KAD 10160/E
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Read through before initial operation and store carefully for later reference!

Mounting, operating and maintenance instructions

for R series surface-cooled three-phase asynchronous motors
with squirrel-cage rotor (type RH, RK, RHR and RKR),
with slip-ring rotor (type RS, RSR, RSB and RSK),
for low voltage (up to 1000 V) and
for medium voltage (up to 6600 V)

General safety instructions

Notes for use
The notes used in the operating instructions have the following significance:

Danger!
Is used for activities that may cause considerable personal or material damage. Please read and observe these notes carefully and act particularly cautiously in these cases. Make other users aware of these notes concerning work safety.

ATTENTION! **Concerns the observation of regulations, notes or the correct sequence of working steps to avoid damaging or destroying the motor, its parts and/or parts of the equipment.**

NOTE General type of notes

General safety instructions
Electrical motors for which these operating instructions were written are designed **for use in commercial installations**. During operation, these motors have dangerous rotating and non-insulated voltage-carrying parts. Serious personal and material damage may be caused by impropter use, impermissible removal of covers and protective installations, wrong handling and insufficient maintenance.

All work to be carried out on electrical motors such as assembly, connection or maintenance must only be carried out **while the system carries no voltage and is out of operation**. **Protect** the system **against unintended reactivation.**

These motors must only be transported, put up, connected, put into operation, maintenanced and operated by specialized staff being trained to observe the relevant safety and installation regulations. All processes must be checked by responsible specialized staff. These specialized staff must have been authorized for their activities by the security system officer (for specialized staff regulations see DIN EN 50110-1 / DIN IEC 60364).

Operation by non-qualified staff is prohibited!

The person responsible for the installation must make sure
- to have safety and operating instructions available and observing them;
- to have all safety installations and personal safety equipment available;
- that safety installations and personal safety equipment are used;
- regulatory maintenance work is carried out;
- the maintenance staff are immediately informed or the electrical motor stopped if abnormal voltages, increased temperatures, oscillations, noises etc. occur so that causes can be determined and damages avoided.

The manufacturer's liability is only maintained if the operating instructions are being observed at any time!

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1 General description

1.1 Basic design

Three-phase asynchronous motors of the **R series** (i.e. squirrel-cage rotors of the **RH, RK, RHR**, and **RKR** type, as well as slip-ring rotors of the **RS, RSR, RSK,** and **RSB** type) are surface-cooled motors (cooled by a ribbed frame), manufactured at a shaft height of 355, 400, 450 respectively 500 mm. According to IEC 60034, the method of cooling is IC 411, the degree of protection IP 56. Other methods of cooling, e.g. IC 416 (with fan cooling), or another degree of protection (e.g. IP 54 or IP 56) are possible as a special version. The horizontal type of construction IM 1001 (IM B3) and the vertical type IM 3011 (IM V1) are standard, as well as special versions are available on request. Please see the plants rating plate or data sheet for the data which is appropriate for your type of motor.

The stator frame with stator feet is made of grey cast iron. Depending on size, the end shields are welded or also made of grey cast iron. The cap covering the fan on the N-side is made of sheet steel. The terminal box is arranged above and pivotable at 180°. A lateral mounting of the stator terminal box is possible in the form of a special version. The terminal box for rotor connection (for slip-ring rotors RS, RSR, RSK and RSB) can be mounted alternatively above, on the left side or on the right side.

R series motors as **squirrel-cage rotors** can be designed as a **deep bar rotor RH** or as a **double squirrel-cage rotor RK**, depending on the kind of drive. With the help of special bearings, they are also suitable for operations with an uncovered pulley (as **RHR** or **RKR**).

The **slip-ring rotor** types **RS** and **RSR** (for belt drive) are designed with slip rings inlying on the N-side and constantly seated carbon brushes. The slip-ring unit is accessible by access openings. Slip-ring rotors of the **RSB** type are designed with a powered or manually operated **brush lifting device**.

Slip-ring rotors of the **RSK** type are in accordance with the RS type concerning structure. But they are especially designed for the stress of 6-, 8-, and 10-pole **crane motors** (mode of operation S3).

Labeled earthing positions are situated in the terminal box and at the stator frame.

1.2 Bearings

Deep groove ball bearings are built in on the D- and on N-sides. The bearings are differently implemented due to different applications and designs. All bearings are dustproof and have relubrication devices with grease quantity adjustment on the D- and N-sides.

NOTE For bearing configuration observe Data sheet “Bearings” and lubrication- and maintenance instructions observe section 5.4.

1.3 Cooling

The motors are surface aerated (**Cooling class IC 411** acc. IEC 60034). The heat is interchanged between the stator plate stack and the cooling fin frame as well as via an internal air circuit, which conveys part of the developing heat loss to hollow webs, which are formed as cooling ducts. The motors are provided with external and internal ventilators. In case of separate ventilation (**Cooling class IC 416**), there is no external ventilator. The air for cooling the surface is taken in by the separate ventilator built into the cap.

