

SIEMENS



Catalog
HB3 ·
Edition 2017

HB3 Generator Circuit-Breaker Switchgear

Medium-Voltage Switchgear

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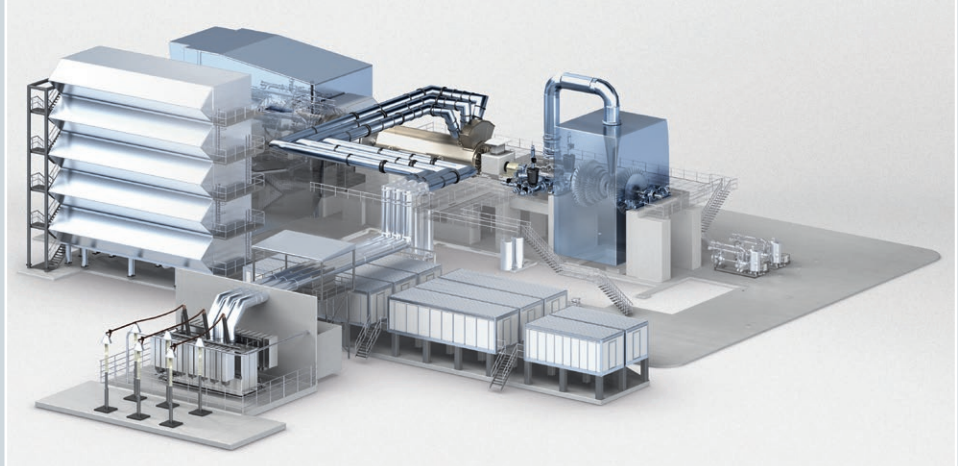
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The products and systems described in this catalog are manufactured and sold according to a certified management system (acc. to ISO 9001, ISO 14001 and BS OHSAS 18001).

Application

Overview



Fig. 1 Example of a HB3 switchgear



Fig. 2 Example of a control panel



Fig. 3 Example of a HB3 switchgear

Overview

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:

- Increases the profitability by minimizing the downtimes
- Increases the earnings due to lower maintenance
- Reduces high investment as a result of unexpected repairs
- Optimizes the availability and security of the power plant.

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

Reliable synchronization and power plant optimization

- One switching operation on the generator side of the Generator Step-Up Transformer (GSUT) only
- Half-sized generator configuration (2 generators feed 1 GSUT)
- 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 interruptions or maintenance.

Improved protection

- Quick interruption of the GSUT and auxiliary transformer in case of generator source faults
 - Quick interruption of the generator in case of 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 without need of capacitors
 - 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 vacuum generator circuit-breaker is a system X/R ratio of 50 (at 60 Hz), which results in a very slow decay of 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.

This phenomenon is referred to in the standard IEEE C37.013 as "delayed current zero's", and it is the basis design of the vacuum generator circuit-breaker, which must be verified by means of a calculation for the applicable generator network. Another aspect of a vacuum 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-

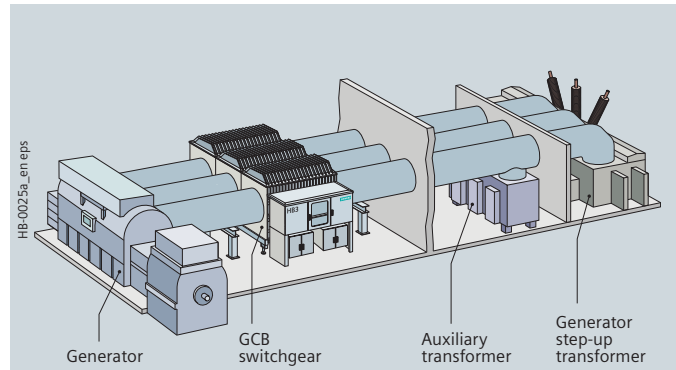


Fig. 4 Typical location of the GCB switchgear in the power plant

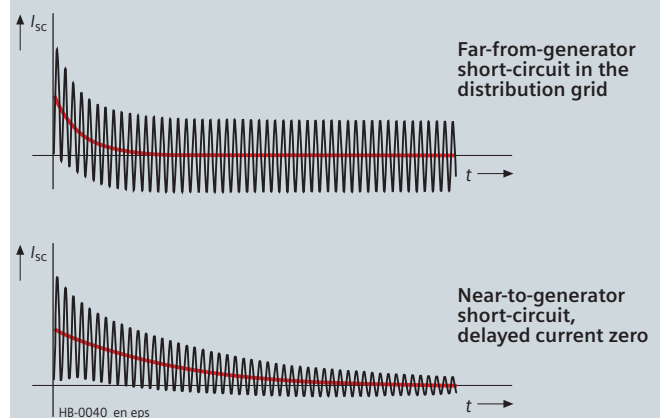


Fig. 5 Short-circuit current profiles

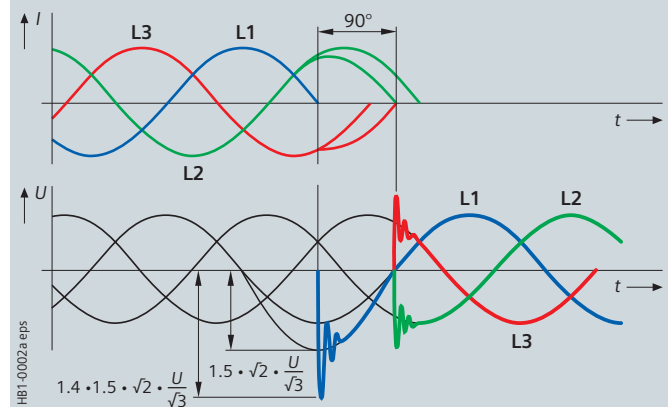


Fig. 6 Transient recovery voltage in generator applications

breaker.

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

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

Typical uses

Siemens generator circuit-breaker switchgear type HB3 is a factory-assembled, single-phase encapsulated, metal-enclosed switchgear for indoor and outdoor installation, which is designed according to the standards IEC 62271-1 and IEC 61936-1 (VDE 0101). It serves for the connection of generators up to rated voltage 24 kV, 12,500 A with the step-up transformer. The type tests of the HB3 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 IEEE/IEC 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 solution which can be configured to the individual needs of our clients.

