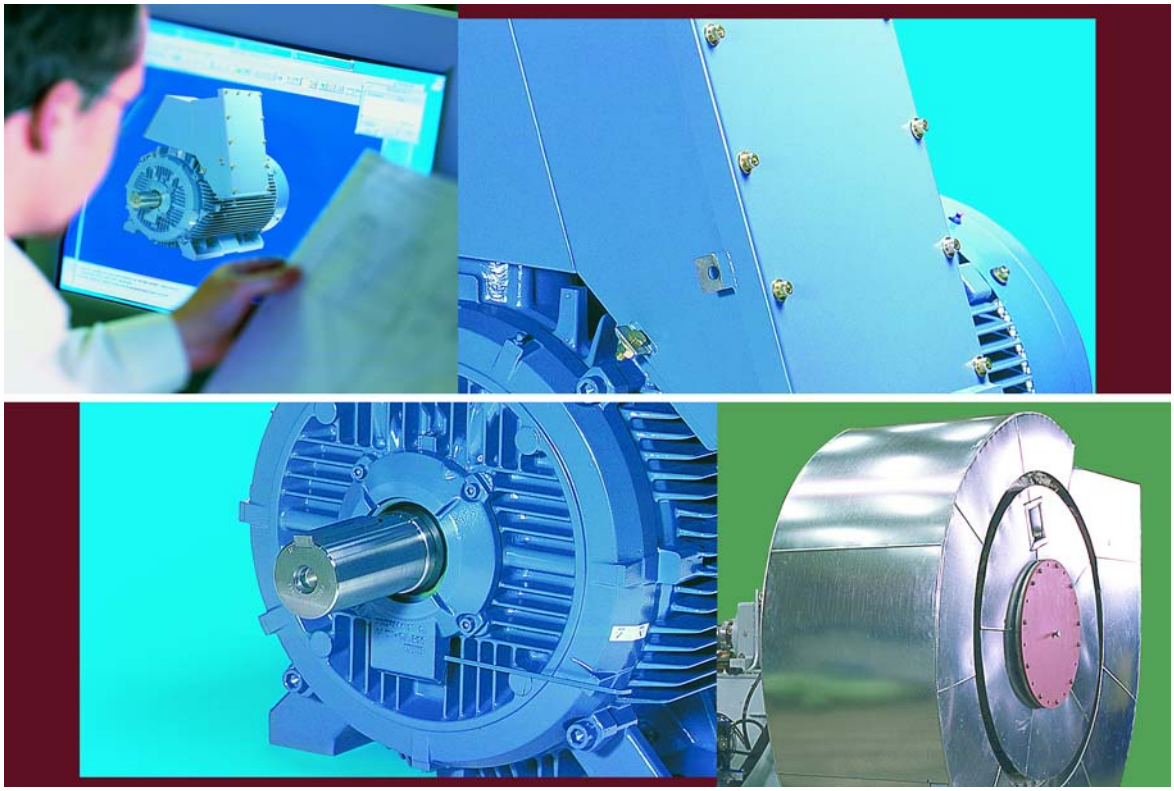
Manual for High Voltage Process Performance Motors



Safety Instructions
AMA, AMB, AMG, AMH, AMI, AMK, AMZ, HXR, M3BM, M3GM

1. General

General safety regulations, specific agreements made for each work site and safety precautions shown in this document must be observed at all times.

2. Intended use

Electric machines have dangerous live and rotating parts and may have hot surfaces. All operations serving transport, storage, installation, connection, commissioning, operation and maintenance shall be carried out by responsible skilled persons (in conformity with EN 50 110-1 / DIN VDE 0105 / IEC 60364). Improper handling may cause serious personal injury and damage to property. Danger!

These machines are intended for industrial and commercial installations as components as defined in the Machinery Directive (MD) 98/37/EC. Commissioning is prohibited until conformity of the end product with this directive has been established (follow particular local safety and installation rules as, for example, EN 60204).

These machines comply with the harmonized series of standards EN 60034 / DIN VDE 0530. Their use in explosive atmosphere is prohibited unless they are expressly designed for such use (follow additional instructions).

On no account, use degrees of protection ≤ IP23 outdoors. Air-cooled models are typically designed for ambient temperatures of -20°C up to +40°C and altitudes of ≤ 1000 m above sea level. Ambient temperature for air-/water-cooled models should be not less than +5°C (for sleeve-bearing machines, see manufacturer's documentation). By all means, take note of deviating information on the rating plate. Field conditions must conform to all rating plate markings.

3. Transport, storage

Immediately report damage established after delivery to transport company. Stop commissioning, if necessary. Lifting eyes are dimensioned for the weight of the machine, do not apply extra loads. Ensure the use of correct lifting eyes. If necessary, use suitable, adequately dimensioned means of transport (for example, rope guides). Remove shipping braces (for example, bearing locks, vibration dampers) before commissioning. Store them for further use.

When storing machines, make sure of dry, dust and vibration free location (danger of bearing damage at rest). Measure insulation resistance before commissioning. At values of ≤ 1 kΩ per volt of rated voltage, dry winding. Follow the manufacturer's instructions.

4. Installation

Make sure of even support, solid foot or flange mounting and exact alignment in case of direct coupling. Avoid resonances with rotational frequency and double mains frequency as a result of assembly. Turn rotor and listen for abnormal slip noises. Check direction of rotation in uncoupled state.

Follow the manufacturer's instructions when mounting or removing couplings or other drive elements and cover them with a touch guard. For trial run in uncoupled state, lock or remove the shaft end key. Avoid excessive radial and axial bearing loads (note manufacturer's documentation). The balance of the machine is indicated as H = Half and F = Full key. In half-key cases, the coupling too, must be half-key balanced. In case of protruding, visible part of the shaft end key, establish mechanical balance.

Make necessary ventilation and cooling system connections. The ventilation must not be obstructed and the exhaust air, also of neighbouring sets, not taken in directly.

5. Electrical connection

All operations must be carried out only by skilled persons on the machine at rest. Before starting work, the following safety rules must be strictly applied:

- De-energize!
- Provide safeguard against reclosing!
- Verify safe isolation from supply!
- Connect to earth and short!
- Cover or provide barriers against neighbouring live parts!
- De-energize auxiliary circuits (for example, anti-condensation heating)!

Exceeding of limit values of zone A in EN 60034-1 / DIN VDE 0530-1 - voltage ± 5%, frequency ± 2%, waveform and symmetry -leads to higher temperature rise and affects the electromagnetic compatibility. Note rating plate markings and connection diagram in the terminal box.

The connection must be made in a way that the permanent safe electrical connection is maintained. Use appropriate cable terminals. Establish and maintain safe equipotential bonding.

The clearances between uninsulated live parts and between such parts and earth must not be below the values of appropriate standards and values possibly given in manufacturer's documentation.

No presence of foreign bodies, dirt or moisture is allowed in the terminal box. Close unused cable entrance holes and the box itself in a dust- and watertight manner. Lock the key when the machine is run without coupling. For machines with accessories, check satisfactory functioning of these before commissioning.

The proper installation (for example, segregation of signal and power lines, screened cables etc.) lies within the installer's responsibility.

6. Operation

Vibration severity in the "satisfactory" range ($V_{rms} \leq 4.5$ mm/s) according to ISO 3945 is acceptable in coupled-mode operation. In case of deviations from normal operation - for example, elevated temperature, noises, vibrations - disconnect machine, if in doubt. Establish cause and consult manufacturer, if necessary.

Do not defeat protective devices, not even in trial run. In case of heavy dirt deposits, clean cooling system at regular intervals. Open blocked condensate drain holes from time to time.

Grease the bearings during commissioning before start-up. Regrease antifriction bearings while the machine is running. Follow instructions on lubrication plate. Use right kind of grease. In

case of sleeve-bearing machines, observe time-limit for oil-change and if equipped with oil supply system make sure the system is working.

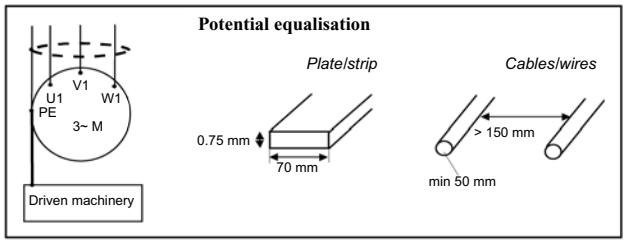
7. Maintenance and servicing

Follow the manufacturer's operating instructions. For further details, see the comprehensive User´s Manual. Preserve these safety instructions!

8. Frequency converter

In frequency converter applications motor frame external earthing must be used for equalising 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 over IEC 280, use 0.75 x 70 mm flat conductor or at least two 50 mm² round conductors. The distance of the round conductors must be at least 150 mm from each other.

This arrangement has no electrical safety function; the purpose is to equalise the potentials. When the motor and the gearbox are mounted on a common steel fundament, no potential equalisation is required.



To comply with EMC-requirements, use only cables and connectors approved for this purpose. (See instruction for frequency converters.)

Additional Safety Instructions for Permanent Magnet Synchronous Machines

Electrical connection and operation

When the machine shaft is rotating, a permanent magnet synchronous machine induces voltage to the terminals. The induced voltage is proportional to the rotational speed, and can be hazardous even at low speeds. Prevent any rotation of the shaft before opening the terminal box and/or working at the unprotected terminals.

WARNING: The terminals of a machine with frequency converter supply may be energized even when the machine is at a standstill.

WARNING: Beware of reverse-power when working at the supply system.

WARNING: Do not exceed the maximum allowed speed of the machine. See product specific manuals.

Maintenance and servicing

Permanent magnet synchronous machines must only be serviced by repair shops qualified and authorised by ABB. For more information concerning service of permanent magnet synchronous machines, please contact ABB.

WARNING: Only qualified personnel familiar with the relevant safety requirements are allowed to open and maintain permanent magnet synchronous machines.

WARNING: It is not allowed to remove the rotor of a permanent magnet synchronous machine without the special tools designed for this purpose.

WARNING: Magnetic stray fields, caused by an open or disassembled permanent magnet synchronous machine or by a separate rotor of such a machine, may disturb or damage other electrical or electromagnetic equipment and components, such as cardiac pacemakers, credit cards and equivalent.

WARNING: Loose metallic parts and waste must be prevented from entering the interior of the permanent magnet synchronous machine as well as getting into contact with the rotor.

WARNING: Before closing an opened permanent magnet synchronous machine, all parts which does not belong to the machine and wastes must be removed from the interior of the machine.

NOTE: Beware of magnetic stray fields and possible induced voltages when rotating the separate rotor of a permanent magnet synchronous machine as they may cause damage to surrounding equipment, for example lathes or balancing machines.

Additional Safety Instructions for Electrical Motors for Explosive Atmosphere

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

WARNING: Motors for explosive atmosphere are specially designed to comply with official regulations concerning the risk of explosion. If improperly used, badly connected, or altered, no matter how minor, their reliability could be in doubt.

Standards relating to the connection and use of electrical apparatus in explosive atmosphere must be taken into consideration, especially national standards for installation. (see standards: EN 60079-14, EN 60079-17, EN 61241-14, EN 61241-17 IEC 60079-14, IEC 60079-17, IEC 61241-14 and IEC 61241-17). All repairs and overhauls must be carried out according to the standard IEC 60079-19. Only trained personnel familiar with these standards should handle this type of apparatus.

Declaration of Conformity

All ABB Ex-machines intended for explosive atmosphere comply with the ATEX Directive 94/9/EC and have a CE-mark on the rating plate.

Validity

These instructions are valid for the following ABB Oy's electrical motor types, when the machine is used in explosive atmosphere.

Non-sparking Ex nA, Class I Div 2, Class I Zone 2

- AMA Induction Machines, sizes 315 to 500
- AMB Induction Machines, sizes 560 to 630
- AMI Induction Machines, sizes 560 to 630
- HXR Induction Machines, sizes 315 to 560
- AMZ Synchronous Machines, sizes 710 to 2500
- M3GM Induction Machines, sizes 315 to 450

Increased safety Ex e

- AMA Induction Machines, sizes 315 to 500
- AMB Induction Machines, sizes 560 to 630
- AMI Induction Machines, sizes 560 to 630
- HXR Induction Machines, sizes 315 to 560

Pressurisation Ex pxe, Ex pze, Ex px, Ex pz

- AMA Induction Machines, sizes 315 to 500
- AMB Induction Machines, sizes 560 to 630
- AMI Induction Machines, sizes 560 to 630
- HXR Induction Machines, sizes 315 to 560
- AMZ Synchronous Machines, sizes 710 to 2500

Dust Ignition Protection (DIP), Ex tD, Class II Div 2, Class II Zone 22, Class III

- AMA Induction Machines, sizes 315 to 500
- AMB Induction Machines, sizes 560 to 630
- AMI Induction Machines, sizes 560 to 630
- HXR Induction Machines, sizes 315 to 560
- M3GM Induction Machines, sizes 315 to 450

(Additional information may be required for some machine types used in special applications or with special design.)

Conformity according to standards

As well as conforming to the standards relating to mechanical and electrical characteristics, motors designed for explosive atmospheres must also conform to the following IEC or EN standards:

EN 60079-0; Std. concerning General Requirements for Explosive Atmospheres

EN 60079-2; Std. concerning Ex p protection

EN 60079-7; Std. concerning Ex e protection

EN 60079-15; Std. concerning Ex nA protection

EN 61241-1; Std. concerning combustible dust, Ex tD protection

IEC 60079-0; Std. concerning General Requirements for Explosive Atmospheres

IEC 60079-2; Std. concerning Ex p protection

IEC 60079-7; Std. concerning Ex e protection

IEC 60079-15; Std. concerning Ex nA protection

IEC 61241-0; Std. concerning General Requirements for combustible dust

IEC 61241-1; Std. concerning combustible dust, Ex tD protection

NFPA 70; National Electric Code (NEC)

C 22-1-98; Canadian Electrical Code, Part I (CE Code)

ABB machines (valid only for group II) can be installed in areas corresponding to following marking:

Zone (IEC)	Category (EN)	Marking
1	2	Ex px, Ex pxe, Ex e
2	3	Ex nA, Ex N, Ex pz, Ex pze

Atmosphere (EN);

G - explosive atmosphere caused by gases

D - explosive atmosphere caused by dust

Incoming inspection

- Immediately upon receipt check the machine for external damage and if found, inform the forwarding agent without delay.
- Check all rating plate data, especially voltage, winding connection (star or delta), category, type of protection and temperature marking.

Notice following rules during any operations!

WARNING: Disconnect and lock out before working on the machine or the driven equipment. Ensure no explosive atmosphere is present while the work is in progress.

Starting and Re-starting

- The maximum number of the sequential starts has been declared in machine's technical documents.
- The new starting sequence is allowed after the machine has cooled to the ambient temperature (-> cold starts) or to operating temperature (-> warm starts).

Earthing and Equipotentialing

- Check before starting that all earthing and equipotentialing cables are effectively connected.
- Do not remove any earthing or equipotentialing cables, which has been assembled by the manufacturer.

Clearances, creepage distances and separations

- Do not make any removal or adjustment in terminal boxes, which could decrease clearances or creepage distances between any parts.
- Do not install any new equipment to terminal boxes without asking for advises from ABB Oy.
- Be sure that air gap between rotor and stator is measured after any maintenance for the rotor or bearings. The air gap shall be the same in any point between stator and rotor.
- Centralize the fan to the center of the fanhood or the air guide after any maintenance. The clearance shall be at least 1% of the maximum diameter of the fan and in accordance with standards.

Connections in terminal boxes

- All connections in main terminal boxes must be made with Ex-approved connectors, which are delivered with the machine by the manufacturer. In other cases ask an advice from ABB Oy.
- All connections, in auxiliary terminal boxes, as marked intrinsically safe circuits (Ex i or EEx i) must be connected to proper safety barriers.

Space heaters

- If an anti-condensation heater, without self-regulation, is turned on immediately after the motor is shut down, take suitable measures to control the inside motor housing temperature. The anti-condensation heaters can only operate within a temperature-controlled environment.

Pre-start ventilation

- Ex nA and Ex e machines may, or in some cases, have to be equipped with a provision for pre-start ventilation.
- Before starting, check the need to purge the machine enclosure to make sure that the enclosure is free of flammable gases. Based on the risk assessment, the customer and/or the local authorities will make the decision, whether the customer needs to use the pre-start ventilation or not.

NOTE: If there are any conflicts between these safety instructions and the user manual, these safety instructions are prevailing.

Chapter 1 - Introduction

Chapter 2 - Transport and Unpacking

Chapter 3 - Installation and Alignment

Chapter 4 - Mechanical and Electrical Connections

Chapter 5 - Commissioning and Start-up

Chapter 6 - Operation

Chapter 7 - Maintenance

Chapter 8 - Trouble Shooting

Chapter 9 - After Sales Support and Spare Parts

Chapter 10 - Recycling

Chapter 1 Introduction

1.1 General information

This User's Manual contains information on the transport, storage, installation, commissioning, operating and maintenance of rotating electrical machines manufactured by ABB.

This manual provides information regarding all aspects of operation, maintenance and supervision of the machine. Careful study of the contents of this manual and other machine related documentation before any actions are taken is necessary to ensure proper functionality and a long lifetime of the machine.

NOTE: Some customer specific items may not be included in this User's Manual. Additional documentation will be found in the project documentation.

Actions described in this manual are only to be performed by trained personnel with previous experience in similar tasks, and authorized by the user.

ABB constantly strives to improve the quality of the information provided in this User's Manual, and will welcome any improvement suggestions. For contact information, see *Chapter 9.1.5 After Sales contact information*.

NOTE: These instructions must be followed to ensure safe and proper installation, operation and maintenance of the machine. They should be brought to the attention of anyone who installs, operates or maintains this equipment. Ignoring the instruction invalidates the warranty.

1.2 Important note

The information in this document may sometimes be of a general nature and applicable to various machines produced by ABB.

Where a conflict exists between the contents herein and the actual machinery supplied, the user must make an engineering judgment as to what to do. If any doubt exists, contact ABB.

The safety precautions presented in the *Safety Instructions* at the beginning of the manual must be observed at all times.

Safety is dependent on the awareness, concern and prudence of all those who operate and service machines. While it is important that all safety procedures be observed, care near machinery is essential - always be on your guard.

NOTE: To avoid accidents, safety measures and devices required at the installation site must be in accordance with the instructions and regulations stipulated for safety at work. This applies to general safety regulations of the country in question, specific agreements made for each work site and safety instructions included in this manual and separate safety instructions delivered with the machine.

1.3 Limitation of liability

In no event shall ABB be liable for direct, indirect, special, incidental or consequential damages of any nature or kind arising from the use of this document, nor shall ABB be liable for incidental or consequential damages arising from use of any software or hardware described in this document.

The warranty issued covers manufacturing and material defects. The warranty does not cover any damage caused to the machine, personal or third party by improper storage, incorrect installation or operating of the machine. The warranty conditions are in more detail defined according to Orgalime S2000 terms and conditions.

NOTE: The warranty issued is not valid, if the operation conditions of the machine are changed or any changes in the construction of the machine, or repair work to the machine have been made without prior written approval from the ABB factory, which supplied the machine.

NOTE: Local ABB sales offices may hold different warranty details, which are specified in the sales terms, conditions or warranty terms.

For contact information, please see the back page of this User's Manual. Please remember to provide the serial number of the machine when discussing machine specific issues.

1.4 Documentation

1.4.1 Documentation of the machine

It is recommended that the documentation of the machines is studied carefully before any actions are taken. This manual and safety instructions are delivered with each machine and is located in a plastic cover attached on the machine frame.

NOTE: The documentation is delivered to the ordering customer. For additional copies of these documents, please contact your local ABB office or the After Sales department, see *Chapter 9.1.5 After Sales contact information.*

In addition to this manual, each machine is supplied with a Dimension Drawing, an Electrical Connection Diagram and a Data Sheet indicating the following:

- Mounting and outline dimensions of the machine
- Machine weight and load on the foundation
- Location of lifting eyes of the machine
- Instrumentation and location of accessories
- Bearing oil and lubricant requirements
- Main and auxiliary connections.

NOTE: Some customer specific items may not be included in this User's Manual. Additional documentation will be found in the project documentation. In case of conflict between this manual and the additional documentation of the machine, additional documentation will prevail.

1.4.2 Information not included in documentation

This User's Manual does not include any information about any starting, protection or speed control equipment. This information is provided in the user's manuals for respective equipment.

1.4.3 Units used in this User's Manual

The measurement units used in this User's Manual are based on the SI (metric) system and the US system.

1.5 Identification of the machine

1.5.1 Serial number of the machine

Each machine is identified with a 7-digit serial number. It is stamped on the rating plate of the machine as well as on the machine frame.

The serial number must be provided in any future correspondence regarding a machine, as it is the only unique information used for identifying the machine in question.

1.5.2 Rating plate

A stainless steel rating plate is attached permanently to the machine frame, and it must not be removed. For the location of the rating plate, see *Appendix Typical position of plates*.

The rating plate indicates manufacturing, identification, electrical and mechanical information, see *Figure 1-1 Rating plate for direct on line machines manufactured according to IEC*.