1.4 Monitoring devices

Monitoring devices (thermal winding protection, monitoring the number of revolutions, and so on) are available on request. For protection of the stator winding against thermal overload, PTC sensors compliant with DIN 44081 can be built in. For monitoring the winding temperature and/or the temperature of the bearings, the installation of Pt100 sensors is possible. These devices are available on request. Please note section 7.1.

2 Transport and storage

ATTENTION! Only use suitable attachment devices (ring bolts, eye bolts) for transportation. The attachment elements that are part of the motor are only made to carry the motor's own weight.

Check whether screw-type eye bolts are firmly screwed in.

It is not allowed to sling parts of the transport gear around shaft ends, pillow blocks, sleeves, hoods or similar elements as this could cause considerable damage.

If a motor or unit is transported on its baseplate you must use the attachment devices provided in the baseplate. Units that must not be transported in one piece are marked by a corresponding notice on the baseplate.

NOTE When transporting parts of disassembled motors ropes for lifting armatures should not be slung around the shaft bearings. If no other way of transporting the element is possible, the bearings must be sufficiently protected.

2.1 Check after delivery

Check the motor for any damages that might have occurred during transportation.
Transport company and manufacturer must be informed immediately of any transport damages.

2.2 Transport locking device

To avoid transport damages to bearings the armature of motors with cylindrical roller bearings is equipped with a transport locking device. This must only be removed when commissioning the motor and reused if the motor is transported again. Motors with spring-loaded groove ball bearings do not need transport protection.

ATTENTION! Remove the transport locking device before putting the motor into operation for the first time.

Refer to the figure 1 or the information given inside the terminal box to learn about how to remove the transport locking device. (Motors with transport locking devices are marked by a corresponding sign.)
Transport locking device is realized on the D side by two fixing screws. To remove it unscrew both hexagonal screws M12x60 [1] by approx. 8 – 10 mm and secure against unintended screwing-in by attaching the counter nuts [2].
After removing the transport locking devices, you should race the motor manually if at all possible.

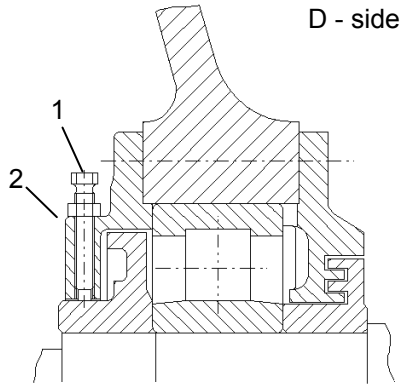


Figure 1: Transport locking device on D – side for cylindrical roller bearings

2.3 Storage instructions

The motors should be stored vibration-free in a dry room free of dust. In this case, special packaging is not required. Otherwise, the motors must be kept in plastic foil with humidity absorbing material. Provide covers to protect it against rain and sun.

ATTENTION! Manually race the armature at regular intervals to avoid damage to the antifriction bearing.

NOTE Armatures of motors provided with transport locking devices are not raced as long as the transport locking devices is applied and functional.

3 Mounting

Danger!
Observe general security information (see page 2)!

3.1 Installation and connection

Installation conditions

- The motor is designed for temperatures of the cooling agent between –25 °C and + 40 °C and a mounting location up to a height of 1000 m. Any other information on the performance label must be observed.

- Make sure to let the cooling air get in trough the air inlets and out again through the air outlets without obstructions or being sucked back in.
- If you are working with external air cooling, make sure to provide the air quantity indicated on the performance label.
- Install the motor on a low-vibration foundation. Avoid tension due to fixing the screws on uneven surfaces. Observe the prescribed tightening torques when tightening the foot screws! (Observe the table below.)

	M16	**M18**	**M20**	**M22**	**M24**	**M27**	**M30**	**M33**	**M36**
Coefficient of friction	**Tightening torques** [Nm]								
μ = 0,10 (lubricated)	180	259	363	495	625	915	1246	1679	2164
μ = 0,14 (not lubricated)	230	329	464	634	798	1176	1597	2161	2778

- Use taring screws for aligning the motor. The final installation position is to be fixed by sheet metal put underneath the motor. Bolt the motor up if necessary (holes are drilled into place already).
- When assembling motors that come to you in several pieces, you have to make sure only to use parts that have been marked as belonging together.
- The motor must only be assembled and operated according to design (see rating plate).
- Make sure to keep sufficient distance to walkways and operating stands as the temperatures of exhaust air or surface can be up to 80 °C.

  ATTENTION! Provide information signs or protective railing.

Mounting of couplings or pulleys:
It is not necessary to remove the corrosion protection at the shaft ends during installation.

ATTENTION! Make sure to use a mounting device for mounting couplings or pulleys.

A suitable means for this is the centring drill hole in the shaft end. When putting in the coupling you have to make sure that the shaft of the drive mechanism and the shaft of the machine to be driven are perfectly aligned. Misalignment must be not greater than 0.05 mm. To avoid angle errors, the gap between the two halves of the coupling must be measured at a 90° offset. The difference must be no greater than 0.05 mm.
If elastic bolt or toothed couplings are used you must make sure to have congruent separations of the two halves of the coupling. Changing the half couplings round is not allowed.