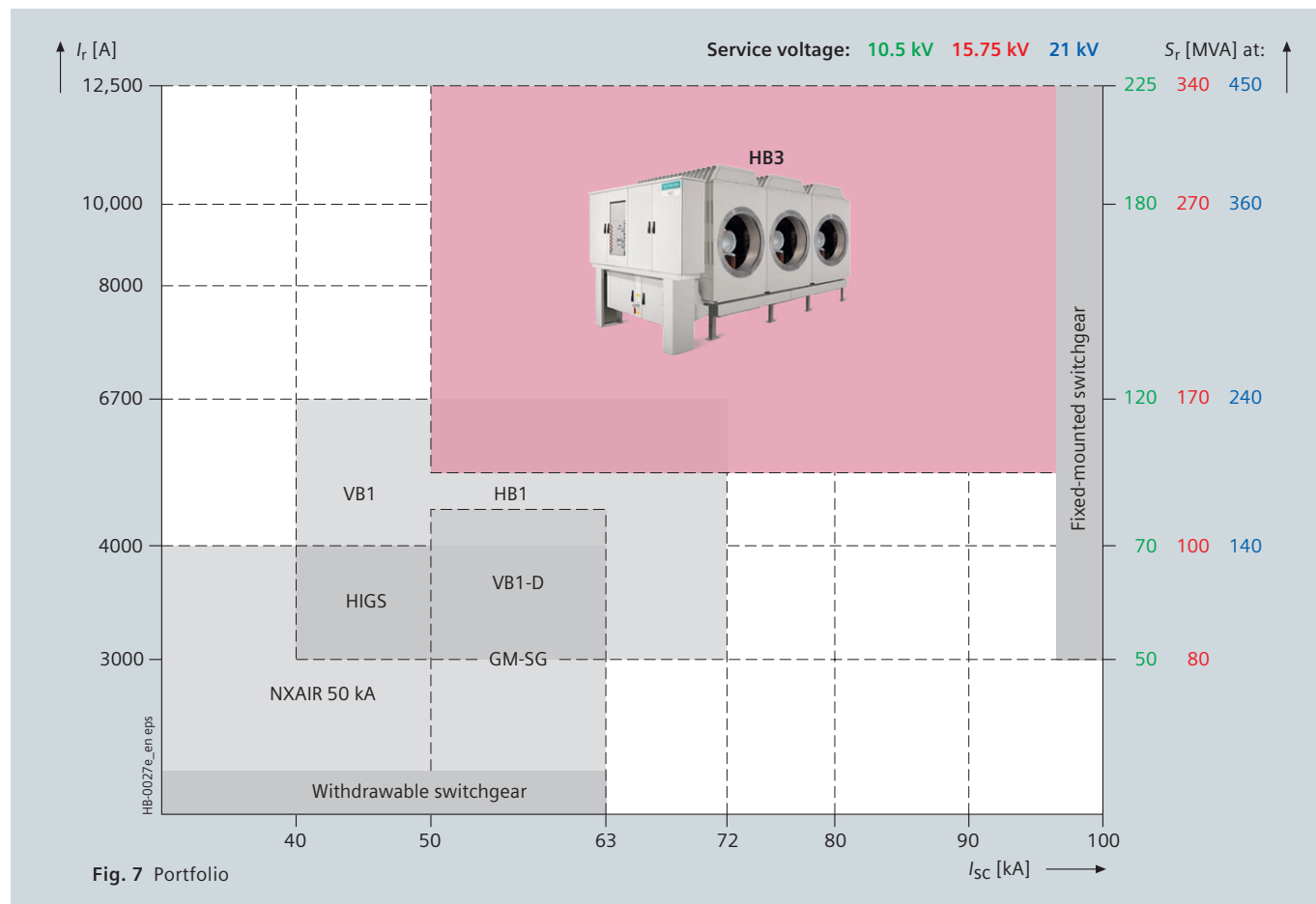
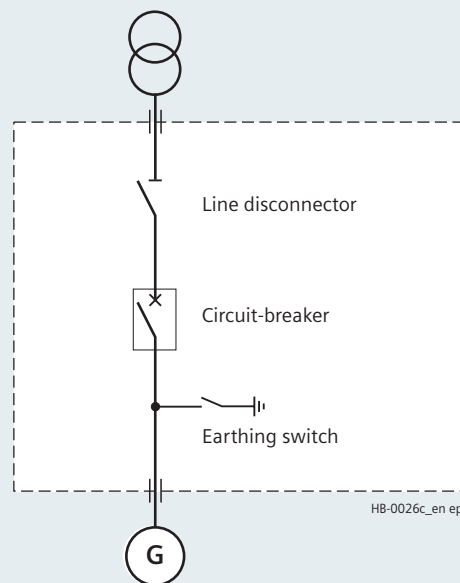
For high-current interruption capabilities, our Siemens vacuum generator circuit-breaker module 3AH36 up to 100 kA is used for:

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

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)





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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, Siemens gained the competence and developed solutions for the unique switching duties of generator circuits.

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

Customer benefits	Design features
<ul style="list-style-type: none"> • Peace of mind 	<ul style="list-style-type: none"> • No handling of switching gas, 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 • Quality assurance in accordance with DIN EN ISO 9001 • Computer-aided calculation and simulation of short-time withstand 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 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 53,550 years)
<ul style="list-style-type: none"> • Optimum safety 	<ul style="list-style-type: none"> • Design and construction according to IEC 62271-1 and IEC 61936-1 • 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 disconnectors 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 3AH36 • Switching devices are electrically interlocked • In the extremely unlikely case of a loss of vacuum, the non-quenching arc between the contacts is of comparatively low energy and will not cause any severe damages of the ceramic-metal housing • Optionally a capacitive voltage indication system is available for generator and step-up transformer • Standard degree of protection IP65, optionally IP66
<ul style="list-style-type: none"> • Easy to install 	<ul style="list-style-type: none"> • The HB3 is "ready to install" switchgear. The phase enclosures, central drive cabinets and control panel form one factory assembled, wired and tested unit, mounted on the support frame. However, 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 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.

Customer benefits

Design features

<ul style="list-style-type: none">• Increases productivity	<ul style="list-style-type: none">• 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• 30 interruptions at 100 % short-circuit current• 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 which are subject to ageing within the vacuum interrupter – only welded connections• No gas decomposition of parts – dielectric quality is constant over the entire lifetime• No monitoring systems required
<ul style="list-style-type: none">• Saves money	<ul style="list-style-type: none">• Use of maintenance-free vacuum circuit-breakers• As result of its compact design and a modular enclosure concept, the necessary space for installation is reduced to a minimum• Factory-assembled and tested, thus reducing installation and commissioning work• Significantly lower life-cycle costs due to reduced inspection and maintenance compared to other switching technologies• In the event of major repairs, the entire medium-voltage compact switching module can be easily lifted out of the enclosure by a hoist• Due to the construction of the switchgear an easy replacement of the existing circuit-breaker and switchgear is possible
<ul style="list-style-type: none">• Preserves the environment	<ul style="list-style-type: none">• Long lifetime of the switchgear and all components (more than 20 years)• Vacuum switching technology, no gas filling every few years• The materials used are fully recyclable without special knowledge• Easy disposal, no toxic decomposition of products by the arc quenching medium
<ul style="list-style-type: none">• Experience	<p>Siemens was one of the first companies to introduce the vacuum switching technology into the market in the early 1970's, and since then continued to optimize the design and to extend the ratings. This technology was further perfected during the 1990's 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:</p> <ul style="list-style-type: none">• 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

Mechanical data of HB3-80 and HB3-100

Dimensions		
Width, including control panel, for standard pole-center distance of 1200 mm	mm	4235
– Depth	mm	2294
– Height, minimum/maximum	mm	2478/2628
– 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
Phase enclosures with cooling fins	A	10,000/12,500
Phase enclosures without cooling fins	A	6300/8000
Weight, approximately		
– 6300 A	kg	6900
– 8000 A	kg	7200
– 10,000 A	kg	7500
– 12,500 A	kg	7500
Degree of protection		
– Phase enclosure, control panel, central drive compartments		IP65
– Optionally available		IP66 (≈ NEMA 4/4X)

Electrical data of HB3-80 and HB3-100

		HB3-80/6300 HB3-80/8000 HB3-80/10,000	HB3-100/8000 HB3-100/10,000 HB3-100/12,500
Current ratings			
Rated normal current at 40°C ambient temperatures at 50 Hz	A	6300/8000/10,000	8000/10,000/12,500
Rated normal current at 40°C ambient temperatures at 60 Hz		6300/8000/9700	8000/10,000/12,000
Operating current at various ambient temperatures *)		see Fig. 8	see Fig. 9
17.5 kV rated voltage			
Rated frequency	Hz	50/60	50/60
Rated power-frequency withstand voltage / across isolating distance	up to kV	50/60	50/60
Rated lightning impulse withstand voltage / across isolating distance	up to kV	110/125	110/125
24 kV rated voltage			
Rated frequency	Hz	50/60	50/60
Rated power-frequency withstand voltage / across isolating distance	up to kV	60/70	60/70
Rated lightning impulse withstand voltage / across isolating distance	up to kV	125/145	125/145
Short-time and peak current			
Rated short-circuit breaking current	kA	80	100
Rated short-circuit making current	kA	219	274
Rated short-time withstand current / duration			
– Generator circuit	kA/s	80/3	100/3
– Earthing circuits	kA/s	80/1	100/1
Rated peak withstand current	kA	219	274
Optional equipment			
Start-up disconnecter			
– Rated voltage	kV	7.2	7.2
– Rated normal current at 40°C ambient temperature at 50/60 Hz	A	1800/1600	1800/1600
– Start-up current at 40°C ambient temperature	A/min	2500/50	2500/50
– Rated short-time (1 s) / peak current	kA	63/173	63/173
Temporary short-circuiting devices			
– KSV 1, 5000 A/30 min and KSV 2, 10,000 A/30 min		KSV 2	KSV 2

*) The operating currents at various ambient temperatures are calculated in accordance with IEC 62271-1, clause 8.2 "Continuous or temporary overload due to changed service conditions". The calculations have been carried out under consideration of a conservative overload exponent $n = 2$. The current values are applicable for indoor installation without restrictions, however, for outdoor installation the values might be subject to review under consideration of solar radiation.

