Catalog
HB3 ·
2025

MEDIUM-VOLTAGE SWITCHGEAR

HB3

Generator Circuit-Breaker Switchgear

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Applications (Examples)
Heating and power station


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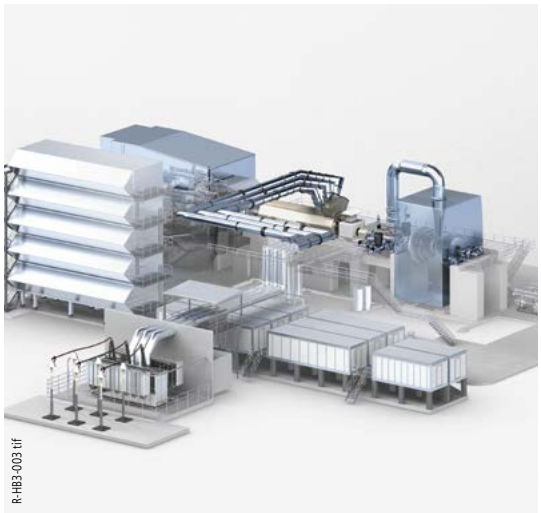
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HB3

Generator Circuit-Breaker Switchgear

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Contents

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
Overview

Fig. 1 Example of an HB3 switchgear

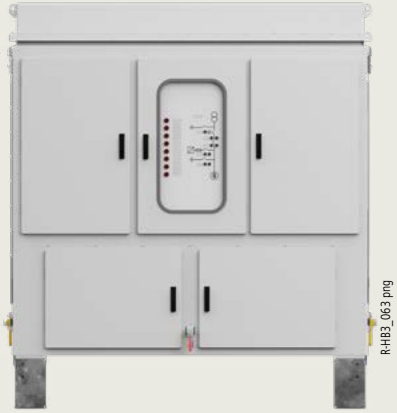


Fig. 2 Example of a control panel

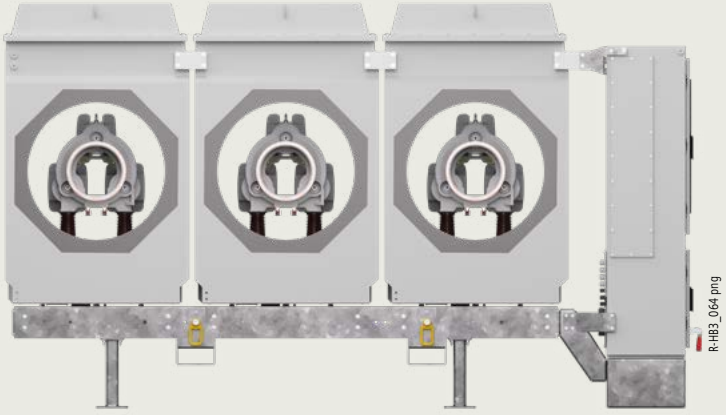


Fig. 3 Example of an HB3 switchgear

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

- Protection
- Security of supply
- Reliable synchronization
- Flexibility and selection
- Compatible to grid codes
- Increases the profitability by minimizing the downtimes
- Increases the earnings due to lower maintenance.

Some of the advantages of using HB3 generator circuit-breaker switchgear are:

Reliable synchronization and power plant optimization

- Optimizes the availability and security of the power plant
- One switching operation on the generator side of the Generator Step-Up Transformer (GSUT) only
- Half-sized generator configuration (2 generators feeding 1 GSUT)
- Pumped-storage: Fast switch-over between generator and motor operation.

Highest security of supply

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

Improved protection

- Quick interruption in case of generator-source faults to protect the GSUT and auxiliary transformer
- Quick interruption in case of system-source faults to protect the generator against fault propagation.

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 (without need of capacitors using generator circuit-breaker with vacuum technology)
- 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.

The rate-of-rise of recovery voltage (RRRV) values can be up to 10 times higher in the standard IEC/IEEE 62271-37-013 respectively IEEE C37.013 than in IEC 62271-100.

This is just a brief overview of the conditions that make a vacuum generator circuit-breaker application quite different from that of standard distribution applications.

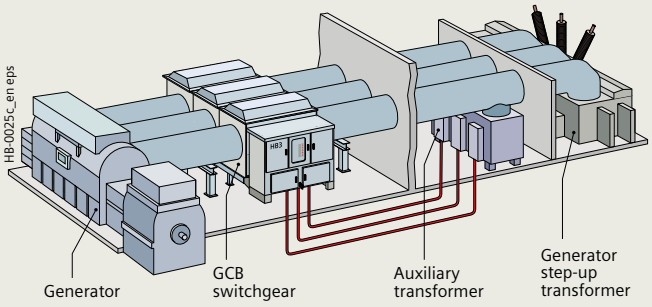


Fig. 4 Typical location of the GCB switchgear HB3 in the power plant

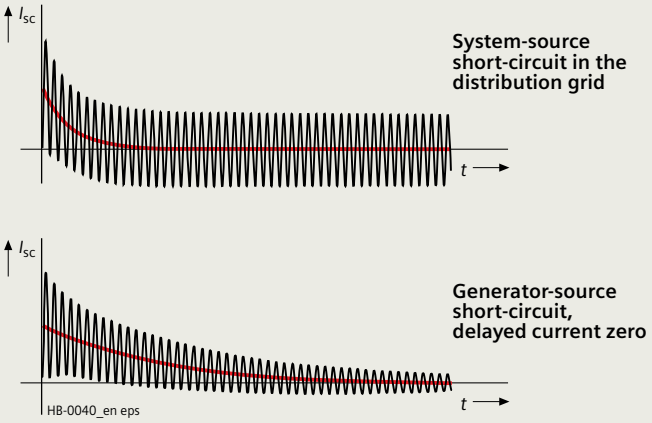


Fig. 5 Short-circuit current profiles

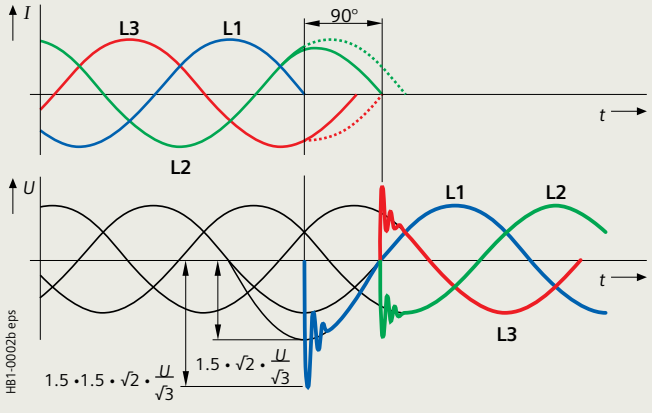


Fig. 6 Transient recovery voltage in generator applications

Application

Typical uses, classification

Typical uses

Siemens generator circuit-breaker switchgear type HB3 is a factory-assembled, single-phase encapsulated and air-insulated, metal-enclosed switchgear for indoor and outdoor installation, which is designed according to the standards IEC 62271-200 and IEC 61936-1. It serves for the connection of generators rated up to 24 kV and 13,500 A with the step-up transformer. The type tests of the HB3 and its components have been carried out according to the standards IEC 62271-1/-100/-102/-200 and IEEE C37.013 for vacuum generator circuit-breakers, as well as the dual code standard IEC/IEEE 62271-37-013.

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 HB3 generator circuit-breaker switchgear provides a compact system which can be configured to the individual needs of our clients.

For high-current interruption capabilities, our Siemens vacuum generator circuit-breaker module 3AH36 up to 110 kA is used for:

- Gas turbine generators
- Steam turbine generators
- Hydro turbine generators
- Synchronous condensers.

Classification

The HB3 generator circuit-breaker switchgear corresponds to the following loss of service continuity category.

LSC 1

Definition: Full shutdown required for access to any compartment of the switchgear (busbar, circuit-breaker, earthing switch, line disconnector in one common compartment)

