

Installation, operation and maintenance manual



(Read this manual carefully before use)

PROMOTOR Y3/YX3/YE3/T2C/T3C/T4C Series

3-Phase Induction Motors

Installation, operation and maintenance manual

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- 1. Safety specification**

NOTE!

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

1.1 Confirm that the parameters on the nameplate meet your requirements.

1.2 Confirm that the motor is not damaged.

1.3 Remove transport shaft locking device if fitted. Re-install it before transportation once more.

1.4 Only lift the motor using the eyebolts or the lifting lugs integrated with the motor frame.

Alternatively, follow any otherwise stated separate lifting instructions.

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

If there is more than one lifting lug, they must be used together to share the weight.

The centre of gravity of motors with the same frame may vary due to different outputs, mounting arrangements and auxiliary equipment.

To move a motor with packing, a sling must be used to lift the motor under the base, or eyebolts or lifting lugs integrated with the motor frame should be used.

1.5 After installation, confirm that the mounting (IM) is in line with the identification on the nameplate. Check that the drain holes are at the lowest position. If there are any questions, please contact Felm Co..

2. Safety considerations

NOTE!

Obey the safety precaution measures as follows.

2.1 The motor is intended for installation and use by qualified personnel, familiar with relevant safety requirements.

If the motor is not installed, operated and maintained correctly, it could become a danger to health and human life.

NOTE!

Safety equipment necessary for the prevention of accidents at the installation and operating site must be provided in accordance with the local regulations.

2.2 Before maintenance is carried out, all electrical supplies connected with the motor and its auxiliary parts must be turned off. Confirm that the motor is already at a standstill.

2.3 Earth connections must be carried out according to local regulations before the motor is connected to the mains supply.

Any protection devices must also be earthed to prevent accidents in service.

2.4 Any fitted thermal protection devices should not be left open circuit and should always be used.

The protection devices can ensure the life of motor.

2.5 Depending on the operating conditions and environment, the most suitable degree of protection must be chosen to prevent any damage and accidental contact with internal rotating parts or with live parts.

2.6 There should be no possibility of contact with live parts. In the case of auto-starting, auto-shutting down and remote starting, there must be a warning notice to state that the motor could start unexpectedly.

2.7 Before starting, confirm that all shaft keys are fitted firmly.

2.8 In order to prevent overload, it is advisable to install a device to monitor the winding temperature.

Felm Co. can install winding temperature monitors, if they are not already fitted as standard, with leads to connect directly with a controller to provide thermal protection.

2.9 No phase failure in service. It is recommended to install a phase failure protection device.

2.10 Coupling halves and pulleys must be fitted using suitable equipment and tools that do not damage the bearings. Never fit a coupling half or pulley by hammering into place, or remove it using a lever pressed against the body of the machine.

2.11 Within the vicinity of the noise source, ear defenders must be worn.

For more information about noise limits, please contact Felm Co. or reference the relevant product standard of Felm Co.

2.12 Protect against the ingress of water.

2.13 When a motor is used with a variable speed mechanism, make sure that it does not exceed the

maximum safety speed of the motor and operate without overload.

(At lower speeds, the ventilation of totally-enclosed fan-cooled motors will decrease. A separate fan motor should be added to avoid any overheating at low speed.) If there is any doubt, please contact Felm Co.

2.14 Confirm safety measures to avoid accidents in brake failures.

2.15 Some Felm motors provide continuous operation re-greasing nipples. These machines are intended for lubrication during operation by qualified personnel who are familiar with relevant safety requirements. Any rotating parts or live parts should be integrally protected.

NOTE!

These safety considerations must be followed to avoid injury from electrical and mechanical hazards.

3. Environmental requirements and operating conditions

3.1 Environmental requirements

3.1.1 Normal ambient temperatures limits are -15°C to 40°C if standard performance is to be achieved.

3.1.2 Maximum altitude 1000 metres above sea level.

3.1.3 Relative humidity should be less than 95%.

NOTE!

If there is any deviation from these maximum environment conditions, such as normal ambient temperatures lower than -15°C or higher than 40°C, or the relative humidity is more than 95%, or the altitude above sea level is more than 1000 metres, or high vibration situations, the suitability of motors for operation must be checked. Any questions, please contact Felm Co.

3.2 Operating conditions

3.2.1 The deviation between supply frequency and rated frequency should be no more than 1%. The deviation between supply voltage and rated voltage should be no more than 5% (except special designs according to prior agreement).

3.2.2 The open-drip-proof motors (IP23, IP21) are suitable for operating indoors in clean, dry, and non-corrosive well ventilated conditions.

NOTE!

If open-drip-proof motors (IP23, IP21) operate outdoors, adverse weather conditions will affect the standard performance of the motors.

3.2.3 The totally-enclosed fan-cooled motors (IP44, IP54, IP55) are suitable for operating in relatively dirty, humid, and dusty environments.

3.2.4 The outdoor anticorrosive motors are suitable for operating outdoors or in corrosive air, and high humidity environments.

3.2.5 For the water-cooled motors and the motors with water-cooled bearings, the ambient temperatures should be no less than 0°C, to avoid the cooling water freezing.

3.2.6 Foundations must be even, and sufficiently rigid to withstand possible short circuit forces. They shall be dimensioned so as to avoid the occurrence of vibration due to resonance.

3.2.7 The installation space should be large enough to facilitate heat dissipation and maintenance.

NOTE!

Check that the motor has sufficient airflow. Ensure that no nearby equipment, surfaces or direct sunshine, radiate additional heat to the motor.

If there are other ventilators, ensure they do not affect the ventilation of the motor. If it is affected, the wind power of the ventilator must be adjusted or change the ventilating path of the motor to ensure that it can ventilate effectively.

4. Transportation and storage

4.1 Transportation

4.1.1 The motors are provided with adequate protection before leaving the factory. Ensure that the same protection is kept to protect from damage and scratching during transportation.

4.1.2 Some medium and large motors are fitted with cylindrical-roller bearings, angular contact bearings and/or sleeve bearing and must be fitted with shaft locking devices during transportation.

4.1.3 Upon receipt of the motor, a check must be made immediately for external damage and if found, take photographs and inform the forwarding agent without delay. It is important to inform the transportation company and the supplier with evidence of damage as soon as possible. Check that it will meet the customer's requirement for products and service.

4.1.4 When motors are not put into operation immediately, adequate protection measures should be undertaken to assure best performance.

4.1.5 For motors with packing, check the following points upon receipt: Is there any damage? Are all accessories in good order? If there is any doubt, please take photographs and inform the supplier immediately.

4.1.6 For motors with packing, lift the motor using the lifting lugs only, or a forklift must be used to carry the motor under the base of the pallet.

4.1.7 The forklift should not be used to carry from the motor base or any other position.

4.2 Short period storage (not exceeding 3 months)

4.2.1 The motors should always be stored in clean, dry, vibration free, dust free and corrosive free conditions.

4.2.2 The motors should always be stored on a smooth foundation surface and entirely free from vibration and easy for handling.

4.2.3 The storage place should not be located in uncertain environments, and not located near to a boiler or a freezer.

4.2.4 The best temperature of the storage place is 5°C to 50°C. If the motor is equipped with space heaters, they should be energized at the voltage shown by the space heater nameplate attached to the motor.

4.2.5 The best relative humidity of the storage place is less than 75%. Keep the temperature of motors above dew point from condensation.

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

Since moisture can be very detrimental to electrical components, the motor temperature should be maintained above the dew point temperature by providing either external or internal heat, if not fitted with a heater.

Incandescent light bulbs can be placed inside open ventilated motors to provide heat. However, if used, they must not be allowed to come in contact with any parts of the motor winding because of the concentrated hot spot that could result.

4.2.6 For motors stored outdoors, the plastic packing must be discarded. Waterproof covers must be used to protect against the ingress of water but not to affect the ventilation. Motors should be placed on a rigid foundation to prevent moisture and dust.

