Medium voltage products

VD4G-50
Vacuum circuit-breaker for generator application – in fixed version

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Your safety first – always!

That’s why our instruction manual begins with these recommendations:

- Only install switchgear and/or switchboards in enclosed rooms suitable for electrical equipment.
- Ensure that installation, operation and maintenance are carried out by specialist electricians only.
- Comply in full with the legally recognized standards (DIN VDE/IEC), the connection conditions of the local electrical utility and the applicable safety at work regulations.
- Observe the relevant information in the instruction manual for all actions involving switchgear and switchboards.

Danger!

Pay special attention to the hazard notes in the instruction manual marked with this warning symbol.

- Make sure that under operation condition of the switchgear or switchboard the specified data are not exceeded.
- Keep the instruction manual accessible to all persons concerned with installation, operation and maintenance.
- The user’s personnel are to act responsibly in all matters affecting safety at work and the correct handling of the switchgear.
- Always observe the five safety rules set out in EN 50110 on establishing and securing the off-circuit condition at the place of work for the duration of work on the switchgear.

- Isolate
  - Secure to prevent reconnection
  - Check the off-circuit condition
  - Earth and short-circuit
  - Cover the guard off adjacent live parts

If you have any further questions on this instruction manual, the members of our field organization will be pleased to provide the required information.
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1 Summary

1.1 General
(Figure 2/1)

The vacuum circuit-breakers of type VD4 are intended for indoor installation in air-insulated switchgear systems. Their switching capacity is sufficient to handle any conditions arising from switching of equipment and system components under normal operating and fault conditions, particularly short-circuits, within the parameters of their technical data.

Vacuum circuit-breakers have particular advantages for use in networks where there is a high switching frequency in the working current range and/or where a certain number of short-circuit breaking operations are expected. Type VD4 vacuum circuit-breakers are suitable for autore-closing, and have exceptionally high operating reliability and long life.

The vacuum circuit-breakers of type VD4, designed in column form, can be supplied as individual units for fixed installation. Their basic structure is shown in figure 2/1.

1.2 Standards and specifications

1.2.1 Switching device manufacture

The switching device complies with the following specifications in accordance with DIN VDE and the relevant IEC publications:
- VDE 0670, part 1000 / IEC 60694 / IEC 62271-1
- VDE 0671, part 100 / IEC 62271-100

1.2.2 Installation and operation

The relevant specifications are to be taken into account during installation and operation, particularly:
- DIN VDE 0101, Power installations exceeding AC 1 kV
- VDE 0105, Operation of electrical installations
- DIN VDE 0141, Earthing systems for special power installations with rated voltages above 1 kV
- Accident prevention regulations issued by the appropriate professional bodies or comparable organisations.

In Germany, these comprise the following safety regulations:
- Health and Safety at Work Standards BGV A1 and BGV A3
- Safety guidelines for auxiliary and operating materials
- Order-related details provided by ABB.

1.3 Operating conditions

1.3.1 Normal operating conditions

Design to VDE 0670, part 1000, “Common specifications for high-voltage switchgear and controlgear standards” and IEC publication 62271-1, with the following limit values:

- Ambient temperature:
  - Maximum: +40°C
  - Maximum 24 hour average: +35°C
  - Minimum (according to “minus 5 indoor class”): −5°C
- Humidity:
  - the average value of the relative humidity, measured over a period of 24 h, does not exceed 95%
  - the average value of the water vapour pressure, over a period of 24 h, does not exceed 2.2 kPa
  - the average value of the relative humidity, over a period of one month, does not exceed 90%
  - the average value of the water vapour pressure, over a period of one month, does not exceed 1.8 kPa
- Maximum site altitude:
  ≤ 1000 m above sea level.

1.3.2 Special operating conditions

Special operating conditions are to be agreed on by the manufacturer and user. The manufacturer must be consulted in advance about each special operating condition:

- Site altitude over 1000 m:
  - Allow for the reduction in the dielectric strength of the air.
  - Increased ambient temperature:
  - Current carrying capacity is reduced.
  - Provide additional ventilation for heat dissipation.
- Climate:
  - Avoid the risk of corrosion or other damage in areas:
    - with high humidity and/or
    - with major rapid temperature fluctuations.
  - Implement preventive measures (e.g. electric heaters) to preclude condensation phenomena.
## Technical data

### 2.1 Technical data Generator circuit-breaker

The technical data are dependent on the network circumstances and the generator to be protected. A generator calculation is therefore necessary in advance.

<table>
<thead>
<tr>
<th>Technical data</th>
<th>VD4G-50 XS</th>
<th>VD4G-50 S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage $U_r$</td>
<td>kV</td>
<td>15</td>
</tr>
<tr>
<td>Rated normal current (40°C) $I_r$</td>
<td>A</td>
<td>3150 4000 1)</td>
</tr>
<tr>
<td>Rated frequency $f_r$</td>
<td>Hz</td>
<td>50 / 60</td>
</tr>
</tbody>
</table>

Withstand voltage at 50 Hz $U_d$ (1 Min.)

- common value | kV | 38 |
- across the insulating distance | kV | 45 |

Impulse withstand voltage $U_p$

- common value | kV | 95 |
- across the insulating distance | kV | 110 |

Rated breaking capacity $I_{sc}$

- symmetrical short-circuit current 2) | kA | 50 |
- asymmetrical short-circuit 2) | kA | 73 |
- first pole-to-clear factor |  | 1.5 |
- operating sequence during short-circuit interruption | CO-30 min-CO 3) |

Rated short-circuit current making (peak) $I_{p}$ 2) | kA | 137 4) |

Rated breaking current under out-of-phase conditions

- breaking current (symmetrical) | kA | 25 |
- breaking current (asymmetrical) | kA | 37 |

Rated short-time withstand current $I_k$ (4 s) | kA | 50 |

Transient recovery voltage

- TRV rate for system-fed faults | kV/µs | 3.5 |
- TRV rate for generator-fed faults | kV/µs | 1.6 |
- TRV rate for out-of-phase | kV/µs | 3.3 |

