VB1-D Generator
Circuit-Breaker Switchgear

Medium-Voltage Switchgear
Application:
- Hydroelectric power plants
- Multi-generator applications
- Hydro power plants
- Geothermal power plants
- Pumped-storage power plants
- Oil and gas industry
- Gas-fired and steam power plants
- Solar thermal power plants
The products and systems described in this catalog are manufactured and sold according to a certified management system (acc. to ISO 9001, ISO 14001 and BS OHSAS 18001).
Fig. 1  Example of VB1-D switchgear

Fig. 2  Example of VB1-D switchgear with withdrawble vacuum generator circuit-breaker

Fig. 3  Front view of circuit-breaker truck
Overview

Independent of the type of power plant, the use of a generator circuit-breaker switchgear provides numerous advantages. The implementation of this equipment in the system:

– increases the profitability by minimizing the production downtimes
– increases the earnings due to lower maintenance
– reduces high investment as a result of unexpected repairs
– optimizes the availability and security of the power plant.

Some of the advantages of using generator circuit-breaker switchgear are:

Reliable synchronization and power plant optimization

• One switching operation on the generator side of the Generator Step-Up Transformer (GSUT) only
• Half-sized generator configuration (2 generators feed 1 GSUT)
• Pump storage: Fast switch-over between generator and motor operation.

Highest security of supply

• Uninterrupted supply of the auxiliary systems if generator circuit-breaker is switched off in case of fault current interruptions or maintenance.

Improved protection

• Quick isolation of the GSUT and auxiliary transformer in case of generator source faults
• Of the generator against system source faults.

Switching of generators means switching under critical conditions, such as:

• High rated currents and short-circuit currents
• High DC components
• High rate-of-rise of recovery voltage
• Out-of-phase switching.

Circuit-breakers used for generator switching applications are subject to conditions quite different from those of normal distribution circuit-breakers used in industrial, commercial and utility systems.

In distribution applications, the DC component is nearly completely decayed after just a few cycles. However, the rating basis for a generator circuit-breaker is a system X / R ratio of 50 (at 60 Hz), which results in a very slow decay of the DC component. This means that the DC component of the current at the instant of interruption is much larger in generator applications than in distribution applications.

The AC component is no longer a constant r.m.s. value, but decays as well. If the decay of the AC component is faster than the corresponding DC decay, the superposition of the DC component on the AC component will result in a potentially long period in which the actual fault current does not pass through zero. This is a problem, because circuit-breakers actually interrupt when the current passes through a normal current zero.
Improved protection (contin.)
This phenomenon is referred to in the standard IEEE C37.013 as "delayed current zeroes", and it is the basis design of the generator circuit-breaker, which must be verified by means of a calculation for the applicable generator network.
Another aspect of a generator circuit-breaker application is that the transient recovery voltage (TRV) across the contacts, as the interrupter opens, is much higher than for a distribution circuit-breaker.
The rate-of-rise of recovery voltage (RRRV) values can be up to 10 times higher in the standard IEEE C37.013 than in IEC.
This is just a brief overview of the conditions that make a generator circuit-breaker application quite different from that of standard distribution applications.

Typical uses
Siemens is one of the leading manufacturers in the field of vacuum circuit-breaker and switchgear technology, providing solutions to the most demanding clients all over the world.
The VB1-D circuit-breaker switchgear provides a compact solution which can be customized to the individual needs of our clients.
The switchgear is suitable for power ratings up to 140 MW. For high current interruption capabilities, the Siemens vacuum generator circuit-breakers type 3AH37 up to 63 kA are used.
VB1-D generator circuit-breaker switchgear can be used in power plants up to 17.5 kV, 4300 A (5100 A with forced cooling) to connect the generator(s) to the step-up transformer(s) and, if applicable, also for auxiliary supply transformers and excitation transformers.

Use of vacuum as switching medium
Siemens has been using vacuum as switching medium for more than 30 years in medium voltage and developed a vacuum interrupter with a special axial magnetic field (AMF) contact system that is able to withstand the requirements of generator switching applications.
Based on years of experience and customer orientation as a pioneer in development of vacuum switchgear technology for reliable transmission and distribution of electric power in medium voltage, Siemens gained the competence and developed solutions for the unique switching duties of generator circuits.

In order to meet the high demands of the merging market for power generation units up to 400 MW, Siemens further optimized its portfolio of high-current and generator circuit-breaker switchgear with this product.