Technical data

Current characteristics, room planning

Current characteristics

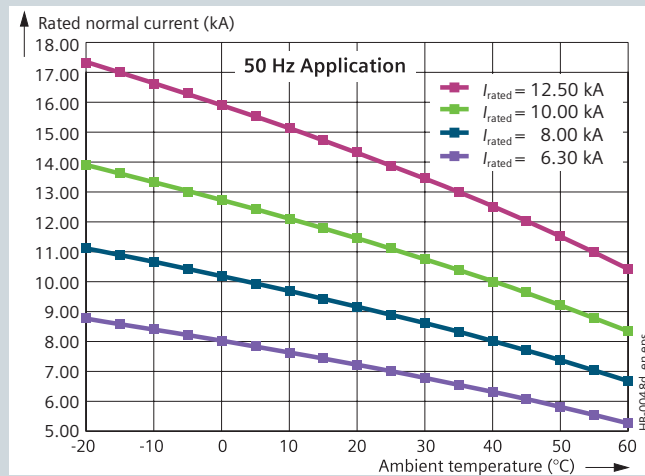


Fig. 8 Permissible operating current for various ambient temperatures HB3/6.30 kA, 8.00 kA, 10.00 kA, 12.50 kA for 50 Hz application

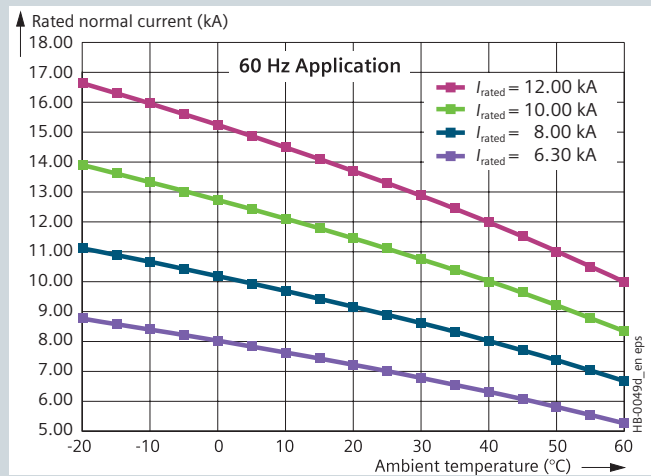


Fig. 9 Permissible operating current for various ambient temperatures HB3/6.30 kA, 8.00 kA, 10.00 kA, 12.00 kA for 60 Hz application

Room planning

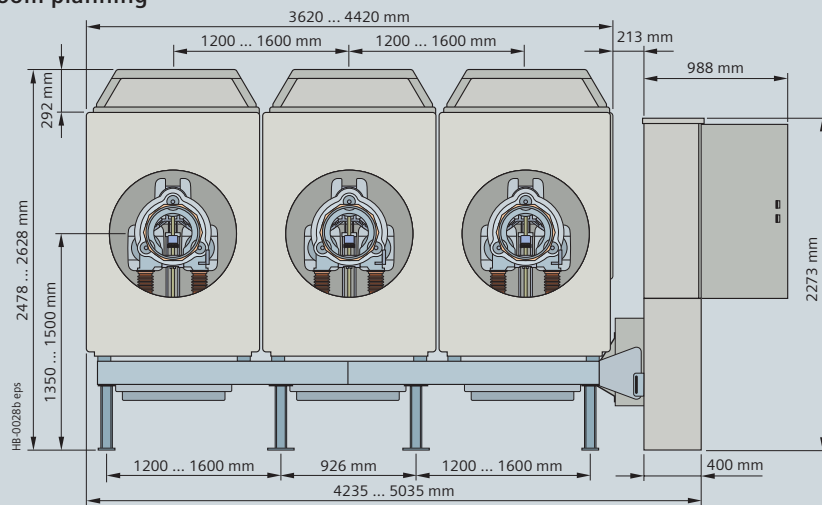


Fig. 10 Front view

Standard pole-center distance of 1200 mm, extendable up to 1600 mm.

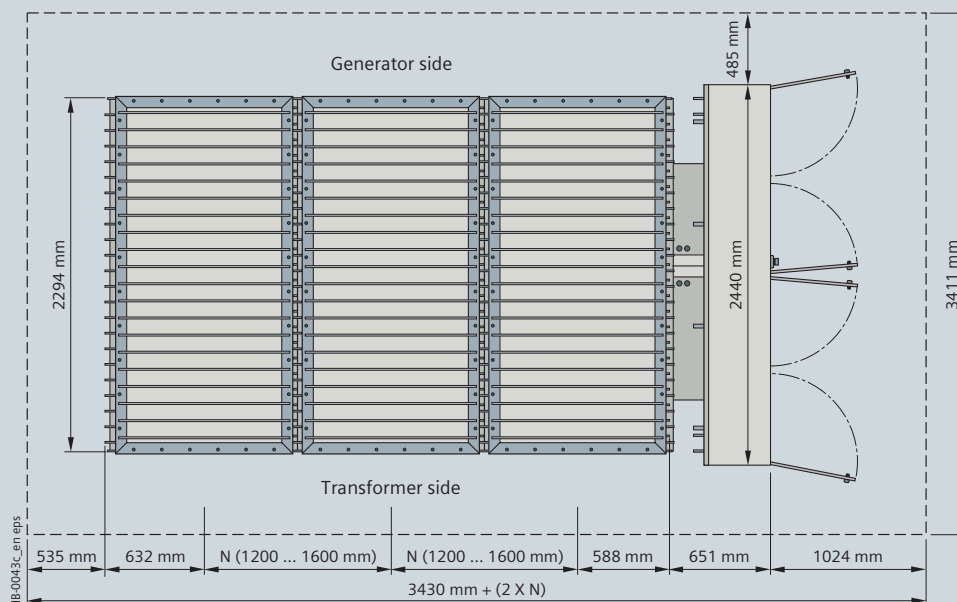


Fig. 11

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

Room planning

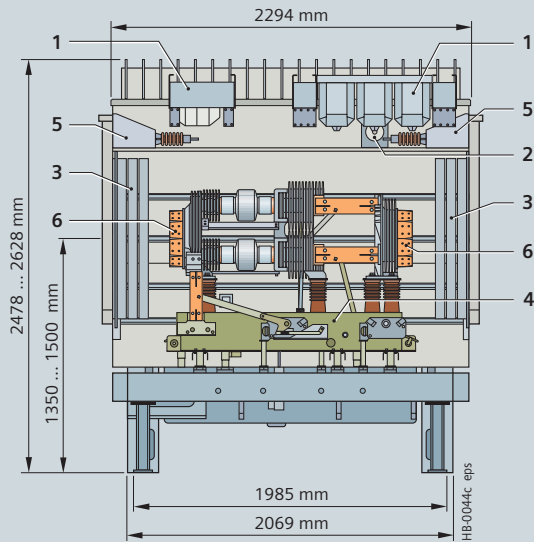


Fig. 12 Side view standard

Legend:

- 1 Voltage transformers
- 2 Surge arresters
- 3 Current transformers
- 4 Switching module
- 5 Surge capacitors
- 6 Terminal

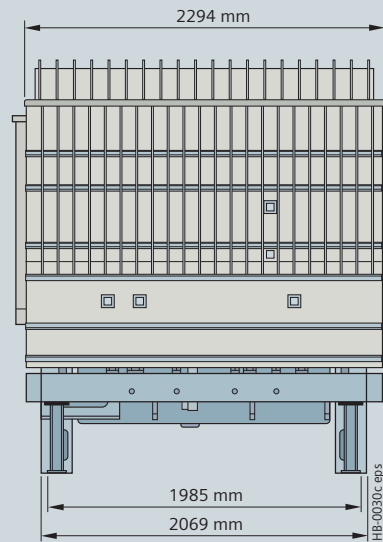


Fig. 13 Side view. Flexible copper connectors not in scope of delivery

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

Transport dimensions, transport weight

(reference HB3/10,000 A with pole centre distance 1200 mm)

Dimension unit	Transport dimensions (approx.)			Transport weight (approx.)	
	Width	Depth	Height	With packing (gross) kg	Without packing (net) kg
mm	mm	mm	mm		
Transport of HB3 with truck					
4130 × 2270 × 2478	4200	2400	3000	7750	7500
Transport of HB3 with ship					
4130 × 2270 × 2478	4500	2700	3000	8950	7500