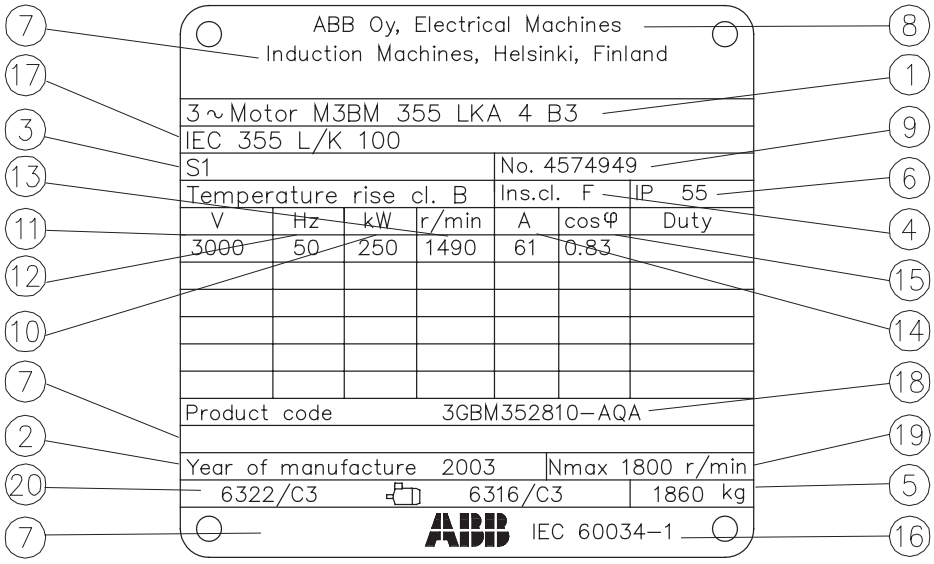


Figure 1-1 Rating plate for direct on line machines manufactured according to IEC

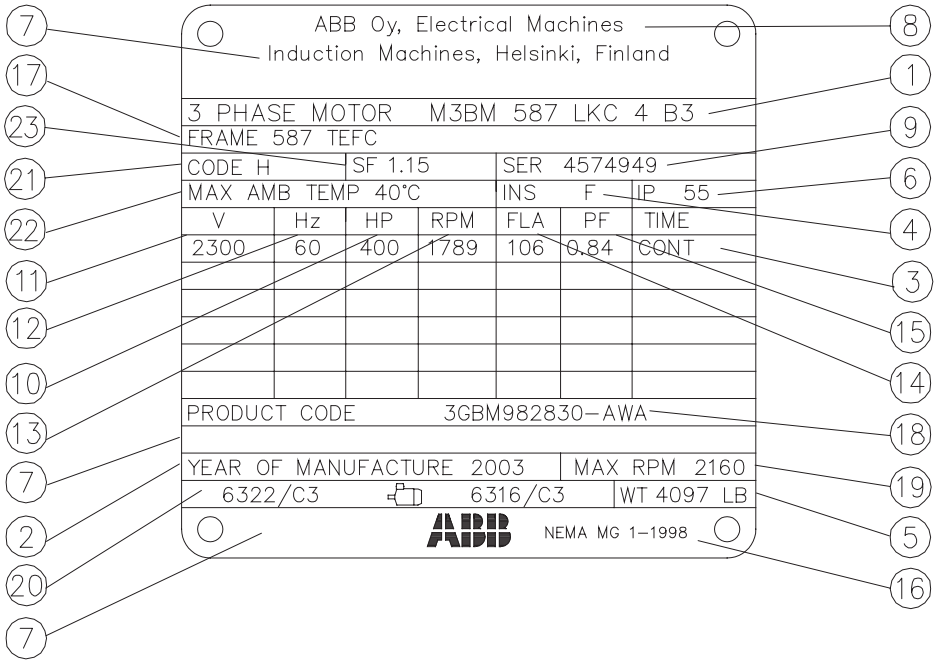


Figure 1-2 Rating plate for direct on line machines manufactured according to NEMA

1. Type designation
2. Manufacturing year
3. Duty
4. Insulation class
5. Machine weight [kg] or [lbs]
6. Degree of protection [IP class]
7. Space for additional information
8. Manufacturer

9. Serial number
10. Output [kW] or [HP]
11. Stator voltage [V]
12. Frequency [Hz]
13. Rotating speed [rpm]
14. Stator current [A]
15. Power factor [cosf]
16. Standard
17. Frame
18. Product code
19. Maximum mechanical rotating speed [rpm]
20. Bearing types
21. Designation for locked-rotot kVA/HP (NEMA)
22. Ambient temperature [°C] (NEMA)
23. Service factor (NEMA)

Chapter 2 Transport and Unpacking

2.1 Protective measures prior to transport

2.1.1 General

The following protective measures are taken before delivery of the machine from the factory. The same protective measures should be taken, whenever the machine is moved:

- Some machines, and all machines with sleeve or roller bearings, have transport locking devices installed
- Ball and roller bearings are greased with lubricant indicated on the bearing plate, which is attached to the machine frame, see *Chapter 2.1.2 Bearing plate*
- Machined metal surfaces, such as the shaft extension, are protected against corrosion with an anti-corrosive coating
- In order to protect the machine properly against water, salt spray, moisture, rust and vibration damages during loading, sea transport and unloading of the machine, the machine should be delivered in a seaworthy package.

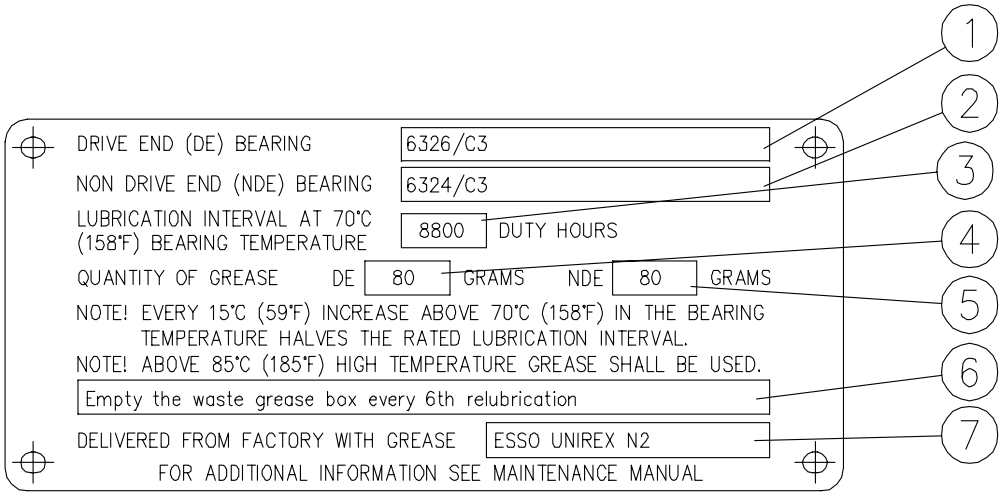


Figure 2-1 Bearing plate for grease lubricated rolling bearings

1. Bearing type of D-end
2. Bearing type of ND-end
3. Lubrication interval
4. Quantity of grease for D-end bearing
5. Quantity of grease for ND-end bearing
6. Additional information
7. Type of grease delivered from factory

2.1.2 Bearing plate

A stainless steel bearing plate is attached to the machine frame. For the location of the bearing plate, see *Appendix Typical position of plates.*

The bearing plate indicates the type of the bearings and lubrication to be used, see *Figure 2-2 Bearing plate for grease lubricated rolling bearing.*

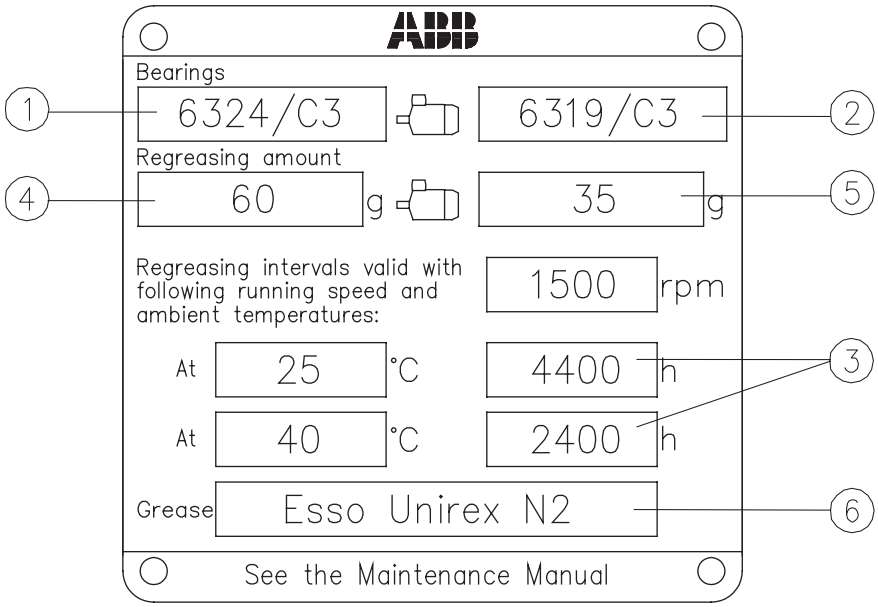


Figure 2-2 Bearing plate for grease lubricated rolling bearing

1. Bearing type of D-end
2. Bearing type of ND-end
3. Lubrication interval
4. Quantity of grease for D-end bearing
5. Quantity of grease for ND-end bearing
6. Type of grease delivered from factory

2.2 Lifting the machine

Before the machine is lifted, ensure that suitable lifting equipment is available and that the personnel is familiar with lifting work. The weight of the machine is shown on the rating plate, dimension drawing and packing list.

NOTE: Use only the lifting lugs or eyes intended for lifting the complete machine. Do not use any small additional lifting lugs or eyes available, as they are there only for service purposes.

NOTE: The center of gravity of machines with the same frame may vary due to different outputs, mounting arrangements and auxiliary equipment.

NOTE: Check that eyebolts or the lifting lugs integrated with the machine frame are undamaged before lifting. Damaged lifting lugs must not be used.

NOTE: Lifting eyebolts must be tightened before lifting. If needed the position of the eyebolt must be adjusted with suitable washers.

2.2.1 Lifting a machine in a seaworthy package

The seaworthy package is normally a wooden box, which is covered with lamina paper on the inside. The seaworthy package should be lifted by forklift from the bottom, or by crane with lifting slings. The sling positions are painted on the package.

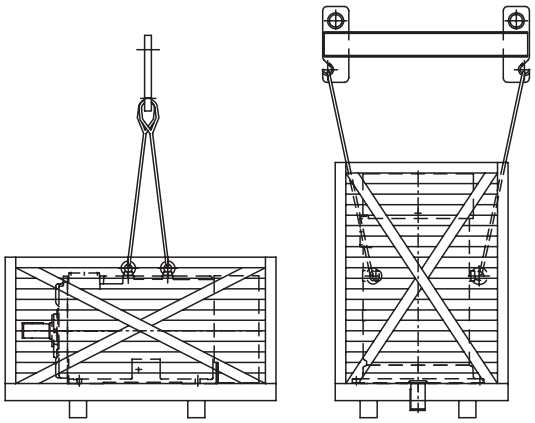


Figure 2-3 Lifting of horizontal and vertical machines in seaworthy packages

2.2.2 Lifting a machine on a pallet

A machine mounted on a pallet should be lifted by crane from the lifting eyes of the machine, see *Figure 2-4 Lifting of horizontal and vertical machines on pallets*, or by forklift from the bottom of the pallet. The machine is fixed to the pallet with bolts.

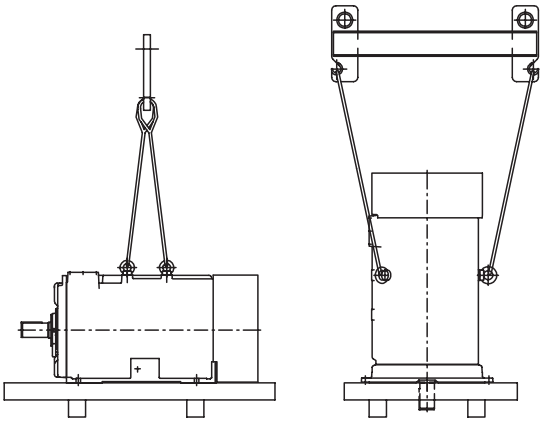


Figure 2-4 Lifting of horizontal and vertical machines on pallets

2.2.3 Lifting an unpacked machine

Suitable lifting equipment must be used! The machine should always be lifted by crane from the lifting eyes on the frame of the machine, see *Figure 2-5 Lifting of unpacked machines*. The machine should *never* be lifted by forklift from the bottom or the feet of the machine.

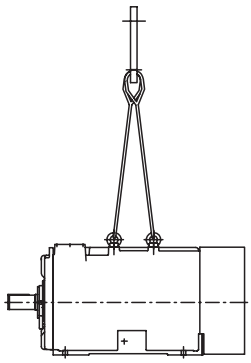


Figure 2-5 Lifting of unpacked machines

2.3 Turning a vertically mounted machine

Vertically mounted machines may be necessary to turn from vertical to horizontal position, e.g. when changing the bearings, and vice versa. This is shown in *Figure 2-6 Machine with turnable lifting eyes: lifting and turning*. Avoid damaging the painting or any parts during the procedure. Remove or install the bearing locking device only when the machine is in vertical position.

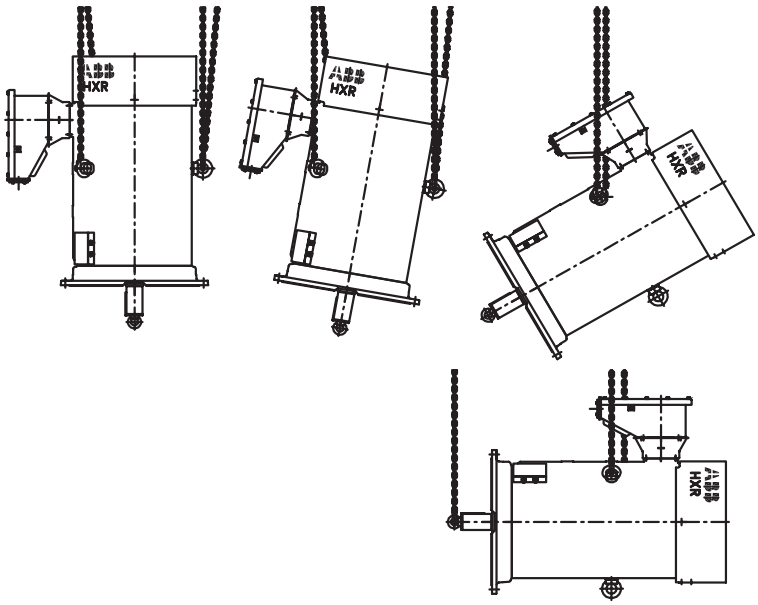


Figure 2-6 Machine with turnable lifting eyes: lifting and turning

2.4 Checks upon arrival and unpacking

2.4.1 Check upon arrival

The machine and the package must be inspected immediately upon arrival. Any transport damage must be photographed and reported immediately, i.e. within less than one (1) week after arrival, if the transport insurance is to be claimed. It is, therefore, important that evidence of careless handling is checked and reported immediately to the transport company and the supplier. Use checklists in *Appendix COMMISSIONING REPORT*.

A machine, which is not to be installed immediately upon arrival, must not be left without supervision or without protective precautions. For more details, see *Chapter 2.5 Storage*.

2.4.2 Check upon unpacking

Place the machine so that it does not hinder the handling of any other goods and on a flat, vibration-free surface.

After the package has been removed, check that the machine is not damaged and that all accessories are included. Tick off the accessories on the packing list which is enclosed. If there is any suspected damage or if accessories are missing, take photographs thereof and report this immediately to the supplier. Use checklists in *Appendix COMMISSIONING REPORT*.

For correct recycling and disposal of the packaging material, see *Chapter 10.3 Recycling of packaging material.*

2.5 Storage

2.5.1 Short term storage (less than 2 months)

The machine should be stored in a proper warehouse with a controllable environment. A good warehouse or storage place has:

- A stable temperature, preferably in the range from 10ºC (50°F) to 50ºC (120°F). If the anti-condensation heaters are energized, and the surrounding air is above 50ºC (120°F), it must be confirmed that the machine is not overheated
- Low relative air humidity, preferably below 75%. The temperature of the machine should be kept above the dew point, as to prevent moisture from condensing inside the machine. If the machine is equipped with anti-condensation heaters, they should be energized. The operation of the anti-condensation heaters must be verified periodically. If the machine is not equipped with anti-condensation heaters, an alternative method of heating the machine and preventing moisture from condensing in the machine must be used
- A stable support free from excessive vibrations and shocks. If vibrations are suspected to be too high, the machine should be isolated by placing suitable rubber blocks under the machine feet
- Air which is ventilated, clean and a free from dust and corrosive gases
- Protection against harmful insects and vermin.

If the machine needs to be stored outdoors, the machine must never be left ‘as is’ in its transportation package. Instead the machine must be

- Taken out from its plastic wrap

- Covered, as to completely prevent rain from entering the machine. The cover should allow ventilation of the machine
- Placed on at least 100 mm (4”) high rigid supports, as to make sure that no moisture can enter the machine from below
- Provided with good ventilation. If the machine is left in its transportation package, large enough ventilation openings must be made in the package
- Protected from harmful insects and vermin.

Use checklists in Chapter 2 Storage in *Appendix COMMISSIONING REPORT*.

2.5.2 Long term storage (more than 2 months)

In addition to the measures described with short-term storage, the following should be applied.

Measure the insulation resistance and temperature of the windings every three months, see *Chapter 7.6 Maintenance of stator and rotor windings.*

Check the condition of the painted surfaces every three months. If corrosion is observed, remove it and apply a coat of paint again

Check the condition of anti-corrosive coating on blank metal surfaces (e.g. shaft extensions) every three months. If any corrosion is observed, remove it with a fine emery cloth and perform the anti-corrosive treatment again

Arrange small ventilation openings when the machine is stored in a wooden box. Prohibit water, insects and vermin from entering the box, see *Figure 2-7 Ventilation holes*.

Use checklists in Chapter 2 Storage in *Appendix COMMISSIONING REPORT*.

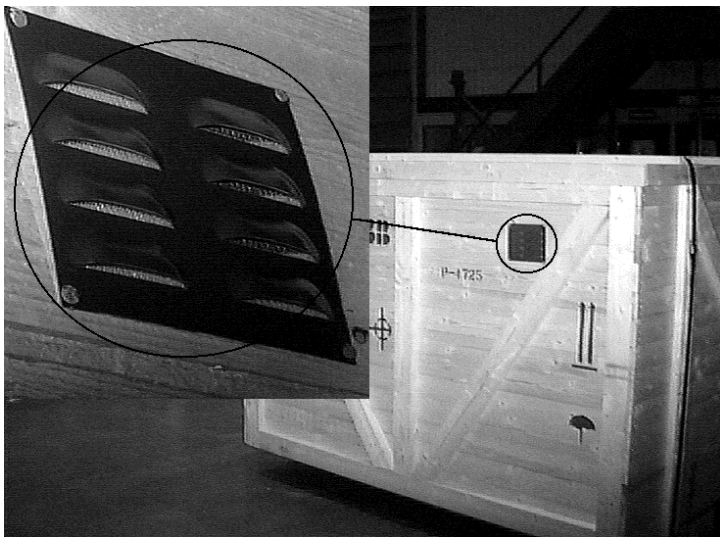


Figure 2-7 Ventilation holes

2.5.3 Rolling bearings

Apply the following measures:

- Rolling bearings should be well lubricated during storage. Acceptable grease types are presented in *Chapter 2.1.2 Bearing plate*
- Turn the rotor 10 revolutions every three months to keep the bearings in good condition. Remove any possible transport locking device during turning the rotor
- Machines may be provided with a locking device to protect the bearings against damage during transport and storage. Check the bearing locking device periodically. Tighten the transport locking device according to the axially locating bearing type, see *Table 2-1 Tightening torque for horizontal machines (lubricated screw).*

NOTE: A too high tightening torque on the transport locking device will damage the bearing.

NOTE: The type of bearings used are found on the bearing plate, see *Chapter 2.1.2 Bearing plate*, and axially locating bearing information from the dimension drawing.

Table 2-1. Tightening torque for horizontal machines (lubricated screw)

Axially locating bearing type	Tightening torque [Nm]	Tightening torque [pound foot]
6316	45	33
6317	50	37
6319	60	44
6322	120	90
6324	140	100
6326	160	120
6330	240	180
6334	300	220
6034	140	100
6038	160	120
6044	230	170

2.5.4 Openings

If there are any openings where cables are not connected to terminal boxes or flanges that are not connected to the piping, they are to be sealed. The coolers and the piping within the machine are to be cleaned and dried before they are sealed. The drying is made by blowing warm and dry air through the pipes.

2.6 Inspections, records

The storage period, taken precautions and measurements, including dates, should be recorded. For relevant check-lists, see *Appendix COMMISSIONING REPORT*.

Chapter 3 Installation and Alignment

3.1 General

Good planning and preparation result in simple and correct installation and assure safe running conditions and maximum accessibility.

Standards relating to the connection and use of electrical apparatus in hazardous areas must be taken into consideration, especially national standards for installation (see standard IEC 60079-14).

