



VERTICAL HOLLOW AND SOLID SHAFT MOTORS

FRAMES 215-5810 NEMA TYPE P-BASE WEATHER PROTECTED TYPE-1

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SAFETY PRECAUTIONS



High voltage and rotating Warning parts can cause serious or fatal injuries.

Installation

Operation and Maintenance of electric machinery should be performed by qualified personnel. Familiarization with NEMA Publication MG-2, Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators, the National Electrical Code and sound local practices is recommended.

For equipment covered by this instruction book, it is important to observe safety precautions to protect personnel from possible injury. Among the many considerations, personnel should be instructed to:

- Avoid contact with energized circuits or rotating parts.
- Avoid bypassing or rendering inoperative any safeguards or protection devices.
- Avoid use of automatic-reset thermal protection where unexpected starting of equipment might be hazardous to personnel.
- Avoid contact with capacitors until safe discharge procedures have been followed.
- Be sure the shaft key is fully captive before the motor is energized.
- Avoid extended exposure in close proximity with high noise levels.
- Use proper care and procedures in handling, lifting, installing, operating and maintaining the equipment.
- The motor should be lifted by the lugs provided. Do not lift anything but the motor with the motor lifting means.

Safe maintenance practices by qualified personnel are imperative. Before starting maintenance procedures, be positive that:

- Equipment connected to the shaft will not cause mechanical rotation.
- Main machine windings and all accessory devices associated with the work area are disconnected from electrical power sources.
- If a high potential insulation test is required, procedures and precautions outlined in NEMA Standard MG-1 and MG-2 should be followed.

These instructions do not purport to cover all of the details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to BMR-USA.





VERTICAL MOTOR INSTALLATION INSTRUCTIONS





The motor should be lifted by the lugs provided.

- Failure to properly ground the frame of this machine can cause serious injury to personnel or death. Grounding should be in accordance with the National Electrical code and consistent with sound local practice.

I. RECEIVING AND STORAGE

The motor should be lifted by the lugs provided. These Lugs are intended for lifting the motor only and must not be used to lift any additional weight. Be careful not to touch overhead power lines with lifting equipment.

Failure to observe this warning may result in personal injury or death.

The motor should be stored in a dry area with factory packaging intact, unless appearance of package indicates possibility of motor damage during shipment. Motor rating and identification data are furnished on label for verification purposes.

Just prior to actual use, unpack motor and rotate shaft by hand to see that it turns freely. (Pertains to vertical solid shaft motors only.) Remove rust preventative paper or any anti-rust compound from shaft extension.

A. Prior to Initial start

For oil lubricated ball or roller bearing motors, drain oil from reservoir that was put in at the time of receipt of the motor or during storage, by removing the drain plug located at the bottom of the oil sump in the bottom of the casting. Do not run the motor until the bearing housings have been filled to the proper level with oil as indicated on the oil lubrication plate (see Lubrication) and allowed to stand one (1) hour with oil in the bearings.



Installation should be in accordance with the National Electrical Code and consistent with sound local practices.

II. INSTALLATION

Coupling guards should be installed as needed to protect against accidental contact with moving parts. Machines accessible to personnel should be further guarded by screening, guardrails or other suitable enclosure to prevent anyone from coming in contact with the equipment.

This is especially important for motors that are remotely or automatically controlled or have automatic resetting overload relays, since such motors may start unexpectedly.

Failure to observe these precautions may result in injury or death to personnel.



- **A. Mounting**

Locate the motor in a place that is clean and well ventilated. The motor enclosure is designed such that dripping, wind blown and splashing water will not damage the motor. Under conditions of extreme weather and moisture, additional protection, such as a pump house, is recommended; however, the free flow of air around the motor must not be obstructed.

The ambient air temperature should not exceed 40°C or 104°F, unless the motor has been specially designed or otherwise cleared for use in a higher ambient temperature. Bolt the motor to the pump head or rigid foundation using bolts of the largest size permitted by the holes in the motor bracket.



Accurate alignment between the motor and the pump is of extreme importance. Misalignment will result in bearing problems.

1. Vertical Hollow shaft Motors (VHS)

When mounting VHS motors, remove the hood or top hat and coupling. Lower the motor onto the pump head with the pump shaft extending through the hollow shaft. The motor bracket should bolt down square with the pump head and at right angles with the pump head shaft. The pump head shaft should be centered within the motor hollow shaft. Fit the coupling onto the motor and key it to the pump shaft using the gib key. Put on the adjusting nut supplied with the pump and draw up on the impellers. Lock the adjusting nut in place with a screw through the nut into a tapped hole in the coupling.

