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1 Introduction

The conformity of the end product according to Directive 2006/42/EC (Machinery) has to be established by the commissioning party when the motor is fitted to the machinery.

1.1 Declaration of Conformity

The conformity of the end product according to Directive 2006/42/EC (Machinery) has to be established by the commissioning party when the motor is fitted to the machinery.

1.2 Validity

These instructions are valid for the following ABB electrical machine types, in both motor and generator operation:

- series MT*, MXMA,
- in IEC frame sizes 56-500
- in NEMA frame sizes 58*, 50**

Additional information is required for some machine types due to special application and/or design considerations.

Additional manual is available for the following motors:

- roller table motors
- water cooled motors
- smoke extraction motors
- brake motors
- motors for high ambient temperatures
- motors in marine applications for mounting on open deck
- of ships or offshore units

There is a separate manual for e.g. Ex motors ‘Low voltage motors for explosive atmospheres: Installation, operation and maintenance and safety manual (3GZF500730-47).
2 Safety considerations

The motor is intended for installation and use by qualified personnel, familiar with health and safety requirements and national legislation.

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

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**WARNING**

Emergency stop controls must be equipped with restart lockouts. After emergency stop a new start command can take effect only after the restart lockout has been intentionally reset.

**Points to be observed:**

1. Do not step on the motor.
2. The temperature of the outer casing of the motor may be hot to the touch during normal operation and especially after shut-down.
3. Some special motor applications may require additional instructions (e.g. when supplied by frequency converter).
4. Observe rotating parts of the motor.
5. Do not open terminal boxes while energized.
3 Handling

3.1 Reception

Immediately upon receipt, check the motor for external damage (e.g. shaft-ends, flanges and painted surfaces) and, if found, inform the forwarding agent without delay.

Check all rating plate data, especially voltage and winding connections (star or delta). The type of bearing is specified on the rating plate of all motors except the smallest frame sizes.

In the case of a variable speed drive application check the maximum loadability allowed according to frequency stamped on the motor’s second rating plate.

3.2 Transportation and storage

The motor should always be stored indoors (above –20 °C), in dry, vibration-free and dust-free conditions. During transportation, shocks, falls and humidity should be avoided. In other conditions, please contact ABB.

Unprotected machined surfaces (shaft-ends and flanges) should be treated against corrosion.

It is recommended that shafts are rotated periodically (once per quarter) by hand to prevent grease migration.

Anti-condensation heaters, if fitted, are recommended to be used to avoid water condensing in the motor.

The motor must not be subject to any external vibrations at standstill so as to avoid causing damage to the bearings.

Motors fitted with cylindrical-roller and/or angular contact bearings must be fitted with locking devices during transport.
3.3 Lifting

All ABB motors above 25 kg are equipped with lifting lugs or eyebolts.

Only the main lifting lugs or eyebolts of the motor should be used for lifting the motor. They must not be used to lift the motor when it is attached to other equipment.

Lifting lugs for auxiliaries (e.g. brakes, separate cooling fans) or terminal boxes must not be used for lifting the motor. Because of different output, mounting arrangements and auxiliary equipment, motors with the same frame may have a different center of gravity.

Damaged lifting lugs must not be used. Check that eyebolts or integrated lifting lugs are undamaged before lifting.

Lifting eyebolts must be tightened before lifting. If needed, the position of the eyebolt can be adjusted using suitable washers as spacers.

Ensure that proper lifting equipment is used and that the sizes of the hooks are suitable for the lifting lugs.

Care must be taken not to damage auxiliary equipment and cables connected to the motor.

Remove eventual transport jigs fixing the motor to the pallet.

Specific lifting instructions are available from ABB.

3.4 Motor weight

The total motor weight can vary within the same frame size (center height) depending on different output, mounting arrangement and auxiliaries.

The following table shows estimated maximum weights for machines in their basic versions as a function of frame material.

| Table 3.1: Minimum cross-sectional area of protective conductors |
|---|---|---|---|
| Frame size | Aluminum, Weight kg | Cast iron, Weight kg | Add. for brake |
| 56 | 4.5 | – | – |
| 63 | 6 | – | – |
| 71 | 8 | 13 | 5 |
| 80 | 14 | 20 | 8 |
| 90 | 20 | 30 | 10 |
| 100 | 32 | 40 | 16 |
| 112 | 36 | 50 | 20 |
| 132 | 93 | 90 | 30 |
| 160 | 149 | 130 | 30 |
| 180 | 162 | 190 | 45 |
| 200 | 245 | 275 | 55 |
| 225 | 300 | 360 | 75 |
| 250 | 386 | 405 | 75 |
| 280 | 425 | 800 | – |
| 315 | – | 1700 | – |
| 355 | – | 2700 | – |
| 400 | – | 3500 | – |
| 450 | – | 4500 | – |
| 5000 | – | 2800 | – |

If the motor is equipped with a separate fan, contact ABB for the weight.
4 Installation and commissioning

4.1 General

All rating plate values must be carefully checked to ensure that the motor protection and connection will be properly done.

When starting the motor for the first time or after it has been in storage more than 6 months, apply the specified quantity of grease.

See section “7.2.2 Motors with re-greasable bearings” for more details.

When fitted in a vertical position with the shaft pointing downwards, the motor must have a protective cover to prevent foreign objects and fluid from falling into the ventilation openings. This task can also be achieved by a separate cover not fixed to the motor. In this case, the motor must have a warning label.

4.2 Motors with other than deep groove ball bearings

Remove transport locking if employed. Turn the shaft of the motor by hand to check free rotation, if possible.

**Motors equipped with cylindrical roller bearings:** Running the motor with no radial force applied to the shaft may damage the roller bearing due to “sliding”.

**Motors equipped with angular contact ball bearing:** Running the motor with no axial force applied in the right direction in relation to the shaft may damage the angular contact bearing.

---

**WARNING**

Disconnect and lock out before working on the motor or the driven equipment.

---

**WARNING**

For motors with angular contact bearings the axial force must not by any means change direction.

---

The type of bearing is specified on the rating plate.
4.3 Insulation resistance check

Measure insulation resistance (IR) before commissioning, after long periods of standstill or storage when winding dampness may be suspected. IR shall be measured directly on the motor terminals with the supply cables disconnected in order to avoid them affecting the result.

Insulation resistance should be used as a trend indicator to determine changes in the insulation system. In new machines the IR is usually thousands of Mohms and thus following the change of IR is important so as to know the condition of the insulation system. Typically, the IR should not be below 10 MΩ and in no case below 1 MΩ (measured with 500 or 1000 VDC and corrected to 25 °C). The insulation resistance value is halved for each 20 °C increase in temperature.