### Customer benefits

**Peace of mind**
- No handling of switching gas, and no low or high pressure monitoring required
- As insulating medium, air is always available
- More than 450,000 Siemens switchgear panels and systems with vacuum switching technology in operation worldwide
- Factory-assembled, type-tested switchgear according to IEC 62271-200
- Use of maintenance-free vacuum circuit-breakers
- Use of standard components available worldwide
- Use of standardized current transformers
- Quality assurance in accordance with DIN EN ISO 9001
- Type test of the vacuum circuit-breaker and earthing switch in the panel
- Flexibility in the low-voltage equipment (different compartment sizes, pluggable wiring, removable low-voltage compartment)
- Retrofitting in case of power increase (additional cables, new instrument transformers) possible without problems

**Optimum safety**
- All operations with closed high-voltage door
- Metallic enclosure, earthed shutters and partitions
- Internal arc classified switchgear according to IAC A FLR for arc duration of 0.3 s (accessibility from the front, laterally and from the rear)
- Loss of service continuity category LSC 2B (separate partitions for busbar, connection and switching-device compartments)
- Partition class PM (metal-clad in pressure-resistant design)
- Use of vacuum circuit-breakers
- Pressure-resistant partitions, concentrated pressure relief through duct
- Standard degree of protection IP4X
- Positively driven shutters, lockable
- Logical mechanical interlocking system
- Minimum use of insulating material
- Rapid interruption of internal arc (optional)
- Verification of properties by complete type-test documentation according to the latest standards
- Control cables in metallic wiring ducts

**Easy to install**
- The VB1-D is factory-tested and all internal wiring is already completed
- Easy installation because of uncomplicated technology
<table>
<thead>
<tr>
<th>Customer benefits</th>
<th>Design features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increases productivity</td>
<td>Properties such as modular design, types tests of the circuit-breaker in the switchgear, confinement of an internal arc to the respective compartment, and thus maximum operational reliability, contribute to optimum operation and a remarkable increase of productivity.</td>
</tr>
<tr>
<td></td>
<td>• Fast accessibility to all compartments provided</td>
</tr>
<tr>
<td></td>
<td>• Fast circuit-breaker replacement possible due to withdrawable design</td>
</tr>
<tr>
<td></td>
<td>• Loss of service continuity category LSC 2B</td>
</tr>
<tr>
<td></td>
<td>• Partition class PM</td>
</tr>
<tr>
<td></td>
<td>• Maximum degree of protection IP42</td>
</tr>
<tr>
<td></td>
<td>• Use of maintenance-free vacuum circuit-breakers for 10,000 operating cycles at rated current</td>
</tr>
<tr>
<td></td>
<td>• Frequent-operation circuit-breakers for up to 120,000 operating cycles available</td>
</tr>
<tr>
<td></td>
<td>• High reliability of vacuum circuit-breakers due to the low number of moving parts inside the arcing chamber</td>
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<tr>
<td></td>
<td>• Extremely high mean-time-to-failure (MTTF) values of the vacuum interrupters</td>
</tr>
<tr>
<td>Saves money</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Use of maintenance-free vacuum circuit-breakers</td>
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<tr>
<td></td>
<td>• Thanks to the compact design of the switching module and the modular enclosure concept, the necessary space for installation is reduced to a minimum</td>
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<tr>
<td></td>
<td>• Factory-assembled and tested, thus reducing installation work and commissioning on site</td>
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<tr>
<td></td>
<td>• Significantly lower life-cycle costs due to reduced inspection and maintenance compared to other switching technologies.</td>
</tr>
<tr>
<td>Preserves the environment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Long lifetime of the switchgear and all components (more than 20 years)</td>
</tr>
<tr>
<td></td>
<td>• As insulating medium, air is environmentally neutral</td>
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<tr>
<td></td>
<td>• Vacuum switching technology, no gas filling every few years</td>
</tr>
<tr>
<td></td>
<td>• No toxic decomposition products in case of switching arcs or internal arcs</td>
</tr>
<tr>
<td></td>
<td>• No pressure monitoring required</td>
</tr>
<tr>
<td></td>
<td>• The materials used are fully recyclable without special knowledge</td>
</tr>
<tr>
<td></td>
<td>• Easy disposal</td>
</tr>
<tr>
<td>Advantages of vacuum as switching medium</td>
<td>Siemens introduced the vacuum switching technology into the market in the early 1970’s and since then continually optimized the design and extended the ratings. This technology was further optimized during the 1990s when circuit-breakers for generator applications conforming to IEC &amp; IEEE were added to the portfolio, where particular emphasis must be placed on measures to withstand high thermal and mechanical stresses, including the following:</td>
</tr>
<tr>
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<td>• Special contact material for minimum contact wear</td>
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<tr>
<td></td>
<td>• Specifically developed contact system</td>
</tr>
<tr>
<td></td>
<td>• Optimized design for efficient cooling</td>
</tr>
<tr>
<td></td>
<td>• Safe breaking operations by controlling long arcing times even in case of delayed current zeros</td>
</tr>
<tr>
<td></td>
<td>• Transient recovery voltages with high rates of rise, typical for generators, are controlled without additional capacitor circuits</td>
</tr>
</tbody>
</table>
### Mechanical and electrical data