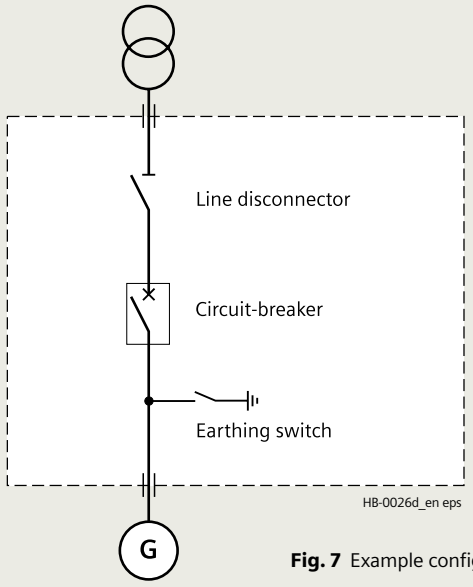


Fig. 7 Example configuration

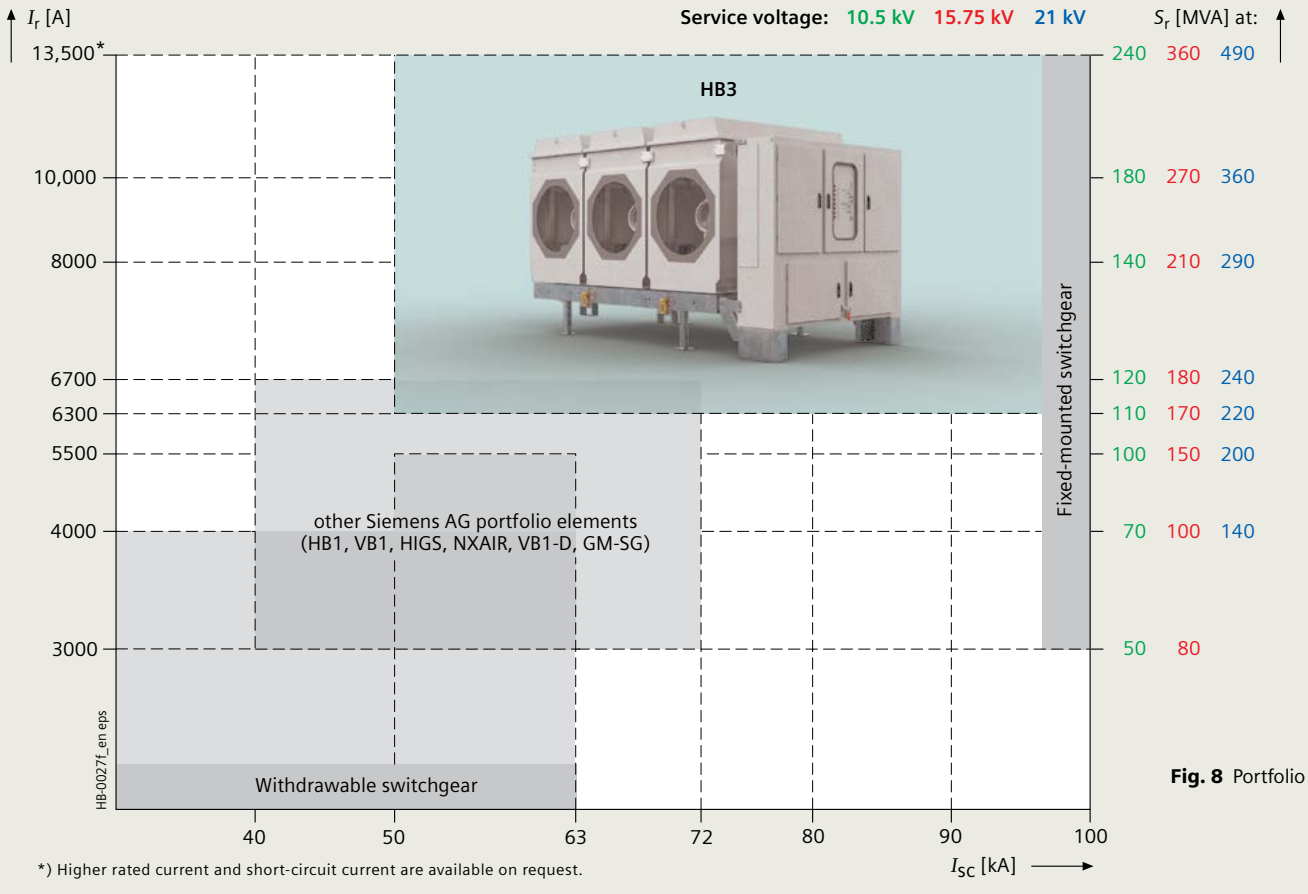


Fig. 8 Portfolio

Customer benefits

Design features

Based on years of experience and customer orientation as a pioneer in development of vacuum switching technology for reliable transmission and distribution of electric power in medium-voltage systems, Siemens gained the competence and developed solutions for the unique requirements and switching duties of generator circuits.

In order to meet the high demands of the emerging market for power generation units up to 450 MW, Siemens further optimized its portfolio of high-current and generator circuit-breaker switchgear with this product.

Customer benefits	Design features
Peace of mind	• No handling of gas products, and no low- or high-pressure monitoring required • More than 450,000 Siemens switchgear panels and systems with vacuum switching technology in operation worldwide • Use of maintenance-free vacuum circuit-breakers, equipped with sealed for life vacuum interrupters • Quality assurance in accordance with DIN EN ISO 9001 • Computer-aided calculation and simulation of short-circuit current and peak current in accordance with IEC 60909 • Dimensioning of enclosure and current path to withstand dynamic and thermal impact of rated and short-circuit currents • Verification of circuit-breaker interruption capabilities under consideration of delayed current zero • High reliability of vacuum circuit-breakers due to the low number of moving parts inside the vacuum interrupters (mean time to failure MTTF of 67,600 years)
Optimum safety	• Design and construction according to IEC 62271-1, IEC 62271-200, IEC 61936-1 and IEC/IEEE 62271-37-013 • All switching devices may be operated electrically from either the local control panel or from the remote end • In case of loss of auxiliary power, manual operation of the disconnector and earthing switches by means of emergency crank handles is possible via the central drive cabinets, and circuit-breaker spring charged open operation via emergency OFF lever, without the need of detaching the enclosure top covers • The position of the switching devices is visible through inspection windows • No explosion in the unlikely event of a fault in the vacuum interrupter of vacuum generator circuit-breaker module 3AH360 • Optionally a capacitive voltage indication system is available for generator and step-up transformer • Standard degree of protection IP65, optionally IP66
Easy to install	• The HB3 switchgear is supplied as a single unit which is “ready to install”. The phase enclosure, central drive cabinets and control panel are factory assembled, wired and tested as one unit, which is mounted on the support frame. On request, the individual enclosures and frame can also be detached for ease of transport, because all internal wiring between phase enclosure and control panel is already prepared by means of cable plug systems and ready-to-connect instrument transformer cables. This also allows installation of the control panel apart from the phase enclosures. For the installation, no gas work and measurement of contact stroke are necessary due to the characteristics of vacuum generator circuit-breakers. • Fast erection • Low dynamic forces of vacuum GCB allows lighter support structure • No on-site drive adjustment • Forklift installation

Customer benefits

Design features

Customer benefits	Design features
Increases productivity	• Up to 20,000 operation cycles • Maintenance-free for 10,000 operation cycles with rated current. Under normal operating conditions no re-lubrication or re-adjustment is required throughout the entire service life of 20 years • Up to 30 interruptions at 100% short-circuit current. Highest electrical durability • Monitoring of contact erosion over the entire lifecycle is not necessary due to the principles of vacuum switching technology. Vacuum interrupter is sealed for life • No major overhauls after 5 or 10 years • No rubber sealing parts within the vacuum interrupter which are subject to ageing – only welded connections • No gas decomposition of parts – dielectric quality is constant over the entire lifetime • No monitoring systems required
Saves money	• Use of maintenance-free vacuum circuit-breakers • No capacitors • Factory-assembled and tested, thus reducing installation and commissioning work • Significantly lower lifecycle costs due to reduced inspection and maintenance compared to other switching technologies • In the event of major repairs, the compact medium-voltage switching module can be easily lifted out of the enclosure by a hoist – for safe and easy accessibility • Due to the construction of the switchgear an easy replacement of the existing circuit-breaker and switchgear is possible
Preserves the environment	• Long lifetime of the switchgear and all components (more than 20 years) • Vacuum switching technology, no regular gas filling necessary every few years • Avoidance of SF_6 gas • The materials used are fully recyclable without special knowledge • Easy disposal, no toxic decomposition of products by the arc quenching medium
Experience	• Siemens was one of the first companies to introduce the vacuum switching technology into the market in the early 1970s, and since then continued to optimize the design and to extend the ratings. This technology was further perfected during the 1990s when circuit-breakers for generator applications conforming to the standards IEC and IEEE were added to the portfolio, where particular emphasis is placed on measures to withstand high thermal and mechanical stresses. Further changes include the following: • Special contact material for minimum contact wear • Specifically developed contact system with more than 19,000 installations • 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 • More than 3650 generator circuit-breaker switchgear installed • More than 19,000 VI with AMF design • Most reliable 3AH3 drive mechanism with more than 40,000 installations/year

Mechanical data of HB3			
Dimensions			
Width, including control panel, for standard pole-center distance of 1200 mm	mm	4422	
– Depth	mm	2294	
– Height, minimum/maximum	mm	2560/2810	
– Range of pole-center distance	mm	1200 – 1600	
– Height of connection terminal center line above ground, minimum/maximum	mm	1350 – 1500	
– Diameter IPB-system	mm	600 – 960	
Weight, approximately			
– 6300 A	kg	6200	
– 8000 A	kg	6200	
– 10,000 A	kg	6200	
– 13,500 A	kg	6600	
Degree of protection			
– Phase enclosure, control panel, central drive compartments		IP65	
– Optionally available		IP66	

Electrical data of HB3			
Current ratings			
Rated continuous current at 40 °C ambient temperatures at 50 Hz	A	13,500	
Rated continuous current at 40 °C ambient temperatures at 60 Hz	A	12,800	
17.5 kV rated voltage			
Rated frequency	Hz	50/60	
Rated power-frequency withstand voltage/across isolating distance	up to kV	50/60	
Rated lightning impulse withstand voltage/across isolating distance	up to kV	110/125	
24 kV rated voltage			
Rated frequency	Hz	50/60	
Rated power-frequency withstand voltage/across isolating distance	up to kV	60/70	
Rated lightning impulse withstand voltage/across isolating distance	up to kV	125/145	
Rated short-time and peak withstand currents			
Rated short-circuit breaking current	up to kA	110	
Rated short-circuit making current	up to kA	301	
Rated short-time withstand current/duration			
– Generator circuits	up to kA/s	130/3	
– Earthing circuits	kA/s	110/1	
Rated peak withstand current	up to kA	302	
Optional equipment			
Start-up disconnector			
– Rated voltage	kV	3.6 (standard)	7.2 (optional)
– Rated continuous current at 40 °C ambient temperature at 50/60 Hz	A	1800/1600	
– Start-up current at 40 °C ambient temperature	A/min	2500/50	
– Rated short-time (1 s)/peak current	kA	63/173	
Temporary short-circuiting devices			
– Manual short-circuiting device – 10,000 A/45 min at 50 Hz			
– Electrical short-circuiting device – 2200 A/45 min at 50 Hz			

