marathon®

marathon® Motors

LARGE THREE PHASE INDUCTION MOTORS

INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS

REGAL®

⚠ WARNING

- Read and follow all instructions carefully.
- Disconnect and lock-out power before installation and maintenance. Working on or near energized equipment can result in severe injury or death.
- Do not operate equipment without guards in place. Exposed equipment can result in severe injury or death.

⚠ CAUTION

- Periodic inspections should be performed. Failure to perform proper maintenance can result in premature product failure and personal injury.

1. SAFETY SPECIFICATION

These instructions must be followed to ensure safe installation, operation and maintenance of the motor. They should be brought to the attention of anyone who installs, operates or maintains this equipment. Ignoring the instructions may invalidate the warranty.

- Ensure that the parameters on the nameplate meet your requirement.
- Ensure that the motor is not damaged.
- Remove transport shaft lock if employed. Reinstall it when in need of further transportation.
- Lift the motor using the eyebolts or the lifting lugs integrated with the motor frame only. If not equipped, consult separate lifting instructions delivered with the motor.

Check that eyebolts or the lifting lugs integrated with the motor frame are undamaged before lifting. Lifting eyebolts must be tightened before lifting. The position of the eyebolt can be adjusted with suitable washers when necessary.

All lifting lugs must be utilised to bear the motor's weight.

The center of gravity of motors of the same frame may vary depending on outputs, mounting arrangements and auxiliary equipment.

When lifting a motor with its packaging, the sling chains must be put under the base the motor is
resting on or eyebolts or lifting lugs integrated with the motor frame must be used.

- Make sure that the mounting arrangement (IM) is in accordance with the mounting specified on the nameplate. Check that the drain holes are at the lowest position. If in doubts, please contact the manufacturers.

2. SAFETY CONSIDERATIONS

Observe the safety precaution measures as follows:

- The motor must be installed and used by qualified personnel, familiar with relevant safety requirements.

If the motor is not installed, operated and maintain correctly, it may harm human health and life.

NOTE: Safety equipment necessary for the prevention of accidents during the installation and operation must be provided in accordance with the local regulations.

- Before maintenance work is carried out, all electrical supplies connected to motor and its auxiliary parts must be isolated. Motor shaft must not be rotating.
- The motor must be earthed before it is connected to the power supply. The motor protection devices must also be earthed to prevent accidents in service.
- The motor protection devices should be employed as they prevent run under faulty condition and ensure the useful life of the motor.
- Depending on the operating conditions and operating environment, the most suitable degree of protection must be chosen to prevent any damage and/or accidental contact with internal rotating parts or live parts of the motor.
- Any contact with live parts of the motor must be prevented. When auto-starting, auto-shutting and/or remote starting is enabled, a suitable sign must be displayed to prevent starting of the motor.
- Make sure that shaft keys are correctly fitted before starting.
- Winding temperature monitoring is recommended to prevent overloading.
- Phase failure in service must be prevented. It is recommended to install the phase failure protection device.
- Half coupling and pulleys must be fitted using suitable equipment and tools and care must be taken not to damage bearings. No hammers or levers are to be used to fit or dismantle half couplings and pulleys.
- Earplugs must be worn in noisy environment. For more information about noise limits, please contact the manufacturers.
- Care must be taken during installation, commissioning and operation to protect the motor against the ingress of water.

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- Motor used for frequency control must not exceed the maximum permissible (safety) speed. Care must be taken not to overload the motor at any point during the frequency control. The ventilation of the to TEFC motor will decrease at low speeds. Force ventilation (separately driven fan) should be considered to avoid overheating. Please contact the manufacturers if in doubts.
- Observe the relevant safety measures to avoid accidents when external brake is utilised.
- All Medium & High Voltage motors supplied equipped with antifriction bearings are provided with continuous operation re-greasing nipples to enable lubrication during operation. Re-greasing is to be carried out by qualified personnel only, familiar with relevant safety requirements. Internal rotating or live parts should be protected.

NOTE: These safety precautions must be followed to avoid electrical and mechanical injury.

3. ENVIRONMENTAL REQUIREMENTS AND OPERATION CONDITIONS

3.1 Environmental requirements

- Standard ambient temperatures limits are -15°C up to +40°C if standard performance is to be achieved (except where special design motors suitable for different temperature ranges have been supplied).
- Maximum altitude 1000m above sea level (m.a.s.l.).
- The relative humidity must be less than 95%.

NOTE: If the motor is to be working at environmental conditions deviating from the above standard conditions, the motor suitability for the given environmental conditions must be checked. Please consult the manufacturers accordingly.

3.2 Operating requirements

- Unless agreed otherwise the deviation of the supplied frequency must be no more than 1% and the deviation of the supplied voltage and must be no more than 5%.
- Open-drip-proof motors (IP23, IP21) are suitable for operating in clean, dry, well ventilated , nocorrosive indoor environment. For more details, please see IEC60034-1 standard.

NOTE: If Open-drip-proof motors (IP23, IP21) operate outdoor, the weather will affect the life and performance of the motors.

- The totally enclosed fan cooled (TEFC, IC411) motors, air to air cooled (IC61A1A) and air to water cooled (IC61A1W) and water cooled motors (IP44, IP54, IP55) are suitable for operation in relatively polluted, humid and dust environment. For more details, please see IEC60034-1 standard.
- The outdoor non-corrosive motor designs are suitable for operation outdoor or in corrosive, high humidity environments.
- Water cooled motors and/or motors with water cooled bearings must not be operated in subzero ambient temperatures to avoid water freezing.
- The motor foundations must be even and rigid to withstand dynamic forces under short circuit conditions. They must be dimensioned to avoid vibrations due to mechanical resonance.
- Extra space must be maintained around the motor to facilitate heat dissipation and access during the maintenance.

NOTE: Check that the motor has sufficient airflow. Ensure that equipment installed nearby does not radiate additional heat towards the motor. Prevent direct sunshine especially in tropical environment.

Any fans or ventilators located nearby the motor must not compromise the airflow, which is cooling the motor and which is delivered by the motor's own cooling fan.

4. TRANSPORTATION AND STORAGE

4.1 Transportation

- The motors are suitably packaged before leaving the factory. The packaging is to be maintained or enhanced depending on the means of transportation to avoid damage during transportation.
- Some medium and large sized motors fitted with cylindrical-roller bearings, angular contact bearings or sleeve bearings must be fitted with shaft locking device during transportation.
- Upon receipt of the consignment check the packaging and the motor for external damage. In case of external damage take photographs of the packaging and the motor and inform the forwarding agent without delay. It is important to inform the manufacturers about any damage or discrepancy before the commencement of the installation.
- Care must be taken when motors are stored in cases when installation is delayed. Suitable protection measures must be taken to assure future trouble-free operation and performance.
- Upon unpacking the motor it must be checked for the following:

  (1) Any visible damage?

  (2) Are all accessories in good order?

  If in doubts, please take photographs and inform the supplier immediately.
- Lift the motor using the lifting lugs only. The motor packaging may be suitable for forklift handling but not for crane lifting as it is not designed to support the motor's weight when suspended.
- Do not use forklift to carry the motor without pallet or wooden base.

4.2 Following are the recommendations for short period storage (not exceeding 3 months):

- The motor should always be stored in clean, dry, vibration and dust free environment free of corrosive conditions.
- The motor should always be stored on plane foundation surface free from vibration, allowing free temperature dilatation.
- The storage place should be sheltered not exposed to a heat source (such as boiler) or freezer.
- The recommended storage temperature is +5°C to +50°C. If the motor is equipped with Anti condensation heaters, they may be energized in humid storage environment.
- The recommended relative humidity in the storage environment should not exceed 75%. Keep motor temperature above dew point to prevent condensation.

Anti condensation heaters (if fitted) should preferably be energized and checked periodically.

Since moisture can have detrimental effect ton electrical components, the motor temperature should be maintained above dew point by providing external heating if Anti condensation heaters are not fitted.

Care must be taken if heating light bulbs are placed within the motor assembly as they can cause hot spots, which may damage the motor winding.