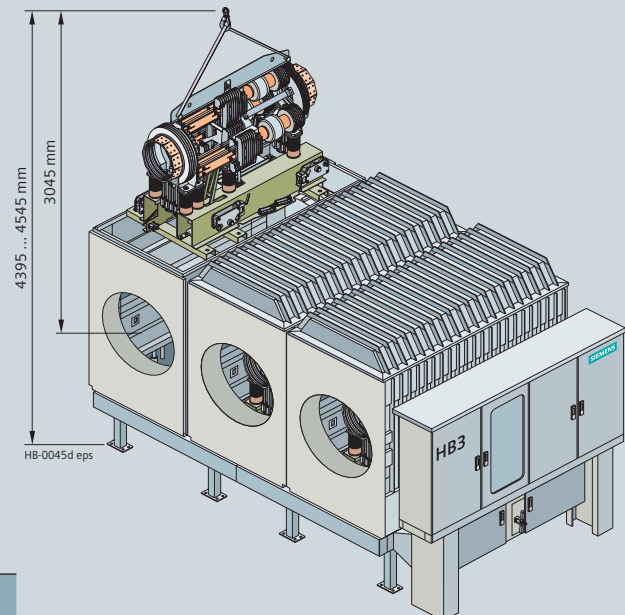
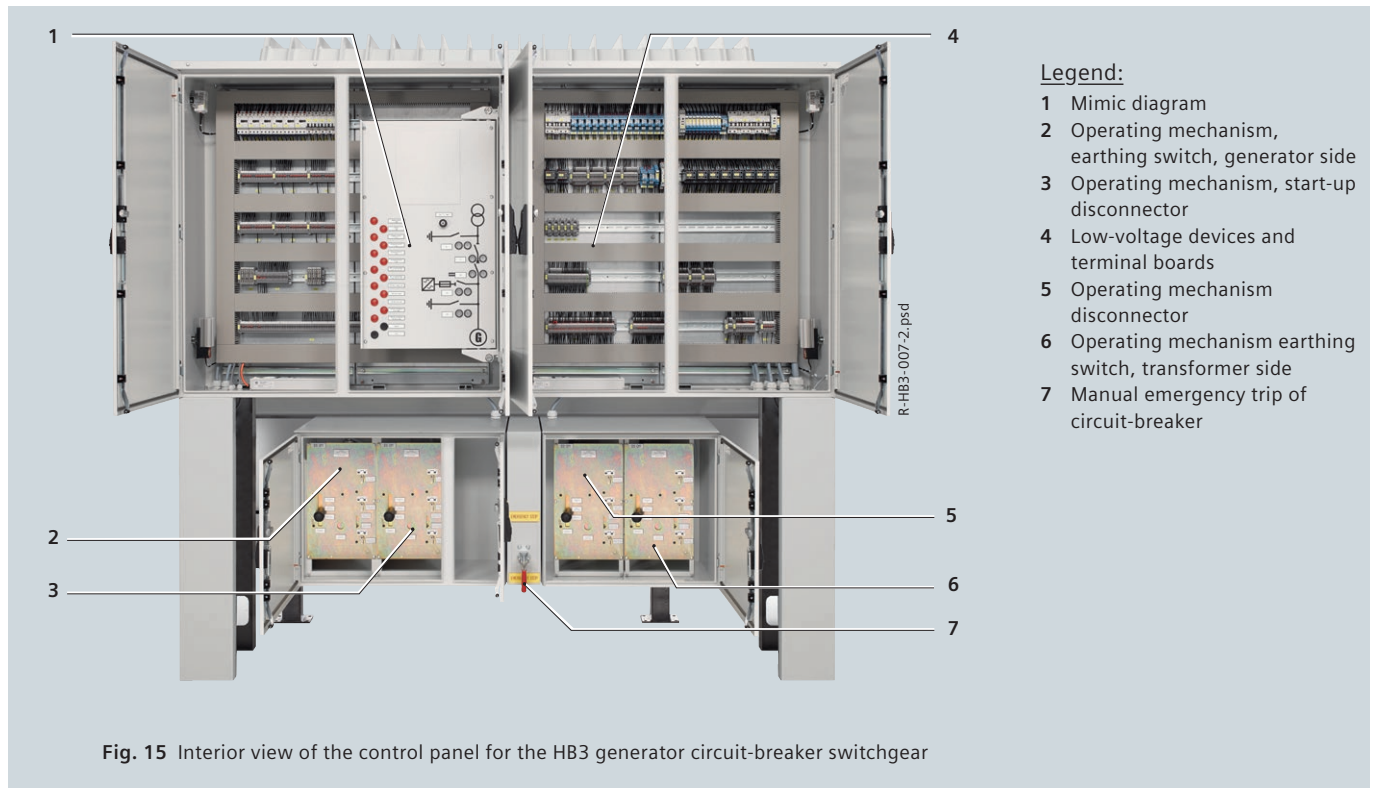


Fig. 14 Space requirements for removal of compact switching module from phase enclosure, clear height approx. 4500 mm from ground to crane hook



Enclosure for HB3

Factory-assembled, air-insulated, metal-enclosed switchgear, designed according to IEC 61936-1 (VDE 0101), IEC 62271-1 and type-tested according to IEC 62271-200 and dual code standard IEEE/IEC 62271-37-013.

The switchgear consists of three individual single-phase encapsulated aluminium 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 a central drive cabinet on the lateral side of the frame.

The enclosure has a degree of protection IP65 for indoor and outdoor installation (optionally 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 MUNSEL. Internal supporting parts are manufactured using stainless steel, aluminium and sendzimir-galvanized steel without further surface coating. The aluminium 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

20 hPa.

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 kV/6300 A: Diameter 600 mm / pole-center distance ≥ 1200 mm
- IPB at 24 kV/6300 A: Diameter 800 mm / pole-center distance ≥ 1200 mm
- IPB at 17.5-24 kV/8000 A: Diameter 800 mm / pole-center distance ≥ 1200 mm
- IPB at 17.5-24 kV/10,000 A: Diameter 960 mm / pole-center distance ≥ 1200 mm
- IPB at 17.5-24 kV/12,500 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.

Optional connection to SFC

In the 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.

Internal interlocks

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

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

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	Disconnecter on HV side of generator step-up transformer
LD	Line Disconnecter
SFC-D	Start-up Disconnecter 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 <u>not relevant</u> for this operation

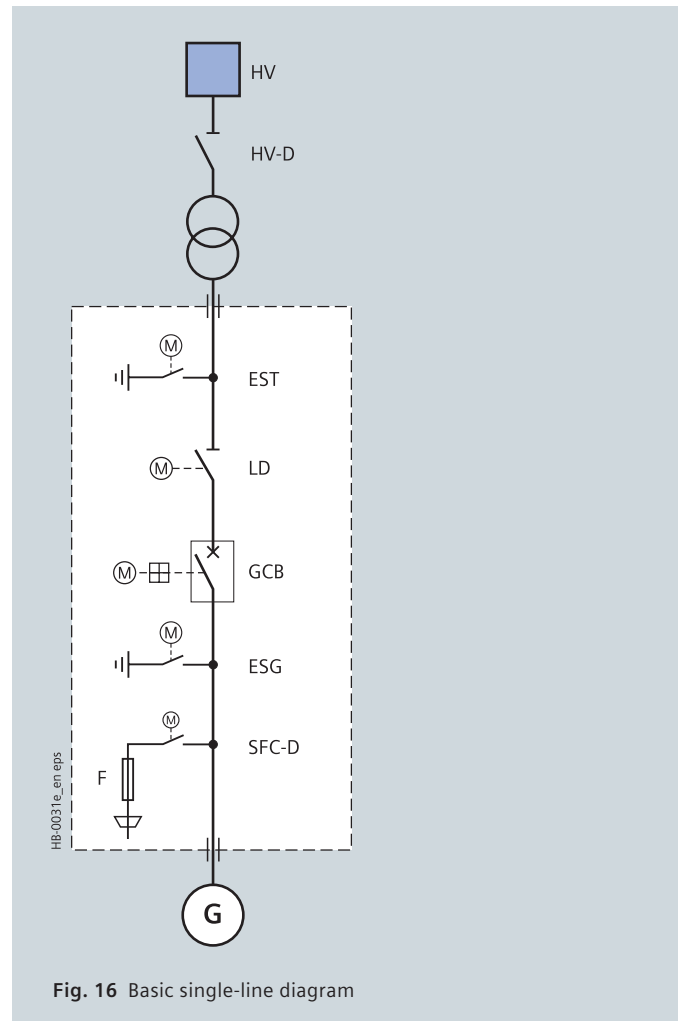


Fig. 16 Basic single-line diagram

Interlocking matrix

Operating mode		Test run	Tripping / Switching off	Normal service						Start-up (optional)		
Switching device		GCB	GCB	GCB	LD	LD	ESG	ESG	EST	EST	SFC-D	SFC-D
shall be selected to the position to:		closed	open	closed	closed	open	closed	open	closed	open	closed	open
The following preconditions for HB3 internal switching devices must be fulfilled:	GCB				open	open	open	open	open	open	open	open
	LD	open	n.r.	closed			open	open	open	open	open	n.r.
	ESG	open	n.r.	open	open	n.r.			n.r.	n.r.	open	n.r.
	EST	open	n.r.	open	open	n.r.	n.r.	open			n.r.	n.r.
	SFC-D (optional)	open	n.r.	open	open	n.r.	open	open	n.r.	n.r.		
The following preconditions for HB3 external switching devices must be fulfilled:	Generator	open	n.r.	closed	n.r.	n.r.	open	open	n.r.	n.r.	open	open
	HV-D	open	n.r.	closed	n.r.	n.r.	n.r.	n.r.	open	open	open	open