Dimensions

Installation

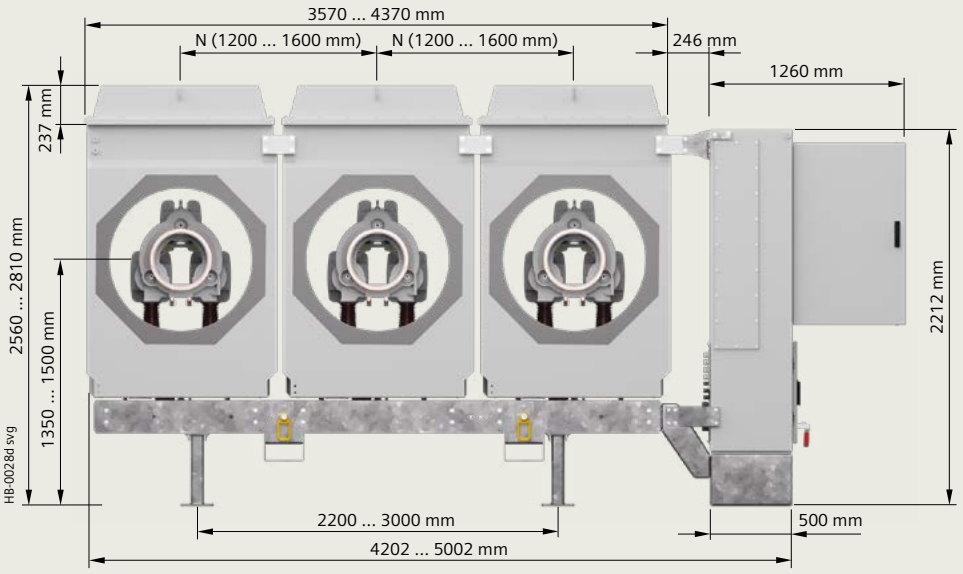


Fig. 9 Front view: Standard pole-center distance of 1200 mm, extendable up to 1600 mm

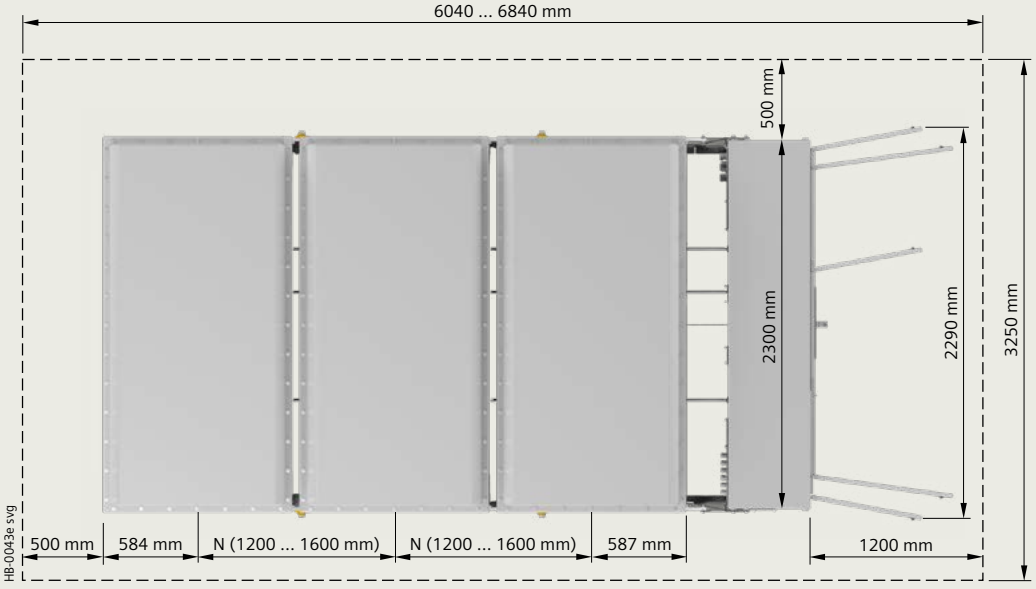


Fig. 10 Top view with dimensions for access to the control panel and front, rear and lateral side

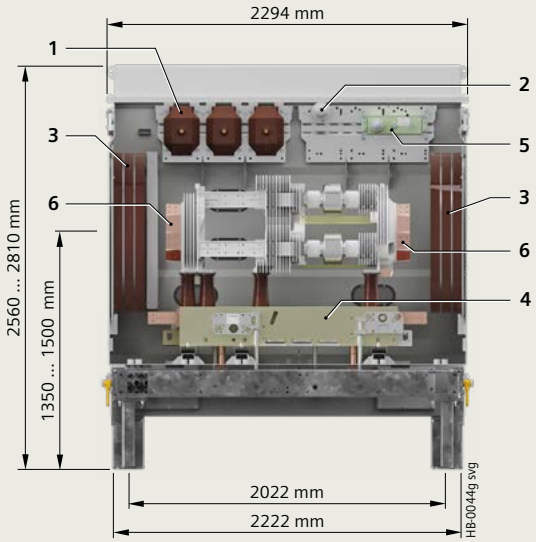


Fig. 11 Side view standard

Fig. 12 Side view

Legend:

1 Voltage transformers
2 Surge arresters
3 Current transformers
4 Switching module
5 Surge capacitors (option)
6 Terminal

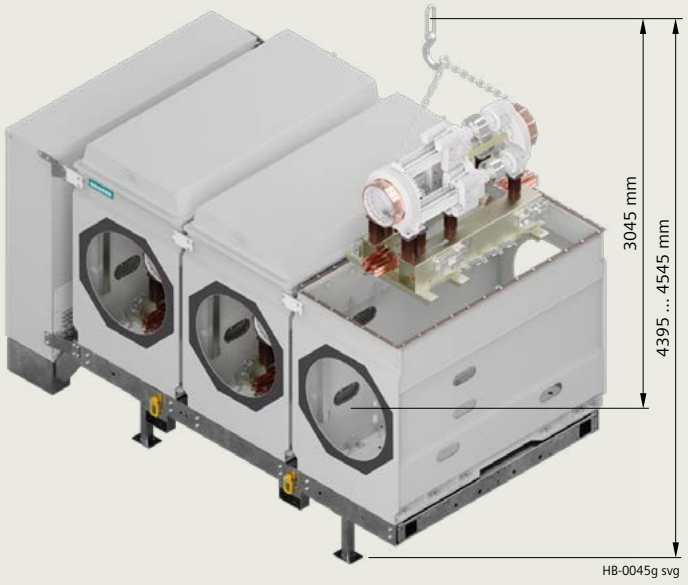


Fig. 13 Space requirements for removal of compact switching module from phase enclosure, clear height approx. 4500 mm from ground to crane hook

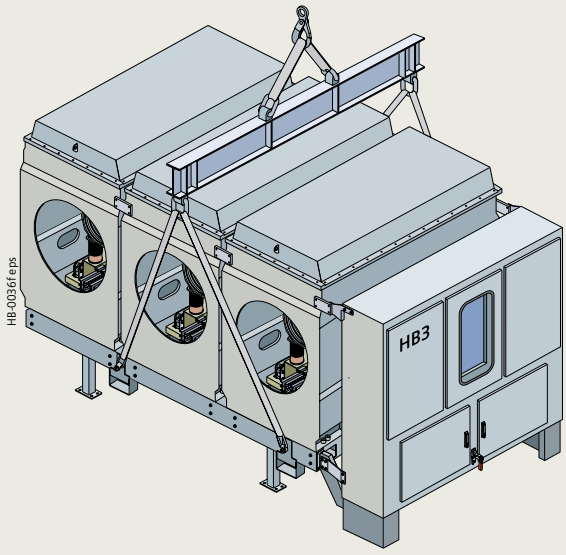


Fig. 14 Installation of HB3

Installation

Closed room

In case of installation in a closed room, there has to be a lockable barrier which ensures that only authorized persons have access.

Outdoor

In case of outdoor installation, there has to be a lockable barrier which ensures that only authorized persons have access. Direct sunlight has to be avoided by constructional measures. A weatherproof or sun protection roof is recommended.

The unpacked unit has to be delivered to its final place by means of a crane (min. 10,000 kg) and a suitable gantry. Optionally a traverse can also be supplied.

Installation area

The switchgear can be fixed to an even concrete floor, on concrete foundations or on a steel platform.

For details concerning the installation, a comprehensive installation & commissioning instruction manual is supplied with the switchgear.

Shipment, packing

Transport, packing, dimensions, weight

Transport

The HB3 switchgear is delivered as one factory-assembled transport unit.

Please observe the following:

- Transport facilities on site
- Transport dimensions and transport weights
- Size of door openings in building.

Packing

Means of transport: Truck

– Open packing with PE protective foil.

Means of transport: Ship

– In closed crates with sealed upper and lower PE protective foil
– With desiccant bags
– With sealed wooden base
– Max. storage time: 12 months
– Optional: shipping in container

Transport dimensions, transport weight

(reference HB3/10,000 A with pole-center distance 1200 mm and pole-center height 1500 mm)

Dimension unit	Transport dimensions (approx.)			Transport weight (approx.)	
	Width	Depth	Height	With packing	Without packing
mm	mm	mm	mm	(gross) kg	(net) kg
Transport of HB3 with truck					
4420 × 2300 × 2560	4600	2400	3000	7750	7500
Transport of HB3 with standard HC container					
4420 × 2300 × 2400	4800	2300	2500	7750	7500
Transport of HB3 with ship					
4420 × 2300 × 2560	4800	2700	3000	8950	7500

Fig. 15 Transport by fork lift

Enclosure for HB3

Factory-assembled, air-insulated, metal-enclosed switchgear, designed according to IEC 61936-1, IEC 62271-1 and type-tested according to IEC 62271-200 and dual code standard IEC / IEEE 62271-37-013.

The switchgear consists of three individual single-phase encapsulated aluminum enclosures mounted galvanically isolated on a common support frame. Inspection windows and access holes for emergency operation crank handles are provided for the disconnectors and earthing switches. Central drive mechanisms for centralized operation and locking of the three phases are provided for the line disconnector and earthing switches, each mounted in the central drive compartment inside the lower part of the control cabinet.

