# TECO Instruction Manual

## Squirrel Cage Induction Motors




**NOTE**

Whilst Motors are installed awaiting commissioning they must be adequately protected against the elements, all external components in particular the shaft extension and external labyrinth seals at the drive end must be fully covered to avoid water ingress entering the motor body whilst stationery.

Please ensure that both the non drive end and drive end antifriction bearings are fully purged with sufficient grease at first start up/commissioning with the recommended grade and quantity of grease.

# TECO Electric & Machinery Co. Ltd.

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# Chapter 1: MOTOR DESCRIPTION

This manual applies to Teco model series types as follows:

AEEB, AEHB, AEHD, AEMB, AEVB, AEUB AEMV, AEJE, AFJE, AFJN, AEJU, AEJH, AFJH and AFJP.

The motors are of Cast Iron Construction, Totally Enclosed Fan Cooled, Squirrel Cage Induction type designed for operation on the following supply voltages 380/415/460/480/525/575/600/690/1000/3,300/6,600V 3 Phase 50Hz/60Hz supply systems equipped with grease lubricated anti friction type bearings.

## SAFETY WARNING

***The following instruction address the more common situations encountered in motor installation, operation and maintenance. For the TECO warranty to remain valid, the motor must be installed and operated in strict accordance with the outline drawing, motor nameplate and these instructions and must not be altered or modified in any unauthorized manner.***
***During the installation & operation of motors in heavy industrial applications there is a danger of live electrical parts and rotating parts. Therefore to prevent injury and/or damage the basic planning work for transport, assembly, installation & operation needs to be carried out by authorized and competent personnel. Points in this manual that are boxed and headed "DANGER", "CAUTION" or "NOTE"(see below) should be observed as they indicate possible danger to personnel and/or the potential of equipment damage.***




***This prompt is used when there is an immediate hazard that WILL result in severe personal injury or death if correct procedures are not followed.***




***This prompt is used to warn against potentially unsafe practices that COULD result in personal injury and/or property damage if correct procedures are not followed.***




***This prompt is used when an operation, condition, or information is of sufficient importance to warrant highlighting***

# Chapter 2: TECHNICAL DATA

This manual covers a power outputs ranging through to 1500kW with varying frame sizes and speeds etc.
For motor technical data refer to appropriate motor data sheet.

# Chapter 3: INSTALLATION AND COMMISSIONING

## 3.1. INSPECTION UPON RECEIPT.

Check the following points upon receipt:

a. Is the nameplate rating identical to your order?
b. Do dimensions and colour comply with your specification?
c. Are the nameplate ratings for the heater, temperature detector etc. identical with what you ordered?
d. Is there any damage due to transportation?
e. Is the original transportation shaft lock fitted to the drive end shaft?
f. Are all accessories in good order?
g. If there are any specific requirements, please check if they conform with your specification.

## 3.2. STORAGE

When storing motor, the following procedures should be undertaken.

3.2.1. Place.

a. It should be dry, well-ventilated and not subject to direct sunlight, dust or corrosive gas.
b. It should not be located close to a boiler or freezer.
c. It should be entirely free from vibration and have easy access.
d. Motor should be stored on pallets to prevent moisture ingress.

3.2.2. During storage, the insulation resistance should be kept above the specified values as follows:-

a. Stator: Above 50MΩ measured with 1000VDC megger.
b. If the motor has absorbed moisture as evidenced by low insulation resistance, it must be dried with external heat until it is thoroughly dry and the value of insulation resistance exceeds the minimum requirements.
c. Measurement of insulation resistance should be performed once every month.
d. Anti-condensation heaters should always be connected where fitted.

3.2.3 Insulation resistance test should be performed before making high voltage test.

a. Use 500VDC megger to measure insulation resistance.

i. Stator: Over 50MΩ between windings.

ii. Stator: Over 50MΩ between windings and earth.

b. High Voltage Test

i. This test can be undertaken only after the values of insulation resistance in item 3.2.3 (a) are assured.

ii. The value of testing voltage is (1000 + 2E) X 0.8 where E: rated voltage.

3.2.4. Care should be taken to keep parts such as the fitting surface, key, shaft extension and axial centre hole free of any foreign matter. Grease should also be generously applied to stop rust.

3.2.5. The shaft should also be rotated by hand a few revolutions once per month.

3.2.6. If practical, a test run should be performed once every three months.

3.2.7. Clean the motor thoroughly, and replenish grease before the machine is put back to operation.

3.2.8. The ventilation system should be covered to avoid the entry of foreign matter or insects. It should be thoroughly cleaned before use.

3.2.9. Make sure the hoisting hook is correctly connected to eye bolts or lugs of motors before hoisting.

**NOTE**

Parts such as fan cowl, terminal boxes, etc. which have their own lifting facilities can only carry their own weight. They should not be used for lifting the entire motor.

**DANGER**

An accident could occur if the motor eyebolt/lifting hook is overloaded.

They are suitable for the motor weights only.

Do not lift motor and load combined with motor lifting hook.

3.2.10. Points to note when hoisting:

a. Do not twist steel wires.

b. Make sure eye bolts have been firmly screwed in.

c. Keep the sling vertical when moving/lifting motor.

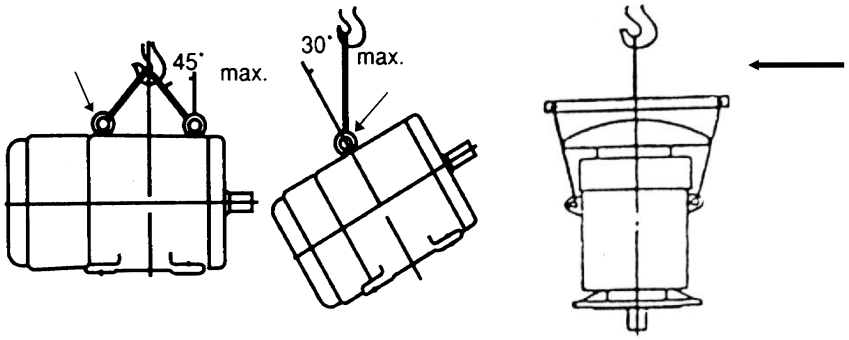
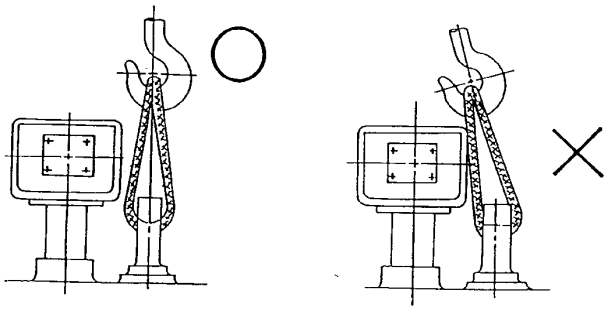



Fig. 1



Please keep the sling vertical when lifting / moving the motor.

Fig. 2

**CAUTION**

Motor is fitted with lifting points (arrowed). These points are designed to lift motor weight only.
Do not use other hooks or handles to lift motor.

## 3.3. TRANSPORTATION

To keep the rotating parts of motor from moving, thus causing damage during Transportation, they should be held securely as follows:

3.3.1. Motors fitted with a retaining plate/bracket to secure the shaft must have it fitted during transportation. Please retain this device for future transportation of the motor.