- **A. Thrust**

The axial thrust load imposed upon the motor by the pump shaft and impellers plus the hydraulic load should not exceed the value for which the motor was designed.

2. Vertical Solid Shaft Motors (VSS)

These motors are provided with a shaft extension suitable for coupled service and are either straight or tapered as selected by the purchaser. If it is necessary to drive the coupling into position, it is important that the end of the shaft opposite the extension be backed up so the force of the blow is not taken in the bearings. Use a pin or puller for removing tight couplings.

Failure to comply may result in extensive damage to the equipment.



Coupling halves should have a close sliding fit on the shaft extension and must be securely locked to avoid hammering out in operation.





Motor and control wiring, overload protection and grounding should be in accordance with the National

- **B. Electrical Connections**

Failure to observe these precautions may result in damage to the equipment, injury to personnel or both.

Be sure the motor is connected as shown on the nameplate diagram and the power supply (voltage, frequency and number of phases) corresponds with the nameplate data. Install wiring, fusing and grounding in accordance with the National Electrical Code and local requirements.

Carefully identify motor auxiliary devices before connection. These might be space heater, winding thermostats, thermocouples, thermostats or other temperature sensors. Be sure they are connected only in circuits for which they are designed and the connections are carefully insulated from the motor power cables.

Connect the power supply through a suitable switch and overload protection.

To change the direction of rotation on a three phase vertical solid shaft motor, interchange any two line leads.

1. Conduit Box

The conduit box may be rotated 360° in 90° steps.

III. OPERATION



Before energizing the motor for the first time or after an extended shut down, it is advisable to check insulation resistance, power supply and mechanical freedom of the motor. If the motor has been stored in a damp location, dry it out thoroughly before operating.



Be sure the motor is not running and the power supply is disconnected before working on the motor.





Before measuring insulation resistance, the machine must be at standstill and all windings to be tested must be electrically connected to the frame and to ground for a time sufficient to remove all residual electrostatic charge.

A. Steps Prior to Initial Start-Up or Start-Up After a Long Idle Period

1. Check insulation resistance as indicated in the caution above. Failure to observe these precautions may result in injury to personnel.

In accordance with established standards, the recommended minimum insulation resistance for the stator winding is as follows:

$$RS = \frac{Vs + 1}{1000}$$

Where RS is the recommended minimum insulation resistance in meg-ohms at 40°C of the entire stator winding obtained by applying direct potential to the entire winding for one minute, and VS is rated machine voltage.

NOTE: See IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machines, Publication No. 43, for more complete information.

If the insulation resistance is lower than this value, it may be wet and it is advisable to eliminate the moisture in one of the following ways:

- a. Dry the stator in an air-circulating oven with the air surrounding the part at 95°C to 115°C until the stator has been above 90°C for at least four hours. Then the air temperature may be raised to 135°C to 155°C. Continue to heat until the insulation resistance is constant for a one-half hour period.
- b. Enclose the motor with canvas or similar covering, leaving a hole at the top for moisture to escape. Insert heating units or lamps and leave them on until the insulation resistance is constant for a one-half hour period. Be careful not to get heating units so close to the winding that they cause localized damage or combustion of the canvas or other covering.
- c. With the rotor locked and using approximately 10% of rated voltage, pass a current through the stator windings. Increase the current gradually until the temperature reaches 90°C. Do not exceed this temperature. Maintain a temperature of 90°C until the insulation resistance becomes constant for a one-half hour period.



2. Check bearing oil reservoirs to be sure they have been filled to the proper level with fresh oil and that grease lubricated bearings are properly greased. (See Lubrication.)
3. Whenever possible, examine the interior of the machine for loose objects or debris which may have accumulated and remove any foreign material.
4. If possible, turn the rotor by hand to be sure it rotates freely.
5. Check all connections with the connection diagram. Check all accessible factory-made connections for tightness to make sure none has become loose during shipment.
6. If possible, leave motor uncoupled (or uncouple it) for initial operation so motor vibration, noise, current and bearings can be checked uncoupled before they are masked by the pump. To run a VHS motor uncoupled, it is recommended that the pump head-shaft be removed. If this cannot be done, remove the upper half-coupling and be sure the pump shaft is well centered in the motor shaft so it will not rub:

IF THIS IS DONE, ROTATE THE MOTOR BY HAND TO BE SURE THERE IS NO INTERFERENCE BETWEEN SHAFTS. Do not try to run the motor uncoupled by just removing the gib key.