Figure 1, in chapter 11, can be used for the insulation correction to the desired temperature.

**WARNING**

To avoid risk of electrical shock, the motor frame must be grounded and the windings should be discharged against the frame immediately after each measurement.

If the reference resistance value is not attained, the winding is too damp and must be oven dried. The oven temperature should be 90 °C for 12-16 hours followed by 105 °C for 6-8 hours.

If fitted drain hole plugs must be removed and closing valves must be opened during heating. After heating, make sure the plugs are refitted. Even if the drain plugs are fitted, it is recommended to disassemble the end shields and terminal box covers for the drying process.

Windings drenched in seawater normally need to be rewound.

4.4 Foundation

The end user has full responsibility for preparation of the foundation.

Metal foundations should be painted to avoid corrosion.

Foundations must be even and sufficiently rigid to withstand possible short circuit forces. They must be designed and dimensioned to avoid the transfer of vibration to the motor and vibration caused by resonance. See figure below.

---

**Note!** Height difference shall not exceed ± 0.1mm referred to any other motor foot.
4.5 Balancing and fitting coupling halves and pulleys

As standard, balancing of the motor has been carried out using half key.
Coupling halves or pulleys must be balanced after machining the keyways. Balancing must be done in accordance with the balancing method specified for the motor.

Coupling halves and pulleys must be fitted on the shaft by using suitable equipment and tools which do not damage the bearings and seals.
Never fit a coupling half or pulley by hammering or removing it by using a lever pressed against the body of the motor.

4.6 Mounting and alignment of the motor

Ensure that there is enough space for free airflow around the motor. It is recommended to have a clearance between the fan cover and the wall etc. of at least ½ of the air intake of the fan cover. Additional information may be found from the product catalog or from the dimension drawings available on our web pages: www.abb.com/motors&generators.
Correct alignment is essential to avoid bearing, vibration and possible shaft failures.
Mount the motor on the foundation using the appropriate bolts or studs and place shim plates between the foundation and the feet.
Align the motor using appropriate methods.
If applicable, drill locating holes and fix the locating pins into position.
Mounting accuracy of coupling half: check that clearance b is less than 0.05 mm and that the difference a1 to a2 is also less than 0.05 mm. See figure 2.
Re-check the alignment after final tightening of the bolts or studs.
Do not exceed permissible loading values for bearings as stated in the product catalogs.
Check that the motor has sufficient airflow.
Ensure that no nearby objects or direct sunshine radiate additional heat to the motor.
For flange mounted motors (e.g. B5, B35, V1), make sure that the construction allows sufficient air flow on the outer surface of the flange.

4.7 Radial forces and belt drives

Belts must be tightened according to the instructions of the supplier of the driven equipment. However, do not exceed the maximum belt forces (i.e. radial bearing loading) stated in the relevant product catalogs.

---

WARNING
Excessive belt tension will damage bearings and can cause shaft damage.
4.8 Motors with drain plugs for condensation

Check that drain holes and plugs face downwards. In vertical position mounted motors, the drain plugs may be in horizontal position. Motors with sealable plastic drain plugs are delivered in an open position. In very dusty environments, all drain holes should be closed.

4.9 Cabling and electrical connections

The terminal box on standard single speed motors normally contains six winding terminals and at least one earth terminal.

In addition to the main winding and earthing terminals, the terminal box can also contain connections for thermistors, heating elements or other auxiliary devices.

Suitable cable lugs must be used for the connection of all main cables. Cables for auxiliaries can be connected into their terminal blocks as such.

Motors are intended for fixed installation only. Unless otherwise specified, cable entry threads are metric. The IP class of the cable gland must be at least the same as those of the terminal boxes.

Certified conduit hub or cable connector has to be used at the time of installation.

<table>
<thead>
<tr>
<th>Cross-sectional area of phase conductors of the installation, $S$, [mm$^2$]</th>
<th>Minimum cross-sectional area of the corresponding protective conductor, $S$, [mm$^2$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
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<tr>
<td>25</td>
<td>25</td>
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<tr>
<td>35</td>
<td>25</td>
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<tr>
<td>50</td>
<td>25</td>
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<tr>
<td>70</td>
<td>35</td>
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<tr>
<td>95</td>
<td>50</td>
</tr>
<tr>
<td>120</td>
<td>70</td>
</tr>
<tr>
<td>150</td>
<td>70</td>
</tr>
<tr>
<td>185</td>
<td>95</td>
</tr>
<tr>
<td>240</td>
<td>120</td>
</tr>
<tr>
<td>300</td>
<td>150</td>
</tr>
<tr>
<td>400</td>
<td>185</td>
</tr>
</tbody>
</table>

In addition, earthing or bonding connection facilities on the outside of electrical apparatus must provide effective connection of a conductor with a cross-sectional area of at least 4 mm$^2$.

The cable connection between the network and motor terminals must meet the requirements stated in the national standards for installation or in the standard IEC/EN 60204-1 according to the rated current indicated on the rating plate.

Cables should be mechanically protected and clamped close to the terminal box to fulfill the appropriate requirements of IEC/EN 60079-0 and local installation standards.

Unused cable entries must be closed with blanking elements according to the IP class of the terminal box.

The degree of protection and diameter are specified in the documents relating to the cable gland.

Use appropriate cable glands and seals in the cable entries according to the type and diameter of the cable.

WARNING

Earthing must be carried out according to local regulations before the motor is connected to the supply voltage.
When the ambient temperature exceeds +50 °C, cables having permissible operating temperature of +90 °C as minimum shall be used. Also all other conversion factors depending on the installation conditions shall be taken into account while sizing the cables.

Ensure that the motor protection corresponds to the environment and weather conditions. For example, make sure that water cannot enter the motor or the terminal boxes.

The seals of terminal boxes must be placed correctly in the slots provided to ensure the correct IP class. A leak could lead to penetration of dust or water, creating a risk of flashover to live elements.

4.9.1 Connections for different starting methods

The terminal box on standard single speed motors normally contains six winding terminals and at least one earth terminal. This enables the use of DOL- or Y/D-starting.

For two-speed and special motors, the supply connection must follow the instructions inside the terminal box or in the motor manual.

The voltage and connection are stamped on the rating plate.

**Direct-on-line starting (DOL):**

Y or D winding connections may be used.

For example, 690 VY, 400 VD indicates Y-connection for 690 V and D-connection for 400 V.

**Star/Delta (Wye/Delta) starting (Y/D):**

The supply voltage must be equal to the rated voltage of the motor when using a D-connection.

Remove all connection links from the terminal block.