3.3.2. After receiving motor, remove all securing studs, nuts, etc. before putting motor into operation. (Fig.3)

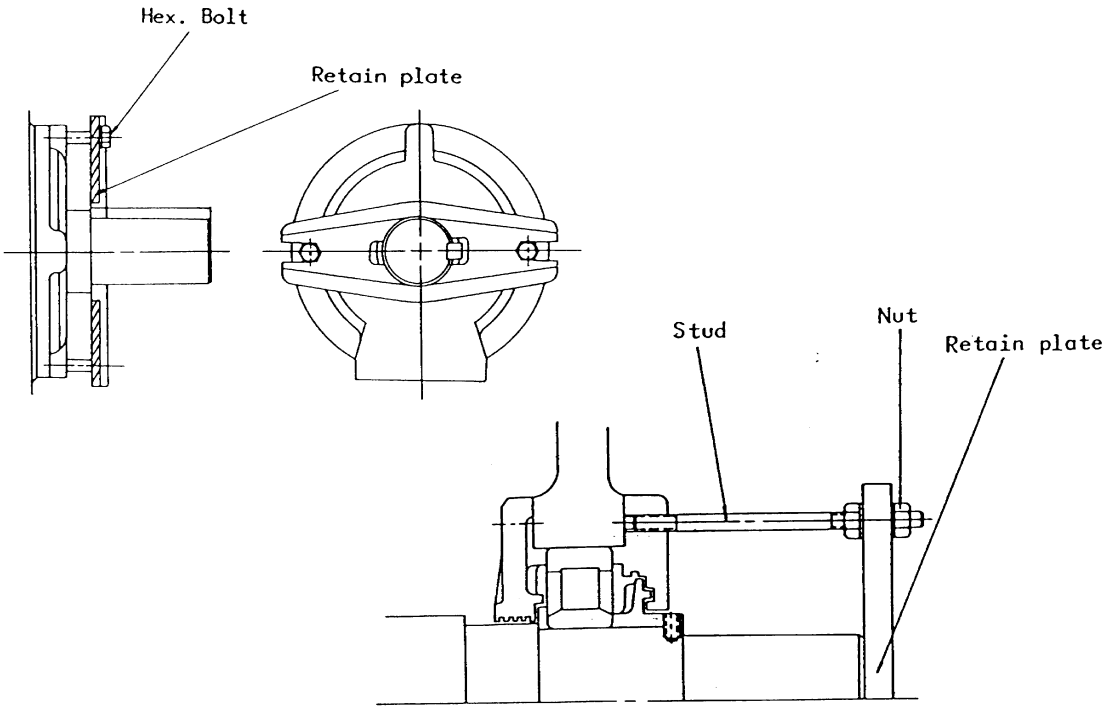



Fig 3

**CAUTION**

Shaft Locks are fitted as standard and these should be fitted during installation and should only be removed once the pulleys and guards are ready to be fitted. The motor must not be transported without the shaft lock fitted, damage to bearings caused by shaft locks being removed or moisture ingress whilst awaiting commissioning is not covered under motor warranty.

## 3.4. INSTALLATION.

3.4.1. Site conditions for motor installation:

Standard site conditions for installation of motors are as follows:

a. Ambient temperature: $-20^0$C~$40^0$C.

b. Humidity: Relative humidity below 90% RH for totally enclosed type.

c. Elevation: Below 1000 metres.

d. Should the installation be in an industrial zone, it should be free of explosive gases and liquids.

e. Foundation should be strong so as not to induce vibration.

3.4.2. Ventilation and Space.

a. Installation should be well ventilated.

b. The area should be large enough to facilitate heat dissipation and maintenance.

3.4.3. Foundation.

Use rigid and solid sole plate or common bed as the foundation.

## 3.5. MOUNTING.

3.5.1. An adequate motor support (which is the responsibility of others) is very important. It must have sufficient rigidity to maintain alignment between the motor and its driven load. Inadequate or improperly designed motor supporting structures can lead to serious vibration and alignment problems.

## 3.6. COUPLING & ALIGNMENT.

**CAUTION**

Two pole motors and motors larger than Frame 315M must not be coupled to the driven equipment by means other than direct connection.
Please refer to TECO if belt connection is to be used.

3.6.1. Installation.

Field application of a coupling to the motor shaft should follow the procedures recommended by the coupling manufacturer. Under no circumstances may the motor shaft be modified as to configuration or diameter without the approval of Teco Australia. The motor shaft extension must not be subjected to either extreme heat or cold during coupling installation. If it is necessary to exert axial force on the shaft, either continuously or intermittently, during coupling application, it must be properly restrained axially to prevent bearing damage.

3.6.2. After the motor has been properly aligned with the driven equipment and the hold down bolts have been installed and tightened, at least two dowel pins should be installed diagonally opposite motor feet.




The exposed rotating parts should be covered to prevent accidents.

3.6.3 Alignment.




Motors must always be accurately aligned. Incorrect alignment can lead to bearing failure, vibration and even shaft fracture. As soon as bearing failure or vibration is detected, the alignment should be checked.

In aligning the motor (and rotor) axially with the driven equipment, consideration should be given to the axial shaft expansion and increase in shaft centre line height due to thermal effects.
Shaft height growth (change in shaft centre line elevation) for TEFC machines can be calculated as follows,
Growth =(0.0005) x (motor foot to shaft centre line dimension [in mm]).

3.6.4 It is desirable, in normal operation that the motor operates, so that no axial force is exerted on the coupling.

The motor shaft and the driven shaft should be aligned within the following tolerances in both angular and parallel alignment (refer Table 1).

Units in mm

| TIR Total Runout Indicated | | Solid Coupling | Flexible coupling |
|---|---|---|---|
| Dimension C | Medium, Low speed up to 2500 RPM | 0.04 | 0.05 |
| | | | |
| | High speed over 2500 RPM | 0.03 | 0.03 |
| Dimension A | Medium, Low speed up to 2500 RPM | 0.03 | 0.04 |
| | High speed over 2500 RPM | 0.03 | 0.03 |

Table 1

3.6.5 Angular misalignment is the amount by which the centre lines of the driver and driven shaft are skewed. It can be measured using a dial indicator set up as shown in fig 4. The couplings are rotated together through 360 degrees so that the indicator does not measure runout of the coupling hub face. The shaft should be forced against either the in or out extreme of their end float while being rotated.

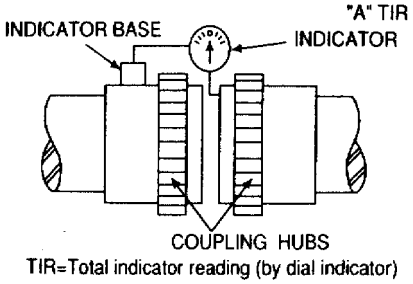



Fig. 4

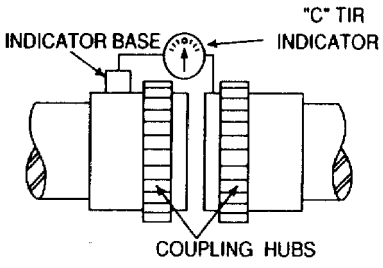



Fig. 5

3.6.6 Parallel misalignment is the amount by which the centre lines of the driver and the driven shafts are out of parallel. It can be measured using the dial indicator as shown in fig. 5. Again the couplings are rotated together through 360 degrees so that the indicator does not measure runout of the coupling hub outside diameter.

3.6.7 After the motor has been properly aligned with the driven equipment and the hold down bolts have been installed and tightened, at least two dowel pins should be installed diagonally opposite motor feet.

## 3.7. INSTALLATION FOR BELT DRIVE

**CAUTION**

Do not hammer the conveyance devices such as coupling, belt sheaves, chain wheels, gears, pulleys etc. onto the motor shaft. Those shaft fitments should be fitted and removed only by means of suitable devices. Heat shrinking may be a better alternative to avoid damaging bearings and other components.

3.7.1. Small, medium and large motors within frame sizes up to and including 315 frame are designed for use with belt transmission or direct coupling.

3.7.2. The diameter ratio between conveyance sheaves should not be greater 5 to 1 for flat belts, and 8 to 1 for V-belts. It is also advisable to limit the belt velocity to under 35m/sec to limit belt abrasion and vibration. The smaller the outer diameter of the V-belt sheave, the greater the shaft bending stress will be. If bending stress is in excess of the shaft fatigue stress, the shaft may break. If concerned please inform TECO of the size of the sheaves and belt details for checking.

**NOTE**

Place the sheave and belt as close as possible to the motor body and shaft shoulder to reduce the bending moment and improve shaft life.

## 3.8. ELECTRICAL CONNECTIONS

3.8.1. The rated conditions of operation for the motors are as shown by the nameplate. Within the limits given below, of voltage and frequency variation from the nameplate values, the motor will continue to operate but with

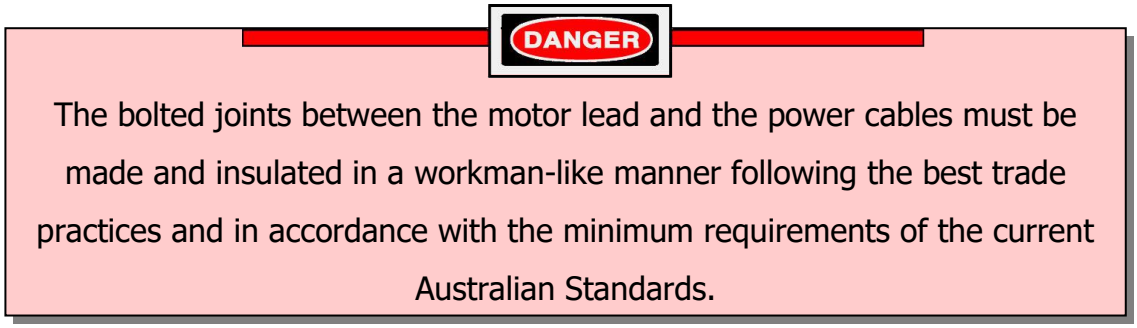
performance characteristics that may differ from those at the rated conditions:

- +/- 10% of rated voltage
- +/- 5% of rated frequency
- +/- 10% combined voltage and frequency variation so long as frequency variation is no more than +/- 5% of rated value.