7. When the driven machine is likely to be damaged by the wrong direction of rotation, it is imperative to uncouple the motor from its load during the initial start and make certain it rotates in the correct direction. If it is necessary to change rotation, interchange any two line leads. For multi-speed motors check each speed independently. On VHS motors do this before installing the pump head-shaft and upper half-coupling. Some motors are designed for uni-directional rotation. Rotation of these motors must be in accordance with the rotation indicated on the nameplate(s) furnished with the equipment.

B. Initial Start

1. After inspecting the machine carefully as outlined above, make the initial start by following the regular sequence of starting operations in the control instructions.
2. Run the motor uncoupled initially, if possible, checking for abnormal noise, vibration or bearing temperatures and for current and voltage balance. Then check motor operation under load for an initial period of at least one hour to observe whether any unusual noise or hotspots develop.
3. In the event of excessive vibration or unusual noise, remove all power and disconnect the machine from the load and check the mounting and alignment.
4. Space heaters (if supplied) should be de-energized during motor operation.
5. Check line voltage on all three phases to be sure it is balanced and within 10% of motor rated voltage with motor drawing load current.
6. Check the operating current against the nameplate value. Do not exceed the value of nameplate amperes X service factor (if any) under steady continuous load. Also check to be sure that current in all three lines is balanced.



C. Jogging and Repeat Starts



Repeated starts and/or Caution jogs of induction motors greatly reduce the life of the winding insulation. The heat produced by each acceleration or jog is much more than that dissipated by the motor at full load. If it is necessary to repeatedly start or jog a motor, it is advisable to check the application with BMR USA.

Check motor heating but do not depend on your hand to determine the temperature. Use the temperature detectors furnished in the motor if there are any (e.g.; RTD's or thermocouples), or use a thermometer. If there is any doubt about the safe operating temperature, take the temperature of the part in question and confer with BMR USA. Give full details, including all nameplate information.

Overheating of the motor may be caused by improper ventilation, excessive ambient temperature, dirty conditions, excessive current due to overload, unbalanced a-c voltage or (if a variable speed controller is used) harmonics in power supplied to the motor.

IV. MAINTENANCE



Before initiating maintenance procedures, disconnect all power sources to the motor and accessories. For machines equipped with surge capacitors do not handle the capacitor until it is discharged by a conductor simultaneously touching all terminals and leads, including ground.

This discharge conductor should be insulated for handling. Replace all normal grounding connections prior to operating. Failure to observe these precautions may result in injury to personnel.

A. General

Inspect the motor at regular intervals, as determined by service conditions. Keep the motor clean and the ventilation openings clear. In addition to a daily observation of the overall condition, it is recommended that a regular inspection routine be set up to periodically check the following items.

1. General cleanliness.
2. Insulation and windings.
3. Lubrication and bearings
4. Coupling bolt tightness



B. General Cleanliness

The interior and exterior of the machine should be kept free from dirt, oil, grease and conducting dust. Oily vapor, debris or dust may build up and block off ventilation. Any of these contaminants can lead to early motor failure. The motor should be disassembled and thoroughly cleaned periodically, as needed.

Motors may be blown out with dry, compressed air of moderate pressure (30 psi, 207 kPa or less). However, cleaning by suction is preferred because of the possibility of water in compressed air lines and the danger of blowing metal chips into the insulation with compressed air.



To prevent injury to eyes and respiratory organs, safety glasses and suitable ventilation or other protective equipment should be used. Operator must not use compressed air to remove dirt or dust from his person or clothing.

Screens and covers are provided as necessary for protection of the equipment and personnel. All screens must be kept free of dirt and debris to ensure proper ventilation and kept in place for protection of personnel.

C. Inspection

Motors should be inspected at regular intervals to check for 1) dirt, 2) moisture, 3) friction and 4) vibration, which accounts for 90% of all motor failures.

D. Guard Against Dirt

Keep the insulation and mechanical parts of the motor clean. Dust that is free from oil or grease may be removed by wiping with a clean, dry cloth, or preferably, by suction. Dust may be blown from inaccessible parts with clean, dry air, using not more than 30 psi (207kPa). Use carefully to prevent personal injury from the air hoses; use goggles to avoid eye injury from flying particles. Before blowing motor windings out with air, make sure the air line is free of condensation and debris.