Other starting methods and severe starting conditions:

In cases where other starting methods e.g. converter or soft starter will be used in the duty types of S1 and S2, it is considered that the device is “isolated from the power system when the electrical machine is running” as in the standard IEC 60079-0 and thermal protection is optional.

4.9.2 Connections of auxiliaries

If a motor is equipped with thermistors or other RTDs (Pt100, thermal relays, etc.) and auxiliary devices, it is recommended they be used and connected by appropriate means. For certain applications, it is mandatory to use thermal protection. More detailed information can be found in the documents delivered with the motor. Connection diagrams for auxiliary elements and connection parts can be found inside the terminal box.

The maximum measuring voltage for the thermistors is 2.5 V. The maximum measuring current for Pt100 is 5 mA. Using a higher measuring voltage or current may cause errors in readings or a damaged temperature detector.

The insulation of thermal sensors fulfills the requirements of basic insulation.

### 4.10 Terminals and direction of rotation

The shaft rotates clockwise when viewing the shaft face at the motor drive end, and the line phase sequence – L1, L2, L3 – is connected to the terminals as shown in figure 3.

To alter the direction of rotation, interchange any two connections on the supply cables.

If the motor has a unidirectional fan, ensure that it rotates in the same direction as the arrow marked on the motor.
5 Operation

5.1 General

The motors are designed for the following conditions unless otherwise stated on the rating plate:

- Motors are to be installed in fixed installations only.
- Normal ambient temperature range is from -20 °C to +40 °C.
- Maximum altitude is 1000 m above sea level.
- The variation of the supply voltage and frequency may not exceed the limits mentioned in relevant standards. Tolerance for supply voltage is ±5 %, and for frequency ±2 % according to the figure 4 (EN / IEC 60034-1, paragraph 7.3, Zone A). Both extreme values are not supposed to occur at the same time.

The motor can only be used in applications for which it is intended. The rated nominal values and operation conditions are shown on the motor rating plates. In addition, all requirements of this manual and other related instructions and standards must be followed.

If these limits are exceeded, motor data and construction data must be checked. Please contact ABB for further information.

WARNING

Ignoring any instructions or maintenance of the apparatus may jeopardize safety and thus prevent the use of the motor.
6 Low voltage motors in variable speed operation

6.1 Introduction

This part of the manual provides additional instructions for motors used in frequency converter supplies. The motor is intended to operate from a single frequency converter supply and not motors running in parallel from one frequency converter. Instructions given by the converter manufacturer shall be followed.

Additional information may be required by ABB to decide on the suitability for some motor types used in special applications or with special design modifications.

6.2 Winding insulation

Variable speed drives create higher voltage stresses than the sinusoidal supply on the winding of the motor. Therefore, the winding insulation of the motor as well as the filter at the converter output must be dimensioned according to following instructions.

6.2.1 Selection of winding insulation for ABB converters
In the case of ABB e.g. AC_8__-series and AC_5__-series single drives with a diode supply unit (uncontrolled DC voltage), the selection of winding insulation and filters can be made according to table 6.1.

6.2.2 Selection of winding insulation with all other converters
The voltage stresses must be limited below accepted limits. Please contact the system supplier to ensure the safety of the application. The influence of possible filters must be taken into account while dimensioning the motor.

6.3 Thermal protection

Most of the motors covered by this manual are equipped with PTC thermistors or other type of RTD’s in the stator windings. It is recommended to connect those to the frequency converter. Read more in chapter 4.9.2.
6.4 Bearing currents

Insulated bearings or bearing constructions, common mode filters and suitable cabling and grounding methods must be used according to the following instructions and using table 6.1.

Table 6.1 Selection of winding insulation for ABB converters

<table>
<thead>
<tr>
<th>$U_n$</th>
<th>$P_n$ &lt; 100 kW</th>
<th>$P_n$ ≥ 100 kW or IEC315 ≤ Frame size ≤ IEC355</th>
<th>$P_n$ ≥ 350 kW or IEC400 ≤ Frame size ≤ IEC450</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 500 V</td>
<td>Standard motor</td>
<td>Standard motor + Insulated N-bearing</td>
<td>Standard motor + Insulated N-bearing + Common mode filter</td>
</tr>
<tr>
<td>500V &gt; $U_n$ ≤ 600V (cable length &gt; 150 m)</td>
<td>Standard motor + Insulated N-bearing</td>
<td>Standard motor + Insulated N-bearing + dU/dt –filter (reactor) OR Common mode filter OR Reinforced insulation + Insulated N-bearing + Common mode filter</td>
<td></td>
</tr>
<tr>
<td>600V &gt; $U_n$ ≤ 690V (cable length &gt; 150 m)</td>
<td>Reinforced insulation</td>
<td>Reinforced insulation + Insulated N-bearing</td>
<td>Reinforced insulation + Insulated N-bearing + dU/dt –filter (reactor) OR Common mode filter</td>
</tr>
</tbody>
</table>

6.4.1 Elimination of bearing currents with ABB converters

In case of ABB frequency converter e.g. AC_8_ _- and AC_5_ _-series with a diode supply unit, the methods according to table 6.1 must be used to avoid harmful bearing currents in motors.

Insulated bearings which have aluminum oxide coated inner and/or outer bores or ceramic rolling elements are recommended. Aluminum oxide coatings shall also be treated with a sealant to prevent dirt and humidity penetrating into the porous coating. For the exact type of bearing insulation, see the motor’s rating plate. Changing the bearing type or insulation method without ABB’s permission is prohibited.

6.4.2 Elimination of bearing currents with all other converters

The user is responsible for protecting the motor and driven equipment from harmful bearing currents. Instructions described in chapter 6.4.1 can be used as guideline, but their effectiveness cannot be guaranteed in all cases.
6.5 Cabling, grounding and EMC

To provide proper grounding and to ensure compliance with any applicable EMC requirements, motors above 30 kW shall be cabled by shielded symmetrical cables and EMC glands, i.e. cable glands providing 360° bonding.

Symmetrical and shielded cables are highly recommended also for smaller motors. Make the 360° grounding arrangement at all the cable entries as described in the instructions for the glands. Twist the cable shields into bundles and connect to the nearest ground terminal/bus bar inside the terminal box, converter cabinet, etc.

For motors of frame size IEC 280 and above, additional potential equalization between the motor frame and the driven equipment is needed, unless both are mounted on a common steel base. In this case, the high frequency conductivity of the connection provided by the steel base should be checked by, for example, measuring the potential difference between the components.

More information about grounding and cabling of variable speed drives can be found in the manual “Grounding and cabling of the drive system” (Code: 3AFY 61201998).