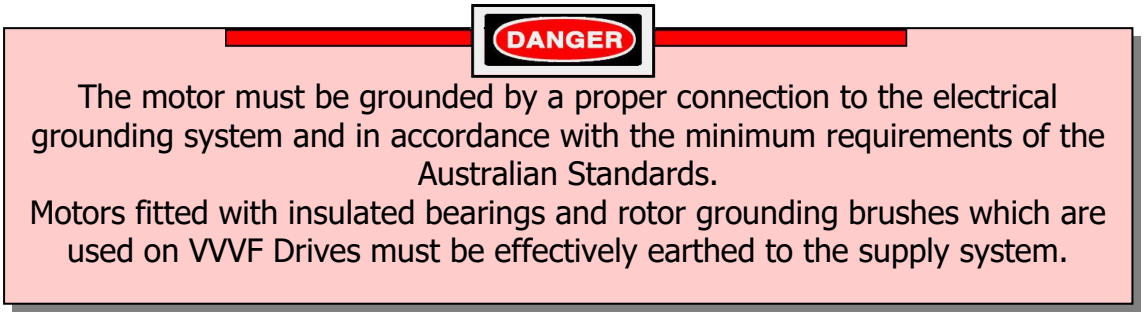
Operating the motor at voltage and frequencies outside of the above limits can result in both unsatisfactory motor performance and damage to/or failure of the motor.

3.8.2. Motor connections should be carried out in accordance with the details applicable to the appropriate supply voltage as shown on the motor nameplate and should be undertaken by suitably qualified personnel.

3.8.3. The main lead box furnished with the motor has been sized to provide adequate space for the make up of the connections between the motor lead cables and the incoming power cables.




3.8.4. The motors are provided with grounding pads and/or bolts for the connection of earthing.



## 3.9. AUXILIARY DEVICES

3.9.1. Please refer to your specification and the motor nameplate to determine if the motor is fitted with thermal winding protection devices.
The following are the most common:
One set (one per phase – total 3 off) of PTC winding thermistors.
Two sets (two per phase – total 6 off) of PTC winding thermistors.
One set (one per phase – total 3 off) of PT100 winding Resistance Temperature Detectors (RTD's).
Two sets (two per phase – total 6 off) of PT100 winding Resistance Temperature Detectors (RTD's).

3.9.2. Where specified motors may also be equipped with PT100 bearing Resistance Temperature Detectors (RTD's).

3.9.3. Thermistors are positive temperature coefficient type (1000 ohm @ tripping temperature) refer to specification table for tripping temperature.
They are a tripping device only and not a temperature detector.
Thermistor leads should be connected to an appropriate thermistor control relay from a reputable supplier.

3.9.4. RTD's where fitted are of the platinum type (PT100) with a reference temperature of 0°C at 100Ω.
RTD leads should be connected to an appropriate motor protection system from a reputable supplier.
Recommended temperature settings for RTD's are as per table 2 below.

| DEVICE | TYPE | LOCATION | ALARM | TRIP |
|---|---|---|---|---|
| RTD | PLATINIUM 100Ω @ $0^{O}$C | WINDING | $140^{0}$C | $150^{0}$C |
| RTD | PLATINIUM 100Ω @ $0^{O}$C | DE & NDE BEARING | $90^{0}$C | $95^{0}$C |

Table 2

**CAUTION**

Thermistors and/or RTD's should not be meggered or tested at a voltage above 2.5Volts.

**CAUTION**

Should the motor thermal protection circuit trip indicating over temperature the cause/s should be thoroughly investigated before a restart is attempted.
Failure to do so may lead to permanent damage or failure of the motor.

3.9.5. Where specified motors may be equipped with internal space heaters (check for nameplate), to prevent the ingress of moisture into the motor insulation system whilst motor is idle.
The incoming supply to the heaters should be in accordance with the details contained on the heater nameplate.
The heater circuit should be inter-locked with the motor starter so as to de-energise heaters when the motor is running.

**DANGER**

Anti Condensation Heaters may be LIVE when the motor is switched off. Isolate supply at all times before working on the motor.

# Chapter 4: OPERATING INSTRUCTIONS

## 4.1. EXAMINATION BEFORE START.

4.1.1. After motor is installed the following points should be noted:-

a. Check all wiring is correct and in accordance with connections appropriate to the supply voltage as shown on motor nameplate.

b. Is the incoming cable size adequate?

c. Are all connections tight and properly insulated?

d. Check the rating of fuses, starter/contactor are correct & operating normally.

e. Check motor is correctly earthed especially if supplied via a VVVF drive.

f. Make sure starter/switches are set in correct position.

g. Check heater circuit if fitted is de-energised when motor is in operation.

h. Check bearings are filled with the correct quantity and grade of grease.

4.1.2. Measurement of insulation resistance.

a. Rated voltage below 1000V, measure with 500VDC megger.

b. In accordance with IEEE-43 clause 9.3 standards, refer to following formula:

$$R\ (M\Omega) = > \frac{(\text{Rated Voltage} + 1)}{1000} \times 10$$

c. If a new winding has a low insulation resistance reading moisture ingress is generally the problem. Drying the winding through the proper application of heat will normally increase the insulation resistance to an acceptable level. Following are several accepted methods for applying heat to a winding:

i. If the motor is equipped with anti condensation heaters these can be can be energised to heat the winding.

ii. Direct current (as from a DC welder) can be passed through the winding. The total current should not exceed approximately 50% of rated full load current. Delta wound motors have six leads and the three phases should be connected into one series circuit.

iii. Heated air can be either blown directly into the motor or into a temporary enclosure surrounding the motor. The source of heated air should preferably

be electrical as opposed to fuelled (such as kerosene) where a malfunction of the fuel burner could result in carbon deposits entering the motor.

**NOTE**

Caution must be exercised, when heating the motor with any source of heat other than self-contained space heaters, to raise the winding temperature at a gradual rate to allow any entrapped moisture to vaporise and escape without rupturing the insulation. The entire heating cycle should extend over 15-20 hours.

**DANGER**

Ensure adequate guarding is provided so live parts cannot be touched.

iv. Insulation resistance measurements can be made while the winding is being heated. However, they must be corrected to $40^0$C for evaluation since the actual insulation resistance will decrease with increasing temperature. As an approximation for a new winding, the insulation resistance will approximately halve for each $10^0$C increase in insulation temperature above the dew point temperature.

d. Should the resistance fail to attain the specified value even after drying, careful examination should be undertaken to eliminate all other possible causes, if any.

4.1.3. Power Supply

a. Is the capacity of the power supply adequate?

b. Do voltage and frequency of supply match with those on the nameplate?

c. Voltage variation should be confined to within +/-10% of the rated value and the phase to phase voltages should be balanced.

4.1.4. Bearing Lubrication

Grease Lubricated Type.

**NOTE**

The bearings are initially lubricated with the correct grade of grease at the factory. After installation, long storage and at initial start up/commissioning the bearings must be fully purged with new grease. Please refer to section 7.

a. Refer to the section "Maintenance of Bearing" for maintenance procedures and grease type.

4.1.5. Other Points to note

a. Make sure the transmission system, including belts, screws, bolts, nuts and set pins are in good condition.

b. Dismantle all locks which fasten the moveable parts of the motor during transportation, and turn the shaft by hand (if practical) to check if it moves freely.

c. Check if there is any evidence of foreign matter inside the motor before starting.

d. Make sure the items above are examined. Test the motor with or without load. Record and check according to "Maintenance" at 15 minute intervals during the first three hours of operation. Then conduct regular examinations after longer intervals. If problems are experienced test without load to ascertain whether it is a load, structure, alignment or motor issue.

## 4.2. STARTING OPERATION.

4.2.1. Starting Load.

The initial test involves running the motor without load. Unless specified, a motor is designed to start with light load, which is then gradually increased to full load, as the motor accelerates to full speed.

4.2.2. Starting.

a. Motor can be restarted if the initial start fails. Three attempts are permissible when the motor is at ambient (cold) temperature. Two starts in succession are permitted when motor is at normal running temperature. Smaller motors have a more frequent starting cycle.

b. Should an additional start be necessary beyond the conditions stated above, the following restrictions should be noted:

i. Let the motor cool down for 60 minutes before a full load restart.

ii. Let the motor cool down for 30 minutes before a no load restart.

iii. Two inching starts can be regarded as one normal start.

c. If the motor rotor fails to start turning after two seconds, shut off power supply immediately. This can result from:

i. Too low a voltage at the motor terminals.

ii. The load is too large for motor rating.

iii. The load has seized mechanically.

iv. Electrical connections incorrect.

v. Single phase power has been applied.

vi. Any combination of the above.