When grease or oil is present, wipe with a cloth moistened (but not dripping) with a petroleum solvent of a "safety type" such as Stoddard solvent or similar materials available under various trade names. When a material is difficult to remove, carbon tetrachloride is more effective than petroleum solvents. Wear rubber gloves to prevent skin irritation when using either petroleum solvents or carbon tetrachloride. Petroleum solvents are flammable, but comparatively nontoxic.



Carbon tetrachloride is non-flammable, but is highly toxic. Suitable ventilation should be provided to avoid breathing vapors. When ventilation is not sufficient to prevent a distinct odor or carbon tetrachloride, a chemical cartridge respirator or gas mask must be used.

Failure to observe these precautions may result in injury to personnel.



E. Guard Against Moisture

The motor should not be subjected to extreme moisture conditions such as high humidity during shut down periods, exposure to water under pressure (such as hosing down) or severe weather conditions.

During prolonged periods of storage, the motor should be run at least once a week, or should be provided with heaters to guard against moisture condensation.

The insulation resistance of motors not in regular use should be checked with a megger, and, if necessary, the windings should be dried by appropriate means before energizing.

F. Guard Against Friction and Vibration

Excessive friction or overheating of bearings is usually traced to one of the following causes:

1. Poor alignment causing excessive vibration or binding.
2. Bent shaft.
3. Excessive thrust.
4. Overgreasing.
5. Wrong oil and/or oil viscosity.

To avoid failures due to vibration, a few simple checks should be made regularly:

1. Check misalignment which may be caused by foundation settling.
2. Check to see if any pump vibration is being transmitted to the motor.
3. Check the motor mounting bolts and bracket holes to be sure they are tight.
4. Check transmission from adjacent machinery or to flexible motor support structure, as well as by motor unbalance itself.

NOTE: If vibration of 0.005" (0.127mm) or more is experienced under running conditions after above checks have been made, then it is highly probable there is some resonance in the system.



G. Coils

Revarnishing the windings when motors are overhauled will lengthen their life.

H. Guide Bearing

The guide bearings are vacuum degassed, single row width Conrad type greasable ball bearings.



The thrust capacity of these bearings vary with supplier and care should be taken to ensure that replacement bearings are equivalent to the original.

1. Coupling Maintenance

The condition of non-reverse couplings should be checked periodically by removing the top cap. If dirt has caused the action of the pins or balls to become sluggish, the pin or ball carrier should be removed, disassembled and thoroughly cleaned with a suitable solvent. The parts should then be dried and reassembled in accordance with the instructions given under NON-REVERSE COUPLINGS.

Sometimes, after a long period of operation with frequent stops and starts, the surface of the holes in the pin or ball carrier becomes polished, so that friction forces will no longer hold the pins or balls clear of the ratchet teeth when the motor is running. The condition can be remedied by roughening these surfaces with a piece of emery paper wrapped around a rod.

NOTE: Whenever the dismantling of couplings is necessary, the use of witness marks will assure a balanced condition when reassembly is complete.

Bolts on both bolted couplings and non-reverse couplings should be checked periodically to be sure they are tight.



V. LUBRICATION

A. Frequency of Re-greasing

The following table suggests re-lubrication intervals for motors on normal, steady running, in a relatively clean atmosphere at 40°C ambient (104°F) temperature or less.

Table 1 / Re-lubrication Intervals

Enclosure	Insulation	210-320 Frame	360-440 Frame
WP-1	F	1 year	9 months
Enclosed Fan Cooled	F	9 months	6 months

NOTE: For motors over 1800 RPM or extra severe duty, dusty locations, use ½ of the period specified in the table.

B. Type of Grease

For maximum bearing life, use only the grease recommended by BMR - USA. Some equivalent greases are:

- For Class F insulated motors:
- Polyrex EM – Exxon
- Chevron BRB -2 – Standard Oil of California
- AeroShell #5 – Shell Oil Company
- Hi Temp – Texaco, Inc.
- Alvania #3

C. Procedure for Re-greasing

When re-greasing, stop the motor, remove the grease outlet plug and add grease with a hand-lever operated gun only. Add only the amount of grease specified in Table 2.