NOTE: General, as well as local work safety instructions must be followed during installation.

NOTE: Ensure the protection of the machine while working nearby.

NOTE: Do not use the machine as a welding earth.

3.2 Foundation design

3.2.1 General

The design of the foundation should assure safe running conditions with maximum accessibility. Sufficient free space should be left around the machine to ensure easy access for maintenance and monitoring. The cooling air should flow to and away from the machine without obstruction. Care has to be taken to ensure that other machines or equipment nearby do not heat the machine cooling air or constructions such as bearings.

The foundation must be strong, rigid, flat and free from external vibration. The possibility of machine resonance with the foundation has to be verified. In order to avoid resonance vibrations with the machine, the natural frequency of the foundation together with machine must not be within a ±20% range of the running speed frequency.

A concrete foundation is preferred, however, a correctly designed steel construction is also acceptable. The anchorage to the foundation, the provision of air, water, oil and cable channels as well as the location of the grouting holes should be considered prior to construction. The position of the grouting holes and the height of the foundation must agree with the corresponding dimensions on the provided dimensional drawing.

The foundation shall be designed to permit 2 mm (0.8 inch) shim plates under the feet of the machine in order to ensure an adjustment margin, and facilitate the possible future installation of a replacement machine. Machine shaft height and foundation feet location have a certain manufacturing tolerance, which are compensated with the 2 mm (0.8 inch) shim plate.

NOTE: The calculation and design of the foundation is not included in the ABB scope of supply and the customer or a third party is therefore responsible for it. Furthermore, the grouting operation is also normally outside the scope and responsibility of ABB.

3.2.2 Forces to the foundation

The foundation and the mounting bolts must be dimensioned to withstand a sudden mechanical torque, which occurs every time the machine is started, or at short circuit. The short circuit force is a gradually damped sine wave that changes direction. The magnitude of these forces is mentioned on the dimensional drawing of the machine.

3.2.3 Flanges for vertically mounted machines

Vertical flange mounted machines are equipped with a mounting flange according to IEC-standard publication 60072. The flange of the machine should always be mounted to an opposite flange on the foundation.

A mounting adapter is recommended to enable an easy coupling connection and inspection during operation.

3.3 Machine preparations before installation

Prepare the machine for installation as follows:

- Measure the insulation resistance of the winding before any other preparations are done as described in *Chapter 3.3.1 Insulation resistance measurements*
- Remove the transport locking device when applicable. Store it for future use. See *Chapter 3.3.2 Disassembly of the transport locking device* for further instructions
- Verify that the grease available is according to the specification on the bearing plate, see *Chapter 2.1.2 Bearing plate*. Additional recommended greases can be found in *Chapter 7.5.1.5 Bearing grease*
- Remove the anti-corrosive coating on the shaft extension, and machine feet with white spirit
- Install the coupling half as described in *Chapter 3.3.4 Assembly of the coupling half*
- Check that the drain plugs at the lowest part of both ends of the machine are in open position, see *Chapter 3.3.6 Drain plugs.*

3.3.1 Insulation resistance measurements

Before a machine 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. This includes measuring the stature winding and all auxiliary devices. For machines equipped with slip ring, the measuring also includes the rotor winding, see *Chapter 7.6.4 Insulation resistance test.*

3.3.2 Disassembly of the transport locking device

Some machines and all machines with sleeve or roller bearings have transport locking devices installed. For machines with sleeve or cylindrical roller bearings, the transport locking device is made of a steel bar attached to both the bearing shield on the D-end and to the end of the shaft extension.

The transport locking device has to be removed prior to installation. The shaft extension has to be cleaned of its anti-corrosive coating. The locking device should be stored for future use.

NOTE: In order to avoid bearing damages, the transport locking device must be fitted to the machine whenever the machine is moved, transported to another location or stored. See *Chapter 2.1 Protective measures prior to transport*.

3.3.3 Coupling type

Machines with rolling bearings must be connected to the driven machine with flexible couplings, e.g. pin couplings, or gear couplings.

If the axially locked bearing is at the N-end (see dimension drawing), make sure that a continuous free axial movement is possible between the coupling halves in order to permit thermal expansion of the machine shaft without damaging the bearings. The expected axial thermal expansion of the rotor can be calculated as defined in the *Chapter 3.6.4 Correction for thermal expansion*.

Vertical machines may be designed to carry some load from the shaft of the driven machine. If this is the case, the coupling halves have to be locked against slipping in the axial direction by a lock plate on the end of the shaft.

NOTE: The machine is not suitable for belt, chain or gear connection unless it is specifically designed for such use. The same applies for high axial thrust applications.

3.3.4 Assembly of the coupling half

3.3.4.1 Balancing of coupling

The rotor is dynamically balanced with half key as standard. The way of balancing is stamped to the shaft end:

- H = half-key and
- F = full key

The coupling half must be balanced respectively.

3.3.4.2 Assembly

The following instructions must be taken into account when assembling the coupling half.

- Follow the general instructions of the coupling supplier
- The weight of the coupling half can be considerable. A suitable lifting gear may be needed
- Clean the shaft extension of its anti-corrosive coating, and check the measurements of the extension and the coupling against the provided drawings. Ensure also that the keyways in the coupling and the shaft extension are clean and free from burrs
- Coat the shaft extension and hub bore with a thin layer of oil as to facilitate the mounting of the coupling half. Never coat mating surfaces with molybdenum disulphide (Molykote) or similar products
- The coupling must be covered with a touch guard.

NOTE: In order not to damage the bearings, no additional forces should be applied to the bearings when assembling the coupling half.

3.3.5 Belt drive

Machines designed for belt drives are always equipped with cylindrical roller bearing in the D-end. If a belt drive is used, make sure that the driving and the driven pulleys are correctly aligned.

NOTE: Suitability of the shaft end and the bearings for the belt drive must be always checked before use. Do not exceed the radial force specified in the order definitions.

3.3.6 Drain plugs

The machines are equipped with drain plugs in the lowest part of the machine. The drain plug is constructed in such a way that it keeps the dust outside the machine and lets the condensation water to drain out. The drain plugs should always be open, i.e. half of the plug is inside and half of the plug is outside. The drain plug is opened by pulling it out from the frame. In AMI machines the drain plug (M12 screw) is opened 6 - 12 mm (0.2” - 0.5”).

For horizontal machines, two drain plugs are fitted at both ends of the machine.

For vertical machines, two drain plugs are fitted to the lower end shield.

The main terminal box has one drain plug at the lowest part of the box which has to be closed during operation.

3.4 Installation on concrete foundation

3.4.1 Scope of delivery

The machine delivery does not normally include installation, shim plates, mounting bolts, foundation plate set or sole plate set. These are delivered according to special orders.

If new fixing holes need to be drilled, please contact ABB to ensure suitability.

3.4.2 General preparations

Before starting the installation procedure, consider the following aspects:

- Reserve sheet steel material for shimming the machine. Possible alignment adjustments require shims with thicknesses of 1, 0.5, 0.2, 0.1 and 0.05 mm (40, 20, 8, 4 and 2 mil)
- Reserve a recoil hammer, adjusting screws or hydraulic jacks for axial and horizontal adjustments
- Reserve dial indicator gauges, or preferably a laser optical analyzer, to achieve accurate and precise alignment of the machine
- Reserve a simple lever arm for turning the rotor during alignment
- With outdoor installations provide sun and rain protection to eliminate measuring errors during installation.

NOTE: Machines are delivered with jacking screws for vertical adjustment at each foot.

3.4.3 Foundation preparations

3.4.3.1 Foundation and grouting hole preparations

Foundation studs or sole plates are used when the machine is anchored to a concrete foundation.

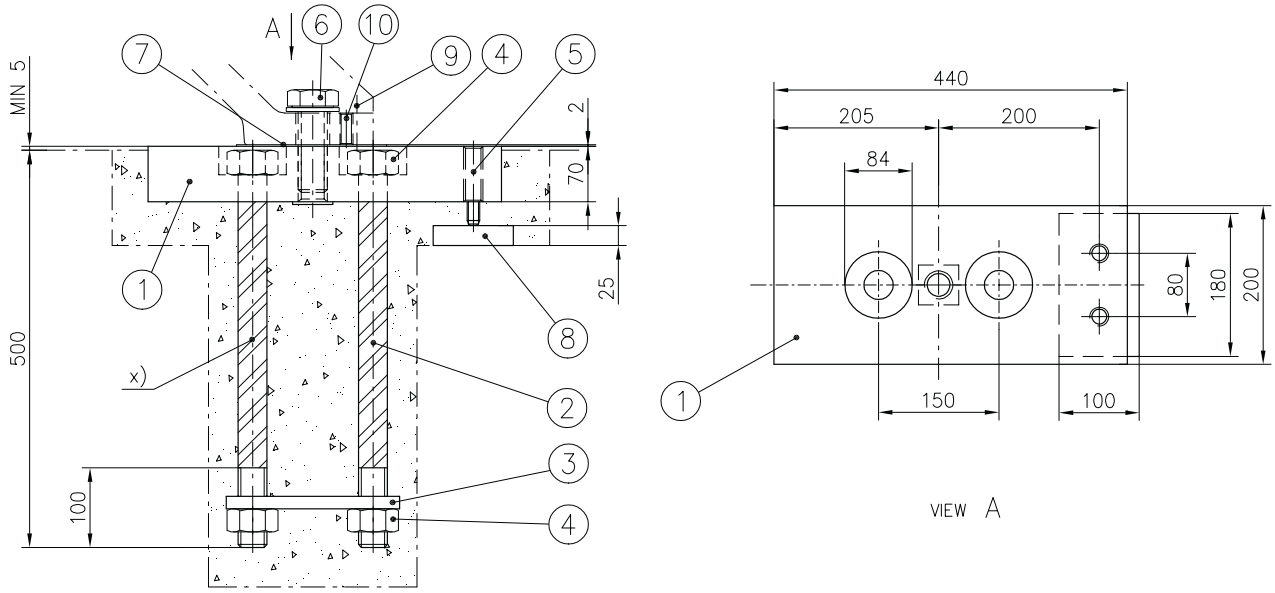
Consider the following aspects when preparing the foundation:

- The upper part of the foundation has to be swept or vacuum cleaned
- Walls of the grouting holes must have rough surfaces to give a good grip. For the same reason they must be washed and rinsed and thus free from pollution and dust. Oil or grease must be removed by chipping away slices of the concrete surfaces
- Check that the position of the grouting holes and the height of the foundation agree with corresponding measurements on the drawing provided
- Attach a steel wire on the foundation to indicate the center line of the machine. Mark also the axial position of the machine.

3.4.3.2 Foundation studs or sole plate preparations

If shims and foundation studs are part of the delivery, they will be delivered as separate items. The assembly of these will be made at site.

NOTE: To ensure that the foundation studs will be satisfactorily attached to the concrete, they must be unpainted and free from pollution and dust.



ITEM	NAME OF THE PARTS	SIZE	QUANTITY/SET [PCS]
1	PLATE	70x200x440	4
2	STUD	M36x500/45+100	8
3	FLANGE	10x60x210	4
4	NUT	M36	16
5	JACKING SCREW	M24x60	8
6	FIXING SCREW	M36x90/90	4
7	SHIM	2x170x250	4
8	SUPPORT PLATE	25x100x180	4
9	TAPER PIN	10x100	2
10	JACKING SCREW	M16x55	4

x) THE TAPER PIN (PART 9) IS NEEDED ONLY AT DRIVE-END OF THE MOTOR.
THE TAPE IS NOT INCLUDED IN THE DELIVERY.

ANCHOR BOLT TO BE MOUNTED IN THE FOUNDATION.
FUNDATION STUD WILL BE DELIVERED AS LOOSE ITEMS.
ONE SET INCLUDES PARTS FOR ONE MACHINE (4 PCS).

Figure 3-1 Typical foundation stud assembly

In order to assemble the foundation stud or sole plate set, the machine must be suspended above the floor by a crane. Proceed as follows, see *Figure 3-1 Typical foundation stud assembly*:

- Clean the parts protected by an anti-corrosive coating with white spirit
- Screw the greased leveling screws into the foundation studs (part 5) or sole plates
- Wrap a layer of tape around the upper part of the anchor bolts (part 2) according to *Figure 3-1 Typical foundation stud assembly*. The tape will prevent the upper part of the bolt from being stuck in the concrete and enables it to be retightened after the concrete has set
- Fit the anchor bolt (part 2) in the foundation plates (part 1) or sole plates so that the top of the anchor bolts is 1...2 mm (40...80 mil) above the upper surface of the nuts (part 4)
- Fit the anchor flange (part 3) and the lower nut (part 4) to the anchor bolts (part 2). Bridge the anchor flange (part 3) to the bolts by welding and tighten the nuts. If the bridging cannot be done, lock the anchor flange between two nuts
- After the assembly of the foundation plates is done; the machine should be lifted up and suspended above the floor. The machine feet, and the side and bottom surfaces of the foundation plates as well as anchor bolts should be cleaned with white spirit

- Mount the assembled foundation studs or sole plates under the machine feet with the mounting bolt (part 6) and washer (part 3). Center the mounting bolt (part 6) in the hole of the machine by wrapping e.g. paper, cardboard or tape on the upper part of the bolt
- Place the 2 mm (0.8 inch) shim (part 7) between the foot and the plate (part 1). Fasten the plate tightly against the foot with the mounting bolt (part 6)
- Place the leveling plate (part 8) under the leveling screw (part 5)
- Check that the space between the plate (part 1) and the anchor bolts (part 2) is tight. If concrete penetrates through this interstice up to the nuts, the retightening cannot be done.

NOTE: The tape and the steel plate are not included in the delivery of the foundation studs.

3.4.4 Erection of machines

The machine is carefully lifted and placed onto the foundation. A rough horizontal alignment is made with the aid of the previously installed steel wire and the marking of the axial location. A vertical alignment is made with the leveling screws. Required positioning accuracy is within 2 mm (80 mil).

3.4.5 Alignment

The alignment is made as described in *Chapter 3.6 Alignment.*

3.4.6 Grouting

The grouting of the machine into the foundation is a very important part of the installation. The instructions of the grouting compound supplier must be followed.

Please use high-quality non-shrinking grouting materials to avoid difficulties with the grouting in the future. Cracks in the grouting compound or a poor attachment to the concrete foundation cannot be accepted.

3.4.7 Final installation and inspection

After the concrete has set, lift the machine from the foundation and retighten the anchor bolts. Lock the nuts by bridging or hitting sufficiently hard with a center punch. Lift the machine back on the foundation and tighten the mounting bolts.

Check the alignment in order to ensure that the machine will run with the permissible vibration. If necessary, make the adjustment with shims, and then complete the doweling according to the holes in the feet at the machine D-end.

3.4.7.1 Dowelling of the machine feet

The machine has one dowel hole per foot at the D-end. Deepen the holes by drilling through to the steel foundation. After that, the holes are tapered with a reaming tool. Suitable tapered pins are fitted to the holes to ensure the exact alignment, and to allow easier reinstallation after any possible removal of the machine.

3.4.7.2 Covers and enclosures

Complete the coupling installation by attaching both coupling halves to each other according to the coupling manufacturer's instruction.

NOTE: The coupling must be covered with a touch guard.

After the machine has been erected, aligned and its accessories are installed, check carefully that no tools or foreign objects have been left inside of the enclosures. Clean also any dust or debris.

Check that all sealing strips are intact when installing the covers.

Store the alignment and assembly accessories together with the transport locking devices for future use.

3.5 Installation on steel foundation

3.5.1 Scope of delivery

The machine delivery does not normally include installation, shim plates or mounting bolts. These are delivered according to special orders.

If new fixing holes need to be drilled, please contact ABB to ensure suitability.

3.5.2 Check of foundation

Before lifting the machine onto the foundation, the following checks should be made.

- Clean the foundation carefully
- The foundations shall be flat and plain parallel within 0.1 mm (4.0 mil) or better
- The foundation shall be free from external vibration.

3.5.3 Erection of machines

The machine is carefully lifted and placed onto the foundation.

3.5.4 Alignment

The alignment is made as described in *Chapter 3.6 Alignment.*

3.5.5 Final installation and inspection

3.5.5.1 Doweling of the machine feet

The machine has one dowel hole per foot at the D-end. Deepen the holes by drilling through to the steel foundation. After that, the holes are tapered with a reaming tool. Suitable tapered pins are fitted to the holes to ensure the exact alignment, and to allow easier reinstallation after any possible removal of the machine.

3.5.5.2 Covers and enclosures

Complete the coupling installation by attaching both coupling halves to each other according to the coupling manufacturer's instruction.

NOTE: The coupling must be covered with a touch guard.

After the machine has been erected, aligned and its accessories are installed, check carefully that no tools or foreign objects have been left inside of the enclosures. Clean also any dust or debris.

Check that all sealing strips are intact when installing the covers.

Store the alignment and assembly accessories together with the transport locking devices for future use.

3.5.6 Installation of flange mounted machines on steel foundation

The purpose of a mounting flange for vertically mounted machines is to enable an easy installation and coupling connection, as well as an easy inspection of the coupling during operation. In order to fit the ABB machines, the mounting flanges shall be designed according to the IEC standard.

The mounting flange is not included in the ABB scope of delivery.

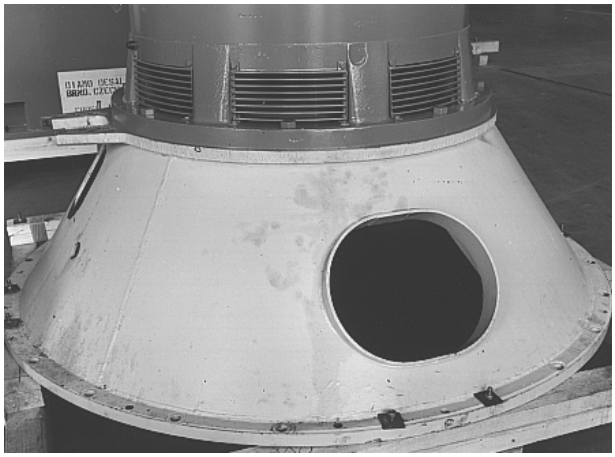


Figure 3-2 Mounting flange

The machine is lifted and placed onto the mounting flange. The mounting bolts are tightened lightly.

3.6 Alignment

3.6.1 General

In order to ensure a long and satisfactory lifetime of both the driving and the driven machine, the machines need to be properly aligned to each other. This means that the radial, as well as the angular deviation between the two shafts of the machines have to be minimized. The alignment

must be performed with great caution because alignment errors will lead to bearing and shaft damages.

Before the alignment procedure is started, the coupling halves have to be installed, see *Chapter 3.3.4 Assembly of the coupling half*. The coupling halves of the driving and driven machines must be bolted together loosely in order to move freely in respect to each other during the alignment.

The following text refers to installation on both concrete and steel foundations. Shimming is not necessary in case of a concrete foundation if the alignment and grouting is done correctly.

3.6.2 Rough levelling

In order to facilitate the alignment and enable the mounting of shims, jacking screws are fitted to the feet of the machine, see *Figure 3-3 Vertical positioning of machine foot*. The machine is left standing on the jacking screws. Note that the machine must stand on all four feet (screws) on a plain parallel within 0.1 mm (4.0 mil) or better. If this is not the case, the frame of the machine will be twisted or bent, which can lead to bearing or other damages.

Check that the machine is vertically, horizontally and axially in level. Make adjustments accordingly by placing shims under the four feet. The horizontal level of the machine is checked with a spirit level.

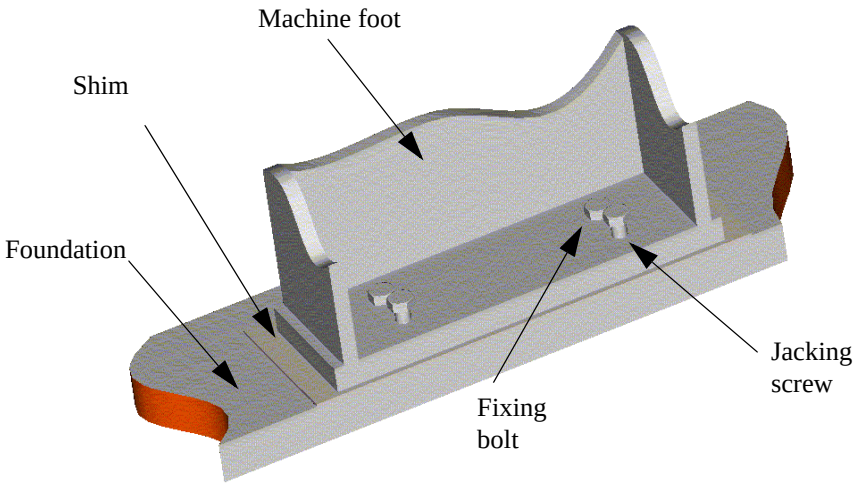


Figure 3-3 Vertical positioning of machine foot

3.6.3 Rough adjustment

In order to facilitate the alignment in axial and transversal directions, place bracket plates with adjusting screws at the corners, see *Figure 3-4 Positioning of bracket plates*.

