HIGS Highly Integrated Generator Circuit-Breaker Switchgear

Medium-Voltage Switchgear
Application:
• Gas-fired and steam power plants
• Oil and gas industry
• Solar thermal power plants
• Geothermal 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).
Application

Types

Fig. 1  Example of HIGS 3200 switchgear with circuit-breaker for auxiliary transformer (right-hand side of switchgear)

Fig. 2  Example of HIGS 3200 switchgear with front doors and covers closed
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.

The main advantages 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)

**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.
Application
Overview, typical uses

Improved protection (contin.)
This phenomenon is referred to in the standard IEEE C37.013 IEC 62271-37-013 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 IEC 62271-37-013 than in IEC 62271-100.

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 HIGS circuit-breaker switchgear provides a compact solution which can be customized to the individual needs of our clients.

The switchgear is suitable for a power range of up to 75 MVA at IP54 and 91 MVA at IP42. For high current interruption capabilities, the Siemens vacuum generator circuit-breakers type 3AH38 up to 63 kA are used.

HIGS generator circuit-breaker switchgear can be used in power plants up to 17.5 kV, 4000 A (4800 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 450 MVA, Siemens further optimized its portfolio of generator circuit-breaker switchgear with this product.

### Customer benefits, design features

<table>
<thead>
<tr>
<th>Customer benefits</th>
<th>Design features</th>
</tr>
</thead>
</table>
| 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 |
| Optimum safety             | • All operations with closed high-voltage door  
• Metallic enclosure  
• Use of vacuum circuit-breakers  
• Pressure-resistant enclosure with pressure relief through flaps  
• Standard degree of protection  
• Minimum use of insulating material  
• Verification of properties by complete type-test documentation according to the latest standards |
| Easy to install            | • The HIGS is factory-tested and all internal wiring is already completed  
• Easy installation because of uncomplicated technology  
• Directly installed at the generator terminal  
• Integrated neutral side treatment  
• Optionally available with integrated auxiliary transformer feeder |
## Requirements

### Customer benefits, design features

<table>
<thead>
<tr>
<th>Customer benefits</th>
<th>Design features</th>
</tr>
</thead>
</table>
| **Increases productivity** | Properties such as modular design, type tests of the circuit-breaker in the switchgear, and thus maximum operational reliability, contribute to optimum operation and a remarkable increase of productivity.  
  - Fast accessibility to all compartments provided  
  - Available degree of protection IP42, IP54 and IP55  
  - Use of maintenance-free vacuum circuit-breakers for 10,000 operating cycles at rated current  
  - High reliability of vacuum circuit-breakers due to the low number of moving parts inside the arcing chamber  
  - Extremely high mean-time-to-failure (MTTF) values of the vacuum interrupters |
| **Saves money** |  
  - Use of maintenance-free vacuum circuit-breakers  
  - Thanks to the compact design of the switching module and the modular enclosure concept, the necessary space for installation is reduced to a minimum  
  - Factory-assembled and tested, thus reducing installation work and commissioning on site  
  - Significantly lower life-cycle costs due to reduced inspection and maintenance compared to other switching technologies  
  - HIGS as integral part of the generator-set provides cost saving due to reduction of: space requirements, connection points, installation |
| **Preserves the environment** |  
  - Long lifetime of the switchgear and all components (more than 20 years)  
  - As insulating medium, air is environmentally neutral  
  - Vacuum switching technology, no gas filling every few years  
  - No toxic decomposition products in case of switching arcs or internal arcs  
  - The materials used are fully recyclable without special knowledge |
| **Advantages of vacuum as switching medium** | 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 & IEEE were added to the portfolio, where particular emphasis must be placed on measures to withstand high thermal and mechanical stresses, including the following:  
  - Special contact material for minimum contact wear  
  - Specifically developed contact system  
  - Optimized design for efficient cooling  
  - Safe breaking operations by controlling long arcing times even in case of delayed current zeros  
  - Transient recovery voltages with high rates of rise, typical for generators, are controlled without additional capacitor circuits  
  - No pressure monitoring required |
Mechanical and electrical data

