn back and forth until all of the brush is in contact with the ring.

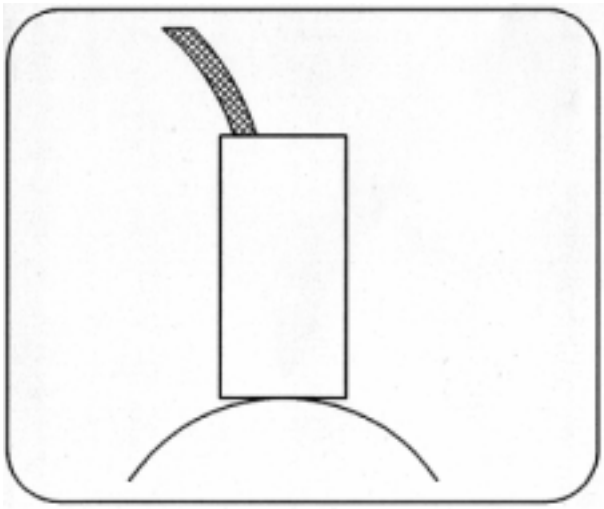


Fig.14 Example of Poor Surface Profile

`The brush surface contact area must not be less than 80% of the surface of each individual brush.
During the initial run, if possible, it is desirable to apply some bedding chalk to the rings before entering under the brush surface, this will promote the final bedding in of the brush.

NOTE ; Bedding chalk is usually available from most service shops or carbon brush suppliers.

7. TERMINAL BOX for High-Voltage Supply

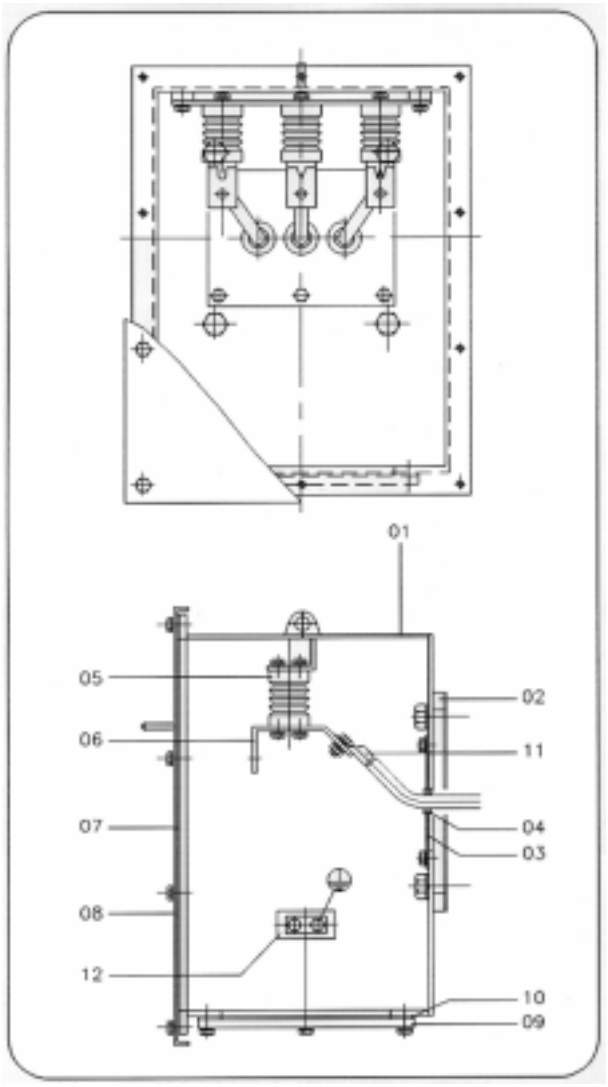
7.1 GENERAL

Transport, Storage
Always keep the cover and the cable entries tightly closed.

7.2 DESCRIPTION

1) Application
In the terminal box, the connection is made between the stator winding and the supply cable from the system. The terminal box is mounted on the machine frame at an easily accessible location.

2) Construction
The typical construction is shown in Fig. 15



01 Terminal box body
02 Packing
03 Cable holder
04 Cable grommet
05 Insulator
06 Connector
07 Packing
08 Terminal box cover
09 Gland plate
10 Packing
11 Terminal lug
12 Earthing terminal

Fig. 15 Construction of terminal box
(Example, delivered design may deviate in details)

3) Degrees of protection
The terminal boxes comply at least with degree of protection IP55 as per IEC 34-5.

4) Connection part for main terminals
The connection part is suitable for connection with cable lug depending on the equipment complement.

7.3 INSTALLATION

1) Termination

General
Ensure that the power supply agrees with the rating plate data. The supply cables should be matched to the rated current and plant-specific conditions(e.g ambient temperature, method of cable installation etc.). Connect the supply-cable conductors.

Connection by means of cable lugs
The size of cable lugs must be matched to the size of the supply cable. Use appropriate units with sufficient current-carrying capacity.

Direction of rotation
When the power supply phase conductors L1, L2, L3 are connected to terminals U, V, W respectively, the motor will rotate in a correct direction. If the connections to any two terminals are reversed, i.e. if lines L1, L2, L3 are connected to terminals V, U, W(or U, W, V or W, V, U) respectively, the motor will rotate in a reverse direction.

Installing and entering the cable
The following steps are recommended for split entry :
- Cut the sealing insert so that its opening is some

millimeters smaller than the cable diameter.

- Introduce the cable into the cable gland. In the case of very small cable diameter the cable diameter should be increased by applying insulation tape at the securing point to ensure concentric positioning of the cable in the sealing insert.

- Provisionally attach the terminal box cover in order to check whether perfect sealing is achieved both at the flange surfaces and at the entry point with sufficient prestressing. If this is not the case enlarge the sealing insert cut out or adjust the cable diameter by means of insulation tape. The securing bolts should then be tightened alternately in steps.

- Unused entry openings always must be closed off by suitable plugs.
These must

- be of permissible resistant material,

- conform to degree of protection IP55,

- be tightened so that they can be removed only by means of a tool.

Earth connection
A earth terminal for connecting the cable earth conductor is provided in the terminal box.

The minimum connection cross-section of earth connections should be selected according to IEC 34-1 with reference to live conductors.
Make sure in any case of installation and maintenance work that the equipotential bonding is maintained.

Final checks
Before closing the terminal box, check the following :

- Conductor connections and, if applicable, the circuit connections have been made correctly.

- Interior of the terminal box is clean and free from remainders of cable material.

- All terminal screws and the appropriate cable entry parts are firmly tightened.

- Clearance in air of ≥8 mm at 500V, ≥10 mm at 660V, ≥14 mm at 1kV, ≥60 mm at 6kV, ≥ 100 mm at 10kV are maintained. Remove any projecting wire ends!

- Connection leads are not subject to strain and the insulation cannot be damaged.

- Unused entry openings are closed off by suitable plugs.

- All seals and sealing surfaces are in perfect condition. If sealing of the joints is effected by metal-to-metal joints only, the surfaces should be cleaned and thinly regreased.

- Entry glands fulfill all requirements concerning degree of protection, conditions of installation, permissible lead diameter.

7.4 OPERATION

Safety advice
Covers to prevent accidental contact with live or rotating parts, and those required for proper air guidance and thus effective cooling should not be opened during operation. During maintenance or inspection work in the immediate vicinity of the terminal box or of the rotating machine suitable measures should be taken to protect personnel against hot gases escaping under short-circuit conditions.

7.5 MAINTENANCE

1) Safety advice
Before any work is started on the machines, particularly before covers are removed from live parts, make sure that the machine/plant has been correctly disconnected from the power supply.
Please adhere to the general "5 safety rules"

- Isolate the equipment from the power supply,

- Provide a safeguard to prevent unintentional reclosing,

- Verify safe isolation from the supply,

- Earth and short-circuit,

- Provide barriers or covers for adjacent live parts.

2) Tightness, high-current loading
The terminal boxes should be inspected regularly to ensure that they are tight, that the insulation in undamaged and that the connections are firmly attached.
If the terminal box is subject to extremely high current loading it is recommended that the insulators, connecting parts and cable connectors be checked.

If any dust or moisture has penetrated the terminal box, clean and dry out the terminal box. The seals and sealing surfaces should also be checked and the cause of faulty sealing should be remedied.

3) Tightening torques

Max. tightening torques for current-carrying bolted joints is given in below table.

Screw Strength class	M5 8.8	M6 8.8
Tightening Torque (Nm)	8.0	8.0

M8 8.8	M10 8.8	M12 8.8	M16 8.8
20	40	70	170

* The tolerance of tightening torques will be ±10%.

8. TERMINAL BOX for Auxiliary Circuits

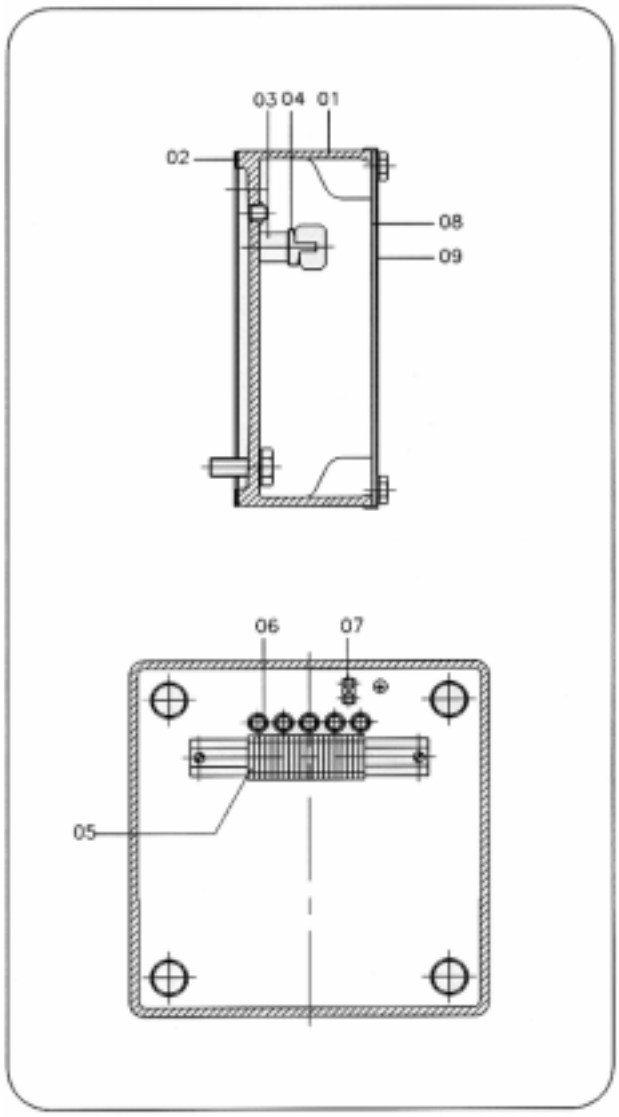
8.1 GENERAL

Transport, storage
Always keep the cover and the cable entries tightly closed.