6.6 Operating speed

For speeds higher than the nominal speed stated on the motor’s rating plate or in the respective product catalog, ensure that either the highest permissible rotational speed of the motor or the critical speed of the whole application is not exceeded.

6.7 Motors in variable speed applications

6.7.1 General

With ABB’s frequency converters, the motors can be dimensioned by using ABB’s DriveSize dimensioning program. The tool is downloadable from the ABB website (www.abb.com/motors&generators).

For application supplied by other converters, the motors must be dimensioned manually. For more information, please contact ABB.

The loadability curves (or load capacity curves) are based on nominal supply voltage. Operation in under or over voltage conditions may influence on the performance of the application.

6.7.2 Motor loadability with AC_8_ _ – Series of converters with DTC control

The loadability curves presented in Figures 5a – 5d are valid for ABB AC_8_ _-series converters with uncontrolled DC-voltage and DTC-control. The figures show the approximate maximum continuous output torque of the motors as a function of supply frequency. The output torque is given as a percentage of the nominal torque of the motor. The values are indicative and exact values are available on request.
6.7.3 Motor loadability with AC_5_ _ – series of converter
The loadability curves presented in Figures 6a – 6d are valid for AC_5_ _ -series converters. The figures show the approximate maximum continuous output torque of the motors as a function of supply frequency. The output torque is given as a percentage of the nominal torque of the motor. The values are indicative and exact values are available on request.

6.7.4 Motor loadability with other voltage source PWM-type converters
For other converters, with uncontrolled DC voltage and minimum switching frequency of 3 kHz (200...500 V), the dimensioning instructions as mentioned in chapter 6.7.3 can be used as guidelines. However, it shall be noted that the actual thermal loadability can also be lower. Please contact the manufacturer of the converter or the system supplier.

6.7.5 Short time overloads
ABB motors can usually be temporarily overloaded as well as used in intermittent duties. The most convenient method to dimension such applications is to use the DriveSize tool.

6.8 Rating plates
The usage of ABB’s motors in variable speed applications do not usually require additional rating plates. The parameters required for commissioning the converter can be found from the main rating plate. In some special applications, however, the motors can be equipped with additional rating plates for variable speed applications.

6.9 Commissioning the variable speed application
The commissioning of the variable speed application must be done according to the instructions of the frequency converter and local laws and regulations. The requirements and limitations set by the application must also be taken into account.

All parameters needed for setting the converter must be taken from the motor rating plates.

The most often needed parameters are:
- nominal voltage
- nominal current
- nominal frequency
- nominal speed
- nominal power

Those include the following information:
- speed range
- power range
- voltage and current range
- type of torque (constant or quadratic)
- and converter type and required minimum switching frequency.

In case of missing or inaccurate information, do not operate the motor before ensuring correct settings!

ABB recommends using all the suitable protective features provided by the converter to improve the safety of the application. Converters usually provide features such as (names and availability of features depend on manufacturer and model of the converter):
- minimum speed
- maximum speed
- acceleration and deceleration times
- maximum current
- maximum torque
- stall protection
7 Maintenance

1. Inspect the motor at regular intervals, at least once a year. The frequency of checks depends on, for example, the humidity level of the ambient air and on the local weather conditions. This can initially be determined experimentally and must then be strictly adhered to.

2. Keep the motor clean and ensure free ventilation airflow. If the motor is used in a dusty environment, the ventilation system must be regularly checked and cleaned.

3. Check the condition of shaft seals (e.g. V-ring or radial seal) and replace if necessary.

4. Check the condition of connections and mounting and assembly bolts.

5. Check the bearing condition by listening for any unusual noise, vibration measurement, bearing temperature, inspection of spent grease or SPM bearing monitoring. Pay special attention to bearings when their calculated rated life time is coming to an end.

When signs of wear are noticed, dismantle the motor, check the parts and replace if necessary. When bearings are changed, replacement bearings must be of the same type as those originally fitted. The shaft seals have to be replaced with seals of the same quality and characteristics as the originals when changing bearings.

In the case of the IP 55 motor and when the motor has been delivered with a plug closed, it is advisable to periodically open the drain plugs in order to ensure that the way out for condensation is not blocked and allows condensation to escape from the motor. This operation must be done when the motor is at a standstill and has been made safe to work on.

7.1 General inspection

7.1.1 Standby motors
If the motor is in standby for a longer period of time on a ship or in other vibrating environment the following measures have to be taken:

1. The shaft must be rotated regularly every 2 weeks (to be reported) by means of starting up of the system. In case a start-up is not possible, for any reason, at least the shaft has to be turned by hand in order to achieve a different position once a week. Vibrations caused by other vessel's equipment will cause bearing pitting which should be minimized by regular operation/hand turning.

2. The bearing must be greased while rotating the shaft every year (to be reported). If the motor has been provided with roller bearing at the driven end, the transport lock must be removed before rotating the shaft. The transport locking must be remounted in case of transportation.

3. All vibrations must be avoided to prevent a bearing from failing. All instructions in the motor instruction manual for commissioning and maintenance have to be followed. The warranty will not cover the winding and bearing damages if these instructions have not been followed.

WARNING
Voltage may be connected at standstill inside the terminal box for heating elements or direct winding heating.
7.2 Lubrication

Bearing types are specified in the respective product catalogs and on the rating plate of all motors, except smaller frame sizes.

Reliability is a vital issue for bearing lubrication intervals. ABB uses mainly the L1-principle (i.e. that 99% of the motors are certain to make the life time) for lubrication.

7.2.1 Motors with permanently greased bearings

Bearings are usually permanently greased bearings of 1Z, 2Z, 2RS or equivalent.

As a guide, adequate lubrication for sizes up to 250 can be achieved for the following duration, according to L1. For duties with higher ambient temperatures, please contact ABB. The informative formula to change the L1 values roughly to L10 values: L10 = 2.0 x L1.