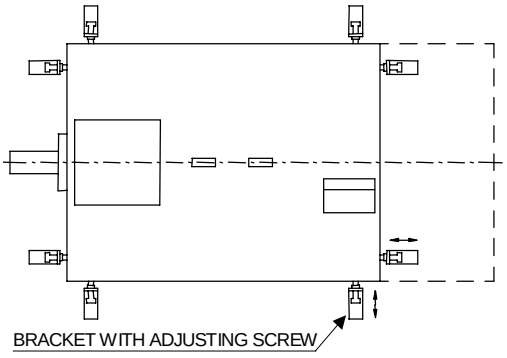


Figure 3-4 Positioning of bracket plates

Bracket plates are placed against the foundation edge and tied down with expansion bolts, see *Figure 3-5 Mounting of the bracket plate*. Move the machine by using the adjusting screws until the shaft centerline and the driven machine centerline are aligned roughly and the desired distance between the coupling halves is reached. Leave all adjusting screws only lightly tightened.

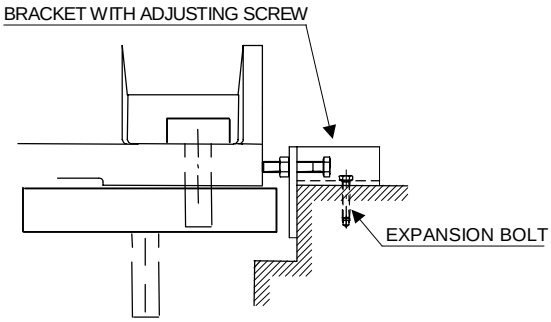


Figure 3-5 Mounting of the bracket plate

NOTE: *Figure 3-5 Mounting of the bracket plate* shows bracket plate mounted to concrete foundation, place similar bracket plate on steel foundation.

3.6.4 Correction for thermal expansion

3.6.4.1 General

Running temperatures have a considerable influence on the alignment, and should therefore be considered during the alignment. The machine temperature is lower during erection than under operating conditions. For this reason, the shaft center will be higher, i.e. further away from the feet during operation than standstill.

It may therefore be necessary to use heat compensated alignment depending on the operating temperature of the driven machine, coupling type, distance between machines, etc.

3.6.4.2 Thermal expansion upwards

The thermal expansion of the distance between the feet and the shaft center of the electrical machine can be approximately calculated according to the formula:

$\Delta H = \alpha \times \Delta T \times H$where

ΔH=thermal expansion[mm]

$\alpha = 10 \times 10^{-6}\ K^{-1}$

ΔT=40 K

H=shaft height [mm]

NOTE: Consider the thermal expansion of the driven machine in respect to the electrical machine in order to define the total thermal expansion.

3.6.4.3 Thermal axial growth

The thermal axial expansion needs to be taken into consideration if the axial movement of the non-drive end bearing is locked. See the dimension drawing in order to determine which end is locked.

The expected axial thermal expansion of the rotor is proportional to the length of the stator frame, and can be approximately calculated according to the formula:

$\Delta L = \alpha \times \Delta T \times L$where

ΔL=thermal expansion[mm]

$\alpha = 10 \times 10^{-6}\ K^{-1}$

ΔT=50 K (for AMA, AMB, AMK, AMI), 80 K (for AMH, HXR, M3BM, M3GM)

L=frame length [mm]

NOTE: Make sure that a continuous free axial movement is possible between the coupling halves (excluding rigid couplings) in order to permit axial thermal expansion of the machine shaft as not to damage the bearings.

3.6.5 Final alignment

3.6.5.1 General

In the following, the final alignment is made with dial gauges, although there is other and more exact measuring equipment on the market. The reason for using dial gauges in this text is to provide some alignment theory.

NOTE: Measurements should be made only after proper shimming and with fixing bolts properly tightened.

NOTE: The final alignment measurements should always be recorded for future reference.

3.6.5.2 Run-out of the coupling halves

The alignment procedure is started by measuring the run-out of the coupling halves. This measurement will show any inaccuracy of the shaft and/ or coupling halves.

The run-out of the coupling half in respect to the bearing housing of the machine is measured. Place the gauges according to *Figure 3-6 Measuring the run-out at the coupling half.* Similarly check the run-out of the coupling half of the driven machine in respect to its bearing housing.

A simple lever arm is needed to turn a rotor of a sleeve-bearing machine.

The admissible run-out error is less than 0.02 mm (0.8 mil).

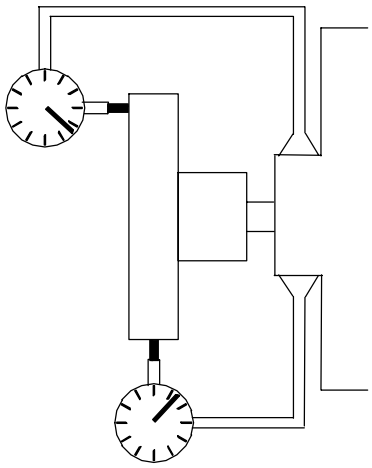


Figure 3-6 Measuring the run-out at the coupling half

3.6.5.3 Parallel, angular and axial alignment

After the machine has been roughly positioned, as described in *Chapter 3.6.2 Rough levelling* and *Chapter 3.6.3 Rough adjustment*, the final alignment can start. This step must be performed with great caution. Failure to do so can result in serious vibrations and damage to both driving and driven machine.

The alignment is done in accordance with the recommendations given by the coupling manufacturer. Parallel, angular and axial alignment of the machine is required. Some standard publications give recommendations for coupling alignment, e.g. BS 3170:1972 "*Flexible couplings for power transmission*".

In accordance with common practice, parallel and angular misalignment should not exceed 0.05-0.10 mm and axial misalignment should not exceed 0.10 mm, see *Figure 3-7 Definition of misalignment* The corresponding run-out is 0.10-0.20 mm for parallel and angular misalignment.

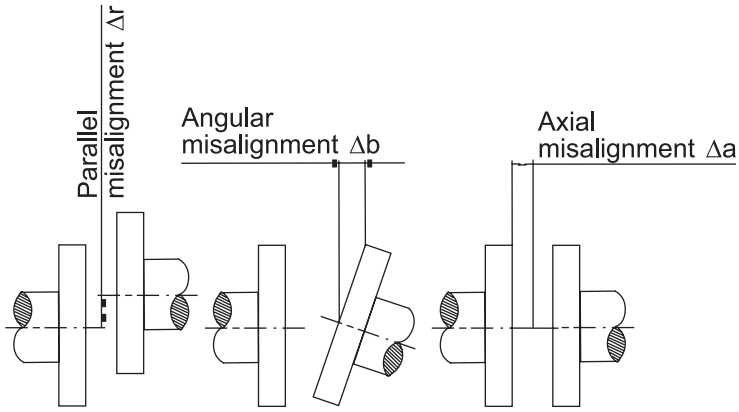


Figure 3-7 Definition of misalignment

3.6.5.4 Alignment

The alignment of the machine is performed according to these guidelines.

1. The machine should stand on its jacking screws
2. Rotate the rotor and check the axial end float, see *Chapter 3.6.3 Rough adjustment*
3. Mount the alignment equipment. If gauges are used, it is practical to adjust the dial gauge in such way that approximately half of the scale is available in either direction. Check the rigidity of the gauge brackets in order to eliminate the possibility of sag, see *Figure 3-8 Alignment check with gauges*

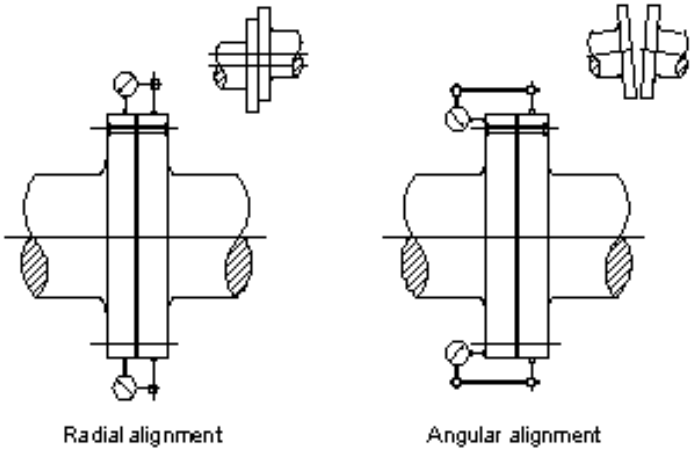


Figure 3-8 Alignment check with gauges

4. Measure and note readings for parallel, angular and axial misalignment in four different positions: top, bottom, right and left, i.e. every 90°, while both shafts are turned simultaneously. The readings are recorded

5. Align the machine vertically by turning the jacking screws or by jacking with hydraulic jacks. To facilitate the alignment in the vertical plane, jacking screws are fitted to the feet of the horizontal machine, see *Figure 3-3 Vertical positioning of machine foot*. The alignment accuracy of the machine is sometimes affected by the thermal expansion of its frame, see *Chapter 3.6.4 Correction for thermal expansion*
6. Measure the distance between the bottom of the machine feet and the bedplate and make corresponding solid blocks or wedges or reserve necessary amount of shims
7. Fit the solid blocks or shims under the machine feet. Slacken the jacking screws and tighten the fixing bolts
8. Check the alignment again. Make corrections if necessary
9. Draw up a record for future checks
10. Re-tighten nuts and lock the nuts by tack welds or hitting sufficiently hard with a center punch
11. Dowel the feet of the machine for easy future re-installation of the machine, see *Chapter 3.4.7.1 Dowelling of the machine feet.*

3.6.5.5 Permissible misalignment

Definite alignment tolerances are impossible to state as too many factors have an influence. Too large tolerances will cause vibration and may possibly lead to bearing or other damages. Therefore, it is recommended to aim at as narrow tolerances as possible. Maximum permissible misalignments are shown in *Table 3-1 Recommended permissible misalignments* For definitions of misalignment, see *Figure 3-7 Definition of misalignment.*

NOTE: Tolerances given by the coupling manufacturers indicate tolerances for the coupling, not for the driving-driven machine alignment. The tolerances given by the coupling manufacturer should be used as a guideline for the alignment only if they are narrower than the maximum permissible misalignments shown in *Table 3-1 Recommended permissible misalignments.*

Table 3-1. Recommended permissible misalignments

Coupling Information		Permissible Misalignment		
Coupling Diameter	Coupling Type	Parallel Δ r	Angular Δ b	Axial Δ a

100 – 250 mm (4 – 10”)	Rigid Flange	0.02 mm (0.8 mil)	0.01 mm (0.4 mil)	0.02 mm (0.8 mil)
	Gear	0.05 mm (2 mil)	0.03 mm (1 mil)	0.05 mm (2 mil)
	Flexible	0.10 mm (4 mil)	0.05 mm (2 mil)	0.10 mm (4 mil)
250 – 500 mm (10 – 20”)	Rigid Flange	0.02 mm (0.8 mil)	0.02 mm (0.8 mil)	0.02 mm (0.8 mil)
	Gear	0.05 mm (2 mil)	0.05 mm (2 mil)	0.05 mm (2 mil)
	Flexible	0.10 mm (4 mil)	0.10 mm (4 mil)	0.10 mm (4 mil)

3.7 Care after installation

If the machine will not be in operation for a longer period after it has been installed, the same measures as mentioned above in *Chapter 2.5.1 Short term storage (less than 2 months)* should be applied. Remember to rotate the shaft 10 revolutions at least every 3 months, and that self-lubricated bearings must be filled with oil. If external vibration is present, the shaft coupling should be opened and suitable rubber blocks should be placed under the feet of the machine.

NOTE: External vibration will damage the bearing rolling surfaces and therefore shorter the bearing lifetime.

Chapter 4 Mechanical and Electrical Connections

4.1 General

Mechanical and electrical connections are made after the installation and alignment procedures. The mechanical connections include the connection of air ducts, water tubes and/or oil supply system where applicable.

The electrical connections include the connection of main and auxiliary cables, earthing cables and possible external blower motors.

In order to determine proper actions, please read the Dimensional Drawing, the Connection Diagram and the Data Sheet provided with the machine.

NOTE: Additional installation holes or threads should never be drilled through the frame, as this may damage the machine.

4.2 Electrical connections

4.2.1 General information

The safety information in *Safety Instructions* at the beginning of the manual must be observed at all times.

The electrical installation should be thoroughly planned before taking any action. The connection diagrams received with the machine have to be studied before starting the installation work. It is important to verify that the supply voltage and the frequency are the same as the values indicated on the rating plate of the machine.

The network voltage and frequency should be within given limits according to the applicable standard. Note rating plate markings and connection diagram in the terminal box. For additional information, see the machine performance data sheet.

NOTE: Prior to installation work, it is important to check that the incoming cables are separated from the supply network, and that the cables are connected to protective earth.

NOTE: Check all rating plate data, especially the voltage and winding connection.

4.2.2 Safety

Electrical work must be carried out only by skilled persons. The following safety rules must be applied:

- De-energize all equipment, including auxiliary equipment
- Provide safeguard against re-energizing the equipment
- Verify that all parts are isolated from their respective supply
- Connect all parts to protective earth and short the circuits
- Cover or provide barriers against live parts in the surrounding area

- If the secondary circuit of the current transformer is extended, make sure that it does not become open-circuited in use

4.2.3 Insulation resistance measurements

Before a machine 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, see *Chapter 7.6.4 Insulation resistance test.*

4.2.4 Main terminal box options

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- and watertight manner.

The main terminal box is equipped with a drain plug at the lowest part of the box. The plug should be in open position, i.e. half of the plug is inside and half of the plug is outside, during transportation and storage. During operation of the machine, the plug should be kept in shut position but opened from time to time. If the box is turned after delivery the drain plug function must be checked, and possibly re-positioned at the lowest part of the box.

Some main terminal boxes can be turned in 90 degrees steps. Before turning, check that the length of the cables between the stator winding and the terminal box is sufficient.

4.2.4.1 Delivery without main terminal box

If the machine is delivered without a main terminal box, the stator connection cables have to be covered with earthed protective structure before commissioning. The structure must have the same or higher enclosure classification and hazardous area certifications as the machine.

To avoid cable failure, stator connection cables must be shortened to minimize free movement of the cables. The supplier of the terminal arrangement is responsible for ensuring that adequate stator connection cable supports are used. The stator connection cable arrangement has to be spacious in order to avoid overheating of the cables. Stator connection cables must not touch sharp corners. The minimum bending radius of stator connection cable is 6 times the cable outer diameter.

4.2.5 Insulation distances of main power connections

The connections of the main power cables must be designed to withstand demanding operation conditions where the insulators can be subjected to dirt, humidity and surge voltages. In order to ensure lasting and trouble-free running, it is therefore important that the length of the insulation and creepage distances are sufficient. The minimum insulation and creepage distances should be equal or exceed demands set by:

- Local requirements
- Standards
- Classification rules
- Hazardous area classification.

The insulation and creepage distances apply both for insulation distances between two different phases, and for insulation distances between one phase and earth. The air insulation distance is

the shortest distance through air between two points with different electrical potential (voltage). The surface creepage distance is the shortest distance along surfaces next to each other between two points with different electrical potential (voltage).

4.2.6 Main power cables

The size of the input cables has to be adequate for the maximum load current and in accordance with local standards. The cable terminals have to be of appropriate type and of correct size. The connection to all devices has to be checked.

The main power cable connections should be tightened correctly to ensure reliable operation. For details, see *Appendix Typical main power cable connections.*

NOTE: For Ex-machines, cable glands or cable bushings for supply cables must be Ex certified. Glands or bushings are not included in the manufacturer's delivery.

NOTE: Prior to installation work, it is important to check that the incoming cables are separated from the supply network, and that the cables are connected to protective earth.

The stator terminals are marked with letters U, V and W according to IEC 60034-8 or T1, T2, and T3 according to NEMA MG-1. The neutral terminal is marked with N (IEC) or with T0 (NEMA). Stripping, splicing and insulating of the high-voltage cables must be performed in accordance with instructions by the cable manufacturer.

The cables must be supported so that no stress is applied to the bus bars in the terminal box.

NOTE: Check the phase sequence from the connection diagram.

4.2.7 Auxiliary terminal box

Auxiliary terminal boxes are attached to the frame of the machine according to accessories and customer needs, and their positions are shown on the dimensional drawing of the machine.

The auxiliary terminal boxes are equipped with terminal blocks and cable glands, see *Figure 4-1 Typical auxiliary terminal box.* The maximum size of the conductors is normally limited to 2.5 mm^2 (0.004 sq. in.), and the voltage is limited to 750 V. The cable glands are suitable for cables of 10 – 16 mm (0.4"– 0.6") diameter.

NOTE: For Ex-machines, cable glands or cable bushings for supply cables must be Ex certified. Glands or bushings are not included in manufacturer's delivery.

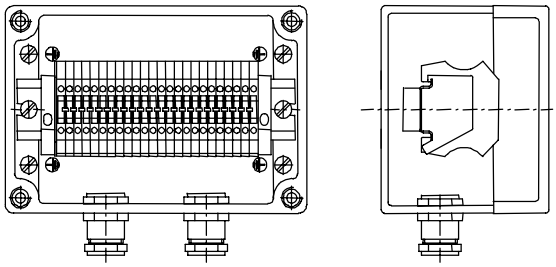


Figure 4-1 Typical auxiliary terminal box

4.2.7.1 Connection of auxiliaries and instruments

Connect the instruments and auxiliary equipment according to the connection diagram.

NOTE: Study the connection diagram delivered with the machine carefully before connecting any cables. The connection and functioning of accessories must be checked before commissioning.

NOTE: Label terminals of accessories, which are normally under voltage when the machine is switched off, correspondingly.

4.2.7.2 Connection of external blower motor

The external blower motor is normally a three phase asynchronous motor. A connection box is usually located on the frame of the blower motor. The external blower motor rating plate shows the voltage and frequency to be used. The direction of rotation of the fan is indicated by an arrow plate on the flange of the main machine.

NOTE: Check visually the direction of rotation of the external blower motor (fan) before starting the main machine. If the blower motor is running in the wrong direction, the phase sequence of the blower motor must be changed.

4.2.8 Earth connections

The machine frame, main terminal box, auxiliary terminal box and associated equipment must be connected to protective earth. The connections to protective earth and power supply have to be able to protect the machine frame from harmful or dangerous electrical potential (voltage).

NOTE: The earthing must be carried out according to local regulations before the machine is connected to the supply voltage.

NOTE: The warranty does not cover destroyed bearings due to improper earthing or cabling.

Mark the machine and terminal boxes with earth symbols according to relevant national standards.

4.2.9 Requirements for machines fed by frequency converters

In compliance with the EMC directive (89/336/ EEC, as amended by 93/68/EEC) it is required that an AC machine fed with frequency converter is installed with screened cables as specified below. For information on other equivalent cables, please contact your local ABB representative.

4.2.9.1 Main cable

The main supply cable between the machine and the frequency converter must be a symmetrical three conductor screened cable in order to fulfil the radiated emission requirements stated in the generic emission standard for industrial environment, EN 50081-2. For further information, see ABB manual *Grounding and cabling of the drive system (3AFY 61201998 R0125 REV A).*

4.2.9.2 Earthing of main cable

The compliance with EMC directive requires high-frequency earthing of the main cable. This is achieved by a 360° earthing of the cable screens at the cable entries in both the machine and in the frequency converter. The earthing at the machine is implemented for example by means of the EMC ROX SYSTEM cable transits for shielded installations.

NOTE: 360° high-frequency earthing of cable entries is made in order to suppress electromagnetic disturbances. In addition, cable screens have to be connected to protective earth (PE) in order to meet safety regulations.

4.2.9.3 Auxiliary cables

The auxiliary cables must be screened to meet the EMC requirements. Special cable glands must be used for the 360° high-frequency earthing of the cable screens at the cable entries.

Chapter 5 Commissioning and Start-up

5.1 General

A commissioning report is a vital tool for future service, maintenance and fault finding.

The commissioning is not to be considered finalized before an acceptable commissioning report has been documented and filed.

The commissioning report has to be available in warranty requests in order to obtain warranty for the machine. For contact information, see *Chapter 9.1.5 After Sales contact information.*

The recommended commissioning report can be found in *Appendix COMMISSIONING REPORT*.

5.2 Check of mechanical installation

Check alignment of the machine prior to commissioning:

- Go through the alignment report and ensure that the machine is accurately aligned according to ABB alignment specifications in *Chapter 3.6 Alignment*
- The alignment protocol should always be included in the commissioning report

Check that the machine is properly anchored to the foundation:

- Check for cracks in the foundation and the general condition of the foundation
- Check the tightness of the mounting bolts.

Additional checks, when applicable:

- Check that the lubrication system is commissioned and is running before the rotor is turned
- If possible, turn the rotor by hand and make sure that the rotor turns freely and that no abnormal sound can be heard
- Check the assembly of the main terminal box and cooling system
- Check the connection of oil and cooling water pipes and check for leaks when running
- Check pressure and flow for oil and cooling water.

5.3 Insulation resistance measurements

Before a machine 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, see *Chapter 7.6.4 Insulation resistance test.*

5.4 Check of electrical installation

The power cables can be permanently connected to the terminals in the main terminal box when the stator insulation resistance has been measured, see *Chapter 7.6.4 Insulation resistance test.*

Check connection of power cables:

- Check that the cable lug bolts are tightened with proper torque

- Check that the power cables are suitably routed
- Check that the power cables are stress-relieved in a proper way
- Check the connections of the auxiliary equipment.