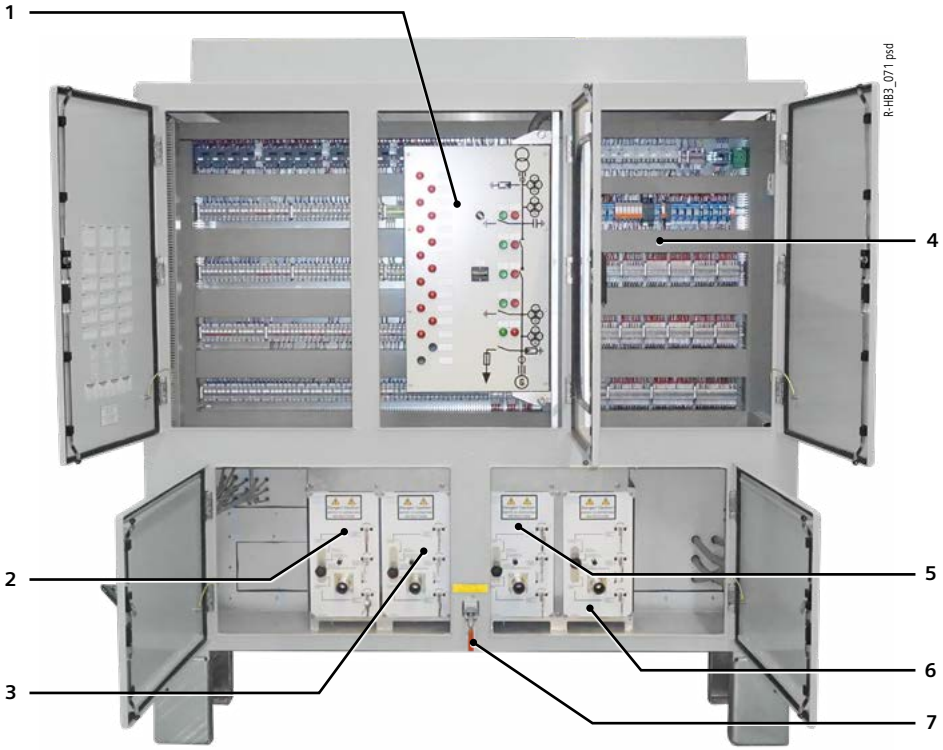
The enclosure has a degree of protection IP65 for indoor and outdoor installation, which can be optionally upgraded to IP66.

The degree of protection for the control panel is IP65, optionally IP66. The standard enclosure including all internal surfaces is painted with color RAL 7035, optionally all other colors RAL or MUNSELL. Internal supporting parts are manufactured using stainless steel, aluminum and galvanized steel without further surface coating. The aluminum enclosure is designed for inductively coupled reverse current in order of 100% of the rated current. The enclosure can continuously withstand an air pressure of 15 mbar (peak 20 mbar).

The earthing concept is available with earthing via IPB and earthing via busbar.

Optional connection to SFC

In case that the SFC must be incorporated in the switchgear design, cable connection compartments underneath the phase enclosures can be supplied with or without HRC fuses.



Legend:

1 Mimic diagram
2 Operating mechanism, earthing switch, generator side
3 Operating mechanism, start-up disconnector
4 Low-voltage devices and terminal boards
5 Operating mechanism disconnector
6 Operating mechanism earthing switch, transformer side
7 Manual emergency trip of circuit-breaker

Fig. 16 Interior view of the control panel for the HB3 generator circuit-breaker switchgear

Design

Interlocks, operating modes

Internal interlocks

All switching devices are equipped with motor-operated driving 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 this case. Access for manual operation of the switching devices may be prevented by means of padlocks.

Operator safety is ensured since all operations are carried out with the enclosure closed. The position of the line disconnector and earthing switches can be observed through inspection windows.
In the manual mode, optional interlocking systems can be provided to prevent unauthorized access into the opening for the crank handles.

Option 1 is an electrically operated key interlocking (via independent power supply). Option 2 are blocking solenoids, activated by a voltage detecting system (e.g. CAPDIS-S2+) or voltage transformers.

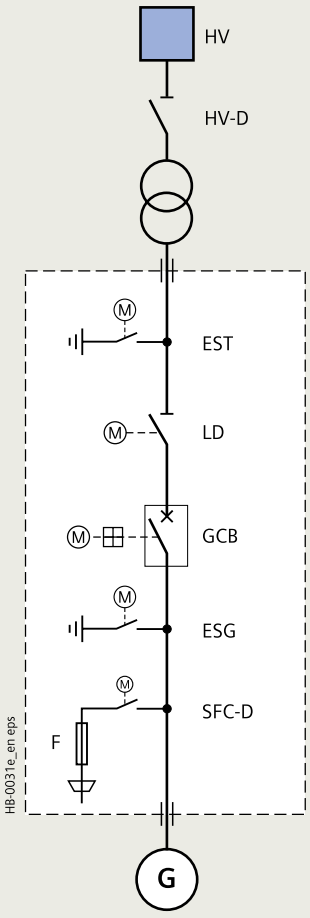


Fig. 17 Basic single-line diagram

Legend for single-line diagram and interlocking matrix:

ESG	Earthing switch, generator side
EST	Earthing switch, transformer side
F	HRC fuses
GCB	Generator circuit-breaker
HV	High voltage
HV-D	Disconnector on HV side of generator step-up transformer
LD	Line disconnector
SFC-D	Start-up disconnector to allow motor operation of the generator by feeding through a SFC static frequency converter (optional scope for gas turbines)
n.r.	Switching position is not relevant for this operation

Interlocking matrix

			Preconditions for HB3 internal switching devices					Preconditions for HB3 external switching devices	
Operating mode	**Switching device**	**operate to:**	**GCB**	**LD**	**ESG**	**EST**	**SFC-D** (optional)	**Generator**	**HV-D**
Test run	GCB	closed	–	open	open	open	open	off	open
Tripping/Switching off	GCB	open	–	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Normal service	GCB	closed	–	closed	open	open	open	on	closed
	LD	closed	open	–	open	open	n.r.	n.r.	n.r.
	LD	open	open	–	n.r.	n.r.	n.r.	n.r.	n.r.
	ESG	closed	open	open	–	n.r.	open	off	n.r.
	ESG	open	n.r.	n.r.	–	n.r.	open	n.r.	n.r.
	EST	closed	open	open	n.r.	–	n.r.	n.r.	open
	EST	open	n.r.	n.r.	n.r.	–	n.r.	n.r.	open
Start-up (optional)	SFC-D	closed	open	n.r.	open	n.r.	–	n.r.	n.r.
	SFC-D	open	open	n.r.	n.r.	n.r.	–	n.r.	n.r.

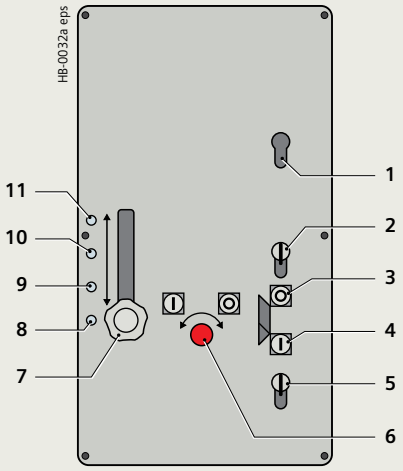


Fig. 18 Central drive control cabinet for disconnector, earthing switch, SFC feeder

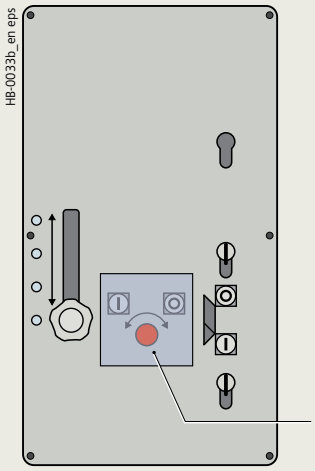


Fig. 19 Central drive control cabinet with additional interlocking

Legend:

1 Key-lock for locking in “Permanent closed“ position
2 Key-lock for locking in “Motor controlled“ position
3 Position indication “Switch closed“
4 Position indication “Switch open“
5 Key-lock for locking in “Permanent open“ position
6 Actuator opening for manual crank handle
7 Pre-selector lever for operating modes:
8 Permanent open pre-selector position
9 Motor controlled pre-selector position
10 Manual crank selector position
11 Permanent closed pre-selector position

Fig. 20 Central drive cabinets for earthing switches, disconnector and start-up disconnector

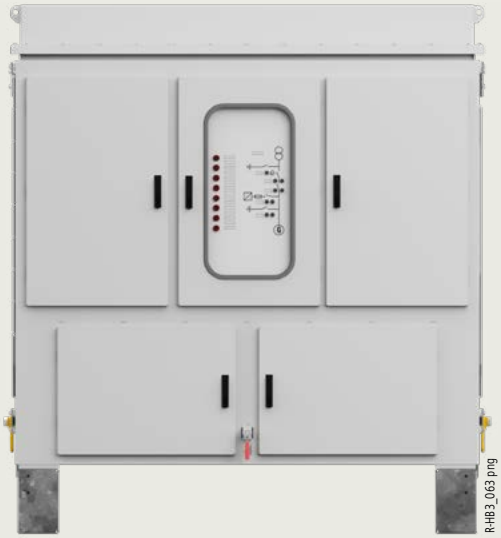


Fig. 21 Side view of HB3 with control panel and central drive cabinets with closed doors

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 the absence of auxiliary control voltage, crank handles are provided for manual operation of the switching devices.

The standard control panel is fixed-mounted to the enclosure. Included therein is the electrical control, control circuit protection, and electrical interlocking of the switching devices. Optionally, metering and overload protection relays / bay controllers can be integrated in the control panel.