8.2 DESCRIPTION

1) Application
The terminal boxes are employed for connection of auxiliary circuits.
If specially ordered for anti-condensation heater, an auxiliary terminal box for anti-condensation heater may be supplied.

2) Construction
The typical construction is shown in Fig. 16.



01 Terminal box body
02 Packing
03 Support ring
04 Rail
05 Terminal block
06 Cable grommet
07 Earthing terminal
08 Packing
09 Terminal box cover

Fig. 16. Construction of terminal box
(example, delivered design may deviate in details)

3) Degrees of protection
The terminal boxes comply at least with degree of protection IP55 as per IEC 34-5.

8.3 INSTALLATION

1) Termination
When making the connections of auxiliary circuits note wiring diagram for auxiliary circuits documented in the approval specification.
The cross-section of a supply cable should be selected on the basis of the rated current and plant-specific conditions.
The connection terminals for auxiliary circuits are suitable for conductor cross-sections of at least 2.5mm2.
The ends of the conductors should be stripped in such a way that the remaining insulation reaches almost up to the terminal.

2) Installing and entering the cable
In addition to the information given for cable selection and preparation, the following specific notes apply, depending on the type of entry fitting used :
To maintain the degree of protection IP all screwed-in glands must be firmly tightened and sealed by suitable measure, e.g. by means of an adhesive or by fitting sealing ring. The same measures are required when fitting screwed-in plugs.
The center rings of screw glands included in the scope of supply are always screwed in place, fixed in position and sealed in accordance with degree of protection IP55 by use of LOCTITE. These glands also are fitted with blind washers for transport protection.
For adapting the cable diameter to the gland conditions it may be necessary to apply a layer of insulation tape to the leads to enlarge its overall diameter or to cut out some rings of the sealing insert. With extreme lead diameter it may be

necessary to replace the glands by those of appropriate dimensions.
Entry plates of terminal boxes may be supplied undrilled in order to allow selection of cable entry screw glands, whose design, number and size are suitable for the cables employed.
The entry elements should be selected so that

- they are suitable for the cable diameter,

- they conform to the degree of protection,

- they are suitable for the installation conditions.

The supply leads-particularly the protective conductor-should be laid loosely in the terminal box with an extra length to protect the cable insulation against splitting.
Unused entry openings always must be closed off by suitable plugs.
These must

- be of permissible resistant material,

- conform to degree of protection IP55,

- be tightened so that they can be removed only by means of a tool.

3) Earth connection
A earth terminal for connecting the cable earth conductor is provided in the terminal box.

9. ANTI-CONDENSATION HEATING with Heating Tube

9.1 DESCRIPTION

1) Application

Anti-condensation heaters fitted in electrical machines warm the air inside the sstationary machine to a temperature above that of the surroundings, thus effectively preventing moisture condensation.

2) Construction

The typical constructions are shown in Fig. 17, 18 and 19.

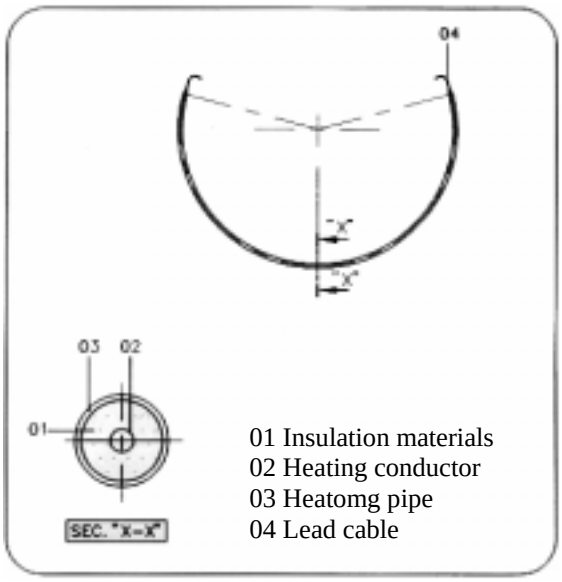


Fig. 17 O type anti-condensation heater
(example, delivered design may deviate in details)

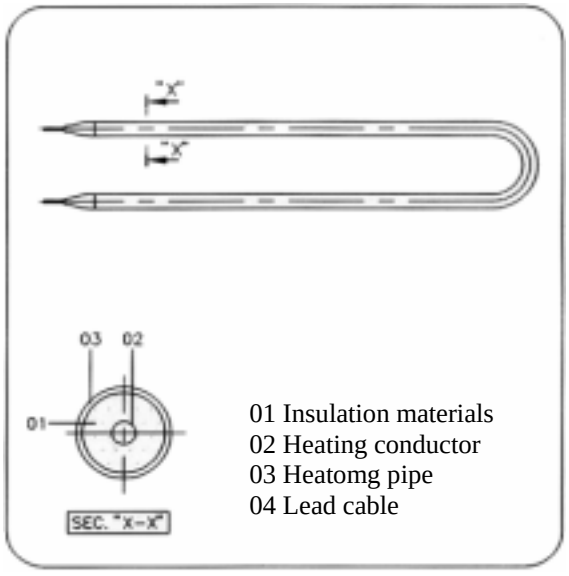


Fig. 18 U type anti-condensation heater
(example, delivered design may deviate in details)

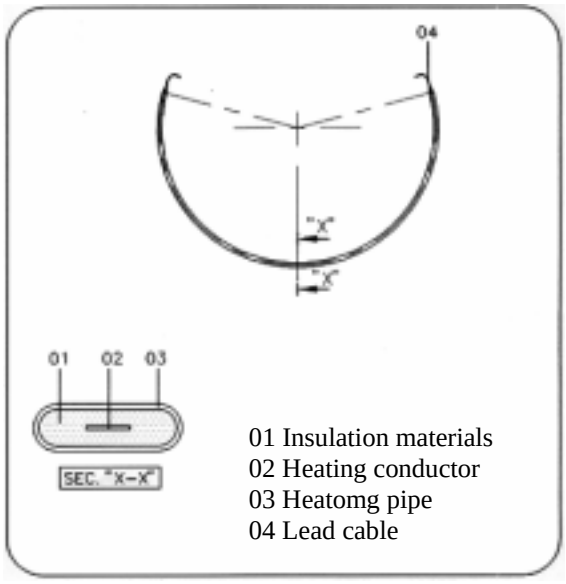


Fig. 19 Strip type anti-condensation heater for explosion-proof machines with "increased safety" (example, delivered design may deviate in details)

The heating tube has a heating conductor which is embedded in insulating material and arranged inside a corrosion-resistant metal tube. The tube ends are sealed to prevent the ingress of moisture.

3) Installation

The anti-condensation heater consists of one or more tubular heating elements connected together. These heating tubes are combined to form units and are installed in the stator frame. The arrangement constitutes the so-called "stabilized design", i.e. the heating temperature stabilizes itself at the rated voltage thanks to the optimum balance of heater rating and heat dissipation. Special temperature monitoring devices are therefore not necessary. This applies to explosion-proof versions as well.

9.2 INSTALLATION

1) Connecting the supply cable

The heater connections are brought to terminals which are located in a separate terminal box and may be made without cable lugs.

Connection must be made in accordance with wiring diagram documented in the approval specification. Examine the data plate to see that the voltage and the power of the heating agree with the main supply. The supply connection of the heaters must be interlocked with the main breaker of the machine to ensure that the heaters are switched off when the machine is running and switched on once the machine has come to a standstill.

Through appropriate series connection of the

heating tubes, even the temperature of explosion -proof machines can be limited such that these machines meet the requirements of "stabilized design" and do not require any additional temperature monitoring measures. For this reason, no changes may be made in the original heating-tube connection!

2) Insulation testing

The heater may only be put into operation if the specified minimum insulation value of 0.5 Mohm is obtained from measurement of the insulation resistance with the heater connected.

For the period after commissioning of machines equipped for anti-condensation heating, it is assumed that either the machine itself is in operation or the anti-condensation heater is heating the stationary machine.

9.3 MAINTENANCE

1) Safety advice

The anti-condensation heater is switched on when the machine has come to a standstill. Therefore, it must be switched off before any protecting cover is opened for maintenance work.

2) Cleaning

With respect to maintenance, occasional cleaning performed during routine maintenance of the machine and the replacement of any damaged parts is sufficient.

3) Repairs

Should replacement of the heating tubes become necessary use the same type of heaters. Install the new tubes securely and lock the fixing elements.

The heating tube units in explosion-proof machines may only be replaced as a whole and must be purchased as whole preformed units to suit the particular application. If repairs and modifications to models covered by the certificate for these machines are not performed in a **HYUNDAI** workshop, an acceptance inspection by an authorized engineer is necessary. If modifications not covered by the certificate are made, the machine must be newly certified.

10. MAINTENANCE OF BEARING

10.1 FLANGE-TYPE SLEEVE BEARING (Ring Lubrication System)

1) Mounting

The flange-type sleeve bearings of electrical machines are of the split type. They are ring-lubricated and are subject to the following instructions supplementing and modifying the operating instructions of the machine:

Corresponding to the operating conditions the sleeve bearings of new machines have a favorable bearing clearance which should not be changed. Also scraping (spot-grinding)is not allowed to do not make worse the antifrictional qualities.