- Plastic packaging must be removed from motors stored outdoor. Motors must be suitably covered to protect against the ingress of water and ensure free ventilation at the same time. Motors must be stored on raised rigid foundation to prevent contact with moisture and dust.
- Motors must be protected against the entry of insects.
- Should motors be stored in the original packaging an opening must be made in the packaging to maintain effective ventilation but not to tamper with protection against rain.
- Extra care must be taken of motors with water coolers or water cooled bearings. Water pipes must be protected against corrosion or breakage.

Adding a mix of water and glycol into the pipes is recommended to prevent freezing. The proportion of glycol should be no less than 50%. The pipes must be suitably plugged to prevent the loss of the antifreeze mix.

4.3 Following are the recommendations for long period storage (exceeding 3 months):

- Make sure that the storage period does not exceed the recommended time period. For advice and guidance please contact the manufacturers.
- Insulation resistance should be tested every two months and a record maintained.
- The environment humidity should be measured every two months and a record maintained. If the relative humidity is exceeding the recommended values, contact the manufacturers.
- Check motor paint every three months. Early signs of corrosion must be cleaned and repainted.
- Check shaft extension and flange face for corrosion every three months. Any rust must be cleaned by fine sand paper and subsequent anticorrosion measures implemented.
- Motors with roller bearings filled with grease before leaving factory need to be refilled during storage. Shaft need to be turned by hand once a month to check free rotation (ten revolutions are recommended).
- Motors with sleeve bearings are delivered without oil. They need oil refill during storage to avoid of building of internal corrosion. Turn shaft by hand in both directions of rotation once a month to check free rotation (ten revolutions either way are recommended).
- Should the storage of motors with sleeve bearings exceed one year, the bearings must be dismantled and anticorrosion measures implemented.
- Inspect bearings for corrosion after a long period of storage. Replace bearings which show early signs of corrosion and fill them with grease.
- Test insulation resistance before installation and commissioning and/or when winding dampness is suspected. Insulation resistance should exceed 1MΩ. If the insulation resistance is lower than 1MΩ, the winding is damp and must be dried. . If the insulation resistance is lower than 1MΩ after drying please contact the manufacturers. The winding is suspected being faulty.

Oven drying:
Dismantle the motor, remove the rotor and put the stator winding into the oven. For the wound-rotor motor, rotor should be put into the oven at the same time. Oven temperature should be less than 100°C. Good ventilation inside and outside of the oven must be maintained. When the insulation resistance exceeds the 1MΩ and is stabilized, the oven drying has been accomplished.
Drying with Electric Current:
Lock the rotor and apply reduced voltage to winding to ensure that the current is between ½ and ½ of the rated current. Winding temperature must not exceed 100°C. When the insulation resistance exceeds the 1MΩ and is stabilized, the Electric Current drying has been accomplished.

4.4 Storage after installation

If after installation or after a period of operation the motor will not be operating for a prolonged period of time, the motor must be protected following the measures as described in 4.3. It is recommended that the motor should be operating at least once every two months.

5. INSTALLATION AND CALLIBRATION

5.1 Inspection before installation

- Verify all rating data on the nameplate, especially voltage and winding connection (where applicable).
- Test the insulation resistance before commissioning and/or when winding dampness is suspected. The insulation resistance should exceed the 1MΩ (when tested with Megger). If the insulation resistance is lower than 1MΩ, the winding is damp and must be dried. . If the insulation resistance is lower than 1MΩ after drying please contact the manufacturers. The winding is suspected being faulty.
- Check the motor for damage, distortion, loose parts etc. Turn shaft by hand to verify free rotation.
- Verify the mounting arrangement. The basic type of construction is foot mounting IM B3 but motors can also be supplied in various other mountings. Consult the manufacturers when mounting arrangement or mounting position (horizontal/vertical) should be modified as other type of constructions may require an additional support, changing bearings (to withstand the axial forces etc).
- Clean dust and other impurities off the motor surface.
- Check the lubricant and replace it if necessary after a long period of storage.

5.2 Foundation

NOTE: The correct foundation design will ensure safe operation and trouble-free operation and maintenance. The area around the foundation should be large enough to facilitate heat dissipation and maintenance.

Cooling air flow alongside the surface or through the cooler of the motor without any blockage must be ensured. Factory equipment in the surrounding area must not compromise the cooling in any way.

Foundations should be strong and free of vibration.]

- Foundations must be even, and sufficiently rigid to withstand possible dynamic forces during short circuit conditions. The motor as well as the driven equipment is to be based on same foundation (made of concrete). The suitable type of shaft connection should be chosen where frequent connection and disconnection is required.
- Motor foundations should be 2mm lower than the base for the driven equipment so the shaft alignment can be achieved.
- The foundation must be made suitable for each motor footprint area. The foundation surface must be bigger than motor footprint.
- Any height differences between the motor and the driven machine must be correctly adjusted. When shims are used the shims' surface must be greater than that of the feet. The number of shims should not exceed 3.
- An appropriate foundation surface must be selected for bed plates (which are sometimes considered more reliable for motor operation).

NOTE: Foundations must be even and sufficiently rigid to withstand possible dynamic forces during short circuit conditions. Incorrect alignment can lead to bearing failure, vibration and even shaft damage as well as further accidents.

5.3 Installation

Preparation for installation

- Make a number of steel shims, 0.1mm, 0.2mm, 0.5mm, 1.0mm thickness available.
- Make basic tools, such as lever, jack and bolts available.
- Make measuring instrument, such as micrometer (for adjusting installation of shaft coupling) or indicator clock available.
- Ensure that the foundation surface is clean before mounting the motor.
- Verify the position and height of the mounting hole.
- Remove transport shaft lock if employed. Reinstall it before further transportation.

Considerations before installation

- Drilled holes for stud insertion must be rough and grouted with concrete.
- In order to grout the studs in the concrete base firmly, the studs must be clean from paint, paint drops and dirt.
- The concrete surface must be clean from grease and dirt.
- The anticorrosive surface protection of the shaft extension and feet must be cleaned (suitable de-greasing agent is to be used).
- Fasten the steel studs and screw cap in the holes. Stainless steel studs should be used when corrosion is likely to occur. The shockproof shims should be used to reduce the vibration.
- Ensure that the motor's drain holes are at the lowest position after installation. When the drain holes are open holes an ingress of objects/insect must be prevented.
- The insulation resistance must be verified before starting after a long period of inactivity or after repair. . The test includes stator winding, rotor winding of the slip-ring motors and auxiliary devices.
- Hoist the motor using the lifting lugs integrated in the motor frame only. The smaller lifting lugs fitted to some auxiliary devices are not suitable for lifting the motor.
- All lifting lugs must be used together to lift the motor's weight.
- If slings chains are used to engage with lifting lugs, keep the sling chains the same lengths and keep them untwisted before lifting.

NOTE: Lifting of the motor must not be carried out using one sling chain with two ends engaged in two motor's lugs. To lift the motor two separate sling chains must be employed.

Installation of shaft coupling

1. The shaft coupling of the motor must be dynamically balanced. As standard, motor shaft balancing has been carried out using half key. In the event of balancing with full key, please contact the manufacturers.
2. Before installing the coupling, the shaft and the coupling hole must be greased. Do not paint the shaft surface with molybdenum bisulfide.
3. The half coupling should be heated up and pushed onto the shaft extension using slight axial force. Do not use a hammer! A bearing damage can occur when a hammer is used.
4. It is recommended that a flexible coupling is used to mechanically connect the motor with the driven machine.
5. Enough space must be kept between the half couplings and motor endshield especially if the motor is equipped with a roller bearing or sleeve bearing.
6. At motors equipped with sleeve bearings, the coupling must be mounted at such a distance on the shaft that axial forces from the rotor and the driven machine are eliminated. Any axial stress would result in the premature bearing failure.
7. Before installing the half coupling, measure the length between coupling hub and the shaft key, then divide it by two (hatch area) to calculate the approximate balance condition.
8. After the half couplings of the motor and the driven machine are coupled together, the shield must fitted on the outside of the coupling.
9. At motors equipped with sleeve bearings the magnetic centre of the rotor/stator must be found and the shaft marked accordingly.