### Mechanical performance

**Guideline values for function times at the rated supply voltage**

<table>
<thead>
<tr>
<th></th>
<th>VD4G-50 XS</th>
<th>VD4G-50 S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum total breaking time from tripping start to final arc extinction) (3 cycles)</td>
<td>ms</td>
<td>≤ 62</td>
</tr>
<tr>
<td>Opening time</td>
<td>ms</td>
<td>≤ 30</td>
</tr>
<tr>
<td>Closing time</td>
<td>ms</td>
<td>≤ 55</td>
</tr>
<tr>
<td>Arcing time (at 50 Hz)</td>
<td>ms</td>
<td>≤ 32</td>
</tr>
<tr>
<td>Minimum command time on closing</td>
<td>ms</td>
<td>20 (120 5)</td>
</tr>
<tr>
<td>Minimum command time on opening</td>
<td>ms</td>
<td>20 (80 5)</td>
</tr>
</tbody>
</table>

### Dimensions

<table>
<thead>
<tr>
<th></th>
<th>VD4G-50 XS</th>
<th>VD4G-50 S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pole centre</td>
<td>mm</td>
<td>275</td>
</tr>
<tr>
<td>Height</td>
<td>mm</td>
<td>636</td>
</tr>
<tr>
<td>Depth</td>
<td>mm</td>
<td>459</td>
</tr>
<tr>
<td>Width</td>
<td>mm</td>
<td>750</td>
</tr>
<tr>
<td>Weight</td>
<td>kg</td>
<td>210</td>
</tr>
</tbody>
</table>

1) Only with forced ventilation.
2) When the operating voltage is lower than the rated voltage, the same values apply as for rated voltage. Higher values on request.
3) Other operating sequences on request.
4) Higher values on request.
5) If the activating relay contact cannot itself interrupt the release coil current.
### 2.2 Technical data

#### Releases and blocking magnet

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Supply voltage</th>
<th>AC</th>
<th>DC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>VA</td>
<td>W</td>
</tr>
<tr>
<td>Shunt release OFF-MBO1, -MBO2</td>
<td>24 - 30 - 48 - 60 - 110 - 220 V DC</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>110 - 220 V AC</td>
<td>310</td>
</tr>
<tr>
<td></td>
<td></td>
<td>125 - 240 V DC</td>
<td>310</td>
</tr>
<tr>
<td></td>
<td></td>
<td>125 - 240 V AC</td>
<td>250</td>
</tr>
<tr>
<td>Shunt release ON-MBC</td>
<td>24 - 30 - 48 - 60 - 110 - 220 V DC</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>110 - 220 V AC</td>
<td>310</td>
</tr>
<tr>
<td></td>
<td></td>
<td>125 - 240 V DC</td>
<td>310</td>
</tr>
<tr>
<td></td>
<td></td>
<td>125 - 240 V AC</td>
<td>250</td>
</tr>
<tr>
<td>Blocking magnet -RLE1</td>
<td>24 - 30 - 48 - 60 - 110 - 220 - 240 V DC</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>110 - 125 - 220 - 240 V AC</td>
<td>10</td>
</tr>
<tr>
<td>Undervoltage release - MBU</td>
<td>undelayed</td>
<td>24 - 30 - 48 - 60 - 110 - 125 - 220 - 240 V DC</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>110 - 125 - 220 - 240 V AC</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>delay</td>
<td>see RN3U for supply voltage</td>
<td>10</td>
</tr>
<tr>
<td>Indirect overcurrent release with intermediate current transformer:</td>
<td></td>
<td></td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>- Two-phase</td>
<td></td>
<td>2.0</td>
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<tr>
<td></td>
<td>- Three-phase</td>
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</tbody>
</table>

#### 2.3 Technical data

#### Charging motor for stored-energy spring mechanism

<table>
<thead>
<tr>
<th>$U_a$</th>
<th>24 - 30 - 48 - 60 - 110 - 125 - 220 - 240 V DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_a$</td>
<td>110 - 125 - 220 - 240 - V AC</td>
</tr>
<tr>
<td>Charging time</td>
<td>max. 15 s</td>
</tr>
<tr>
<td>Service tolerances</td>
<td>85 ... 110 % $U_a$</td>
</tr>
<tr>
<td>Power consumption during charging</td>
<td>approx. DC 200 ... 260 W, approx. AC 260 VA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rated power supply V</th>
<th>Motor fuse A</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>S 281 UC-K</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>DC</td>
<td>S 282 UC-K</td>
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1) Depends on application
2) With short-circuited intermediate current transformer
2.4 Permissible number of vacuum interrupter switching operations in relation to breaking current

Diagram A)

Figure 2/3: Permissible number of vacuum interrupter operating cycles $n$ as a function of the breaking current $I_a$
(Reference see section 2.1 – Technical data page 7)
Figure 2/4: Dimensional drawing of a circuit-breaker, type VD4G-50, 15 kV, 3150 ... 4000 A, 50 kA

Note!
Lifting lug T only fitting for transport, remove prior to commissioning and store.

K = Cable entry
M = Minimum distance acc. to DIN VDE 0101
T = Transport boring for handling on both sides
⊙ = Earthing conductor connection – use contact washer

Application conditions for 4000 A rated current:
The suitability of VD4G-50 generator circuit-breaker for 4000 A applications has been proved successfully in an ABB switchgear panel. The usage of a fan in the switchgear panel is necessary for ensuring the required cooling. Each customer has to verify the proper operation of their custom application.
3 Structure and function

3.1 Structure of the breaker poles
(Figures 3/2, 3/3 and 3/4)

The basic structure of a vacuum circuit-breaker and a vacuum interrupter is explained in figures 3/2 and 3/3.

The poles, which are constructed in column form, are mounted on the bracket-shaped rear part of mechanism enclosure 1. The live parts of the breaker poles are located in the insulating material pole tubes 12 and protected from impacts and other external influences.

With the breaker closed, the current path leads from the upper breaker terminal 13 and a chamber holder fixed in the pole tube to the fixed contact 15.2 in the vacuum interrupter 15, then via the moving contact 15.3 and the roller contact 16.2, to the lower breaker terminal 14. The switching motion is effected by means of the insulated coupling rod 18 with internal contact force springs 17.

3.2 Structure of the breaker operating mechanism
(Figures 3/1, 3/4 and 3/5)

The operating mechanism is of the stored-energy spring type and acts on the three breaker poles. The necessary operating energy is stored ready for activation by charging the spring energy store.

The stored-energy spring mechanism essentially consists of drum 33 containing the spiral spring, the charging system, the latching and operating mechanism and the linkages which transmit the force to the breaker poles. In addition, there are supplementary components such as the charging motor, releases, auxiliary switches and the controls and instruments located on the front of the mechanism enclosure 1.

The basic structure of a stored-energy spring mechanism is explained in figure 3/4.

