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Operating Manual
BA 169 05 E

Spring-loaded brake operated by direct-current electromagnet
Model E500B

1 Safety information

Connection, setup and maintenance work must be conducted only as directed by the safety instructions as specified in the attached code of practice no. 122.

2 General information

In addition to holding loads in the idle state, the spring-loaded brake slows rotating and linear moving masses, thus reducing unwanted overtravel distances and times.
The brake is released electromagnetically. Without electrical power the braking force is generated by spring pressure. Because in this system the braking effect may also be generated by an accidental power failure, this device can be classified as a safety brake as defined by accident prevention regulations. During the braking process, the kinetic energy of the mass moments of inertia is converted into heat via the brake disc. The brake disc, which consists of high-quality, asbestos-free material, is highly resistant to wear and heat. However, a certain amount of wear is unavoidable. Therefore, the limit values listed in section 9 regarding energy capability and minimum lining thickness must be observed under all circumstances.

3 Operating principle

The operating principle is described in Figure 1.

3.1 Brakes

The brake disc (1) is pressed against the flange plate (4) by the springs (3) via the retaining plate (2). Radial movement of the retaining plate is prevented by the cap screws (5). The braking torque is transferred to the rotor via spline connecting the brake disc and the carrier (6) fixed to the shaft. The braking torque can be adjusted in stages by changing the number of springs (see Sec. 7).

3.2 Brake release

Supplying the coil (7) with the correct DC voltage causes the retaining disc to be attracted by the magnetic field generated in the magnet housing (8) against the spring force. This relieves the brake disc and as a result allows the rotor to move freely.
The large size of the electromagnets allows an increased air gap sL caused by the wear of the brake disc to be closed. No adjustment facility is hence provided.
All brakes can be optionally fitted with either a latching or non-latching manual release, which may be used to release the brake manually e.g. in the event of a power failure.

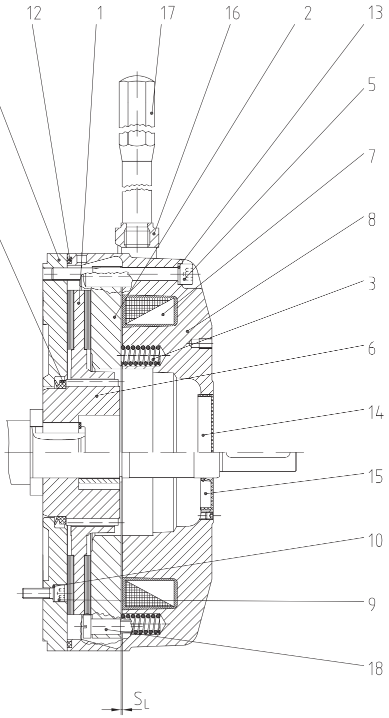

Figure 1: Spring-loaded brake of the E500B series

4 Electrical connection

4.1 General information

There are 2 different options for the voltage supply of the DC solenoid:

1. Externally from an existing DC control network or by a rectifier in the switch cabinet.
2. By a rectifier integrated in the motor terminal box.
   In this instance, the rectifier can be supplied either directly from the motor terminal board or from the mains.
   In the following instances, the rectifier must not however be connected to the motor terminal board:

- Pole-changing motors and wide range motors
- Operation with frequency converter
- Other designs in which the motor voltage is not constant, e.g. operation on smooth-start equipment, starting transformers, ...

4.1.1 Brake release

If the solenoid is energised using nominal voltage, the coil current and the magnetic field build up follow an exponential function. Only when the current has reached a specified value (I_{vent}) is the spring power overcome and the brake begins to ventilate.