Duty hours for permanently greased bearings at ambient temperatures of 25 °C and 40 °C are:

<table>
<thead>
<tr>
<th>Frame size</th>
<th>Poles</th>
<th>Duty hours at 25 °C</th>
<th>Duty hours at 40 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>2</td>
<td>52 000</td>
<td>33 000</td>
</tr>
<tr>
<td>56</td>
<td>4-8</td>
<td>65 000</td>
<td>41 000</td>
</tr>
<tr>
<td>63</td>
<td>2</td>
<td>49 000</td>
<td>31 000</td>
</tr>
<tr>
<td>63</td>
<td>4-8</td>
<td>63 000</td>
<td>40 000</td>
</tr>
<tr>
<td>71</td>
<td>2</td>
<td>67 000</td>
<td>42 000</td>
</tr>
<tr>
<td>71</td>
<td>4-8</td>
<td>100 000</td>
<td>56 000</td>
</tr>
<tr>
<td>80–90</td>
<td>2</td>
<td>100 000</td>
<td>65 000</td>
</tr>
<tr>
<td>80–90</td>
<td>4-8</td>
<td>100 000</td>
<td>96 000</td>
</tr>
<tr>
<td>100–112</td>
<td>2</td>
<td>89 000</td>
<td>56 000</td>
</tr>
<tr>
<td>100–112</td>
<td>4-8</td>
<td>100 000</td>
<td>89 000</td>
</tr>
<tr>
<td>132</td>
<td>2</td>
<td>67 000</td>
<td>42 000</td>
</tr>
<tr>
<td>132</td>
<td>4-8</td>
<td>100 000</td>
<td>77 000</td>
</tr>
<tr>
<td>160</td>
<td>2</td>
<td>60 000</td>
<td>38 000</td>
</tr>
<tr>
<td>160</td>
<td>4-8</td>
<td>100 000</td>
<td>74 000</td>
</tr>
<tr>
<td>180</td>
<td>2</td>
<td>55 000</td>
<td>34 000</td>
</tr>
<tr>
<td>180</td>
<td>4-8</td>
<td>100 000</td>
<td>70 000</td>
</tr>
<tr>
<td>200</td>
<td>2</td>
<td>41 000</td>
<td>25 000</td>
</tr>
<tr>
<td>200</td>
<td>4-8</td>
<td>95 000</td>
<td>60 000</td>
</tr>
<tr>
<td>225</td>
<td>2</td>
<td>36 000</td>
<td>23 000</td>
</tr>
<tr>
<td>225</td>
<td>4-8</td>
<td>88 000</td>
<td>56 000</td>
</tr>
<tr>
<td>250</td>
<td>2</td>
<td>31 000</td>
<td>20 000</td>
</tr>
<tr>
<td>250</td>
<td>4-8</td>
<td>80 000</td>
<td>50 000</td>
</tr>
</tbody>
</table>

Data is valid up to 60 Hz.

7.2.2 Motors with regreasable bearings

Lubrication information plate and general lubrication advice.

If the motor is equipped with a lubrication information plate, follow the given values.

Greasing intervals regarding mounting, ambient temperature and rotational speed are defined on the lubrication information plate.

During the first start or after a bearing lubrication a temporary temperature rise may appear, approximately 10 to 20 hours.

Some motors may be equipped with a collector for old grease. Follow the special instructions given for the equipment.

A. Manual lubrication

Regreasing while the motor is running
- Remove grease outlet plug or open closing valve if fitted.
- Be sure that the lubrication channel is open.
- Inject the specified amount of grease into the bearing.
- Let the motor run for 1-2 hours to ensure that all excess grease is forced out of the bearing. Close the grease outlet plug or closing valve, if fitted.

Regreasing while the motor is at a standstill
- In this case, use only half the amount of grease and then run the motor for a few minutes at full speed.
- When the motor has stopped, apply the rest of the specified amount of grease to the bearing.
- After 1–2 running hours, close the grease outlet plug or closing valve, if fitted.

B. Automatic lubrication

The grease outlet plug must be removed permanently with automatic lubrication or open closing valve, if fitted.

ABB recommends only the use of electromechanical systems.

The amount of grease per lubrication interval stated in the table should be multiplied by three if a central lubrication system is used. When using a smaller automatic re-grease unit (one or two cartridges per motor) the normal amount of grease can be used.
When 2-pole motors are automatically re-greased, the note concerning lubricant recommendations for 2-pole motors in the Lubricants chapter should be followed.

The used grease should be suitable for automatic lubrication. The automatic lubrication system delivers and the grease manufacturer’s recommendations should check.

**Calculation example of amount of grease for automatic lubrication system**

Central lubrication system: Motor IEC M3_P 315-4-pole in 50 Hz network, re-lubrication interval according to Table is 7600 h/55 g (DE) and 7600 h/40 g (NDE):

(DE) \( RLI = \frac{55}{7600 \times 3 \times 24} = 0,52 \text{ g/day} \)

(NDE) \( RLI = \frac{40}{7600 \times 3 \times 24} = 0,38 \text{ g/day} \)

**Calculation example of amount of grease for single automation lubrication unit (cartridge)**

(DE) \( RLI = \frac{55}{7600 \times 24} = 0,17 \text{ g/day} \)

(NDE) \( RLI = \frac{40}{7600 \times 24} = 0,13 \text{ g/day} \)

RLI = Re-lubrication interval, DE = Drive end, NDE = Non drive end

---

### 7.2.3  **Lubrication intervals and amounts**

Lubrication intervals for vertical motors are half of the values shown in the table below.

As a guide, adequate lubrication can be achieved for the following duration, according to \( L_1 \). For duties with higher ambient temperatures please contact ABB. The informative formula to change the \( L_1 \) values roughly to \( L_{10} \) values is \( L_{10} = 2.0 \times L_1 \), with manual lubrication. The lubrication intervals are based on a bearing operating temperature of 80 °C (ambient temperature +25 °C).