The operating mechanism is fundamentally suitable for auto-reclosing and, due to the short charging times, also for multi-shot auto-reclosing.

In the basic version of the circuit-breaker, the spring energy store is charged manually. The operating mechanism can optionally be fitted with a charging motor.

There is one rating plate with the main data of the switch equipment on front plate 1.1, and another at the lower front right in mechanism enclosure 1.

The basic version of the stored-energy spring mechanism is fitted with the following auxiliary equipment:
- Shunt release OFF -MBO1
- Five-pole auxiliary switch -BGB2 for annunciation purposes 38
- Auxiliary switch -BGB4 for fault annunciation
- Mechanical ON push-button 2
- Mechanical OFF push-button 3
- Mechanical position indicator 4

The following additional equipment can be installed:
- Blocking magnet -RLE1 with auxiliary switch -BGL1
- Shunt release ON -MBC
- Second shunt release OFF -MBO2
- Indirect overcurrent release -MBO3
- Undervoltage release -MBU
- Five-pole auxiliary switches -BGB1 and -BGB3
- Charging motor -MAS 36
- Five-pole auxiliary switch -BGS1 to switch the charging motor.

3.2.1 Releases, blocking magnet and auxiliary switches
(Figures 3/1, 3/5, 7/1, 7/2, 7/3 and 7/5)

- The releases and the blocking magnet are mounted at the top left on the spring operating mechanism.
- The allocation of the auxiliary switches can be seen in the wiring diagram of figures 7/5, 7/6 and 7/7.
- The five-pole auxiliary switch -BGS1 is operated by the charging condition indicator 8. It controls the charging motor -MAS, serves as an electrical interlock for shunt release OFF -MBO2 when the spring mechanism is not sufficiently charged, and also provides an electrical switching readiness signal.
- Operation of the five-pole auxiliary switches -BGB1, -BGB2 and -BGB3 is dependent on the switching position of the circuit-breaker.
- Auxiliary switch -BGB1 interrupts the circuit of the optional additional shunt release OFF -MBO2 with the circuit-breaker in the open position, and the circuits of shunt release ON -MBC and the optional blocking magnet -RLE1 with the circuit-breaker in the closed position. There is one further NOC for other purposes.
- On failure or absence of the control voltage, blocking magnet -RLE1 mechanically locks the ON half shaft and simultaneously acts on the corresponding auxiliary switch -BGL1 to interrupt the circuit of shunt release ON -MBC.
- Blocking magnet -RLE1 is accessible when front plate 1.1 is removed.
- Auxiliary switch -BGB2 interrupts the circuit of shunt release OFF -MBO2 with the circuit-breaker in the open position. One further NOC and three NCCs are available for annunciation, control and interlock purposes.
- Auxiliary switch -BGB3 can be optionally designed with any possible combination of contacts from five NOCs to five NCCs. Its contacts are available for any required control, annunciation or interlock functions. The auxiliary switch is normally configured as shown in figures 7/5, 7/6 and 7/7.
- The single pole auxiliary switch -BGB4 (fleeting contact time ≥ 30 ms) serves to provide a fault signal ("breaker released").

With remote control, the auxiliary switch is necessarily operated by:
- Shunt release OFF -MBO1 or
- Shunt release OFF -MBO2 or
- Undervoltage release -MBU or
- Indirect overcurrent release -MBO3.
Note:
1. Shunt releases OFF (-MBO1) and ON (-MBC) are exclusively provided for opening and closing in normal operation. For safety breaking operations, the second shunt release OFF (-MBO2) must be used, in most cases with a separate control voltage supply. These three releases are of the solenoid type and suitable for a large number of operating cycles.

2. The undervoltage release (-MBU) and/or indirect overcurrent release (-MBO3) are pure safety and protection releases and must not be used for switching in normal operation.

3.2.2 Mounting of the VD4G-50 on trucks from other manufacturers

VD4G-50 generator circuit-breakers which are not installed on ABB withdrawable parts must be fitted with one or two additional auxiliary switches which are dependent on the mechanical lock and release device. These must interrupt the circuit of shunt release ON -MBC.

Similarly to auxiliary switches -BGT2 and -BGT1 in ABB withdrawable parts, no electrical pulse may arrive during and before mechanical blocking of the spindle mechanism, and may only be applied again after the end of mechanical blocking.

This ensures that the shunt release ON cannot be loaded with an electrical ON pulse when the withdrawn part is in an intermediate position, which could burn out the coil.

3.3 Function

3.3.1 Charging of the spring energy store
(Figures 3/1 and 3/4)

To provide the necessary motive energy, the spring energy store, either charged automatically by a charging motor or manually in a vertical pumping action with charging lever 9, depending on the equipment fitted to the circuit-breaker. The current charging condition is shown at charging condition indicator 8.

As a precondition for an auto-reclosing sequence, the operating mechanism is either (re-)charged after a closing operation automatically by the charging motor, or it requires (re-)charging by hand if the operating mechanism is of the manual type.

3.3.2 Closing procedure
(Figures 3/1, 3/3, 3/4 and 3/5)

The closing process is started by the mechanical ON push-button 2, or by activation of shunt release ON -MBC. The release mechanism 31 then permits drive shaft 30 to be rotated by the (previously) charged spiral spring. The moving contact 15.3 in vacuum interrupter 15 is moved until the contacts touch by cam disk 21 and further kinematic links. In the further sequence of motion, spring arrangement 17 is tensioned and the appropriate amount of contact force thus applied. The available overtravel is higher than the maximum value of contact erosion during lifetime of the interrupter. During the closing process, opening springs 19 are simultaneously tensioned.

3.3.3 Opening procedure
(Figures 3/1, 3/3, 3/4 and 3/5)

The opening procedure is initiated by mechanical OFF push-button 3 or by activation of one of releases -MBO1, -MBU, -MBO3 or -MBO2. Observe the notes in section 3.2.1 on control of the releases. Release mechanism 31 then permits drive shaft 30 to be turned further by the spring energy store, which is still sufficiently charged. Opening spring 19, which is thus released, moves contact 15.3 into the open position at a defined speed.

3.3.4 Auto-reclosing sequence

An OFF-ON or OFF-ON-OFF auto-reclosing sequence is activated and checked by the protection system. It is necessary for the spiral spring in the operating mechanism to be in the (re-)charged condition, with the circuit-breaker in the closed position. The (re-)charging process is carried out automatically after closing of the breaker on breakers with motor charging mechanisms, but must be carried out manually on breakers without charging motors (or when the charging motor has broken down). Opening of the breaker is also possible during the (re-)charging process, but subsequent closing of the breaker is however blocked until the charging process has been completed.