NOTE: There must be left enough space between motor half coupling and the half coupling of the driven machine to prevent axial force caused by shaft dilatation. Not observing this rule would lead to a bearing failure.

Installation of pulleys

The majority of motors are NOT suitable for belt drive unless specially designed for such service. Any belt sheave must be specially designed in accordance with the manufacturers' instructions.

1. Flat belts cannot be used with 2pole motors above 4kW and 4pole motors above 30kW.
2. The length of the sheave must not be greater than the shaft extension.
3. The second shaft end of the double shafted motors must be connected with the driven equipment via coupling only.
4. Ensure the parallelism of the motor shaft and the driven machine shaft.
5. The belt sheave must be dynamically balanced before installation.
6. The motor shaft must be painted with cosmoline before installation of the belt sheave.
7. For belt connection motors with roller bearings at DE are used. Do not exceed the maximum belt forces. Observe radial bearing loading in relation to the position of the pulley on the shaft.
8. The diameter ratio between the pulleys should not be greater than 5 : 1 for flat belts and 8 : 1 for V-belt(s). It is also advisable to limit the belt velocity by 32m/min to limit belt abrasion and vibration.
9. Place the sheave and belt as close as possible to the motor endshield to reduce the bending moment and prevent shaft or bearing failure.

Gear transmission

1. Make sure the loading capacity of shaft and bearing is appropriate for the size and installation position of the gear. Contact the manufacturers to ensure that the shaft and bearings will meet your requirements.
2. Pay close attention to the parallelism of shafts.
3. The gears should be correctly and precisely matched to minimize transmission forces. The shaft centers should be on the same line.
4. There should be no skip or vibration or unusual noises during operation.

Thermal effect

In aligning the motor (and rotor) axially with the driven equipment, consideration should be given not only to the end-play indicator position but also to axial shaft expansion (dilatation) and movement of the shaft centerline height due to thermal effects.

1. Shaft height movement (change in shaft centerline height) for TEFC motor can be calculated as follows:

   $\Delta = (0.00045) \times$ (motor foot to shaft centerline dimension) mm

NOTE: Thermal effect of the driven machine must be considered at the same time in order to calculate the total thermal effect.

2. A space must be left between half couplings depending on the load. Shaft elongation for motor can be calculated as follows:

   $\Delta = (0.0005) \times$ (motor frame dimension) mm

NOTE: Ensure that the half couplings (except rigid couplings) have free movement axially. This is necessary for allowing shaft elongation due to thermal dilatation.

Installation of rigid foundation

1. Clean the surface of the foundation.
2. The foundation must be even. The tolerance must not exceed 0.1mm.
3. The motor connected with driven equipment can be resting on the sole frame or common bed with the driven equipment (which is considered more reliable for motor operation). It is better to embed the sole frame or common bed in concrete together
4. Put motor on the foundation carefully to prevent any damage.
5. (Check the mounting surface. Each footprint area must be of the same rigidity to prevent motor vibration during operation.
6. For large motors and high voltage motors, the foot fame must be equipped with a localiser after installation. The motor has one dowel hole in each foot at the DE. Deepen the holes by drilling through to the steel foundation. After that, the holes should be tapered with a reamer. Suitable tapered pins should be inserted in the holes to ensure the exact alignment and to allow easier reinstallation after future motor removal.
7. All shims and foot plates must be welded after installation to prevent any movement during motor operation.

Installation of rigid foundation

1. Clean the surface of the foundation.
2. Ensure that the foundation is strong enough to support the weight of the motor.
3. Ensure that the concrete is completely dry before the bolts are tightened.
4. Use rigid and solid base plate or common bed on the surface of the foundation. The tolerance of the surface flatness should be less than 0.1mm.
5. Check the mounting surface. Each foot plate must rest on the bed of the same rigidity to prevent motor vibration during operation.
6. At large motors the foot plate must be equipped with localizer after installation. There is an extra hole provided in the foot plate for locating.
7. All shims and foot plates must be welded after installation to prevent shifting position during motor operation.

Installation of rigid foundation

1. Clean the surface of the foundation.
2. Ensure that the foundation is strong enough to support the weight of the motor.
3. Ensure that the concrete is completely dry before the bolts are tightened.
4. Use rigid and solid base plate or common bed on the surface of the foundation. The tolerance of the surface flatness should be less than 0.1mm.
5. Check the mounting surface. Each foot plate must rest on the bed of the same rigidity to prevent motor vibration during operation.
6. At large motors the foot plate must be equipped with localizer after installation. There is an extra hole provided in the foot plate for locating.
7. All shims and foot plates must be welded after installation to prevent shifting position during motor operation.

Installation of vertical motor

1. If the motor is connected to a pump, both the motor and the pump are installed on the same foundation. The foundation must be rigid and must provide adequate support for the weight to prevent vibration.
2. All mounting surfaces must be clean and level.
3. The foundation must be leveled at least at 8 points and the flatness tolerance must be maximum 1.5mm.
4. Observe all the above requirements before the motor is seated on the mounting foundation.

Adjustment and alignment

The motor shaft and the driven machine shaft must be aligned within the limited tolerances in both angular and parallel alignment. Misaligned shafts will lead to premature bearing failure.

1. Before adjustment, the half couplings of the motor and the driven machine must be coupled together and be made ready for adjustment.
2. For the large motors with the adjustment bolts in feet, the bolts must be fitted in the foot plates of the motor prior to the adjustment.
3. The adjustment bolts may also be fitted in the feet of the driven machine for high accuracy of installation.
4. Use high accuracy instruments to measure shaft alignment.
5. All measured data must be recorded for further reference.

6. CONNECTION

6.1 Connection of Cooler

Connection of air-to-air coolers (IC61A1A)

Generally the air-to-air cooler is equipped with a force ventilation, which has its fan motor. The force ventilation must be installed in accordance with the fan motor manufacturers' instructions to ensure effective cooling.

Connection of ventilated ducts

Motors designed for air cooling (to and/or from the motor cooler) with air ducts are equipped with connection flanges as specified in the dimensional drawing. Clean the air ducts thoroughly before connecting them to the motor cooler. Remove all possible obstructions from the ducts. Seal the joints with appropriate gaskets. Check the ducts for air leaks after they have been connected.

Connection of air-to-water coolers (IC61A1W)

Motors equipped with an air-to-water heat exchanger are equipped with flanges as specified in the dimensional drawing. Connect the water pipes to the flanges and seal the joints with appropriate gaskets. Ensure that the sufficient water flow is achieved prior to the commissioning of the motor.

Connection of direct water-cooled motor

Steel frame water-cooled construction is only to be used with a closed fresh water circulation system. The water cooling piping and flanges are made according to the customer's specifications, and are defined on the dimensional drawing.

The cooling water circulates in piping integrated with the motor frame. The material of the frame and ducts is carbon steel. This material is prone to corrosion in saline and contaminated water. The corrosion results in fouling deposits, which might block the water flow in the piping.

It is important to use clean inhibited water in the cooling system. In most cases, normal tap water (i.e. water for domestic consumption) fulfils these requirements. If normal tap water does not fulfill these requirements, the cooling water must also be inhibited with an agent protecting the cooling system against corrosion and also against freezing. Standard cooling water requirements are as follows:

- pH 7.0 - 9.0
- Alkalinity ($CaCO_3$) > 1 mmol/kg
- Chloride (Cl) < 20 mg/kg
- Sulphate < 100 mg/kg
- $KMnO_4$-concentration < 20 mg/kg
- Al-concentration < 0.25mg/kg
- Mn-concentration < 0.05 mg/kg

6.2 Connection of sleeve bearings to oil circulation system

- Motors with flood lubrication system are equipped with oil pipe flanges and often also with pressure gauges and flow indicators. Connect all oil pipes of the oil circulation unit.
- The oil circulation pump system should be installed as close to the motor as possible and in equal distance from each bearing.
- Connect the oil inlet pipes to the bearings.
- Connect the oil outlet pipes to the bottom of the bearings at a minimum angle of 10°. The oil level inside the bearing would increase if the slope of the outlet pipes is below 10°. The oil flow from the bearing to the oil tank would be too slow and can result in oil leaks or disturbances in the oil flow.
- Fill the oil supply system with appropriate oil of correct viscosity. The correct type of oil and its viscosity is indicated on the dimensional drawing. The use of a mesh to filter contaminating particles in the oil is recommended.
- Turn the oil supply system on and check the oil circuit for possible leaks prior to the commissioning of the motor. Check the oil level using the glass gauge.