It is recommended that the contour of the transmission element remains within the hatched range (see Fig.19) to remove the upper part of the bearing housing for maintenance without removing the transmission element.

Before the machines are aligned and commissioned, the bearings should be filled with lubricating oil, because the machines are delivered without oil in the bearings. (Oil type is indicated on the name plate for bearing)

2) Oil Change

Check the bearing temperature regularly. The governing factor is not the temperature rise itself, but the temperature variations over a period of time. If abrupt variations without apparent cause are noticed., shut down the machine and renew the oil.

The lubrication oil indicated on the data plate is used for starting up the machines at an ambient temperature of above +5℃.At lower temperatures (to about -20℃), it is sufficient to preheat the oil. If the ambient temperature are below -20℃ another type of oil according to the special conditions is used. Do not mix oils of different grades. Recommended oil changing intervals are about 3000 and 6000 operating hours in the case of intermittent and continuous duty. When cleaning, first flush the bearings with kerosene and then with oil. Pour in the kerosene and oil through the top sightglass hole. Leave the drain open until all the kerosene has been removed and clean oil runs out. Now plug the drain and fill the bearing with oil up to the centre of the lateral inspection glass.

When the machine has run up to speed, check the oil ring through the top inspection glass to see that it rotates correctly, and check the bearing temperature, Should the bearing temperature not drop to the normal value after the oil change, it recommended that the surfaces of the bearing shells be inspected.

If the bearings are fitted with thermometers for checking the bearing temperature, fill the thermometer well in the upper bearing shell for thermofeeler with oil to improve heat transfer and top up with oil every time the lubricating oil is changed.

3) Dismantling, Assembling

When dismantling the machine the lower part of the bearing housing need not be unscrewed from the end shield, When opening the bearing housing, locate before, if on which side of the machine the adjusting shims.(upper and lower parts)are installed. These shims must be installed at the same place when assembling the machine. Exceptions are possible if the stator core was changed. Drain the oil, take off the upper part of the bearing housing and the upper bearing shell, lift the shaft very slightly and turn out the lower bearing shell and the sealing rings in peripheral direction. The oil ring can be withdrawn by holding it at an inclined position to the shaft.

If only slight damage has occurred to the bearing surface, it may be re-conditioned by scraping as long as the cylindrical shape of the bore is maintained, so that a good oil film can form. The lining must be renewed if more serious damage is found. The oil pockets and grooves of the new lining or scraped shell should be cleaned and finished with particular care

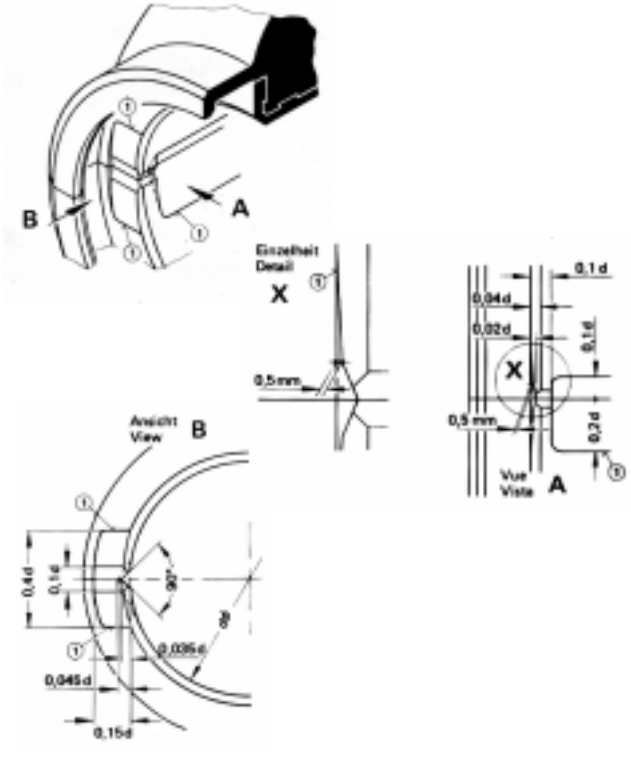
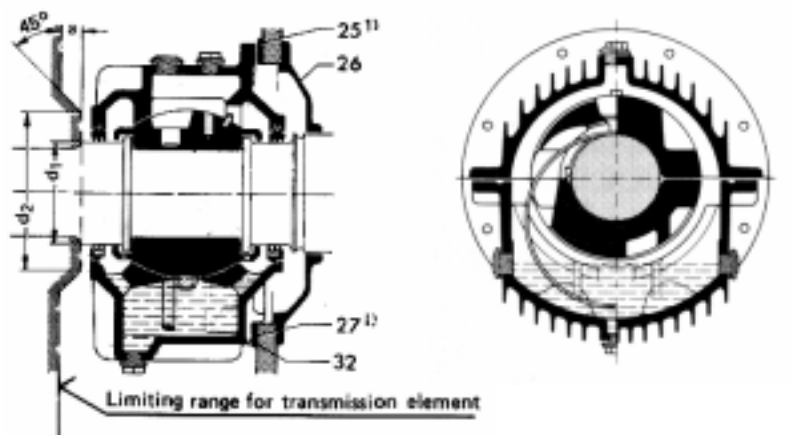
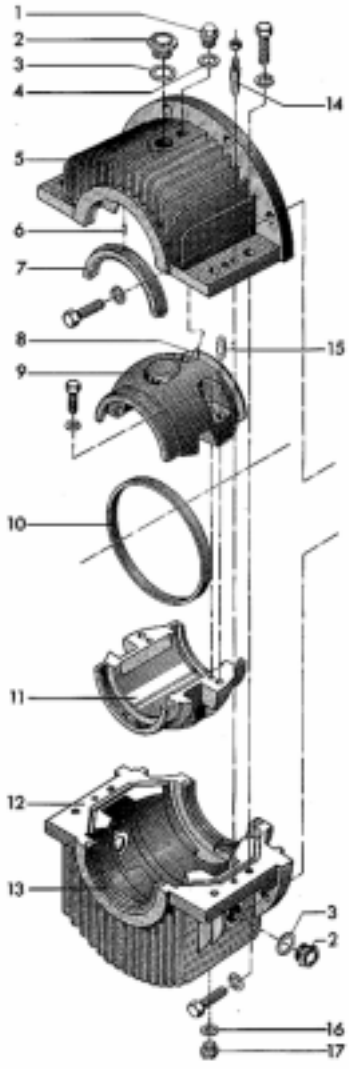


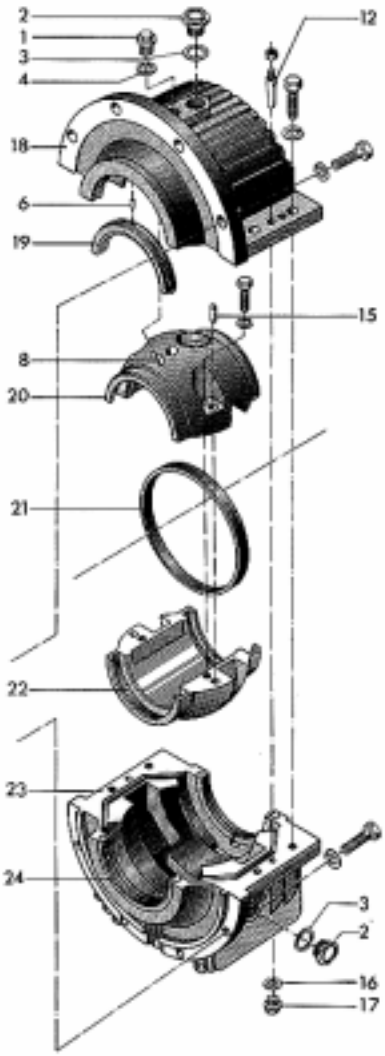
Fig. 20 Oil pockets and oil grooves

The replacement bearing shells are delivered by the works with a finished inner diameter. Only if the bearing shells were delivered unfinished, the inner diameter is 1mm smaller than the finished diameter. Oil rings which have become bent through careless handling will not turn evenly. Straighten or replace such rings. Replace any damaged sealing rings.





1. Screw plug(thermometer mounting)
2. Inspection glass
3. Sealing ring for 2
4. Sealing ring for 1
5. Bearing housing, upper part drive end
6. Cylindrical pin
7. Sealing ring, upper half, drive end
8. Guide pin to prevent twisting
9. Upper bearing shell, drive end
10. Oil ring, drive end
11. Lower bearing shell, drive end
12. Bearing ring, lower half, drive end
13. Sealing ring, lower half, drive end
14. Taper pin
15. Guide pin to fix bolted parts
16. Sealing ring for 17
17. Drain plug
18. Bearing housing, upper part, non-drive end
19. Sealing ring, upper half, non-drive end
20. Upper bearing shell, non-drive end
21. Oil ring, non-drive end
22. Lower bearing shell, non-drive end
23. Bearing housing, lower part, non-drive end
24. Sealing ring, lower half non-drive end
25. Upper adjusting shim, drive end
26. Sealing cover drive end
27. Lower adjusting shim, drive end
28. Upper adjusting shim, non-drive end
29. Sealing cover, non-drive end
30. Lower adjusting shim, non-drive end
31. Protective cap
32. Pressure compensation opening



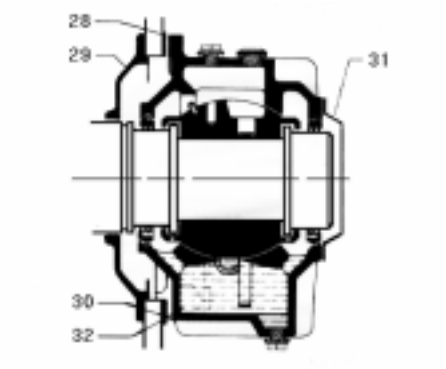


Fig. 21 Ring-lubricated flange-type sleeve bearings(examples, delivered design may deviate in details

10.2 FLANGE-TYPE SLEEVE BEARINGS (Forced Lubrication System)

1) Mounting

These flange bearings of electrical machines are of the split type. They are lubricated by and oil ring and are provided for additional forced lubrication. They are subject to the following instructions supplementing and modifying the operation instructions of the machine: Corresponding to the operating conditions the sleeve bearings of new machines have a favorable bearing clearance which should not allowed to do not make worse the antifrictional qualities.