Run the motor for about ten minutes before replacing the outlet plug.



Table 2 - Reference Table for Guide Thrust Bearings

Shaft Diameter (at face of bracket)	Amount of Grease to Add
3/4 to 1-1/4 in	1/8 cu-in or 0.1 oz (3.0ml)
1-1/4 to 1-7/8 in(Guide)	1/4 cu-in or 0.2 oz (5.9ml)
1-7/8 to 2-3/8 in (Bearings)	3/4 cu-in or 0.6oz (17.7ml)
2-3/8 to 3-3/8 in	2 cu-in or 1.6 oz (47.3ml)

*1 oz = 1.3 cu-in by weight



Over greasing is a major cause of bearing and motor failure. Make sure dirt and contaminants are not introduced when adding grease.

D. Thrust Bearing

1. Re-Lubrication

a. Oil Lubricated Bearings

Motors 320 frame size and larger have an oil lubricated upper bearing. The following instructions apply to that bearing.

The thrust bearings are either angular contact ball bearings or spherical roller thrust bearings depending on the motor's thrust rating. The angular contact bearings are mounted singularly, tandem or back-to-back. The bearing is grease or oil lubricated and the oil reservoir is cooled by means of the motor cooling air passing over the reservoir.



Motors with oil lubricated ball or roller bearings (320-440 frame) that are going to be stored for any period of time should have the oil reservoir filled to the center of the sight gage with a good grade of rust inhibiting oil.



2. Mounting

Oil lubricated ball or roller bearing machines must be mounted on a level surface to prevent leakage of oil to ensure the level indication will be correct.

3. Prior to Initial Start

For oil lubricated ball or roller bearing motors, drain oil from the reservoir that was put in at the time of receipt of the motor or during storage, by removing the drain plug located at the bottom of the oil sump in the bottom of the casting.

Do not run motor until the bearing housings have been filled to the proper level with oil as indicated on the oil lubrication plate (see Lubrication) and allowed to stand one (1) hour with oil in the bearings.

4. Lubrication

With the motor at standstill, fill the top bearing reservoir with a good grade of lubricating oil having a viscosity equivalent to S.A.E. # 10W; 150 SUS (ISO 32) @ 100°F for ball bearings and S.A.E. #40W, 600 SUS@100°F for roller bearings.

Before starting the motor, replace the filler plug. Refer to the lubrication nameplate on the motor.

Maintain proper lubrication by checking the oil level periodically and adding oil when necessary. Because of the clearing action of the bearing as the motor accelerates up to speed, and the expansion of the oil as it comes up to operating temperature, the oil level will be higher after the motor has been in operation for a while than it is with the motor at standstill. The normal level, with the motor stopped and the oil cold, is marked STANDSTILL LEVEL on the sight gage.

Overfilling should be avoided not only because of the possibility that expansion may force the oil over the oil sleeve and into the motor, but also because operating with the oil level too high prevents the bearing from cleaning itself of excess oil. The resultant churning can cause extra loss, high temperatures and oxidized oil. If during operation, the oil level goes above the maximum shown on the sight gage, drain enough oil to bring the level back within the operating range. To drain the oil, remove the drain plug below the sight gage.

Do not permit the operating oil level to fall below the minimum shown on the gage. Should it ever become necessary to add excessive amounts of make-up oil, investigate for all oil leaks.

Change oil at regular interval. The time between oil changes depends upon the severity of operating conditions and, hence, must be determined by the motor user. One or two changes a year is average, but special conditions, such as high ambient temperature, may require more frequent changes. Avoid operating motor with oxidized oil.

Use only best grade, oxidation and corrosion inhibited turbine oil produced by reputable oil companies. The viscosity (weight) of the oil to be used depends upon the type and size of the bearing, its load and



speed, the ambient temperature, and the amount and temperature of the cooling water (if used). The lubrication nameplate or instruction with each motor specifies the viscosity range of oil suitable for average conditions. The unusual recommendations are summarized in Table 3, Oil viscosity. Operation in ambient temperatures that are near or below freezing may require preheating the oil or the use of a special oil.

Too heavy and oil could cause the following:

- a. Increased fluid friction losses resulting in higher operating temperatures. Higher temperatures will cause the oil to oxidize or break down at an accelerated rate.
- b. A heavy oil tends to churn or foam more than a lighter weight oil.
- c. Bearings may run warmer because of reduced oil circulation through and around the bearings.