ATTENTION! Because of the danger of damages occurring on the bearings, hammering or knocking the driving elements on is not allowed.

NOTE The rotor is dynamically balanced. The balancing state is marked in accordance with DIN ISO 8821 at the D-side shaft-end.

Pulleys are only allowed for motors of the type IM C2 as special feature design; they too must be dynamically balanced. Furthermore you must make sure to carefully align the two disks making up one pulley, i.e. both shafts must be parallel to each other and the connecting line between the two disk centres must be at a right angle to the shafts.

ATTENTION! Check the pull of the belt. For information about the max. admissible belt tension please contact the manufacturer. Increasing the pull of the belt shortens the serviceable motor life.

3.2 Electrical connection

ATTENTION! Only have specialized staff set up the electrical connection in accordance with applicable safety regulations.

Observe all applicable national and international regulations. Connect the motor up according to the information given on the wiring diagram stuck on inside the terminal box. Refer to the wiring diagram for the terminal points to connect the temperature winding protection, the bearing monitoring device, the speed control device and the standstill heating system.

ATTENTION! Connect the motors to earth using the corresponding protective earth terminals inside the terminal box and on the foot of the motor stand.

Tightly set all connections to avoid high transitory resistances. At the same time permissible tightening torques have to be held (according to DIN 46200):

Thread	M 10	M 12	M 16	M 20
Tightening torque [Nm]	10	15.5	30	52

Align the cable lugs at the largest possible distance to other connecting points and to the casing.

3.2.1 Electrical connection at low voltage (up to 1000 V)

The connections of terminals for the supplementary installationes and monitoring devices are in the terminal box (in the auxiliary terminal box upon special request).

ATTENTION! Do not fall below the follwing distances between live components and to the case:

Rated voltage U_N [V]	≤ 550	≤ 725	≤ 1000
Minimum distance [mm]	8	10	14

Round terminal bolts have not been designed to serve as conductors for the rating current. You must therefore always make sure to put cable lug on cable lug. Arrangement of cable lugs, nuts and counternuts is to be made according to the figure 2 below.

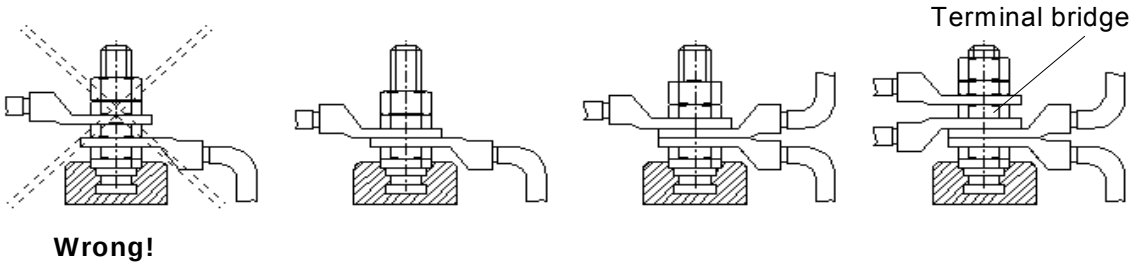


Figure 2: Cable lug arrangement inside the terminal box

3.2.2 Electrical connection at medium voltage (up to 6600 V Y)

The connections of terminals for the supplementary installationes and monitoring devices are in the auxiliary terminal box.

ATTENTION! Do not fall below the follwing distances between live components and to the case:

Rated voltage U_N [kV]	3	6
Minimal distance [mm]	36	60

Arrangement of cable lugs, nuts and counternuts is to be made according to the figure 3 below.

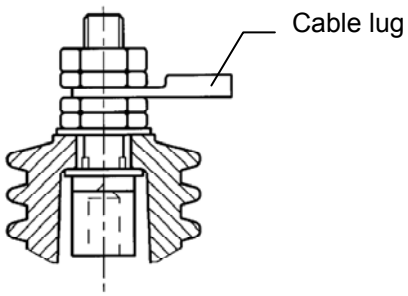


Figure 3: Cable lug arrangement inside the terminal box.

3.3 Direction of rotation

The terminals are obligatorily marked in accordance with **DIN EN 60034-8 / IEC 60034-8.** In standard design the motors support both directions of rotation. Correct connection of phases **L1, L2, L3** to the terminals **U-V-W** will cause the motors to rotate right-hand, i.e. rotating clockwise when viewed from the driving side. If you want left-hand rotation, exchange 2 phases.

NOTE Motors that have been made to work only in one direction of rotation, this direction is marked by an arrow on the motor, the ventilator or on the rating plate.

Contact the manufacturer if you want to change the direction of rotation of this typ of motor!

Direction of rotation	Rotation right only	Rotation left only
Direction symbol	➔	➔

Change of direction of rotation
If you have motors that are switched on directly, the direction of rotation can be changed by exchanging two conductors at the terminal board of the motor. In motors with star-delta starting and pole changing motors with Dahlander winding, 2 conductors supplying the motor switch have to be exchanged.

4 First startup

When putting the motor into operation for the first time or after long downtimes, the following checks have to be made.

4.1 Electrical check

ATTENTION! All checks to be made by specialized staff only!