#### Mechanical data of VB1-D

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Up to 17.5 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width (spacing)</td>
<td>I_{sc} (kA)</td>
</tr>
<tr>
<td>Circuit-breaker panel</td>
<td>63</td>
</tr>
<tr>
<td>Connection panel</td>
<td>63</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Height</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard panel with standard low-voltage compartment</td>
<td>2400</td>
</tr>
<tr>
<td>Panel with pressure relief duct and arc absorber</td>
<td>2900</td>
</tr>
<tr>
<td>Panel with forced ventilation</td>
<td>2900</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Depth</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>All panel types</td>
<td>2300</td>
</tr>
</tbody>
</table>

#### Electrical data of VB1-D

<table>
<thead>
<tr>
<th>Technical data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>kV</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>Hz</td>
</tr>
<tr>
<td>Rated power-frequency withstand voltage</td>
<td>kV</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage</td>
<td>kV</td>
</tr>
<tr>
<td>Rated short-time withstand current, max.</td>
<td>kA</td>
</tr>
<tr>
<td>Rated duration of short circuit, max.</td>
<td>s</td>
</tr>
<tr>
<td>Rated peak withstand current, max.</td>
<td>kA</td>
</tr>
<tr>
<td>Rated normal current of busbar, max.</td>
<td>A</td>
</tr>
<tr>
<td>Circuit-breaker, natural cooling</td>
<td>A</td>
</tr>
<tr>
<td>Circuit-breaker, forced cooling</td>
<td>A</td>
</tr>
</tbody>
</table>

### Transport

The VB1-D switchgear is delivered in form of individual panels.
Please observe the following:
- Transport facilities on site
- Transport dimensions and transport weights
- Size of door openings in building and obstructions.

#### Packing

**Means of transport: Rail and truck**
- Panels on pallets
- Open packing with PE protective foil.

**Means of transport: Seafreight**
- Panels on pallets
- Sealed in PE protective foil, with closed wooden crate
- With desiccant bags
- With sealed wooden base
- Max. storage time: 12 months.

**Means of transport: Airfreight**
- Panels on pallets
- In wooden latticed crate with sealed upper and lower PE protective foil.

### Transport dimensions, transport weight for individual panels 1) 2) 3)

<table>
<thead>
<tr>
<th>Panel widths</th>
<th>Transport dimensions (approx.)</th>
<th>Transport weight (approx.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Width</td>
<td>Depth</td>
</tr>
<tr>
<td></td>
<td>mm</td>
<td>mm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transport of VB1-D by rail and truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>VCB panel</td>
</tr>
<tr>
<td>1x1200 mm</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1300</td>
</tr>
<tr>
<td>2550</td>
</tr>
<tr>
<td>2450</td>
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<tr>
<td>2500</td>
</tr>
<tr>
<td>2400</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transport of VB1-D by seafreight, airfreight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus riser panel</td>
</tr>
<tr>
<td>1x1200 mm</td>
</tr>
<tr>
<td>1300</td>
</tr>
<tr>
<td>2550</td>
</tr>
<tr>
<td>2450</td>
</tr>
<tr>
<td>1500</td>
</tr>
<tr>
<td>1400</td>
</tr>
</tbody>
</table>

1) Average values depending on the degree to which panels are equipped
2) The pressure relief duct is transported as a separate delivery
3) Transport of circuit-breaker separately
Technical data
Room planning

<table>
<thead>
<tr>
<th>VB1-D enclosure</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>approx. 2400 mm + end walls</td>
</tr>
<tr>
<td>Depth</td>
<td>2300 mm + end walls</td>
</tr>
<tr>
<td>Height</td>
<td>2400 mm (2900 mm including pressure duct) + base frame of 70 mm</td>
</tr>
</tbody>
</table>

Arrangement

- Clearances of the surrounding walls at least 100 mm.
- In back of the switchgear preferred free area of 850 mm.
- In front of the switchgear preferred free area of 2000 mm.

Depending on the room height, the pressure relief system of the switchgear is designed with exhaust ducts leading out of the switchgear building.

- Room height min. 3200 mm.

Fig. 8 Recommended minimum distances

Fig. 9 Front view

Fig. 10 Top view

Fig. 11 Side view
### Classification

Siemens generator circuit-breaker switchgear type VB1-D is a factory-assembled, type-tested, metal-enclosed and metal-clad switchgear for indoor installation, which is designed according to the standards IEC 62271-1 and IEC 62271-200 (VDE 0671-200). The type tests of the VB1-D have been carried out according to the standards IEC 62271-200.

All switching devices used in the VB1-D are type-tested according to IEC 62271-100 / -102. In addition, our generator circuit-breakers are type-tested according to IEEE C37.013 and fulfill the requirements of IEC/IEEE 62271-37-013.