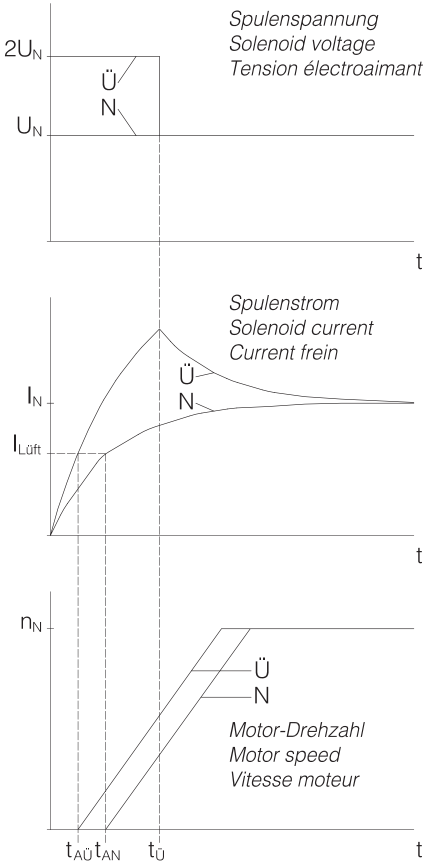

Figure 2: General trend of coil voltage, coil current and motor speed at normal excitation (N) and overexcitation (Ü).
$t_Ü$: overexcitation time; t_{AN}, $t_{AÜ}$: response times at normal excitation and overexcitation

Two different cases can occur during response time t_A, assuming the power is supplied to the motor and the brake at the same time:

- Motor is blocked - condition: $M_A < M_L + M_{Br}$
  The motor takes the inrush current and is thereby subjected to additional thermal loading. This scenario is shown in Figure 2.
- Motor drives through brake - condition: $M_A > M_L + M_{Br}$
  At the start, the brake is subject to thermal loading and wears more rapidly.

M_A: Locked-rotor torque of the motor, M_L: Load torque, M_{Br}: Braking torque

In both scenarios, the motor and brake are therefore subjected to additional loading. The response time becomes noticeably longer as the size of the brakes increases. A reduction in response time is therefore especially recommended for medium and large-sized brakes as well as with a high frequency of braking operations. This can be implemented relatively easily by electrical means with the principle of "overexcitation". In this instance, the solenoid is briefly supplied with twice the nominal voltage when switched on. The associated steeper increase of the current reduces the response time to about half of that achieved with "normal excitation". This overexcitation function is integrated into the MSG special rectifier (see Sec. 4.4).

As the air gap gets larger, the release current and therefore the response time increase. As soon as the release current exceeds the nominal coil current, the brake no longer releases during normal excitation and the brake disc wear limit is reached.

4.1.2 Brakes

The braking torque is not effective immediately after the power supply to the solenoid is switched off. Firstly, the magnetic energy has to reduce until the spring force can overcome the magnetic force. This occurs at holding amperage I_{Hold} which is far smaller than the release current. Dependent on the circuit design, different response times result.

4.1.2.1 Switching off the AC supply of the standard rectifier SG

a) Rectifier supply from the motor terminal board (Figure 3, graph 1)
   Response time t_{A1}: Very long
   Cause: after switching off the motor voltage a slowly decaying voltage is induced by the remanence of the motor and the power supply to the brake is continued. The magnetic energy of the brake solenoid declines relatively slowly through the freewheeling circuit of the rectifier.

b) Separate rectifier supply (Figure 3, graph 2)
Response time t_{A2}: Long
Cause: After switching off the rectifier voltage the magnetic energy of the brake solenoid declines relatively slowly through the freewheeling circuit of the rectifier.

No significant switch-off voltages arise on the solenoid during an AC interruption.

4.1.2.2 Interruption in the DC switching circuit of the solenoid (Figure 3, graph 3)

a) By mechanical switch
- for separate supply from a DC control network or
- at the DC switching contacts (A2, A3) of the standard rectifier
Response time t_{A3}: Very short
Cause: the magnetic energy of the brake solenoid is reduced very quickly by the arc occurring at the switch.

b) Electronically
By use of the MSG special rectifier
Response time t_{A3}: Short
Cause: the magnetic energy of the brake solenoid is quickly reduced by a varistor integrated in the rectifier.