- Check whether all terminals are firmly connected and connections made to wiring diagram!
- Check whether all monitoring devices are connected and set correctly!
- In case of star-delta start check that starting current in star connection is goin down sufficient before switching to delta!
- Check the system for proper earthing and for protection lead connection!
- Check whether voltage, frequency and rotary field of motor and network coincide before switching the system on for the first time!
- Check the direction of rotation!
- Check the insulation resistances between winding and earth and between the parts of the winding.

4.2 Measuring of the insulation resistance

Danger!
Protect the system against unintended reactivation!
Earth the windings before and after the measuring of insulation at least 10 s.
Don’t touch the windings before!

Measuring instrument: The messaurement shoult be effected by a standard measuring instrument. Obser ve exactly the operating instruction.
Measuring voltage: Observe the table below.
Measuring time: The measuring time shoult be 1min at least.

Insulation resistance
The following table serve to estimate the insulation resistance. Always estimate the insulation resistance (R_{is}) of the cold motor, i.e. on room temperature (approx. 25 °C). “Warm-values“ are not to comprehend clearly.
The minimum insulation resistance on room temperature of a brand new motor or a repaired motor with a new winding you find under item 1. of the next table.
This value can drop by virtue of transportation and storage under bad environmental conditions. In this case the insulation is not damaged. Motors, which stand still under bad environmental conditions for a long time and do not have a standstill heater (dew on the windings), can be started-up, so long as the insulation resistance of the cold motor do not drop under the values like shown in item 2. of the next table.
Drop the insulation resistance under values of item 2, the windings must be dried. Under special operating conditions the windings must be cleaned before drying (for that look to the section 5.3 “Drying the winding“).
The insulation resistance must rise after a short operation of the motor.
Under normal transportation, storage and operating conditions the insulation resistance of the cold motor must not drop under the values in item 2.

Table: Insulating resistances R_{is}		
Voltage	Rated voltage < 1.5 kV	Rated voltage > 1.5 kV
Measuring voltage	> 100 V to max. 500 V	1000 V
1. Winding new or repaired dry, 25 °C	R_{is} > 50 MΩ	R_{is} > 100 MΩ
2. Winding after long period of operation condition unknown, 25 °C	R_{is} > 1 MΩ	R_{is} > 5 MΩ / kV

4.3 Mechanical check

- Make sure that the motor is clean and free from dust! Are removed all strange parts and tools?
- Check whether air inlets and outlets are clean, making sure that the air can enter and exit unobstructedly!
- Check the temperature of the coolant!
- If you are working with a water-cooled motor, make sure that the cooling water circuit is properly connected and operating!
- Check whether the motor and all screws fastening are connected correctly!
- Check whether the terminal box is closed and all wire entry sleeves properly sealed!
- Check the belt tension of belt-driven motors.
- In motors equipped with transport locking devices – marked by a special notice plate – check whether the device has been removed.
- After longer storage periods, check the lubrication of the bearings (see section 5.4).
- We recommend first of all running every motor without load for at least one hour. The motor is operating properly if it does not shake and if the noise of the bearings is even.

ATTENTION! Remove the transport locking device before starting operation. Then race every motor manually and listen to monitor it.

5 Maintenance

5.1 General informations

Maintenance activities include bearings, cleaning the motor and the cooling air filters, if exist.
The following must be done according to operating condition but at least once every year:

- Check the terminal boxes and terminals for cleanliness and corrosion
- Check the electrical connections for tight fit
- Check the cooling air circuit for cleanliness and sufficient operability.

Insulation value and standstill heater

Regularly check the insulation value of motors that are not used permanently or used in particularly damp environments (see section 4.2 "Measuring of the insulation resistance").
If the motor is equipped with a standstill heater, then the heater bands and corresponding switching elements must be checked every six months.

Preventive maintenance

Depending on operating conditions, preventive maintenance is to be carried out every 15000 to 24000 h by experienced and specialized staff. Maintenance activities include cleaning the inside of the motor, checking bearings and close fitting of the end-wire binding bands and, if necessary, appliying a new coat of finishing varnish.
Check the alignment of motors and the safe connection of all screws.

5.2 Cleaning

Use a vacuum cleaner or bellows to remove dust from the motors, do not use pressurized air containing oil or water. Make sure not to blow any dirt or dust into the inside of the motor. **Do not use sharp tools for cleaning.**
If the winding is very dirty (oil vapours or grease squelching out of the bearings), use industrial solvent-based cleaners (petroleum ether or diluter on petrol basis) or other aqueous industrial cleaners or emulsion cleaners to remove the dirt. Make sure that the cleaners do not dissolve paint coats or plastic materials.

ATTENTION! Provide sufficient ventilation when cleaning the motor and make sure not to let any cleaning agents get into the waste water. Observe the environmental protection regulations.

5.3 Drying the winding

Selection of the drying method depends on the type of motor and the possibilities provided at the location. Redrying can be achieved by warming up the winding using direct current (e.g. welding machine). The current intensity used should not exceed 60 % of the rated current indicated on the performance plate. Ensure power feed to two phases. Minimum drying time is 1 hour.