### Mechanical data of HIGS

<table>
<thead>
<tr>
<th>Width (spacing)</th>
<th>Dimensions (mm) up to 17.5 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard panel (incl. control panel)</td>
<td>4330&lt;br&gt;4705</td>
</tr>
<tr>
<td>Height (including adjustable feet)</td>
<td>2500&lt;br&gt;(2540-2580)&lt;br&gt;2800&lt;br&gt;(2840-2880)</td>
</tr>
<tr>
<td>Standard panel for indoor installation IP4</td>
<td>2595&lt;br&gt;(2635-2675)&lt;br&gt;2895&lt;br&gt;(2935-2975)</td>
</tr>
<tr>
<td>Standard panel for indoor installation IP42 AN</td>
<td>3062&lt;br&gt;(3102-3142)&lt;br&gt;3362&lt;br&gt;(3402-3442)</td>
</tr>
<tr>
<td>Standard panel for outdoor installation IP54</td>
<td>2720&lt;br&gt;(2760-2800)&lt;br&gt;3041&lt;br&gt;(3081-3121)</td>
</tr>
</tbody>
</table>

### Electrical data of HIGS

<table>
<thead>
<tr>
<th>Technical data</th>
<th>HIGS 2400</th>
<th>HIGS 3200</th>
<th>HIGS 3400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage acc. to IEC kV</td>
<td>12.0</td>
<td>17.5</td>
<td>17.5</td>
</tr>
<tr>
<td>Rated voltage acc. to IEEE kV</td>
<td></td>
<td></td>
<td>15.0</td>
</tr>
<tr>
<td>Rated frequency Hz</td>
<td>50/60</td>
<td>50/60</td>
<td>50/60</td>
</tr>
<tr>
<td>Rated power-frequency withstand voltage (ratings across isolating distance) kV</td>
<td>28&lt;br&gt;(32)</td>
<td>38&lt;br&gt;(45)</td>
<td>38&lt;br&gt;(45)</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage (ratings across isolating distance) kV</td>
<td>75&lt;br&gt;(85)</td>
<td>75&lt;br&gt;(85)</td>
<td>95&lt;br&gt;(110)</td>
</tr>
<tr>
<td>Rated short-time withstand current, max. Generator circuit kA</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Auxiliary circuit kA</td>
<td>50</td>
<td>50</td>
<td>63</td>
</tr>
<tr>
<td>Rated duration of short circuit, max. s</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Rated peak withstand current, max. Generator circuit kA</td>
<td>125</td>
<td>125</td>
<td>137</td>
</tr>
<tr>
<td>Auxiliary circuit kA</td>
<td>125</td>
<td>158</td>
<td>164</td>
</tr>
<tr>
<td>Rated normal current of generator circuit at 40°C A</td>
<td>2400&lt;br&gt;50Hz&lt;br&gt;60Hz</td>
<td>3200&lt;br&gt;3050</td>
<td>2400&lt;br&gt;50Hz&lt;br&gt;60Hz</td>
</tr>
<tr>
<td>Rated normal current of auxiliary circuit A</td>
<td>1000&lt;br&gt;50Hz&lt;br&gt;60Hz</td>
<td>1000&lt;br&gt;50Hz&lt;br&gt;60Hz</td>
<td></td>
</tr>
</tbody>
</table>

1) AN = Natural cooling
2) AF = Forced cooling

### Connection

The HIGS switchgear can be connected directly to the generator terminal as a replacement of the main terminal box (MTB). Due to its unique design HIGS is applicable for various types of generator with a power output of up to 75 MVA at IP54 respectively 91 MVA at IP42.

### Transport

The HIGS switchgear is delivered as one integral enclosure including control panel and neutral box. Please observe the following:
- Transport facilities on site
- Transport dimensions and transport weights.