It is recommended that the contour of the transmission element remains within the hatched range to remove the upper part of the bearing housing for maintenance without removing the transmission element.

Before the machines are aligned, the bearings should be filled with lubricating oil (oil type is indicated on the name plate for bearing), because the machines are delivered without oil in the bearings.

Connect the bearings to the oil pump, oil tank and cooler before commissioning the machines. No reducers must be fitted in the piping. Install a regulating orifice on the oil supply line to protect the bearing from flooding. If the oil pump fails, the lubrication maintained by the oil ring is effective for about 15 to 30 minutes, provided the oil contained in the bearing does not drain away. To prevent this, connect the oil discharge tube on that side where the oil rings moves downwards into the oil. In addition to this, install a non-return valve in the oil supply line. As an alternative, the oil 100 mm high, to raise the level of the oil in the bearing. Oil discharge tubes must terminate flush with the inside surface of the bearing housing to prevent the oil rings from rubbing against the tubes.

Fill the oil tank with lubricating oil indicated on the data plate. This oil is used for starting up the machine at an ambient temperature of above +5℃. At lower temperatures preheat the oil. It is recommended to use a control system adjusted in such a manner to have an oil temperature of 15 to 20℃ in the tank and to have a preheated oil flow through the cold bearings for 5 to 10 minutes before starting up the machine. Do not mix oils of different grades.

The necessary pressure of the oil entered the bearings and the oil flow rate are indicated on the data plate. Adjust to these values when starting up the machine for the first time and correct them when the bearing has attained its normal running temperature. The oil in the bearing housing must not ascend over the center of the lateral inspection glass.

If the bearings are fitted with thermometers for checking the bearing temperature, fill the thermometer well in the upper bearing shell for the thermofeeler with oil to improve heat transfer and top up with oil every time the lubricating oil is changed.

In the case of insulated bearings, make sure that the insulation is not bridged by the tubes; interrupt the electrical conductivity of the tubes near the bearings, e.g. by installing oil-resistant fittings of plastic material or hoses of rubber or plastic material.

Switch on the oil pump before starting up the machine. The use of a pump driven from the shaft of the main machine is permitted only in special cases, i. e. when the acceleration and coasting times are short.

2) Oil change

Check the bearing temperature regularly. The governing factor is not the temperature rise itself, but the temperature variations over a period of time, if abrupt variations without apparent cause are noticed, shut down the machine and renew the oil.

Recommended oil changing intervals are about 20,000 operating hours. After the machine is come to a standstill and the old oil is drained out of the bearings and oil tank operate the oil pump with kerosene for a short time and then with oil to clean the bearings. the oil pump, the oil tank, the cooler and the pipe lines. Pour in the kerosene and then the oil through the filling opening of the oil tank. Leave the drains open from time to time until all the kerosene has been removed and clean oil runs out of the bearings and oil tank. Now, plug the drains and fill the tank with oil. Should the bearing temperature not drop to the normal value after the oil change, it is recommended that the surfaces of the bearing shells be inspected.

3) Dismantling, Assembling

When dismantling the machine the lower part of the bearing housing need not be unscrewed from the end shield. When opening the bearing housing, locate before, if and on which side of the machine the adjusting shims(upper and lower parts)are installed. These shims must be installed at the same place when assembling the machine. Exceptions are possible, if the stator core was changed. Drain the oil, take off the upper part of the bearing housing and the upper bearing shell, lift the shaft very slightly and turn out the lower bearing shell and the sealing rings in peripheral direction. The oil ring can be withdrawn by holding it at an inclined position to the shaft.

If only slight damage has occurred to the bearing surface, it may be re-conditioned by scraping as long as the cylindrical shape of the bore is

maintained, so that a good oil film can form. The lining must be renewed if more serious damage is found. The oil pockets and grooves of the new lining or scraped shell should be cleaned and finished with particular care.

The replacement bearing shells are delivered by the works with a finished inner diameter. Only the bearing shells were delivered unfinished, the inner diameter is 1mm smaller than the finished diameter.

Oil rings which have become bent through careless handling will not turn evenly. Straighten or replace such rings. Replace any damaged sealing rings.

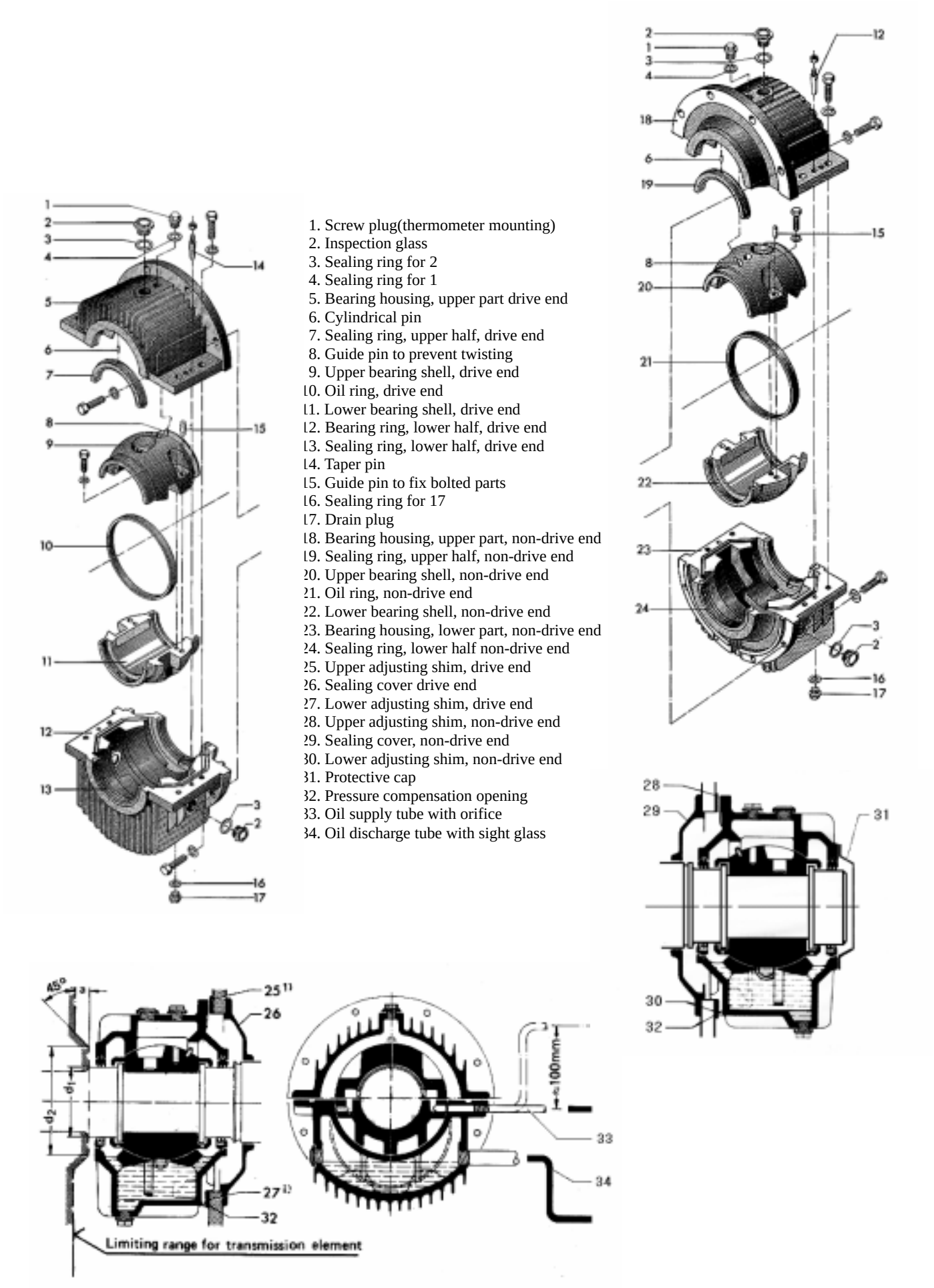


Fig. 22 Flange-type sleeve bearing for forced-oil lubrication

(examples, delivered design may deviate in details)

10.3 ROLLING- CONTACT BEARING

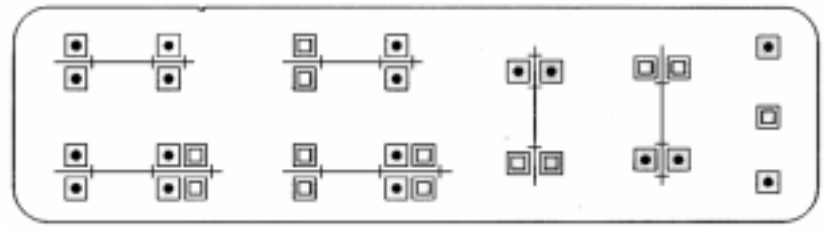
1) Mounting

Electrical machines fitted with rolling-contact bearings mentioned above are subject to the following instructions supplementing and modifying the operating instructions of the machine:

The locating bearings are deep-groove ball bearings for horizontally mounted machines. These bearings may also be in pairs with cylindrical roller bearings in the case of bearings is not guide radially and is prevented from rotating by compression springs.

The locating bearings for vertically mounted machines are angular-contact ball bearings of type range 72 or 73 (angular-contact ball bearings with increased axial fixation see supplementary operating instructions.)

The floating bearings are deep-groove ball bearings or cylindrical roller bearings. In case of deep-groove ball bearings as floating bearings, the axial play is compensated by means of compression springs.



Deep-groove ball bearing

Cylindrical roller bearing

Angular contact ball bearing

Fig. 23 Examples for bearing combination

1) Regreasing

Initial lubrication of the bearings is normally carried out in the works with a Alvania #2 grease satisfying the conditions of running test at a test temperature of 120℃ to DIN 51 806. If a different type of grease is required, this is indicated on the data plate, provided that the particular operating conditions were given in the order.