3.3.5 Quenching principle of the vacuum interrupter

Due to the extremely low static interrupter chamber pressure of $10^{-2}$ to $10^{-6}$ Pa, only a relatively small contact gap is required to achieve a high dielectric strength. The arc is extinguished on one of the first natural current zeros.

Due to the small contact gap and the high conductivity of the metal vapour plasma, the arc drop voltage, and additionally, due to the short arcing time, the associated arc energy, are extremely low, which has advantageous effects on the life of the contacts and thus on that of the vacuum interrupters.
Figure 3/1: Circuit-breaker front with controls and annunciations

1  Mechanism enclosure
1.1 Front plate
2  ON push-button
3  OFF push-button
4  Position indicator
5  Operating cycle counter
6  Recess for charging lever 9
7  Rating plate
8  Charging condition indicator
9  Charging lever

Figure 3/2: Sectional view of a vacuum circuit-breaker, type VD4, schematic diagram

1  Mechanism enclosure
1.1 Front plate, removable
12 Insulating material pole tube
13 Upper breaker terminal
14 Lower breaker terminal
15 Vacuum interrupter
16.2 Roller contact
17 Contact force spring
18 Insulated coupling rod
19 Opening spring
20 Shift lever pair

Figure 3/3: Partial section of a vacuum interrupter, simplified schematic diagram

(details vary according to the specified switching duties)

15.1 Insulator
15.2 Fixed contact
15.3 Movable contact
15.4 Metal bellows
15.5 Screen
15.6 Guide
15.7 Interrupter lid
Figure 3/4: Basic structure of the stored-energy spring mechanism

6  Recess
9  Charging lever
15  Vacuum interrupter
15.3  Movable contact
16.2  Roller contact
17  Contact force spring
18  Insulated coupling rod
19  Opening spring
20  Shift lever pair
21  Cam disk
30  Drive shaft
31  Release mechanism
32  Stop disk
33  Drum with spiral spring
34  Chain drive
35  Ratchet wheel
50  Left-hand control cam

Figure 3/5: View of the stored-energy spring mechanism and auxiliary equipment with the front plate removed

6  Recess for charging lever 9
31  Release and control mechanism on the drive shaft
34  Chain drive
35  Ratchet wheel
36  Charging motor
37  Release and control mechanism area
38  Auxiliary switch block
4 Despatch and storage

4.1 Condition on delivery

- The factory-assembled switching devices are checked at the works for completeness of the equipment installed and simultaneously subjected to a routine test in accordance with VDE 0670, part 1000, or IEC publication 62271-1, thus verifying their correct structure and function.

4.2 Packaging

The switching devices are mounted individually on a wooden pallet and sealed in film and/or packed in cardboard for delivery.

Packaging for overseas shipment:
- Drying agent bags inserted in the film-sealed packaging
- Drying agent bags in accordance with DIN 55 473.

4.3 Transport

Loading of the package units must only be carried out with a
- crane,
- fork-lift truck and/or
- trolley jack.

Notes:

- Avoid impact during handling.
- Do not subject to other damaging mechanical stresses.
- Lifting gear must not be attached to the breaker poles or parts of the operating mechanism. Use the lifting lugs 1.3 for hoists (Figure 6/1).

4.4 Delivery

The duties of the consignee on receipt of the switching devices at site include the following:
- Checking the delivery for completeness and freedom from damage (e.g. moisture and its adverse effects).
- Any short quantities, defects or damage in transit:
  - Must be precisely documented on the consignment note.
  - The shipper/carrier is to be notified immediately in accordance with the liability provisions of the German general conditions for forwarders (ADSp/KVO).

Note:
Always take photographs to document any major damage.

4.5 Intermediate storage

Intermediate storage of the switching device in the switch position OFF and the stored-energy spring mechanisms discharged

Indicator DISCHARGED: 📸

Conditions for optimum intermediate storage:

1. Devices with basic packaging or unpacked:
   - A dry and well ventilated storeroom with climate in accordance with VDE 0670, part 1000 / IEC 60694 / IEC62271-1.
   - Room temperature which does not fall below –5 °C.
   - Do not remove or damage the packaging.
   - Unpackaged devices:
     - Are to be loosely covered with protective sheeting.
     - Sufficient air circulation must be maintained.
     - Check regularly for any condensation.

2. Devices with seaworthy or similar packaging with internal protective sheeting:
   - Store the transport units:
     - protected from the weather,
     - dry,
     - safe from damage.
   - Check the packaging for damage.
   - If the maximum storage period starting from the date of packaging has been exceeded:
     - The protective function of the packaging is no longer guaranteed.
     - Suitable action must be taken if intermediate storage is to continue.
5 Installation

Careful and professional installation of the switching device is one of the fundamental conditions of trouble-free circuit-breaker operation.

- Install the mechanism enclosure in the panel without tension or distortion, inserting dished washers below the nuts or bolt heads at each of the four mounting points (dependent on the order).
- Connect the main terminals without any permanent tension or pressure forces, exerted for example by the conductor bars.
- When connecting the conductor bars, the bolts must be inserted to the depth shown on the dimensional drawing.
- Take account of any tested terminal zone.
- Use DIN bolts of tensile class 8.8, fastening conductor bars together with dished washers.
- Make a short-circuit proof connection between the PE conductor and the main earthing bar in the switchgear, using contact washers.
- Remove any dirt. See also section 7.3.1.

<table>
<thead>
<tr>
<th>Thread size</th>
<th>Recommended rated tightening torque (Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lubricant without (dry) Oil or grease</td>
</tr>
<tr>
<td>M 6</td>
<td>10.5</td>
</tr>
<tr>
<td></td>
<td>4.5</td>
</tr>
<tr>
<td>M 8</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td>M 10</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>20</td>
</tr>
<tr>
<td>M 12</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>40</td>
</tr>
<tr>
<td>M 16</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>80</td>
</tr>
</tbody>
</table>

1) Rated tightening torques for fasteners without lubrication are based on the thread friction coefficient 0.14 (the actual values of which are subject to unavoidable, in some cases not insignificant, spread).
2) Thread and contact face of head lubricated.

Take account of any tightening torques which deviate from the general table (e.g. for contact systems or device terminals) as stated in the detailed technical documentation.