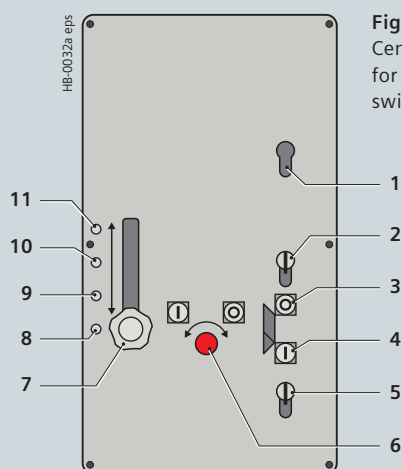


Fig. 17
Central drive control cabinet
for disconnector, earthing
switch, SFC feeder

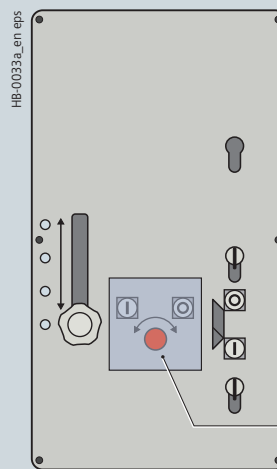


Fig. 18
Central drive control cabinet
with additional interlocking

Additional interlocking:
Cover to deny access in
actuator opening for
crank handle

Legend:

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



Fig. 19 Central drive cabinets for earthing switches,
disconnector and start-up disconnector



Fig. 20 Side view of HB3 with control panel and
central drive cabinets with closed doors

Operation, control panel

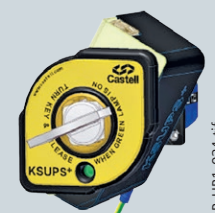
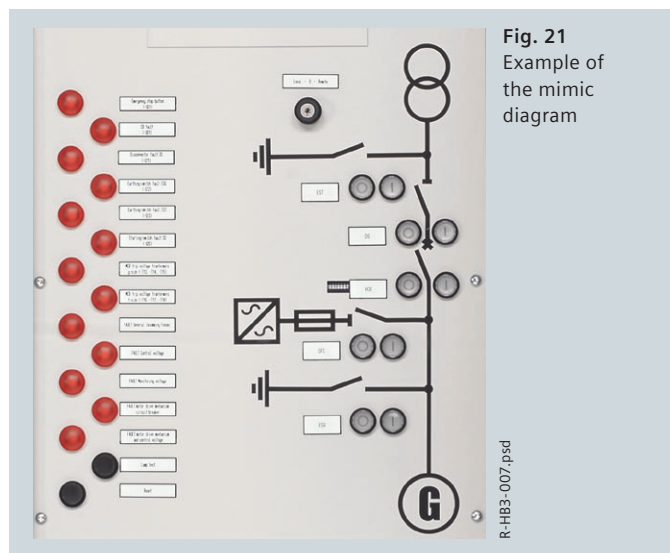
The switching devices of the generator switchgear can be operated locally via the control panel as well as from remote. In case of the absence of auxiliary control voltage, crank handles are provided for manual operation of the switching devices.

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, 1.0 mm² for control, signaling and power supply, 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.



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 on the construction 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.