---

| Table 7.2 | Amount of grease g/bearing | kW | 3600 r/min | 3000 r/min | kW | 1800 r/min | 1500 r/min | kW | 1000 r/min | kW | 500-900 r/min |
|框架尺寸 | | | | | | | | | | | |
| Frame size | | | | | | | | | | | |
| 112 | 10 | all | 10 000 | 13 000 | all | 18 000 | 21 000 | all | 25 000 | all | 28 000 |
| 132 | 15 | all | 9 000 | 11 000 | all | 17 000 | 19 000 | all | 23 000 | all | 26 500 |
| 160 | 25 | ≤ 18.5 | 9 000 | 12 000 | ≤ 15 | 18 000 | 21 500 | ≤ 11 | 24 000 | all | 24 000 |
| 160 | 25 | > 18.5 | 7 500 | 10 000 | > 15 | 15 000 | 18 000 | > 11 | 22 500 | all | 24 000 |
| 180 | 30 | ≤ 22 | 7 000 | 9 000 | ≤ 22 | 15 500 | 18 500 | ≤ 15 | 24 000 | all | 24 000 |
| 180 | 30 | > 22 | 6 000 | 8 500 | > 22 | 14 000 | 17 000 | > 15 | 21 000 | all | 24 000 |
| 200 | 40 | ≤ 37 | 5 500 | 8 000 | ≤ 30 | 14 500 | 17 500 | ≤ 22 | 23 000 | all | 24 000 |
| 200 | 40 | > 37 | 3 000 | 5 500 | > 30 | 10 000 | 12 000 | > 22 | 16 000 | all | 20 000 |
| 225 | 50 | ≤ 45 | 4 000 | 6 500 | ≤ 45 | 13 000 | 16 500 | ≤ 30 | 22 000 | all | 24 000 |
| 225 | 50 | > 45 | 1 500 | 2 500 | > 45 | 5 000 | 6 000 | > 30 | 8 000 | all | 10 000 |
| 250 | 60 | ≤ 55 | 2 500 | 4 000 | ≤ 55 | 9 000 | 11 500 | ≤ 37 | 15 000 | all | 18 000 |
| 250 | 60 | > 55 | 1 000 | 1 500 | > 55 | 3 500 | 4 500 | > 37 | 6 000 | all | 7 000 |
| 280H | 60 | all | 2 000 | 3 500 | all | 8 000 | 10 500 | all | 14 000 | all | 17 000 |
| 280H | 60 | all | 2 000 | 3 500 | all | 8 000 | 10 500 | all | 14 000 | all | 17 000 |
| 280 | 35 | all | 1 900 | 3 200 | all | 7 800 | 9 600 | all | 13 900 | all | 15 000 |
| 315 | 35 | all | 1 900 | 3 200 | all | 7 800 | 9 600 | all | 13 900 | all | 15 000 |
| 315 | 35 | all | 1 900 | 3 200 | all | 7 800 | 9 600 | all | 13 900 | all | 15 000 |
| 355 | 35 | all | 1 900 | 3 200 | all | 7 800 | 9 600 | all | 13 900 | all | 15 000 |
| 355 | 70 | all | 1 500 | 2 700 | all | 4 400 | 5 600 | all | 7 600 | all | 10 700 |
| 400 | 40 | all | 1 500 | 2 700 | all | 4 400 | 5 600 | all | 7 600 | all | 10 700 |
| 400 | 40 | all | 1 500 | 2 700 | all | 4 400 | 5 600 | all | 7 600 | all | 10 700 |
| 450 | 95 | all | 1 500 | 2 700 | all | 4 400 | 5 600 | all | 7 600 | all | 10 700 |
| 500 | 40 | all | 3 000 | 5 300 | all | 1 500 | 2 700 | all | 4 400 | all | 7 600 |
| 500 | 40 | all | 3 000 | 5 300 | all | 1 500 | 2 700 | all | 4 400 | all | 7 600 |
| 500 | 85 | all | 3 000 | 5 300 | all | 1 500 | 2 700 | all | 4 400 | all | 7 600 |
| 500 | 85 | all | 3 000 | 5 300 | all | 1 500 | 2 700 | all | 4 400 | all | 7 600 |

**Ball bearings, lubrication intervals in duty hours**

An increase in the ambient temperature raises the temperature of the bearings correspondingly. The interval values should be halved for a 15 °C increase in bearing temperature and may be doubled for a 15 °C decrease in bearing temperature.

Higher speed operation, e.g. in frequency converter applications, or lower speed with heavy load will require shorter lubrication intervals.

**WARNING**

The maximum operating temperature of the grease and bearings, +110 °C, must not be exceeded. The designed maximum speed of the motor must not be exceeded.
7.2.4 Lubricants

Do not mix different types of grease. Incompatible lubricants may cause bearing damage.

WARNING

When re-greasing, use only special ball bearing grease with the following properties:

- good quality grease with lithium complex soap and with mineral- or PAO-oil
- base oil viscosity 100-160 cST at 40 °C
- consistency NLGI grade 1.5 - 3 *)
- temperature range –30 °C to +120 °C, continuously

*) A stiffer end of scale is recommended for vertical mounted motors or in hot conditions.

The above mentioned grease specification is valid if the ambient temperature is above –30 °C or below +55 °C, and the bearing temperature is below 110 °C, otherwise, consult ABB regarding suitable grease.

Grease with the correct properties is available from all major lubricant manufacturers.

Admixtures are recommended, but a written guarantee must be obtained from the lubricant manufacturer, especially concerning EP admixtures, that admixtures do not damage bearings or the properties of lubricants at the operating temperature range.

In general, lubricants containing EP admixtures are not recommended. In some cases it can cause harm in the bearing, therefore its use has to be evaluated case by case together with lubricant suppliers.

The following high performance greases can be used:

- **Mobil** Unirex N2 or N3 (lithium complex base)
- **Mobil** Mobilith SHC 100 (lithium complex base)
- **Shell** Gadus S5 V 100 2 (lithium complex base)
- **Klüber** Klüberplex BEM 41-132 (special lithium base)
- **FAG** Arcanol TEMP110 (lithium complex base)
- **Lubcon** Turmogrease L 802 EP PLUS (special lithium base)
- **Total** Multis Complex S2 A (lithium complex base)

Always use high speed grease for high speed 2-pole motors where the speed factor is higher than 480,000 (calculated as Dm x n where Dm = average bearing diameter, mm; n = rotational speed, r/min).

The following greases can be used for high speed cast iron motors but not mixed with lithium complex greases:

- **Klüber** Klüber Quiet BQH 72-102 (polyurea base)
- **Lubcon** Turmogrease P703 (polyurea base)

If other lubricants are used, check with the manufacturer that the qualities correspond to those of the above mentioned lubricants. The lubrication intervals are based on the listed high performance greases above. Using other greases can reduce the interval.

<table>
<thead>
<tr>
<th>Frame size</th>
<th>Amount of grease g/bearing</th>
<th>3600 kW</th>
<th>3000 kW</th>
<th>1800 kW</th>
<th>1500 kW</th>
<th>1000 kW</th>
<th>500-900 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>160</td>
<td>25</td>
<td>± 18.5</td>
<td>4 500</td>
<td>6 000</td>
<td>± 15</td>
<td>9 000</td>
<td>10 500</td>
</tr>
<tr>
<td>160</td>
<td>25</td>
<td>&gt; 18.5</td>
<td>3 500</td>
<td>5 000</td>
<td>&gt; 15</td>
<td>7 500</td>
<td>9 000</td>
</tr>
<tr>
<td>180</td>
<td>30</td>
<td>± 22</td>
<td>3 500</td>
<td>4 500</td>
<td>± 22</td>
<td>7 500</td>
<td>9 000</td>
</tr>
<tr>
<td>180</td>
<td>30</td>
<td>&gt; 22</td>
<td>3 000</td>
<td>4 000</td>
<td>&gt; 22</td>
<td>7 000</td>
<td>8 500</td>
</tr>
<tr>
<td>200</td>
<td>40</td>
<td>± 37</td>
<td>2 750</td>
<td>4 000</td>
<td>± 30</td>
<td>7 000</td>
<td>8 500</td>
</tr>
<tr>
<td>200</td>
<td>40</td>
<td>&gt; 37</td>
<td>1 500</td>
<td>2 500</td>
<td>&gt; 30</td>
<td>5 000</td>
<td>6 000</td>
</tr>
<tr>
<td>225</td>
<td>50</td>
<td>± 45</td>
<td>2 000</td>
<td>3 000</td>
<td>≥ 45</td>
<td>6 500</td>
<td>8 000</td>
</tr>
<tr>
<td>225</td>
<td>50</td>
<td>&gt; 45</td>
<td>750</td>
<td>1 250</td>
<td>&gt; 45</td>
<td>2 500</td>
<td>3 000</td>
</tr>
<tr>
<td>250</td>
<td>60</td>
<td>≤ 55</td>
<td>1 000</td>
<td>2 000</td>
<td>≤ 55</td>
<td>4 500</td>
<td>5 500</td>
</tr>
<tr>
<td>250</td>
<td>60</td>
<td>&gt; 55</td>
<td>500</td>
<td>750</td>
<td>&gt; 55</td>
<td>1 500</td>
<td>2 000</td>
</tr>
</tbody>
</table>