It is recommended that the threads or head contact surfaces of the bolts be lightly oiled or greased, so as to achieve a precisely defined rated tightening torque.
6 Commissioning / Operation

6.1 Note on safety at work

⚠️
- This switching device may only be operated by specially trained personnel who are familiar with the characteristics of the particular device.
- Observe the relevant instructions in section 1.2.
- Due to safety reasons, the circuit-breaker has to be treated as „switched on“ if the switching position cannot clearly be determined.
  In this case all high voltage connections to the breaker have to be de-energized and zero potential on the primary side of the breaker has to be confirmed prior to commissioning, operation, maintenance or repair work.

6.2 Preparatory activities
(Figures 2/3, 3/1 and 6/1)

(Prior to application of primary voltage)
- Check the circuit-breaker for any kind of damage or other injurious environmental influence, and restore to the proper condition where necessary.
- Remove any contamination, particularly on insulating parts, which has occurred during transit, storage or installation.
- Check the primary and secondary connections and the protective conductor terminal.
- Charge the spring energy store by hand (see section 6.3.1).
- Perform a trial opening or closing operation of the circuit-breaker using push-button 2 or 3 (taking into account any required supply voltage and any relevant interlocks).
- Check the charging motor on circuit-breakers with motor-operated mechanisms by applying supply voltage.
- Ensure that the Instruction Manual is available to the operators at all times.
- Remove the lifting lugs 1.3 for hoists (Figure 6/1).

6.3 Operation of the circuit-breaker
(Figures 3/1 and 6/1)

6.3.1 Charging the spring energy store

Circuit-breakers with charging motors:
- Charging takes place automatically.
- If the charging motor breaks down, the charging process can be carried out or completed manually.

Circuit-breakers with manual charging mechanisms:
- Insert charging lever 9 into recess 6 and pump up and down for approx. 25 strokes until the charged condition is displayed.
- When the charged condition is reached, the charging mechanism automatically disengages, and further strokes of the charging lever have no effect.

Key to the charging condition indications:

Discharged 🙋‍♀️ Charged 🙌

As a precondition for an auto-reclosing sequence, the operating mechanism is either (re-)charged after a closing operation automatically by the charging motor, or it requires (re-)charging by hand if the operating mechanism is of the manual type.

6.3.2 Closing and opening

- Closing:
  Press mechanical ON push-button 2, or operate the electrical control unit.

- Opening:
  Press mechanical OFF push-button 3, or operate the electrical control unit.

Observe the notes in section 3.2.1.

The operating cycle counter 5 is automatically incremented by one complete figure with each switching cycle. On completion of a switching operation the position indicator 4 in the window of front plate 1.1 shows the appropriate position of the circuit-breaker.

- Anti-pumping relay:
  The anti-pumping relay -KFN (wiring diagram in figures 7/5, 7/6 and 7/7) prevents repeated ON-OFF switching operations if, for example, the breaker is tripped by a protection relay in response to a primary side fault while a permanent electrical closing command is simultaneously applied. The circuit-breaker can then only be closed after the closing command has been interrupted.

- Closing on failure of supply voltage:
  - With standard equipment:
    On failure of the control voltage, mechanical closing by means of ON push-button 2 is possible at any time.
  - With blocking magnet -RLE1 fitted:
    On failure of the control voltage, blocking magnet -RLE1 mechanically locks the ON haflshaft and simultaneously interrupts the circuit shunt release ON -MBC via the corresponding auxiliary switch -BGL1.

  Closing with the blocking magnet de-energised requires manipulation of the circuit-breaker operating mechanism:
  - Remove front plate 1.1.
  - Take care to avoid rotating parts!

- Opening on failure of supply voltage:
  On failure of the supply voltage, mechanical opening by means of OFF push-button 3 is possible at any time.
6.3.3 Run-on block

When any irregularities occur in the internal control mechanism or with the charging function of the spring energy store, the run-on stop blocks the next closing operation.

This is a protective function to prevent damage to the circuit-breaker.

⚠️

Release of the run-on block may only be performed by servicing personnel from ABB or adequately trained specialist stuff.

---

**Figure 6/1: Operation**

1.3 Lifting lug (remove prior to commissioning)
2 Mechanical ON push-button
3 Mechanical OFF push-button
4 Mechanical position indicator
5 Mechanical operating cycle counter
8 Charging condition indicator
9 Charging lever
7 Maintenance

Maintenance serves to ensure trouble-free operation and achieve the longest possible working life of the switchgear. In accordance with DIN 31051 / IEC 61208 / IEC 62271-1 it comprises the following closely related activities:

- **Inspection**: Determination of the actual condition
- **Servicing**: Preservation of a functional condition
- **Repair**: Measures to restore the functional condition.

7.1 General

Vacuum circuit-breakers are characterized by their simple and robust construction. They have a long life expectancy. Their operating mechanisms have a low maintenance requirement, and the interrupters are maintenance-free during their working life. There is no adverse effect on the vacuum, even from frequent switching of operating and short-circuit currents.

The servicing intervals and scope are determined by environmental influences, the switching sequences and number of short-circuit breaking operations.

**Note:**
The following must be observed for all maintenance work:
- The relevant specifications in section 1.2.2
- Notes on safety at work in section 6.1
- Standards and specifications in the country of installation.

Maintenance work may only be performed by fully trained personnel, observing all the relevant safety regulations. It is recommended that ABB after-sales service personnel should be called in, at least during the performance of servicing and repair work.

While the work is in progress, all supply voltage sources must also be disconnected and secured to prevent reconnection.

**Note:**
In order to prevent accidents (particularly injury to hands!) extreme care should be taken during all repair work on the operating mechanism, especially with front plate removed.

The spiral spring in the spring energy store, for instance, retains a basic tension which is independent of the charging and discharging processes during switching, so as to ensure correct function. This spring energy can be inadvertently released if work is performed incorrectly on the spring mechanism!

7.1.1 Service life

Typical life expectancies for VD4G-50 Generator circuit-breakers:
- The maintenance-free vacuum interrupters up to 10,000 operating cycles (see section 2.4 figure 2/2).
- The breaker itself, depending on presupposing carefully performed inspection and servicing work and normal operating conditions, up to 10,000 operating cycles.

The service life data fundamentally apply to all components which are not directly influenced by the operator.

Components operated manually (movement of the withdrawable part, etc.) may deviate.