The control panel may be provided as a separate unit on request, if local operation is required from another location.

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, 2.5 mm² for instrument transformers and power supply, 1.5 mm² for control and signaling, with ferrules. Colored wiring, wire end markings and other cable cross-sections are available on request
- Mimic diagram with illuminated pushbuttons for CLOSE/OPEN operation of switching devices and position indication
- Selector switch for LOCAL / REMOTE (optionally key-operated)
- Voltage detecting system CAPDIS-S1+ or CAPDIS-S2+ on request
- Terminals: Screw terminals for control, signaling and power supply circuits, disconnect terminals for voltage transformer circuits, short-circuit terminals for current transformers
- Auxiliary power: 110 V, 125 V, 220 V DC and 220 – 240 V AC, to be provided by the customer
- Standard interface for signals: Terminal strips within the control panel
- 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
- Numerical control with generator and transformer protection available on request.

Fig. 22 Pushbutton

Fig. 23 LED luminous indicators (optional)

Fig. 24 Illuminated pushbutton

Fig. 25 Standard position indicator

Fig. 26 Standard local / remote switch

Fig. 27 Key-operated local/ remote switch (optional)

Fig. 28 Voltage detecting systems CAPDIS-S1, -S2 (optional)

Fig. 29 7PA30 trip supervision relay (optional)

Fig. 30 Key-operated interlocks (optional)

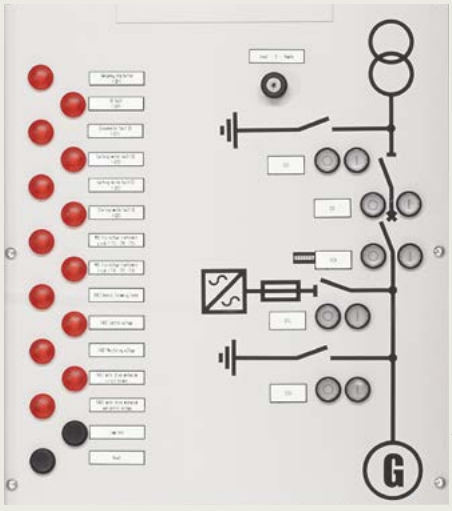


Fig. 31 Example of the mimic diagram

Connection

The connection to generator and transformer is implemented by Insulated Phase Busbars (IPB) on the front and rear side of the phase enclosures. The IPB-flanges are to be welded to the phase enclosures at the commissioning site. Connection of the IPB-conductors to the terminals inside the phase enclosures are implemented by means of bolted flexible copper straps.

All the connection parts are third-party equipment, and are not included in the scope of supply.

The diameter and pole-center distance of the IPB-systems which may be connected to the HB3 are listed in the table on page 9: Mechanical data of HB3.

Optionally a connection flange for installation of solid-insulated busbars (range up to 6000 A) is available.

All switching devices are fixed-mounted. The standard type of connection to generator and transformer are isolated phase busbars (IPB). The following busbar systems can be connected to the enclosure

- IPB at 17.5-24 kV / 10,000 A: Diameter 960 mm / pole-center distance ≥ 1200 mm
- IPB at 17.5-24 kV / 13,500 A: Diameter 960 mm / pole-center distance ≥ 1400 mm

Since the diameter of the enclosure opening is 870 mm, for smaller IPB-diameter an adapter flange has to be provided by the supplier of the IPB-system.

Optionally an adapter for the connection of solid-insulated busbars can be provided.