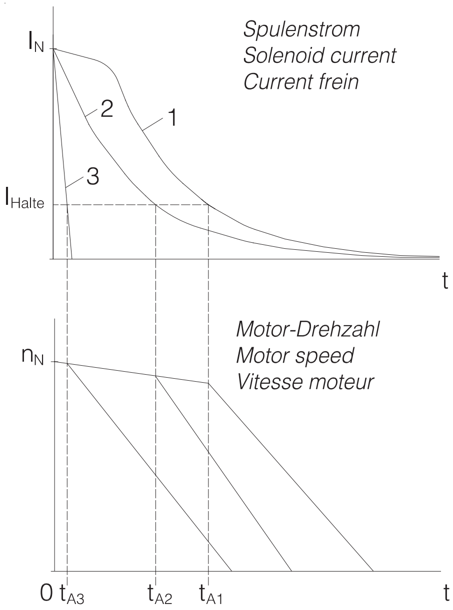

Figure 3: General curve of the coil current and the motor speed after alternating current (1, 2) and direct current (3) switch-off

In the case of direct-current interruption voltage peaks uq are induced by the solenoid. The magnitude of the peaks depends on the following relationship of the self-inductance L of the coil and the switch-off speed di/dt:

$$u_q = L \cdot \frac{di}{dt}$$

As a consequence of the winding design, inductivity L increases as the solenoid rated voltage increases. With higher solenoid voltages, the cut-off voltage spikes may therefore be dangerously high. All brakes for voltages in excess of 24V are therefore connected with a varistor.
The varistor is there simply to protect the solenoid and not to protect surrounding electronic components and devices against EMC faults.
On request, brakes for voltages of less than or equal to 24V can also be produced with varistors.

If the direct current interruption is produced by a mechanical switch, high levels of burn down are caused by the arc produced on the switch contacts. Only special DC direct current contactors or adapted AC alternating current contactors can be used with contacts of usage category AC3 as defined in EN 60947-4-1.

4.2 External DC voltage supply

If the brake is supplied directly from a DC control power supply.

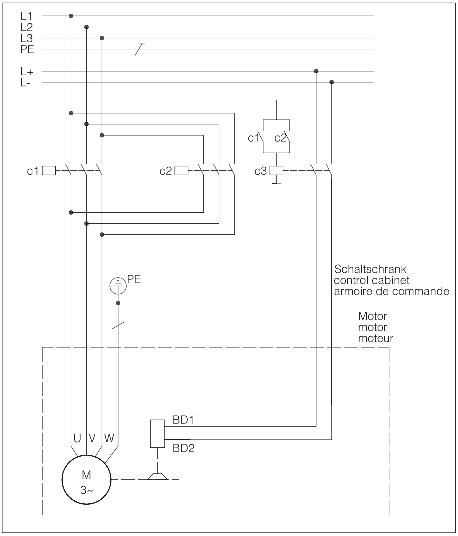

Figure 4: DC power supply directly from a control network

4.3 Through standard rectifier SG 3.575A

Rectifier technical data

Operating principle	Half-wave rectifier
Supply voltage U_1	maximum 575 V AC +5%, 50/60 Hz
Output voltage	0.45 * U1 V DC
Maximum output current	2 A DC when fitted in motor terminal box 2.5 A DC when fitted in switch cabinet
Ambient temperature	-20° C to 40° C
Possible conductor cross-sections	max. 1.5 mm^2