7.2 Inspection and functional testing

7.2.1 Switching devices in general

- The proper condition of the switching device is to be verified by regular inspection.
- The checks are to be performed in accordance with BGV A3 standard. If further standards exist in the country of installation they shall be considered in the checks.
- Inspection at fixed intervals may be waived if the switchgear is permanently monitored by a qualified personnel.
- The checks first and foremost comprise visual examination for contamination, corrosion, moisture and discharge phenomena.
- In unusual operating conditions (including adverse climatic conditions and/or special environmental pollutions (e.g. heavy contamination and aggressive atmosphere), inspection may also be necessary at shorter intervals.
- If an incorrect condition is found, appropriate servicing measures are to be initiated.

7.2.2 Stored-energy spring mechanism

(Figures 7/1 to 7/4)

Functional testing of the operating mechanism is to be performed for the generator circuit-breaker.

Breakers with rated short-circuit breaking current with 50 kA:
- after 5,000 operating cycles or
- during servicing work as set out in 7.2.1.

Prior to functional testing, switch the breaker off and isolate the outgoing feeder.

**Note:**
Isolate and secure the working area in accordance with the safety regulations specified by DIN VDE/IEC.
Scope of functional testing:
- Perform several switching operations under no load, above all with circuit-breakers seldom operated in normal service.
- Switch off the charging motor (if fitted) and discharge the spring energy store by ON/OFF switching operations.
- Examine visual the condition of the lubrication on rotary bearings, sliding surfaces, etc.
- Check the proper mechanical/electrical sequence of the individual functions.

7.2.3 Breaker pole

No inspection of the breaker pole above and beyond the stipulations of section 7.2.1 is necessary.

7.3 Servicing

7.3.1 Switching devices in general

If cleaning is found to be necessary during inspections as set out in 7.2.1, the following procedure is to be adopted:
- Prior to cleaning, the working area is to be isolated and secured against reclosing where necessary in accordance with the safety regulations of DIN VDE/IEC.
- Cleaning of surfaces in general:
  - Dry, lightly adhering dust deposits with a soft, dry cloth.
  - More strongly adhering contamination with slightly alkaline household cleanser or Isopropanol.
- Cleaning of the insulating material surfaces and conductive components:
  - Light contamination: with Isopropanol.

Wipe down after cleaning, using clean water, and dry properly.

Note:
Use only halogen free cleansers, and in no case 1.1.1-trichloroethane, trichloroethylene or carbon tetrachloride!

7.3.2 Stored-energy spring mechanism
(Figures 7/1 to 7/4)

Servicing of the operating mechanism is to be performed after the following number of operating cycles:
- Breakers with rated short-circuit breaking currents up to 50 kA after 10,000 operating cycles.

Prior to servicing, switch the breaker off, and
- move it out of the panel (with withdrawable breakers) or
- isolate the outgoing feeder (with stationary mounted breakers).

⚠️ Observe the safety regulations.

Details of the servicing:
- Switch off the charging motor (if fitted), and discharge the spring energy store by closing and opening the breaker once.
- Replace parts subject to high climatic and mechanical stresses as a precaution.
- For replacing highly stressed parts neutralize basic tension of the spiral spring, state the rate. Be careful when carrying out!
- Relubricate pawls, support shafts, sliding and rotating bearing surfaces. Lubricant: Isoflex Topas NB 52.
- Check the fit of fasteners (e.g. locking pins) in cranks, pins, bolts etc. Check the tightness of fastening bolts.
- Always replace any spring lock washers, split pins and other fasteners removed during the work with new parts when reassembling the equipment.
- Check the general condition of the operating mechanism and recharge the spring energy store.
- Perform comprehensive mechanical and electrical functional tests.
- Observe the instructions on setting.
- Ensure that the bolted joints at the contact locations of the conductor bar system and the earthing connections are tight.

Note:
Above mentioned work may only be performed by the after-sales service personnel of ABB or adequately qualified personnel.

7.3.3 Breaker pole

The breaker pole with the vacuum interrupter is maintenance-free up to reaching the permissible number of vacuum interrupter operating cycles in accordance with section 2.4.

Checking of the vacuum is only necessary when there is good cause to suspect that force applied externally to a pole tube has caused damage to the vacuum interrupter inside.

If the pole tube is damaged or destroyed, it may be necessary to replace the complete breaker pole.

The working life of the vacuum interrupter is defined by the sum current limit corresponding to the equipment data in individual cases in accordance with section 2.4:

- When the sum current limit is reached, the complete breaker poles are to be replaced.

⚠️ Note:
Dismantling and Replacement of the complete breaker poles should only be carried out by ABB after-sales service personnel or by specially trained personnel, particularly as proper adjustment is necessary.
For testing the vacuum without dismantling the circuit-breaker you may use:

- Vakuumtester VIDAR, der Firma Programma Electric GmbH
  Bad Homburg v. d. H.

The following test values have to be set for checking of the internal interrupter chamber pressure with the VIDAR vacuum tester:

<table>
<thead>
<tr>
<th>Rated voltage of the circuit-breaker</th>
<th>DC test voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 kV</td>
<td>40 kV</td>
</tr>
</tbody>
</table>

Testing is to be performed at the rated contact distance in the OFF condition.

Procedure for vacuum interrupter testing for stationary mounted switching devices:
- Isolate and secure the working area in accordance with the Safety Regulations to DIN VDE / IEC.
- Open the VD4G-50 generator circuit-breaker.
- Earth all poles of the VD4G-50 generator circuit-breaker on one side.
- Connect the earthed test lead of the the VIDAR vacuum checker conductively to the station earth.
- Connect the high voltage test lead of the VIDAR vacuum checker with phase L1 of the unearthed pole side and test the vacuum interrupter chamber with the circuit-breaker contact gap open. Repeat for phases L2 and L3.

Note:
Connected cables may lead to a “detective” indication on the vacuum checker as a result of their cable capacitance. In such cases, the cables are not be removed.

7.4 Repair

7.4.1 Replacement of circuit-breaker parts and accessories

Only remove and reassemble circuit-breaker parts and accessories when the breaker has been switched off and the working area is to be isolated and secured against reclosing. The spring energy store must be discharged.

All supply voltage sources must be disconnected and secured against reclosing during the removal and installation work.

7.4.2 Touch up of surfaces

- Sheet steel parts, painted:
  - Remove rust, e.g. with a wire brush.
  - Grind off paint coat and grease.
  - Apply anti-rust primer and top coat.
  - Use top coat paint in the standard colour RAL 7035.