4.2.7 Protect against the ingress of insects.

4.2.8 Store in the original packing, which must be opened with enough holes to maintain effective ventilation but not to affect the protection against rain.

4.2.9 Ensure that water is filled into the cooling pipes of water-cooled motors and water-cooled bearings, to protect against corrosion or possible fractured pipes.

Add the mixture of water and glycol anti-freeze into the pipes to prevent fractured pipes.

The proportion of glycol should be no less than 50%. After adding the mixture, the entrance and exit of pipes should be sealed to prevent the loss of the mixture.

4.3 Long period storage (exceeding 3 months)

Check the following points in addition to the requirement of short period storage:

4.3.1 The storage period is not too long, and motors are not piled too high to damage them.

4.3.2 Insulation resistance should be measured once every two months and the value should be recorded.

4.3.3 The humidity should be measured once every two months and recorded. If the humidity is more than recommended, change the storage place.

4.3.4 The paint of motor surfaces should be checked once every three months. If there is rust, it must be cleaned and repainting must be done.

4.3.5 The shaft extensions and flanges should be checked for rust once every three months. If there is rust, it must be cleaned carefully with emery cloth and the antirust compound must be re-applied.

4.3.6 Motors with rolling bearings will have been filled with the correct lubrication before leaving the factory, and they do not need to be re-filled during storage. Turn the shaft by hand at least ten revolutions once a month to check for free rotation.

4.3.7 Motors with sleeve bearings will have the lubrication drained before leaving the factory, but they need to be re-filled with the correct lubrication during prolonged storage periods to avoid rusting. Turn shafts by hand at least ten revolutions in both directions of rotation once a month to check for free rotation.

4.3.8 If the storage of motors with sleeve bearings exceeds one year, the sleeve bearings must be dismantled and antirust measures must be applied.

4.3.9 After long periods of storage, check the bearings. Change the rusting bearings and fill with lubrication.

4.3.10 Measure insulation resistance before starting and when winding dampness is suspected. Resistance should exceed 1M ohm. If the 1M ohm resistance value is not achieved, the winding is too damp and must be dried in an oven. If after oven drying, the 1M ohm resistance value is still not achieved, the motor must be rewound.

Oven drying method :

Dismantle the motor and put the stator frame containing the winding into an oven. For wound-rotor motors, the rotor should also be put into the oven at the same time. Oven temperature should be less than 100°C. Keep good ventilation inside and outside the oven. When insulation resistance exceeds the 1M ohm or insulation resistance value gets steady, oven drying is sufficient.

Alternatively, stall the rotor with a low voltage applied to the winding, ensure that the measured current is only 1/3 to 1/2 of rated current. Winding temperature should be less than 100°C. When insulation resistance exceeds the 1M ohm or insulation resistance value gets steady, drying is sufficient.

4.4 Storage after installation

After installation or after operating for a period, if the motor will be not in operation for a long period, protect the motor as measures stated in 4.3. Otherwise the motor should be in operation once every two months.

5. Installation and calibration

5.1 Check before installation

5.1.1 Check all rating data on the nameplate, especially voltage and winding connection (star or delta).

5.1.2 Measure insulation resistance before commissioning and when winding dampness is suspected. Resistance should exceed 1M ohm (measured with a Megger). If this reference resistance value is not achieved, the winding is too damp and must be oven dried. Oven temperature should be less than 100°C.

5.1.3 Check the motor for damage and loose fixings. Turn the shaft by hand to check free rotation.

5.1.4 Check the mounting arrangement. Apart from the basic type of construction IM B3, the motors can also be supplied in various other types of construction. The basic type of construction IM B3 can also be used as IM V5 by additional support and/or by changing the bearing arrangements to carry the axial force.

5.1.5 Clean dust and other foreign bodies from the motor.

5.1.6 After a long period of storage, check the lubrication and replace it if necessary.

5.2 Foundation

NOTE!

The best foundation design can ensure safe operation and convenient maintenance. The space around the motor foundation should be large enough to facilitate heat dissipation and necessary maintenance.

Ensure cooled air flow through the surface and parts of the motor without any restriction. Ensure that any other devices or heating elements do not to affect the cooling of the motor.

Foundations should be strong and free of vibration.

5.2.1 Foundations must be even, and sufficiently rigid to withstand possible short circuit forces. If motors are connected with other equipment, both should be installed on foundations made in concrete. A suitable type of construction should be chosen for frequent shock loading.

5.2.2 Foundations should be 2mm lower than the base of the driven equipment for installation adjustment to attain the correct alignment.

5.2.3 The foundation must be suitable for each footplate area. The foundation surface must be bigger

than the footplate areas.

5.2.4 Any height differences between the motor and the driven machine should be adjusted with shims. The surface for the shims must be a larger area than that of the feet. The amount of the shims should be less than 3mm.

5.2.5 Select an appropriate foundation surface for any soleplate or common bed which will be considered more reliable for motor operation.

NOTE!

Foundations must be even, and sufficiently rigid to withstand possible short circuit forces. Incorrect alignment can lead to bearing failure, vibration and even shaft fracture, as well as accidents.

5.3 Installation

5.3.1 Preparation for installation

5.3.1.1 A number of steel shims may be required of 0.1mm, 0.2mm, 0.5mm, 1.0mm thickness.

5.3.1.2 Simple tools, such as lever, jack and bolts.

5.3.1.3 Measurement instruments, such as micrometer for adjusting installation of shaft coupling.

5.3.1.4 Before mounting the motor, the foundation surface must be clean.

5.3.1.5 Check the position and height of the mounting holes.

5.3.1.6 Remove transport locking device if fitted. Re-install it before transportation once more.

5.3.2 Consideration before installation

5.3.2.1 The fixing bolts for mounting must be set into the concrete firmly.

5.3.2.2 The studs must be clean from concrete, paint, and dirt.

5.3.2.3 The concrete surface must be clean from oil, grease and dirt.

5.3.2.4 The anti-rust protection applied to the shaft extension and the feet must be removed by a cleaning spirit.

5.3.2.5 Fasten the steel studs to the holes. Stainless steel studs should be used where water or moisture is expected to cause rust. Shockproof locking washers should be used where vibration is expected.

5.3.2.6 Ensure that the drain holes are at the lowest position after installation. When the drain holes are open, measures must be taken to protect against the ingress of dirt or insects etc.

5.3.2.7 After long periods of storage or the motor is repaired, the insulation resistance must be checked before starting. This includes stator windings, rotor windings of slip-ring motors, and other auxiliary devices.

5.3.2.8 Lift the motor using only the eyebolts or lifting lugs integrated with the motor frame. Any smaller lifting lugs for auxiliary devices are not suitable for lifting the motor.

5.3.2.9 If there is more than one eyebolt or lifting lug, they must be used together to share the weight.

5.3.2.10 If slings are used on the lifting lugs, keep the slings the same length and not twisted before lifting.

NOTE!

Do not lift the motor with two ends of the same sling. If there are two eyebolts or lifting lugs, lift the motor with two separate slings.

5.3.3 Installation

5.3.3.1 Installation of shaft coupling

(1) The shaft coupling of the motor must be separately dynamically balanced. As standard, balancing of the motor has been carried out using **half key**. If required with **full key** balance, please contact Felm Co.

(2) Before installing the coupling, the shaft and the coupling bore must be greased. Do not paint the surface with molybdenum disulfide.

(3) Basically, the coupling should be heated and pushed onto the shaft extension with only light axial force. To avoid bearing damage, do not hammer the coupling.

(4) When the coupling and the driven machine are coupled together, it is recommended that a flexible coupling be used, for either rolling bearings or sleeve bearings.

(5) There must be adequate space between the couplings of motors with rolling bearings and of the driven machines.

(6) For motors with the sleeve bearings, the couplings must be spaced apart an adequate distance to prevent that axial force of the driven machine being exerted on the coupling which could cause serious stresses to be exerted on the bearings.

(7) Before installing the coupling, it should be balanced using half a shaft key to achieve an overall balance condition.