Note – Investigate thoroughly and take corrective action before attempting a restart.

4.2.3. Direction of Rotation.

a. Motors are generally bi-directional. Some 2 pole and low noise motors are uni directional only. If motor is uni-directional the fan cowl will be fitted with a direction of rotation arrow.

b. If direction of rotation must be changed on a bi-directional motor, cut power and wait until the motor stops, then interchange any two of the three incoming phase leads.

4.2.4. Power Supply. Voltage/Current.

a. Check if the voltage and frequency of the power supply are identical to that shown on the nameplate.

b. Voltage variation should be confined to within +/-10% of nameplate voltage, and the three phase voltages should be balanced.

c. Check if the phase currents of the motor, without load, are within +/-5% of the average values.

4.2.5. Frequency.

Frequency variation should be confined to within +/-5% of the nameplate frequency. The aggregate variation of voltage and frequency should be confined to within +/-10% of the absolute value of the rating.

4.2.6. Run Up Time.

**NOTE**

The Run Up time is longer for motors connected to a load with a large inertia. However, if the run up time exceeds what is deemed normal or there is abnormal noise, the motor and load should be examined to establish the cause before attempting a restart.

## 4.3. CAUTIONARY POINTS TO NOTE:

4.3.1. Bearings:

a. The motor is fitted with grease lubricated bearings. Following initial start up the bearing temperatures should be closely monitored. A rapid rate of rise in bearing temperature is more indicative of impending trouble, however, when greasing an expected higher temperature is normal and should equalize after a period of time.

b. When the rate of bearing temperature rise is less than 1°C per half hour, the bearing temperature is considered to be stabilised.

c. If the total bearing temperature exceeds 100°C, the motor should be shut down immediately and subsequent checks be undertaken.

4.3.2. Vibration:

a. The ideal values generally for motors are figures below 2.8mm/sec.
If vibration exceeds this level, an examination of the motor, load, structure etc, should be made to determine the cause, the first check to undertake would be to run the motor un-coupled and check if the vibration is still evident, see section 5.4 Vibration.

4.3.3. Starting:

a. If the motor acceleration time exceeds the typical ramp time for this application, shut off the power immediately.
Investigate thoroughly and take corrective action before attempting to restart.

b. It should be recognised that each start of an induction motor subjects the motor to current greater than full load current with resulting heating of the stator and rotor windings. Each start can produce more heat than is produced and dissipated by the motor under a full load condition.

c. The starting duty for which the motor is designed must not be exceeded if long motor life is expected. Abnormally low terminal voltage and/or excessive load torque during motor start up can cause lengthened acceleration times during which the rotor ventilation is reduced. This can cause rotor damage or lead to shortened rotor life.

# Chapter 5: ROUTINE MAINTENANCE

## 5.1. IMPORTANCE OF DAILY INSPECTION.

5.1.1. Normally electric motors do not fail suddenly. It happens over time, and regular inspection will detect a problem before a serious situation develops. If operators in the plant are alert, faults can be detected early and action taken to eliminate trouble.

Daily inspection, can be performed without interrupting the end user's normal operation.

5.1.2. Do not overlook any minor irregularities. If necessary, stop the machine immediately to check and repair. Essentially, inspections should be performed by the operator daily. But a maintenance technician should also check the machine once a week together with the operator.

## 5.2. POINTS TO NOTE WHEN STARTING.

a. Check power supply to see if voltage and frequency are normal.
b. Is starter set at starting position?
c. Are there sparks during start?
d. Is the motor accelerating normally?

## 5.3. TEMPERATURE RISE.

5.3.1. The temperature of a motor is often determined by measuring the temperature of the frame. This is not indicative of actual internal winding operating temperature, however, this method can often be referred to and compared with previous readings. If the temperature is found to be higher than usual please check the following possibilities.

**CAUTION**

**DO NOT MAKE TEMPERATURE READINGS WITH THE SENSE OF TOUCH**. Often the temperature of a motor is determined by touch. Human hands can only tolerate temperatures below $60^0$C. Most motors safely operate at temperatures greater than this, therefore, the sense of touch should not be used. Temperature readings by hand are also inaccurate. Readings should be made using a thermometer probe or non-contact infra red thermometer.

5.3.2. Main causes of high temperature:

a. Motor Conditions

i. Voltage and frequency variation of power source is in excess of tolerance.

ii. Unbalanced three phase voltage, open circuit or poor contact.

iii. Insufficient or excessive lubrication.

iv. Abnormal frequency of starts.

v. Single-phasing due to open circuit or short circuit.

vi. Damaged starter or improper operation.

vii. Blocked ventilation ducts.

viii. Motors cooling vents blocked.

b. Due to load or mechanical conditions:

i. Overload.

ii. Defective transmission coupling.

iii. Poor installation causing overload.

iv. High ambient temperature or radiant heat emitted from driven load or surroundings.

## 5.4. VIBRATION.

5.4.1. Main causes inducing vibration:

i. Unbalanced load.

i. Misalignment of couplings.

ii. Unbalanced belt-sheaves.

iii. Improper couplings with belts or chains.

iv. Unsuitable foundation or poor installation.

v. Unbalanced motor rotor.

vi. Serious abrasion to motor or load machine drive bearing.

vii. Defective bearing or subsequent bearing damage.

5.4.2. No matter what causes the vibration, if it is not eliminated, the following faults may develop:

i. Bearing damage.

ii. Deformation of shaft.

iii. Loose parts or couplings.

## 5.5. NOISE.

5.5.1. Points to Note.

Not all noise is the result of a fault or abnormality. For instance, wind and slight electromagnetic sounds are perfectly normal. They will remain at the same level no matter how long the motor is in operation. Generally the louder the noise, the larger the vibration amplitude will be.

5.5.2. Bearing Sound.

i. Bearing noise is a guide to the condition of the motor bearings without dismantling the motor.

ii. Normal bearing sound in general is continuous, not intermittent. The sound may tend to increase with the age of the bearings, but its increase is gradual and hardly noticeable by the ear.

iii. Abnormal bearing sound is intermittent, rarely continuous.

iv. Some motors will emit noise when unloaded or after greasing due to skating. This is normal and temporary.

5.5.3. Abnormal bearing sound generally develops from the following causes:

i. Foreign matter in grease.

ii. Scratches on the contact surface of the bearing.

iii. Rust on the contact surfaces of the bearing due to moisture ingress.

iv. Poor quality of grease or wrong type of grease.

v. Insufficient grease (the sound could be continuous).

5.5.4. Causes of abnormal electromagnetic sound:

i. Single phasing.

ii. Short circuit in windings.

iii. Unbalanced air gap resulted from serious bearing wear.

## 5.6. ODOUR.

5.6.1. Causes of motor odours:

i. Short circuit or over current causing overheating of varnish.

ii. Poor lubrication due to insufficient or contaminated grease.

## 5.7. MEASUREMENT OF THREE PHASE CURRENT.

5.7.1. Causes & effects

When load current is above the rating on the nameplate, it means the motor may be overloaded. However, the cause of over current is not confined to overloading, but may be caused by poor coupling installation, transmission structure, excessive high or low voltage, etc.

a. Causes of unbalanced three phase current.

i. Unbalanced three phase voltage.

ii. Open circuit in power distribution lines.

iii. Poor switch contact.

iv. Open or short circuit in winding.

v. Open circuit at power transformer.

b. Effects:

i. Overheating of the windings causing fire or short circuit.

ii. Vibration of motor.

iii. Reduction of motor output torque.

c. Causes of wavering of ammeter indicator:

The characteristics of devices such as compressor or press are apt to cause wavering of the indicator. Other causes are,

i. Poor contact of switches.

ii. Uneven mechanism.

iii. Unbalanced air gap due to serious bearing aberration.

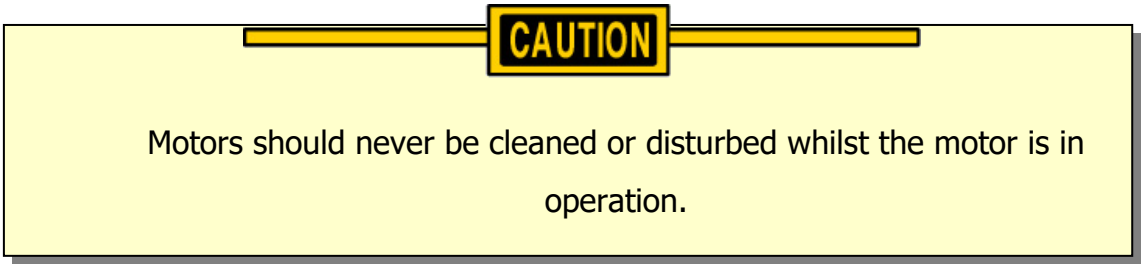
iv. Broken conductors of squirrel cage rotor.