ATTENTION! Check the heating up of the casing or measure the temperature of the winding by thermocouples or a thermometer.
Only to be carried out by specialized staff.

After drying you must measure the insulation resistance.

Drying conditions:

- Keep check-up records with values measured!
- Always dry the motor slowly and thoroughly.
- The maximum drying temperature is 75 °C.
- Continue the drying process until the insulation resistance increases considerably and arrives at the minimum value. Keep check-up records with values measured!
- Ensure condensation drain by opening terminal box and / or covers.
- Put the motor back into a normal operating state after drying.

5.4 Lubrication and maintenance instructions for antifriction bearings

For the actual bearing configuration please see our documentation KAD 00810!

5.4.1 Lubricant information

The manufacturer lubricates the bearings in the factory using **Bechem / Ceritol HIGH LUB LM 3 EP**, a lithium-based multigrade grease of consistency class 3 with a temperature range of **-40 °C** to **+140 °C** (unless otherwise agreed).
We recommend also using this type of grease for relubrications. This is a sure way of avoiding damages to the bearings due to wrong lubricants. The following lubricants can replace each other without limitations due to useful characteristics or lubrication intervals.

Lubricant	Manufacturer	Lubricant	Manufacturer
HL 3	ARAL	Energrease LS 3	BP
Epexa 3	ELF	MM - EP2	BP
Centoplex 3	Klüber	Mobilux 3 / EP 3	Mobil
Alvania RL3	SHELL	Unirex 3	ESSO
Total Multic EP3	TOTAL	Turmoplex 3 EP	Lubcon
Glissandro EP2-3	DEA	SPEEROL AP3	Castrol

If new sort of grease will be used (with same consistency class and saponification also) the bearings should be regreased 3 times with half regreasing periods.
In case of longer downtimes or storage please remember that the maximum storage time of these greases is 36 months. So we recommend **to regrease brand new motors too** with half regreasing periods after longer standstill time.
Check the proper functioning of the motor before and after each lubrication.

5.4.2 Bearings with relubrication device

ATTENTION! Lubricate the bearings only with the motor running.

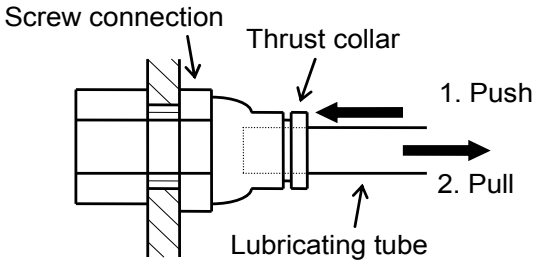
Relubrication is done via the button head lubricating nipple in accordance with DIN 3404. All lubrication points are marked on the motor. Information plates and the data sheet „Antifriction bearings" tell you about lubrication dates and grease quantities.
In case the grease indicated for motors to be relubricated or another grease of the same type of saponification is not available, open the bearings and remove the grease. Then clean the bearing and relubricate using a grease of a similar quality.

NOTE Avoid mixing greases of different type of saponification for antifriction bearing lubrication, because the greases loose their lubricity in this case.

NOTE Extending the recommended lubrication periods causes danger to the bearings and may lead to a loss of bearing sealing usually provided by the grease thus allowing dust to enter the bearing.

Concerning the RS type (slip-ring rotor), regreasing takes place by a lubrication tube on the N-side.

ATTENTION! To remove the hood or the end shield of bearings with relubrication device, you have to separate the lubrication tube from the screw connection (figure 4).



Disassembly:
1. Push thrust collar against screw connection
2. Pull at the tube at the same time

Aassembly:
Push tube right in

Figure 4: Disassembly of lubricating tube

5.4.3 Removing used grease

The used grease comes out of a covered gap in the bearing cover or is automatically collected in a chamber (grease collector) underneath the bearing. The grease collector must be emptied after three lubrication cycles unless otherwise stated. The grease collectors are marked by particular signs on the motor.

Danger!
Remove the used grease only while the motor is standing still.

- It is mandatory to observe the dates for removing the used grease, because too much increased grease quantities would lead to an impermissible warming-up of the bearings.
- In some motor types, the used grease comes out of a covered gap in the bearing cover, accumulates around the end shield and must be removed from there after several lubrication cycles.
- To remove used grease by means of grease slides pull out and empty the slides while the motor is standing still. On the N side, the grease collector is located below the ventilation cap. For cleaning, open the cap, pull out the grease collector and empty it.
- Motors of type V1 are equipped with grease pipes on the D and the N side. To clean these, you remove the plugs on either side and push the used grease out to the left or right using a round stick (Ø approx. 25 mm).

ATTENTION! Make sure to dispose of the used grease in an environmentally friendly way.

5.4.4 Maintenance instructions

Listen for unusual sounds from the bearings and check them for staying within the admissible bearing temperature range once every month. If there are SPM measuring nipples or vibration pickups, then the values measured must be analysed at the same time intervals.

6 Slip-ring system (only for types RS, RSR, RSK and RSB)

6.1 Design

Access to the slip-ring system:
The slip-ring system is accessible via attendance openings in the slip-ring casing.