(8) After the couplings of the motor and the driven machine are coupled together, a guard must be fitted around the couplings.

(9) For motors with sleeve bearings, during installation, check the indicator is located in the groove on the shaft and ensure that the magnetic centre of the stator and the rotor are in line.

NOTE!

There must be enough space left between the couplings of motor and of the driven machine to prevent axial force caused by heat expansion which could lead to bearing failure.

5.3.3.2 Installation of pulleys

Most motors are not suitable for V-belt connection unless specially designed for such service. Any V-belt drive must be specially designed according to the supplier's instructions for use with motors.

(1) Flat belts are not suitable for 2 pole motors above 4 KW and 4 pole motors above 30 KW for power transmission.

(2) The length of the pulley should not be greater than the shaft extension, otherwise this can lead to shaft fracture.

(3) The fan end of a double shaft extension motor should be connected with a direct coupling only.

(4) Ensure the parallelism of the motor shaft and the driven shaft. And ensure the square ness of the motor shaft and the belts.

(5) The belt pulley must be dynamically balanced before installation.

(6) The motor shaft must be painted with cosmoline before installation of the belt pulley.

(7) Cylindrical roller bearings are more suitable for motors with V-belt drives. Do not exceed the maximum belt forces (i.e. radial bearing loading) stated in the relevant bearing manuals. It is important to make sure that the chosen motor will meet your requirements.

(8) The diameter ratio between motor and driven pulleys should not be greater than 5 to 1 for flat belts, and 8 to 1 for V-belt. It is also advisable to limit the belt velocity to under 32 m/min to minimize belt abrasion and vibration.

(9) Place the pulley and belt as close as possible to the motor body to reduce the bending moment and prevent shaft fractures.

5.3.3.3 Gear Drives

(1) Make sure the loading capacity of the shaft and bearings is appropriate for the size and installation position (overhung) of the gear drive. If necessary, please contact us to ensure the shaft and bearings will meet your requirements.

(2) Pay close attention to ensure the parallelism of shafts.

(3) The teeth of gears should be correctly and precisely matched, the force conveyance centres should lie on the same line.

(4) There should be no slip, jumping, vibration or unusual noises during operation.

5.3.3.4 Thermal effects.

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 and increase in shaft centerline height due to thermal expansion effects.

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

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

NOTE!

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

(2) A space must be left between couplings according to the load. Shaft length growth for motor can be calculated as follows:

$$\Delta=(0.0005)\times(\text{ motor frame length dimension }) \text{ mm}$$

NOTE!

Ensure the couplings, except rigid couplings, can move free axially. Thermal effects will lead to axial shaft expansion.

5.3.3.5 Installation on rigid foundation

(1) Clean the surface of the foundation.

- (2) The foundation must be even. The tolerance should be no more than 0.1mm.
- (3) Motors connected with other equipment should be installed on a soleplate or common bed which will be considered more reliable for motor operation. It is better to embed the soleplate or common bed in concrete together.
- (4) Put the motor on the foundation carefully to prevent damage.
- (5) Check the mounting surface. Each motor footplate area must be rigid on the foundation to prevent misalignment during operation.
- (6) For large motors and high voltage motors, the footplate must be pinned after installation. These motors have one dowel hole per foot at the drive end. Deepen the holes by drilling through to the steel foundation. After that, the holes should be tapered with a reaming tool. Suitable tapered dowel pins should be fitted to the holes to ensure the exact alignment, and to allow easier re-installation after any possible removal of the motor.
- (7) All shims and footplates must be welded after installation to prevent any unexpected change in position during motor operation.

5.3.3.6 Installation on concrete foundation

- (1) Clean the surface of foundation.
- (2) The foundation must be strong enough to ensure stability.
- (3) Make sure the concrete is completely dry, then tighten the bolts.
- (4) Use rigid and solid soleplate or common bed as the surface of the foundation. The tolerance of the surface should less than 0.1mm.
- (5) Check the mounting surface. Each motor footplate area must be rigid on the foundation to prevent misalignment during operation.
- (6) For large motors and high voltage motors, the footplate must be pinned after installation. There should be holes in the footplate for locating.
- (7) All shims and footplates must be welded after installation to prevent any unexpected change in position during motor operation.

5.3.3.7 Installation of vertical motors

- (1) If motors are to be connected with a pump, and both are installed on the same foundation, the foundation of the motor/pump must be rigid and firm to provide adequate support. There must be no vibration due to inadequate foundations.
- (2) All mounting surfaces must be clean and level.
- (3) The foundation must be leveled at least at 4 points (up to H180), 8 points (for H200 and above) and guaranteed to be below 0.04mm (1.5mil) flatness and level.
- (4) Make sure the above requirements are acceptable, before setting the motor on the mounting foundation.

5.3.3.8 Adjustment of installation

The motor shaft and the driven shaft should be aligned within limited tolerances in both radial and parallel alignment. In excess of the limited tolerances will lead to bearing failure.

- (1) Before adjustment, the couplings of the motor and the driven machine must be coupled together and be convenient for adjustment.
- (2) For large motors with foot fixing, adjustment bolts must be installed in the feet of the motor before adjustment.
- (3) Adjustment bolts may also be installed in the driven machine for high accuracy installation.
- (4) It is necessary to use high accuracy instruments to measure installation for high accuracy adjustment.
- (5) All measured data must be recorded to be referenced later.

6. Connection

6.1 Connection of Coolers

6.1.1 Connection of air-to-air coolers.

Generally, the air-to-air cooler is supplied with the motor. It is not installed by the user, but the user is required to keep its ventilation clear. If the air-to-air cooler is sent to the user separately, install it according to the manufacturer's instructions.

6.1.2 Connection of ventilation ducts.

Motors designed for cooling airflow to and/or from the machine with air ducts have connection flanges as specified in the dimensional drawing. Clean the air ducts thoroughly before connecting them to the

motor, and check for possible obstructions in the ducts. Seal the joints with appropriate gaskets. Check for possible leaks in the air ducts after they have been connected.

6.1.3 Connection of air-to-water coolers.

Motors equipped with an air-to-water heat exchangers have flanges specified in the dimensional drawing. Connect the flanges and seal the joints with appropriate gaskets. Prior to starting the motor, the water has to be turned on.

6.1.4 Connection of direct water-cooled motor.

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

The cooling water circulates in ducts integrated in the motor frame. The material of the frame and ducts is carbon steel. This material is prone to corrosion in saline and foul water. The corrosion products and fouling deposits might block the water flow in the ducts.

This is why it is important to use pure and inhibited water in the cooling system. In most cases, normal tap water, i.e. water for domestic consumption fulfils all these requirements. If normal tap water does not fulfill these requirements, the cooling water must also have added an agent for protecting the cooling system against corrosion or fouling and when necessary, against freezing. Standard values for the cooling water to be used in the cooling system :

- pH 7.0 - 9.0
- Alkalinity (CaCO₃) > 1 mg/kg
- Chloride (Cl) < 20 mg/kg
- Sulphate < 100 mg/kg
- KMnO₄-concentration < 20 mg/kg
- Al-concentration < 0.25mg/kg
- Mn-concentration < 0.05 mg/kg

6.2 Connection of sleeve bearings

6.2.1 Motors with flood lubrication systems are equipped with oil pipe flanges, and possibly with pressure gauges and flow indicators. Install all necessary oil pipes and connect the oil circulating units.

6.2.2 Install the oil supply system near the motor at an equal distance from each bearing.

6.2.3 Install and connect the oil inlet pipes to the bearings.

6.2.4 Install the oil outlet pipes downwards from the bearings at a minimum angle of 10°. The oil level inside the bearing will increase if the slope of the pipes is too small, the oil will flow too slowly from the bearing to the oil container, and this can result in oil leaks or disturbances in the oil flow.

6.2.5 Fill the oil supply system with appropriate oil with the correct viscosity. The correct type of oil and viscosity is indicated on the dimensional drawing. If in any doubt of the cleanliness of the oil, use a mesh to filter unwanted debris from the oil.