## 5.8. MOTOR APPEARANCE.

5.8.1. Reasons for Cleaning

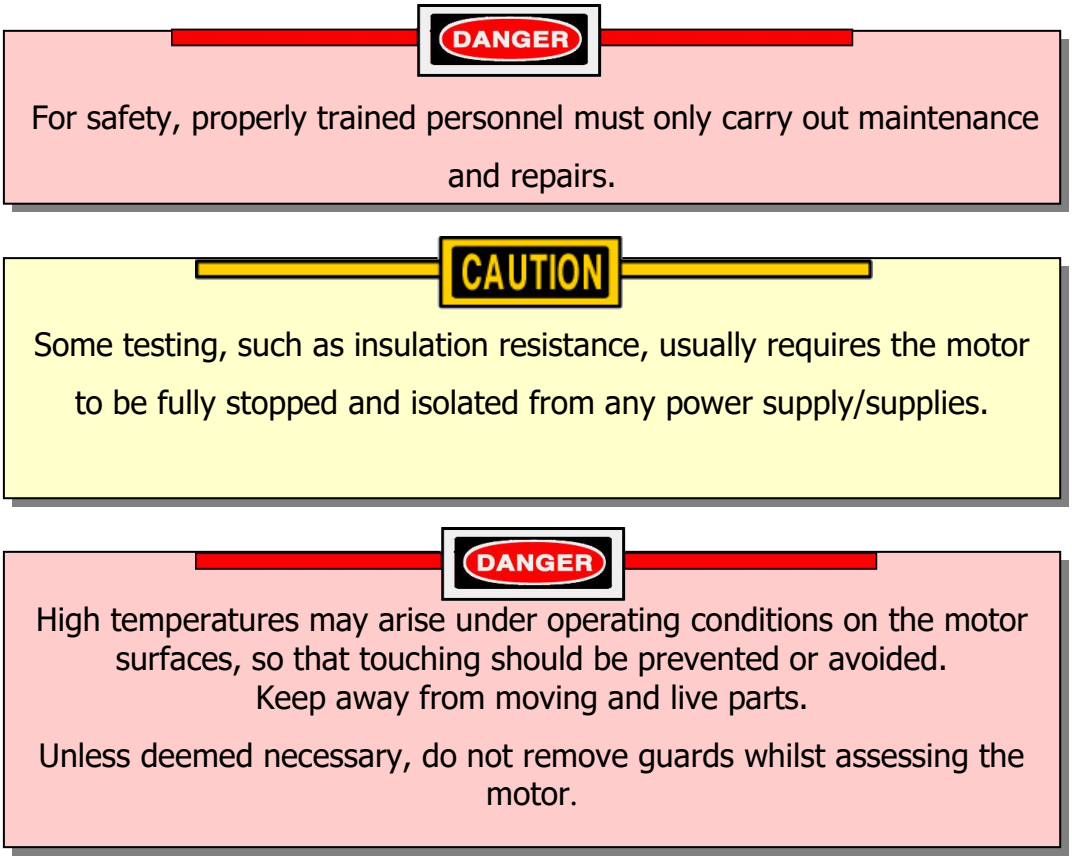
a. Excessive dust or oil accumulation on the motor surface leading to the clogging of ventilation channels between cooling ribs will reduce the motors cooling efficiency.

b. Keeping the motor and equipment clean will improve appearance and longevity.



# Chapter 6: PERIODIC MAINTENANCE

## 6.1. REGULAR INSPECTION & MAINTENANCE.




6.1.1. Major points in regular inspection and maintenance:

a. Routine inspection and maintenance are usually performed by operators with the sense of touch, sight, smell and simple meters. But it is difficult to detect trouble such as insulation deterioration etc. unless the motor is stopped and checked.

b. Replacement of worn-out parts will increase longevity and prevent breakdown.

c. Regular inspection and maintenance is important in preventing breakdown and lengthening service life.

c. Owing to the varied uses and environments motors are placed in, it is difficult to set periods for regular inspection and maintenance. However, it has to be performed at least once every 6 months. Generally, the inspection time is determined by the following factors:

i. Ambient conditions.
ii. Start and stop frequency.
iii. Trouble with components affecting motor functions.
iv. Parts which wear (eg. bearings).
v. The important position of a motor in operation of a factory, mine etc. should be fully recognised. Therefore, its condition should be monitored, especially when it is operating in severe conditions.

6.1.2. Motor Windings.

a. For measurement of insulation resistance and tests to determine quality of insulation resistance, please refer to measures stated in Section 4.1.2.

b. Inspection of coil end:
   i. Grease and dust accumulated on coil may cause insulation deterioration and a reduction in cooling efficiency.
   ii. Moisture.
   iii. Discolouring from original colour. Overheating mainly causes this.

c. Stator wedges, is there any change from their original position?

d. Is the tie wire at the coil ends in correct position with no movement?

6.1.3. Bearings.

a. Please refer to section 7 for bearing maintenance.

6.1.4. Cleaning the interior of the motor.

a. After a motor has been in operation for some time, accumulation of dust, carbon powder and grease etc., on the inside is unavoidable, and may cause damage. The inside should therefore, be regularly cleaned and examined to assure reliable performance.

b. Points to note during cleaning:

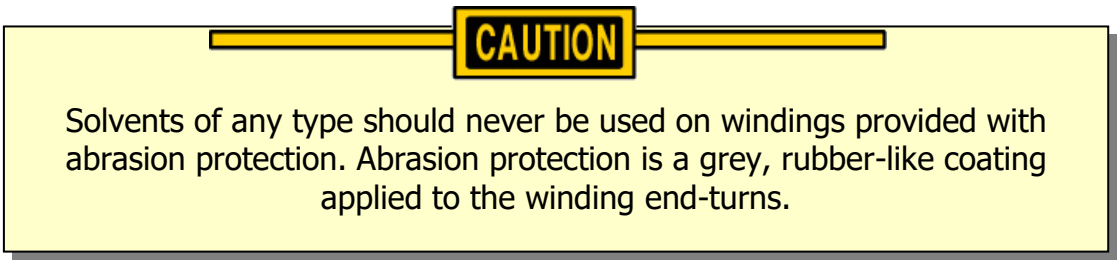
i. If using compressed air or a blower (Typically for squirrel cage only).
   - Compressed air should be free of moisture.
   - Maintain air pressure at 4kg/cm$^2$, since high pressure can cause damage to coils.

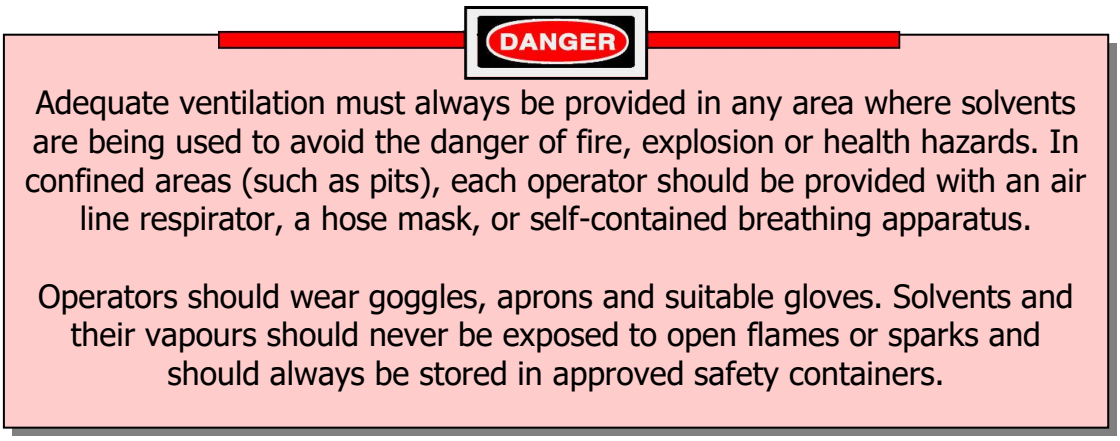
ii. Vacuum – Recommended for wound rotor/slip ring type.

Vacuum cleaning can be used, both before and after other methods of cleaning, to remove loose dirt and debris. It is a very effective way to remove loose surface contamination from the winding. Vacuum cleaning tools should be non-metallic to avoid any damage to the winding insulation.

iii. Wiping.