Keep the new grease meticulously clean. Greases having a different soap base should not be mixed since this would reduce the grease quality.

For regreasing clean the lubricating nipple and press in the grease quantity indicated on a data plate, using a grease gun. The shaft should rotate during regreasing, hence the machines need not be stopped. After regreasing, the bearing temperature will rise by a few degrees and will drop to the normal value when the grease has reached its normal service viscosity and the excess grease has been forced out of the bearing.

It is recommended that the lubricating instructions be strictly followed. Special cases may require lubrication to special instructions, e.g. where there is an extreme coolant temperature or aggressive vapours. The old grease from several regreasing operations gathers in the space inside the outer bearings caps. Remove the old grease when overhauling the machines.

The model of bearing is favorably chosen as for direction and size of load (type of construction, forces acting on the shaft)and therefore it should not be changed.

The permissible values of axial and radial forces may be taken from the list of machine or may be inquired.

The machines should operate in only one type of construction as shown the rating plate, because another type of construction required perhaps further measures in addition to a modification of the model of bearing. Always in this case an inquiry is necessary.

2) Lubrication

Regrease the bearings if the machines have been stored unused for longer than 2 years.

3) Dismantling, Assembling

For working on the locating bearing in the vertical position of the machine, support or discharge the rotor.

It is recommended that new rolling bearings be installed as follows: Heat the ball bearings or the inner ring of the roller bearings in oil or air to a temperature of approx. 80℃ and slip them onto the shaft. Heavy blows may damage the bearings and must be avoided.

When installing single angular-contact ball bearings, make sure that the broad shoulder of the inner ring(and the narrow shoulder of the outer ring) in operating position points upwards, i.e.in a direction opposite to that of the axial thrust.

When assembling the machines, avoid damage to the sealing rings. Rubber sealing rings(V-rings) should be carefully fitted over the shaft as shown the illustration. New felt sealing rings should be so dimensioned that the shaft can run easily while proper sealing is still effected. Before fitting new rings, soak them thoroughly in highly viscous oil(normal lubricating oil N68 to DIN 51 501) having a temperature of approx. 80℃.

4) Locating Faults.

The trouble shooting table helps to trace and remove the causes of faults. It is partly difficult to be found the damages of bearings. In the case doubt it is recommended to renew the bearings.

10.4 INSULATION TO PREVENT SHAFT CURRENT (High Voltage And Large Machines)

To prevent the shaft current according to the unbalance of magnetic reluctance in magnetic circuits, the insulator is provided at end shield side as shown in Fig. 24.

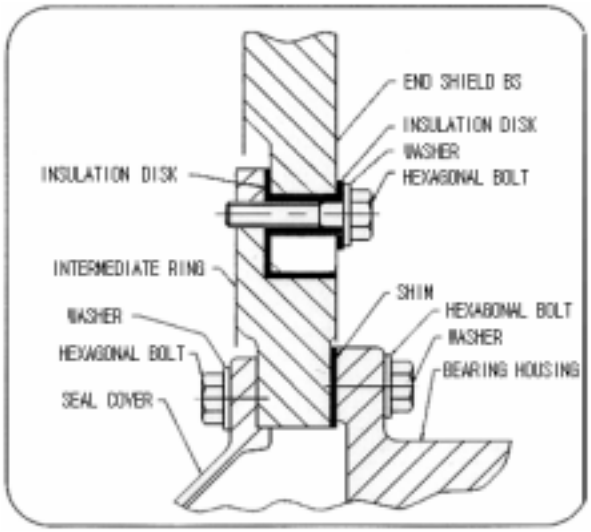


Fig. 24 Bearing insulation

With motors having one shaft extension, the bearing at non-drive end is insulated. Motors with double end shafts are insulated at drive & non-drive end bearings. When double end shaft motor is coupled with driven load, insulation must be supplied in the coupling of one end to prevent bridging of bearing insulation.

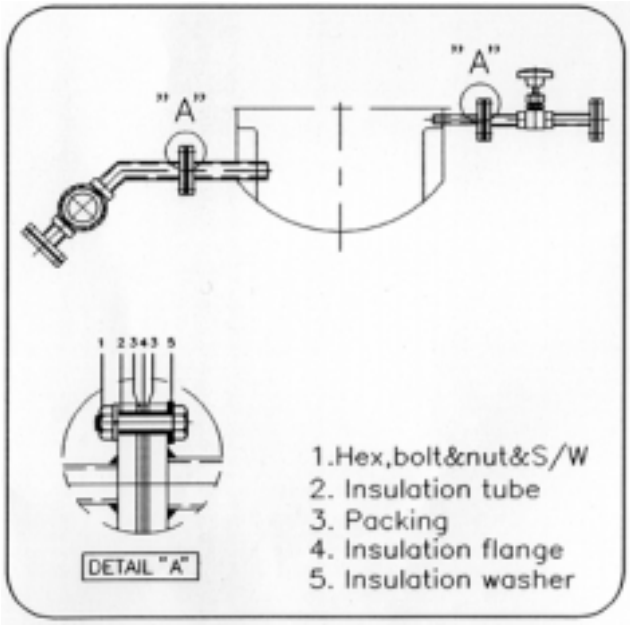
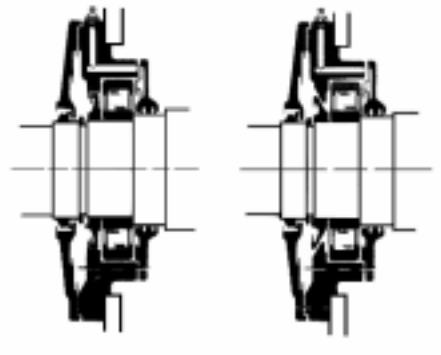
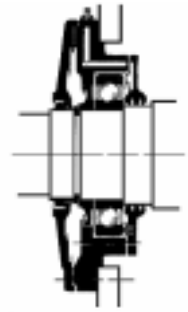


Fig. 25 Bearing cooling pipe system for forced-oil lubrication

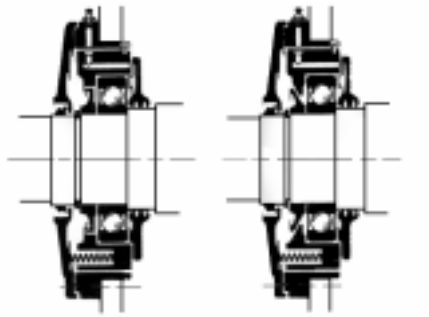
A care should be taken that this insulation is not shorted out. All lines (Lubrication oil pipes, B.T.D, Vibration sensors etc.) fitted at the workshop are insulated from the end shield, but it is necessary to ascertain whether or not the insulation is required for all lines which are connected at the time of the motor installation at the site. The bearing cooling pipe for forced-oil lubrication is insulated as shown in Fig.25. The shaft voltage(Peak to peak) is high frequency voltage of usually 1 volt or less and rarely several volt. When a shaft current by this voltage flows, the shaft and journal part are tarnished and in the worst case sparking can make minute black spots on shaft and journal part. There is a possibility that the oil film is broken locally, developing a bum-out trouble. When disassembling or assembling, be sure to measure the insulation resistance. The value of 1 to 3kΩ will be satisfactory.



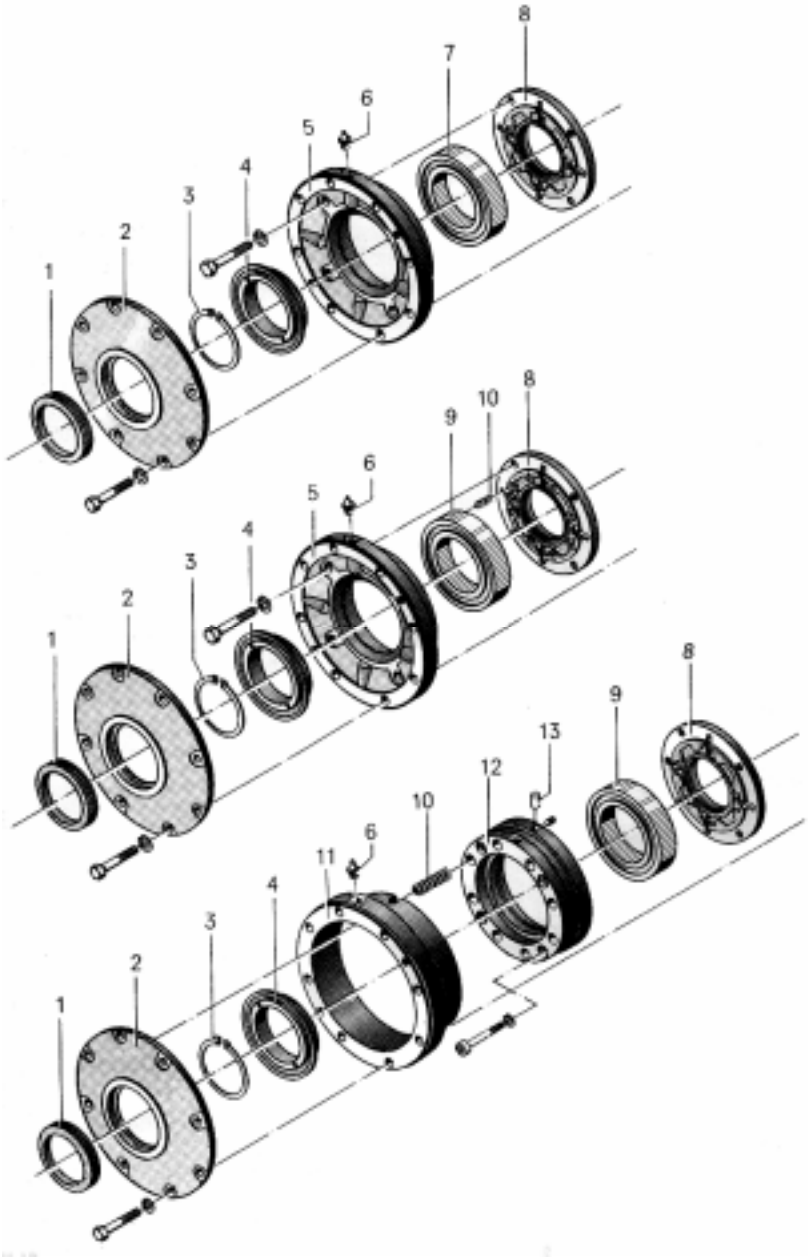
Cylindrical roller bearing



Deep-groove ball bearing
with compensation of axial play



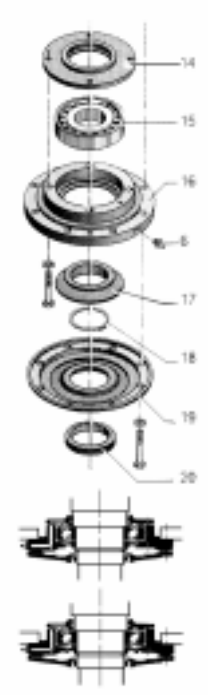
Deep-groove ball bearing with compensation of axial play, with bearing housing bush and intermediate ring