4.3.1 Rectifier voltage supply from the motor terminal board

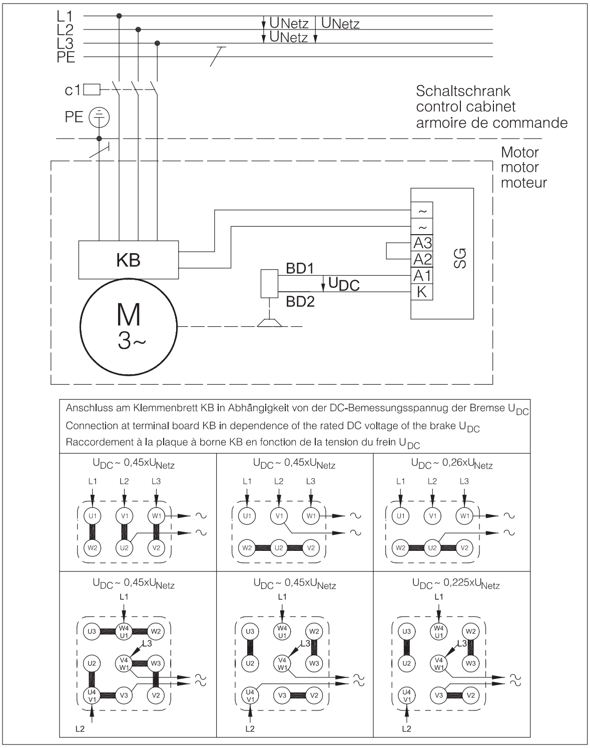

Figure 5: Alternating current switch-off → Terminals A2 and A3 bridged

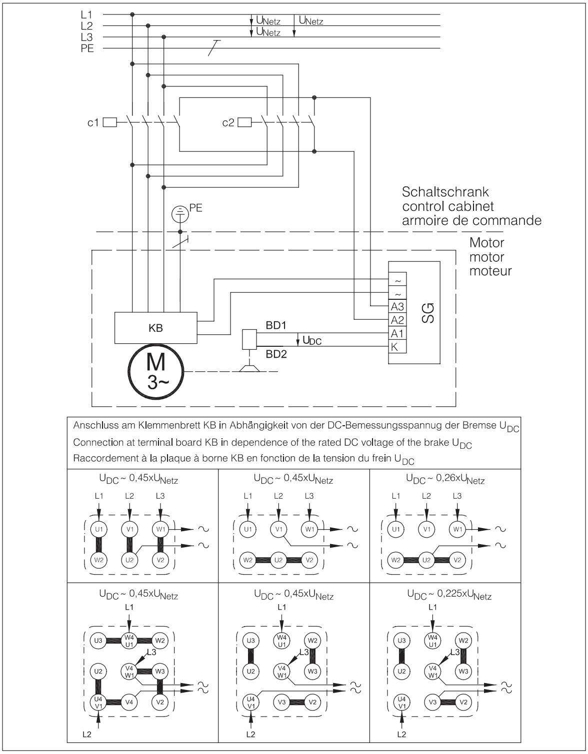

Figure 6: direct current switch-off at terminals A2 and A3
e.g. via direction of rotation contactor

4.3.2 Rectifier voltage supply via separate contactor

As previously explained in Sec. 4.1, in all models with variable motor voltage and with pole-changing motors the rectifier must not be connected to the motor terminal board. Instead, the input voltage of the rectifier must be connected through a separate contactor. The implementation principle when operating on the frequency inverter is shown in Figure 7 by way of example.

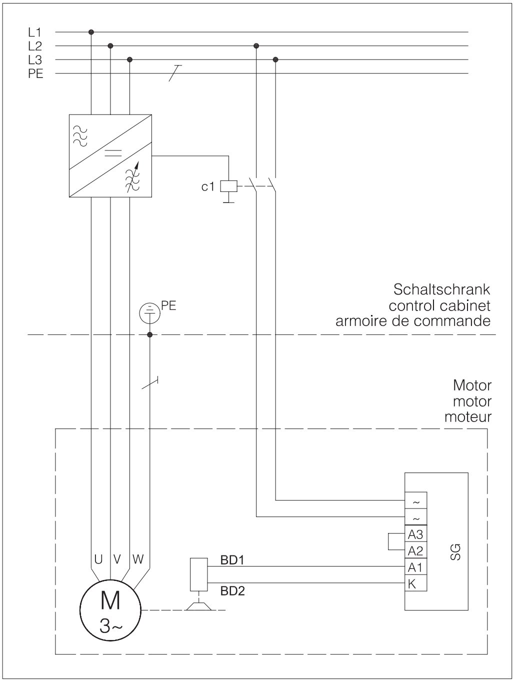

Figure 7: Operation with frequency converter
Alternating current switch-off ⟶ Terminals A2 and A3 bridged

4.4 Through special rectifier MSG

Rectifier technical data

Operating principle	Half-wave rectifier with time-limited overexcitation and electronic direct current interruption
Supply voltage U_1	220 - 480 V AC +6/-10 %, 50/60 Hz
Output voltage	0.9 * U1 V DC during overexcitation 0.45 * U1 V DC after overexcitation
Overexcitation period	0.3 s
Maximum output current	2 A DC
Ambient temperature	-20° C to 40° C
Possible conductor cross-sections	max. 1.5 mm^2

The MSG special rectifier is available in two models which differ in terms of the type of switch-off detection.

4.4.1 MSG 2.480U

Principle: quick switch-off because of failure of input voltage. This type is used if the supply voltage is supplied separately.