Surface contamination on the winding can be removed using a soft, lint-free cloth. If the contamination is oily, the cloth can moistened (not dripping wet) with a safety type petroleum solvent. In hazardous locations, a solvent such as inhibited methyl chloroform may be used, but must be used sparingly and immediately removed. While this solvent is non-flammable under ordinary conditions, it is toxic and proper health and safety precautions should be followed while using it.




6.1.5. Clean the exterior of the motor.

a. The inlet air openings should not be allowed to accumulate any dirt, dust, slurry, lint, etc. that could restrict free air movement.
b. Totally enclosed fan cooled motors require special cleaning consideration. The external fan must be cleaned thoroughly since any dirt build up not removed can lead to balance issues and vibration.

**CAUTION**

Motors should never be cleaned or disturbed whilst the motor is in operation.

6.1.6. Checking motor installation and coupling.

a. Installation:

i. Is foundation solid?

ii. Are all bolts and/or nuts tight and in good order?

b. Coupling:

i. Is coupling in good order?

ii. Are fasteners tight and in good order?

## 6.2. CLEANING OF COILS, DRYING & VARNISHING TREATMENT.

Age, constant heating and cooling and other factors may cause insulation deterioration. Also, salt deposits or grease may lower insulation resistance. Steam cleaning, drying and re-varnishing may be necessary if the motor has been flooded or showing deterioration from age.

6.2.1. Cleaning:

a. If the coils are slightly contaminated, compressed air, cloth or a nylon brush can be used to do the cleaning. However, when contamination is serious, thorough washing has to be performed. The cleaning methods are as follows:

b. Cleaning with water:

i. This method is applicable to motors having been immersed in water or insulated with no cotton yarn and paper materials.

ii. After washing, dry immediately.

iii. Cleaning with steam.

- If the motor has been immersed in sea-water or a chemical solution, clean with steam after washing thoroughly.
- Steam pressure must be kept between 2 – 4 kg/cm$^2$. High pressure may cause insulation damage.

c. Steam temperature should be maintained between $50^0$C – $80^0$C.

d. After cleaning, dry immediately.

6.2.3. Drying Method.

a. Application:

i. Drying after cleaning.

ii. Motor has absorbed moisture.

b. Hot air method (using heater and blower).

i. Parts to be dried are surrounded inside a steel plate leaving an inlet and an outlet for hot air. Hot air will enter the inlet to dry parts (stator, rotor, etc.), and will leave via the outlet carrying away moisture.

ii. The temperature within the area surrounded by the steel plate should be maintained at $90^0$C – $100^0$C.

c. Drying with infrared ray lamp:

i. Install the infrared ray lamp in a baking area surrounded with steel plate with openings at the bottom.

ii. This method can cause partial overheating. So attention must be paid to the parts heated and the temperature must be kept below $100^0$C.

d. Drying method with electric current:

i. The winding must have a minimum insulation resistance above 0.5MΩ measured with 500VDC megger before using this method so as to avoid a short circuit.

ii. Lock the rotor (short the secondary winding of the wound rotor motor), apply rated voltage of approximately 5% - 10% to the winding.

iii. Temperature control settings:
Squirrel cage rotor induction motor: $70^0$C – $80^0$C for the stator.

e. Measurement of insulation resistance.

i. Measure the insulation resistance periodically during drying.

ii. At the initial stage of drying, insulation resistance may decline slightly. When it returns to normal, the drying process is complete.

iii. When the current method is applied, be sure to turn off the power to measure insulation resistance.

## 6.3. VARNISH.

Kind of Varnish

JIS-W-25 or W-28 are highly recommended.

a. Method of Varnish Treatment

i. Dipping method: Immerse windings completely into varnish until no air bubbles appear.

ii. Pouring Method: Pour varnish completely over windings

Note: Let varnish drip to dry after dipping or pouring. Changing position of the motor will obtain an even coverage.

b. Curing of Varnish

i. Set oven temperature at 110°C.

ii. Curing time should be 12 – 16 hours

iii. Ensure ventilation is adequate during curing. Combustible gases are present.

To ensure adequate insulation the above procedure should be repeated.

## 6.4. KEY POINTS FOR MAINTENANCE & INITIAL OPERATION INSPECTION AFTER LONG STORAGE.

6.4.1. If the motor has been out of service in excess of three months, careful inspection should be made before putting the motor into operation again.

6.4.2. When the motor is not in operation, the following precautionary measures should be undertaken:

The place for storage should be dry and well-ventilated. If the motor has to be placed at work site for some time, it should be completely covered and stored on pallets to prevent dust and moisture contamination.

Inspection and maintenance prior to storage.

Please refer to "Regular Inspection and Maintenance" (Section 6.1).

6.4.3. Items to be examined prior to initial operation.

a. Cleaning:

- Outside of motor.
- Motor interior.

b. Measurement of insulation resistance:

Measurement of insulation resistance and standards to determine quality if Insulation resistance, please refer to measures stated in Section 4.1.2. Measurement of insulation resistance.

6.4.4. Drying: If the motor has absorbed moisture, it must be dried.

6.4.5. Examination of bearings.

Turn the motor shaft by hand (if practical) to see if it rotates smoothly and if there is any unusual noise.

6.4.6. Replenishment of grease. (Refer to bearing maintenance Section 7).

6.4.7. Switches and starters.

Clean off dust and any foreign matter etc.
Check if the operation is normal.
Are the moving parts functioning smoothly?
Check if all bolts and nuts are tight and in good order.

6.4.8. Examination and maintenance of standby motor.

Important: The purpose of a standby motor is to substitute as an emergency motor if the motor in operation breaks down, this motor should not be exposed to induced vibration whilst stationery.
It is important to always maintain the standby motor in top condition.
Maintenance should be performed strictly according to items and notes stated previously.

## 6.5. RECORDS OF OPERATION AND MAINTENANCE.

6.5.1. Objective:

a. Fully understand the site conditions of the motor in operation and discover any abnormalities in advance.

b. Prevent the neglect and act of maintenance.

c. Map pertinent maintenance plans after fully understanding the operation of motor.

d. Assess the life of parts to determine the quantity of spare parts to be kept.

e. To plan the number of spare motors and replace or repair the motors in operation according to a schedule.

6.5.2. Records of operation.

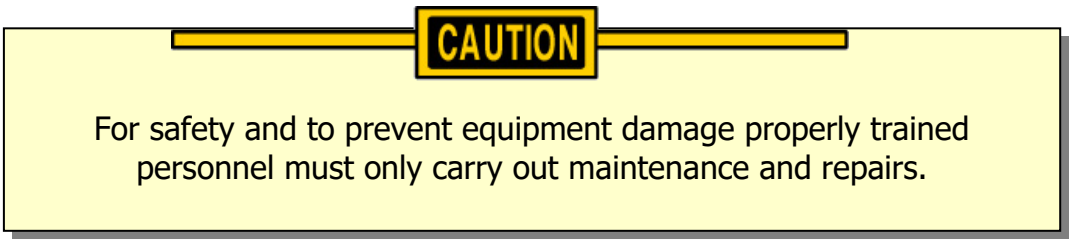
a. A maintenance card in table form is acceptable.

b. Principle contents:

   i. Serial number of machine
   ii. Model
   iii. Three phase voltage
   iv. Three phase current
   v. Temperature of a motor in operation
   vi. Ambient temperature, humidity, weather, date and time
   vii. Time of start and stop
   viii. Special remarks
   ix. Operator's name

## 6.6. POINTS TO NOTE ON DISASSEMBLY.

a. Disassemble according to the pre-set steps.
b. Necessary tools should be ready before disassembly.
c. Mark the disassembled parts so as to facilitate re-assembly.
d. Place parts, bolts and nuts etc, in a box to avoid misplacing.
e. Avoid damage to heavy parts during transportation.
f. Dust accumulation on coil-end, ducts etc., should be cleaned during disassembly.
g. Coat parts with light oil.
h. Note if there is any shaft deflection or bearing damage when re-assembling.
i. Disassemble and assemble bearing according to the bearing maintenance manual.



# Chapter 7: BEARINGS

## 7.1. MAINTENANCE OF ROLLING BEARING.

**NOTE**

Whilst Motors are installed awaiting commissioning they must be adequately protected against the elements, all external components in particular the shaft extension and external labyrinth seals at the drive end must be fully covered to avoid water ingress entering the motor body whilst stationery.

Please ensure that both the non drive end and drive end antifriction bearings are fully purged with sufficient grease at first start up/commissioning with the recommended grade and quantity of grease.

7.1.1. General.

Bearings play a very important role in motor performance. It is essential to keep bearings in good order for the motor to operate at optimum performance. For this reason, please maintain bearings according to this manual.