NOTE: If the machine is delivered without a main terminal box, see *Chapter 4.2.4.1 Delivery without main terminal box*.

NOTE: If an anti-condensation heater, without self-regulation, is turned on immediately after the motor is shut down, take suitable measures to control the inside motor housing temperature. The anti-condensation heaters can only operate within a temperature-controlled environment.

5.5 Control and protection equipment

5.5.1 General

The machine is equipped with temperature detectors to be connected to a temperature monitoring and protection system. The location and type, as well as the settings for these detectors, can be found on the dimensional drawing, and the connection diagram of the machine.

The temperature alarm level for resistance temperature detectors (RTD, Pt-100) should be set as low as possible. The level can be determined based on the test results, or the noticed operating temperature. The temperature alarm can be set 10K (20°F) higher than the operating temperature of the machine during maximal load at highest ambient temperature.

If a two-function temperature monitoring system is used, the lower level is normally used as an alarm level and the higher as a trip level.

NOTE: In case the machine trips, the reason must be found and eliminated before the machine is restarted. In case of an alarm, find the reason and correct the situation. Use the trouble shooting guide, see *Chapter 8.1 Trouble shooting*.

5.5.2 Stator winding temperature

5.5.2.1 General

The stator windings are manufactured according to temperature rise class F, which has a temperature limit of 155°C (300°F). A high temperature will age the insulation and shorten the lifetime of the winding. Therefore, thorough consideration should be made when deciding the temperature trip and alarm levels for the winding.

5.5.2.2 Resistance temperature detectors

Recommended maximum temperature settings:

For determining the temperature settings, see the Connection Diagram delivered with the machine. It is recommended to apply the method described in *Chapter 5.5.1 General* when setting the temperature alarm.

5.5.2.3 Thermistors

If the machine is equipped with thermistors (PTC), the operating temperature of the thermistors is found on the Connection Diagram. The operating function can be chosen to be an alarm or a trip signal. If the machine is equipped with six thermistors, both alarm and trip signals can be used respectively.

5.5.3 Bearing temperature control

5.5.3.1 General

The bearings can be equipped with temperature detectors for monitoring the bearing temperatures. The viscosity of the grease or oil used will become smaller as a function of higher temperature. When the viscosity falls below a certain limit, the ability to form a lubricating film inside the bearing will cease, and the bearing will fail, and possibly, shaft damage will occur as a result.

If the machine is equipped with resistance temperature detectors, the temperature of the bearings should preferably be monitored continuously. If the temperature of a bearing unexpectedly starts to rise, the machine should be shut down immediately, as the temperature rise might indicate a bearing failure.

5.5.3.2 Resistance temperature detectors

Recommended maximum temperature settings:

For determining the temperature settings, see the Connection Diagram delivered with the machine. It is recommended to apply the method described in *Chapter 5.5.1 General* when setting the temperature alarm.

5.5.3.3 Thermistors

If the rolling bearings are equipped with thermistors (PTC), the operating temperature of the thermistors is found on the Connection Diagram. The operating function can be chosen to be an alarm or a trip signal. If the rolling bearings are equipped with two thermistors, both alarm and trip signals can be used respectively.

5.5.4 Protection equipment

The machine has to be protected against various disturbances, faults and overloading that might damage the machine. The protection must be in accordance with the instructions and regulations for each country where the machine is used.

The machine parameter values for relay settings are informed in the document “Performance data of machine” which is included in the documentation provided with the machine.

NOTE: The machine manufacturer is not responsible for the adjusting the protection equipment at the site.

5.6 First test start

5.6.1 General

The first test start is a standard procedure after the installation and alignment procedure is finished, the mechanical and electrical connections are made, the commissioning procedure is gone through and the protective devices are active.

NOTE: If possible, the first start is made with uncoupled coupling between the driving and driven machine. The load on the machine must in any case be as small as possible.

5.6.2 Precautions before first test start

A visual inspection of the machine and its equipment is made before the first test start. It is verified that all necessary tasks, checking and adjustments have been performed.

Before the test start, the following checks and measures must be made:

- If the coupling half is not assembled, the shaft extension key is either locked or removed
- The rotor is turned by hand, and it is verified that no abnormal noises are heard from the bearings. To turn a rotor with sleeve bearings, a simple lever arm is needed
- The cabling, cables and bus bar connections are verified to be according to the connection diagram
- The earth connections and earthing devices are verified
- The starting, control, protection, and alarm relays of each device are inspected
- The insulation resistance of the windings and other equipment verified
- The machine covers are assembled, and the shaft seals are tightly fitted in
- The machine and the environment are cleaned

5.6.3 Starting

The first start should last only about one (1) second, during which the direction of rotation of the machine is verified. The direction of rotation of possible external blower motors must also be verified. It is also verified that the rotating parts do not touch any stationary parts.

NOTE: If the machine does not have an axially locating bearing, and the machine is started uncoupled, it is normal that the shaft will move axially before stabilizing.

5.6.3.1 Direction of rotation

The objective of the first starting is to check the direction of rotation of the machine. The machine should turn in the same direction as is shown with an arrow located on the frame or the fan cover. The direction of rotation of the external blower motor is indicated by an arrow near the blower motor. The machine may only be operated in the specified direction of rotation. The direction of rotation is indicated on the marking plate, see *Appendix Typical position of plates*.

Machines suitable for reversing operation are labelled with a double-headed arrow on the rating plate, as well as on the frame.

If the desired direction of rotation for some reason is different from the one specified on the machine, the cooling fans, in inner and/or outer cooling circuit, must be changed, as well as the stamp on the rating plate.

To alter the direction of rotation, interchange the power supply phases.

5.7 Running the machine the first time

After a successful first test start, the coupling between the driving and driven machine should be coupled, and the machine can be restarted.

5.7.1 Supervision during the first run

During running the machine the first time, it is verified that the machine functions as expected. The vibration level, the temperature of the windings and bearings, and other equipment are monitored frequently. If the machine functions as expected, the machine can be left running for a longer time.

Check the operating load of the machine by comparing the load current with the value given on the rating plate of the machine.

Record the temperature readings given by the temperature detectors placed in the windings and possibly in the bearings. Check the temperatures frequently to ensure that they remain below the limits. Continuous temperature monitoring is recommended.

NOTE: If resistance temperature detector (RTD, Pt-100) or equivalent is not available, the surface temperature of the bearing area shall, if possible, be measured. The bearing temperature is approximately 10°C (20°F) higher than the surface temperature.

In case of any deviations from expected normal operation, e.g. elevated temperatures, noise or vibration, shut down the machine, and find the reason for the deviations. If necessary, consult the manufacturer of the machine.

NOTE: Do not disengage any protective devices during running of the machine, or during search for a reason for unexpected function of the machine.

5.7.2 Checks during running of the machine

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

5.7.3 Bearings

The rotating electrical machines manufactured by ABB are equipped with either rolling or sleeve bearings.

5.7.3.1 Machines with rolling bearings

In case of a newly installed machine or a machine, 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 machine is running, and is injected until old grease or excess new grease is discharged through the lubrication channel in the bottom of the bearing housing, see *Figure 5-8 Example of lubrication channel through bearing arrangement of horizontal machine*.

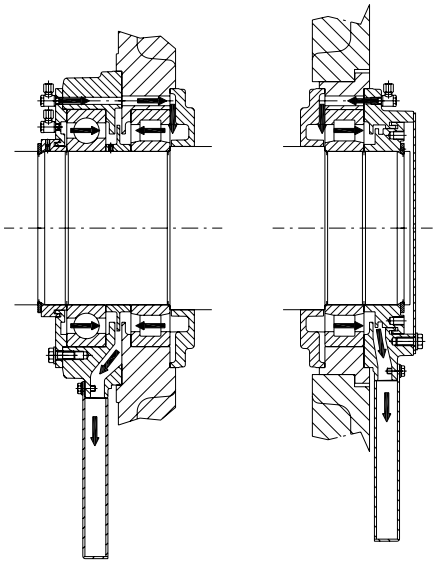


Figure 5-8. Example of lubrication channel through bearing arrangement of horizontal machine

NOTE: The re-lubrication interval will never be longer than 12 months.

The type of original grease used is found on the bearing plate on the machine. Acceptable types of grease can be found in *Chapter 7.5.1 Rolling bearings*.

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

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

5.8.1 Vibrations

For a comprehensive discussion on vibrations, see *Chapter 7.4.2 Vibration and noise*.

5.8.2 Temperature levels

The temperatures of the bearings, stator windings and cooling air should be checked when the machine is running.

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 machine. 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.

Recommended settings for alarm and trip levels see main connection diagram and *Chapter 7.4.3.3 Evaluation*.

5.9 Shut down

The shutdown of the machine depends on the application, but main guidelines are:

- Reduce the load of the driven equipment, if applicable
- Open the main breaker
- Switch possible anti condensation heaters on, if not automatically done by switch gear

Chapter 6 Operation

6.1 General

To ensure trouble-free running a machine must be looked after and carefully supervised.

Always before starting up the machine ensure that:

- The bearings are greased or filled with oil to a correct level in accordance with the manufacturer's technical specifications and the dimensional drawing
- The cooling system is functioning
- The machine enclosure has been purged and is pressurized if applicable
- No maintenance is ongoing
- The personnel and equipment associated with the machine are ready to start up the machine.

For start-up procedure, see *Chapter 5.6.3 Starting*.

In case any deviations from expected normal operation are noticed, e.g. elevated temperatures, noise or vibration, shut down the machine, and find the reason for the deviations. If necessary, consult the manufacturer of the machine.

NOTE: The machine may have hot surfaces when running with load.

6.2 Normal operating conditions

The machines manufactured by ABB are individually designed to operate in normal operation conditions according to the IEC or NEMA standards, customer specifications and internal ABB standards.

The operation conditions, such as maximum ambient temperature and maximum operating height, are specified in the performance data sheet delivered as a part of the project documentation. The foundation shall be free from external vibration, and the surrounding air shall be free of dust, salt and corrosive gases or substances

NOTE: The safety precautions shown in *Safety Instructions* at the beginning of the manual must be observed at all times.

6.3 Number of starts

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

For information on the allowed consecutive or annual starts, please see the performance data sheet or consult the manufacturer. The load characteristics of the application are needed for determining the starting frequency. As a guideline, the maximum number of starts in a typical application is 1000 starts per year.

A counter system for controlling the number of starts should be used and maintenance intervals should be determined based on equivalent operating hours, see *Chapter 7.3 Maintenance program*.

NOTE: The safety precautions shown in the *Safety Instructions* at the beginning of the manual must be observed at all times.

6.4 Supervision

The operating personnel should inspect the machine at regular intervals. This means that they should listen, feel and smell the machine and its associated equipment in order to obtain a feeling for normal operating condition.

The object of the supervision inspection is to familiarize the personnel with the equipment. This is essential in order to detect and fix abnormal occurrences in time.

The difference between supervision and maintenance is rather diffuse. Normal supervision of operation includes logging of operating data such as load, temperatures and vibrations. This data is useful basis for maintenance and service.

- During the first period of operation (- 200 hours) supervision should be intensive. Temperatures of bearings and windings, load, current, cooling, lubrication and vibration shall be checked frequently
- During the following duty period (200 - 1000 hours), a check-up once a day is sufficient. A record of supervision inspections should be filed and saved for further reference. The time between inspections may be extended if the operation is continuous and stable.

For relevant check-lists, see *Appendix COMMISSIONING REPORT*.

6.4.1 Bearings

The bearing temperatures and lubrication should be monitored closely, see *Chapter 5.7.3 Bearings.*

6.4.2 Vibrations

The vibration levels of the driving-driven machine system should be monitored, see *Chapter 7.4.3 Vibrations*.

6.4.3 Temperatures

The temperatures of the bearings, stator windings and cooling air should be checked when the machine is running, see *Chapter 5.8.2 Temperature levels.*

6.5 Follow-up

The follow-up of operation includes logging of operating data such as load, temperatures and vibrations. This data is useful basis for maintenance and service.

6.6 Shut down

When the machine is not in operation, anti-condensation heaters have to be switched on where applicable. This is to avoid condensation effect inside the machine.

NOTE: Voltage may be connected to the terminal box for heating element.

Chapter 7 Maintenance

7.1 Preventive 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.

The purpose of maintenance is therefore to:

- Secure that the machine will function reliably without any unforeseen actions or interventions
- Estimate and plan service actions in order to minimize down time.

The difference between supervision and maintenance is rather diffuse. Normal supervision of operation and maintenance includes logging of operating data such as load, temperatures, vibrations, as well as verification of the lubrication, and measurement of the insulation resistances.

After commissioning or maintenance, the supervision should be intensive. Temperature of bearings and windings, load, current, cooling, lubrication and vibration shall be checked frequently.

This chapter presents recommendations regarding maintenance program, and work instructions how to conduct common maintenance tasks. These instructions and recommendations should be read carefully and be used as a basis when planning the maintenance program. Note that the maintenance recommendations presented in this chapter represent a minimum level of maintenance. By intensifying maintenance and supervision activities, the reliability of the machine and the long-term availability will increase.

The data obtained during supervision and maintenance is useful for estimating and planning additional service. In case some of this data indicates something out of the ordinary, the trouble shooting guides in *Chapter 8 Trouble Shooting*, will aid in locating the reason for the trouble.

ABB recommends the use of experts in the creating maintenance programs, as well as in performing the actual maintenance and possible trouble shooting. The ABB After Sales organization is happy to assist in these issues. The ABB After Sales contact information can be found in *Chapter 9.1.5 After Sales contact information*.

An essential part of the 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. Ready-made spare part packages can be obtained from the ABB After Sales, see *Chapter 9.1.2 Spare Parts*.

7.2 Safety precautions

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. This should be made according to instructions of the security personnel.

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

Machines for hazardous areas are specially designed to comply with official regulations concerning the risk of explosion. If improperly used, badly connected, or altered, no matter how minor, their reliability could be in doubt.

Standards relating to the connection and use of electrical apparatus in hazardous areas must be taken into consideration, especially national standards for installation (see standards: IEC 60079-14, IEC 6000-17 and IEC 6007-19). Only trained personnel familiar with these standards should handle this type of apparatus.

Disconnect and lock out before working on the machine or the driven equipment. Ensure that no explosive atmosphere is present while the work is in progress.

For general safety instructions, see *Safety Instructions* at the beginning of the manual.

NOTE: The terminals of a machine with frequency converter supply may be energized even when the machine is at standstill.

7.3 Maintenance program

This chapter presents a recommended maintenance program for ABB machines. This maintenance program is of a general nature, and should be considered as a minimum level of maintenance. Maintenance should be intensified when local conditions are demanding or very high reliability is required. It should also be noted that even when following this maintenance program, normal supervision and observation of the machine's condition is required.

Please note that even though the maintenance programs below have been customized to match the machine, it might contain references to accessories not available on all machines.

The maintenance program is based on four levels of maintenance, which rotate according to operating hours. The amount of work and down time vary, so that level 1 includes mainly quick visual inspections and level 4 more demanding measurements and replacements. More information about the spare part packages suitable for these maintenances can be found in *Chapter 9.2 Spare parts for rotating electrical machines*. The recommended maintenance interval can be seen in *Table 7-1 Maintenance intervals*. The operation hour recommendation in this chapter is given as equivalent operating hours (Eq. h), that can be counted by the following formula:

Equivalent operating hours (Eq. h) = Actual operating hours

Equivalent operating hours (Eq. h) = Actual operating hours + Number of starts x 20

Level 1 (L1)

Level 1 or L1 maintenance consists of visual inspections and light maintenance. The purpose of this maintenance is to do a quick check whether problems are beginning to develop before they cause failures and unscheduled maintenance breaks. It gives also suggestions what maintenance issues must be performed in the next lager overhaul.

The maintenance can be estimated to last approximately 4 - 8 hours, depending on the type and installation of the machine and the depth of the inspections. Tools for this maintenance include normal servicing tools i.e. wrenches and screw drives. The preparations consist of opening the inspection covers. It is recommended that at least the Operational spare part package is available when commencing this maintenance. The packages are shown in *Chapter 9.2.5 Typical recommended spare parts in different sets*.

The first Level 1 maintenance should be performed after 4 000 equivalent operating hours or six months after commissioning. Subsequently the L1 maintenance should be performed yearly halfway between Level 2 maintenances, see *Table 7-1 Maintenance intervals*.

Level 2 (L2)

Level 2 or L2 maintenance consists mainly of inspections and tests and small maintenance tasks. The purpose of this maintenance is to find out whether there are problems in the operation of the machine and to do small repairs to ensure uninterrupted operation.

The maintenance can be estimated to last approximately 8 - 16 hours, depending on the type and installation of the machine and the amount of servicing to be done. Tools for this maintenance include normal servicing tools, multi meter, torque wrench and insulation resistance tester. The preparations consist of opening the inspection covers and bearings if necessary. Spare parts suitable for this level of maintenance are included in the Operational spare part package. The packages are shown in *Chapter 9.2.5 Typical recommended spare parts in different sets*

The first Level 2 maintenance should be performed after 8 000 equivalent operating hours or one year after commissioning. Subsequently the L2 maintenance should be performed yearly or after every 8 000 equivalent operating hours, see *Table 7-1 Maintenance intervals*.

Level 3 (L3)

Level 3 or L3 maintenance consists of performing extensive inspections, tests and larger maintenance tasks that have come up during L1 and L2 maintenances. The purpose of this maintenance is to repair encountered problems and replace parts subjected to wear.

The maintenance can be estimated to last approximately 16 - 40 hours, depending on the type and installation of the machine and the amount of repairs and replacements to be done. Tools for this maintenance include the same tools as for L2 and in addition an endoscope and an oscilloscope. The preparations consist of opening the inspection covers, the bearings and the water cooler, if applicable. Spare parts suitable for this level of maintenance are included in the Recommended spare parts package. The packages are shown in *Chapter 9.2.5 Typical recommended spare parts in different sets*.

The Level 3 maintenance should be performed after every 24 000 equivalent operating hours or at a three to five year interval. When L3 maintenance is conducted it replaces the L1 or L2 maintenance otherwise scheduled, and it leaves their rotation unaffected, see *Table 7-1 Maintenance intervals*.

Level 4 (L4)

Level 4 or L4 maintenance consists of performing extensive inspections and maintenance tasks. The purpose of this maintenance is to restore the machine into a reliable operating condition.

The maintenance can be estimated to last approximately 40 - 80 hours, depending mostly on the condition of the machine and the needed reconditioning actions. Tools for this maintenance include the same tools as for L3, and in addition, the rotor removal equipment. The preparations consist of opening the inspection covers, bearings and water cooler, if applicable, and the removal of rotor.

The amount of spare parts required for this level of maintenance needs to be determined before the maintenance. At least the Recommended spare part is needed. Spare parts included in the capital spare part package would ensure a fast and successful execution of this maintenance.

The Level 4 maintenance should be performed after every 80 000 equivalent operating hour. When a L4 maintenance is conducted it replaces the L1, L2 or L3 maintenance otherwise scheduled, and it leaves their rotation unaffected, see *Table 7-1 Maintenance intervals*.

7.3.1 Recommended maintenance program

Abbreviation used in maintenance program:

- V = Visual checking
- C = Cleaning
- D = Disassembling and assembling
- R = Reconditioning or replacement
- T = Testing and measurement.

Not all options are applicable for all machines.

Table 7-1. Maintenance intervals

Maintenance object	**MAINTENANCE INTERVAL** In equivalent operating hours or time period, which ever comes first				
	L1	**L2**	**L3**	**L4**	
	4 000 Eq. h 12 000 Eq. h 20 000 Eq. h 28 000 Eq. h	8 000 Eq. h 16 000 Eq. h	24 000 Eq.h	80 000 Eq.h	
	½ year	Annual	3-5 years	Overhaul	**Check / Test**

7.3.1.1 General construction

Maintenance object	L1	L2	L3	L4	Check / Test
Machine operation	V / T	V / T	V / T	V / T	Starting, shut down, vibration measurement, no-load point
Mounting and foundation	V	V / T	V / T	V / T / D	Cracks, rust, alignment
Exterior	V	V	V	V	Rust, leakage, condition
Fastenings	V	V / T	V / T	V / T	Tightness of all fastenings
Anchor bolts	V	V	V / T	V / T	Fastening, condition

Main supply connection

Maintenance object	L1	L2	L3	L4	Check / Test
High voltage cabling	V	V / T	V / T	V / T / D	Wear, fastening
High voltage connections	V	V / T	V / T	V / T / D	Oxidation, fastening

Maintenance object	L1	L2	L3	L4	Check / Test
Terminal box accessories, i.e. surge capacitors, arrestors and current transformers	V	V	V	V	General condition
Cable transits	V	V	V	V	Condition of cables entering the machine and inside the machine

7.3.1.2 Stator and rotor

Maintenance object	L1	L2	L3	L4	Check / Test
Stator core	V	V	V	V / C	Fixing, cracks, welds
Stator winding insulation	V	V / T	V / T / C	V / T / C	Wear, cleanliness, insulation resistance, turn insulation test, (high voltage test)
Stator coil over hangs	V	V	V	V	Insulation damages
Stator coil supports	V	V	V	V	Insulation damages
Stator slot wedges	V	V	V	V	Movement, tightness
Stator terminal bars	V	V	V	V	Fixing, insulation
Instrumentation	V	V	V	V	Condition of cables and cable ties
Rotor winding insulation	V	V / T	V / T / C	V / T / C	Wear, cleanliness, insulation resistance
Rotor balancing weights	V	V	V	V	Movement
Shaft	V	V	V	V	Crack, corrosion
Connections in rotor	V	V	V / T	V / T	Fixing, general condition
Earthing brushes	V	V	V	V	Operation and general condition

NOTE: It is not recommended that totally enclosed machines are dismantled and inspected internally more often than every 3-5 years (L3).