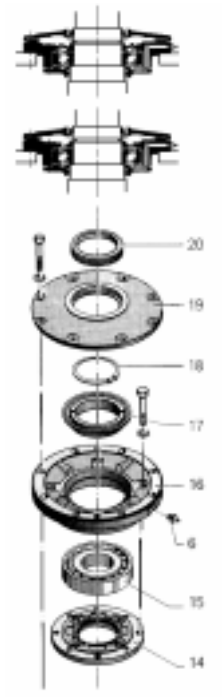
1. V-ring 1)
2. Outer bearing cap 1)
3. Circlip 1)
4. Grease slinger 1)
5. Bearing housing 1)
6. Lubricating nipple
7. Cylindrical roller bearing 1)
8. Inner bearing cap with felt sealing rings1)
9. Deep groove ball bearing (floating-bearing)
10. Compression spring 1)
11. Bearing housing ring
12. Bearing housing bush
13. Cylindrical pin

1) floating bearing side

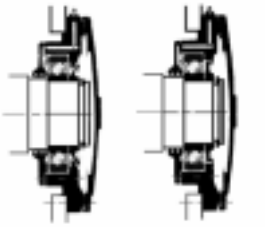
Fig. 26 Floating bearings (examples, delivered design may deviate in details)



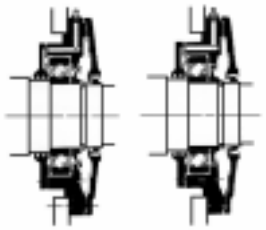
Angular-contact ball bearing placed below



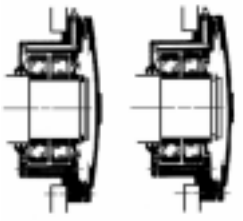
Angular-contact ball bearing placed above



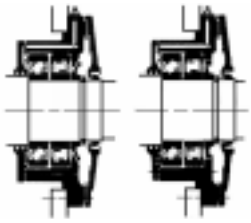
Single bearing, shaft does not pass through the outer bearing cap



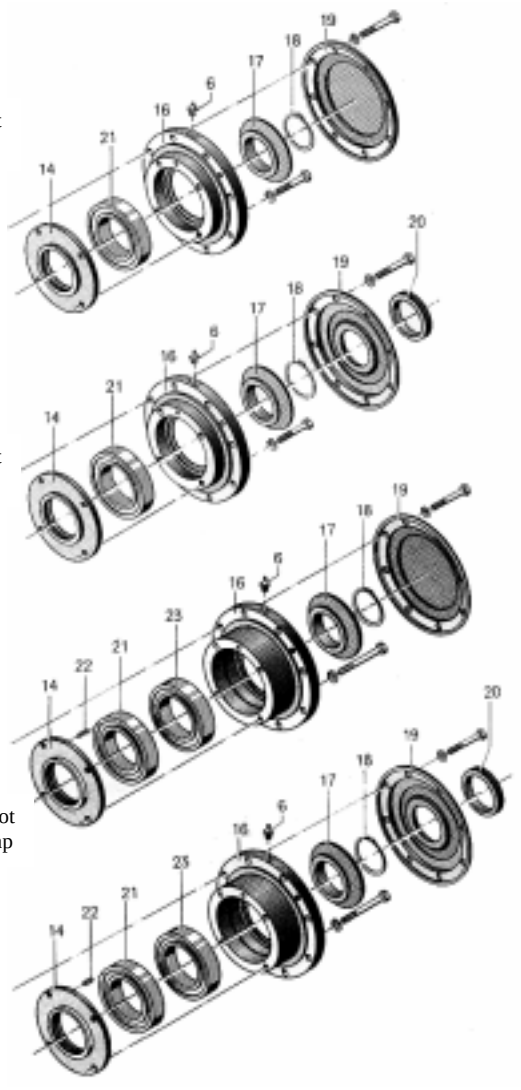
Single bearing, shaft does not pass through the outer bearing cap



Single bearing, shaft does not pass through the outer bearing cap



Single bearing, shaft does not pass through the outer bearing cap



14. Inner bearing cap with felt sealing rings 2)
15. Angular-contact ball bearing
16. Bearing slinger 2)
17. Grease slinger 2)
18. Circlip 2)
19. Outer bearing cap 2)
20. V-ring 2)
21. Deep-groove ball bearing (locating bearing) or angular-contact ball bearing
22. Compression spring 2)
23. Compression spring 2)
24. Cylindrical roller bearing 2)
25. Oil seal for shaft 1) 2) 3)

1) floating bearing side
2) locating bearing side
3) special operating conditions only

Fig. 27 Locating bearings (examples, delivered design may deviate in details)

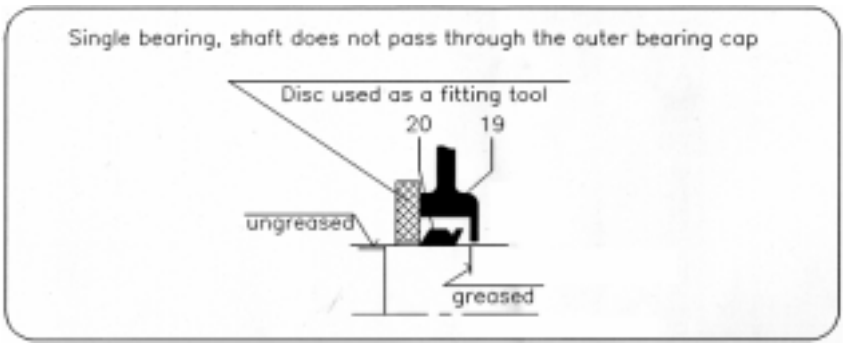


Fig. 28 Fitting instructions for V-ring and oil seal for shaft

11. AIR FILTER AND COOLER

11.1 AIR FILTER

Air Filter Cleaning Period
The cleaning period depends on the site conditions and can change. The cleaning of the filter is requested if the record of the stator winding temperature (using the stator winding sensors) indicates an abnormal increase in temperature.

Air Filter Cleaning Procedure
The filter element (flat or cylindrical) is immersed in a tank of cold or warm water (temperature less than 50℃). Use water with detergent added.
Shake the filter gently to ensure that the water flows through the filter in both directions.
When the filter is clean, rinse it with clear water.
Drain the filter properly (there must be no more formation of droplets).
Refit the filter on the machine.

> **CAUTION** ; Do not clean the filter using compressed air. This procedure would reduce filter efficiency.

11.2 COOLER

1) General Points
The purpose of the cooler is the remove machine heat losses (mechanical, ohmic etc). The exchanger is located on the top of the machine.

Normal Operation
The air is pulsed by a fan fixed to the machine shaft.

Description of air-water double tube exchanger
The double-tube technique keeps the cooling circuit from being affected by possible water leakage. The double tube provides a high safety level. In case of leakage, the water goes from the inside of the internal tube to the coaxial space between the two tubes. The water is drained axially to a leakage chamber where it may activate a sensor. An exchanger comprises a fin-tube block containing :
-. a steen frame
-. a fin-tube block expanded mechanically to the tubes.
The tube bundle is roll-expanded in the end plates. The water distribution in the tubes is provided by two removable water boxes. A water box is equipped with collars for fitting the inlet and outlet lines. Neoprene seals ensure water boxes and the end plates.

2) Cleaning
The frequency of cleaning operations depends essentially on the purity of the water used. We recommend a minimum of one inspection per year. The life of zinc block for anti-corrosion is about a year. Therefore replace it with a new one every year. Cut off the water supply by isolating the inlet and outlet lines and drain the water. Disconnect the leak sensor(option with double-tube cooler) and make sure that there are no leaks. Remove the water boxes on each side of the machine. Rinse and brush each water box.

Note : Do not use a hard wire brush as this will remove the protective tar-epoxy layer which has formed on the surface of the water boxes. Clean each tube with a metal scraper. Rinse in soft water. Keep the leakage chamber dry(double-tube water-cooler only)

3) Stop The Machine
Leak detection for a double-tube exchanger. If a leak is detected, cut off the power supply of the water in/outlet lines and change to emergency operations, it is necessary to ascertain and repair it. Remove the two water boxes, apply a slight positive pressure in the leakage chamber and thus between the two tubes (only concerns double-tube coolers). If a tube is damaged plug it at both ends. Use a tapered plug. The plug should preferably be made of salt-water resistance aluminum bronze or of a synthetic material.

4) Leak Detection (Float System)
A magnet float activates a switch located in the float guiding rod.