- Sheet steel parts, with zinc surface and passivated functional parts:
  - Remove white rust with a wire brush or cleaning pad (e.g. Scotch-Brite white).
  - Remove loosely adhering particles with a dry cloth.
  - Apply zinc spray or zinc dust primer.

- Functional parts, phosphated:
  - Remove rust with a wire brush or cleaning pad (e.g. Scotch-Brite white).
  - Clean with a dry cloth.
  - Grease with Isoflex Topas NB 52.
Figure 7/1: Auxiliary switch block, equipment example

41 Mounting plate
42 Auxiliary shaft
42.1 Crank
43 Fastening screw
45 Magnet holder, complete

Figure 7/2: Undervoltage release and operation area, equipment example

47 Interlock plate for -MBU
-RLE1 Blocking magnet
-MBC Shunt release ON
-MBU Undervoltage release

Figure 7/3: Indirect overcurrent release and operation area, equipment example

2.1 ON push-rod
3.1 OFF push-rod
5 Operating cycle counter
-MBO3 Indirect overcurrent release

Figure 7/4: Charging motor, charging system and spring energy store

34 Chain
35 Ratchet wheel
36 Charging motor with gearing
36.1 Fastening screw (gearbox)
Note:
Shown with the spring energy store in the discharged state. The wiring diagram comprises the basic components and all further equipment options for the various VD4 types.

The scope of equipment possible within an individual type series is listed in the relevant switching device list, and the equipment fitted in each individual case can be found in the order documentation.

Shunt releases and blocking magnets are fundamentally wired with rectifiers (e.g. magnet holder 45 with integrated rectifiers -TB4, -TB1, -TB3 and -TB2). Rectifiers function as free-wheeling diodes if d.c.-supply.

Figure 7/5: Wiring diagram (without plug)

Maximum of equipment

- RLE1 Closing block magnet with rectifier -TB4
- MBO1 1. Shunt release OFF with rectifier -TB1
- MBC Closing release with rectifier -TB3
- MBU Undervoltage release U< with rectifier -TB6
- MBO3 Indirect overcurrent release with rectifier -TB7
- MBO2 2. Shunt release OFF with rectifier -TB2
- MAS Charging motor
- KFN Antipumping relay
- BGS1 Auxiliary switch on mechanism
- BGL1 Auxiliary switch on block magnet -RLE1
- BGB1 Auxiliary switch on switch shaft
- BGB2 Auxiliary switch on switch shaft
- BGB3 Auxiliary switch on switch shaft
- BGB4 Wiping contact 35 ms for circuit-breaker tripped indication

Mode of presentation:
Auxiliary switch -BGS1 shown for circuit-breaker mechanism discharged.

See page 27 for comparison of VDE/IEC designations.
Note:
Shown with the spring energy store in the discharged state. The wiring diagram comprises the basic components and all further equipment options for the various VD4 types.

The scope of equipment possible within an individual type series is listed in the relevant switching device list, and the equipment fitted in each individual case can be found in the order documentation.

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Mode of presentation:
Auxiliary switch -BGS1 shown for circuit-breaker mechanism discharged.

See page 27 for comparison of VDE/IEC designations.
Note:
Shown with the spring energy store in the discharged state. The wiring diagram comprises the basic components and all further equipment options for the various VD4 types.

The scope of equipment possible within an individual type series is listed in the relevant switching device list, and the equipment fitted in each individual case can be found in the order documentation.

Shunt releases and blocking magnets are fundamentally wired with rectifiers (e.g. magnet holder 45 with integrated rectifiers -TB4, -TB1, -TB3 and -TB2). Rectifiers function as free-wheeling diodes if d.c.-supply.

Mode of presentation:
Auxiliary switch -BGS1 shown for circuit-breaker mechanism discharged.

See page 27 for comparison of VDE/IEC designations.

Figure 7/7: Wiring diagram (with 64-pole plug)
Maximum of equipment
### 7.5 Spare parts and auxiliary materials

#### 7.5.1 Spare parts

**Note:** Please quote always the serial number of the generator circuit-breaker when ordering parts

<table>
<thead>
<tr>
<th>Designation</th>
<th>Item no.</th>
<th>Rated supply voltage</th>
<th>Ident no. (order code)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxiliary switch</td>
<td>-BGS1</td>
<td>-BGB1</td>
<td>-BGB2</td>
</tr>
<tr>
<td>(with clamp-type terminal)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auxiliary switch on blocking magnet</td>
<td>-BGL1</td>
<td>GCE7003022R0...</td>
<td></td>
</tr>
<tr>
<td>Auxiliary switch for fault annunciation</td>
<td>-BGB4</td>
<td>GCE0905121P0...</td>
<td></td>
</tr>
<tr>
<td>1st shunt release OFF</td>
<td>-MBO1</td>
<td>24 V ... 240 V DC</td>
<td>GCE7004590P11...</td>
</tr>
<tr>
<td>2nd shunt release OFF</td>
<td>-MBO2</td>
<td>110 V ... 240 V AC</td>
<td>GCE7004590P012...</td>
</tr>
<tr>
<td>Shunt release ON</td>
<td>-MBC</td>
<td>24 V ... 240 V DC</td>
<td>GCE7004590P010...</td>
</tr>
<tr>
<td>Blocking magnet</td>
<td>-RLE1</td>
<td>110 V ... 240 V AC</td>
<td>GCE0478103P011...</td>
</tr>
<tr>
<td>Undervoltage release with spring mechanism</td>
<td>-MBU</td>
<td>24 V ... 240 V DC</td>
<td>GCE9371466R0...</td>
</tr>
<tr>
<td>Delayed undervoltage release with spring mechanism</td>
<td>-MBU</td>
<td>see RN3U for supply voltage</td>
<td>GCE9371466R0...</td>
</tr>
<tr>
<td>Indirect overcurrent release with intermediate current transformer and spring mechanism</td>
<td>-MBO3</td>
<td>24 V ... 240 V DC</td>
<td>GCE9371466R0212</td>
</tr>
<tr>
<td>Intermediate current transformer for indirect overcurrent release</td>
<td></td>
<td>24 V ... 220 V DC</td>
<td>GCE9371466R0248</td>
</tr>
<tr>
<td>Magnet holder, complete (with integrated rectifiers -TB4, -TB1, -TB3, -TB2)</td>
<td></td>
<td>24 V ... 220 V DC</td>
<td>GCE7000880R0121</td>
</tr>
<tr>
<td>Series rectifier</td>
<td>-TB6/-TB7</td>
<td></td>
<td>GCE7004050R0129</td>
</tr>
<tr>
<td>Charging motor (with gearing)</td>
<td>-MAS</td>
<td>24 V ... 240 V DC</td>
<td>GCE9040084P013...</td>
</tr>
<tr>
<td>Push-on sleeve 4.8-2.5 for push-on blade 0.8 thick (for additional external connections)</td>
<td></td>
<td></td>
<td>DIN 46247 Page 2</td>
</tr>
</tbody>
</table>