Danger!
Removing of mounting covers can be done at standstill of motor only.

After removing the screws you can take off the cap. This, at the same time, removes the filter segment that is fixed to the cap. Be sure to remove the cap carefully to prevent any coal dust adhering to the filter from falling back into the motor.

6.1.1 Slip rings

Slip-ring frame:
The slip rings are made of insulated moulding material. Bronze GCuSn10 compliant with DIN EN 1982 is used as slip-ring material. The product is delivered with precision-turned slip rings. Metal slip rings have a surface roughness, R_z of 0.8 µm.

Slip-ring wear:
Due to the friction between brush and slip ring, slip-rings wear out by up to 1 mm per 1.000 operating hours.

ATTENTION! The wear limit is marked with a marking groove on the slip ring and must not be undershot.

Thumbrule: Inner diameter of slip ring – 15 mm = wear limit

Reworking the slip rings:
Check operation and ambient conditions when any deep scoring occurs. Inform the manufacturer immediately if these conditions considerably differ from the order specifications.
Rework the slip rings only in case of mechanical damage.
Scoring can be eliminated by reworking the slip rings. Keep a surface roughness of 0.8 µm.

Eccentricity:
Tolerable eccentricity after reworking must not exceed the values of the table below. The eccentricity value found during check-up measurements of slip rings that have been used for a longer period of time can be twice as great without endangering operating safety. Thus, sparkless working of the slip rings as well as conservation of existing patina should be mainly watched and given priority over the observation of recommended eccentricity.

Number of revolutions [rpm]	≤ 500	≤ 750	≤ 1800	> 1800
Eccentricity [mm]	0.10	0.07	0.05	0.03

Replacing the slip rings:
The slip rings are fixed on the shaft with a press fit. The motor is delivered with precision-turned slip rings. When the wear mark falls below the set limit, the slip-ring frame must be replaced.
Heat the slip ring up to 100 °C before installing it. Rework the slip rings after installation and put them into operation as described in section 6.2 "First startup".

6.1.2 Carbon brushes

Design:
The brushes are located in pocket brush holders. The pocket brush holders are built in alongside. The brushes must glide in easily into the pocket brush holders. The brush pressure amounts to **20 kPa ± 10 %.** If the motor is exposed to vibration, brush holders with increased rated pressure (25 kPa) can be put in.
The motors are equipped with metal graphite brushes and, regarding the brush profile, adequate for operation at 70 to 100 % of their rated power.
Contact the manufacturer to choose the brush type that is best suited for loads frequently remaining under 70 % of the rated power.

Brush wear:
The standard brush wear of the bronze slip rings used amounts to between 1 and 5 mm per 1000 operating hours.
Bush wear must be checked at regular intervals. The wear-out largely depends on the actual operation and ambient conditions and can be higher during the running-in period. Thus, the directly responsible operator must set the corresponding check-up intervals.

Replacing the brushes:
If the brush wear amounts to more than 18mm, brushes have to be replaced.

ATTENTION! Use the original brush brand or a similar quality for the replacement of the carbon brushes!

With new brushes or reworked slip rings, the brush running faces must be bedded, so that a contact pattern of about 70 % of the running face is achieved.
To do so, put a piece of abrasive paper or cloth between carbon brushes and slip-ring surface and move it around in peripheral direction. Do the finishing touches with abrasive cloth as thin and as finely grained as possible only in direction of rotation. Thus the carbon brushes in the brush holder take a position equal to that during the operation of the motor. Remove the abrasive dust that has penetrated into the running face with a glass brush. Remove the developing brush dust from the motor by means of a vacuum cleaner.

Replacing the brush holders:
When replacing the brush holders make sure that the distance between the pocket brush holders and the outside diameter of the slip rings amounts to about 2 mm.

6.2 Startup

- Prior to initial operation, check whether the slip rings and carbon brushes have clean running faces and whether the brush holders are working.
- We recommend grinding bronze slip rings over with abrasive cloth of granulation 80 and polishing them afterwards with polish cloth of granulation 500.
- If any dirt has accumulated during storage or downtimes, clean the slip ring with solvent.
- If necessary grind the brushes (see "Replacing the brushes").

Running in the slip-ring system:
To ensure secure and low wear-out operation of the sliding contact it is necessary that a patina layer develops on the slip rings. Generally the patina is regarded as a protective layer on the slip-ring surface. Its effect is comparable to a liquid film on sliding bearings.

The developing of patina depends on the following factors:

- Influence of atmospheric oxygen
- Atmospheric humidity
- Brush and slip-ring temperature
- Gases, vapours and dust.

According to experience it takes about **100 to 500 operating hours** for the patina layer to develop, depending on different influences of the above factors. Thus, on a new or reworked slip ring there can be no patina. Sometimes during the running-in period, compact parts of fine slip-ring dust are welded together in the brush running face. The slip rings are channelled by these hard inclusions in the brush running face until these inclusions either disappear from the hard brush running face on their own or until they are removed after check-up and maintenance activities. After long years of observation we can now safely say that after developing the patina layer, the metal inclusions in the brush running face which occur during the running-in period do not appear any more, and operation is stabilizing. For this reason make sure that careful check-up and maintenance activities are done during the running-in period.