<table>
<thead>
<tr>
<th>Loss of service continuity category and partition class</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of service continuity category</td>
<td>LSC 2B</td>
</tr>
<tr>
<td>Partition class</td>
<td>PM</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accessibility to compartments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busbar compartment</td>
</tr>
<tr>
<td>Switching-device compartment</td>
</tr>
<tr>
<td>Connection compartment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Internal arc classifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>The following internal arc classifications are fulfilled: IAC A FLR, $I_{sc}$, $t$</td>
</tr>
<tr>
<td>IAC</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>F</td>
</tr>
<tr>
<td>L</td>
</tr>
<tr>
<td>R</td>
</tr>
<tr>
<td>$I_{sc}$</td>
</tr>
<tr>
<td>$t$</td>
</tr>
</tbody>
</table>

In this way, VB1-D switchgear is suitable for unrestricted application (wall- or free-standing arrangement) in electrical service locations up to the maximum short-circuit ratings.

### Enclosure

Doors and lateral switchgear end walls are powder-coated with resistant epoxy resin, all other walls are of galvanized steel or non-magnetic material.

The complete enclosure as well as the partitions between the individual compartments and shutters are metallic and earthed. All doors at the operating side are bolted with hinges. This guarantees the highest possible loss of service continuity category LSC 2B of the switchgear (metal-clad design) and the highest possible personal safety with partition class PM according to IEC 62271-200.

The partition class PM ensures that only earthed steel sheets can be touched during access to the individual compartments. This guarantees the highest possible personal safety during maintenance work.

The loss of service continuity category LSC 2B allows access to compartments while other adjacent compartments remain in operation. For example, it is possible to maintain the connection compartment and busbar compartment of the same panel, as well as all compartments of the adjacent panels, in operation while the switching device compartment is open. In this way, the category LSC 2B provides the highest possible service continuity.

In case of an arc fault, pressure is generally relieved upwards into a duct overlapping all panels. VB1-D switchgear is tested for resistance to internal faults and fulfills all criteria of the internal arc classification IAC A FLR according to IEC 62271-200. It is therefore adequate for access from all sides.

Inspection windows and access holes for the emergency operating tools are provided for all switching devices.

The enclosure has a degree of protection of IP4X for indoor installation. The degree of protection for the internal partitions is IP2X.

The standard enclosure including all internal surfaces is epoxy powder-coated with color RAL 7035, optionally all other colors RAL. The aluminium enclosure is designed for inductively coupled reverse current in order of 100 % of the rated current.
Design
Basic panel design, operation

Features

- Modular design
- Integrated mimic diagram
- All switching operations always with high-voltage door closed
- Inspection windows and access holes for the emergency operating tools are provided for all switching devices.
- Ergonomically favorable height for all control and indicator elements

Interlocks

All switching devices are equipped with motor operating mechanisms which are incorporated in the electrical interlocking scheme.

In case of emergency (e.g., loss of auxiliary power), the switching devices can be operated manually. However, there are no interlocks in case of manual operation.

The mechanical position indicators and control elements of the respective switching devices are visibly integrated in a mimic diagram in the door of the switching device compartment and low voltage compartment.

The position of the switching devices can be observed by indicators and/or through inspection windows.

In connection with the logical mechanical interlocking system, this avoids any mal-operation.

Due to the door interlock, the switching device compartment is an "interlock-based accessible compartment" according to IEC 62271-200.

Each switchgear is equipped with a top mounted pressure duct system, overlapping all switchgear panels. In case of internal fault the pressure of the panel compartments will be relieved into the pressure duct and being relieved out of the switchgear.

Hot gases and particles can be absorbed by connection of an arc absorber (optional) or relieved out of the room through a pressure relief channel (optional), which is located at the lateral side of the switchgear.
Basic panel design

Fig. 13 Sectional view of circuit-breaker panel design (in service position)

1. Metallic shutters for high-voltage contacts
2. Low-voltage connection, plug-in type
3. Vacuum circuit-breaker
4. Circuit-breaker truck
5. Current transformer
6. Isolated busbar
7. Earthing switch
8. Voltage transformer
9. Insulator
10. Contact system
11. Busbars
12. Surge arrester
13. Fan (optional)
Design
Basic panel design, operation

Circuit-breaker panel

Due to the withdrawable design of the circuit-breaker panel, a high availability and possibility of fast circuit-breaker replacement is ensured. No additional disconnector is required.

While racking from the service to the test position or vice versa, the withdrawable part opens or closes the metal shutters (positively driven) covering the fixed contacts in the connection and busbar compartments (A).

The connection of the low-voltage wiring between the withdrawable part and the fixed part of the panel is done via a 64-pole plug connection (B).

Generally, the low-voltage wiring is laid in metallic ducts with removable covers.

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Fig. 14 Service position

Fig. 15 Testing position
Fig. 16 Sectional view of bus riser panel design

1  Current transformer
2  Isolated busbar
3  Earthing switch
4  Voltage transformer
5  Insulator
6  Busbars
7  Bushing-type insulation

A  Additional compartment for highvoltage function
B  Busbar compartment
C  Connection compartment
D  Low-voltage compartment
E  Pressure duct/channel
**Optional extended connection compartment**

The VB1-D switchgear is extendable by additional connection compartments, to fulfil the individual requirements of the clients.