1) State the type of release and voltage  
2) State rated supply voltage, serial no. of switch (on identification sign) as well as the manufacturer of the motor  
3) Quote contact arrangement

#### 7.5.2 Auxiliary materials

<table>
<thead>
<tr>
<th>Auxiliary materials</th>
<th>Ident no. (order code)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lubricants:</td>
<td>GCE0007249P0100</td>
</tr>
<tr>
<td>Isoflex Topas NB 52</td>
<td></td>
</tr>
<tr>
<td>Cleaning agents for general cleaning:</td>
<td>1VB0000463P0100</td>
</tr>
<tr>
<td>Isopropanol</td>
<td></td>
</tr>
<tr>
<td>Touch-up paint:</td>
<td>GCE9014060R0103</td>
</tr>
<tr>
<td>Standard colour RAL 7035</td>
<td>GCE0007895P0100</td>
</tr>
<tr>
<td>- 1 kg-box</td>
<td></td>
</tr>
<tr>
<td>- Spray tin</td>
<td></td>
</tr>
</tbody>
</table>
8 Application of the X-ray regulations

One of the physical properties of vacuum insulation is the possibility of X-ray emissions when the contact gap is open. The specified test performed by the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig demonstrates that the local dosage output of 1 µSv/h at a distance of 10 cm from the touchable surface is not exceeded when the rated voltage is applied.

The results are as follows:

- Testing of the switching device or the vacuum interrupter to VDE 0671 part 100 or IEC 62271-100 at the relevant rated power frequency withstand voltage may only be performed by trained personnel observing the stipulations of the EU basic standard (Directive 96/29/Euratom of the Council of 13 May 1996 (ABI.L 159 of 29 June 1996)).
- Application of the rated voltage specified for the switching device by VDE 0671 part 100 or IEC 62271-100 is completely safe.
- Higher voltages than the rated voltage or DC test voltage specified in VDE or IEC standards must not be applied!
- The containment of the above mentioned local dosage output with the vacuum interrupter in the open position is dependent on maintenance of the specified distance between the contacts (which is automatically ensured with correct mechanism function and force transmission).
- Safety clearances must be maintained.

9 Comparison of designations to IEC 81346-1 / IEC 81346-2, IEC 61346-1 / IEC 61346-2 and VDE-DIN 40719 Part 2

<table>
<thead>
<tr>
<th>Beschreibung</th>
<th>IEC 81346-1 / IEC 81346-2</th>
<th>IEC 61346-1 / IEC 61346-2</th>
<th>VDE DIN 40719 Part 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auxiliary switch on operating mechanism</td>
<td>-BGS1</td>
<td>-BS1</td>
<td>-S1</td>
</tr>
<tr>
<td>Auxiliary switch on blocking magnet -RLE1</td>
<td>-BGL1</td>
<td>-BL1</td>
<td>-S2</td>
</tr>
<tr>
<td>Auxiliary switch on the breaker shaft</td>
<td>-BBG1</td>
<td>-BB1</td>
<td>-S3</td>
</tr>
<tr>
<td>Auxiliary switch on the breaker shaft</td>
<td>-BBG2</td>
<td>-BB2</td>
<td>-S4</td>
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<td>Auxiliary switch on the breaker shaft</td>
<td>-BBG3</td>
<td>-BB3</td>
<td>-S5</td>
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<tr>
<td>Auxiliary switch for fault annunciation</td>
<td>-BBG4</td>
<td>-BB4</td>
<td>-S7</td>
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<td>Fleeting contact time ≥ 35 ms</td>
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<tr>
<td>Blocking magnet</td>
<td>-RL1</td>
<td>-RL1</td>
<td>-Y1</td>
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<tr>
<td>Shunt release OFF</td>
<td>-MO1</td>
<td>-MO1</td>
<td>-Y2</td>
</tr>
<tr>
<td>Shunt release ON</td>
<td>-MC</td>
<td>-MC</td>
<td>-Y3</td>
</tr>
<tr>
<td>Undervoltage release</td>
<td>-MU</td>
<td>-MU</td>
<td>-Y4</td>
</tr>
<tr>
<td>Indirect overcurrent release</td>
<td>-MO3</td>
<td>-MO3</td>
<td>-Y7</td>
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<tr>
<td>Series rectifier for -RLE1</td>
<td>-TB4</td>
<td>-TR4</td>
<td>-V1</td>
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<tr>
<td>Series rectifier for -MBO1</td>
<td>-TB1</td>
<td>-TR1</td>
<td>-V2</td>
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<td>Series rectifier for -MBO3</td>
<td>-TB6</td>
<td>-TR6</td>
<td>-V4</td>
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<td>Series rectifier for -MBO2</td>
<td>-TB7</td>
<td>-TR7</td>
<td>-V9</td>
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<tr>
<td>Series rectifier for -MBU and -KFN</td>
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<tr>
<td>Series rectifier for -MBU</td>
<td>-TB3</td>
<td>-TR3</td>
<td>-V5</td>
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<tr>
<td>Series rectifier for -KFN</td>
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<tr>
<td>Series rectifier for -MBO3</td>
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<tr>
<td>Charging motor for spring energy store</td>
<td>-MAS</td>
<td>-MS</td>
<td>-M0</td>
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<tr>
<td>Antipumping relay</td>
<td>-KFN</td>
<td>-KN</td>
<td>-K0</td>
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<tr>
<td>Series resistor</td>
<td>-RR</td>
<td>-RR</td>
<td>-R0</td>
</tr>
<tr>
<td>Circuit-breaker</td>
<td>-QDB</td>
<td>-Q0</td>
<td>-X0</td>
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<td>Terminal blocks for circuit-breaker auxiliary circuits</td>
<td>-XDB</td>
<td>-XB</td>
<td>-X2</td>
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</table>
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