### 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

<table>
<thead>
<tr>
<th>Panel widths</th>
<th>Transport dimensions (approx.)</th>
<th>Transport weight (approx.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>Depth</td>
<td>Height</td>
</tr>
<tr>
<td>mm</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td><strong>Transport of HIGS by rail and truck</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panel</td>
<td>4500</td>
<td>1200</td>
</tr>
<tr>
<td><strong>Transport of HIGS by seafreight, airfreight</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panel</td>
<td>4750</td>
<td>2000</td>
</tr>
</tbody>
</table>

3) Average values depending on the degree to which panels are equipped
**Technical data**

**Room planning**

### Outer dimensions of HIGS switchgear

<table>
<thead>
<tr>
<th>HIGS enclosure</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Width</strong></td>
<td>Approx. 4300 mm</td>
</tr>
<tr>
<td><strong>Depth</strong></td>
<td>1200 mm</td>
</tr>
<tr>
<td><strong>Height</strong></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.
Classification

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

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

<table>
<thead>
<tr>
<th>Loss of service continuity category and partition class</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Loss of service continuity category</strong></td>
</tr>
<tr>
<td><strong>Accessibility to compartments</strong></td>
</tr>
<tr>
<td>Compartment for starpoint treatment (neutral side)</td>
</tr>
<tr>
<td>Switching-device compartment</td>
</tr>
<tr>
<td>Connection compartment</td>
</tr>
</tbody>
</table>

Enclosure

HIGS consists of the generator connection compartment, the main transformer feeder and the auxiliary transformer feeder, as well as the separate control cabinet. These compartments are metal-enclosed. 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 is metallic and earthed. All doors at the operating side are bolted with hinges. Inspection windows and access holes for the emergency operating tools are provided for all switching devices to allow visual inspection of the switching position and manual operation with all covers closed. Pressure relief is provided as standard through pressure relief flaps at the top of the front doors.

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

The enclosure has the degrees of protection IP54 and IP42 for indoor installation, and for outdoor installation the degrees of protection IP54 or IP55 with a roof are also available.

The standard enclosure including all internal surfaces is epoxy powder-coated with color RAL 7035, optionally all other colors RAL.

This summary represents the current status of the HIGS type test documentation:

The switchgear opposite complies with the standards that are quoted in the particular test documents.

This summary may contain test documents that refer to switchgear with different technical ratings. These test documents are also valid for the object opposite.
Design
Features, interlocks

Features
- Direct connection to the generator terminal
- Customizable for every generator type
- All switching devices can be operated with all compartment doors closed, either electrically with control power or manually by emergency crank handle
- Inspection windows and access holes for the emergency operating tools are provided for all switching devices
- The auxiliary feeder compartment can be equipped with a vacuum circuit-breaker or fuse load-break switch available up to 125 A.

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 with all doors and covers closed.

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 access to the manual operation of the switching devices may be protected by means of padlocks. Operator safety is ensured since all operations are done with the doors closed. The position of the disconnector and earthing switches can be observed through inspection windows.

An optional interlocking system with electromagnetic keys for additional interlocking features can be provided. Interlocks to external components of the system can be considered in the interlocking concept (electrical or by means of key systems).

Fig. 10 Basic panel design
Type of connections

Connection to transformer can be done by means of cables or solid-insulated busbars. The connection to the power terminals can be either from bottom or top. The 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 8 single-core cables per phase with 1000 mm² which covers up to operating current of the HIGS. In case more cables are requested, a customized solution can be designed. Entry from bottom or top 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.

Generator connection terminal

The generator terminal flange at the rear side of the enclosure can be customized for any type of generator. Interconnection of the busbars to be made by flexible copper straps (not in our scope of supply).

Bus duct connection, solid-insulated busbars

Bus duct connections or solid-insulated busbars are available on request.

Fig. 11 Example of cable connection
Design
Operation, control panel, features

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 with (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, PROFIBUS, etc. can be provided on request in case of numerical control and protection devices)
• Key-operated interlocks available on request
• Automatic voltage regulator (AVR) can be installed as pre-assembled unit provided by the generator manufacturer.
Product range
HIGS switchgear

Option

Disconnector
Vacuum generator circuit-breaker
Current transformer
Earthing switch
Capacitive voltage detecting system
Surge capacitor
Earthing
Generator transformer
Surge arrester
Fuse
Short circuit link
Cable connection
Generator
Configuration possibilities
Example of customized switchgear
Components

Vacuum generator circuit-breaker 3AH38

Vacuum generator circuit-breaker 3AH38

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 3AH38 combines low resistance of the main circuit with high mechanical stability and ideal cooling performance.