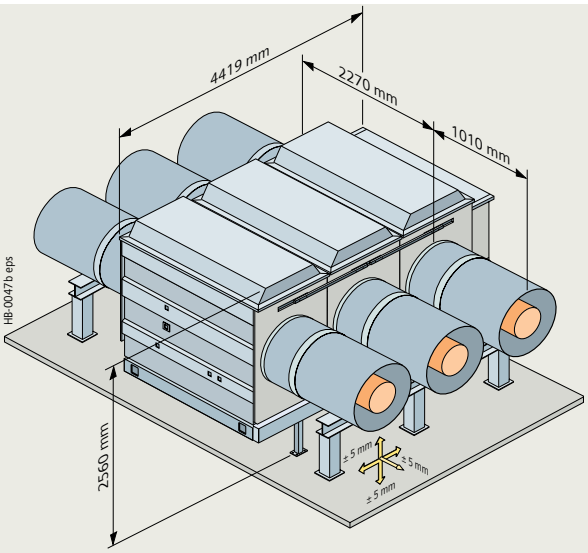


Fig. 32 Typical view of HB3 switchgear with connected IPB

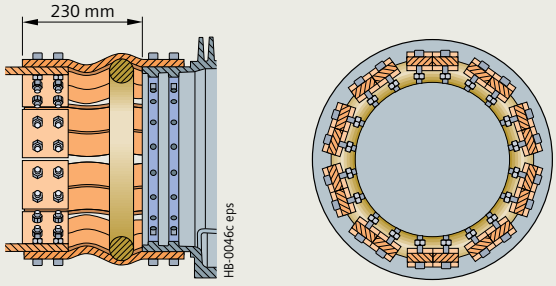


Fig. 33 Typical view of interconnection beween IPB and connection terminal

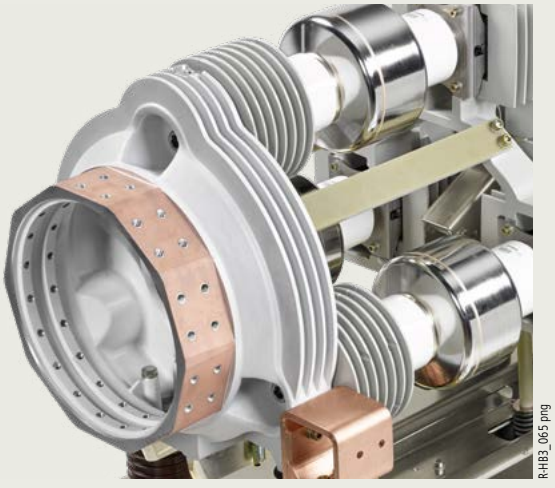


Fig. 34 Connection terminal for 13,500 A

Configuration possibilities

Selection guide

Disconnector

Vacuum generator circuit-breaker

Current transformer

Voltage transformer

Surge arrester

Earthing switch

Start-up disconnector

Start-up disconnector with HRC fuses

Short-circuiting device

Generator step-up transformer

Generator

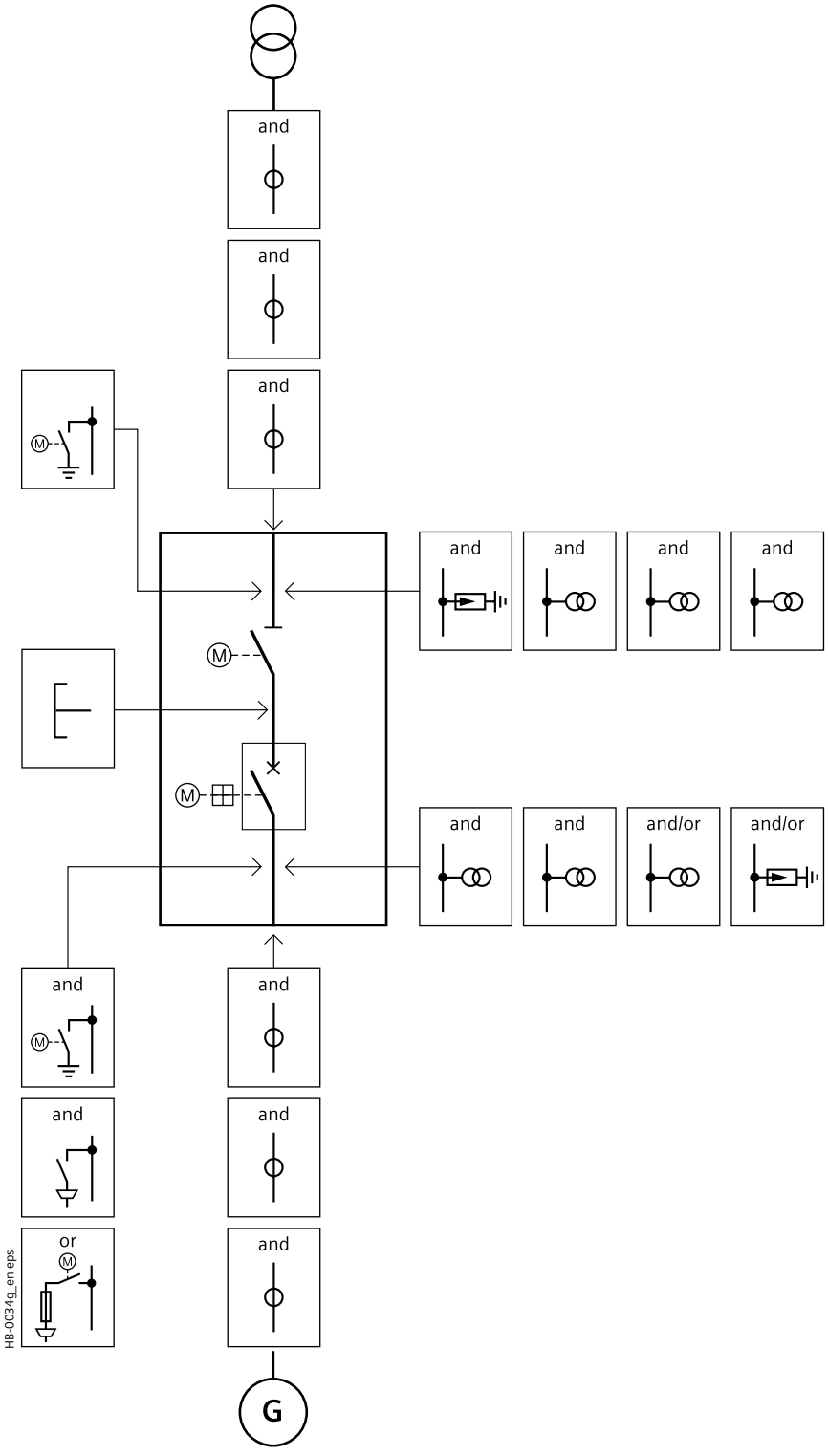


Fig. 35 Single-line diagram, configuration possibilities

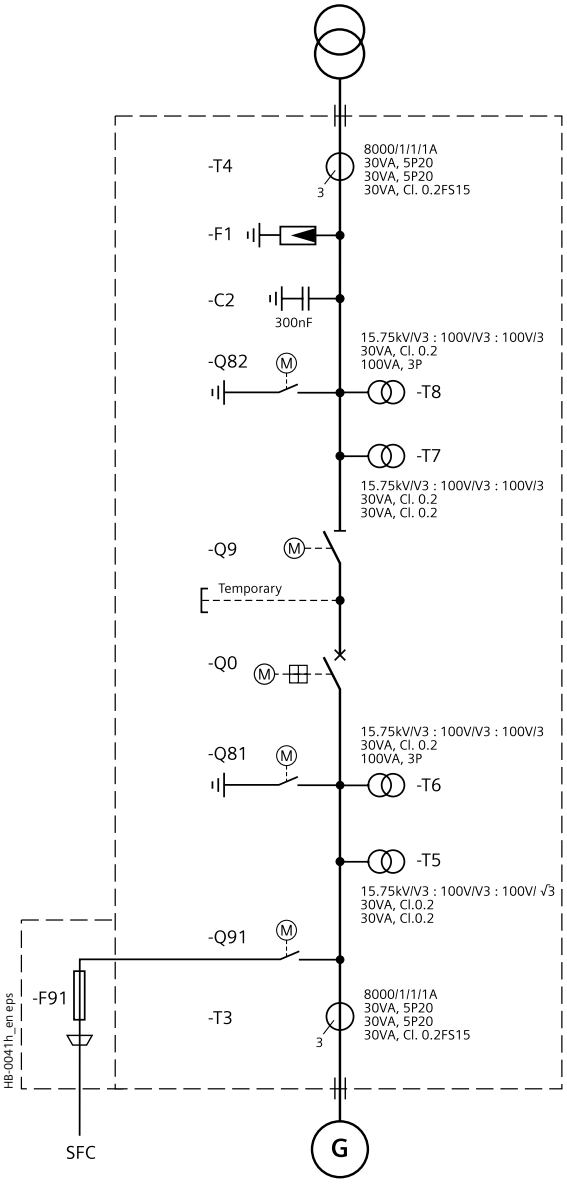


Fig. 36 Sample of a comprehensive solution

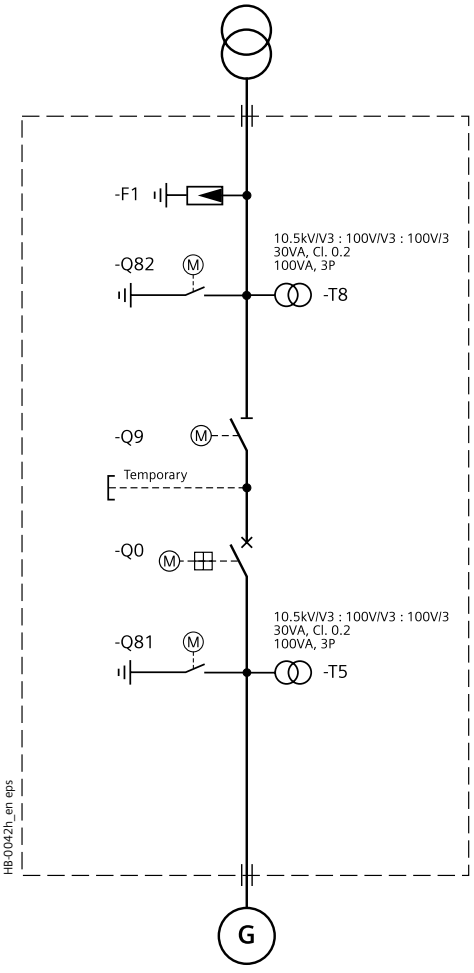


Fig. 37 Sample of a basic solution

Disconnector

Vacuum generator circuit-breaker

Current transformer

Voltage transformer

Surge arrester

Surge capacitor

Earthing switch

Start-up disconnector

Start-up disconnector with HRC fuses

Short-circuiting device

Generator step-up transformer

Generator

Components

Components of the integrated medium-voltage switching module

All the medium-voltage switching components including the vacuum generator circuit-breaker are mounted on a removable fully integrated compact switching module. All the components and the module assembly are specially designed and optimized for this application.

Vacuum generator circuit-breaker

Three vacuum interrupters are mounted in parallel to specially designed interrupter supports. The spring charging operating mechanism housing is mounted on the module frame. The switching movement is transferred by means of operating rods and levers.

Switching medium

The vacuum switching technology, proven and fully developed for more than 40 years, serves as arc-quenching medium within vacuum interrupters.

Pole assemblies

The pole assemblies consist of three vacuum interrupters per phase and the interrupter supports. The vacuum interrupters are air-insulated and freely accessible. This makes it possible to clean the insulating parts easily in adverse ambient conditions. The vacuum interrupter is mounted rigidly to the upper interrupter support. The lower part of the interrupter is guided in the lower interrupter support, allowing axial movement. The braces absorb the external forces resulting from switching operations and the contact pressure.

Operating mechanism housing

The whole operating mechanism with releases, auxiliary switches, indicators and actuating devices is accommodated in the operating mechanism housing. The extent of the secondary control and devices depends on the case of application and offers a multiple variety of options in order to meet almost every requirement.

Operating mechanism

The operating mechanism is a stored-energy mechanism. The closing spring is charged electrically. It latches tightly at the end of the charging process and serves as an energy store. The force is transmitted from the operating mechanism to the pole assemblies via operating rods.

To close the breaker, the closing spring can be unlatched electrically either by means of the local “ON” pushbutton or by remote control. The closing spring charges the opening and contact pressure springs as the breaker closes. The now discharged closing spring will be charged again automatically by the mechanism motor.

The complete operating sequence OPEN-CLOSE-OPEN is then stored in the springs. The charging state of the closing spring can be checked electrically by means of an indicator.

Trip-free mechanism

3AH36 vacuum generator circuit-breakers have a trip-free mechanism according to IEC 62271-100. In the event of an opening command being given after a closing operation has been initiated, the moving contacts return to the open position and remain there even if the closing command is sustained. This means that the contacts of the vacuum generator circuit-breakers are momentarily in the closed position, which is permissible according to IEC 62271-100.

Circuit-breaker tripping signal

The NO contact makes brief contact while the vacuum generator circuit-breaker is opening, and this is often used to operate a hazard-warning system which, however, is only allowed to respond to automatic tripping of the circuit-breaker. Therefore, the signal from the NO contact must be interrupted when the circuit-breaker is being opened intentionally. This is accomplished under local control with the cut-out switch that is connected in series with the NO contact.

Releases

A release is a solenoid device which transfers electrical commands from an external source, such as a control room, to the latching mechanism of the vacuum generator circuit-breaker so that it can be opened or closed. Apart from the closing solenoid, the maximum possible releases are one shunt and two other releases.

- The closing solenoid unlatches the charged closing spring of the vacuum generator circuit-breaker, closing it by electrical means. It is suitable for DC or AC voltage.
- Shunt releases are used for automatic tripping of vacuum generator circuit-breakers by suitable protection relays and for deliberate tripping by electrical means. They are intended for connection to an external power supply (DC or AC voltage) but, in special cases, may also be connected to a voltage transformer for manual operation.
- Current-transformer operated releases comprise a stored energy mechanism, an unlatching mechanism and an electromagnetic system. They are used when there is no external source of auxiliary power (e.g. a battery). Tripping is effected by means of a protection relay (e.g. overcurrent-time protection) acting on the current-transformer operated release. When the tripping current is exceeded (= 90% of the rated continuous current of the c.t.-operated release), the latch of the energy store, and thus opening of the circuit-breaker, is attained.
- Undervoltage releases comprise a stored-energy mechanism, an unlatching mechanism and an electromagnetic system which is permanently connected to the secondary or auxiliary voltage while the vacuum generator circuit-breaker is closed. If the voltage falls below a predetermined value, unlatching of the release is enabled and the circuit-breaker is opened via the stored-energy mechanism. The deliberate tripping of the undervoltage release generally takes place via an NC contact in the tripping circuit or via an NO contact by short-circuiting the magnet coil. With this type of tripping, the short-circuit current is limited by the built-in resistors. Undervoltage releases can also be connected to voltage transformers. When the operating voltage drops to impermissibly low levels, the circuit-breaker is tripped automatically. For delayed tripping, the undervoltage release can be combined with energy stores.

Closing

In the standard version, 3AH36 vacuum generator circuit-breakers can be remote closed electrically. Only manual electrical closing is available. In this version, the closing circuit of the circuit-breaker is controlled electrically by a pushbutton instead of the mechanical button. In this way, switchgear-related interlocks can also be considered for local operation in order to prevent involuntary closing.

If constant CLOSE and OPEN commands are present at the circuit-breaker at the same time, the circuit-breaker will return to the OPEN position after closing. It remains in this position until a new CLOSE command is given. In this manner, continuous closing and opening (= “pumping“) is prevented.