7.1.2. Motors within frame sizes D180 and below are complete with sealed for life Bearings. (Unless the specification dictates these need to be re-greasible) This type of bearing is a non maintainable item and has been pre packed with grease and fitted with containment shields at point of manufacture. These bearings do not require greasing for the life of the bearing.

7.1.3. Motors within frame sizes D200 and larger are equipped with through flush greasing facilities.

Grease replenishment is required, if the motor has been out of service for 3 months or more and should also be carried out on initial start and at regular intervals thereafter.

a. Replenishment of grease is recommended when the motor is running.
b. Clean the grease nipple and open the grease drain (if applicable) prior to greasing. Restore after greasing.
c. A slight leakage of grease between the flinger and bearing cover is normal and assists in totally sealing the bearing from ingress of dust and foreign matter.

7.1.4. Grease Lubricated Type.

Keeping the bearing lubricant in top condition is extremely important in the maintenance of bearings. It is a prerequisite of extended bearing life to replenish grease using the correct grade, quantity and time interval, please do not mix different types of grease.

The reasons for grease replenishment are:

a. Assure the rolling contact surface has no metal to metal contact.
b. Form a lubrication membrane on the rolling contact surface to reduce noise.
c. Purge the motor of old and contaminated grease, please ensure that the grease in the discharge chute is pliable and will allow new grease to enter.
d. The presence of the correct grade and quantity of grease reduces corrosion, protects and seals the bearing and lowers vibration.

7.1.5. Grease replenishment period:

The life of grease varies depending on model, speed, temperature, operational conditions etc., it is, therefore, impossible to determine the exact time interval for replenishment.

However, under normal conditions the greasing interval is shown in Table 3 can be used as a guide.

| Bearing Number | | Speed(RPM) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 600 | 720 | 750 | 900 | 1000 | 1200 | 1500 | 1800 | 3000 | 3600 |
| 62XX | 10 | 19000 | 18000 | 17500 | 16500 | 15500 | 14500 | 12500 | 11000 | 6000 | 4500 |
| 63XX | 12 | 18000 | 17000 | 16500 | 15000 | 14500 | 13000 | 11000 | 9000 | 4500 | 3500 |
| 72XX | 13 | 17500 | 16500 | 16000 | 14500 | 14000 | 12000 | 10000 | 8500 | 4000 | 3000 |
| 73XX | 14 | 16500 | 15500 | 15000 | 13500 | 12500 | 11000 | 9000 | 7000 | 3500 | 2500 |
| | 15 | 16500 | 15500 | 15000 | 13500 | 12500 | 11000 | 9000 | 7000 | 3000 | 2000 |
| | 16 | 16000 | 15000 | 14500 | 13000 | 12000 | 10500 | 8500 | 6500 | 2500 | 1500 |
| | 17 | 16000 | 14500 | 14000 | 12500 | 11500 | 10000 | 8000 | 6000 | 2500 | 1500 |
| | 18 | 15500 | 14000 | 13500 | 12000 | 11000 | 9500 | 7500 | 5500 | 2500 | 1500 |
| | 20 | 14500 | 13000 | 12500 | 11000 | 10000 | 8500 | 6000 | 4500 | | |
| | 22 | 13500 | 12000 | 11500 | 10000 | 9000 | 7500 | 5500 | 4000 | | |
| | 24 | 13000 | 11500 | 11000 | 9000 | 8000 | 6500 | 4500 | 3500 | | |
| | 26 | 12000 | 10500 | 10000 | 8500 | 7500 | 6000 | 4000 | 3000 | | |
| | 28 | 11500 | 10000 | 9500 | 8000 | 7000 | 5500 | 3500 | 2500 | | |
| | 30 | 11000 | 9500 | 9000 | 7000 | 6500 | 4500 | 3000 | 2000 | | |
| | 32 | 10500 | 8500 | 8500 | 6500 | 5500 | 4000 | 3000 | 2000 | | |
| | 34 | 10000 | 8000 | 8000 | 6000 | 5500 | 4000 | 2500 | 1500 | | |
| | 36 | 9500 | 7500 | 7500 | 5500 | 5000 | 3500 | | | | |
| | 38 | 9000 | 7000 | 7000 | 5000 | 4500 | 3000 | | | | |

| Bearing Number | | Speed(RPM) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 600 | 720 | 750 | 900 | 1000 | 1200 | 1500 | 1800 |
| NU2XX | 14 | 14000 | 12500 | 12000 | 10500 | 9500 | 8000 | 6000 | 4500 |
| NU3XX | 15 | 13500 | 12000 | 11500 | 11000 | 9000 | 7000 | 5500 | 4000 |
| | 16 | 13000 | 11500 | 11000 | 9500 | 8500 | 6500 | 5000 | 3500 |
| | 17 | 12500 | 11000 | 10500 | 9000 | 8000 | 6000 | 4500 | 3000 |
| | 18 | 12000 | 10500 | 10000 | 8500 | 7500 | 5500 | 4000 | 2500 |
| | 20 | 11000 | 9500 | 9000 | 7000 | 6000 | 4500 | 3000 | 2000 |
| | 22 | 10000 | 8500 | 8000 | 6000 | 5500 | 4000 | 2500 | 1500 |
| | 24 | 9000 | 7500 | 7000 | 5500 | 4500 | 3500 | 2000 | 1500 |
| | 26 | 8500 | 7000 | 6500 | 5000 | 4000 | 3000 | 1500 | 1000 |
| | 28 | 8000 | 6000 | 6000 | 4500 | 3500 | 2500 | 1000 | 500 |
| | 30 | 7000 | 5500 | 5500 | 4000 | 3000 | 2000 | 1000 | 500 |
| | 32 | 6500 | 5000 | 5000 | 3500 | 2500 | 1500 | 500 | 500 |
| | 34 | 6000 | 4500 | 4500 | 3000 | 2500 | 1500 | 500 | |
| | 36 | 5500 | 4000 | 4000 | 2500 | 2000 | 1000 | 500 | |
| | 38 | 5000 | 4000 | 3500 | 2500 | 1500 | 1000 | 500 | |
| | 40 | 5000 | 3500 | 3000 | 2000 | 1500 | 1000 | | |
| | 44 | 4000 | 3000 | 2500 | 1500 | 1000 | 500 | | |
| | 48 | 3500 | 2500 | 2500 | 1000 | 1000 | 500 | | |

Table 3.

Remarks:

a. Please refer to lubrication nameplate fitted and follow the recommended schedule stated.

b. The data as shown in Table 3 and/or lubrication nameplates are the maximum recommended intervals under good conditions, please consider site conditions, as a shortening of these periods may be necessary.

7.1.6. Type of grease:

TECO motors can utilise different types of grease including Shell Gadus & Mobil Polyrex EM Grease which has been selected based on the proposed application.

Please check on the lubrication nameplate to confirm the type of grease installed. Please use identical grease when servicing or alternatively lubricants of different brands that have been established as being equivalent in the areas of composition, physical properties and thickeners.

7.1.7. Amount of grease replenishment:

Amount of grease replenishment depends on the type, size and construction and the bearings. For the maximum quantity used in one replenishment of each bearing, as a guide, please refer to Table 4.

Please refer to lubrication nameplate fitted and follow the recommended quantity stated.

7.1.8. Key points to note with grease filling:

Filling method for grease relief type bearing.

Use a good quality grease gun to pump grease through the grease nipple into the bearings. The old contaminated grease is forced to drain out of the discharge chute. While greasing it is recommended that the greasing procedure is undertaken whilst the motor is running. The discharge outlet may not be visible on some models, grease should be pumped in at the recommended quantity and the sound of bearing should return to normal. It is advisable to grease when the motor is operating as old grease is expelled more easily.

| Bearing No. | | Amount of replenishment |
|---|---|---|
| 62XX<br>72XX<br>NU2XX<br>222XX | 6210 | 30g |
| | 6212 | 40 |
| | 6213 | 50 |
| | 6214 | 50 |
| | 6215 | 60 |
| | 6216 | 60 |
| | 6217 | 80 |
| | 6218 | 80 |
| | 6220 | 100 |
| | 6222 | 120 |
| | 6224 | 120 |
| | 6226 | 140 |
| | 6228 | 160 |
| | 6230 | 180 |
| | 6232 | 200 |
| | 6234 | 250 |
| | 6236 | 300 |
| | 6238 | 350 |
| | 6240 | 400 |
| | 6244 | 450 |
| | 6248 | 500 |

| Bearing No. | | Amount of replenishment |
|---|---|---|
| 63XX<br>73XX<br>NU3XX<br>223XX | 6310 | 40g |
| | 6312 | 60 |
| | 6313 | 80 |
| | 6314 | 80 |
| | 6315 | 100 |
| | 6316 | 100 |
| | 6317 | 120 |
| | 6318 | 120 |
| | 6320 | 160 |
| | 6322 | 220 |
| | 6324 | 270 |
| | 6326 | 300 |
| | 6328 | 400 |
| | 6330 | 450 |
| | 6332 | 500 |
| | 6334 | 600 |
| | 6336 | 700 |
| | 6338 | 800 |
| | 6340 | 900 |
| | 6344 | 900 |
| | 6348 | 900 |

Table 4.