NOTE: The bearings are delivered without oil. Commissioning the motor without oil will result in instantaneous bearing damage.

6.2 Power supply wiring

Safety regulations and recommendations when wiring the power supply.

1. The power supply wiring and earthing must be strictly in accordance with national standards and local regulations.
2. The wiring should be carried out by qualified and trained personnel whilst observing the relevant safety requirements.
3. De-energize all equipment, including auxiliary equipment. Verify that all electrical parts are isolated from their respective supply. Secure the power supply against accidental switching and display a comprehensive sign informing about the work-in-progress.
4. Connect all relevant parts to protective earth.
5. Cover or provide a barrier protecting against live parts in the surrounding area.

Power

Check the motor nameplate for the rated values and make sure that available power supply is in full compliance with motor rated values. Following are the limits of voltage and frequency variation of the power supply. Please note that the motor will continue to operate within these limits but the performance characteristics may differ significantly from the one at the rated conditions:

- +/- 5% of rated voltage.
- +/- 2% of rated frequency.
- +/- 5% combined voltage and frequency variation so long as frequency variation is no more than +/- 2% of rated frequency.

Operating the motor at voltages and frequencies outside of the above limits can result in both unsatisfactory motor performance and damage of the motor. For further information please contact the manufacturers.

Main power supply wiring

1. Certain motor constructions are available with terminal boxes rotatable at 90°. The terminal box can then be adjusted according to the requirement of the user but must be correctly resealed.
2. Large LV motors are equipped with the 6 terminal board marked with letters U1, V1 , W1 and U2, V2, W2. The terminal boxes with 3 terminals have the terminals marked U, V , W. The phase-segregated terminal boxes are equipped with 1 terminal per phase compartment, 3 compartments U, V, W in total. The 6 terminals may be connected Δ or Y according to the connection diagram. The 3 terminals are to be connected according to A-U, B-V, C-W.

NOTE: Check the phase sequence in the connection diagram. The phase sequence is normally marked for clockwise rotation looking from the DE shaft of the motor.

If counter-clockwise rotation has been specified in the order the phase sequence would be marked accordingly.

3. It is important to verify that the power supply voltage and frequency are of the same as indicated on the nameplate of the motor before commissioning.
4. Care should be taken when multi-speed motor is wired up. The connection diagram received with the motor has to be consulted before the commencement of the installation work to determine the direction of rotation at all speeds. Please contact the manufacturers if in doubts.
5. Observe the insulation length and creepage distances between input cables in the terminal box to ensure continuous and trouble-free operation.

Stripping, splicing, crimping and insulating of the high-voltage cables must be performed in accordance with instructions supplied by the cable manufacturer.

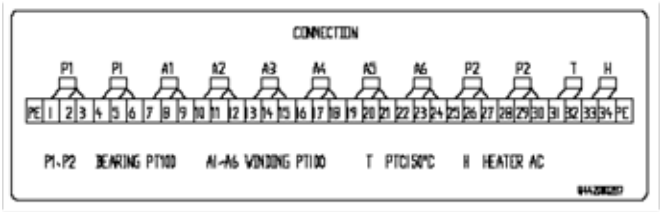
NOTE: The stripped, spliced cables must be insulated to avoid accident.

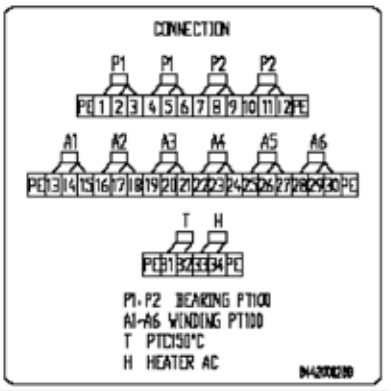
6. Suitable cable glands or bushes must be employed in the terminal box. Unused cable entries must be blinded.
7. The inside of the main terminal box must be free from impurities, moisture and foreign debris. The terminal box itself, the cable glands, and unused cable entry holes must be all sealed to comply with the relevant IP rating.

6.4 Auxiliary terminal boxes

- Protection RTDs and Anti-condensation heaters etc. are terminated in auxiliary terminal box/boxes on the motor. Auxiliary terminal boxes are attached to the frame of the motor. Their positions are shown on the dimensional drawing of the motor.
- Protection wiring must be in accordance with the wiring standard and safety standard.
- Auxiliary devices such as PTC thermistors, thermocouples, PT100 resistance thermometers, anti-condensation heating elements etc. will generally terminate in terminal blocks located in the auxiliary terminal box/boxes. The maximum voltage applicable on various elements terminated in auxiliary terminal box/boxes is 750V.
- Caution must be taken when handling wiring in auxiliary terminal box/boxes as anticondensation heater circuit is often automatically switched on when the motor is not running.
- Connect the circuits and auxiliary equipment according to the connection diagram which can be found in the auxiliary terminal box. An electronic copy is available from the manufacturers upon request.
- Ensure that the inside of the auxiliary terminal box is free from impurities, moisture and foreign debris. The box itself, the cable glands, and unused cable entry holes must be all sealed to comply with the relevant IP rating.

The connection diagram can be found inside the terminal box lid. Examples are below:





6.5 Power supply and rotor connection of slip-ring motors

- There are two ways to connect to rotor circuit at the slip-ring motors. The cable can be connected directly to the brush holder (rocker) or rotor circuits are terminated on the main terminal board.
- Observe the connection diagram supplied with the motor before connecting any cables.

6.6 Connection of external blower motor

- The AC motors supplied via frequency inverter are generally equipped with an external blower to ensure its standard cooling at different speeds.
- The external blower motor is normally a three phase induction motor. The terminal box is usually located on the frame of the blower motor.
- The connection of the external blower motor is the same as the main power supply connection.
- The earthing must be carried out in accordance with the local regulations before the external blower motor is connected to the power supply.
- No warranty claims for failed bearings will be entertained when improper earthing and/or cabling is carried out.

NOTE: The external blower motor must be connected to protective earth in accordance with local regulations.

6.7 Earth connections

- The earthing must be carried out in accordance with the local regulations before the motors are connected to the power supply.
- The motors usually have a protective earth terminal in the terminal box and extra external earthing terminals on the frame, feet or flange. All these terminals must be connected to protective earth.
- The motor must be earthed to the electrical power system earth.

6.8 Requirements for motors supplied via frequency inverters

For VSD applications motor frame external earthing must be used for equalizing the potential between the motor frame and the driven machine. Mounting both the motor and the driven mach ine on the same metallic base helps.

For motors above 280frame the use 1 x70mm flat copper conductor or at least two 50mm2 round copper conductors is recommended. The distance between the round conductors must be at least 150mm.

7. COMMISSIONING

7.1 Check before starting

Check the wiring against the connection diagram supplied with the motor before commissioning. Note the following points to ensure trouble free operation of the motor:

- Check that the motor is properly anchored to the foundation. Check the foundation for cracks and make sure that the general condition of the foundation is good.
- Check the tightness of the fixing bolts.
- Make sure that wiring (inclusive of wiring of auxiliary equipment) is correct.
- Check the cable sizes in relation to the current and make sure that all cable connections are correctly made.
- Ensure all connections are well insulated with regard to the voltage and temperature.
- Make sure that all cable joints (if any) outside the terminal box are insulated.
- Make sure that frame and terminal box are earthed. Ensure that correct size of fuse, circuit breakers, switches, contactors, magnetic switches, thermo-relays etc. have been fitted and are in good condition.
- Make sure that the starting method is correct and in accordance with the manufacturer's recommendations.
- Check the assembly of the main terminal box and cooling system terminal box.
- Check that the lubrication system has been commissioned and is running before the rotor is turned. See paragraph 8.2 for more information.
- Check the connection of oil and cooling water pipes for correctness and leakage when running.
- Check oil and cooling water pressure and flow (when appropriate).
- Check main cable to avoid any stress.
- Ensure that anti-condensation heater is not switched on when the motor is in operation, as it should be automatically applied when the motor is out of operation.