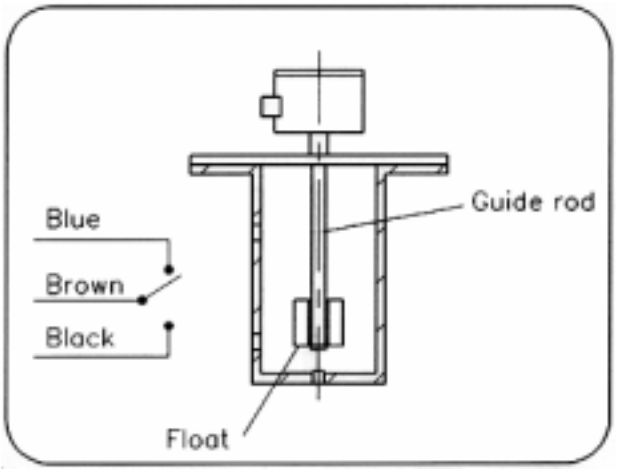


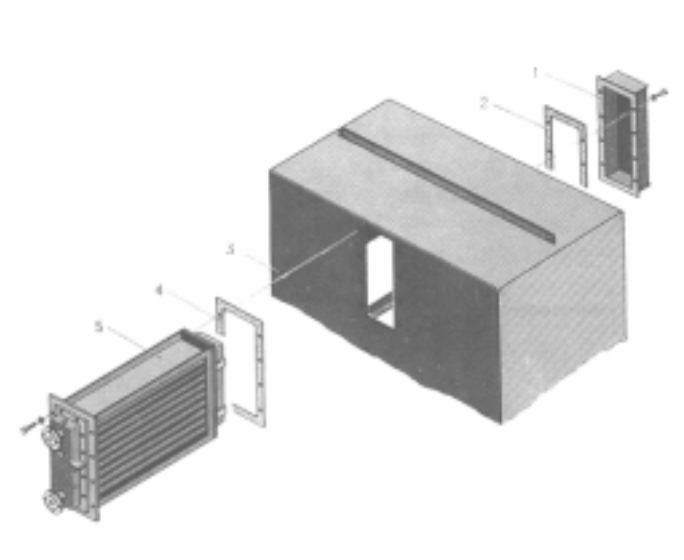
Fig. 29 Leakage detector

5) Cooler Removal

The cooler unit is slid into its housing. It is possible to remove the cooler from the housing without removing the water boxes. The cooler is fastened to the housing via a series of screws on the housing. Remove the supply and return pipes. Provide two supports to hold the cooler when it comes out of its housing. Remove the cooler using slings that can be attached to the connecting flanges.

6) Cooler Re-Assembly

Carry out the operations of th "Cooler Removal" in the reverse order. Be careful to push the cooler completely into its housing before tightening the fastening screws of the cooler to the casing.



1. Cover
2. Gasket for 1
3. Cooler housing
4. Gasket for 5
5. Air to water cooling element

Fig. 30 Cooler Removal

12. PROTECTION(GENERAL)

It is our recommendation that all electric motors are fitted with motor protection. The preferred type of motor protection should provided the following protection features;

1) Current limit by a programmable thermal limit curve with thermal modeling based by winding temperature.

2) If installed RTD for winding temperature detector, winding temperature detection by RTDs should be separated alarm and trip setpoints.

3) Ambient temperature RTD located in the motor ambient air stream.

4) If installed bearing temperature indicator, alarm and trip setpoints separate.

5) Calculation of motor thermal capacity available.l

6) Ground fault detection.

7) Current unbalance detection.

8) Capacity for the protection system to learn motor cooling times.

A motor protection system with these features should reward you with better reliability and will allow you to optimize the motor to is maximum performance

PROTECTION SETTING RECOMMENDED

Guide values for adjustment of tripping temperature.

Description	Insulation Class 'B'			Insulation Class 'F'		
	Permissible Max. Temp.rise (T)	Alarm	Trip	Permissible Max. Temp.rise (T)	Alarm	Trip
Winding Temperature	max. 130 deg	125K	130K	max. 150 deg	145K	150K
Bearing Temperature Anti-friction*)	max. 90 deg	85K	90K	max. 90 deg	85K	90K
Bearing Temperature (Sleeve)	max 90 deg	85K	90K	max 90 deg	85K	90K
Current unbalance	max. 10%	6% (10sec delay)	10% (Inst.)	max. 10%	6% (10sec delay)	10% (Inst.)

-. T means operation temperature including ambient temperature.
-. Max. permissible temp.rise includes ambient temperature.
⋆ In the case when a suitable heatproof lubricant is used or a greasing interval is changed, the limit of temperature rise shall be determined by agreement between manufacturer and purchaser

13. FAILURE AND REMEDIES OF INDUCTION MOTORS

Abnormality		Probable cause	Remedy
Motor fails to start	Power source & line	1. Drop in line voltage	A check is to be made with a voltmeter.
		2. Great drop in voltage due to inadequate line capacity and impedance drop.	a. A check is to be made on voltage at motor terminal before and at time of starting. b. Similar change in voltage is to be checked at motor terminal.
		3. Cut line or unbalanced	Defective parts are to be repaired.
	Starter	4. Erroneous wire connection.	To be repaired
		5. Cut line or unbalanced voltage.	To be reconditioned.
		6. Drop in line voltage	Compensator tap connection is to be raised.
		7. Cut line or unbalance in starting resistor.	Resistance is to be measured; repairs are to be made.
	Motor	8. Cutting of stator coil or of rotor coil.	Resistance and current are to be measured, and repairs are to be made.
		9. Erroneous connection of stator coil.	To be reconditioned
		10. Defect of rotor.	a. Squirrel cage motor; Rotor conductor is to be checked for disconnection. b. Wound motor; A check is to be made for line cutting and unbalance. c. Repairs or renewal is to be made.
		11.Stator core is in contact with rotor.	a. A check is to be made by turning by hand.
		12. Defective bearing	b. Bearing is to be disassembled and examined.
		13. Insufficient starting torque	a. Squirrel cage motor; Motor is to be replaced with the one having larger capacity and of the wound type. b. Wound motor; Tap for starting resistor is to be replaced.
	Load	14.	Load is to be reduced.

Abnormality	Probable cause	Remedy
Length of time required for acceleration after starting	1. Inadequately low voltage.	A check is to be made on voltage drop of power source and line.
	2. Defective rotor.	a. Squirrel cage rotor; Rotor bar and end ring are to be checked for contact. b, Wound motor; A check is to be made on coil for unbalance and on brush for imperfect contact.
	3. Overload or inadequate torque	Load is to be checked; If load is normal, motor capacity is to be changed.
Rotation in reversal direction	Phase reversal	Two phases of U.V.W(or R.S.T) at starter or motor terminal are to be changed.
Motor body overheated	1. Overload	Load is to be reduced(to rated current)
	2. Overcurrent due to voltage drop.	a. A check is to be made with a voltmeter Power source voltage is to be raised.. b. Load is to be reduced.
	3. Excessive iron loss due to overvoltage.	A check is to be made with a voltmeter Power source voltage is to be reduced.
	4. Cut line or imperfect contact in one phase	To be reconditioned
	5. Short-circuiting and grounding of coil	Resistance and current are to be checked, and reconditioned.
	6. Contact between stator and rotor	Judgement can be made according to noise; Bent shaft, bearing, etc. are to be corrected.
	7. Inadequate ventilation due to dust.	Cleaning is to be carried out.
Vibration	1. Unbalance of rotor a. Bending of shaft b. Loose joint c. Residual unbalance d. Critical speed of shafting e. Dust attached to rotor f. Imperfect connection between coupling and shaft	 To be repaired. To be tightened by bolts securely. To be readjusted. To be cleaned. To be reconditioned.

Abnormality	Probable cause	Remedy
	2. Improper magnetic center	To be reconditioned.
	3. Defective bearing	Refer to the section "Bearing"
	4. Coupling deflection	To be reconditioned.
	5. Abnormal contact between shaft and stationary part, such as end cover,etc.	a. To be checked by turning manually. b. To be disassembled for detecting defects.
	6. Unsatisfactory contact of brush.	Brush is to be checked for contact.
	7. Improper alignment.	To be reconditioned.
	8. Sinking of foundation.	To be reconditioned.
	9. Transmission of vibration from combined machine.	Insulation for vibration.
	10. Unequal pitch of claw coupling.	Reconditioning of pitch.
	11. Improper bush of flexible coupling.	Reconditioning of pitch.
Noise	1. Disagreement of air gap.	Cause are to be detected; and repairs are to be made.
	2. Single phase operation.	Causes of single phase operation such as line cutting and imperfect contact are to be detected; and repairs are to be made.
	3. Short-circuits of layer and phase of stator coil and rotor coil.	To be reconditioned.
	4. Abnormal contact between shaft and stationary part such as end cover.	a. A check is to be made by turning manually. b. To be disassembled for inspection.
	5. Unsatisfactory foundation and installation.	readjustment of installation.
	6. Loose bolts for foundation	Foundation bolts are to be tightened.
	7. Gap between foundation and base.	Reconditioning of installation
	8. Resonance with foundation	Readjustment of foundation
	9. Crackings at brazed joint rotor bar and end ring.	To be disassembled and defective parts are to be repaired.
Unbalance of phase current	1. Voltage unbalance.	Power source and lines are to be checked and balanced.
	2. Single phase operation.	Line cutting and improper contact are to be reconditioned.