7.3.1.3 Auxiliaries

Maintenance object	L1	L2	L3	L4	Check / Test
Pt-100 elements (stator, cooling air, bearing)	V	V / T	V / T	V / T	Resistance
Anticondensation heaters	V	V / T	V / T	V / T	Operation, insulation resistance
Encoders	V	V	V / T	V / T	Operation, general condition, alignment
Auxiliary terminal boxes	V	V / T	V / T	V / T	General condition, terminals, wiring condition

7.3.1.4 Lubrication system and bearings

Maintenance object	L1	L2	L3	L4	Check / Test
Bearing during operation	T	T	T / R	T / R	General condition, extra noise, vibration
Waste grease	V	V / C	V / C	V / C	Condition, purging
Re-greasing	V	V / R	V / R	V / R	According to bearing plate
Seals	V	V / D	V / D	V / D	Leakage
Bearing insulation	V / C	V / C	V / C / T	V / C / T	Endshield cleanliness, insulation resistance

7.4 Maintenance of general constructions

To ensure a long life span for the general construction of the machine, the machine exterior should be kept clean and should periodically be inspected for rust, leaks and other defects. Dirt on the machine exterior exposes the frame to corrosion and can affect the cooling of the machine.

7.4.1 The tightness of fastenings

The tightness of all fastenings should be verified regularly. Special focus should be given to the grouting, the anchor bolts and the rotor parts, which must remain correctly tightened at all times. Loose fastening in these parts can lead to sudden and severe damage to the entire machine.

General values for tightening torques are presented in *Table 7-2 General tightening torques.*

Table 7-2. General tightening torques

	Tightening torque in Nm (pound-feet) Property class 8.8 for bolts			
Size	Oiled [Nm]	Oiled [pound feet]	Dry [Nm]	Dry [pound feet]
M 4	2.7	2.0	3.0	2.2
M 5	5.0	3.7	5.5	4.1
M 6	9	6.6	9.5	7.0
M 8	22	12	24	18
M 10	44	32	46	34
M 12	75	55	80	59
M 14	120	88	130	96
M 16	180	130	200	150
M 20	360	270	390	290
M 24	610	450	660	490
M 27	900	660	980	720
M 30	1200	890	1300	960
M 36	2100	1500	2300	1700
M 39	2800	2100	3000	2200
M 42	3400	2500	3600	2700
M 48	5200	3800	5600	4100

NOTE: The values in *Table 7-2 General tightening torques* are general, and do not apply to various items, such as diodes, support insulators, bearings, cable terminals or pole fastenings, bus bar terminals, surge arrestors, capacitors, current transformers, rectifier and thyristor bridges, or if some other value is given elsewhere in this manual.

7.4.2 Vibration and noise

High or increasing vibration levels indicate changes in the machine's condition. Normal levels vary greatly depending on the application, type and foundation of the machine. The vibration measurements and levels are discussed in detail in *Chapter 7.4.3 Vibrations*. Some typical reasons that might cause high noise or vibration levels are:

- Alignment, see *Chapter 3 Installation and Alignment*
- Bearing wear or damage
- Vibration from connected machinery, see *Chapter 7.4.3 Vibrations*

- Loose fastenings or anchor bolts, see *Chapter 3 Installation and Alignment*
- Rotor imbalance
- Coupling.

7.4.3 Vibrations

The following instructions are part of the following two ISO standards: ISO 10816-3:1998 Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts: Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ and ISO 8528-9:1995 Reciprocating internal combustion engine driven alternating current generating sets: Part 9: Measurement and evaluation of mechanical vibrations.

7.4.3.1 Measurement procedures and operational conditions

Measurement equipment

The measurement equipment shall be capable of measuring broad-band r.m.s. vibration with flat response over a frequency range of at least 10 Hz to 1 000 Hz, in accordance with the requirements of ISO 2954. Depending on the vibration criteria, this may require measurements of displacement or velocity or combinations of these (see ISO 10816-1). However, for machines with speeds approaching or below 600 r/min, the lower limit of the flat response frequency range shall not be greater than 2 Hz.

Measurement locations

Measurements will usually be taken on exposed parts of the machine that are normally accessible. Care shall be taken to ensure that measurements reasonably represent the vibration of the bearing housing and do not include any local resonances or amplification. The locations and directions of vibration measurements shall be such that they provide adequate sensitivity to the machine dynamic forces. Typically, this will require two orthogonal radial measurement locations on each bearing cap or pedestal, as shown in *Figure 7-1 Measuring points*. The transducers may be placed at any angular position on the bearing housings or pedestals. Vertical and horizontal directions are usually preferred for horizontally mounted machines. For vertical or inclined machines, the location that gives the maximum vibration reading, usually in the direction of the elastic axis, shall be one of those used. In some cases it may be recommended to measure also in the axial direction. The specific locations and directions shall be recorded with the measurement.

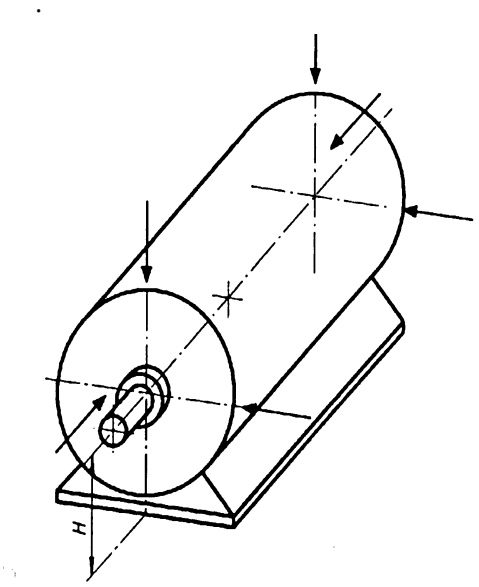


Figure 7-1 Measuring points

7.4.3.2 Classification according to support flexibility

Two conditions are used to classify the support assembly flexibility in specified directions:

- rigid supports
- flexible supports

These support conditions are determined by the relationship between the machine and foundation flexibilities. If the lowest natural frequency of the combined machine and support system in the direction of measurement is higher than its main excitation frequency (this is in most cases the rotational frequency) by at least 25 %, then the support system may be considered rigid in that direction. All other support systems may be considered flexible.

7.4.3.3 Evaluation

ISO 10816-1 provides a general description of the two evaluation criteria used to assess vibration severity on various classes of machines. One criterion considers the magnitude of observed broad-band vibration; the second considers changes in magnitude, irrespective of whether they are increases or decreases.

Evaluation zones

The following evaluation zones are defined to permit a qualitative assessment of the vibration of a given machine and provide guidelines on possible actions.

Zone A: The vibration of newly commissioned machines would normally fall within this zone.

Zone B: Machines with vibration within this zone are normally considered acceptable for unrestricted long-term operation.

Zone C: Machines with vibration within this zone are normally considered unsatisfactory for long-term continuous operation. Generally, the machine may be operated for a limited period in this condition until a suitable opportunity arises for remedial action.

Zone D: Vibration values within this zone are normally considered to be of sufficient severity to cause damage to the machine.

Operational limits

For long-term operation, it is common practice to establish operational vibration limits. These limits take the form of ALARMS and TRIPS.

Setting of ALARMS

The ALARM values may vary considerably, up or down, for different machines. The values chosen will normally be set relative to a baseline value determined from experience for the measurement position or direction for that particular machine.

It is recommended that the ALARM value should be set higher than the baseline by an amount equal to 25 % of the upper limit for zone B. If the baseline is low, the ALARM may be below zone C.

Setting of TRIPS

The TRIP values will generally relate to the mechanical integrity of the machine and be dependent on any specific design features which have been introduced to enable the machine to withstand abnormal dynamic forces. The values used will, therefore, generally be the same for all machines of similar design and would not normally be related to the steady-state baseline value used for setting ALARMS.

Table 7-3. Classification of vibration severity zones for large machines with rated power above 300 kW and not more than 50 MW; electrical machines with shaft height H/315 mm or higher

Support class	Zone boundary	R.m.s. velocity [mm/s]
Rigid	A/B B/C C/D	2.3 4.5 7.1
Flexible	A/B B/C C/D	3.5 7.1 11.0

7.5 Maintenance of bearings and lubrication system

This chapter covers the most important maintenance tasks in the bearings and in the lubrication system.

7.5.1 Rolling bearings

7.5.1.1 Bearing construction

In normal operating conditions, rolling bearings require little maintenance. To ensure reliable operation, the bearings should be regularly re-greased with high-quality rolling bearing grease.

7.5.1.2 Bearing plate

All machines are supplied with bearing plates attached to the machine frame. The bearing plates provide bearing information, such as:

- Bearing type
- Lubricant used
- Re-greasing interval, and
- Re-greasing amount.

For more details regarding the bearing plate, see *Chapter 2.1.2 Bearing plate*.

NOTE: It is essential that the information provided on the bearing plate is taken into account when using and maintaining the machine.

7.5.1.3 Re-greasing intervals

Rolling bearings of electrical machines need to be re-greased at regular intervals. The re-greasing interval is found on the bearing plate.

NOTE: Regardless of the re-greasing interval, the bearings need to be re-greased at least once per year.

The re-greasing intervals are calculated for an operating temperature of 70°C (160°F). If the operating temperature is lower or higher than the assumed, the re-grease interval has to be altered accordingly. Higher operating temperature decreases the re-greasing interval.

NOTE: An increase in the ambient temperature raises the temperature of the bearings correspondingly. The values for the re-greasing interval should be halved for every 15°C (30°F) increase in bearing temperature and may be once doubled for a 15°C (30°F) decrease in bearing temperature.

Re-greasing intervals for frequency converter drives

Higher speed operation, e.g. in frequency converter applications, or lower speed with heavy load will require shorter lubrication intervals or a special lubricant. Consult manufacturing ABB factory After Sales department in such cases.

NOTE: The constructional maximum speed of the machine must not be exceeded. The suitability of the bearings for high-speed operation must be checked.

7.5.1.4 Re-greasing

All rolling bearings of rotating electrical machines need to be re-greased, see *Chapter 7.5.1.3 Re-greasing intervals*. The re-greasing can be performed either manually or by means of an automatic system. In either case, it has to be verified that a suitable amount of the correct grease is entering the bearing at suitable intervals.

NOTE: Grease can cause skin irritation and eye inflammation. Follow all safety precautions specified by the grease manufacturer.

Manual re-greasing of the bearings

Machines suited for manual re-greasing are equipped with grease nipples. In order to prevent debris from entering the bearings, the grease nipples, as well as the surrounding area has to be cleaned thoroughly before re-greasing.

Manual re-greasing while the machine is running

Re-greasing while the machine is running:

- Verify that the grease to be used is suitable
- Clean the grease nipples and the area around them
- Verify that the lubrication channel is open, if equipped with a handle, open it.
- Press the specified amount and type of grease into the bearing
- Let the machine run 1-2 hours in order to ensure that all excess grease is forced out of the bearing. The bearing temperature may temporarily increase during this time
- If equipped with a handle, close it.

NOTE: Beware of all rotating parts during the re-greasing.

For the locations of the handles, see *Appendix Typical position of plates*.

Manual re-greasing while the machine is at a standstill

Preferably, re-grease the machine while it is running. If this is not possible, or considered dangerous, the re-greasing has to be carried out while the machine is at a standstill. In this case:

- Verify that the grease to be used is suitable
- Stop the machine
- Clean the grease nipples and the area around them
- Verify that the lubrication channel is open, if equipped with a handle, open it.
- Press only half the amount of the specified type of grease into the bearing
- Run the machine for a few minutes at full speed
- Stop the machine
- After the machine has stopped, press the specified amount of the correct grease into the bearing
- Let the machine run 1-2 hours in order to ensure that all excess grease is forced out of the bearing. The bearing temperature may temporarily increase during this time

- If equipped with a handle, close it.

Automatic re-greasing

A variety of automatic re-lubrication systems is available on the market. However, ABB recommends only the use of electromechanical re-lubrication systems. The quality of the grease entering the bearing has to be checked at least once per year: the grease has to look and feel like new grease. Any separation of the base oil from the soap is not acceptable.

NOTE: If an automatic re-greasing system is used, double the amount of grease indicated on the bearing plate.

For the locations of the handles, see *Appendix Typical position of plates.*

7.5.1.5 Bearing grease

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

Grease used for re-greasing should have the following properties:

- Be special rolling bearing grease
- Be of good quality with a lithium complex soap, and with mineral-, or PAO-oil
- Have a base oil viscosity of 100 to 160 cSt at 40°C (105°F)
- Have a consistency NLGI grade between 1.5 and 3. For vertically or in hot conditions mounted machines, NLGI grade 2 or 3 is recommended
- Have a continuous temperature range between -30°C (-20°F) and at least +120°C (250°F).

Grease with the correct properties is available from all major lubricant manufacturers. If the make of grease is changed and compatibility is uncertain, consult the manufacturing ABB factory, see *Chapter 9.1.5 After Sales contact information.*

NOTE: Different makes of grease must not be mixed, unless the compatibility has been verified.

NOTE: Grease additives are recommended. However, a written guarantee should be obtained from the lubricant manufacturer stating that the additives do not damage the bearings or the properties of the grease in the field of the operating temperature. This is especially important for EP additives.

NOTE: Lubricants containing EP admixtures are not recommended.

Recommended rolling bearing grease

ABB recommends any of the following high performance greases to be used:

- Esso Unirex N2, N3 (lithium complex base)
- Mobilith SHC 100 (lithium complex base)
- Shell Albida EMS 2 (lithium complex base)
- Klüber Klüberplex BEM 41-132
- Lubcon Turmogrease Li 802 EP

- Total Multiplex S 2 A
- Fag Arcanol Temp 110

Re-greasing intervals for greases fulfilling the required properties other than the ones mentioned above should be halved.

Rolling bearing grease for extreme temperatures

If the bearing operating temperature is above 100°C (210°F), please consult the manufacturing ABB factory for suitable greases.

7.5.1.6 Bearing maintenance

The lifetime of the bearings is likely to be shorter than the lifetime of the electrical machine. Therefore, the bearings will have to be changed periodically.

The maintenance of rolling bearings requires special care, tools and arrangements as to ensure a long lifetime of newly fitted bearings.

During bearing maintenance, ensure that:

- No dirt or foreign debris is allowed to enter the bearings at any time during the maintenance
- The bearings are washed, dried and pre-greased with suitable and high quality rolling bearing grease before assembly
- The disassembly and mounting of the bearings does not damage the bearings. The bearings must be removed by using pullers and fitted by heating, or using special tools for the purpose.

If there is a need to change bearings, please contact ABB After Sales. See After Sales contact information in *Chapter 9.1.5 After Sales contact information*.

7.6 Maintenance of stator and rotor windings

The windings of rotating electrical machines are subjected to electrical, mechanical and thermal stresses. The windings and insulation gradually age and deteriorate due to these stresses. Therefore, the service life of the machine often depends on the insulation durability.

Many processes leading to damages can be prevented or at least slowed down with appropriate maintenance and regular testing. This chapter offers a general description on how to perform basic maintenance and tests.

In many countries, ABB Service offers complete service maintenance packages, which include comprehensive testing.

Before conducting any maintenance work on the electrical windings, general electrical safety precautions are to be taken and local regulations are to be respected in order to prevent personnel accidents. See *Chapter 7.2 Safety precautions* for more information.

Independent test and maintenance instructions can also be found in the following international standards:

1. IEEE Std. 43-2000, IEEE Recommended Practice for Testing Insulation Resistance of Rotating Machines

2. IEEE Std. 432-1992, IEEE Guide for Insulation Maintenance for Rotating Electrical Machinery (5 hp to Less Than 10 000 hp)

7.6.1 Particular safety instructions for winding maintenance

Some of the hazardous works of the winding maintenance include:

- Handling of hazardous solvents, varnishes, and resins. Hazardous substances are required for cleaning and re-varnishing windings. These substances can be dangerous if inhaled, swallowed or in any contact with skin or other organs. Seek proper medical care if an accident occurs
- Dealing with flammable solvents and varnishes. Handling and use of these substances should always be by authorized personnel and proper safety procedures must be followed
- Testing at high voltage (HV). High-voltage tests should only be conducted by authorized personnel and proper safety procedures must be followed.

Dangerous substances used in winding maintenance are:

- White spirit: solvent
- 1.1.1-trichloroethane: solvent
- Finishing varnish: solvent and resin
- Adhesive resin: epoxy resin.

NOTE: There are special instructions for handling dangerous substances during maintenance work. These instructions must be followed.

Some general safety measures during winding maintenance are as follows:

- Avoid breathing air fumes: ensure proper air circulation at the work site or use respiration masks
- Wear safety gear such as glasses, shoes, hardhat and gloves and suitable protective clothing to protect the skin. One should always use protective creams
- Spray-varnish equipment, the frame of the machine, and the windings should be earthed during spray varnishing
- Take necessary precautions when working in pits and cramped places
- Only people trained to do high-voltage work can carry out a voltage test
- Do not smoke, eat, or drink at the work site.

For a test record for winding maintenance, see *Appendix COMMISSIONING REPORT*.

7.6.2 The timing of the maintenance

There are three main principles for timing the winding maintenance:

- Maintenance of the windings should be arranged according to other machine maintenance
- Maintenance should be performed only when necessary
- Important machines should be serviced more often than the less important ones. This also applies to windings that become contaminated rapidly and to heavy drives.

NOTE: As a thumb rule, an insulation resistance test should be made once a year. This should suffice for most machines in most operating conditions. Other tests should only be conducted if problems arise.

A maintenance program for the complete machine, including windings, is presented in *Chapter 7.3 Maintenance program*. This maintenance program however, should be adapted to the customer's particular circumstances, i.e. servicing of other machines and operating conditions as long as recommended servicing intervals are not exceeded.

7.6.3 The correct operating temperature

The correct temperature of the windings is ensured by keeping the exterior surfaces of the machine clean, by seeing to the correct operation of the cooling system and by monitoring the temperature of the coolant. If the coolant is too cold, water may condense inside the machine. This can wet the winding and deteriorate the insulation resistance.

The stator operating temperatures must be monitored with resistance temperature detectors. Significant temperature differences among the detectors could be a sign of damage in the windings. Make sure that the changes are not caused by the drifting of the measuring channel.

7.6.4 Insulation resistance test

During general maintenance work and before the machine is started up for the first time or after a long period of standstill, the insulation resistance of stator and rotor windings must be measured.

The insulation resistance measurement provides information about the humidity and dirtiness of the insulation. Based upon this information, correct cleaning and drying actions can be determined.

For new machines with dry windings, the insulation resistance is very high. The resistance can, however, be extremely low if the machine has been subjected to incorrect transportation and storage conditions and humidity, or if the machine is operated incorrectly.

NOTE: Windings should be earthed briefly immediately after measurement in order to avoid risk of electric shock.

7.6.4.1 Conversion of measured insulation resistance values

In order to be able to compare measured insulation resistance values, the values are stated at 40°C. The actual measured value is therefore converted to a corresponding 40°C value with the help of the following diagram. The use of this diagram should be limited to temperatures fairly near to the standard value of 40°C, since large deviations from it could result in errors.