7.2 Insulation resistance test

Upon commissioning or after a long period of inactivity or during the general maintenance work, the insulation resistance of the motor must be tested. The insulation resistance of both stator and rotor windings (where applicable) must be tested.

The insulation resistance is very high at new motors with dry winding. The resistance can, however, become extremely low if the motor has been subjected to incorrect transportation and storage conditions and humidity or if the motor is operated incorrectly.

The insulation resistance test provides information about the humidity and contamination of the insulation. Based on the test result, correct cleaning and drying actions can be determined.

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Before insulation resistance test

1. If the tested value is considered low the winding must be cleaned and/or dried. If these two measures do not bring the insulation resistance back up, please contact the manuafcturers.
2. Motors, suspected to be damp must be dried carefully.
3. The insulation resistance value decreases when the winding temperature rises. The resistance is halved for every 10 K temperature rise above the dew point.
4. The insulation resistance indicated in the test report is normally considerably higher than the value tested on site. New motors are leaving the factory with dry windings.

Minimum values for insulation resistance

Generally, the insulation resistance values for dry windings should exceed the minimum values significantly. The minimum insulation resistance values depend on motor type, size, local conditions etc. Additionally, the insulation resistance is affected by the age and usage of the motor.

Calculation method of minimum values for insulation resistance

The following formula for the minimum value of the insulation resistance is to be applied on motors after the factory load test has been accomplished:

$$R = \frac{U1}{1000 + P/100} \ (M\Omega)$$

Where:

R - insulation resistance (MΩ);

U1 - rated voltage (V)

P - rated power(kW)

The control value of insulation resistance

Low-voltage motor	When the value of insulation resistance is more than 10MΩ, it is considered a standard condition.
High-voltage motor:	When the value of insulation resistance is more than 100MΩ, it is considered a standard condition.
Slip-ring motor (LV or HV):	When the value of insulation resistance is more than 10MΩ, it is considered a standard condition.
If the values of insulation resistance are lower than these values, the motor should be checked for moisture and dust.	

Stator winding insulation resistance testing

The insulation resistance is tested using an insulation resistance meter (megger). The different meters are used according to the different voltages.

1. For rated voltage below 1140V (including 1140V), 500VDC megger should be used.
2. For rated voltage above 1140V, 2500VDC megger should be used.

NOTE: Do not touch the terminals during or immediately after testing as they carry residual voltages dangerous to human health!

If power supply cables are connected during testing, make sure that the power supply is disconnected and that the motor shaft is stationary before the commencement of the insulation resistance test. Also in this instance you test and record the insulation resistance not only of the motor but also of the incoming cable.

Irrespective what meter is used, the test time must last 1 minute, after which the insulation resistance value gets recorded. Before the insulation resistance test is conducted, the **following precautions must be taken:**

1. Verify that all power supply cables are disconnected.
2. Verify that the frame of the motor and the stator windings that are not being tested are earthed.
3. Verify that all auxiliary device are earthed.
4. The insulation resistance test should be carried out inside the terminal box. The test is usually performed on the whole winding as a group, in which case the meter is connected between the frame of the motor and the winding.
5. When required, the meter can be connected between the frame of the motor and one of the windings. The frame and the two phases (which are not tested) need to be earthed.
6. The winding temperatures should be measured and recorded. If the insulation resistance test is carried out after a long period of time from motor shut down, measure the temperature of the enclosure rather than the temperature of the winding.
7. After the insulation resistance winding test is accomplished, connect the winding to the earth for a short period of time to discharge the winding.

Insulation resistance test applied on a slip-ring motor

Insulation resistance test applied on a motor slip ring motor is similar to the test applied on the squirrel cage motor.

1. Verify that all supply cables are disconnected from the main power supply.
2. Verify the slip ring rotor connection cables are disconnected from the regulator.
3. Verify that the shaft, the frame of the motor and the rotor windings are earthed.
4. Verify that the carbon brush connections are in good order.
5. If the insulation resistance test is carried out after a long period of time from motor shut down, measure the temperature of the enclosure rather than the temperature of the winding.

Then the insulation resistance of the rotor winding need to be tested. The followings notes should be observed:

1. Verify that the frame of the motor and the stator windings are all earthed.
2. Verify that the shaft is earthed.
3. The rotor winding can be generally connected in a STAR connection. If each phase must be tested separately, the rotor winding phases which are not subject to testing need to be earthed.
4. After the insulation resistance winding test is accomplished, connect the winding to the earth for a short period of time to discharge the winding.

Insulation resistance test carried out on auxiliary devices

1. The test voltage applied on the anti-condensation heaters should be 500VDC.
2. The insulation resistance test on PT100 thermometers is not recommended.
3. The insulation resistance test can be carried out on the shaft where insulated bearings are fitted at both ends. Should the insulated bearing be fitted on one side only, the endshield at the opposite side must be removed before the commencement of the test

7.3 Commissioning and Start-up

First test start

NOTE: The starting current can be 2-8 times higher when direct-on-line starting is applied.

The starting torque is in a direct proportion with the square of voltage when auto-transformer starting.

Use auto-transformer starting at a reduced voltage and use direct-on-line starting for heavy loads only.

The motor load must be kept as low as possible during commissioning.

- The first startup should last only about one (1) second. The objective of the first start is to check the direction of rotation of the motor. The motor should turn in the same direction as is shown with an arrow located on the frame or the fan cover. The motor may be operated in both directions of rotation - no arrow located on the frame or fan cover..
- The direction of rotation of the external blower motor is indicated by an arrow near the blower motor.
- Verify that no rotating parts touch stationary parts during the initial brief startup.
- If the preferred direction of rotation is different from the one indicated on the motor, it must be changed by the manufacturer and stamped on the nameplate.
- To alter the direction of rotation, any two line cables need to be swapped.
- Slip ring motors cannot operate without a starter (regulator).
- If possible, the first start should be made with coupling uncoupled.
- The first startup should be without shaft coupling between the motor and driven machine. There may be certain axial shaft shift noted during the power shutdown.

Running unloaded

- The motor can be left running unloaded for longer time during commissioning to verify that it functions as expected.
- It is recommended that during the first one or two hours of operation the motor be closely monitored to ensure the vibration or temperature levels be within tolerances and that no abnormal sounds occur. Shut the motor down immediately should any problem occur. Contact the manufacturer if necessary.
- The motor may be direct-on-line started or auto-transformer started.
- If the motor rotor fails to start running within one or two seconds from power-up, shut the power supply off immediately. Investigate the cause thoroughly and take corrective action before attempting a restart.

Running unloaded

- Initially run the motor unloaded prior to coupling the shaft to the driven machine.
- If the motor rotor fails to start running within one or two seconds, shut the power supply off immediately. Investigate the cause thoroughly and take corrective action before attempting a restart.
- If the rate of the temperature rise is excessive or if the motor exhibits excessive vibration or noise, it must be shut down immediately and a thorough investigation carried out before attempting a restart.
- If an abnormal noise or vibration occur shut the power supply off immediately. Check the motor/ driven machine shaft alignment. Increased vibration can also indicate an unbalanced rotor or a stator winding problem.
- Ensure that the voltage and frequency of the power supply are identical to the ratingsdisplayed on the nameplate and that they do not change during motor operation. Make sure that the current is balanced across the 3-phases.
- The number of permissible consecutive starts of DOL supplied motors depends essentially on the load characteristics (torque vs. speed curve and inertia), and on the motor type and design. Too many starts or too heavy starts cause high temperature rise and thermal stresses on the motor winding, effecting the insulation thus reducing the life of the motor or premature insulation failure.
    1. Motor can be restarted after the initial failed startup. Two starts are generally permissible when the motor is cold.
    2. Allow the motor to cool down for 60 minutes before restarting whilst fully loaded. Allow the motor cool down for 30 minutes before restarting whilst unloaded. Two inching starts can be regarded as one normal start.
    3. The load characteristics and inertia of the driven machine is necessary for determination of the frequency of starting. As a guideline, the maximum number of starts whilst fully loaded is 800 starts per year.
- For motors with PT100 resistance thermometers, the temperatures of the bearings, stator windings and cooling air should be monitored and recorded when the motor is ruin operation. After a period of time, the motor's cooling system should be inspected. Verify that the cooling fluid (where applicable) and the cooling air are circulating without any obstruction. Monitor and record the temperatures at the inlet and outlet ofthe cooling system.