Vacuum generator circuit-breaker 3AH36

Electrical data of 3AH36 vacuum generator circuit-breaker		
Rated short-circuit breaking current I_{SC}	**kA**	**up to 110**
DC component of the rated short-circuit breaking current	%	60
Asymmetrical breaking current (system source)	kA	144
Rated short-circuit making current	kA	302
Generator short-circuit breaking current $I_{SC\ generator\ (symmetrical)}$	**kA**	**up to 110**
DC component of the short-circuit breaking current (Class G2)	%	130
Asymmetrical breaking current	kA	230
Rated voltages		
17.5 kV [1]		x
24 kV [2]		x
Rated operating sequence		
– at short-circuit breaking current		CO – 30 min – CO
– at continuous current		CO – 3 min – CO
– mechanical		CO – 1 min – CO
Operating times		
Rated opening time (no load)	ms	55 ± 5
Rated minimum opening time	ms	45
Rated closing time (no load)	ms	50 ± 5
Endurance		
Mechanical life endurance in number of operating cycles		20,000
Number of operating cycles at rated current		10,000
Electrical life at 100% fault current in number of operating cycles		up to 30

1) 50/60 Hz; U_p = 110 kV; U_d = 50 kV (IEC 62271, IEC/IEEE 62271-37-013)
2) 50/60 Hz; U_p = 125 kV; U_d = 60 kV (IEC 62271; IEC/IEEE 62271-37-013)

Fig. 38 View of 3AH36 vacuum generator circuit-breaker module

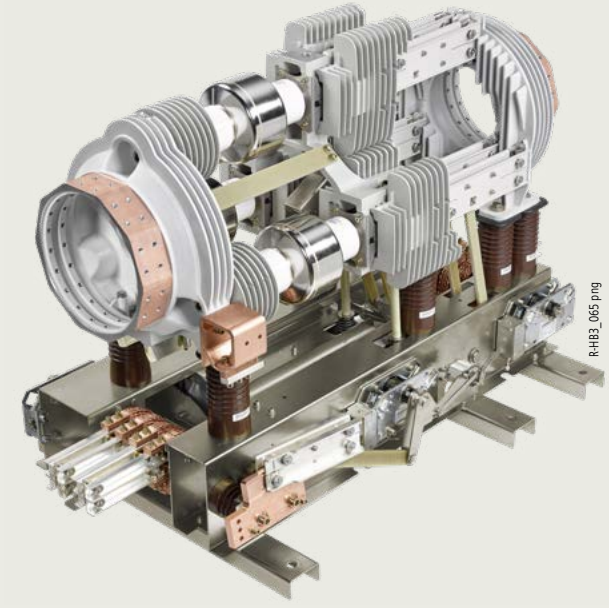


Fig. 39 View of 3AH36 module with integrated vacuum generator circuit-breaker

Components

Line disconnector, earthing switch

Line disconnector

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

A line disconnector is provided in order to isolate the generator from the grid, respectively the step-up transformer. Switching of the disconnectors must take place under no load conditions.

Line disconnector / IEC 62271-102	
Insulating medium	Air
Rated voltage	24 kV
Rated frequency	50 / 60 Hz
Rated lightning impulse withstand voltage / across isolating distance	125 kV / 145 kV
Rated power-frequency withstand voltage – 1 min / across isolating distance	60 kV / 70 kV
Rated continuous current at 40 °C, HB3 50 Hz	Current curves see Fig. 8 and 9, page 10
Rated continuous current at 40 °C, HB3 60 Hz	Current curves see Fig. 8 and 9, page 10
Rated short-time withstand current	up to 110 kA / 3 s
Operating mechanism	manual / motor
Position indication	mechanical / electrical
Electrical switching capacity	no load
Auxiliary switch	4 (max. 8) NC, NO
Rated auxiliary voltage	max. 250 V AC / 220 V DC
Mechanical endurance	20,000 operating cycles

Fig. 40 Line disconnector open

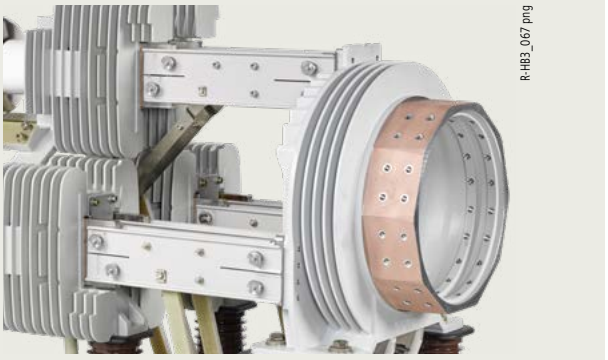


Fig. 41 Line disconnector closed

Earthing switch

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

The disconnectors and earthing switches are designed in accordance with the requirements of IEC 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 manually operated crank handles is possible.

Two contact blades per pole are inserted into the fixed contacts of the disconnector.

Four earthing blades per pole are inserted into the earthing contact of the earthing switch. In open state, the blades are in horizontal position. In closed state the device is earthed and the blades are in vertical position and rest on the contact surface.

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

Operation can be done electrically (local and remote) or manually by means of crank handles for operating the motor operating mechanism from the central drive control cabinet.

Mechanical endurance for the earthing switch:
5000 mechanical switching operations.

Electrical endurance class (in accordance with IEC 62271-102) for the disconnector earthing switch:
Class E0 = no load and no short-circuit making capacity.

Earthing switch / IEC 62271-102	
Insulating medium	Air
Rated voltage	24 kV
Rated frequency	50 / 60 Hz
Rated lightning impulse withstand voltage	125 kV
Rated power-frequency withstand voltage – 1 min	60 kV
Rated short-time withstand current	up to 110 kA / 1 s
Operating mechanism	manual / motor
Position indication	mechanical / electrical
Electrical switching capacity	no load
Auxiliary switch	4 (max. 8) NC, NO
Rated auxiliary voltage	max. 250 V AC / 220 V DC
Mechanical endurance	5000 operating cycles

Fig. 42 Earthing switch open

Start-up disconnector

In order to ramp-up the gas turbine it is required to speed up the generator in motor operation by means of a frequency converter. This SFC feeder is provided with a start-up disconnector which has to fulfill two requirement:

– Isolate the frequency converter during normal operation
– Carry the SFC load current during a short period < 40 minutes with a service voltage of approx. 2000 V.

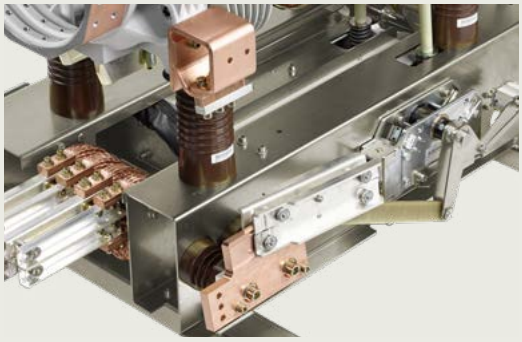


Fig. 43 Start-up disconnector in open position

Start-up disconnector / IEC 62271-102	
Insulation medium	Air
Rated frequency	50 / 60 Hz
Rated voltage	3.6 kV / 7.2 kV
Rated power-frequency withstand voltage	
– Closed position (starting mode)	10/20 kV
– Open position (normal operation)	70 kV
Rated lightning impulse withstand voltage	
– Closed position (starting mode)	40/60 kV
– Open position (normal operation)	145 kV
Rated continuous current at 40 °C ambient temperature	
– at 50 Hz	1600 A/1800 A
– at 60 Hz	1250 A/1600 A
Start-up current at 40°C ambient temperature / duration	2500 A, 40 min./50 min.
Rated short-time withstand current / duration	63 kA / 1 s
Rated peak withstand current	173 kA
Operating mechanism	manual / motor
Position indication	mechanical / electrical
Electric switching capacity	no load
Auxiliary switch	4 (max. 8) NC, NO
Rated auxiliary voltage	max. 250 V AC / 220 V DC
Mechanical endurance	5000 operating cycles

Fig. 44 Start-up disconnector (SFC) in closed position

Components

Surge arresters, capacitors, current 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 vacuum 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.

Surge arresters with line discharge class 1 to 4 are available (3.5 kJ / kV to 10 kJ / kV).

Independently of the size of the generator or transformer, surge capacitors with capacitances up to 130 nF per phase may be considered appropriate to ensure safe limitation of the possible stresses without having to verify this by detailed calculations.

Current transformers

Features:
- Cast-resin insulated
- Max. operating voltage up to 24 kV in conjunction with aluminum support construction
- Max. rated primary current up to 13,500 A
- Max. rated short-time thermal current up to 110 kA, 3 s
- Max. rated peak withstand current up to 302 kA
- 3 secondary cores, more possible depending on project data
- Large range of accuracy class combinations
- Secondary multiple possible
- Current transformer certifiable.

Fig. 45 Surge arrester type 3EK7

Fig. 46 Surge capacitor

Fig. 47 Surge arrester type 3EJ2

Fig. 48 Current transformers on aluminum support structure

Voltage transformers
Features:
– Fixed-mounted
– Cast-resin insulated, single-pole
– Primary operating voltage up to 24 kV
– Max. secondary operating voltage up to 100 V or divided by √3
– Large range of accuracy class combinations
– Rating up to 200 VA
– Earth-fault winding optional with damping resistor.

Fig. 49 Voltage transformer, fixed-mounted

Short-circuiting devices
For commissioning and measurement purposes it is possible to install a short-circuiting device between the vacuum generator circuit-breaker and the disconnector over all three phases.

There is a short-circuiting device available:
• Manual short-circuiting device – 10,000 A/45 min at 50 Hz
• Electrical short-circuiting device – 2200 A/45 min at 50 Hz

When using the short-circuiting devices it is necessary to open the top roof cover of all three phase enclosure housings to obtain access to the connection point on the circuit-breaker poles.

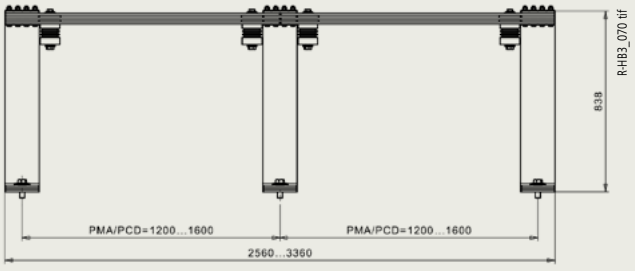


Fig. 50 Fixation of the short-circuiting devices on the vacuum generator circuit-breaker pole

Standards

Standards, specifications, verifications

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.