*Fig. 17 Side view of panel with extended connection compartment*
Operation, control panel

The switching devices of the generator switchgear can be operated locally via the control panel as well as from remote. In case of absence of auxiliary control voltage, hand cranks are provided for manual operation of the switching devices.

The standard control panel is fixed-mounted to the enclosure. It includes the electrical control and electrical interlocking of the switching devices. Optionally, metering and protection devices can be integrated in the control compartment.

Features

- Bottom or top entry for external control cables by means of gland plates is provided (optional) or without cutouts. Glands for external cables are optional on request
- Standard wiring: Black, PVC, type H07 VK with markings at the low voltage compartment side, 2.5 mm² for instrument transformers, 1.5 mm² for all other circuits. Colored wiring and other cable cross-sections are available on request
- Mimic diagrams with pushbuttons (optionally with additional LEDs) for CLOSE / OPEN operation of switching devices and position indication (optionally with LED position indicators) of switching devices
- Selector switch for LOCAL / REMOTE (optionally key-operated).
- Voltage detecting system CAPDIS-S1+ or CAPDIS-S2+ on request
- Standard terminal: UTTB 4 Screw terminals for control, signaling and power supply circuits, disconnect terminals for voltage transformer circuits, short-circuit terminals for current transformers
- Standard auxiliary power: 230 V AC, to be provided by the customer (other auxiliary voltages are available on request)
- Standard interface for signals: Terminal strips within the control compartment
- External signals: By means of potential-free contacts and relays. Communication protocols (e.g., IEC 61850, PROFI-BUS, etc. can be provided on request in case of numerical control and protection devices)
- Key-operated interlocks available on request
- Numerical control with generator and transformer protection available on request.

Fig. 18 Control unit

Fig. 19 Push-button
Fig. 20 LED luminous indicators (optional)
Fig. 21 Illuminated push-button

Fig. 22 Standard position indicator
Fig. 23 LED position indicators (optional)

Fig. 24 Standard local/remote switch
Fig. 25 Key-operated local/remote switch (optional)

Fig. 26 7PA30 trip supervision relay (optional)
Fig. 27 Voltage detecting systems CAPDIS-S1, -S2 (optional)

Fig. 28 Key-operated interlocks (optional)
Fig. 29 Door locking device with solenoid (optional)
Design
Connection

Type of connections

Connection to generator and transformer can be done by means of cables, bus duct or solid-insulated busbars. The connection to the power terminals can be either from bottom or rear. Access to the connection terminals is covered with non-magnetic sheet metal. Cable glands, bus duct flanges or flexible connectors are not included in our scope of supply.

Cable connection

Standard connection of up to 4 single-core cables per phase with 630 mm² (4 x 1 x 3 x 630 mm²) which covers up to approx. 2500 A. In case more cables are requested, a customized solution can be designed. Entry from bottom side.

The bottom gland plate is sectionalized and made of non-magnetic sheet metal.

Cable glands, sealing flanges or cut-outs for cables are not included in the scope of supply.

Bus duct connection

Connection to the generator and step-up transformer can be done by means of three-phase or single-phase encapsulated bus duct.

A flange will be provided for connection of the bus duct system. Interconnection of the busbars to be made by flexible copper straps (not in our scope of supply).

Solid-insulated busbar

Connection terminal suitable for one solid-insulated busbar per phase.

Busbar entry either from bottom or rear side.

Access to the connection terminals through the enclosure is covered with non-magnetic sheet metal.

Sealing flanges and flexible copper connection straps are not included in the scope of supply.
Product range
VB1-D switchgear

Circuit-breaker panel

Busbar connection panel

Metering panel

Auxiliary transformer panel

a) Feeding from the busbar

b) Feeding by cable from incoming feeder

Bus sectionalizer (mirror-image installation also possible)

Current transformer

Voltage transformer

Voltage transformers with primary fuses

Make-proof earthing switch, optionally manual or motor operating mechanism

Capacitive voltage detecting system

Cable sealing ends

Bar feeder

Withdrawable vacuum generator circuit-breaker with motor operating mechanism

Forced ventilation

Auxiliary transformer

Fixed-mounted switch-disconnector/fuse combination

Withdrawable disconnector link with manual operating mechanism
Configuration possibilities
VB1-D switchgear

Basic switchgear

Fig. 33 Example of basic solution
Example of customized switchgear

**Fig. 34** Example of customized solution

**Example A**

**Fig. 35** Example of customized solution

**Example B**
Components

Vacuum generator circuit-breaker 3AH37

Vacuum generator circuit-breaker 3AH37

Due to the modular design of the circuit-breaker, the best materials can be used each for the current path, electric flux and cooling. Thus, the 3AH37 combines low resistance of the main circuit with high mechanical stability and ideal cooling performance.