6.2.6 Turn the oil supply on, and check the oil circuit for possible leaks prior to starting the machine. The normal oil level is obtained when half of the oil sight glass is covered.

NOTE!

The sleeve bearings are delivered without lubricant. Running the motor without lubricant will result in immediate bearing damage.

6.3 Main supply wiring

6.3.1 Safety regulations of supply wiring.

(1) All interconnecting wiring for controls and grounding should be in strict accordance with national standard and local regulations.

(2) All interconnecting wiring should be finished by qualified personnel, familiar with relevant safety requirements.

(3) De-energize all equipment, including auxiliary equipment. Verify that all parts are isolated from their respective supply. Install an obvious notice board on the switch to provide a safeguard against accidental re-energizing of the equipment.

(4) Connect all parts to protective earth.

(5) Cover or provide barriers against live parts in the surrounding area.

6.3.2 Power

The rated conditions of operation for the motor are as shown on 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 :

- (1) +/- 10% of rated voltage.
- (2) +/- 5% of rated frequency.
- (3) +/- 10% combined voltage and frequency variation so long as frequency variation is no more than +/- 5% of rated frequency.

Operating the motor at voltages and frequencies outside of the above limits can result in both unsatisfactory motor performance and damage, and even failure of the motor.

6.3.3 Main supply wiring

- (1) Motors are available with terminal boxes rotatable through 4 x 90°. The terminal box can be adjusted according to the requirement of the user but must be sealed.
- (2) Note nameplate markings and connection diagram in the terminal box. The 6 terminals are marked with letters U1, V1, W1 and U2, V2, W2 or the 3 terminals are marked with letters U, V, W. The 6 terminals may be connected Δ or Y according to the connection diagram, or a star delta type starter. The 3 terminal are connected according to A-U, B-V, C-W.

NOTE!

Check the phase sequence from the connection diagram, the standard phase sequence is for clockwise rotation looking from the drive end of the motor.
For counter-clockwise rotation, the phase sequence is in accordance with the order instructions.

- (3) It is important to verify that the supply voltage and the frequency are the same as the values indicated on the nameplate of the motor before starting.
- (4) For multi-speed motor, the connection diagrams received with the motor have to be studied before starting the installation work to determine the rotation direction at different speeds. Any question, please contact Felm Co..
- (5) In order to ensure continuous and trouble-free running, it is therefore important that the length of the insulation and creepage distances between input cables and terminal-box are sufficient. Stripping, splicing and insulating of the high-voltage cables must be performed in accordance with instructions by the cable manufacturer.

NOTE!

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

- (6) The space between the cable entries and the cables must have a cable gland installed and be insulated. Unused cable entries must be properly sealed. The plastic plugs provided with the motor are for transport purposes only.
- (7) The inside of the main terminal box must be free from dirt, moisture and foreign debris. The box itself, cable glands, and unused cable entrance holes must be closed in a dust-tight and watertight manner according to the manufacturer's instructions.

6.4 Auxiliary terminal boxes

- 6.4.1 Thermal protection connections could be located in an auxiliary terminal box on the motor. Auxiliary terminal boxes are attached to the frame of the motor according to the number of accessories and customer needs, and their positions are shown on the dimensional drawing of the machine.
- 6.4.2 Various protection device wiring must be according to the wiring regulations and safety standard.
- 6.4.3 Auxiliary devices such as thermistors, thermocouples, PT 100 resistance temperature detectors, and anti-condensation heating elements will generally terminate on terminal blocks located in the auxiliary terminal box on the motor. The maximum voltage is 750V.
- 6.4.4 Caution must be exercised anytime contact is made with the incoming space heater circuit as space heater voltage is often automatically applied when the motor is shutdown.
- 6.4.5 Connect the instruments and auxiliary equipment according to the connection diagram in the auxiliary terminal box.
- 6.4.6 The inside of the auxiliary terminal box must be free from dirt, moisture and foreign debris. The box itself, cable glands, and unused cable entrance holes must be closed in a dust-tight and watertight manner according to the manufacturer's instructions.

6.5 Connection of rotor supply of slip-ring motors

6.5.1 To gain access to the rotor circuit through the sliprings for slip-ring type motors. The cable should be connected with proper terminations. The cable can be directly connected with the brush holder rocker or the rotor terminal board.

6.5.2 Study the connection diagram delivered with the motor carefully before connecting any cables.

6.6 Connection of external blower motors

6.6.1 AC motors fed with frequency converters are generally equipped with an external blower to ensure their normal operation at different speeds.

6.6.2 The external blower motor is normally a three phase induction motor. A connection box is usually located on the frame of the blower motor.

6.6.3 The connection of the external blower motor is the same as the main power cable connections.

6.6.4 Earth connections must be carried out according to local regulations before the external blower motor is connected to the supply.

6.6.5 The warranty does not cover damaged bearings due to improper cabling or earth connection.

NOTE!

The external blower motor must be connected to a protective earth according to local regulations.

6.7 Earth connections.

6.7.1 Earth connections must be carried out according to local regulations before the motors are connected to the mains supply.

6.7.2 The motors usually have a protective earth terminal in the terminal box. However, larger motors also have an external earth terminal on the frame, foot or flange. These terminals must be connected to a protective earth at the same time.

6.7.3 The motor must be grounded by a proper cable connection to the electrical system ground point.

6.8 Requirements for motors with frequency converters

In frequency converter applications the motor frame external earth must be used for equalizing the potential between the motor frame and the driven machine, unless the two machines are mounted on the same metallic base.

For motor frame sizes above H280, it is necessary to use 1 x70 mm flat copper conductor or at least two 50 mm² round copper conductors. The distance of the round conductors must be at least 150 mm from each other.

7. Commissioning

7.1 Check before starting

When the motors are installed, ensure the wiring is according to the diagram. Also, the following points should be noted to achieve the normal operation of the motor.

7.1.1 Check that the motor is properly anchored to the foundation. Check for cracks in the foundation and the general condition of the foundation.

7.1.2 Check the tightness of the fixing bolts.

7.1.3 Make sure all wiring, including auxiliary equipment, is correct.

7.1.4 Ensure the sizes of cable wires are appropriate and all connections are well made for the currents they will carry.

7.1.5 Ensure all connections are properly insulated for the voltage and temperature they will experience.

7.1.6 Make sure that all cable joints outside the terminal box are insulated.

7.1.7 Make sure that frame and terminal box are grounded.

7.1.8 Ensure the capacity of fuses, switches, magnetic switches and thermo-relays etc. are appropriately rated and the contactors are in good condition.

7.1.9 Make sure that the starting method is correct.

7.1.10 Check the assembly of the main terminal box and the cooling system.

7.1.11 Check that the lubrication system is commissioned and is running before the rotor is turned. See **8.2** for more information.

7.1.12 Check the connection of oil and cooling water pipes and check for leaks when running.

7.1.13 Check pressure and flow for oil and cooling water.

7.1.14 Check that the mains cable is not stressed in any way.

7.1.15 Ensure that heater voltage is not applied when the motor is operation, especially when the heater voltage is often automatically applied when the motor is shutdown.

7.2 Measurement of insulation resistance

Before a motor is started up for the first time, after a long period of standstill or within the scope of general maintenance work, the insulation resistance of the machine must be measured. The insulation resistance of both stator and rotor windings must be measured.

For new motors with dry windings, the insulation resistance should be very high. The resistance can, however, be 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 measurement provides information about the humidity and dampness of the insulation. Based upon this information, correct cleaning and drying actions can be necessary.

7.2.1 Results of measurement of insulation resistance.

(1) If the measured value is considered too low the winding must be cleaned and/or dried. If these measures are not sufficient, please contact with Felm Co.

(2) Motors which are suspected to have moisture problems should be dried carefully independent of the measured insulation resistance value.

(3) The insulation resistance value will decrease 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 values measured on site, because the insulation resistance is very high for new machines with dry windings when leaving the factory.