Features of the 3AH38 vacuum generator circuit-breaker:
- Type-tested according to IEEE standard C37.013 and IEC 62271-37-013
- High DC components of 65 %, 75 % for 50 kA
- Maintenance-free for 10,000 operating cycles
- MTBF (mean-time-between failures) 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>
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<tbody>
<tr>
<td>Rated voltage</td>
</tr>
<tr>
<td>Rated frequency</td>
</tr>
<tr>
<td>Rated power-frequency withstand voltage</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage</td>
</tr>
<tr>
<td>Rated short-time withstand current, max.</td>
</tr>
<tr>
<td>Rated duration of short circuit, max.</td>
</tr>
<tr>
<td>Rated peak withstand current, max.</td>
</tr>
<tr>
<td>Rated normal operating current, max.</td>
</tr>
<tr>
<td>Asymmetrical breaking current</td>
</tr>
<tr>
<td>DC component</td>
</tr>
<tr>
<td>Rated operating sequence</td>
</tr>
<tr>
<td>Endurance classes</td>
</tr>
<tr>
<td>Auxiliary voltage</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Make time</td>
</tr>
<tr>
<td>Total break time</td>
</tr>
</tbody>
</table>
**Components**

**Disconnectors, fuse load-break switches and earthing switches**

Disconnectors are used to electrically isolate the switchgear or the associated equipment (e.g. generator, main transformer, etc.) from the network, in order to guarantee safe maintenance or repair work where it is required.

For each fixed-mounted vacuum circuit-breaker an associated disconnector is provided. Switching of the disconnectors must take place under no-load conditions.

Fuse load-break switches are used to protect and switch transformers < 1250 kVA.

Earthing switches are used to connect the switchgear’s busbar or the associated equipment (e.g. generator, main transformer, etc.) to earth, in order to guarantee safe maintenance or repair work where it is required.

Disconnectors, fuse load-break switches and earthing switches are designed in accordance with the requirements of EN 62271-102. A motor operating mechanism attachment enables actuation independent of the operator, with a switching angle of 90°.

One isolating blade is inserted into the impact contact per pole for the disconnector.

One earthing blade is inserted into the earth terminal per earthing pole for the earthing switch.

The switch positions OPEN or CLOSED are available as potential-free switch signals for each pole via an auxiliary switch and wired to the terminals in the control panel.

The operation can be done electrically (local and remote) or manually by means of a hand crank for operating the motor operating mechanism from outside the switchgear.

Mechanical class (in accordance with EN 62271-102) for the disconnector:
Class M1 = 2000 mechanical switching operations.

Mechanical class (in accordance with EN 62271-102) for the fuse load-break switch:
Class M1 = 2000 mechanical switching operations.

Mechanical class (in accordance with EN 62271-102) for the earthing switch:
Class M0 = 1000 mechanical switching operations.

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

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**Fig. 25** Earthing resistor 635 ohm from Telema

**Fig. 26** Disconnector

**Fig. 27** Earthing switch

**Fig. 28** Fuse load-break switch
Components
Surge arresters, surge capacitors, current transformers, voltage transformers

Surge arresters, surge capacitors
Vacuum generator circuit-breakers do not require additional surge 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 surge arresters can be provided on the generator side terminals, too.

Independently of the size of the generator or transformer, surge capacitors with capacitances up to 300 nF per phase may be considered appropriate to ensure safe limitation of the possible stresses by reducing the stress of the installed equipment 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 4000 A
- Max. rated short-time thermal current up to 50 kA, 3 s and 63 kA, 1 s
- Max. rated peak withstand current up to 137 res. 164 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 120 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
- Earthing resistor and transformer.
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)
- 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 above sea level 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 \( K_a \).