In all cases 4 000 5 250 all 7 000 all 8 500

280

70 – – – all 4 000 5 250 all 7 000 all 8 500

280

40 – – – all 4 000 5 300 all 7 000 all 8 500

315

55 – – – all 2 900 3 800 all 5 900 all 6 500

355

70 – – – all 2 000 2 800 all 4 800 all 5 400

440

85 – – – all 1 600 2 400 all 4 300 all 4 800

450

95 – – – all 1 300 2 000 all 3 800 all 4 400

5008

40 – – – all 1 300 2 000 all 3 800 all 4 400

5008

85 – – – all 3 200 4 700 all 8 600 all 9 700

5010

40 – – – all 1 200 – – – – –

5010

85 – – – all 2 500 3 600 all 6 600 all 7 400

5012

85 – – – all 1 300 1 900 all 3 500 all 4 000

* M3AA
8 After Sales Support

8.1 Spare parts

Unless otherwise stated, spare parts must be original parts or approved by ABB.

When ordering spare parts, the motor serial number, full type designation and product code, as stated on the rating plate, must be specified.

8.2 Dismantling, re-assembly and rewinding

Rewinding should always be carried out by qualified repair shops.

Smoke venting and other special motors should not be rewound without first contacting ABB.

8.3 Bearings

Special care should be taken with the bearings.

These must be removed using pullers and fitted by heating or using special tools.

Bearing replacement is described in detail in a separate instruction leaflet available from the ABB Sales Office.

Any directions placed on the motor, such as labels, must be followed. The bearing types indicated on the rating plate must not be changed.
Most of ABB’s motors have a sound pressure level not exceeding 82 dB (A) (± 3 dB) at 50 Hz. Values for specific motors can be found in the relevant product catalogs. At 60 Hz sinusoidal supply, the values are approximately 4 dB(A) higher compared to 50 Hz values stated in the product catalogs.

For sound pressure levels at frequency converter supplies, please contact ABB. When motor(s) need to be scrapped or recycled, appropriate means, local regulations and laws must be followed.
These instructions do not cover all details or variations in equipment nor provide information for every possible condition to be met in connection with installation, operation or maintenance. Should additional information be required, please contact the nearest ABB Sales Office.