Applicable standards

Switchgear, enclosure	
IEC 61936-1	Power installations exceeding 1 kV AC – Part 1: Common rules
IEC 60071-1	Insulation co-ordination: Definitions, principles and rules
IEC 60071-2	Insulation co-ordination: Application guide
IEC 60529	Degree of protection provided by enclosures (IP-code)
IEC 62271-1	Common specifications for high-voltage switchgear and controlgear
IEC 62271-200	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)
IEC 62271-210	Seismic qualification for metal enclosed switchgear and controlgear assemblies for rated voltage above 1 kV and up to and including 52 kV

Devices	
IEC 61869-2	Instrument transformers Part 2: Additional requirements for current transformers
IEC 61869-3	Instrument transformers Part 3: Additional requirement for inductive voltage transformers
IEC 62271-100	High-voltage alternating-current circuit-breakers
IEC 62271-102	Alternating-current disconnectors and earthing switches
IEC 60099-4	Surge arresters: Metal-oxide surge arresters without gaps for AC systems
IEC 61243-5	Voltage detecting systems

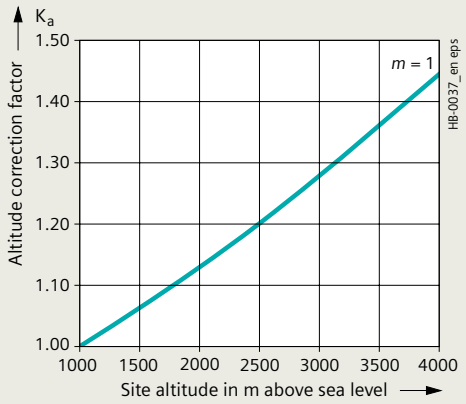
Vacuum generator circuit-breaker	
IEEE/IEC 62271-37-013	High-voltage switchgear and controlgear – Part 37-013: Alternating-current generator circuit-breakers

Current carrying capacity

- According to IEC 62271-1 and IEC/IEEE 62271-37-013, the rated continuous current refers to the following ambient air temperatures:
  - Maximum of 24-hour mean + 40 °C
  - Maximum + 45 °C
- The rated continuous current of the panels and busbars depends on the ambient air temperature outside the enclosure.

Altitude correction factor K_a

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



Rated short-duration power-frequency withstand voltage to be selected for site altitudes > 1000 m
≥ Rated short-duration power-frequency withstand voltage up to ≤ 1000 m · K_a

Rated lightning impulse withstand voltage to be selected for site altitudes > 1000 m
≥ Rated lightning impulse withstand voltage up to ≤ 1000 m · K_a

Example:
3000 m site altitude above sea level
17.5 kV switchgear rated voltage
110 kV rated lightning impulse withstand voltage
Rated lightning impulse withstand voltage to be selected =
110 kV · 1.28 = 141 kV
Result: According to the above table, a switchgear for a rated voltage of 24 kV with a rated lightning impulse withstand voltage of 125 kV is to be selected.

Type of service location

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

- 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 and IEC/IEEE 62271-37-013 (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)

Dielectric strength (contin.)
- 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
  - 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

Rated voltage (r.m.s. value)	kV	17.5	24
Rated short-duration power-frequency withstand voltage (r.m.s. value)			
– Between phases and to earth	kV	50	60
– Across isolating distances	kV	60	70
Rated lightning impulse withstand voltage (peak value)			
– Between phases and to earth	kV	110	125
– Across isolating distances	kV	125	145

Protection against solid foreign objects, electric shock and water

The following degrees of protection are fulfilled:

Switchgear panel	HB3
Degree of protection for the enclosure	IP65
– optionally	IP66
Degree of protection for the control cabinet	IP65
– optionally	IP20 (open)
	IP66

Climate and environmental influences

HB3 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: +45 °C,
  Average value over a period of 24 h: +40 °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: ≤ 80%
- Air pollution according to IEC 60815: I
- Air pollution according to IEC 60815 (optional): II, III, IV.

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 compliance

HB3 switchgear has been tested with additional reinforcement for seismic compliance up to the highest requirements specified in the standards IEC/TS 62271-210:

Test standards:
- IEC/TS 62271-210 Ed. 1 Part 210: Seismic qualification for metal enclosed switchgear and controlgear assemblies for rated voltages above 1 kV and up to and including 52 kV.
- IEEE 693 Recommended Practice for Seismic Design of Substations.

Test conducted:
- Severity level 2 (ZPA value of 10 [m/s²]). Acceptance Class 2 according to IEC/TS 62271-210 & IEEE 693
- Severity level 1 (ZPA value of 5 [m/s²]). Acceptance Class 2 according to IEC/TS 62271-210 & IEEE 693

Fig. 51 Certificate of seismic compliance

Fig. 52 HB3 switchgear during seismic testing

GCB application verification

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_{rG}, U_{rG}, x_d, $x_{d'}$, $x_{d''}$, T_a, $T_{d'}$, $T_{d''}$
  - Transformer – including S_{rT}, U_{rT}, u_k
  - Auxiliary transformer and motors, if applicable
- 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 fulfills all the service conditions, including tripping in case of a fault. The short-circuit calculation is carried out according to the standards IEC 60909 and IEC/IEEE 62271-37-013 respectively IEEE C37.013. This calculation provided by Siemens, serves as the manufacturer confirmation for the circuit-breaker suitability.

Among other things, the results of the calculations contain a graphical representation of the current characteristics, as shown below.

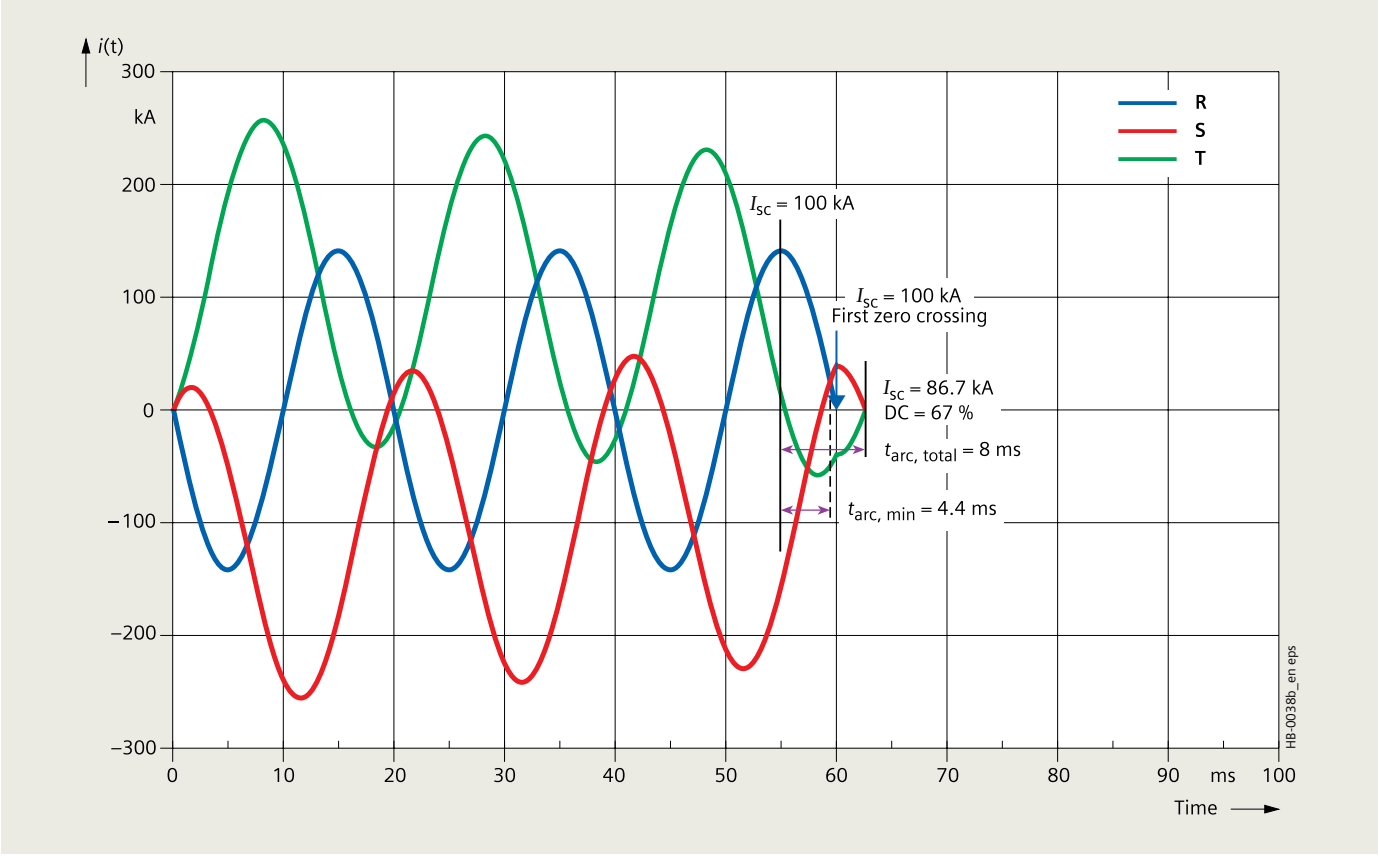


Fig. 53 Example of short-circuit simulation to confirm the breaking capacity

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We work together with customers and partners to create an ecosystem that both intuitively responds to the needs of people and helps customers achieve their business goals.

It helps our customers to thrive, communities to progress and supports sustainable development to protect our planet for the next generation.

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Medium-Voltage Switchgear

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