Too light an oil may allow the oil film to wipe or break down.

For standard applications the oil viscosity called for on the lube nameplate should be used. Do not use E.P. oil.



Disassembly of motor by other than an authorized service shop will void the warranty.

Table 3 - Oil Viscosity

Bearing function And Location	Bearing Type	Oil Viscosity - SUS	
		@100°F	@210°F
Thrust Bearing (in top end shield 320-450 Frame)	Angular Contact Ball	A150	45

(For a particular motor, refer to the lubrication nameplate or instructions.)



5. To Disassemble Motor

To service or inspect the thrust bearing, the parts should be removed in the following order: hood or top hat, drive nut from pump shaft, coupling, ratchet pins, locknut and washer, ratchet plate, bearing runner and bearing. When the thrust bearing is removed, the upper bracket can be lifted off the frame after removing the bracket bolts. If required, the rotor and shaft can be lifted out with the upper bracket removing the lower bearing cap bolts.

VI. ADJUST SHAFT END PLAY

On the standard vertical high thrust motors, the lower guide ring is restrained to take momentary up thrust. On spherical bearing motors, the restrained lower bearing also maintains spring tension on the thrust bearing during any periods the motor is running without external load.

When reassembling the motor, it is important a preload stress is not left on the guide and thrust bearing. The following assembly procedure should be used.

- A. Leave the locknut holding the runner on the shaft loose.
- B. Tighten the lower bearing cap bolts.
- C. Tighten down on the shaft locknut until the bearings are just starting to preload.
- D. After slightly preloading the bearings, back off the locknut approximately $\frac{1}{4}$ turn for angular contact bearing motors and $\frac{1}{2}$ turn for spherical roller bearing motors.

Solid shaft motors will not have a pump shaft nut, coupling or ratchet pins. This does not apply to special units with DB thrust bearings for continuous up or down thrust.

E. Shaft endplay for angular contact bearing motors should be 0.005 in. to 0.020 in. (0.127 mm to 0.508mm)

F. If the equipment is available, it is desirable for the shaft endplay be checked using a dial indicator to measure movement as the rotor and shaft are raised and lowered.

G. When endplay is established, lock the nut in place with the lock washer.

NOTE: The bearing style number is on the motor nameplate. The grease type is also identified on the motor nameplate.



VII. REPAIR AND RENEWAL PARTS

Repair and renewal parts information may be obtained from BMR USA. Be sure to describe the part or parts required and give the complete nameplate information on the motor for positive identification.

VIII. WARRANTY

Contact BMR USA for details of warranty coverage. Generally, BMR USA will correct by repair or replacement all its products against defeats in material and workmanship, provided the product has been properly cared for, and operated in the application for which the product was designed, for 24 months from date of installation or 36 months from date of manufacture, whichever expires first.

IX. TROUBLE SHOOTING CHART

- Affected Parts
- Difficulty
- What to Check
- Windings
- Overheating
- Calibration of measuring instrument
- Excessive load
- Unbalanced a-c current
- Improper or restricted ventilation
- Excessive ambient temperature
- Short circuited coil or windings
- Dirty windings
- Unbalanced voltage
- Harmonics in power supply(variable frequency control)
- Bearings
- Overheating
- Calibration of measuring instrument
- Worn out or dirty oil
- Insufficient oil or grease
- Misalignment
- Excessive thrust or radial loading
- Shaft currents
- Improper end-play
- Bearing Housing
- Oil Leaks
- Incorrect grade of oil (type or viscosity)
- Loose fittings
- Cracked/porous casting
- Over-filled
- Water in oil
- Motor



- Excessive Vibration
- Unbalance
- Misalignment
- Improper or settled foundation
- Non-uniform air gap
- Rubbing parts
- Bent shaft
- Unbalanced stator current
- Damaged bearings
- Reed Critical Frequency
- Incorrect end-play
- Motor
- Failure to Start
- Wrong transformer taps
- Wrong connections
- Open circuit
- Excessive line drop(low voltage at motor)
- Excessive load
- Rotor rubs
- Wrong direction of rotation
- Insulation
- Low Insulation Resistance or Insulation Failure
- Moisture, dirt, metal particles, oil or other contaminants on the insulated windings
- Wrong voltage
- Excessive temperature
- Voltage surges/lightning
- Mechanical damage
- Excessive vibration with resultant mechanical damage
- Single-phasing