6.3 Checks and maintenance

- Check whether electrical connections are tightly fixed
- Check whether channels, damages and changes of the patina appear on the slip-ring surface
- Check the brush wear and install new carbon brushes, if necessary
- Remove the wear dust produced by the carbon brushes from the components and from the interior of the casing (vacuum-cleaner).
- Check whether the carbon brushes are gliding in easily into the pocket brush holders and whether the lever in the operation area of the brush moves freely
- Check whether the brush holders are tightly fixed on the brush pin
- Check whether brush sparking appears
- Check the insulation components of the slip-ring system for fissures and ageing.

NOTE Preserve the insulation parts with air-drying electric insulation varnish, if necessary.

The time intervals of this servicing, maintenance and inspection work must be defined by the operator themselves, however, they may not be longer than 1000 operating hours.

The **check of brushes** has to be done at the following intervals:

- After 24 operating hours, check the slip-ring surface (beginning patina development) and check the brush wear
- After 100 operating hours, patina should have developed, brush wear up to 1 mm
- After 500 operating hours, check the running-in process again

If small channels appear, check whether there are metal inclusions in the brush running face. The metal inclusions have to be removed from the brush running face (drawing pin). Please make sure not to grind the not fully developed patina, if small channels and inequalities or bright and dark stripes appear on the slip ring, for the sliding contact will not stabilise otherwise.

7 Supplementary installations

These only exist in customized solutions upon special request.

7.1 Temperature monitoring

7.1.1 Thermal winding protection

The thermal winding monitoring reacts to invalid temperature increases in the stator winding and is realized by PTC thermistors or by platinum measuring resistors. They are included in the installation according to agreement.
Rules and information given in section 3.2 "Electrical connections" apply.

Reactions are specified for problem conditions such as

- exceeding the rated power
- reduced cooler performance (e. g. congestion of the air filter)
- increased ambient temperatures
- excessive occurrence of motor switching operations.

NOTE This protective systems only indirectly protects rotor and other windings.

7.1.2 Thermal bearing monitoring

According to agreement measuring and monitoring bearing temperatures are possible. To realize these options, sensors on the basis of PTC thermistors or Platinum measuring resistors and / or thermometers are used after pressure-resistant mounting in corresponding screw-type casings.
The actual casing used depends on the corresponding end shield, crown or the bearing to be monitored.
Please refer to the wiring plan for the sensor connections inside the terminal box.

7.1.3 Thermal cooling air monitoring

For cooling air monitoring of motors with water/air cooler, air/air cooler or pipe connection, there is the option of installing a Pt100 sensor and / or a thermometer at the cold air end (inlet).
If agreed, another sensor and / or a thermometer can be connected to the warm air side (outlet).

7.1.4 PTC resistor temperature probe (PTC thermistors in acc. to DIN 44081)

In this case, the sudden increase in thermistor resistance occurring in the range of ± 5 K of rated reaction temperature is used for temperature monitoring. In an electronic module, this change in resistance is converted to a signal which can then be used for switching off the motor or for outputting a warning.
PTC resistors with rated reaction temperatures between 90 °C and 170 °C are used.
Type designation includes the rated reaction temperature.

PTC thermistors in accordance with DIN 44081 can be exchanged or switched in series.
A typical stator winding has one PTC thermistor per phase. The stranded hook-up wires of these three thermistors are series connected. It is possible to install a second set of thermistors which is then used in conjunction with a second module either as reserve, for two separate windings or for thermal warning.

7.1.5 Platinum measuring resistors (Pt100 sensors in acc. to DIN EN 60751)

In this case, temperature monitoring is based on the linear change of Pt100 sensor resistances in a wide temperature range. In conjunction with suitable temperature limit switches or Pt100 temperature measuring circuits they can be used for both automatic triggering at certain preset temperatures or for permanent measurement, control or indication of temperatures.
Pt100 sensors can be installed in windings like thermistors.
Each sensor is connected separately to the terminal panel and must be analyzed separately.
Special Pt100 slot resistance thermometers can be installed in the motor slots according to agreement. This allows very precise checking of the winding temperature and the sheet metal package even in very inaccessible places.
Temperature control of components, cables and bea-rings in particular is possible by using surface sensors.

NOTE Create a four-wire connection by later adding two additional terminals in conjunction with a terminal bridge or parallel terminals for the current and voltage wires (figure 5).