Abnormality	Probable cause	Remedy
	3. Secondary circuit	a. Rotor shaft coil resistance is to be measured and reconditioned. b.Contact of brush or shortcircuit ring is to be checked. c. A check is to be made on endring contact of a squirrel cage motor.
Flaking (a) Flaking of rolling elements	1. Excess of tightening allowance.	1. A care should be taken of shaft at time of assembling and of bearing box at time of matching.
	2. Erroneous selection of clearance.	2. Clearance is to be reinspected.
	3. Minus operating clearance.	3. A care should be taken at time assembly.
	4. Thermal expansion	4. Examination of working condition
(b) Local flaking of a race	1 Inclusion of dust and other foreign substances or rust, bruises	
(c) Flaking all over a race	1. Shaft or bearing box is distored elliptically.	Machining accuracy and tightening of bearing box are to be checked.
	2. Improper tightening	
(d) Flaking on component parts opposite to a race	3. Inaccuracy due to improper matching.	
	4. Deterioration with time	
(e) Flaking all over around track center	Abnormal thrust load	Design of bearing system is to be checked
(f) Flaking across a race	1. Shaft bending	
	2. Oblique fitting of outer and inner rings	
(g) Flaking similar to pitting on a race	1. Vibration during stoppage	Examination of working condition.
	2. Rust	

Abnormality	Probable cause	Remedy
Seizing (a) Race ring and rolling discolored and turned soft (b) Damage	1. Inadequate clearance.	Proper clearance is to be provided.
	2. Inadequate lubrication	Oil amount of lubricant is to be checked.
	3. Improper overload of lubricant	Reconsideration of working condition and handling.
Breakage (total or partial) (a) Fracture (b) Cutting	1. Advancement of flaking caused by shock and below. 2. Great tightening allowance & large round corner of fitted part.	Careful handling Examination of tightening Examination of machining accuracy of shaft & bearing housing
Breakage of retainer (a) Fracture (b) Non-uniform abrasion (c) Wear of pocket section (d) 'Biting-off'	1. Moment load 2. Rotation at shift speed 3. Inadequate lubrication 4. Inclusion of foreign substances	Careful handling and reconsideration of working condition. Examination of oil supply and lubricant.
Rust (a) Rust formed all over surface (b) Rust on local place (c) Contact erosion on joint surface	1. Unsatisfactory condition of storage. 2. Left alone 3. Inadequate cleaning 4. rust preventive reagent 1. Unsatisfactory packing 2. Sweet 1. Inadequate allowance of tightening. 2. Change in load	Inspection of storage room. Careful handling Examination of rust preventive reagent. Re-examination of machining of shaft & bearing housing. Re-examination of working condition.
Wear (a) Abnormal wear of race and rolling element (b) Abnormal wear of retainer	1. Inclusion of foreign substances. 2. Occurrences of wear. Inadequate lubrication.	Examination of lubrication and oil supply
Electrode (a) Cratershaped depression and corrugated scars	Passage of current	Examination of design of bearing system

Abnormality	Probable cause	Remedy
Dent and scratch (a) Indentation (on a race, etc.) (b) Aventurine hardening (c) Dents given during handling (d) Scratches during assembly	Dust and foreign substances pressed between race and body Careless handling (dropping, etc.)	Examination of handling and assembling conditions. Careful handling Careful assembling
Smearing Biting-off on a race and rolling element.	1. Inadequate lubrication 2. Skewing of rolling element. 3. Selection of lubricant.	Examination of lubricant and lubricating condition.
Creep wear of outer and inner surface, sliking and discoloring.	1. Inadequate tightening allowance. 2. Inadequate tightening of sleeve.	1. Examination of tightening. 2. Examination of machining accuracy of shaft and bearing box. 3. Examination of design.

LONG TERM STORAGE MANUAL

FOR

INDUCTION MOTORS

HYUNDAI ELECTRIC & ENERGY SYSTEM CO., LTD.

Maintenance Work during Relatively Long Storage Periods before First Operation or while Shutdown for Servicing

Induction Motors / Generators

Maintenance

If a machine has been out of service for more than three months, the following procedures should be followed. The intervals depend on the operating and site conditions. The following works are recommended under normal conditions.

Package conditions. Table 1

<table>
<tr><td rowspan="2">Package condition</td><td>Machine with export packing.</td><td>Without packing or machine with domestic packing.</td></tr>
<tr><td colspan="2">Machine should be stored in a correct mounting position. Machine should be covered with suitable water-proof canvases.</td></tr>
<tr><td>Storage location</td><td>1. Machine with packing should preferably not be stored in outdoors. where possible, machines should be stored indoors in a clean, dry area.
2. If indoor storage is impossible for machine with packing, it is recommended that the storing it under a weather-proof roof. or alternatively cover it with canvases.</td><td>1. Machine should not be stored in outdoors. where possible, machines should be stored indoors in a clean, dry area.
2. If indoor storage is impossible for totally-enclosed, outdoor application machine, it is recommended that covering it with canvases.</td></tr>
<tr><td>Works for packing</td><td colspan="2">1. In the case of condition before installation.
(1) Stacking of heavy machine stop one another should be avoided. Machine should be stored in such a way that no base frame will suffer distortion.
(2) Attention should be paid to the loading capacity of floor. Care should be taken, so that the floor, on which machine is stored, is not subjected to vibration and free from moisture.
(3) Storing of machine for longer than one year is not recommended. If the storing is continued, following procedures described in Table 2 should be done in year :
1) Seal the silica-gel within packing and replace at regular intervals.
2) Fully seal the packing.
(3) The store room should be well ventilated and selected for possible protection against moisture and dirt.
2. Cover the air intake and discharge openings of open-enclosure machine by canvases to prevent the dust deposits inside the machine.
3. If the other works are still in progress even after completed installation of machine, machine should be protected from ingress of foreign matters by a temporary protection covering.</td></tr>
</table>

Maintenance work preparatory on machine parts. Table 2

	During long storage	Prior to operation
External, unpainted metal surfaces.	Apply the following rust-preventive materials or equal : RUST VETO 244. 342.(E.F.Houghton). P101(Nippon Sekiyu). TECTYL 506(Valvoline Oil).	Remove the rust-preventives with suitable solvents.
Bearings.	Rotate the shaft slowly at least 10 revolutions by hand (*) or for several minutes by temporarily operate (**) the machine once every three months. Exception : In machine with export packing.	1. Check to see that shaft locking-provisions and temporary-covers have been removed, when provided. 2. Check for irregular noise by shaft rotation by hand. 3. If possible, check that bearings are free from rust.
Regreasable anti-friction bearings.	Supply the following amount of grease to the bearing while rotating the shaft by hand. Regreasing amount is indicated on the rating plate. Supply the grease once a year. Prior to grease supply, Open the grease outlet. Remove the original grease to avoid excessive filling the bearing cavity and to avoid grease leaks from shaft seals.	1. Remove the old grease from the grease outlet opening before beginning operation. 2. Supply new lubricant of the amount indicated on rating plate while rotating the shaft by hand or while the machine is running. 3. Remove old grease by running the machine for a few hours with the grease outlet open.

<table>
<tr><td>Oil lubricated bearings</td><td>1. Check the reservoir filled with lubricant up to the proper line on the oil level gauge.
2. If a machine is out of service for more than one month, the following procedures should preferably be followed monthly :
(1) Lubricate a machine with combined angular-contact ball (72 or 73 series) bearings by operating it for about 10 minutes. Lubricate a bearing of large output machine, provided with oil inlet plug on the top of oil reservoir, by pouring oil through the oil inlet. Then immediately rotate its shaft at least 10 revolutions by hand. After that, drain off excess oil.
(2) For a machine with a spherical-roller thrust (293 or 294 series) bearings. A machine should be run for about 10 minutes or the shaft rotated at least 10 revolutions by hand.
(3) In a machine with sleeve bearings, a machine should be run for about 10 minutes or the shaft rotated at least 10 revolutions by hand. When rotate the shaft, supply about 50 to 100cm3 of the lubricating oil through the screw plug (or sight-glass) of bearing housing.
3. Replace with new oil once per year.</td><td>1. Open the drain plug and remove the original oil. Fill the reservoir with the new lubricant up to the proper line on the oil level gauge.
2. In the forced-feed, oil-lubricated bearing.
(1) Clean the inside of the oil pipings and refresh them, when required.
(2) Fill the bearings connected to a feed-oil system with specified oil, check the system for satisfactory operation.</td></tr>
<tr><td>Insulated windings</td><td colspan="2">Insulation resistance between winding and earth be measured every six months (Every one year in machine with export packing) and before the machine is started. If the lower insulation resistance value is measured, open the terminal-box cover and, if the value does not increase, winding should be dried before being energized.</td></tr>
<tr><td>Anti-condensation heater, when provided.</td><td>Heater should be energized, in machine without packing, when power-supply cables and heater leads are connected. To prevent moisture accumulation, some form of heating must be utilized to prevent condensation. This heating should maintain the winding temperature at a minimum of 5℃ above ambient.</td><td>Heater should be disconnected before machine is started up.</td></tr>
<tr><td>Water drain</td><td colspan="2">Drain water by opening the drain plug in the enclosure.</td></tr>
</table>

plug, when provided.	At regular intervals of not longer than six months. One year in machine with export packing.	-
Slip rings	Check the surface for signs of corrosion every six months and prior to operation (one year in machine with export packing.)	
Openings	Any unused cable entry into terminal box(s) should be closed.	Remove the temporary protection covers, when provided
Painted external surfaces	Repaint at regular intervals, when necessary.	

Notes (*) : When possible. (**) : When the machine is installed ready for operation.

Check and inspection items prior the operation, addition to items described above

Enclosure :

(1) Check that cooling air can flow unobstructed to and form the machine.

(2) Check the enclosure and external rotating parts for damage or corrosion.

(3) Check to insure that rotating parts do not contact with stationary one.

(4) Inspect the shaft sealing for correct mounting.

(5) Check the screws and base or flange-bolts have been tightened.

(6) In maintain the necessary degree of protection required for enclosures of machines used for outdoor applications, refit gaskets. When provided, and carefully coat all surfaces to be sealed with a sealed with a sealing agent when reassembling.

Terminal box, terminals :

(1) Check cable terminals are correctly connected electrically.

(2) Check all electrical terminals have been tightened.

(3) With flexible leads : Check the cable connections are properly insulated, all bare, live metal should be wrapped with insulation tape.

(4) Make sure that direction of rotation of machine is correct.

Storage of spare parts

Storage locations :

Packing should be stored in the storeroom. The storeroom should be well ventilated and selected for possible protection against moisture and dirt. Spare machine with anti-friction bearings should be stored in a place not subject to vibration.

Packing conditions :

(1) Anti-friction bearings : Spare bearings with packing which protects for long storage-periods should preferable be purchased.

(2) Sleeve bearings : Apply RUST VETO HEAVY (E.F.Houghton), TECTYL 506 (Valvoline Oil) or equal to finished surface, P103 (Nippon Sekiyu) or equal on lining. Coat the painting for other faces. Re-coat them every one year.

(3) Other parts : Fully seal the packing.

End.

HHIS-WZ-RE-006-09 2017.04 Designed by ADPARK

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