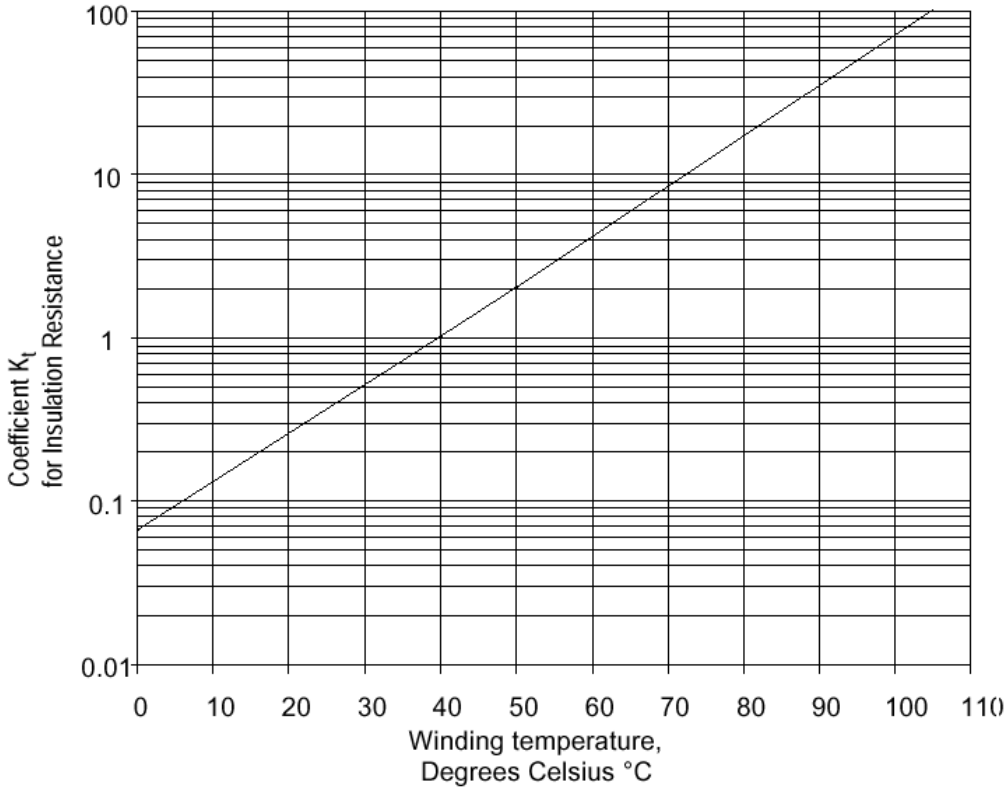


Figure 7-2 Correlation between the insulation resistance and the temperature

R = Insulation resistance value at a specific temperature

R40 = Equivalent insulation resistance at 40°C

R40 = k x R

Example:

R = 30 MΩ measured at 20°C

k = 0.25

R40 = 0.25 x 30 MΩ = 7.5 MΩ

Table 7-4. Temperature values in degrees Celsius (ºC) and degrees Fahrenheit (ºF)

°C	0	10	20	30	40	50	60	70	80	90	100	110
°F	32	50	68	86	104	122	140	158	176	194	212	230

7.6.4.2 General considerations

The following consideration should be noted, before deciding any actions based upon the insulation resistance tests:

- If the measured value is considered too low the winding must be cleaned and/or dried. If these measures are not sufficient, expert help should be acquired
- Machines, that are suspected to have moisture problem, should be dried carefully independent of the measured insulation resistance value
- The insulation resistance value will decrease when the winding temperature rises
- The resistance is halved for every 10 ... 15 K temperature rise.

NOTE: The insulation resistance indicated in the test report is normally considerably higher than the values measured on site.

7.6.4.3 Minimum values for insulation resistance

Criteria for windings in a normal condition:

Generally, the insulation resistance values for dry windings should exceed the minimum values significantly. Definite values are impossible to give, because resistance varies depending on the machine type and local conditions. In addition, the insulation resistance is affected by the age and usage of the machine. Therefore, the following values can only be considered as guidelines.

The insulation resistance limits, which are given below, are valid at 40 °C, and when the test voltage has been applied for 1 minute or longer.

- Rotor

For induction machines with wound rotors: $R_{(1\text{-}10 \text{ min at } 40 \text{ °C})} > 5$ MΩ

NOTE: Carbon dust on slip rings and naked copper surfaces lower the insulation resistance values of the rotor.

- Stator

For new stators: $R_{(1\text{-}10 \text{ min at } 40 \text{ °C})} > 1000$ MΩ. If the measuring conditions are extremely warm and humid, $R_{(1\text{-}10 \text{ min at } 40 \text{ °C})}$ values above 100 MΩ can be accepted

For used stators: $R_{(1\text{-}10 \text{ min at } 40 \text{ °C})} > 100$ MΩ

NOTE: If the values given here are not reached, the reason for the low insulation resistance should be determined. A low insulation resistance value is often caused by excess humidity or dirt, although the actual insulation is intact.

7.6.4.4 Stator winding insulation resistance measurement

The insulation resistance is measured using an insulation resistance meter. The test voltage is 1000 VDC. The test time is 1 minute, after which the insulation resistance value is recorded. Before the insulation resistance test is conducted, the following actions must be taken:

- Check that the secondary connections of the current transformers (CT's), including spare cores are not open. See *Figure 7-3 Connections of the stator windings for insulation resistance measurements*
- Verify that all power supply cables are disconnected

- Verify that the frame of the machine and the stator windings not being tested are earthed
- The winding temperature is measured
- All resistance temperature detectors are earthed
- Possible earthing of voltage transformers (not common) must be removed.

The insulation resistance measuring 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 machine and the winding; See *Figure 7-3 Connections of the stator windings for insulation resistance measurements*. The frame is earthed and the three phases of the stator winding remain connected at the neutral point, see *Figure 7-3 Connections of the stator windings for insulation resistance measurements*.

If the measured insulation resistance of the whole winding is lower than specified, and the phase windings can easily be disconnected from each other, each phase can also be measured separately. This is not possible for all machines. In this measurement, the tester is connected between the frame of the machine and one of the windings. The frame and the two phases not measured are earthed; see *Figure 7-3 Connections of the stator windings for insulation resistance measurements*.

When phases are measured separately, all star-points of the winding system must be removed. If the star-point of the component cannot be removed, as in a typical tri-phase voltage transformer, the whole component must be removed.

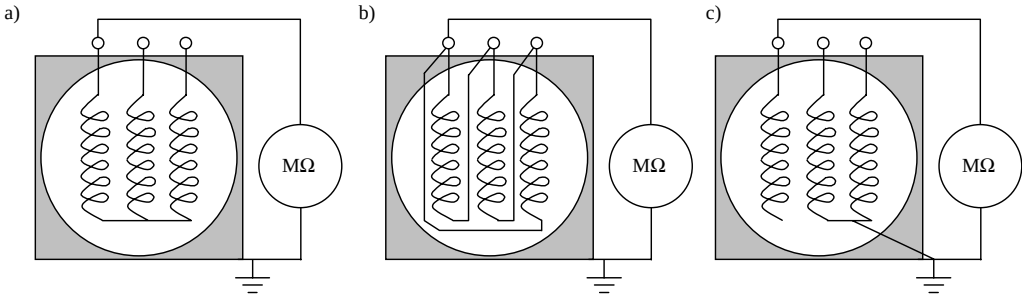


Figure 7-3 Connections of the stator windings for insulation resistance measurements

a) Insulation resistance measurement for star connected winding

b) Insulation resistance measurement for delta connected winding

c) Insulation resistance measurement for one phase of the winding. The 'MΩ' represents the insulation resistance meter.

After the insulation resistance measurement the winding phases must be earthed briefly in order to discharge them.

7.6.5 Insulation resistance measurement for auxiliaries

To ensure correct operation of the machines protections and other auxiliaries, their condition can be determined by an insulation resistance test. The procedure is described in detail in *Chapter 7.6 Maintenance of stator and rotor windings*. The test voltage for the space heater should be 500 VDC and for other auxiliaries 100 VDC. The insulation resistance measurement for Pt-100 detectors is not recommended.

7.6.6 The polarization index

For the polarization index test the insulation resistance is measured after the voltage has been applied for 15 seconds and 1 minute (or 1 minute and 10 minutes). The polarization index test is less dependent on the temperature than the insulation resistance. When the winding temperature is below 50ºC (122ºF), it may be considered independent of temperature. High temperatures can cause unpredictable changes in the polarization index, therefore the test should not be used at temperatures above 50ºC (122ºF).

Dirt and humidity accumulating in the winding normally reduces the insulation resistance, and the polarization index, as well as their dependence on temperature. Thus, the line in *Figure 7-2 Correlation between the insulation resistance and the temperature* becomes less steep. Windings with open creepage distances are very sensitive to the effects of dirt and humidity.

There are several rules for determining the lowest acceptable value with which the machine can be safely started. For the polarization index (PI), the values usually range between 1 and 4. Values close to 1 indicate that the windings are humid and dirty.

The minimum PI value for class F stator windings is more than 2.

NOTE: If the insulation resistance of the winding is in the range of several thousands of MΩ, the polarization index is not a meaningful criterion of the condition of the insulation, and it can be disregarded.

$$PI = \frac{R_{1\,\mathrm{min}}}{R_{15\,s}} or \left(\frac{R_{10\,\mathrm{min}}}{R_{1\,\mathrm{min}}} \right)$$

7.6.7 Other maintenance operations

Usually, ABB-made winding are trouble free and in addition to periodical monitoring they require only occasional cleaning and drying as described above. If extraordinary circumstances occur and other maintenance is required, it is best to acquire professional help. The ABB After Sales organization is eager to assist in questions regarding maintenance of electrical machine winding, for contact information see *Chapter 9.1.5 After Sales contact information*.

7.7 Repairs, disassembly and assembly

All the actions related to repairs, disassembly and assembly should be done by trained service personnel. For more information, please contact After Sales, see *Chapter 9.1.5 After Sales contact information*.

NOTE: Machines in hazardous areas must only be serviced by repair shops qualified and authorized by ABB.

Chapter 8 Trouble Shooting

8.1 Trouble shooting

This chapter is intended as a help in the event of an operational failure with an ABB delivered rotating electrical machine. The trouble shooting charts given below can aid in locating and repairing mechanical, electrical and thermal problems, and problems associated with the lubrication system. The checks and corrective actions mentioned should always be conducted by qualified personnel. If in any doubt, the After Sales of ABB should be contacted for more information or technical assistance regarding trouble shooting and maintenance.

8.1.1 Mechanical performance

Trouble shooting

Mechanical performance

Experienced malfunction		Possible cause		Corrective action
Vibration	Noise			
●	●	Lubrication malfunction		Check lubricant quality and quantity and lubrication system function
●	●	Bearing malfunction	Damaged bearing parts	Check bearing condition and replace bearing parts
●	●		Faulty bearing assembly	Open and readjust the bearing
●	●	Faulty cooling fan(s)	Imbalanced or damaged fan(s)	Check and repair cooling fan(s)
	●	Malfunctioning cooling system		Inspect and repair cooling system
●	●	Machine misalignment		Check machine alignment
●	●	Rotor or shaft imbalance		Rebalance rotor
●	●	Vibration coming from connected machinery		Check the balance of connected machinery and coupling type
●	●	Axial load coming from connected machinery		Check alignment and coupling function and type
●	●	Faulty or incorrectly assembled coupling		Check coupling function
●		Insufficient foundation strength		Reinforce foundation as per ABB instructions
	●	Winding fault		Check windings
●	●	Excessive network unbalance		Check that network balance fulfils requirements
	●	Foreign material, moisture or dirt inside the machine		Check and clean machine interior, dry windings

8.1.2 Lubrication system and bearings

8.1.2.1 Lubrication system and rolling bearings

Trouble shooting

Lubrication system and antifriction bearings

oil supply and self lubrication

Experienced malfunction			Possible cause		Corrective action
High bearing temperature	Lubricant leaks	Bearing noise or vibration			
●		●	Insufficient lubrication	Insufficient amount of grease	Check bearing condition, add grease
●	●	●	Unsuitable grease quality or viscosity		Check ABB grease recommendations, change grease
●			Excessive axial forces	Faulty coupling or mounting	Check coupling, mounting and alignment
●		●	Reduced grease quality	Incorrect regreasing period	Check ABB recommendations, regrease
●		●		Faulty operating conditions	Check ABB operating and grease recommendations
●	●		Excessive lubrication		Clean bearing and add correct amount of lubricant
●		●	Damaged bearing parts	Impurities in grease	Change grease, check bearing condition
●		●		Bearing currents	Check bearing and insulation condition
●		●		Complete bearing failure	Replace bearing
●		●		Normal wearing	Replace worn bearing parts
●			Faulty instrumentation	Faulty temperature detector	Check bearing temperature measurement system
	●	●	Faulty bearing seals		Check bearing seals and lubricant quality
●			Incorrectly assembled bearing		Replace bearing, ensure correct assembly
●		●	Outer ring is rotating due to unbalanced load		Rebalance machine, repair bearing bore and replace bearing
		●	Bearing noise due to deformed roller element		Replace bearing
		●	Foreign matter inside the bearing		Clean bearing assembly, check seal conditions and replace bearing

8.1.3 Thermal performance

8.1.3.1 Thermal performance, rib cooled

Trouble shooting

Thermal performance
rib cooled

Experienced malfunction: High winding temperature	Possible cause	Corrective action
●	Overload — Control system setting	Check machine controls, eliminate overload
●	Overspeed	Check actual speed and ABB speed recommendations
●	Network unbalance	Check that network balance fulfils requirements
●	Faulty instrumentation or measurement system	Check measurements, sensors and wiring
●	Too many starts	Let the machine cool down before restarting
●	Winding fault	Check windings
●	Dirty machine exterior	Clean machine exterior
●	Air flow is reduced	Remove obstacles. Ensure sufficient air flow, *see Dimension Drawing of the machine*

NOTE: For high bearing temperature, see *Chapter 8.1.2 Lubrication system and bearings*.

8.2 Electrical performance, excitation, control and protection

The electrical performance of a rotating electrical machine is mostly defined by the condition of the rotor and stator windings, and the operation of the excitation system, if applicable. The main machine winding maintenance is described in *Chapter 7.6 Maintenance of stator and rotor windings*. In this chapter, the focus is on the trouble shooting of the excitation, the control and protection systems.

8.2.1 Protection trips

The machine needs to be protected with alarms and trips for abnormal running conditions, both electrical and mechanical. Some of these protections can be reset and the machine restarted directly as the fault is located.

Examples of protections that, if they give an alarm or trip, may need further investigation:

- Diode fault protection
- High temperature in bearing, see *Chapter 7.5 Maintenance of bearings and lubrication system*
- High temperature in winding or in cooling air, see *Chapter 7.6 Maintenance of stator and rotor windings*.
- Overcurrent, current and voltage unbalance, bus bar voltage
- Vibration protection, *Chapter 7.4.2 Vibration and noise.*

8.2.2 Pt-100 resistance temperature detectors

Pt-100 resistance temperature detectors are an essential part in the machine's condition monitoring and protection system. They are used to measure temperatures in the windings, bearings and in the cooling air. The Pt-100 detector uses a fine platinum filament for the temperature measurement, which can be damaged e.g. by incorrect handling or excessive vibration.

The following symptoms might suggest a problem in a Pt-100 detector:

- Infinite or zero resistance over the detector
- Disappearance of measurement signal during, or after start up
- A significantly different resistance value in a single detector.

If a Pt-100 failure is suspected the findings should always be confirmed from the connection box, by measuring the resistance at the detector with its cables disconnected. The findings should by registered. For the correct measuring current see the appropriate Pt-100 detector. For resistance values at different temperatures, see *Table 8-1 Temperature values for Pt-100 elements*.

Table 8-1. Temperature values for Pt-100 elements

PT100 RES Ω	TEMP °C	TEMP °F	PT100 RES Ω	TEMP °C	TEMP °F	PT100 RES Ω	TEMP °C	TEMP °F
100.00	0	32.00	127.07	70	158.00	153.58	140	284.00
100.78	2	35.60	127.84	72	161.60	154.32	142	287.60
101.56	4	39.20	128.60	74	165.20	155.07	144	291.20
102.34	6	42.80	129.37	76	168.80	155.82	146	294.80
103.12	8	46.40	130.13	78	172.40	156.57	148	298.40
103.90	10	50.00	130.89	80	176.00	157.31	150	302.00
104.68	12	53.60	131.66	82	179.60	158.06	152	305.60
105.46	14	57.20	132.42	84	183.20	158.81	154	309.20
106.24	16	60.80	133.18	86	186.80	159.55	156	312.80
107.02	18	64.40	133.94	88	190.40	160.30	158	316.40
107.79	20	68.00	134.70	90	194.00	161.04	160	320.00
108.57	22	71.60	135.46	92	197.60	161.79	162	323.60
109.35	24	75.20	136.22	94	201.20	162.53	164	327.20
110.12	26	78.80	136.98	96	204.80	163.27	166	330.80
110.90	28	82.40	137.74	98	208.40	164.02	168	334.40
111.67	30	86.00	138.50	100	212.00	164.76	170	338.00
112.45	32	89.60	139.26	102	215.60	165.50	172	341.60
113.22	34	93.20	140.02	104	219.20	166.24	174	345.20
113.99	36	96.80	140.77	106	222.80	166.98	176	348.80
114.77	38	100.40	141.53	108	226.40	167.72	178	352.40
115.54	40	104.00	142.29	110	230.00	168.46	180	356.00
116.31	42	107.60	143.04	112	233.60	169.20	182	359.60
117.08	44	111.20	143.80	114	237.20	169.94	184	363.20
117.85	46	114.80	144.55	116	240.80	170.58	186	366.80
118.62	48	118.40	145.31	118	244.40	171.42	188	370.40
119.40	50	122.00	146.06	120	248.00	172.16	190	374.00
120.16	52	125.60	146.81	122	251.60	172.90	192	377.60
120.93	54	129.20	147.57	124	255.20	173.63	194	381.20
121.70	56	132.80	148.32	126	258.80	174.37	196	384.80
122.47	58	136.40	149.07	128	262.40	175.10	198	388.40
123.24	60	140.00	149.83	130	266.00	175.84	200	392.00
124.01	62	143.60	150.57	132	269.60	176.57	202	395.60
124.77	64	147.20	151.33	134	273.20	177.31	204	399.20
125.54	66	150.80	152.04	136	276.80	178.04	206	402.80
126.31	68	154.40	152.83	138	280.40	178.78	208	406.40

There are two possible remedies for stator Pt-100 detector damage. If there are operational spare detectors remaining in the stator core, they can be taken into use. If all the working factory assembled detectors are in use, a new detector can be retrofitted in the winding end.

Chapter 9 After Sales Support and Spare Parts

9.1 After Sales

The After Sales support for rotating electrical machines manufactured by ABB, and Strömberg in Helsinki, Finland since 1889.

9.1.1 Site Services

The Site Services department provides:

- Installation and commissioning
- Maintenance and inspections
- Trouble shooting and service
- Upgrading and modifications.

9.1.2 Spare Parts

The Spare Parts department:

- Co-ordinates spare parts packages delivered with the machine
- Sells genuine spare parts after the machines has been delivered.

For spare part packages, see *Chapter 9.2 Spare parts for rotating electrical machines*.

9.1.3 Support and Warranties

The Support department:

- Handles warranty issues under warranty period based on written claims
- Makes warranty determination
- Decides about corrective actions
- Provides technical support.

9.1.4 Support for Service Centers

The Service Center Support provides help for authorized Service Centers in questions concerning the mechanical construction as well as in electromagnetic and insulation technology issues.

9.1.5 After Sales contact information

Contact the After Sales department by:

- Phone 7 am - 5 pm (GMT +2): +358 (0)10 22 11
- 24-Hour Support Line: +358 (0)10 22 27100

- Fax: +358 (0)10 22 22544
- e-mail for spare parts: aftersales.machines@fi.abb.com
- e-mail for site services: siteservice.machines@fi.abb.com
- e-mail for warranties and technical support: support.machines@fi.abb.com

NOTE: If available, please add the serial number of the machine (seven digits, starting with 45#####) to your e-mail for reference information.

9.2 Spare parts for rotating electrical machines

9.2.1 General spare part considerations

The machines manufactured by ABB are designed and manufactured to provide reliable and trouble-free operation for decades. This requires, however, that the machines are properly maintained and operated. This maintenance includes changing of parts subjected to normal wear.

There is always an inevitable amount of uncertainty related to wearing. The wear rates of these parts vary greatly according to application, environment and particular conditions. Therefore, the condition of these parts should be checked regularly and a sufficient amount of spare parts should be kept in stock. These spares help to minimize down time if the need appears. The extent of the stock should be decided based upon the importance of the application, the availability of the particular spare part and the expertise of the local maintenance personnel.

9.2.2 Periodical part replacements

There is always mechanical wear when two moving surfaces are in contact with each other. In electrical machines most of the mechanical wear occurs between the rotating shaft and stationary parts. The bearing parts such as rolling bearings, bearing shells and oil rings in sleeve bearings will eventually wear out and need to be replaced, even if correct lubrication is maintained. Other wearing parts include seals that are in constant contact with the rotating shaft and brushes, brush gears and slip rings of the slip ring unit.

The parts mentioned above make an extensive, but not a complete, list of the mechanically wearing parts. These parts have an estimated life span, but as mentioned earlier, their actual durability can vary significantly. For this reason, at least these parts should be kept in stock. It should also be noted that the replacement of these parts, due to normal wearing, is not covered by the warranty.

9.2.3 Need of spare parts

Other types of wear occur due to elevated temperatures, electrical disturbances and chemical reactions. The wear of the diodes in the rectifier bridge is usually related to abnormal electrical operating conditions. It is usually a slow process, but it is strongly dependent on the operation conditions of the machines and system disturbances.

Air filters, which protect the machine interior from contamination, become themselves saturated with air impurities and need to be replaced to ensure the correct operation of the cooling unit, and the continuous protection of sensitive machine parts.

The electrical windings of the ABB machines have good protection against wear, but only if correct maintenance and operating conditions are followed. The correct operating temperature must not be exceeded and the windings must be cleaned from dirt regularly. The winding can also be subjected to accelerated wear due to a number of electrical disturbances.

There are stator winding Pt-100 temperature detectors located inside the stator core slots, which cannot be replaced. Therefore, the ABB practice is to add spare Pt-100 detectors in the stator core. These detectors are not to be considered as regular spare parts because they are intended to be used as a replacement in case of a stator Pt-100 element failure during commissioning. However, these elements can be taken into use also during operation if the primary detector fails. If the spare element should fail, the possible corrective action is to add Pt-100 elements into the stator winding end.