7.2.2 Minimum values for insulation resistance.

Generally, the insulation resistance values for dry windings should exceed the minimum values significantly. Definite values are impossible to give, because resistance varies depend on the motor type and local conditions. In addition, the insulation resistance is affected by the age and usage of the motor.

7.2.2.1 Calculation method of minimum values for insulation resistance.

After temperature rise test, the following formula should be applied to minimum values for insulation resistance:

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

Where

R-insulation resistance (MΩ);

U1-rated voltage (V)

P-rated power(kW)

7.2.2.2 The control value of insulation resistance.

The normal value of insulation resistance for a low-voltage motor is more than 10MΩ.

The normal value of insulation resistance for a high-voltage motor is more than 100MΩ.

If the values of insulation resistance are lower than these two values, a check should be made of the motors particularly for moisture and dust.

For a slip-ring motor, the normal value of insulation resistance for a low-voltage motor and a high-voltage motor is more than 10MΩ.

7.2.3 Stator winding insulation resistance measurement.

The insulation resistance is measured using an insulation resistance meter (megger).

Different meters are used according to the different rated voltages .

(1) For rated voltages up to and including 1,140V, measure with a 500VDC megger.

(2) For rated voltages above 1,140V, measure with a 2,500VDC megger.

NOTE!

During or after measuring, the terminals must not be touched together immediately as they may carry residual dangerous voltages. Furthermore, if the supply cables are connected, make sure that the

power supplies are clearly disconnected and that the rotor is not turning before insulation resistance measurement is taken.

No matter what meters are used, the test time must last 1 minute, after which the insulation resistance value is recorded. Before the insulation resistance test is conducted, the following actions must be taken:

- (1) Verify that all power supply cables are disconnected.
- (2) Verify that the frame of the motor with the stator windings being tested is earthed.
- (3) Make sure that auxiliary devices are earthed.
- (4) The insulation resistance measurement should be carried out in the terminal box. The test is usually performed to the whole winding as a group, in which case the meter is connected between the frame of the motor and the winding.
- (5) If necessary, the tester is connected between the frame of the motor and one of the windings. The frame and the two phases not measured should be earthed.
- (6) The winding temperatures should be measured. After a long time of shut down before the test, measure the temperature of the enclosure instead of that of the winding.
- (7) After the insulation resistance measurement the winding phases must be earthed briefly in order to discharge them.

7.2.4 Insulation resistance measurement for a motor with slip rings.

Insulation resistance measurements for a motor with slip rings should be carried out same as general motors.

- (1) Verify that all supply cables are disconnected from the main supply.
- (2) Verify the slip ring unit connection cables are disconnected from their supply.
- (3) Verify that the shaft, the frame of the motor and the rotor windings are earthed.
- (4) The carbon brush connections should be checked to be in good order.
- (5) The winding temperatures should be measured. After a long time of shut down before the test, measure the temperature of the enclosure instead of that of the winding.

The insulation resistance of the rotor winding should be measured. Take note and measure as follows:

- (1) Verify that the frame of the motor and the stator windings are earthed.
- (2) Verify that the shaft is earthed.
- (3) The rotor winding can generally be connected in a star connection. If each phase must be measured separately, the rotor winding phases not been tested should be earthed.
- (4) After the insulation resistance measurement the winding phases must be earthed briefly in order to discharge them.

7.2.5 Insulation resistance measurement for auxiliaries

- (1) The test voltage for the space heater should be 500 VDC.
- (2) The insulation resistance measurement for PT-100 detectors is not recommended.
- (3) For the motors which are equipped with insulated bearings, if both the shaft ends are insulated from the frame, disconnect the earth terminal. If both the shaft ends are not insulated from the frame, separate the bearing sleeve or end-shield from the bearing.

7.3 Commissioning and Start-up

7.3.1 First test start

NOTE!

There is 5-8 times starting current when direct-on-line starting, and the starting torque is directly proportional with the square of the voltage when auto-transformer starting. For star delta starting the starting current and starting torque will be approximately one third of the direct-on-line values. Set auto-transformer starting for under-voltage and use direct-on-line starting for heavy loads. The load on the motor must in any case be as small as possible.

7.3.1.1 The first start 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 when there is no indicator arrow.

7.3.1.2 The direction of rotation of an external blower motor is indicated by an arrow near the blower motor.

7.3.1.3 It should also be verified that the rotating parts do not touch any stationary parts.

7.3.1.4 If the desired direction of rotation for some reason is different from the one specified on the

motor, the cooling fans of inner and/or outer cooling circuits, must be changed by the manufacturer, as well as the stamp on the nameplate.

7.3.1.5 To alter the direction of rotation, interchange the connection of any two line cables.

7.3.1.6 Motors with slip rings cannot be operated without a starter.

7.3.1.7 If possible, the first start is made with an uncoupled coupling between the motor and driven machine.

7.3.1.8 Without a coupling between the motor and driven machine, it is normal that there is shaft over-run during shutting down.

7.3.2 Running unloaded.

7.3.2.1 During running the motor for the first time, if the machine functions as expected, the motor can be left running unloaded for a longer time.

7.3.2.2 During the first one or two hours of running, it is important to keep a close surveillance of the motor in case of any changes in vibration or temperature levels. If any abnormal sounds occur, shut down the motor, and find the reason for the changes. If necessary, consult the manufacturer of the motor.

7.3.2.3 The motor may be direct-on-line starting, star delta starting or auto-transformer starting.

7.3.2.4 If the motor rotor fails to start turning within one or two seconds, shut off the power supply immediately. Investigate thoroughly and take corrective action before attempting a restart.

7.3.3 Running loaded.

7.3.3.1 Initially run the motor unloaded prior to coupling to other machines.

7.3.3.2 If the motor rotor fails to start turning within one or two seconds, shut off the power supply immediately. Investigate thoroughly for something wrong in the connections or wiring, and take corrective action before attempting a restart.

7.3.3.3 If the rate of rise in temperature is excessive or if the motor exhibits excessive vibration or noise, it should be shut down immediately and a thorough investigation made as to the cause before it is operated again.

7.3.3.4 Any abnormal noise or vibration should be immediately investigated and corrected. Increased vibration can be indicative of a change in balance due to mechanical failure of a rotor part, a stator winding problem or a change in motor alignment.

7.3.3.5 Ensure the voltage and frequency of the power source are identical to the ratings shown on the nameplate. Check current balance of all the 3-phases of the windings.

7.3.3.6 The number of recommended consecutive starts of direct on line supplied motors depends essentially on the load characteristics (torque curve vs. rotational speed, and load inertia), and on the motor type and design. Too many and/or too heavy starts will cause abnormally high temperatures and stresses on the motor, thus accelerating the ageing of the motor insulation and resulting in an abnormally short lifetime, or even a premature motor insulation failure.

(1) The motor can be restarted if the initial start should fail. Two starts are generally permissible when the motor is cold.

(2) Let the motor cool down for 60 minutes before restarting, fully loaded. Let the motor cool down for 30 minutes before restarting, unloaded. Two inching starts can be regarded as one normal start.

(3) The load characteristics of the application are needed for determining the starting frequency. As a guideline, the maximum number of evenly spaced starts in a typical application is 800 starts per year.

7.3.3.7 For the motors with PT-100 resistance temperature detectors, the temperatures of the bearings, stator windings and cooling air should be recorded when the motor is running. After running the motor for some time, the cooling system should be checked. Verify that the cooling fluid, where applicable, and air is circulating without any obstruction. Record the temperatures of the cooling system, inlet and outlet.

The winding and bearing temperature may not reach a stable temperature until after several (4-8) hours, when running at full load.

The stator winding temperature depends on the load of the motor. If full load cannot be obtained during or soon after commissioning, the present load and temperature should be noted and included in the commissioning report.

7.3.3.8 If the bearing temperature rise and motor operation appear to be normal, operation should continue until the bearing temperatures stabilize.

(1) The temperature limit on roller bearings is no more than 95°C.

(2) The temperature limit on sleeve bearings is no more than 90°C.