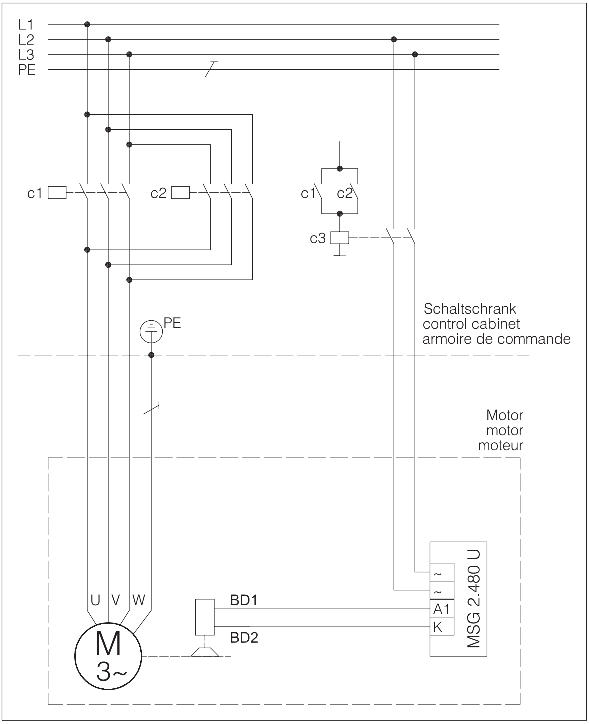

Figure 8: electrical connection of the MSG 2.480U type

4.4.2 MSG 2.480I

Principle: quick switch-off because of failure of motor current in one phase. This type is used if the voltage is supplied by the motor terminal board.

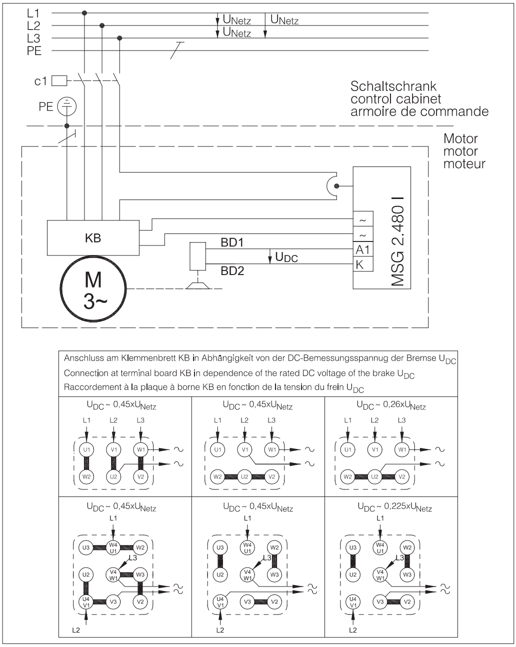

Figure 9: Electrical connection of the MSG 2.480I type

For current recording purposes, one core of the connection cable must be routed through the bracket fitted to the side of the rectifier. Because the current detection is limited downwards, the wire must be looped through several times with motor no-load currents less than 0.6 A. In this instance, a sticker specifying the number of conductor loops can be stuck on the rectifier under the bracket.

Attention:
It is necessary for the function of the rectifier that a motor supply line is routed through the bracket. Otherwise the rectifier does not switch on and could even be destroyed in the worst case.
The procedure shown in Figure 10 is recommended for as simple an assembly as possible:

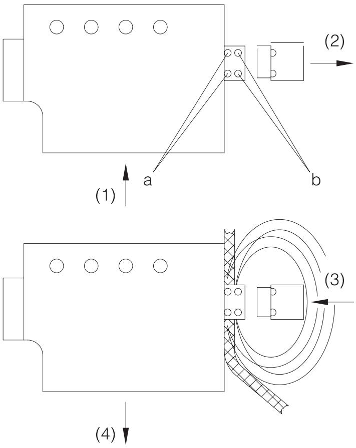

Figure 10: Fixing the wire to the rectifier
a: detent 1, b: detent 2

- Pull rectifier out of terminal box guide (1)
- Pull bracket off (sideways) (2)
- Press wire or wire loops within the bracket against the wall of the rectifier and insert the mount again (3)
- Slide rectifier back onto guide (4)

The bracket can be fixed in two detent positions. Select detent 1 if detent 2 cannot fit in small terminal boxes. Depending on the number of conductor loops, the following conductor cross-sections must not be exceeded in detent 1:
triple bushing: max. 1.5 mm^2
double bushing: max. 2.5 mm^2
single bushing: max. 6 mm^2
In detent 2, a maximum cross-section of 16 mm^2 is permissible.