The winding and bearing temperatures may not stabilize until after several (4-8) hours, when running at full load.

The stator winding temperature depends on the load of the motor. If the motor cannot run at the full load during commissioning, the partial load and temperature should be obtained and included in the commissioning report.

- If the bearing temperature rise and the motor operation appear to be standard, the operation should continue until the bearing temperatures stabilize.
  1. The temperature limit on antifriction bearings is max 95°C.
  2. The temperature limit on sleeve bearing is max 90°C.

If the temperature rise in bearings is excessive or if the motor exhibits excessive vibration or noise, it must be shut down immediately and thorough investigation carried out to establish the cause before attempting a restart.

At motors without PT100 resistance thermometers in bearings, the temperature of the endshield should be measured instead of that of bearings. The temperature of endshield is usually 10°C lower than that of the bearing.

- Any cause of excessive temperature rise, noise or vibration should be immediately investigated and corrected. Increased temperature rise can be also indicative of a change in balance due to mechanical failure of the rotor, a stator winding problem or change in motor alignment.
- Starting time is longer when starting machines with large inertia. However, if starting time is longer than usual or if the motors has a sudden problem in starting the load, or if there is excessive noise or vibration during startup, shut the motor down and contact the manufacturers.
- If the capacity of the transformer is not large enough to start several motors at the same time, starting should be made successively from the largest power motor to the smallest one.
- Motor protection should not be disconnected during motor operation and during fault investigation.
- It is important to monitor the motor's operation for the first few days after commissioning to make sure that no changes in vibration or temperature levels occur.
- SPM nipples (where available) should be used for vibration monitoring. The vibration values should be recorded for future reference.

If the motor is not equipped with SPM nipples, check the motor vibration using portable vibration analyzer. The test place should be near the rotor. Avoid locating the probe on a thin material such as fan cover.

After installation, the vibration value of the motor will be a little higher than it was before the motor left the factory.

Use the following values as a reference:

Foundation	Frame size	Max Vibration velocity (mm/s)
Rigid	Up to 355frame	3.5
Rigid	Up to 355 for 2pole motors	4.5
Rigid	Above 355frame	4.5
Rigid	Above 355 for 2pole motors	5.0
Flexible	Up to 355frame	4.0
Flexible	Up to 355 for 2pole motors	5.0
Flexible	Above 355frame	5.0
Flexible	Above 355 for 2pole motors	6.0

If the vibration is not in accordance with the values in the above table, do not use the motor and commence with an investigation. If in doubts contact the manufacturers.

- Check that the brushes at the slip ring motors are not sparking.

Ensure that the slip ring surfaces are smooth. If not, the slip rings must be machined.

- During the early period of operation, the heat-exchange system should be checked. Verify that the cooling fluid (where applicable) or the cooling air are circulating without obstructions.
- The motor surfaces may become hot under operating conditions. Touching of the motor should be prevented or avoided.

NOTE: If the motor exhibits excessive vibration or noise, it should be shut down immediately and a thorough investigation carried out to establish the cause of the failure before attempting a restart.

Any mechanical failure such as a loose bolt, an unbalanced rotor, a stator winding problem or motor shaft misalignment will cause excessive noise and/or vibration.

Shut down

- The requirements on the motor shutdown depend on the application, but the main guidelines are the same.
- Reduce the load of the driven equipment, if possible.
- Open the main circuit breaker.
- When the motor is not in operation, anti-condensation heaters should be switched on (where applicable).
- For motors with water-cooling, the cooling water supply must be stopped in order to avoid condensation inside the stator.

8. LUBRICATION

It is essential to use good quality grease of correct specification. This will ensure a long and trouble free lifetime of the bearings.

8.1 Re-greasing for the antifriction bearings

- Bearings of the ZZ type are lubricated for life and are being installed in smaller motors.
- The re-greasing device can be found at the large motors. It is necessary to re-lubricate at regular intervals.
- In case of a newly installed motor or when a motor has been out of service for more than 2 months, re-lubrication is recommended to be carried out immediately after commissioning. the re-lubrication is to be carried out when the motor is running. Keep injecting new grease until the used grease or excess amount of the new grease is discharged through the lubrication valve in the bottom of the bearing housing.

The temperature of the bearings will initially increase due to excess grease. After a few hours the excess grease will be discharged through the lubrication valve and the temperature of the bearing will return to normal running temperature.

- Change the oil at regular intervals. The time between oil changes depends upon the severity of operating conditions and must be determined by the motor user. Two or three oil changes a year is typical pattern but special conditions, such as high ambient temperature, may require more frequent oil changes. The re-lubrication interval must never be longer than 12 months.

The recommended re-lubrication intervals (based on standard load) are as follow.

Rated power (kW)	Speed (rpm)	The recommended lubrication intervals		
		Normal condition	Severe condition	Extreme condition
<18.5	1500	5 years	3 years	1 year
18.5-90	1500	1 year	6 months	3 months
90-200	1500	3 months	3 months	1 month
200-1600	1500	3 months	1 month	15 days
<18.5	3000	5 years	3 years	1 year
18.5-90	3000	1 year	6 months	3 months
90-200	3000	3 months	1 month	1 month
200-1600	3000	3 months	1 month	15 days

NOTE:

Normal condition	refers to the motors operating at rated power (or below rated power) in clean environment. Duty cycle is not more than 8h per day.
Severe condition	refers to the motor operating at rated power or (or below rated power) in dust laden environment with the light load shocks and vibration. Duty cycle is 24h per day.
Extreme condition	refers to the motor operating in polluted environment with heavy load shocks and vibration.

Re-greasing method

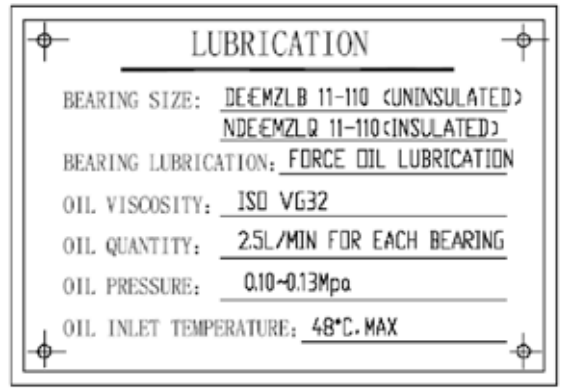
- Before re-greasing, the inlet re-greasing nipple should be thoroughly cleaned to prevent any accumulated impurities from being carried into the bearing with the new grease. The outlet of grease discharge should be opened to allow purging of the used grease. A suitable grease gun should be used to pump grease through grease nipple into the bearing.
- After re-greasing, operate the motor for 10-20 minutes to allow any excess grease to discharge. Plug the grease nipple and the discharge (if plug is provided).

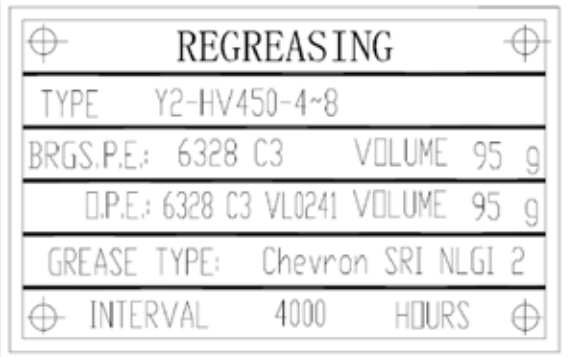
Types of grease

Grease with of correct specification is available from all major lubricant manufacturers. If the grease is to be changed and a product of different manufacturer used and the compatibility cannot be verified please consult the motor manufacturer.