*Fill new grease until it displaces the old grease completely.

Do not grease the motor whilst it is at standstill. If there is a draw-out device for grease, draw out the used grease after greasing, please leave excess grease on the rake as this will further protect the exit port from moisture entry.

**WARNING**

Stay clear of rotating parts while relubricating motor when it is in operation.

7.1.9. Temperature of bearing.

Temperature of the bearing will rise slightly, but this is temporary while greasing and will return to normal a few minutes after greasing. Brief temperature variations are of no concern, grease should be pumped in sparingly to avoid excess temperatures being experienced.

7.1.10. Selection of grease gun.

There are two types of grease gun. High pressure lever type and hand press type. As the hand press type has a lower force, grease replacement will take more time. Greasing can be achieved quickly by using a lever type gun, however, care should be taken to adjust the pressure and rate to avoid excessive grease entry which may enter the motor's interior.

## 7.2. NOISE OF BEARING.

a. Normal noise.

Noise is congenital to movement of the bearing. Generally bearing noise that has a continuous rhythm with no sudden change is normal.

b. Abnormal noise.

It is difficult to detect the early stages of bearing failure with the human ear. It takes a lot of experience and a sharp ear to detect abnormal noise. Any sudden change in bearing noise should be investigated. Motors with roller bearings at the drive end can emit more rotational noise than a ball bearing and it is normal to hear skating/skidding of the rolling elements.

## 7.3. VIBRATION.

If the vibration of the bearing is unusually high, please test with vibroscope. The preferred level for vibration should be below 2.8mm/sec. If the values exceed this figure, an investigation should be undertaken to find and rectify the problem.

## 7.4. REGULAR INSPECTION.

7.4.1. Regular monthly inspection.

Grease replenishment (refer to Section 7.1) and the motor lubrication plate.

7.4.2. Regular yearly inspection.

It is important to undertake regular inspection every year when the machine is out of service for maintenance.

7.4.3. Inspection Notes.

a. Electrical etching.

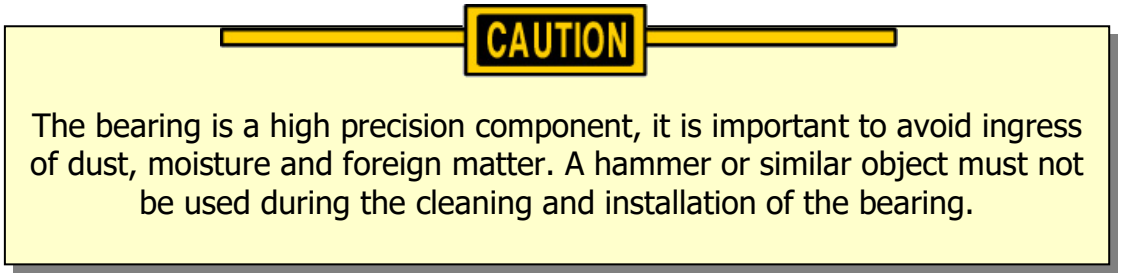
When there are dark spots on bearing surface or outside the face of outer ring and / or inside face of bearing housing, please check with a microscope to see if they look like pock marks or fish scales which could be the result of electrical etching due to poor installation etc.

b. Motors on VVVF Drives.

All TECO motors are suitable for running on VVVF drives, however, this does depend on the application, kilowatt demand and speed range. TECO recommend that when motors of 280/315 frame and above be fitted with at least an insulated bearing at the non drive end and rotor grounding brush fitted at the drive end, this is not categorical that this feature must be fitted, purely a recommendation based on TECO's experience, please consult with the engineering specification whether the motor supplied requires this feature.

c. Precision of installation.

The degradation of the bearing may be the result of misalignment due to sinking foundations etc, after the motor has been in use for a long period. Regularly check and record the alignment of couplings, and make adjustments as necessary.



# Chapter 8: Troubleshooting.

## 8.1. FAULT FINDING & RECOGNITION

| ***Kind of Fault*** | ***Symptom*** | ***Cause*** | ***Remedy*** |
|---|---|---|---|
| Fail to start without load | Motionless And soundless | Power-off | Consult power company |
| | | Switch-off | Switch-on |
| | | No fuse | Install fuse |
| | | Broken wires | Check wires and repair |
| | | Broken lead | Check leads and repair |
| | | Faulty winding | Check winding and repair |
| | Fuse blowing – (Circuit Breaker trips off, slow start with electromagnetic noise | Short circuit | Check circuit |
| | | Incorrect wiring | Check wiring |
| | | Poor contact in circuit switches | Check and repair |
| | | Broken wiring | Check and repair |
| | | Poor contact of starting switch | Check and repair |
| | | Incorrect connection of starting switch | Check and repair |
| Overload after start | Fuse blowing – Fail to restart due to circuit breaker tripping | Insufficient capacity of fuse or breaker | Replace fuse or breaker |
| | | Overload | Lighten load |
| | | High load at low voltage | Check circuit capacity and reduce load |

| ***Kind of Fault*** | ***Symptom*** | ***Cause*** | ***Remedy*** |
|---|---|---|---|
| Overload after start | Overheating of Motor | Overload or Intermittent Overload | Lighten Load |
| | | Under-voltage | Check circuit capacity and power source |
| | | Over-voltage | Check power source |
| | | Ventilation duct clogged | Remove the foreign matter in the duct |
| | | Ambient temperature exceeds $45^0$C | Lower ambient temperature |
| | | Friction between rotor and stator | Repair |
| | | Fuse blowing (Single phase rotating) | Install the specified fuse |
| | | Poor contact of circuit switches | Check and repair |
| | | Poor contact of starting switch | Check and repair |
| | | Unbalanced three phase voltage | Check circuit or consult power company |
| | Speed falls sharply | Voltage drop | Check circuit and power source |
| | | Sudden overload | Check machine |
| | | Single phase rotating | Check circuit and repair |
| | Switch overheat | Insufficient capacity of switch | Replace switch |
| | | High load | Lighten load |

| ***Kind of Fault*** | ***Symptom*** | ***Cause*** | ***Remedy*** |
|---|---|---|---|
| Overload after start | Bearing Overheat | Misalignment between motor and load | Re-align |
| | | Not enough grease | Fully purge bearings with grease |
| | | High bearing noise | Replace damaged bearing |
| Noise | Electro-magnetic noise induced by electricity | Occurrence from first operation | Check noise not normal |
| | | Sudden sharp noise and smoking | Short circuit of windings. Repair. |
| | Bearing noise | Not enough grease | Fully purge bearings with grease |
| | | Deterioration of grease | Clean bearing and re-grease |
| | | Excessive noise | Replace the damaged bearing |
| | Mechanical noise caused by machinery | Loose belt sheaf | Adjust key and lock the screw |
| | | Loose coupling | Adjust the position of couplings and tighten |
| | | Loose screw | Tighten screw |
| | | Fan rubbing | Adjust fan position |

| ***Kind of Fault*** | ***Symptom*** | ***Cause*** | ***Remedy*** |
|---|---|---|---|
| Noise | Mechanical noise caused by machinery | Rubbing as a result of ingress of foreign matter | Clean motor interior and ventilation ducts |
| | | Wind noise | Noise induced by air flowing through ventilation ducts |
| | | Induced by conveyance machine | Repair machine |
| Vibration | Electro-magnetic vibration | Short circuit of windings | Repair |
| | | Open circuit of rotor | Repair |
| | Vibration | Unbalanced rotor | Repair |
| | | Unbalanced fan | Repair |
| | Mechanical vibration | Broken fan blade | Replace fan |
| | | Un-symmetrical centres between belt sheaf | Align central points |
| | | Central points of couplings do not lie on the same level | Adjust the central points of couplings on the same level |
| | | Improper mounting installation | Lock the mounting screw |
| | | Motor mounting bed is not strong | Reinforce mounting bed |

Remarks:

i. Circuit switches: This includes knife switch, electromagnetic switch, fuse and other connection switches etc.

ii. Starting switches: This includes Delta-Star starter, compensate starter, reactance starter, resistor starter, starting controllers etc.