Features of the 3AH37 vacuum generator circuit-breaker:
- Type-tested according to IEEE standard C37.013 and it fulfills all requirements according to IEC/IEEE 62271-37-013
- High DC components > 65 %
- Maintenance-free for 10,000 operating cycles
- MTTF (mean-time-to failure) 13,290 years
- No toxic decomposition products of the arc-quenching medium.

Electrical data

<table>
<thead>
<tr>
<th>Type-tested according to IEEE C37.013</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>kV</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>Hz</td>
</tr>
<tr>
<td>Rated power-frequency withstand voltage</td>
<td>kV</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage</td>
<td>kV</td>
</tr>
<tr>
<td>Rated short-time withstand current, max.</td>
<td>kA</td>
</tr>
<tr>
<td>Rated duration of short circuit, max.</td>
<td>s</td>
</tr>
<tr>
<td>Rated peak withstand current, max.</td>
<td>kA</td>
</tr>
<tr>
<td>Rated normal current of busbar, max.</td>
<td>A</td>
</tr>
<tr>
<td>Asymmetrical breaking current</td>
<td>kA</td>
</tr>
<tr>
<td>DC component</td>
<td>%</td>
</tr>
<tr>
<td>Rated operating sequence</td>
<td>CO – 30 min – CO</td>
</tr>
<tr>
<td>Endurance classes</td>
<td>E2 - M2 - C2</td>
</tr>
<tr>
<td>Auxiliary voltage</td>
<td>V</td>
</tr>
<tr>
<td>Make time</td>
<td>ms</td>
</tr>
<tr>
<td>Total break time</td>
<td>ms</td>
</tr>
</tbody>
</table>
Components
Vacuum generator circuit-breaker 3AH37

Vacuum generator circuit-breaker truck

- No separate service truck required
- Disconnector link with automatically coupling contact system
- Silver-plated tulip contacts with 2,000 operating cycles (M1)

Earthing switch
Earthing switches are used to connect the connection terminal of the generator or transformer side to earth, in order to guarantee safe maintenance or repair work where it is required.

Earthing switches are designed in accordance with the requirements of EN 62271-102. A motor operating mechanism enables actuation with a switching angle of 90°. In case of loss of auxiliary power, emergency operation by means of a manually operated hand crank is possible.

Mechanical class (in accordance with EN 62271-102):
Class M0 = 1000 mechanical switching operations

Electrical class (in accordance with EN 62271-102):
Class E0 = no short-circuit making capacity
Class E1 = short-circuit making capacity (optional)

<table>
<thead>
<tr>
<th>Earthing switch / IEC 62271-102</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulating medium</td>
<td>Air</td>
</tr>
<tr>
<td>Rated voltage</td>
<td>17.5 kV</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Rated power-frequency withstand voltage – 1 min</td>
<td>50 kV</td>
</tr>
<tr>
<td>Rated short-time withstand current</td>
<td>63 kA/3 s</td>
</tr>
<tr>
<td>Operating mechanism</td>
<td>motor</td>
</tr>
<tr>
<td>Position indication</td>
<td>mechanical/electrical</td>
</tr>
<tr>
<td>Electrical switching capacity</td>
<td>no load</td>
</tr>
<tr>
<td>Auxiliary switch</td>
<td>4 (max. 8) NC, NO</td>
</tr>
<tr>
<td>Rated auxiliary voltage</td>
<td>max. 250 V AC / 220 V DC</td>
</tr>
<tr>
<td>Mechanical endurance</td>
<td>1000 operating cycles</td>
</tr>
</tbody>
</table>

Fig. 38 Front view of circuit-breaker truck

Fig. 39 Rear view of circuit-breaker truck

Fig. 40 Earthing switch
Components
Surge arresters, capacitors, current transformers, voltage transformers

Surge arresters, capacitors
Vacuum generator circuit-breakers do not require additional capacitors or surge arresters to withstand the system inherent rate-of-rise of the recovery voltage.

For other system phenomena, such as overvoltages transferred via the step-up transformer or transmission of zero-sequence voltages via the step-up transformer, it is recommended to install surge arresters and surge capacitors on the step-up transformer side terminals of the generator circuit-breaker. The system planner is responsible to ensure that these stresses are limited to permissible values, as such phenomena must be taken into account for all the electrical equipment, both for the step-up transformer and the generator, which are the most expensive electrical devices of the system.

The vacuum generator circuit-breaker will not be negatively influenced or will not change its proper switching behavior if surge capacitors and surge arresters are installed on the line side terminals of the switchgear. Additional surge capacitors and arresters can be provided on the generator side terminals, too.

Independently of the size of the generator or transformer, surge capacitors with capacitances of 250 nF up to 300 nF per phase may be considered appropriate to ensure safe limitation of the possible stresses without proving this by detailed calculations.