If the rate of rise in temperature is excessive or if the motor exhibits excessive vibration or noise, it should be shut down immediately and a thorough investigation made as to the cause before it is operated again.

For the motors without PT-100 resistance temperature detectors, the temperature of the end-shield should be measured instead of that of the bearing. The temperature of the end-shield is usually 10°C lower than that of the bearing.

7.3.3.9 Any abnormal temperature rise, noise or vibration should be immediately investigated and corrected. Increased temperature rise can be indicative of a change in balance due to mechanical failure of a rotor part, a stator winding problem or a change in motor alignment.

7.3.3.10 Starting time is longer for the motors with large inertia. However, if starting time is longer than usual or if there is difficulty in starting, or there is abnormal noise, do not run the motor and contact with Felm Co.

7.3.3.11 If the capacity of the mains transformer is not big enough to start several motors at the same time, they should start respectively from larger motors to smaller ones.

7.3.3.12 During the running and any investigations, protection devices should not be disconnected.

7.3.3.13 During the first several days of running, it is important to keep a close surveillance of the motor in case of any changes in vibration or temperature levels or abnormal sounds occur.

7.3.3.14 If available, and after the motor has been running for several hours, measure the vibrations or SPM-values from the SPM-nipples, and record the values for future reference use.

If not equipped with SPM monitor, check the motor with a vibration measurement instrument. The measurement place should be on the frame or the end shield of the motor at each end, but avoid locating on thin plate such as fan-covers.

After installation, the vibration value of the motor will be a little higher than it was before leaving the factory. For check purposes refer to the following:

Foundation	Frame size	Vibration velocity(mm/s)
Rigid	Up to H355	3.5
Rigid	Up to 355 for 2P	4.5
Rigid	Above H355	4.5
Rigid	Above H355 for 2P	5.0
Flexible	Up to H355	4.0
Flexible	Up to 355 for 2P	5.0
Flexible	Above H355	5.0
Flexible	Above H355 for 2P	6.0

If the vibration values are not in accordance with the values in the table, please check the motor. Any questions, contact Felm Co.

7.3.3.15 Check that the carbon brushes on the slip rings are not sparking.

Ensure that the slip ring surfaces are smooth. If not, the slip rings must be smoothed on a lathe.

7.3.3.16 During the first period of running, the heat-exchange system should be checked. Verify that the cooling fluid, where applicable, and air is circulating without any obstruction.

7.3.3.17 High temperatures may arise on the motor surfaces under normal operating conditions, so touching should be prevented or avoided.

NOTE!

If the motor exhibits excessive vibration or noise, it should be shut down immediately and a thorough investigation made as to the cause before it is operated again.

Any mechanical failure of a loose bolt, a rotor part, a stator winding problem or a change in motor alignment can cause abnormal noise or vibration.

7.3.4 Shut down.

7.3.4.1 The shutdown of the motor depends on the application, but main guidelines are the same.

7.3.4.2 Reduce the load of the driven equipment, if applicable.

7.3.4.3 Open the main breaker.

7.3.4.4 When the motor is not in operation, anti-condensation heaters have to be switched on where applicable.

7.3.4.5 For motors with water-cooling, the cooling water supply must be switched off in order to avoid

condensation inside the motor.

8. Lubrication

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

8.1 Re-greasing for rolling bearings

8.1.1 Bearings of ZZ types are usually permanently greased for the smaller machines.

8.1.2 Re-greasing facilities are provided for larger motors (H200 and above) and other specific motors. It is necessary to carry out the lubrication at regular intervals.

8.1.3 In the case of a newly installed motor, or a motor which has been out of service for more than 2 months, inject new grease into the bearings immediately after start-up. New grease must be injected when the motor is running, and should be injected until old grease or excess new grease is discharged through the lubrication exit valve in the bottom of the bearing housing. See 8.1.5.

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

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

The recommended lubrication intervals are as follow.

Rated power(kW)	Speed (rpm)	The recommended lubrication intervals		
		Normal conditions	Severe conditions	Extreme conditions
<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
200-630	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
200-630	3000	3 months	1 month	15 days

NOTE!

Normal conditions refer to motors operated at rated power or below in a clean environment within normal ambient temperature, with a duty cycle of no more than 8 hours per day.

Severe conditions refer to motors operated at rated power or below in a dirty/dusty environment with light shock loading and/or vibration, with a duty cycle of 24 hours per day.

Extreme conditions refer to motors operated in a very dirty/dusty environment with heavy shock load and vibration, and extremes of high ambient temperatures.

8.1.5 Re-greasing method (See Annex 1)

(1) Before re-greasing, the grease nipples should be thoroughly cleaned to prevent any accumulated dirt from being carried into the bearing with the new grease. The exit grease relief valve or plug should be opened to allow the proper venting of the old grease. Use a grease gun to pump grease through the grease nipple into the bearings.

(2) After re-greasing, operate the motor for 10-20 minutes to allow any excess grease to vent out. Close the grease inlet and outlet plug if fitted.

8.1.6 Types of grease.

Grease with the correct properties is available from all major lubricant manufacturers. If the brand of grease is changed and its compatibility is uncertain, consult the Felm Co.

Chevron SRI-2 grease is standard for FELM motors except some special models for which special grease will be confirmed according to the specification. Please use identical grease or its equivalents when maintaining and re-lubricating.

NOTE!

If re-lubrication is to be performed by the authorized personnel when the motor is running, rotating parts and live parts must be protected.

Please refer to the grease types, lubrication intervals and the amounts on the lubrication nameplate, if attached to the motor.

8.2 Lubrication for sleeve bearings

8.2.1 For motors with sleeve bearings, they should be lubricated before running, because no oil lubrication is provided on leaving the factory.

8.2.2 Install the oil supply system near to the motor, which should be turned on first before starting the motor.

8.2.3 The rotation of the oil ring should be verified through the inspection window on top of the bearing when the motor is running. If the oil ring is not rotating, the motor must be stopped immediately, as a stationary oil ring will result in bearing failure.

8.2.4 Verify that no rotating parts are rubbing against any stationary parts.

8.2.5 Verify through the oil sight glass that the oil level inside the bearing is correct. The correct oil level is in the middle of the oil sight glass, but as long as the oil level is within the oil sight glass, the level is acceptable.

8.2.6 For flood-lubricated motors, the oil supply pressure is adjusted with the pressure valve and orifice. The normal supply pressure is $120 \text{ kPa} \pm 20 \text{ kPa}$. This gives the correct flow of oil to the bearing. Using higher supply pressure gives no additional benefit, but can cause bearing oil leakages.

8.2.7 Check the temperature and the oil level of the bearings continuously in the beginning. This is particularly important for self-lubricating bearings. If the temperature of the bearing suddenly rises, the motor should be stopped immediately, and the reason for the temperature rise must be found before the motor is re-started. If no logical reason is found from the measurement equipment, it is recommended that the bearing is opened, and its condition verified. If the motor is under warranty, the manufacturer Felm Co must always be contacted before any action is taken.

8.2.8 An oil check should be performed a few days after the first test run of the machine, just before the first oil change, and subsequently as required. If the oil is changed just after the commissioning, it can be used again after removing wear particles by filtering or centrifuging.

8.2.9 The oil reservoirs of self (not flood) lubricated bearings should be drained and refilled approximately every six (6) months. More frequent changes may be needed on high-speed (3000-rpm) motors or if severe oil discoloration or contamination occurs.

9. Inspection and maintenance

A rotating electrical machine often forms an important part of a larger installation and if it is supervised and maintained properly, it will be reliable in operation and guarantee a normal lifetime.

9.1 The purpose of inspection and maintenance

9.1.1 To ensure that the motor will function reliably without any unforeseen actions or interventions.

9.1.2 To estimate and plan service actions in order to minimize down time.

9.1.3 The purpose of this inspection is to do a quick check to identify any problems which are starting to develop before they cause failures and unscheduled maintenance breaks.