**10 Troubleshooting**

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

---

### Table 10.1: Troubleshooting

<table>
<thead>
<tr>
<th>TROUBLE</th>
<th>CAUSE</th>
<th>WHAT TO DO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Motor fails to start</strong></td>
<td>Blown fuses</td>
<td>Replace fuses with proper type and rating.</td>
</tr>
<tr>
<td></td>
<td>Improper trips</td>
<td>Check and reset overload in starter.</td>
</tr>
<tr>
<td></td>
<td>Improper power supply</td>
<td>Check to see that power supplied agrees with motor rating plate and load factor.</td>
</tr>
<tr>
<td></td>
<td>Improper line connections</td>
<td>Check connections against diagram supplied with motor.</td>
</tr>
<tr>
<td></td>
<td>Open circuit in winding or control switch</td>
<td>Indicated by humming sound when switch is closed. Check for loose wiring connections and ensure that all control contacts are closing.</td>
</tr>
<tr>
<td></td>
<td>Mechanical failure</td>
<td>Check to see if motor and drive turn freely. Check bearings and lubrication.</td>
</tr>
<tr>
<td></td>
<td>Short circuited stator</td>
<td>Contact ABB or ensure that the supply is disconnected and grounding for work done, disconnect the cables and measure the insulation resistance.</td>
</tr>
<tr>
<td></td>
<td>Poor stator coil connection</td>
<td>Indicated by blown fuses. Motor must be rewound. Remove end shields and locate fault.</td>
</tr>
<tr>
<td><strong>Motor stalls</strong></td>
<td>Motor may be overloaded</td>
<td>Reduce load.</td>
</tr>
<tr>
<td></td>
<td>One phase may be open</td>
<td>Check lines for open phase.</td>
</tr>
<tr>
<td></td>
<td>Wrong application</td>
<td>Change type or size. Consult equipment supplier.</td>
</tr>
<tr>
<td></td>
<td>Overload</td>
<td>Reduce load.</td>
</tr>
<tr>
<td></td>
<td>Low voltage</td>
<td>Ensure the rating plate voltage is maintained. Check connection.</td>
</tr>
<tr>
<td></td>
<td>Open circuit</td>
<td>Fuses blown. Check overload relay, stator and push buttons.</td>
</tr>
<tr>
<td><strong>Motor runs and then dies down</strong></td>
<td>Power failure</td>
<td>Check for loose connections to line, fuses and control.</td>
</tr>
<tr>
<td><strong>Motor does not accelerate up to nominal speed</strong></td>
<td>Not applied properly</td>
<td>Consult equipment supplier for proper type.</td>
</tr>
<tr>
<td></td>
<td>Voltage too low at motor terminals because of line drop</td>
<td>Use higher voltage or transformer terminals or reduce load. Check connections. Check conductors for proper size.</td>
</tr>
<tr>
<td></td>
<td>Starting load too high</td>
<td>Check the motor’s starts against “no load”.</td>
</tr>
<tr>
<td></td>
<td>Broken rotor bars or loose rotor</td>
<td>Look for cracks near the rings. A new rotor may be required, as repairs are usually temporary.</td>
</tr>
<tr>
<td></td>
<td>Open primary circuit</td>
<td>Locate fault with testing device and repair.</td>
</tr>
<tr>
<td>TROUBLE</td>
<td>CAUSE</td>
<td>WHAT TO DO</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Motor takes too long to accelerate and/or draws high current</td>
<td>Excessive load</td>
<td>Reduce load.</td>
</tr>
<tr>
<td></td>
<td>Low voltage during start</td>
<td>Check for high resistance. Make sure that an adequate cable size is used.</td>
</tr>
<tr>
<td></td>
<td>Defective squirrel cage rotor</td>
<td>Replace with new rotor.</td>
</tr>
<tr>
<td></td>
<td>Applied voltage too low</td>
<td>Correct power supply.</td>
</tr>
<tr>
<td>Wrong rotation direction</td>
<td>Wrong sequence of phases</td>
<td>Reverse connections at motor or at switchboard.</td>
</tr>
<tr>
<td>Motor overheats while running</td>
<td>Overload</td>
<td>Reduce load.</td>
</tr>
<tr>
<td></td>
<td>Frame or ventilation openings may be full of dirt and prevent proper ventilation of motor</td>
<td>Open vent holes and check for a continuous stream of air from the motor.</td>
</tr>
<tr>
<td></td>
<td>Motor may have one phase open</td>
<td>Check to make sure that all leads and cables are well connected.</td>
</tr>
<tr>
<td></td>
<td>Grounded coil</td>
<td>Motor must be rewound.</td>
</tr>
<tr>
<td></td>
<td>Unbalanced terminal voltage</td>
<td>Check for faulty leads, connections and transformers.</td>
</tr>
<tr>
<td>Motor vibrates</td>
<td>Motor misaligned</td>
<td>Realign.</td>
</tr>
<tr>
<td></td>
<td>Weak support</td>
<td>Strengthen base.</td>
</tr>
<tr>
<td></td>
<td>Coupling out of balance</td>
<td>Balance coupling.</td>
</tr>
<tr>
<td></td>
<td>Driven equipment unbalanced</td>
<td>Rebalance driven equipment.</td>
</tr>
<tr>
<td></td>
<td>Defective bearings</td>
<td>Replace bearings.</td>
</tr>
<tr>
<td></td>
<td>Bearings not in line</td>
<td>Repair motor.</td>
</tr>
<tr>
<td></td>
<td>Balancing weights shifted</td>
<td>Rebalance rotor.</td>
</tr>
<tr>
<td></td>
<td>Contradiction between balancing of rotor and coupling (half key - full key)</td>
<td>Rebalance coupling or rotor.</td>
</tr>
<tr>
<td></td>
<td>Poly phase motor running single phase</td>
<td>Check for open circuit.</td>
</tr>
<tr>
<td></td>
<td>Excessive end play</td>
<td>Adjust bearing or add shim.</td>
</tr>
<tr>
<td>Scraping noise</td>
<td>Fan rubbing end shield or fan cover</td>
<td>Correct fan mounting.</td>
</tr>
<tr>
<td></td>
<td>Loose on bedplate</td>
<td>Tighten holding bolts.</td>
</tr>
<tr>
<td>Noisy operation</td>
<td>Air gap not uniform</td>
<td>Check and correct end shield fits or bearing fits.</td>
</tr>
<tr>
<td></td>
<td>Rotor unbalance</td>
<td>Rebalance rotor.</td>
</tr>
<tr>
<td>Hot bearings</td>
<td>Bent or sprung shaft</td>
<td>Straighten or replace shaft.</td>
</tr>
<tr>
<td></td>
<td>Excessive belt pull</td>
<td>Decrease belt tension.</td>
</tr>
<tr>
<td></td>
<td>Pulleys too far away from shaft shoulder</td>
<td>Move pulley closer to motor bearing.</td>
</tr>
<tr>
<td></td>
<td>Pulley diameter too small</td>
<td>Use larger pulleys.</td>
</tr>
<tr>
<td></td>
<td>Misalignment</td>
<td>Correct by realignment of the drive.</td>
</tr>
<tr>
<td></td>
<td>Insufficient grease</td>
<td>Maintain proper quality and amount of grease in bearing.</td>
</tr>
<tr>
<td></td>
<td>Deterioration of grease or lubricant contaminated</td>
<td>Remove old grease, wash bearings thoroughly in kerosene and replace with new grease.</td>
</tr>
<tr>
<td></td>
<td>Excess lubricant</td>
<td>Reduce quantity of grease, bearing should not be more than half full.</td>
</tr>
<tr>
<td></td>
<td>Overloaded bearing</td>
<td>Check alignment, side and end thrust.</td>
</tr>
<tr>
<td></td>
<td>Broken ball or rough races</td>
<td>Replace bearing, clean housing thoroughly first.</td>
</tr>
</tbody>
</table>
1.0
0.5
0.1
0.05

Figure 1. Diagram illustrating the insulation resistance dependence from the temperature and how to correct the measured insulation resistance to the temperature of 40 °C.

Figure 2. Mounting of half-coupling or pulley

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| X-axis: Winding temperature, Celsius Degrees |
| Y-axis: Insulation Resistance Temperatures, kTC |

Key

1) To correct observed insulation resistance, $R_i$, to 40 °C multiply it by the temperature coefficient $kTC$: $R_{40°C} = R_i \times kTC$. 

---

Figure 1.

---

Figure 2.
Figure 3. Connection of terminals for main supply.

Figure 4. Voltage and frequency deviation in zones A and B.

<table>
<thead>
<tr>
<th>Key</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>zone A</td>
</tr>
<tr>
<td>2</td>
<td>zone B (outside zone A)</td>
</tr>
<tr>
<td>3</td>
<td>rating point</td>
</tr>
</tbody>
</table>

X axis: frequency p.u.
Y axis: voltage p.u.
Guideline loadability curves with converters with DTC control

Figure 5a. Convetor with DTC control, 50 Hz, temperature rise B

Figure 5b. Convetor with DTC control, 60 Hz, temperature rise B

Figure 5c. Convetor with DTC control, 50 Hz, temperature rise F

Figure 5d. Convetor with DTC control, 60 Hz, temperature rise F

1 Self-ventilated, EEC frame sizes 56-132
2 Self-ventilated, EEC frame sizes 160-450
3 Separate motor cooling (force ventilated)
Guideline loadability curves with other voltage source PWM type

Figure 6a. Other voltage source PWM type converter, 50 Hz, temperature rise B
Figure 6b. Other voltage source PWM type converter, 60 Hz, temperature rise B
Figure 6c. Other voltage source PWM type converter, 50 Hz, temperature rise F
Figure 6d. Other voltage source PWM type converter, 60 Hz, temperature rise F