In the case of motors with rated currents of more than approximately 25 A, the magnetic field sensor of the rectifier is saturated as a result of the relatively high initial currents and subsequently no longer detects currents of less than 1 A. That means that a rectifier which was originally operated on a large motor (I_N > 25 A) cannot subsequently be used for small motors.
The sensor can be subjected to a maximum continuous loading of 60 A.

Attention:
If the drive unit is subjected to a high-voltage test, the two connection conductors of the rectifier are to be disconnected beforehand.

5 Attachment

Generally, the spring-loaded brakes are installed ready for operation on the motor. Proceed as follows for retro-fitting (see Figure 1):

5.1 Attach flange plate (4) to the motor end housing or the fan hood with the fillister screws (9) and the USIT rings (10), secure with Loctite.
Note tightening torque, max. torque = 22 Nm.
When attaching to end housing:
seal joint between flange plate and end housing with gasket material.
5.2 Mount carrier (6) on shaft – for installation on fan hood with V-ring (11), note the complete load length of the parallel key and fix axially with a locking ring.
5.3 Slide brake disc (1) on to the carrier by hand, the brake disc collar points in the direction of the brake. Ensure that the gearing moves easily.
Do not damage.
5.4 Fasten brake with O-ring (12) to the flange plate with the fillister screws (5) and the USIT rings (13). Note tightening torque, max. torque = 45 Nm.
5.5 For motor design without 2nd shaft end mount cap closure (14), for design with 2nd shaft end mount shaft sealing ring (15).

The brake is ready for operation once the electrical connection has been made.

6 Installing the manual release

The manual release can only be assembled with the brake removed.

Procedure (see Figures 1 and 11):
6.1 Remove brake from flange plate (4).
6.2 Remove stopper plugs from the manual-release holes in the magnet housing (8).
6.3 Push compression springs (19) onto the manual-release bolts (20).
6.4 Push manual-release bolts (20) with compression springs (19) into the manual-release holes on the magnet housing (8) from the inside (in the direction of the coil (7)).
6.5 Push the O-rings (21) onto manual-release bolts (20) and push into the countersinks on the magnet housing (8).
6.6 Push spacer plates (22) onto the manual-release bolts (20).
6.7 Locate manual release bracket (16), push on washer (23) and screw on self-locking nut (24) loosely.
6.8 Tighten both lock nuts (24) until the retaining plate (2) is flush with the magnet housing (8).
6.9 Slacken the two locknuts (24) by 1.5 revolutions and set the air gap between retaining plate (2) and solenoid housing (8) or the test dimension $X(= 2.4^{+0.1}$ mm).
6.10 Screw in manual release rod (17) into manual release bracket (16) and tighten it.

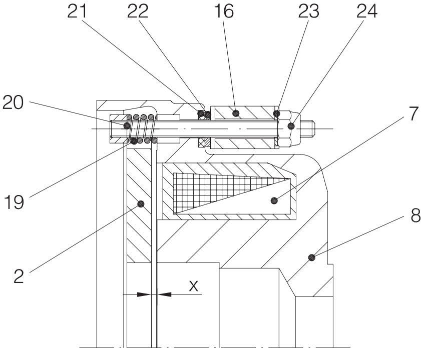

Figure 11: Installing the manual release

7 Setting the braking torque

The braking torque can be changed in steps by the number of springs. The braking torques, which depend on the installed springs, are listed in Sec. 9.

Procedure for changing the spring configuration (see Figure 1):

7.1 Unscrew brake from flange plate (4).
7.2 Remove fastening screws (5).
7.3 Unscrew the shoulder screws (18) from the magnet housing (8) and remove the retaining plate (2).

Attention:
The springs (3) press against the retaining plate. To remove the shoulder screws, the retaining plate must be pressed against the magnet housing to avoid releasing the springs too quickly.
Observe the installation position of the retaining plate and make sure that no springs fall out.

7.4 Insert springs (3) corresponding to the desired braking torque (see Sec. 9).

Attention:
The springs should be arranged **symmetrically**.