9.2 Notice for inspection and maintenance

9.2.1 Before working on any electrical equipment, general electrical safety precautions are to be taken into account, and local regulations are to be respected in order to prevent personnel injury.

9.2.2 Personnel performing maintenance on electrical equipment and installations must be properly qualified. The personnel must be trained in, and familiar with, the specific maintenance procedures and tests required for rotating electrical machines.

9.2.3 Motors for hazardous areas are specially designed to comply with official regulations concerning the risk of explosion. Safety precautions should be taken into account when inspection and maintenance takes place.

9.2.4 These instructions and recommendations should be read carefully and be used as a basis when planning the maintenance program.

9.2.5 An essential part of preventative maintenance is to have a selection of suitable spare parts available. The best way to have access to critical spare parts is to keep them on stock.

9.3 The levels of inspection and maintenance

9.3.1 Routine inspection

The purpose of routine inspection is to ensure the normal operation of the motor.

9.3.2 Regular inspection

The purpose of regular inspection is to prevent motor failure.

9.3.3 Maintenance intervals

After a period of running, the motors must be maintained. Owing to the varied time and circumstances, which motors are used, it is difficult to set the items and periods for regular inspection and maintenance. However, as a guide it is recommended to be performed periodically once a year. Motors operated in bad conditions should have the maintenance interval shortened.

Generally, the scope of inspection is determined by the following factors :

- (1) Ambient temperature and operating conditions.
- (2) Starting and stopping frequency.
- (3) Easily worn parts.
- (4) Supply voltage and frequency variation.
- (5) The vibration of the driven machine.
- (6) The important position of motor in the operational system of the plant.

9.4 Routine checks during running of the motor

NOTE!

Any changes in vibration or temperature levels or abnormal sounds which occur, the motor should be shut down immediately to check. During the running, it is important to keep a close surveillance of the temperature of bearings, at least once a day.

9.4.1 The surfaces of the motor should be kept smooth and clean.

The motor exterior should be kept clean and should periodically be inspected for rust, leaks, oil, water and other dirt.

9.4.2 Check that the connections are tight and there is no leakage in the system. Verify that the cooling fluid, where applicable, and air is circulating without any obstruction. Check the condition of the fan-cover to ensure good air circulation over the motor.

9.4.3 The vibration levels of the driving/driven machine system should be monitored when the motor is running. If any changes in vibration or temperature levels or abnormal sounds occur, shut down immediately to check.

9.4.4 Check that the windings indicator of sleeve bearing motors is located in the groove on the shaft, indicating that the magnetic centre of the stator and the rotor are in line. If they are not then friction between shaft and bearing occurs, and the motor should be shut down immediately.

9.4.5 If any of the following abnormal conditions occur, the motor should be shut down immediately to check.

- (1) Heavy vibration,
- (2) The driven machine damaged
- (3) Bearing worn or overheated
- (4) Bearing misalignment, axial vibration
- (5) Speed reduced suddenly
- (6) Friction between stator and rotor, enclosure overheated.
- (7) Smell of burning.
- (8) Personnel accident.

9.5 Regular checks

9.5.1 Many processes leading to damage can be prevented or at least slowed down with appropriate maintenance and regular checks.

- (1) The tightness of all fastenings should be verified regularly.
- (2) Check the condition of connections, mounting bolts and assembly bolts.
- (3) Check that the carbon brushes are in good condition and that they can move freely in the brush holders. Follow the wear of the carbon brushes and change them before the wear limit is reached. Verify that the brushes are not sparking.
- (4) Check all earth connections.
- (5) Check the condition of shaft seals and replace if necessary. If you are not familiar with which type of seals are fitted, please contact Felm Co.
- (6) Check the alignment of shaft couplings.
- (7) Check that water, grease, oil, or dust has not been permitted to enter the motor housing.

- (8) Check the condition of bearings and replace if necessary.
- (9) Check the condition of painting and repaint if necessary.

9.6 Maintenance

Maintenance is important in preventing motor failure and lengthening the service life. Generally speaking, there should be light maintenance once a month, and overall maintenance once a year.

9.6.1 The light maintenance should include:

- (1) Clean the motor.
- (2) Measure the insulation resistance of the motor.
- (3) Tighten the electrical connections, mounting bolts and earth connection bolts.
- (4) Clean the starter and insulation terminals.
- (5) Remove carbon dust from the slip rings and brush gear.
- (6) Check the condition of fan-covers and ensure good air circulation over the motor.

9.6.2 The overall maintenance should include:

- (1) All the items of light maintenance.
- (2) Clean the interior of the motor.
- (3) Check the condition of bearings and replace if necessary. It is suggested that replacement of the bearings once a year under normal conditions (operating about 8,000 hours/year).
- (4) If it is not necessary to replace the bearings, clean the bearings and replace the grease.
- (5) Clean and replace other parts of motor as required.

9.7 Maintenance method

9.7.1 Clean the exterior of the motor.

- (1) Totally enclosed air-to-air cooled and totally enclosed fan cooled motors (IP 44 and above) require special cleaning considerations. The external fan must be cleaned thoroughly since any dirt build-up which is not removed can lead to unbalance and vibration. All of the tubes of the air-to-air heat exchanger should be cleaned using a suitable tube brush having synthetic fibre bristles (not wire of any type).
- (2) If the motor is equipped with fan-covers, they should be replaced (disposable type) or cleaned and reconditioned (permanent type) at a frequency that is dictated by conditions.
- (3) On open ventilated motors (ODP motor with IP 23 and below), screens and louvres over the inlet air openings should not be allowed to accumulate any build-up of dirt, lint, etc. that could restrict free air circulation.

NOTE!

Screens and louvres should never be cleaned or disturbed while the motor is in operation because any dislodged dirt or debris can be drawn directly into the motor.

9.7.2 Clean the interior of the motor.

After a motor is in operation for a long time, accumulation of dust, carbon powder and grease etc., on the inside is unavoidable, and may cause damage to the motor. Regular cleaning and examination is necessary to assure top performance. Points to note during cleaning:

- (1) 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 without scattering. Vacuum cleaning tubes should be non-metallic to avoid any damage to the winding insulation.
- (2) If using compressed air or a blower, it must be noted that compressed air should be free of moisture. Maintain air pressure at 4 kg/cm², since high pressure can cause damage to coils.
- (3) Surface contamination on the winding can be removed by wiping using a soft, lint-free wiping material.
- (4) If the contamination is oily, the wiping material can be moistened (not dripping wet) with a safety type petroleum solvent.
- (5) 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) The proper health and safety precautions should be followed while cleaning the motor. When using a solvent such as inhibited methyl chloroform to clean the motor, ensure good air circulation around the motor.
- (7) For radial ventilation motors, the ventilation route should not be allowed to accumulate any build-up of dirt, lint, etc. that could restrict free air circulation and lead to higher temperature rise.

9.7.3 The cleanliness of rolling bearings.

Rolling bearings will need to be washed periodically after operating a long time.

(1) The bearings should be washed, dried and pre-greased with a suitable high quality bearing grease before assembly.

(2) No dirt or foreign debris should be allowed to enter the bearings at any time during the maintenance.

(3) To replace bearings they should be heated using an induction heater to a controlled temperature of 90°C.

(4) The bearings must be removed by using pullers and re-fitted by heating, or using other special tools for the purpose. Do not hammer the bearing as this will cause bearing damage.

9.7.4 The cleanliness of sleeve bearings.

(1) The importance of cleanliness :

- Check the oil visually with respect to colour.
- Check the oil visually with respect to deposits.
- The original viscosity must be maintained within a tolerance of $\pm 15\%$.
- Smell the oil. Strong acid or burnt smell is not acceptable.

(2) The method of cleaning.

When any of the conditions mentioned above (1) occurs, a suitable oil change and cleaning of the bearing must be carried out.

Mineral oil must be used to clean the bearing.

(3) Caution during cleaning.

Be careful during cleaning. Any slight knock and impact will damage the bearing surface.

10 Motor troubleshooting chart

Your motor service and any troubleshooting must be handled by qualified persons with proper tools and equipment.