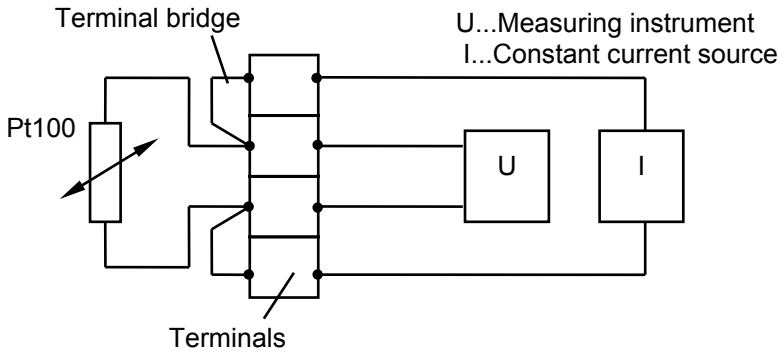


Figure 5: Four-wire-connection

7.1.6 Silicon sensors (KTY sensors)

KTY series silicon sensors can also be used for temperature measurement and for limit value monitoring. This series' silicon sensors are semiconductors with a similar design to a diode. Their working temperature range extends from –55 to +300 °C.
Just like PTC thermistors, they have positive temperature coefficients. However, unlike PTC thermistors they have an approximately linear characteristic curve. The resistance behaviour of KTY sensors is comparable with that of a measuring shunt with large temperature coefficient.
KTY sensors are used analogous to the Pt100 sensors.

7.1.7 Note on repairs and retrofit packages

The module reacts to interrupting the stranded hook-up wires like to an increase to sensor resistance, therefore outputting the triggering signal. Stranded hook-up wire interruptions occurring in the accessible part can be easily removed so that thermal protection resumes full operability. However, defect sensors require replacement.
Please make sure to first determine the resistance value for the defect sensor.

ATTENTION! The measuring voltage must not exceed 2.5 V max.

The Pt100 sensor resistance amounts for ambient temperatures of 20 °C approx. 108 Ω.
Put in new sensors in direct proximity of the defect ones always making sure not to remove the old ones to avoid damaging the winding. See the relevant motor to find the exact mounting locations.
Unless otherwise stated, defect Pt100 sensors must be replaced by a 100 Ω resistor in the triggering device.

ATTENTION! This renders thermal protection ineffective.

Below the rated reaction temperature, PTC thermistors have a resistance of 20 – 250 Ω. For cases of exchange we will tell you the exact PTC type designation if you tell us the motor number.

KTY sensors may be replaced by the same types only. If you inform us of the motor number, we will notify you of the precise KTY type designation.

7.2 Standstill heater

Standstill heaters are available for using the motors in shipbuilding, in tropical zones or upon request. The standstill heater consists of heating pipes that are located inside the motor on the D- and N-side.

Danger!
Switch off the standstill heater via the control centre before opening the terminal box! Check whether the system is in a voltage-free condition.

The following heating output is assigned to the shaft centre heights:

Shaft centre height [mm]	225 - 250	315 - 400	450 - 500	560 / 630	710
Heating output [W]	84	150	300	520	780

The connecting terminals are marked and located in the motor's terminal box.

The network voltage is 220 / 230 V unless otherwise agreed. Connect the standstill heater to the relevant terminals in the terminal box according to the current switching diagram.

NOTE For specific heater output and voltage : see information sign in the terminal box

ATTENTION! Activate the standstill heater only after switching off the motor.
Provide suitable means to avoid unintentional operation of the standstill heater while the motor is running (locking mechanism).

8 Trouble shooting information

Malfunction			Possible cause	Remedy
Bear-ing is too hot	Bearing noises *)	Motor is running rough		
xxx			Too much grease in the bearing	Remove excessive grease
xxx			Bearing dirty	Replace / clean bearing
xxx			Belt tension too high	Reduce belt tension
xxx		**xxx**	Appearing coupling forces	Align motor and coupling
xxx			Coolant temperature above 40 °C	Adjust temperature of cooling air
xxx	**xxx**		Not enough grease in the bearing	Grease acc. to instructions
xxx	**xxx**	**xxx**	Wrong location of the motor	Check structural shape of motor
xxx			Dark coulored grease in bearing(s)	Check for bearing currents
	xxx		Channels on the inside ring of bearing	Replace bearing
		xxx	Balance error caused by coupling	Balance exactly
		xxx	Motor not properly fixed	Check fixing
*) If the remedial measures do not solve the problem, we recommend replacing the bearings.				

Malfunction				Possible cause	Remedy
Motor does not run up	Motor is too hot	Speed drops consid.	Security device releases		
xxx		**xxx**		Load moment too high	Check motor and load moment
xxx		**xxx**		Network voltage too low	Check network conditions
xxx		**xxx**	**xxx**	Phase interrupt	Check network
xxx	**xxx**	**xxx**	**xxx**	Wrong circuit	Heed wiring diagram
	xxx	**xxx**	**xxx**	Overload	Check with rating plate
	xxx		**xxx**	Number of switching actuations too high	Heed defined operating conditions
	xxx			Insufficient aeration	Check cooling air channels Check direction of rotation
	xxx			Aeration channels dirty	Clean cooling air channels
			xxx	Short circuit of winding or binder	Check insulation resistance
			xxx	Rise time exceeded	Check rise time conditions

9 Spare parts

The following information is required for ordering spare parts:

What?	Where?
Name of part	Enclosed spare parts list
Motor type	Rating plate
Output	”
Voltage	”
Serial number of motor (**absolutely necessary!**)	”

Carry out dynamic balancing after replacing any rotating parts.

Bearing configuration - see Data sheet “Bearings”

Spare parts and names of parts - see appendix