Altitude correction factor \( K_a \)

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

<table>
<thead>
<tr>
<th>Site altitude in m above sea level</th>
<th>( K_a )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000</td>
<td>1.00</td>
</tr>
<tr>
<td>1,500</td>
<td>1.10</td>
</tr>
<tr>
<td>2,000</td>
<td>1.20</td>
</tr>
<tr>
<td>2,500</td>
<td>1.30</td>
</tr>
<tr>
<td>3,000</td>
<td>1.40</td>
</tr>
<tr>
<td>3,500</td>
<td>1.50</td>
</tr>
<tr>
<td>4,000</td>
<td></td>
</tr>
</tbody>
</table>

Rated short-dur. power-freq. withstand volt. to be selected for site altitudes \( > 1000 \text{ m} \)

\[
\text{Rated short-duration power-frequency withstand voltage up to } \leq 1000 \text{ m } \cdot K_a
\]

Rated lightning impulse withstand voltage to be selected for site altitudes \( > 1000 \text{ m} \)

\[
\text{Rated lightning impulse withstand voltage up to } \leq 1000 \text{ m } \cdot K_a
\]

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 \( = 75 \text{ kV } \cdot 1.2 = 90 \text{ kV} \)

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.

Table – Dielectric strength

<table>
<thead>
<tr>
<th>Rated voltage (r.m.s. value) acc. to IEC 62271-1 kV</th>
<th>2400</th>
<th>2400</th>
<th>3200</th>
<th>3200</th>
<th>3400</th>
</tr>
</thead>
<tbody>
<tr>
<td>– Between phases and to earth</td>
<td>28</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td>38</td>
</tr>
<tr>
<td>– Across isolating distances</td>
<td>32</td>
<td>45</td>
<td>45</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage (peak value) kV</td>
<td>75</td>
<td>75</td>
<td>95</td>
<td>85</td>
<td>85</td>
</tr>
</tbody>
</table>
Standards
Standards, specifications, guidelines

Standards
The switchgear complies with the relevant standards and specifications. 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>
</tr>
</thead>
<tbody>
<tr>
<td>Switchgear</td>
</tr>
<tr>
<td>62271-1</td>
</tr>
<tr>
<td>62271-200</td>
</tr>
<tr>
<td>61936-1</td>
</tr>
<tr>
<td>Switching devices</td>
</tr>
<tr>
<td>Circuit-breakers</td>
</tr>
<tr>
<td>IEC 62271-100</td>
</tr>
<tr>
<td>IEEE C37.013</td>
</tr>
<tr>
<td>Earthing switches</td>
</tr>
<tr>
<td>62271-102</td>
</tr>
<tr>
<td>Voltage detecting systems</td>
</tr>
<tr>
<td>61243-5</td>
</tr>
<tr>
<td>Insulation</td>
</tr>
<tr>
<td>60071-1</td>
</tr>
<tr>
<td>Degree of protection</td>
</tr>
<tr>
<td>60529</td>
</tr>
<tr>
<td>Instrument transformers</td>
</tr>
<tr>
<td>Current transformers</td>
</tr>
<tr>
<td>61869-1</td>
</tr>
<tr>
<td>61869-2</td>
</tr>
<tr>
<td>Voltage transformers</td>
</tr>
<tr>
<td>61869-3</td>
</tr>
<tr>
<td>Installation, erection</td>
</tr>
<tr>
<td>61936-1</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: + 40 °C
  – Maximum: + 45 °C
The rated normal current of the HIGS panels and busbars depends on the ambient air temperature at site. The current carrying capacity is mainly influenced by means of the installation location (indoor or outdoor), the degree of protection and the optional forced ventilation.

Protection against solid foreign objects, electric shock and water
HIGS switchgear fulfills according to the standards
– IEC 62271-200
– IEC 60529
the following degrees of protection:

<table>
<thead>
<tr>
<th>Switchgear panel</th>
<th>HIGS</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></td>
<td>IP54</td>
</tr>
<tr>
<td></td>
<td>IP55</td>
</tr>
<tr>
<td>Degree of protection of the internal partitions</td>
<td>IP2X</td>
</tr>
</tbody>
</table>

Climate and environmental influences
HIGS 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: – 25 °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.

HIGS 17.5 kV switchgear is type-tested in accordance with the following internationally accepted requirements:
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 $S_n$, $U_n$, $x_a$, $x_d$, $x_d'$, $T_a$, $T_d'$
  – Transformer – including $S_n$, $U_n$, $u_k$
  – 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.

![Graph](image.png)

**Fig. 35** Example of short-circuit simulation to confirm the breaking capacity