Chevron SRI-2 grease is standard for majority of Marathon motors (except of some special motor types for which special grease would have been confirmed). Please use identical grease or its equivalents for re-lubrication.

Examples of the Lubrication Plate (oil) and Re-greasing Plate (grease) (which can be found on motor's frame) are shown below:





NOTE: Re-lubrication is to be performed by authorized and trained personnel whilst the motor is in operation. The rotating parts and live parts must be protected.

Please refer to the oil/grease type, re-lubrication intervals and the amount of the lubricant, which cab be found on the lubrication/re-greasing nameplate attached to the motor frame.

8.2 Sleeve bearings re-lubrication

- Motors with the sleeve bearings leave factory without lubrication oil. They need to be oil filled before commissioning.
- Oil lubrication system should be installed as close to the motor as possible. The oil lubrication system must be switched on before starting the motor.
- Check the oil gauge in the top of the bearing to ensure oil circulation. Stop the motor immediately should the oil circulation be impaired in any way.
- Verify that no rotating parts rub against stationary parts.
- Use the oil gauge to verify the correct oil level inside bearing. The correct oil level is achieved when the oil level is in the middle of the oil gauge.
- At flood-lubricated motors the oil supply pressure is adjusted with the pressure valve and orifice. The normal oil supply pressure is 120 kPa ± 20 kPa. This provides the correct oil flow to the bearing. Using higher oil pressure gives no additional benefit and can cause oil leakage.
- Monitor the oil temperature and the oil level in the bearings continuously. This is particularly important for self-lubricating bearings. If the oil temperature suddenly rises, the motor should be stopped immediately and the reason for the temperature rise investigated and the fault rectified before the motor is re-started. If no logical reason for high oil temperature can be established the bearing should be opened and its condition verified. If still in warranty contact the manufacturer before taking any action.
- Perform the oil check a few days after the commissioning, before the first oil change and subsequently as may be required.
- The oil tanks of the self (not flood) lubricated bearings should be drained and refilled approximately every six (6) months. More frequent oil changes may be required at motors running at high speed (3000rpm) or if severe oil discoloration or contamination occurs.

9. INSPECTION AND MAINTENANCE

Rotating electrical machines often form an important part of a large installation and if it is monitored and correctly maintained it will deliver reliable and trouble free operation during the expected lifetime.

9.1 The purpose of inspection and maintenance

- To ensure that the motor will function reliably without any unforeseen failures.
- Plan service actions and maintenance in order to minimize down time.
- The purpose of the maintenance is to perform a quick assessment of the motor's condition and to avoid problems and conditions which generate failures and unscheduled maintenance breaks.

9.2 Notice of inspection and maintenance

- Whilst working on any electrical equipment, general electrical safety precautions are to be observed as well as the local regulations to prevent injury.
- Personnel performing maintenance on electrical equipment and installations must be qualified and trained in specific maintenance procedures pertaining the rotating electrical machines.
- Hazardous area motors are specially designed to comply with regulations applicable for explosion-proof motors.
- These instructions and recommendations should be carefully observed and used for planning the motor maintenance.
- The access to spare parts forms an essential part of the preventative maintenance. It is recommended that critical spare parts are kept in stock with the motor.

9.3 The inspection and maintenance levels

- Routine inspection : The purpose of routine inspection is to ensure the standard operation of the motor.
- Regular inspection: The purpose of the regular inspection is to prevent motor failure.
- Maintenance intervals: Every motor must be maintained after a period of operation. The maintenance work should be carried out based on the circumstances the motor is operating. As a general guideline it is recommended to perform periodical maintenance at least once a year. Motors operating in extreme conditions should have the maintenance interval shortened.

The frequency of inspections should be determined by the following factors:

- The ambient temperature and operating conditions.
- The frequency of starting and stopping.
- The presence of parts which have reduced wear life.
- The supply voltage and frequency variation.
- Increased vibration conveyed from the driven machine.
- The importance of motor use within the factory operation.

9.4 Routine checks can be carried out during the motor operation

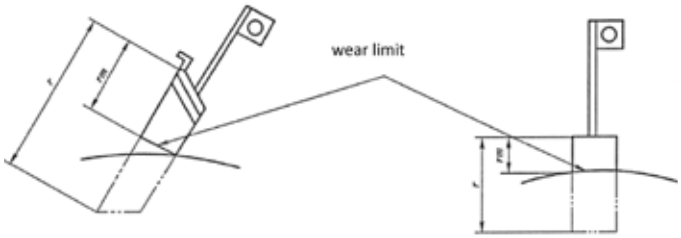
NOTE: Any changes in vibration severity or temperature levels or when noise is increased, the motor should be shut down immediately and investigation commenced. It is important to monitor bearing temperature during the motor operation.

- All motor surfaces should be kept clean. The motor exterior should be kept clean and be periodically inspected for corrosion and oil or water leaks.
- Check that the pipe connections are tight and that there is no leakage of the system. Verify that the cooling fluid (where applicable) and the cooling air are circulating without any obstruction. Check the condition of the fan cover and ensure that good air circulation inside the motor is maintained.
- Monitor the vibration severity of the driven machine as increased vibrations would effect the motor in negative way. If any changes in vibration or temperature levels occur or when increase noise is noted, shut down the motor immediately and carry out an investigation.
- If the windage pointer of sleeve bearing is coming out of the scale, friction between shaft and bearing is occurring. Shut down the motor immediately and carry out an investigation.
- If any of the following conditions occur, shut down the motor immediately and carry out an investigation.
    1. Heavy vibration,
    2. The driven machine is damaged
    3. Bearings show signs of wear or overheat
    4. Shaft misalignment or axial vibration
    5. Speed slows down suddenly
    6. Friction between stator and rotor apparent (motor enclosure overheating)
    7. Generation of air fumes
    8. Personnel accident or injury

9.5 Regular checks

- Deteriorating performance can be prevented or chances reduced when the motor is subject to appropriate maintenance and regular inspections.
    1. The tightness of all fasteners should be verified regularly.
    2. All connections and mounting bolts should be check regularly.
    3. Check the brushes for excessive wear and that they can move freely in the brush holders. Change worn brushes before the wear limit is reached. Verify that the brushes are not sparking.

The wear limit should be not less than the 0.35 *brush height (rm≥0.35r). See figure below



4. Check earthing connections.
5. Check the condition of shaft seals and replace them when necessary. Contact the manufacturers if in doubts.
6. Check the alignment of shaft coupling.
7. Check the motor enclosure. No water, grease, oil, or dust must be penetrating the motor enclosure.
8. Check the bearing conditions and replace bearings when necessary.
9. Check the surface coating condition and repaint when necessary.

9.6 Maintenance

The regular maintenance is important for preventing of the motor failure and for extending the motor's service life. Motors should be maintained once a month and thorough overall maintenance should be performed once a year.

- The monthly maintenance should include:
    1. Cleaning of the motor.
    2. Testing the insulation resistance of motor winding.
    3. Tightening the connection and mounting bolts as well as earthing bolts.
    4. Cleaning the motor starter (slip-ring motors) and insulation terminal.
    5. Removing carbon dust from the slip rings and brushes.
    6. Checking the condition of fan covers and ensuring good air circulation inside the motor.

- The annual maintenance should include:
  1. All the above items of the monthly maintenance.
  2. Cleaning the interior of the motor.
  3. Checking the condition of bearing (and replacing them if necessary). It is recommended to replace the bearings annually at continuously running motors (operating hours 8 000h/year).
  4. If it is not necessary to replace bearings, they need to be cleaned and grease replaced.
  5. Clean and replace other worn parts of the motor.