7.5 Position retaining plate (2) on solenoid housing (8) or springs (3) (note installation position), press retaining plate down against the spring power and screw in shoulder screws (18) to the stop.
7.6 Mount brake on flange plate (4) with the fastening screws (5) and the USIT rings (13). Note tightening torque, max. torque = 45 Nm.

8 Maintenance

The E500B brake is generally maintenance-free, because the robust and wear-resistant brake disc has a very long service life.
However, if the brake disc becomes worn due to high total friction and the function of the brake is therefore no longer guaranteed, replacing the brake disc will restore the brake to its original condition.
The wear of the brake disc must be checked regularly by measuring the air gap or the thickness of the brake disc. The brake disc must be replaced at the latest on reaching the maximum values listed in Sec. 9 for the air gap or the minimum values for the thickness of the brake disc (see Sec. 8.2).

8.1 Measuring the air gap

Procedure (see Figure 1):

8.1.1 Disconnect power to brake.
8.1.2 Open hole in periphery of the solenoid housing (8) by removing the stopper.
8.1.3 Measure the distance between the retaining plate (2) and solenoid housing (= air gap s_L) by inserting a feeler gauge through the hole.
8.1.4 Close hole again.

8.2 Measuring the thickness of the brake disc, replacing the brake disc

Procedure (see Figure 1):

8.2.1 Disconnect motor and brake from the mains. Disconnect supply line on brake.
8.2.2 Remove brake from the flange plate (4) by unscrewing the fastening screws (5).
8.2.3 Clean brake. Remove abrasion material using compressed air.
8.2.4 Remove brake disc (1) from the carrier (6).
8.2.5 Measure the thickness of the brake disc. If necessary, replace the brake disc.
8.2.6 Check retaining plate (2) for wear and parallelism (there should be no significant grooving). If necessary, replace retaining plate (procedure described in section 7.3 and 7.5).
8.2.7 Push brake disc (1) onto carrier (6) and check for radial play.
If there is increased play in the gear teeth between the carrier and brake disc, the carrier must be removed from the shaft and replaced.
8.2.8 Mount brake on flange plate (4) with the fastening screws (5) and the USIT rings (13). Note tightening torque,
max. torque = 45 Nm.

9 Technical data

Type	M_N [Nm]	**NS**	W_{max} [$*10^3$J]	W_{th} [$*10^3$J]	W_L [$*10^6$J]	t_A [ms]	t_{AC} [ms]	t_{DC} [ms]	S_{Lmax} [mm]	d_{min} [mm]
E500B9	500	12	100	700	1200	370	800	80	1,0	17,9
E500B8	400	10	113	700	1600	310	1000	90	1,2	17,7
E500B7	350	8	120	700	2000	280	1200	100	1,4	17,5
E500B5	250	6	135	700	2800	220	1500	140	1,8	17,1
E500B4	200	5	150	700	3400	190	1700	160	2,1	16,8

Electrical power consumption of the solenoid at 20° C: P_{el}= 150 W.

Explanation of abbreviations

M_N	Nominal braking torque. This value is not reached until after a specific warm-up time of the brake disc and then may deviate by approx. -10 / +30% depending on the operating temperature and the wear status of the friction partners.
NS	Number of springs
W_{max}	Maximum permissible switching energy for a single braking operation. The switching energy W_{Br} of a braking operation is calculated as follows: $W_{Br} = \frac{J \cdot n^2}{182,5}$ J – moment of inertia [kgm²] of the total system in relation to the motor shaft n – motor speed [1/min] that is braked
W_{th}	Maximum permissible switching energy per hour
W_L	Maximum permissible switching until replacement of the brake disc
t_A	Response time when releasing with normal excitation. Overexcitation by the MSG special rectifier results in response times that are approximately half as long.
t_{AC}	Response time for brakes with alternating current switch-off, i.e. by interruption of the power supply of a separately powered standard rectifier
t_{DC}	Response time when braking with direct current interruption by mechanical circuit breaker. The response times are approximately twice as high with electronic direct current interruption by the MSG special rectifier.

Dependent on the operating temperature and the state of wear of the brake disc, the actual response times (t_A, t_{AC}, t_{DC}) can deviate from the guide values indicated here.

s_{Lmax}	Maximum permissible air gap
d_{min}	Minimum permissible thickness of the brake disc