Current transformers
Features:
– Cast-resin insulated
– Max. operating voltage up to 17.5 kV
– Max. rated primary current up to 5000 A
– Max. rated short-time thermal current up to 63 kA, 3 s
– Max. rated peak withstand current up to 173 kA
– Max. 4 secondary cores
– Very large range of accuracy class combinations
– Secondary multiratio possible
– Current transformer certifiable

Voltage transformers
Features:
– Fixed-mounted
– Cast-resin insulated, single-pole
– Primary operating voltage up to 17.5 kV
– Max. secondary operating voltage up to 100 V or divided by \( \sqrt{3} \)
– Very large range of accuracy class combinations
– Rating up to 200 VA
– Earth-fault winding optional with damping resistor.
Type of service location

The switchgear can be used as indoor installation according to IEC 61936 (Power installations exceeding AC 1 kV) and VDE 0101

• Outside lockable electrical service locations at places which are not accessible to the public. Enclosures of switchgear can only be removed with tools
• In lockable electrical service locations. A lockable electrical service location is a place outdoors or indoors that is reserved exclusively for housing electrical equipment and which is kept under lock and key. Access is restricted to authorized personnel and persons who have been properly instructed in electrical engineering. Untrained or unskilled persons may only enter under the supervision of authorized personnel or properly instructed persons.

Dielectric strength

• The dielectric strength is verified by testing the switchgear with rated values of short-duration power-frequency withstand voltage and lightning impulse withstand voltage according to IEC 62271-1 / VDE 0671-1 (see table "Dielectric strength")
• The rated values are referred to sea level and to normal atmospheric conditions (1013 hPa, 20 °C, 11 g/m3 humidity according to IEC 60071 and VDE 0111)
• The dielectric strength decreases with increasing altitude.
• For site altitudes above 1000 m (above sea level) the standards do not provide any guidelines for the insulation rating, but leave this to the scope of special agreements
• Site altitude
• The dielectric strength of air insulation decreases with increasing altitude due to low air density. This reduction is permitted up to a site altitude of 1000 m according to IEC and VDE
• For site altitudes above 1000 m, a higher insulation level must be selected. It results from the multiplication of the rated insulation level for 0 to 1000 m with the altitude correction factor $K_a$.

### Table – Dielectric strength

<table>
<thead>
<tr>
<th>Rated voltage (r.m.s. value)</th>
<th>kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.5</td>
<td></td>
</tr>
</tbody>
</table>

| Rated short-duration power-frequency withstand voltage (r.m.s. value) |
|-------------------------------------------------|---|
| Between phases and to earth                     | kV |
| Across isolating distances                       | kV |
| -                                               | 50 |
| -                                               | 50 |

| Rated lightning impulse withstand voltage (peak value) |
|--------------------------------------------------------|---|
| Between phases and to earth                           | kV |
| Across isolating distances                            | kV |
| -                                                     | 110|
| -                                                     | 110|

Altitude correction factor $K_a$

Above 1000 m, the altitude correction factor $K_a$ is recommended, depending on the site altitude above sea level.

![Graph showing altitude correction factor $K_a$](graph.png)

Rated short-duration power-freq. withstand volt. to be selected for site altitudes $> 1000$ m $\geq$ Rated short-duration power-frequency withstand voltage up to $\leq 1000$ m $\cdot K_a$

Rated lightning impulse withstand voltage to be selected for site altitudes $> 1000$ m $\geq$ Rated lightning impulse withstand voltage up to $\leq 1000$ m $\cdot K_a$

**Example:**

2500 m site altitude above sea level
12 kV switchgear rated voltage
75 kV rated lightning impulse withstand voltage
Rated lightning impulse withstand voltage to be selected $= 75$ kV $\cdot 1.2 = 90$ kV

**Result:** According to the above table, a switchgear for a rated voltage of 17.5 kV with a rated lightning impulse withstand voltage of 95 kV is to be selected.
Standards

The switchgear complies with the relevant standards and specifications applicable at the time of type tests. In accordance with the harmonization agreement reached by the countries of the European Union, their national specifications conform to the IEC standard.

Overview of standards

<table>
<thead>
<tr>
<th>IEC/EN/IEEE standard</th>
<th>Switchgear</th>
</tr>
</thead>
<tbody>
<tr>
<td>62271-1</td>
<td>Common specifications for high-voltage switchgear and controlgear</td>
</tr>
<tr>
<td>62271-200</td>
<td>AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV (according to list of performed tests)</td>
</tr>
<tr>
<td>61936-1</td>
<td>Power installations exceeding 1 kV AC – Part 1: Common rules</td>
</tr>
</tbody>
</table>