9.2.4 Selection of the most suitable spare part package

ABB provides three levels of ready-made spare part packages. The personnel best informed of the machine's operational conditions should select the most suitable package based on criticality of the application and on the financial risk related to the duration of downtime and loss of production.

Operational spare part package for commissioning and to ensure usability:

- These are the most essential spare parts that should always be available.

Recommended spare part package for trouble shooting and scheduled maintenance:

- These parts should be available during medium term maintenance. These parts also enable fast recovery in case of failure in the accessories.

Capital spare parts to reduce repair time in case of serious damage:

- These spare parts are recommended when the machine is a part of an essential process. These spare parts enable fast recovery even in case of a serious damage.

9.2.5 Typical recommended spare parts in different sets

Below is presented a general recommendation of the typical spare parts for different packages. To receive a quotation for specific parts for a specific machine, please contact the ABB After Sales organization.

Please note that even though ABB has customized the spare part sets to match the machine, they might contain references to accessories not found on all machines.

9.2.5.1 Operational spare part package

Spare part	Amount
Rolling bearing	2 pcs
Bearing RTD	1 pc

9.2.5.2 Recommended spare part package

Spare part	Amount
Operational spare part package	1 pc
Space heater	1 pc
Stator Pt-100, retrofit kit	1 pc
Support or bushing insulators	1 pc

9.2.5.3 Capital spare parts

Spare part	Amount
Stator	1 pc
Rotor	1 pc

9.2.6 Order information

To ensure fast and correct spare part order and delivery, our After Sales personnel should be provided with the serial number of the machine in question. The serial number can be found either on the rating plate fixed to the machine frame, or stamped on the machine frame. In addition, provide specific and detailed information about the parts ordered.

The contact information of ABB's After Sales organization can be found in *Chapter 9.1.5 After Sales contact information*.

Chapter 10 Recycling

10.1 Introduction

ABB is committed to its environmental policy. ABB continuously strives to make its products more environmentally sound by applying results obtained in recyclability and life cycle analyses. Products, manufacturing processes and even logistics have been designed to take environmental aspects into account. ABB's environmental management system, certified to ISO 14001, is the tool for carrying out the environmental policy.

The following instructions should only be seen as recommendations for environmentally sound disposal of machines. It is the customer's responsibility to ensure that local regulations are followed. Some customer-specific items may not be included in this User's Manual. Additional documentation will be found in the project documentation.

10.2 Average material content

The average material content used in the manufacturing of the electrical machine is as follows:

	Cast iron frame induction machines	**Modular steel frame induction machines**
Steel	46 - 55 %	77 - 83 %
Copper	7 - 12 %	10 - 12 %
Cast iron	35 - 45 %	1 - 5 %
Aluminium	0 - 2 %	0 - 1 %
Plastics, rubber, insulation materials etc.	1 - 2 %	1 - 2 %
Stainless steel	less than 1 %	less than 1 %
Other	less than 1 %	less than 1 %

10.3 Recycling of packaging material

Once the machine has arrived on site, the packaging material will need to be removed.

- Any wood packaging can be burned
- For some countries, the packaging used for shipping by sea is made of impregnated wood that must be recycled according to local regulations
- Plastic material around the machine can be recycled
- Any anti-corrosive agent covering the machine surface can be removed using a petrol based detergent and a cleaning rag. The rag must be disposed of in accordance with local regulations.

10.4 Dismantling of the machine

Dismantling the machine is a basic procedure as it is assembled with bolts. However, due to the weight, it requires an operator trained in handling heavy components to prevent dangerous situations.

10.5 Separation of different materials

10.5.1 Frame, bearing housing, covers and fan

These parts are made of structural steel, which can be recycled according to local instructions. All the auxiliary equipment, cabling as well as bearings have to be removed before melting the material.

10.5.2 Components with electrical insulation

The stator and the rotor are the main components, which include electrical insulation materials. There are, however, auxiliary components which are constructed of similar materials and which are hence dealt with in the same manner. This includes various insulators used in the terminal box, exciter, voltage and current transformers, power cables, instrumentation wires, surge arrestors and capacitors. Some of these components are used only in synchronous machines and some are used only in a very limited number of machines.

All these components are in an inert stage once the manufacturing of the machine has been completed. Some components, in particular the stator and the rotor, contain a considerable amount of copper which can be separated in a proper heat treatment process, where the organic binder materials of the electrical insulation are gasified. To ensure a proper burning of the fumes, the oven shall include a suitable after burning unit. The following conditions are recommended for the heat treatment and for the after burning to minimize the emissions from the process:

Heat treatment

Temperature:	380-420°C (716...788°F)
Duration:	After obtaining 90% of the target temperature, the object shall stay a minimum of five hours at this temperature

After burning of the binder fumes

Temperature:	850-920°C (1562-1688°F)
Flow rate:	The binder fumes shall stay a minimum of three seconds in the burning chamber

NOTE: The emission consists mainly of O_2-, CO-, CO_2-, NO_x-, C_xH_y-gases and microscopic particles. It is on the user's responsibility to ensure that the process complies with the local legislation.

NOTE: The heat treatment process and the maintenance of the heat treatment equipment require special care in order to avoid any risk for fire hazards or explosions. Due to various installations used for the purpose it is not possible for ABB to give detailed

instructions of the heat treatment process, or the maintenance of the heat treatment equipment and these aspects must be taken care of by the customer.

10.5.3 Permanent magnets

If the permanent magnet synchronous machine is melted down as a whole, nothing needs to be done to the permanent magnets.

If the machine is dismantled for more thorough recycling and if the rotor must be transported after it, it is recommended that the permanent magnets are demagnetized. The demagnetization is done by heating the rotor in the oven until the permanent magnets reach a temperature of +300 °C (572°F).

WARNING: Magnetic stray fields, caused by an open or disassembled permanent magnet synchronous machine or by a separate rotor of such a machine, may disturb or damage other electrical or electromagnetic equipment and components, such as cardiac pacemakers, credit cards and equivalent.

10.5.4 Hazardous waste

The oil from the lubrication system is a hazardous waste and has to be handled according to local instructions.

10.5.5 Land fill waste

All insulation material can be handled as a land fill waste.

COMMISSIONING REPORT

Rating plate information:	
	Serial no.
Manufacturer:	ABB Oy
Address: Telephone: Fax:	P.O. Box 186 FIN-00381 HELSINKI FINLAND +358 (0) 10 22 11 +358 (0) 10 22 22544
Customer:	
Customer address:	
Contact person:	
Telephone:	
Mobile phone:	
Fax:	
Email:	

1 Transportation

General:

Arrival date of the machine:	
Inspection date and location:	
Signature of consignee:	
Open box inspection:	☐ no ☐ yes, done by:

Damages:

Packing list:	☐ no ☐ yes, missing items:
Machine:	☐ no ☐ yes, what kind of:
Package:	☐ no ☐ yes, what kind of:
Accessories:	☐ no ☐ yes, what kind of:
Spare parts + tools:	☐ no ☐ yes, what kind of:

Actions taken in response to damages:

Photographed:	☐ no ☐ yes, date:		
Reported to the transportation company:	☐ no ☐ yes, to whom:		date:
Reported to the supplier:	☐ no ☐ yes, to whom:		date:
Reported to the insurance company:	☐ no ☐ yes, to whom:		date:

Method of transportation:

☐ Railway	☐ Airfreight	☐ Truck	☐ Mail	☐ Shipped by M/S _____	☐ Other:

Comments:

2 Storage

General:

Storage:	☐ no ☐ yes, begin:_____end:_____
Storage time longer than 6 months:	☐ no ☐ yes
Person responsible for storage:	

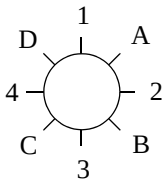
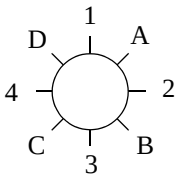
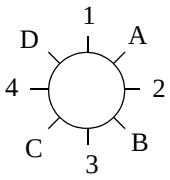
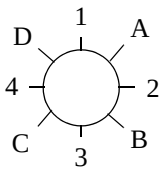
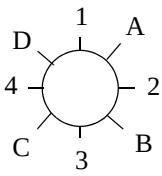
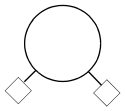
Storage place:

	☐ indoors ☐ outdoors
	☐ in packing case ☐ protected by a waterproof cover
	Daily temperature: min/max._____ - _____^{o}C Humidity:_____%

Storage actions:

Transportation package is ventilated:	☐ no ☐ yes
External heating/fan is used:	☐ no ☐ yes, type:_____
Machine space heaters are used:	☐ no ☐ yes, voltage:_____
Bearings are flushed:	☐ no ☐ yes, oil type:_____
Bearing shells are removed:	☐ no ☐ yes, date:_____
Shaft end anti-corrosion protection checked:	☐ no ☐ yes, type:_____
Shaft end anti-corrosion protection renewed:	☐ no ☐ yes, date:_____
The rotor is turned 10 revolutions every two months:	☐ no ☐ yes
There are vibrations in the storage place:	☐ no ☐ yes, _____mm/s, rms
There are corrosive gases in the air:	☐ no ☐ yes, what kind of:_____
Brushes are lifted up:	☐ no ☐ yes
Machine documents are saved and protected for future use:	☐ no ☐ yes, location:_____
Comments:	

3 Mechanical Installation

Foundation is checked according to machine drawing:	☐ no ☐ yes, drawing number:_____
Possible foundation anchor bolts or sole plates are mounted according to instructions:	☐ no ☐ yes
Air gap is measured, if applicable: For pedestal bearings, mark values 1-4, and for flanged bearings, values A-D 1 _____ A _____ 2 _____ B _____ 3 _____ C _____ 4 _____ D _____	D-end top  N-end top  Exciter N-end top 
For alignment of the coupling, use either values 1-4 or values A-D 1 _____ 2 _____ 3 _____ 4 _____ A _____ B _____ C _____ D _____	Radial alignment of coupling top  Angular alignment of coupling top  Axial position of the rotor: ET #1:_____mm, ET #2:_____mm Axial distance between shaft ends: _____mm Rotor support distance:  _____mm _____mm
Crankshaft deflection is checked:	☐ no ☐ yes
Tapered guide pins are used to lock the position of the machine after alignment:	☐ no ☐ yes
Foundations bolts are tightened with torque wrench:	☐ no ☐ yes, bolt size:_____torque:_____Nm
Bolt lubrication:	☐ dry ☐ oil, ☐ MoS_2
Cooling water:	☐ no ☐ yes, amount: ☐ m^3/s
Cooling element piping:	☐ flexible ☐ rigid
Transport locking device is removed:	☐ no ☐ yes
Rotor rotates without noise or scraping:	☐ no ☐ yes

4 Lubrication check

4.1 Self lubrication

Bearing oil:	Manufacturer:_____ Type:_____
The oil quality is the same as recommended:	☐ no ☐ yes
Bearing oil is filled up to the indicated level: *Please mark the level in the sight glass circle on the right*	◯ Sight Glass
Lubrication rings rotate freely:	☐ no ☐ yes

4.2 Flood lubrication

Bearing oil:	Manufacturer:_____ Type:_____
The oil quality is the same as recommended:	☐ no ☐ yes
Lubrication rings rotate freely:	☐ no ☐ yes
Flood lubrication oil pressure:	_____kPa
Oil flow:	_____liters/min
Rotation of the pumps checked:	☐ no ☐ yes
Jack-up pumps checked:	☐ no ☐ yes, alarm setting:_____kPa, relief valve setting:_____kPa
Oil filters checked:	☐ no ☐ yes

4.3 Grease lubricated bearings:

Grease:	Manufacturer:_____ Type:_____
The grease quality is the same as recommended on the bearing plate:	☐ no ☐ yes
The first greasing has been done:	Date:_____ Quantity:_____g
Comments:	

5 Electrical installation

Network variation:	☐ no ☐ yes, voltage:_____-_____V, frequency:_____-_____Hz
Space heater operation:	☐ no ☐ manual ☐ automatic, controlled by:_____
Space heater for slip ring unit:	☐ no ☐ yes, voltage:_____V, power:_____W

5.1 Insulation resistance test

Stator winding (1 min., 1000 VDC):	_____MΩ, tested by_____ kV, winding temperature:_____°C
Stator winding (15 / 60 s. or 1 / 10 min.):	PI =_____, tested by_____ kV, winding temperature:_____°C
Rotor winding (1 min.):	_____MΩ, tested by_____ kV, winding temperature:_____°C
Exciter stator (1 min., 500 VDC):	_____MΩ, tested by_____ kV, winding temperature:_____°C
Space heater:	_____MΩ (500 VDC)
Temperature detectors:	_____MΩ (100 VDC)
N-end bearing insulation:	_____MΩ (100 VDC)

5.2 Accessories resistance test

Stator 1 Pt 100: Stator 2 Pt 100: Stator 3 Pt 100: Stator 4 Pt 100: Stator 5 Pt 100: Stator 6 Pt 100:	_____Ω _____Ω _____Ω _____Ω _____Ω _____Ω
Bearing Pt 100 D-end: Bearing Pt 100 N-end:	_____Ω _____Ω
Air temperature 1 Pt 100: Air temperature 2 Pt 100:	_____Ω _____Ω
Anti-condensation heater:	_____Ω

6 Machine protection settings

Overcurrent tripping:	_____A _____ s
Instant overcurrent tripping:	_____A _____ s
Overvoltage setting:	☐ no ☐ yes, setting:
Earth fault setting:	☐ no ☐ yes, setting:
Reverse power setting:	☐ no ☐ yes, setting:
Differential protection setting:	☐ no ☐ yes, setting:
Vibration monitoring:	☐ no ☐ yes, alarm:_____mm/s, trip:_____mm/s
Temperature monitoring: - in stator winding - in bearing - in _____	 ☐ no ☐ yes, alarm:_____°C, trip:_____°C ☐ no ☐ yes, alarm:_____°C, trip:_____°C ☐ no ☐ yes, alarm:_____°C, trip:_____°C
Other protection units:	☐ no ☐ yes, type:

7 Test Run

7.1 First start (a few seconds only)

Note: Check that possible flood lubrication is on!

Direction of rotation (viewed from D-end):	☐ CW ☐ CCW
Are there abnormal noises?	☐ no ☐ yes, from:

7.2 Second start (uncoupled, if possible)

Note: Check that possible flood lubrication is on!

Are there abnormal noises?	☐ no ☐ yes, from:
Does the machine vibrate abnormally?	☐ no ☐ yes, where/how:
Bearing vibration level measured:	D-end:_____ mm/s, rms; N-end:_____ mm/s, rms
Running:	☐ machine run OK ☐ operation stops, why:

Checking schedule and information

Time	Bearing temperature		Bearing vibration levels		Stator			Stator winding temperature		
	D-end	N-end	D-end mm/s	N-end mm/s	Current	Power Factor	Excit. Current	U	V	W
h:min	°C	°C	rms	rms	A	cos ϕ	A	°C	°C	°C
0:00										
0:05										
0:10										
0:15										
0:20										

Comments:
Observations:

8 Test run (with load)

Checking schedule and information

Time	Load	Bearing temp.		Bearing vibration levels		Stator			Stator winding temperature		
		D-end	N-end	D-end mm/s	N-end mm/s	Current	Power Factor	Excit. Current	U	V	W
h:min	%	°C	°C	rms	rms	A	cos ϕ	A	°C	°C	°C
0:00											

Vibration spectrum attached:	☐ no ☐ yes
Acceleration time:	_____ s.
Cooling air temperature:	Inlet: _____ °C Outlet:_____ °C
Cooling water temperature:	Inlet: _____ °C Outlet:_____ °C
Comments:	

9 Machine approval

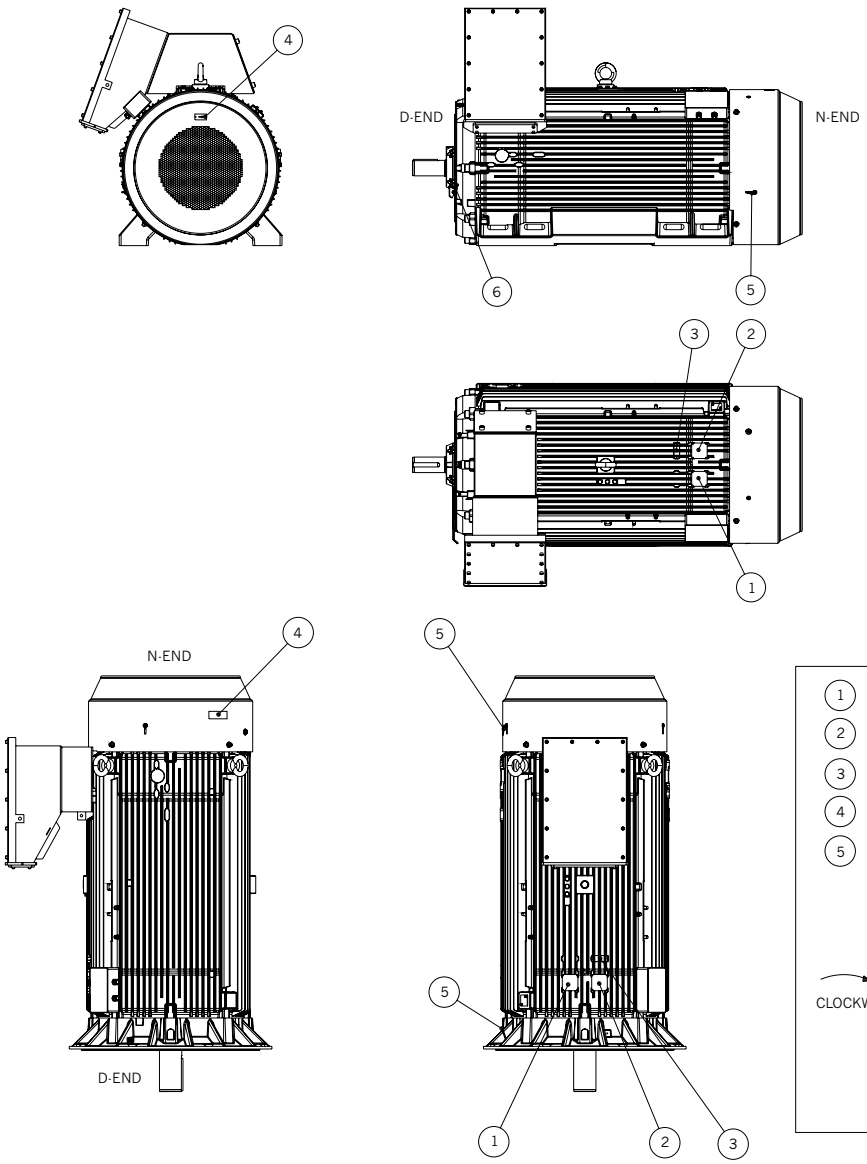
Machine approved for use	Date:
Commissioning done by:	
Approved by:	

Fax Cover Sheet

Date:	
To:	ABB Oy Telefax: +358 (0) 10 22 22544
From:	
Fax number:	
Phone number:	
Email:	
Number of pages:	1 + 9 + _____

Message:

Typical position of plates



1 RATING PLATE OF THE MACHINE

2 BEARING PLATE OF THE MACHINE

3 ADDITIONAL PLATE

4 MARKING PLATE FOR DIRECTION OF ROTATION

5 HANDLE OF WASTE GREASE EXHAUST VALVE

DIRECTION OF ROTATION SEEN FROM
THE DRIVE END TOWARDS THE MACHINE

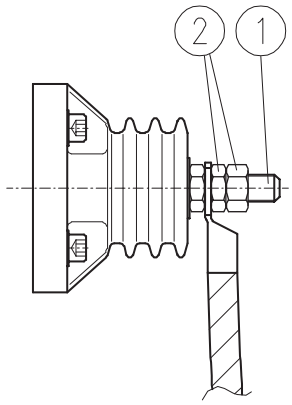
CLOCKWISE COUNTER-CLOCKWISE REVERSING OPERATION

MACHINE ENDS:

D-END = DRIVE END

N-END = NON-DRIVE END

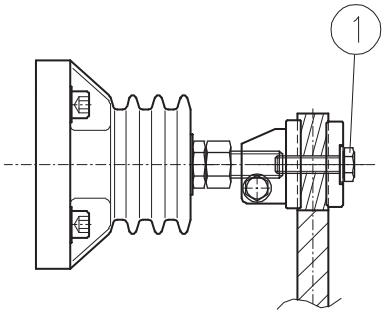
Typical main power cable connections



CONNECTION SCREW

1. Screw: M16-bronze
2. Hexagon nut: M16-brass

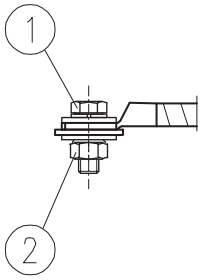
Tightening torque 40 Nm.



ROUND-TERMINAL: DIN 46223

1. Screw: M10-steel

Tightened until a reliable connection is obtained



EARTHING SCREW M12

1. Screw: M12 - AISI 316
2. Hexagon nut: M12-AISI 316

Tightening torque 55 Nm. Do not tighten with machine.
It is recommended to use grease with spring locked nuts.

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