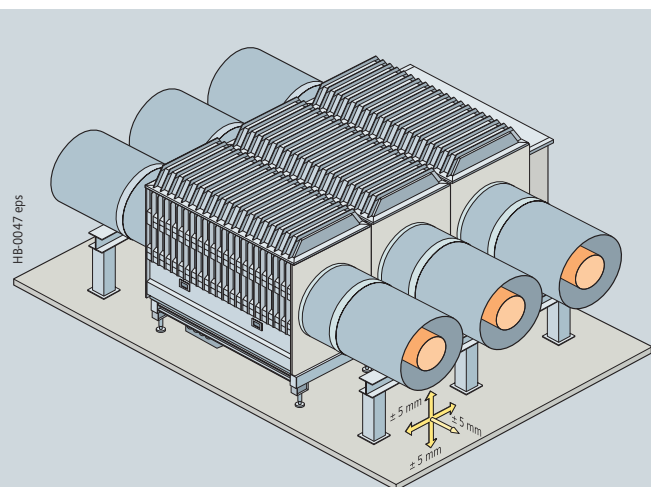


Fig. 33 Typical view of HB3 switchgear with connected IPB

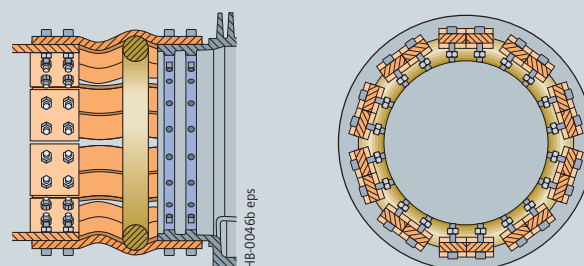


Fig. 34 Typical view of interconnection between IPB and connection terminal

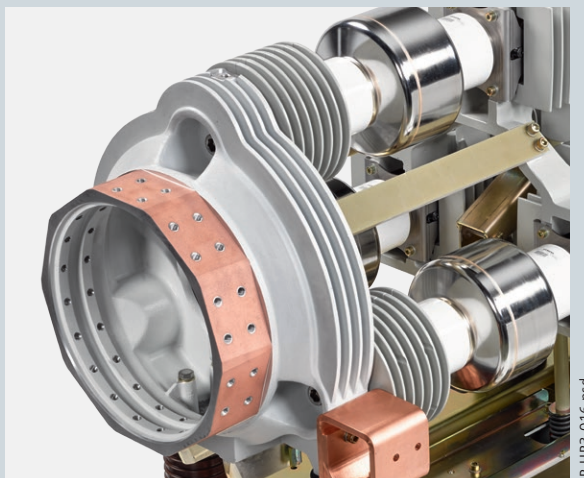


Fig. 35 Connection terminal for 12,500 A

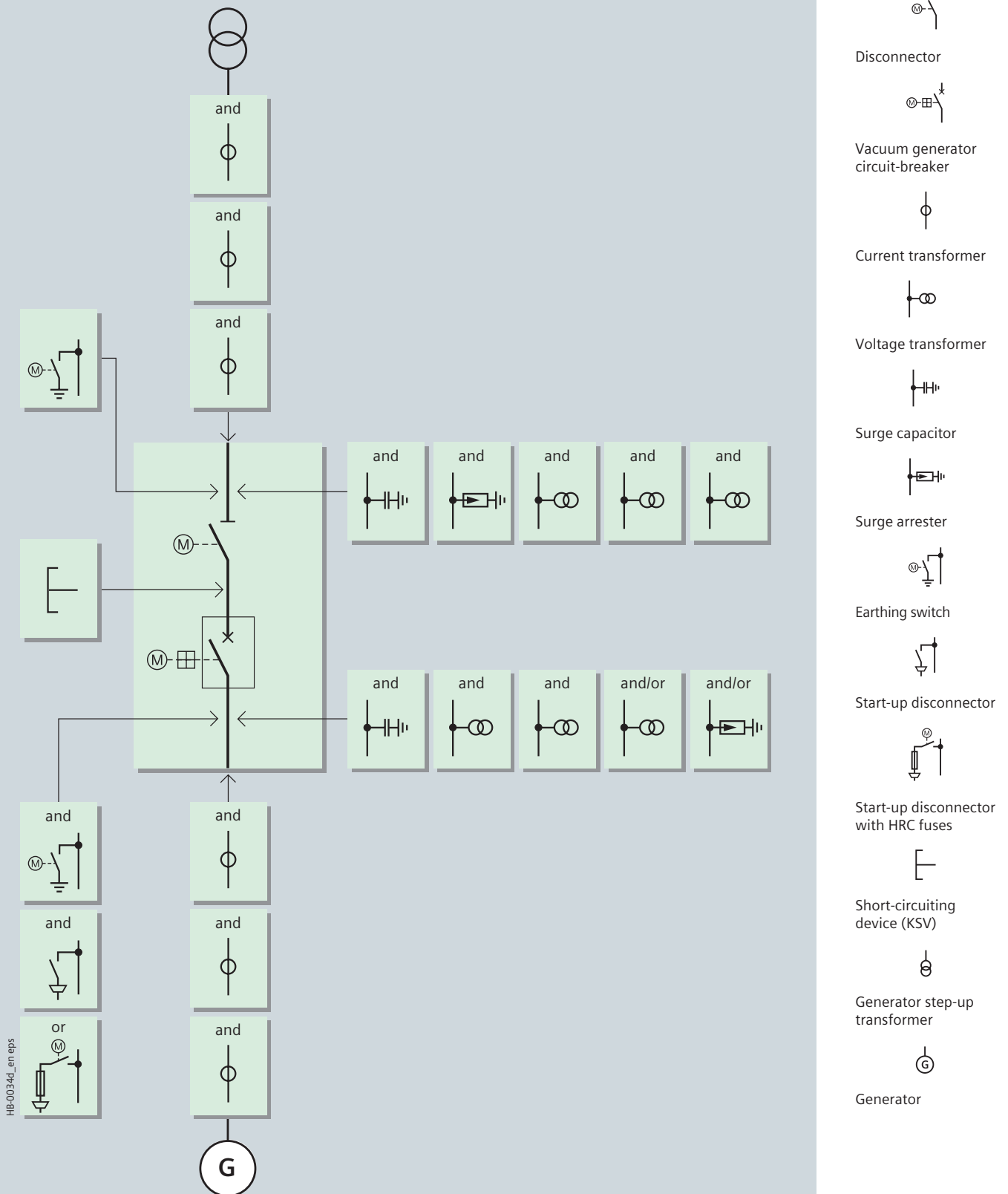


Fig. 36 Single-line diagram, configuration possibilities

Configuration possibilities

Selection guide

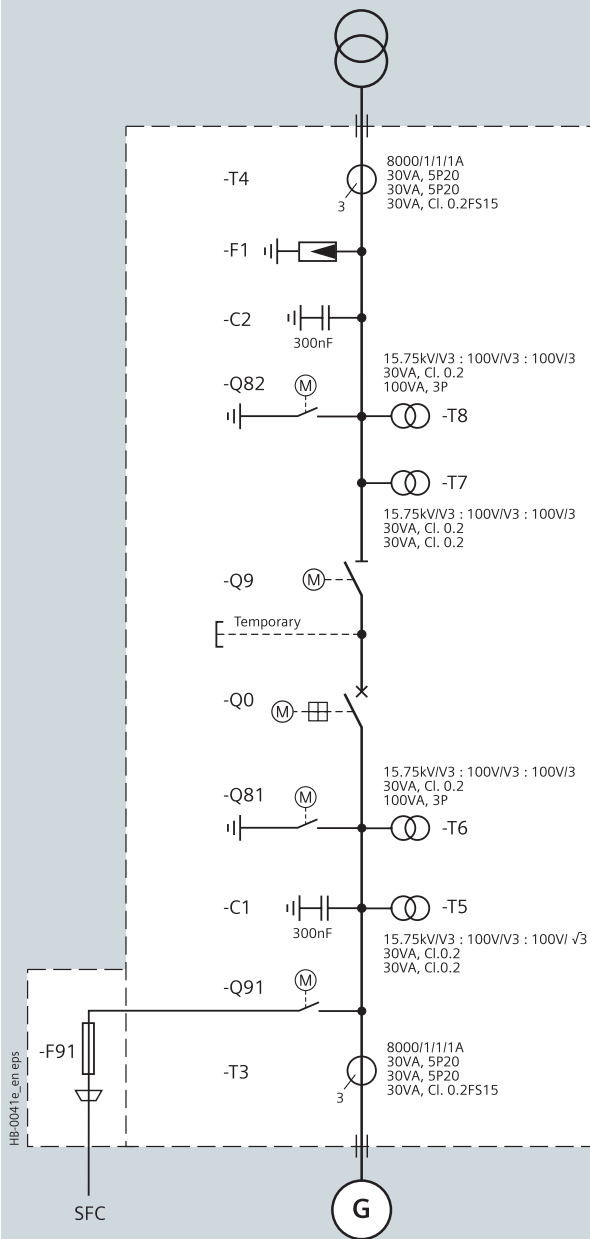


Fig. 37 Sample of a comprehensive solution

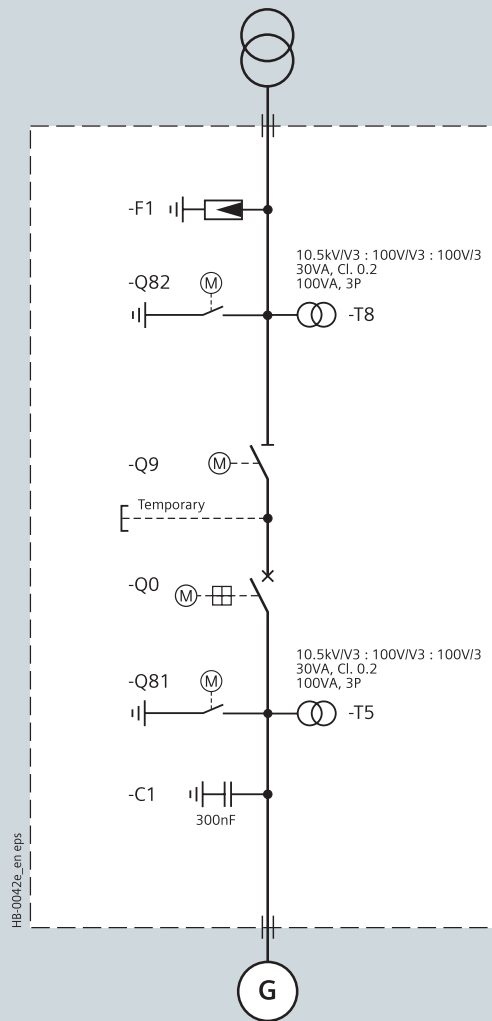














Fig. 38 Sample of a basic solution

-  Disconnecter
-  Vacuum generator circuit-breaker
-  Current transformer
-  Voltage transformer
-  Surge capacitor
-  Surge arrester
-  Earthing switch
-  Start-up disconnecter
-  Start-up disconnecter with HRC fuses
-  Short-circuiting devices (KSV)
-  Generator step-up transformer
-  Generator

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 either electrically or manually. 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 either mechanically by means of the local "ON" pushbutton or electrically by remote control. The closing spring charges the opening or 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 is 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 electro-magnetic 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 normal 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. They can also be closed locally by mechanical unlatching of the closing spring via pushbutton. Instead of this "manual mechanical closing", "manual electrical closing" is also 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.