Switching devices

<table>
<thead>
<tr>
<th>IEC/EN/IEEE standard</th>
<th>Switching devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>62271-100</td>
<td>Circuit-breakers</td>
</tr>
<tr>
<td></td>
<td>IEC</td>
</tr>
<tr>
<td>C37.013</td>
<td>IEC standard for AC high-voltage generator circuit-breakers rated on a symmetrical current basis, Amendment 1: Supplement for use with generators rated 10 – 100 MVA</td>
</tr>
<tr>
<td>C37.013a</td>
<td></td>
</tr>
<tr>
<td>62271-102</td>
<td>Earthing switches</td>
</tr>
<tr>
<td></td>
<td>Interlocking switches</td>
</tr>
<tr>
<td>61243-5</td>
<td>Voltage detecting systems</td>
</tr>
<tr>
<td>60071-1</td>
<td>Insulation co-ordination: Definitions, principles and rules</td>
</tr>
<tr>
<td>60529</td>
<td>Degree of protection provided by enclosures (IP-code)</td>
</tr>
</tbody>
</table>

Instrument transformers

<table>
<thead>
<tr>
<th>IEC/EN/IEEE standard</th>
<th>Instrument transformers</th>
</tr>
</thead>
<tbody>
<tr>
<td>61869-1</td>
<td>Current transformers</td>
</tr>
<tr>
<td>61869-2</td>
<td>Instrument transformers Part 2: Additional requirements for current transformers</td>
</tr>
<tr>
<td>61869-3</td>
<td>Instrument transformers Part 3: Additional requirements for inductive voltage transformers</td>
</tr>
<tr>
<td>61936-1</td>
<td>Power installations exceeding 1 kV AC – Part 1: Common rules</td>
</tr>
</tbody>
</table>

Current carrying capacity

- According to IEC 62271-1 / VDE 0671-1 and IEC 62271-200 / VDE 0671-200, the rated normal current refers to the following ambient air temperatures:
  - Maximum of 24-hour mean: +35 °C
  - Maximum: +40 °C
- The rated normal current of the panels and busbars depends on the ambient air temperature outside the enclosure.

Protection against solid foreign objects, electric shock and water

VB1-D switchgear fulfills according to the standards
- IEC 62271-200
- IEC 60529

the following degrees of protection:

<table>
<thead>
<tr>
<th>Switchgear panel</th>
<th>V81-D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of protection for the enclosure optionally</td>
<td>IP4X</td>
</tr>
<tr>
<td></td>
<td>IP42</td>
</tr>
<tr>
<td>Degree of protection of the internal partitions</td>
<td>IP2X</td>
</tr>
</tbody>
</table>

Climate and environmental influences

VB1-D switchgear is suitable for application in indoor installations under normal operating conditions as defined in the standard IEC 62271-1 as follows:
- Max. value of ambient air temperature: +40 °C
- Average value over a period of 24 h: +35 °C
- Minimum ambient air temperature: −5 °C
- Altitude of installation ≤ 1000 m
- Average value of relative humidity over a period of 24 h: ≤ 95 %, over a period of one month: ≤ 90 %
- No significant pollution of the ambient air (dust, gases, vapors, salts)

The switchgear may be used, subject to possible additional measures, under the following environmental influences:
- Natural foreign materials
- Chemically active pollutants
- Small animals
and the climate classes:
- 3K3
- 3K5.

The climate classes are defined according to IEC 60721-3-3.

Seismic withstand capability

VB1-D 17.5 kV switchgear is type-tested in accordance with the following internationally accepted requirements:
Internal arc classification
• Protection of operating personnel by means of tests for verifying the internal arc classification
• Internal arcing tests must be performed in accordance with IEC 62271-200/VDE 0671-200
• The switchgear complies with all criteria specified in the standards (page 26) for the basic version up to 63 kA.
• VB1-D complies with the internal arc classification: IAC A FLR up to 63 kA, 0.3 s.
  This provides maximum personal safety for switchgear accessible from all sides.
• Definition of criteria:
  – Criterion 1
    Correctly secured doors and covers do not open, limited deformations are accepted
  – Criterion 2
    No fragmentation of the enclosure, no projection of small parts above 60 g
  – Criterion 3
    No holes in accessible sides up to a height of 2 m
  – Criterion 4
    No ignition of indicators due to hot gases
  – Criterion 5
    The enclosure remains connected to its earthing point.

Guidelines
You know your application and we know the behavior and features of our switching devices. Together we can work out the perfect solution for your application.

For this purpose, we kindly ask you to submit the following data:
• Data sheets of:
  – Generator – including Sn, Un, xd, xd’, xd” Ta, Td, Td”
  – Transformer – including Sn, Un, uk
  – Auxiliary transformer and motors, if applicable
  – Neutral treatment of generator and transformer
• Single-line diagram
• Information on operation of the equipment, e. g. interconnected circuits.

Based on the information concerning your application, our experts will select a circuit-breaker which reliably controls all service conditions, including tripping in case of a fault. Among other things, the results of the calculations contain a graphical representation of the current characteristics, as shown below.

Fig. 47 Example of short-circuit simulation to confirm the breaking capacity
For further information please contact our Customer Support Center.
Phone: +49 180 524 70 00
Fax: +49 180 524 24 71
E-mail: generatorswitchgear.energy@siemens.com
siemens.com/generatorswitchgear

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