No	TROUBLE	CAUSE	REMEDY
1	Motor fails to start	Power-off	Check wiring. Switch-on. Change fuse. Check leads.
		Stator winding failure	Check windings short circuit or broken.
		Motor may be overloaded	Reduce load.
		Wrong wiring	Check wiring connections.
2	Motor does not reach full load speed	Voltage too low at motor terminals because of line drop.	Check connections. Check conductors for proper size.
		Poor contact of control switches or short circuit of starting switches.	Check and repair control switches.
		Phase failure of power.	Check power and connections.
		Poor contact of power line.	Check power connections.
		Windings earthed or short circuited.	Factory repair.
3	Motor trips out when reaching full load	Insufficient capacity of switches and fuses.	Replace switches and fuses if wiring permits.
		Under-voltage.	Check power source.
		Overload.	Lighten load.
4	Live enclosure	Connection between the wiring of power lines and earth connections.	Correct the wiring.
		Insulation contains moisture or is aged.	Dry out or replace winding.
		Connection between live leads and enclosure.	Check leads near enclosure and insulate them.
5	Motor surface overheating	Overload.	Lighten load or replace motor.
		Ambient temperature exceeds 40°C.	Replace with higher insulation class, or lower ambient temperature.
		Under-voltage.	Check power line, transformer capacity and source voltage.
		Over-voltage.	Check power source.

		Fuse blown (Single-phase operation).	Replace the specified fuse
		Ventilation duct clogged.	Remove the foreign matter in the ducts.
		Friction between rotor and stator.	Factory repair or replace motor.
		Unbalanced three-phase voltage.	Check circuit or consult power company.
6	Motor speed falls suddenly	Sudden overload.	Check load and mechanical connection.
		Single-phase operation.	Check starter switch, fuses and circuits and repair.
		Voltage drop.	Check control circuit and power source.
7	Electro-magnetic noise	Occurrence from first operation of motor.	May be normal.
		Sudden sharp noise.	Check short circuit of windings.
		Friction between rotor and stator.	Should be repaired at factory.
8	Mechanical noise	Wind noise.	Noise caused by air flowing through ventilation ducts, maybe normal.
		Loose belt pulley or loose coupling.	Adjust key and the position of belt or couplings and lock the screw.
		Loose screw on fan-cover.	Lock fan cover screws tightly.
		Friction between fan and end-shield, fan-cover.	Adjust the distances between fan and end-shield, and fan-cover.
		Rubbing as a result of ingression of foreign matters.	Clean motor interior and ventilation ducts.
		Caused by driven machine	Check the driven machine.
9	Bearing noise	Even sound.	May be normal.
		Light rumbling sound.	Re-grease.
		Obvious bearing sound.	Clean bearings and re-grease.
		Broken ball or rough races.	Replace the damaged bearing.
10	Vibration abnormal	Improper installation.	Tighten the mounting screws.
		Motor mounting bed is not strong enough.	Reinforce mounting bed.
		Unsymmetrical centers between belt pulleys.	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.
		Short circuit of windings of stator or rotor.	Factory repair.
		Mounting bed vibration caused by near machines.	Eliminate the vibration source near motor.
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 couplings.
		Friction between bearing and bearing housing or shaft.	Replace the damaged shaft or end-shield.
		Improper assembly.	Re-assembly motor.

11. Handling for discarded motors

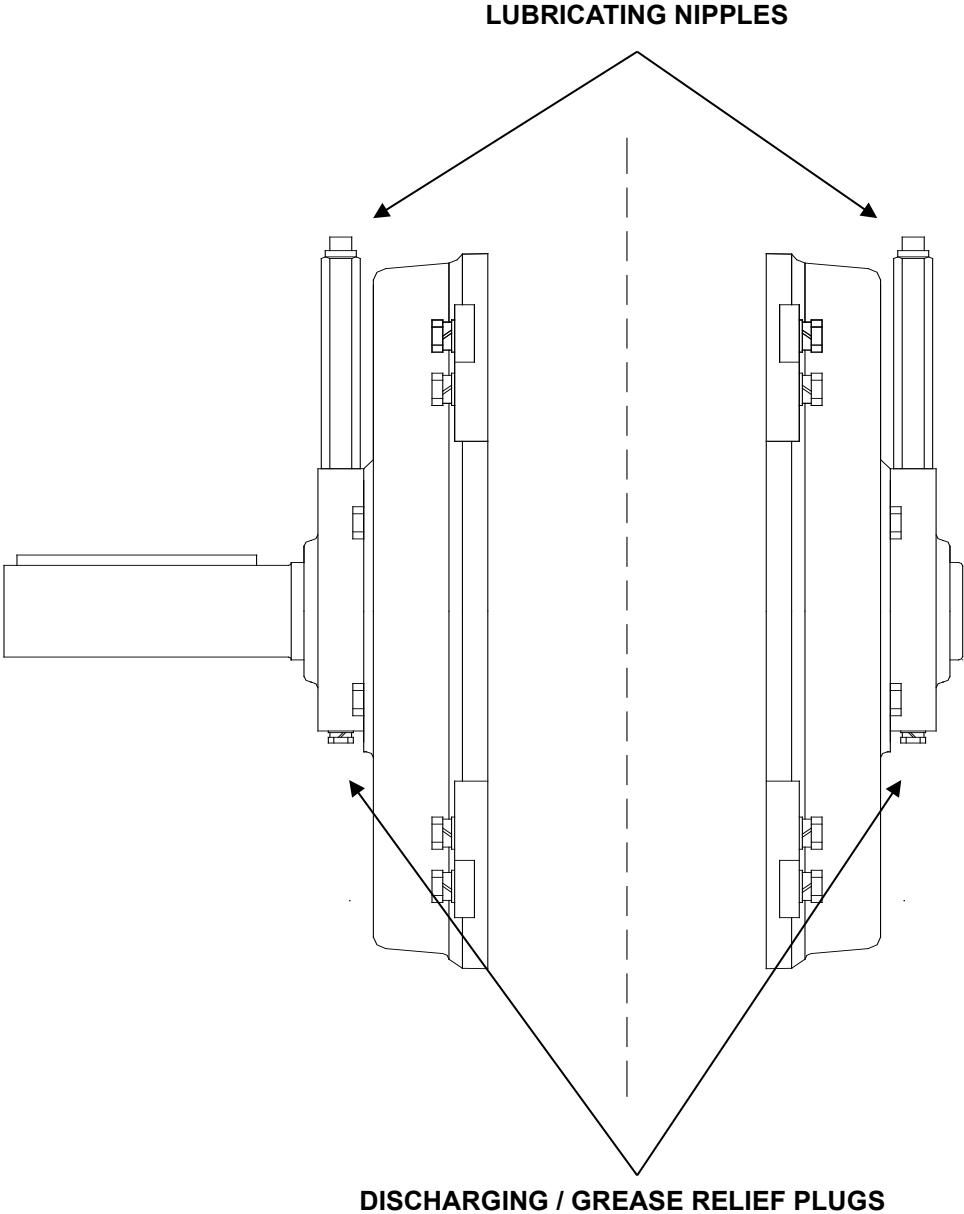
Scrap motors must be recycled according to the local regulations.

The material content used in the manufacturing of the motor is as follows: cast iron, steel, copper, aluminium, insulation materials.

For metals that account for a large part of the product, the choice of base metals that facilitate material recycling is necessary. The nonmetals should be either incinerated or disposed of in landfills. Attention should be paid to ensuring that such processes do not adversely affect the environment.

Motor products, manufacturing processes and even logistics have been designed to take environmental aspects into account.

ANNEX 1



ANNEX 3

Storage at low temperature

When motors are stored in ambient with very low temperature, the space heaters shall be energized continuously.

Bearings shall be provided with grease suitable for these conditions in order to avoid problems during the motor operation.

The suggested type of grease is :

LGHP2

Manufacturer : **SKF**

Utilization range : - **40** / **+150 °C**