Components

Vacuum generator circuit-breaker 3AH36

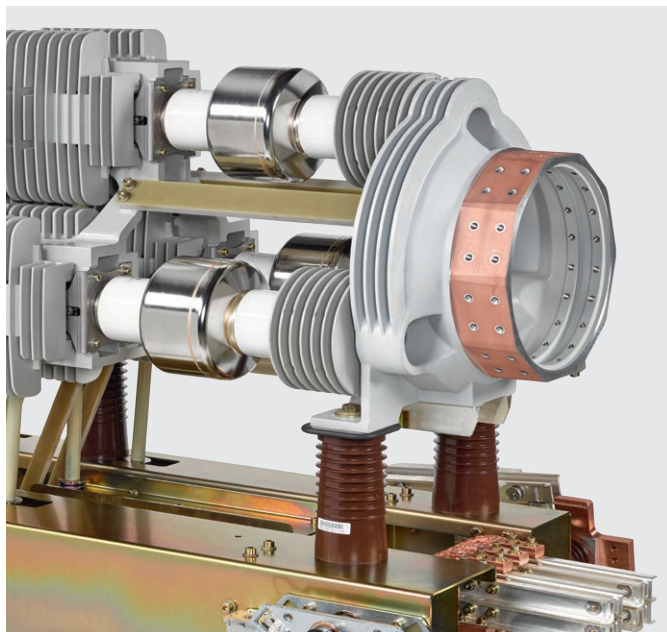


Fig. 39 View of 3AH36 vacuum generator circuit-breaker module

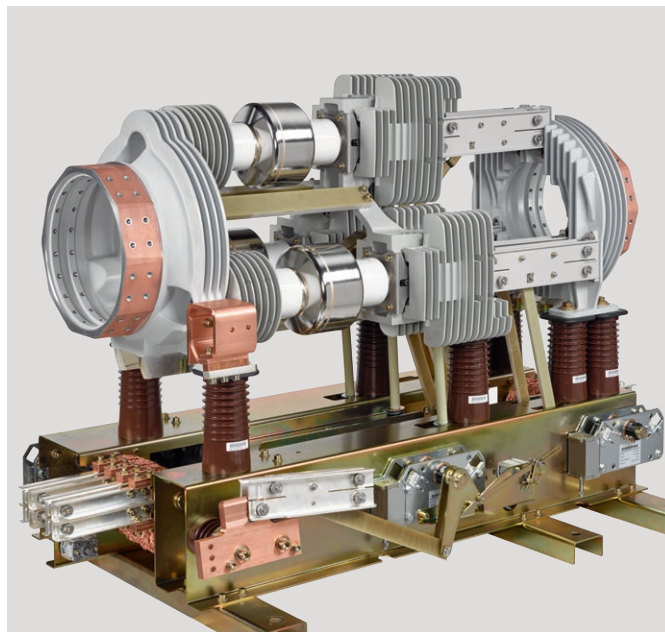


Fig. 40 View of 3AH36 module with integrated vacuum generator circuit-breaker

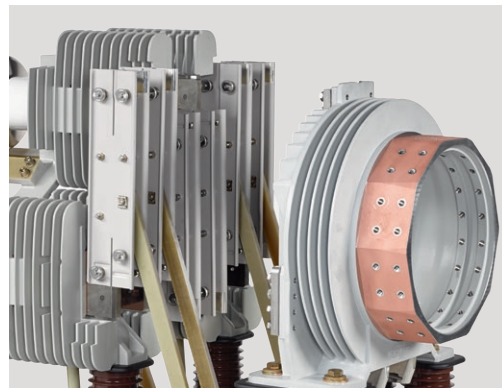
Electrical data of 3AH36 vacuum generator circuit-breaker

		HB3-80	HB3-100
Rated short-circuit breaking current I_{SC} (3 s)		kA 80	100
DC component of the rated short-circuit breaking current		% 65	75
Asymmetrical breaking current (system source)		kA 109	146
Rated short-circuit making current		kA 219	274
Generator short-circuit breaking current $I_{SC \text{ generator}}$ (symmetrical)		kA 40	63
DC component of the short-circuit breaking current		% 110	130
Asymmetrical breaking current		kA 74	132
Rated voltages			
17.5 kV (IEC 62271, IEEE C37.013)	50/60 Hz; $U_p = 110$ kV; $U_d = 50$ kV	x	x
24 kV (IEC 62271, IEEE C37.013)	50/60 Hz; $U_p = 125$ kV; $U_d = 60$ kV	x	x
Rated operating sequence			
– at short-circuit breaking current		CO - 30 min - CO	
– at normal 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 M2 in number of operating cycles		10,000	10,000
Electrical life E2 in number of operating cycles		10,000	10,000
Electrical life at 100% fault current in number of operating cycles		30	30

Line disconnect

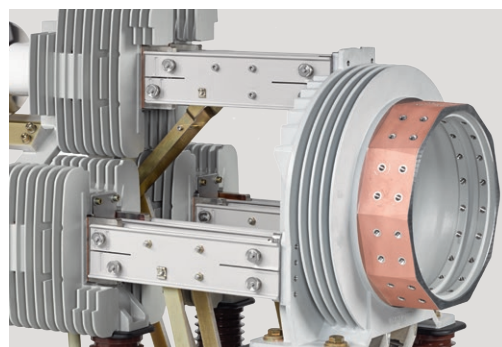
Line disconnectors are used to electrically isolate the switchgear or the associated equipment (e.g., generator, main transformer, etc.) from the grid, in order to guarantee safe maintenance or repair work where it is required.

Line disconnect/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 current at 40°C, HB3 50 Hz	Current curves see Fig. 8 and 9, page 10
Rated current at 40°C, HB3 60 Hz	Current curves see Fig. 8 and 9, page 10
Rated short-time withstand current	up to 100 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	10,000 operating cycles



R-HB3-018.psd

Fig. 41
Line disconnect open



R-HB3-019.psd

Fig. 42
Line disconnect closed

Earthing switch

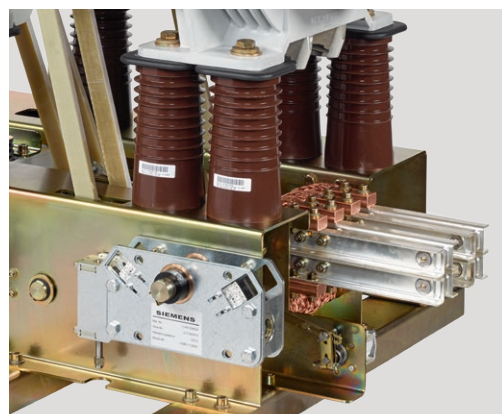
Earthing switches are used to connect the connection terminal of the generator or transformer side to earth, in order to guarantee safe maintenance or repair work where it is required.

Earthing 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 100 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

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

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

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 earthing state, they are in vertical position and rest on the contact surface.



R-HB3-020.psd

Fig. 43
Earthing switch open

Components

Earthing switch, start-up disconnecter

Earthing switch (contin.)

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.

Start-up disconnecter

For the start-up generator of a 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 disconnecter 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.

Start-up disconnecter / 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)	20 kV
– Open position (normal operation)	60 kV
Rated lightning impulse withstand voltage	
– Closed position (starting mode)	60 kV
– Open position (normal operation)	125 kV
Rated normal 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

Mechanical endurance class (in accordance with EN 62271-102) for the earthing switch:

Class M0 = 1000 mechanical switching operations.

Electrical endurance class (in accordance with EN 62271-102) for the disconnecter earthing switch:

Class E0 = no load and no short-circuit making capacity.

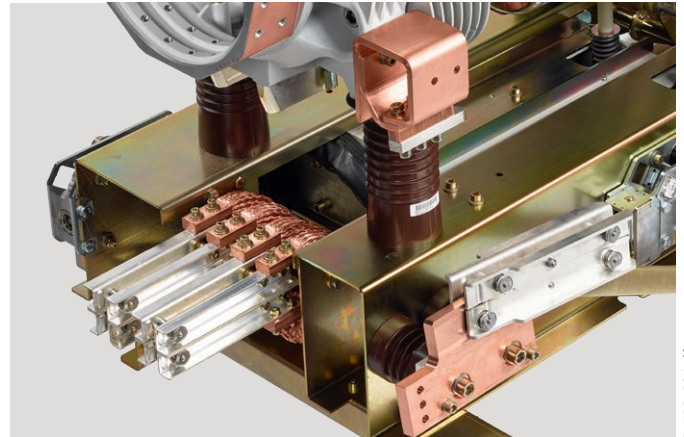


Fig. 44 Start-up disconnecter in open position (right), earthing switch (left)

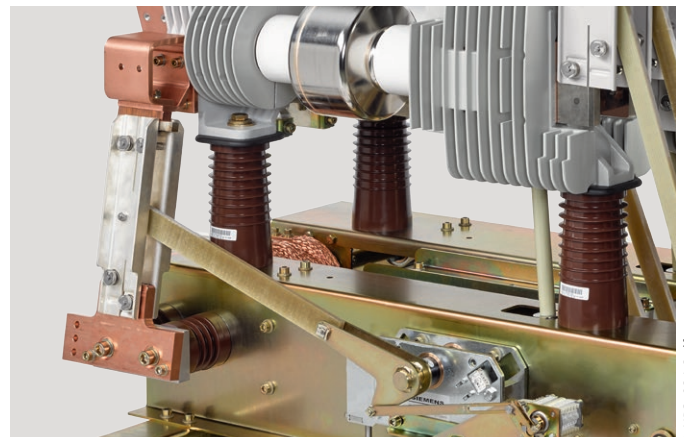


Fig. 45 Start-up disconnecter (SFC) in closed position

Surge arresters, capacitors, current transformers, voltage transformers, short-circuiting devices

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 300 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 aluminium support construction
- Max. rated primary current up to 12,500 A
- Max. rated short-time thermal current up to 100 kA, 3 s
- Max. rated peak withstand current up to 274 kA
- 3 secondary cores, more possible depending on project data
- Large range of accuracy class combinations
- Secondary multiple possible
- Current transformer certifiable.