9.7 Maintenance method

Clean the exterior of the motor

1. Totally enclosed air-to-air cooled and totally enclosed fan cooled (TEFC) motors (IP 44 and above) require special cleaning considerations. The external fan must be cleaned thoroughly since any build-up of dirt would lead to unbalance and vibration. All of the tubes of the air-toair heat exchanger must be cleaned using a suitable tube brush with synthetic bristles (not a wirebrush of any type).
2. If the motor is equipped with fan-covers, they should be cleaned and re-conditioned when necessary.
3. Open drip-proof motors(ODP motors of IP23 and below) must have all screens and louvers over the inlet air openings cleaned. No build-up of dirt or lint should be allowed that could restrict free air circulation.

NOTE: Screens and louvers should never be cleaned whilst the motor is in operation because the dirt or lint would be sucked directly into the motor enclosure..

Clean the interior of the motor

After a motor is in operation for long time, the accumulation of dust, carbon powder and grease in the inside is unavoidable and may cause damage of the motor. Regular inspecting and cleaning is required to enable trouble-free operation. The following points are to be observed during cleaning:

- Vacuum cleaning can be used, both before and after other cleaning methods have been employed to remove loose dirt and debris. Vacuum cleaning is a very effective way of removal of loose surface contamination from the winding. Vacuum cleaning tubes should be nonmetallic to avoid any damage to the winding.
- When compressed air or a blower is used for cleaning, it must be ensured that the compressed air is moisture free. The air pressure should be maintained at 4bar (4 kg/cm2), as high pressure can cause damage to the winding.
- Surface contamination of the winding can be removed by wiping whilst soft, lint-free wiping material is used.
- If the motor is contaminated with oil, the wiping material can be moistened (not dripping wet) in a petroleum based solvent.
- In hazardous locations, a solvent such as inhibited methyl chloroform may be used but it must be used sparingly and removed immediately. This solvent is non-flammable under normal conditions but it is toxic. Its use is to be a subject to a risk assessment and health and safety precautions should be followed.
- The cleaning of the motor use is to be a subject to a risk assessment. Health and safety precautions must be followed while cleaning the motor. When using a solvent such as inhibited methyl chloroform to clean the motor, face mask must be worn and good air circulation around the motor maintained.
- For radial ventilated motors, the ventilation route should not be allowed to accumulate any build-up of dirt or lint, etc. that could restrict free air circulation and lead to high temperature rise.

The cleanliness of the antifriction bearings

The antifriction bearings will have to be cleaned periodically after operating for a period of time.

- The bearings need to be cleaned, dried-up and re-greased with suitable high quality antifriction bearing grease before assembly.
- No dirt or foreign debris is allowed to enter inside the bearings at any time during the maintenance.
- The antifriction bearing should be heated before re-assembly. The temperature must be controlled at 90°C.
- The disassembly and mounting of the antifriction bearings must not damage the bearings. Use pullers to remove the bearings. Heat the bearing before re-fitting. Do not use hammer on the bearings to prevent bearing damage.

The cleanliness of the sleeve bearing

- The verification of oil cleanliness
  1. Check the oil visually and assess its color.
  2. Check the oil visually and look for deposits.
  3. The original oil viscosity must be maintained within the tolerance of ±15%.
  4. Smell the oil. Strong acid or burnt smell is not acceptable.
- The method of cleaning the sleeve bearing. When a condition mentioned at (1) is identified, the oil must be changed and the bearing cleaned. The carbon oil must be used to clean the bearing.
- Precaution to be observed during cleaning. Handle the bearings with care. Any impact will damage the bearing surface.

10. MOTOR TROUBLESHOOTING CHART

The motor must be serviced and troubleshooting handled by qualified and trained personnel equipped with necessary tools and repair equipment.

No	Symptoms	Cause	Recommended action
1	Motor fails to start	Power-off	Check wiring. Switch the breaker on. Change fuse. Check power supply cables.
		Stator winding failure	Check winding for short circuit or open circuit.
		Motor overloaded	Reduce load.
		Incorrect wiring	Check the wiring
2	Motor does not come up to full rotating speed	Voltage too low at motor terminals because of line drop.	Check connections. Check cabling for correct size.
		Poor contact of control switches or short circuit of starting switches.	Check and repair control switches.
		Phase failure.	Check power supply and connections.
		Poor contact of power supply.	Check power supply connection.
		Windings earthed or short circuit detected.	Factory repair.
3	Fail to run under load after start, due to tripped switch/ circuit breaker	Insufficient capacity of switches and fuse/circuit breaker.	Replace switches and fuse/circuit breaker if the wiring cable size permits.
		Under-voltage.	Check the power supply.
		Overload.	Reduce the load.
4	Live enclosure	Incorrect wiring of power supply and earthing.	Correct the wiring.
		Insulation moist or aged.	Dry or replace the winding.
		Short connection between the power lead and enclosure.	Check power lead and enclosure and insulate them.
5	Motor	Overload.	Reduce the load or replace motor.
	overheating	Ambient temperature exceeds 40°C.	Replace with higher insulation class, or lower ambient temperature.
		Under-voltage.	Check power line, transformer capacity and supply voltage.
		Over-voltage.	Check power supply.
		Fuse /Circuit breaker tripped (Single-phase operation).	Fuse /Circuit breaker tripped (Single-phase operation). Install the specified fuse/ circuit breaker
		Ventilation duct clogged.	Remove the debris from the duct.
		Friction between rotor and stator.	Factory repair or replace motor.
		Unbalanced three-phase voltage.	Check circuits or consult power supply company.

6	Speed falls sharply	Sudden overload.	Check load and mechanical connection.
		Single-phase operation.	Check switch, fuse and circuit breaker.
		Voltage drop.	Check control circuit and power supply.
7	Electromagnetic noise.	Noted from time of commissioning	May be standard performance.
		Sudden sharp noise.	Check winding for short circuit.
		Friction between rotor & stator.	Should be repaired at manufacturers.
8	Mechanical noise	Ventilation noise.	Noise caused by air flowing through ventilation ducts, maybe standard noise.
		Loose belt sheave or loose coupling.	Adjust key and the position belt or couplings and lock the screw.
		Loose screw on fan-cover.	Adjust key and the position belt or couplings and lock the screw.
		Friction between fan and endshield or fan-cover.	Adjust the distances between fan and end-shield or fan-cover.
		Rubbing as a result of ingress of foreign particles.	Clean motor interior and ventilation ducts.
		Caused by driven machine	Check & repair the driven machine
9	Bearing noise	Even sound.	May be standard noise.
		Lightly collided sound.	Re-greasing needed.
		Loud bearing sound.	Cleaning bearing and grease change.
		Broken ball or rough races.	Replace the damaged bearing.
10	Vibration too high	Incorrect installation.	Tighten the mounting screws.
		Motor mounting bed is not strong enough.	Reinforce mounting bed.
		Asymmetrical centers between belt sheaves.	Align central points.
		Central points of couplings do not lie on the same level.	Adjust the central points of couplings to the same level.
		Unbalanced rotor.	Balance rotor again.
		Unbalanced fan or broken fan blade.	Replace fan or balance fan again.

10	Vibration too high	Short circuit in windings (stator or rotor).	Factory repair.
		Mounting bed vibratTion caused by nearby machines.	Eliminate the vibration source nearby.
11	Bearing overheating	Damaged bearing.	Replace the damaged bearing.
		Poor lubrication.	Change grease.
		Misalignment between motor and driven machine shafts.	Adjust belt tension or align coupling.
		Friction between bearing and bearing housing or shaft.	Replace the damaged shaft or endshield.
		Incorrect assembly.	Re-assembly motor.

11. MOTOR TROUBLESHOOTING CHART

The discarded motor at the end of its useful life must be recycled in accordance with the local regulations.

The material content used for manufacturing of the motors is as follows:
Cast iron, steel, copper, aluminum, insulation materials.

Metals account for a large part of the product. They are all subject to material recycling. The nonmetal materials should be either incinerated or disposed of in landfills. Attention should be paid to such processes so they do not have adversely affect on the environment.

marathon®

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