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 $\sqrt{3}$
- Large range of accuracy class combinations
- Rating up to 200 VA
- Earth-fault winding optional with damping resistor.

Short-circuiting devices

For commissioning and measurement purposes it is possible to install a bridge between the vacuum generator circuit-breaker and the disconnecter over all three phases.

There are two short-circuiting devices available:

- KSV1 5000 A, 30 minutes at 50/60 Hz
- KSV2 10,000 A, 30 minutes at 50/60 Hz.

When using the short-circuiting devices type KSV 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. 46
Surge arrester
type 3EK7

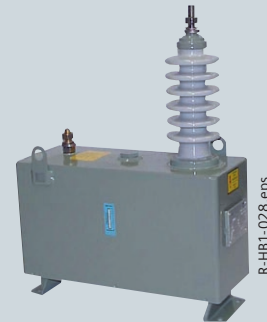


Fig. 47
Surge capacitor

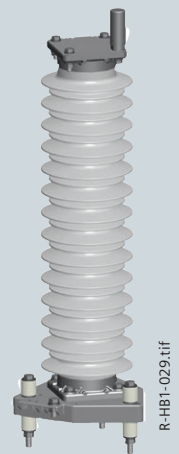


Fig. 48
Surge arrester
type 3EL2

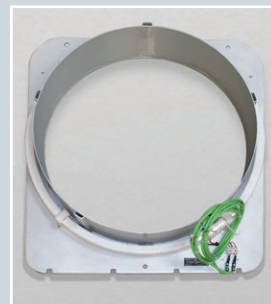


Fig. 49 Current transformers on
aluminium support structure



Fig. 50 Voltage transformer, fixed-mounted

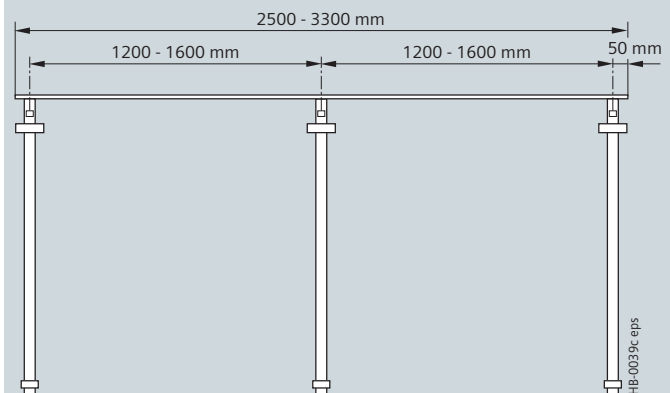


Fig. 51 Fixation of the short-circuiting devices on the vacuum
generator circuit-breaker pole

Type of service location

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

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

Dielectric strength

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

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

VDE 0101	IEC 61936-1	Power installations exceeding 1 kV AC – Part 1: Common rules
VDE 0111-1	IEC 60071-1	Insulation co-ordination: Definitions, principles and rules
VDE 0111-2	IEC 60071-2	Insulation co-ordination: Application guide
VDE 0470-1	IEC 60529	Degree of protection provided by enclosures (IP-code)
VDE 0670-1000	IEC 60694	Common specifications for high-voltage switchgear and controlgear standard
VDE 0671-1	IEC 62271-1	Common specifications for high-voltage switchgear and controlgear
VDE 0671-200	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
VDE 0671-100	IEC 62271-100	High-voltage alternating-current circuit-breakers
VDE 0671-102	IEC 62271-102	Alternating current disconnectors and earthing switches
VDE 0675-4	IEC 60099-4	Surge arresters: Metal-oxide surge arresters without gaps for AC systems
VDE 0682-415	IEC 61243-5	Voltage detecting systems

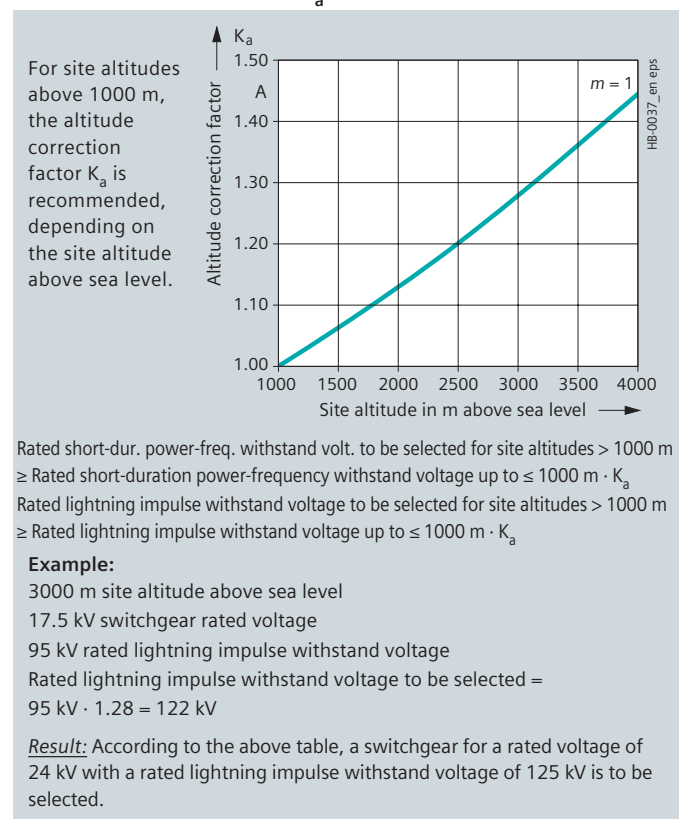
Vacuum generator circuit-breaker

	IEEE/IEC 62271-37-013	High-voltage switchgear and controlgear – Part 37-013: Alternating-current generator circuit-breakers
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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	95	125
– Across isolating distances	kV	125	145

Altitude correction factor K_a



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 panels and busbars depends on the ambient air temperature outside the enclosure.

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 central operating mechanism	IP66
	IP20 (open)
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.

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.

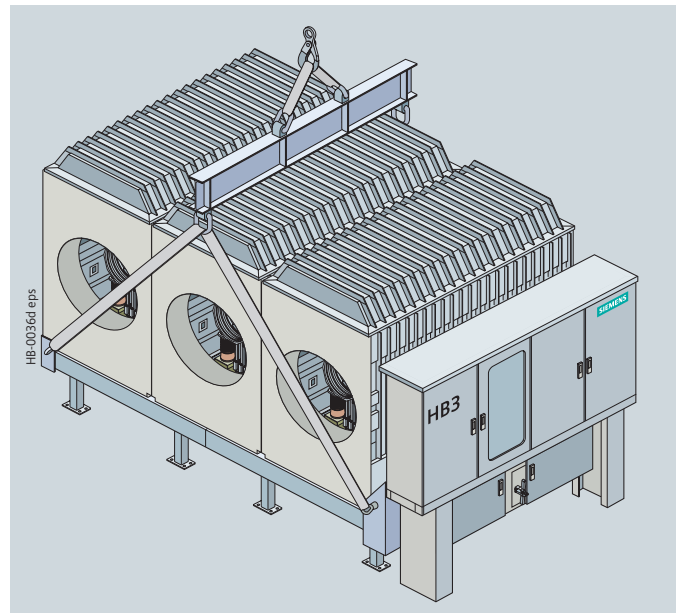


Fig. 52 Installation of HB3

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.

Standards

Standards, specifications, verifications

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:

Text 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: 2 times severity level 2 (ZPA value of 10 [m/s²]).

Acceptance Class 2 according to
IEC/TS 62271-210 & IEEE 693

2 times severity level 1 (ZPA value of 5 [m/s²]).
Acceptance Class 2 according to
IEC/TS 62271-210 & IEEE 693



Fig. 53 Certificate of seismic compliance



Fig. 54 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_n , U_n , x_d , x_d' , x_d'' , T_a , T_d , T_d''
 - Transformer – including S_n , U_n , 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 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.

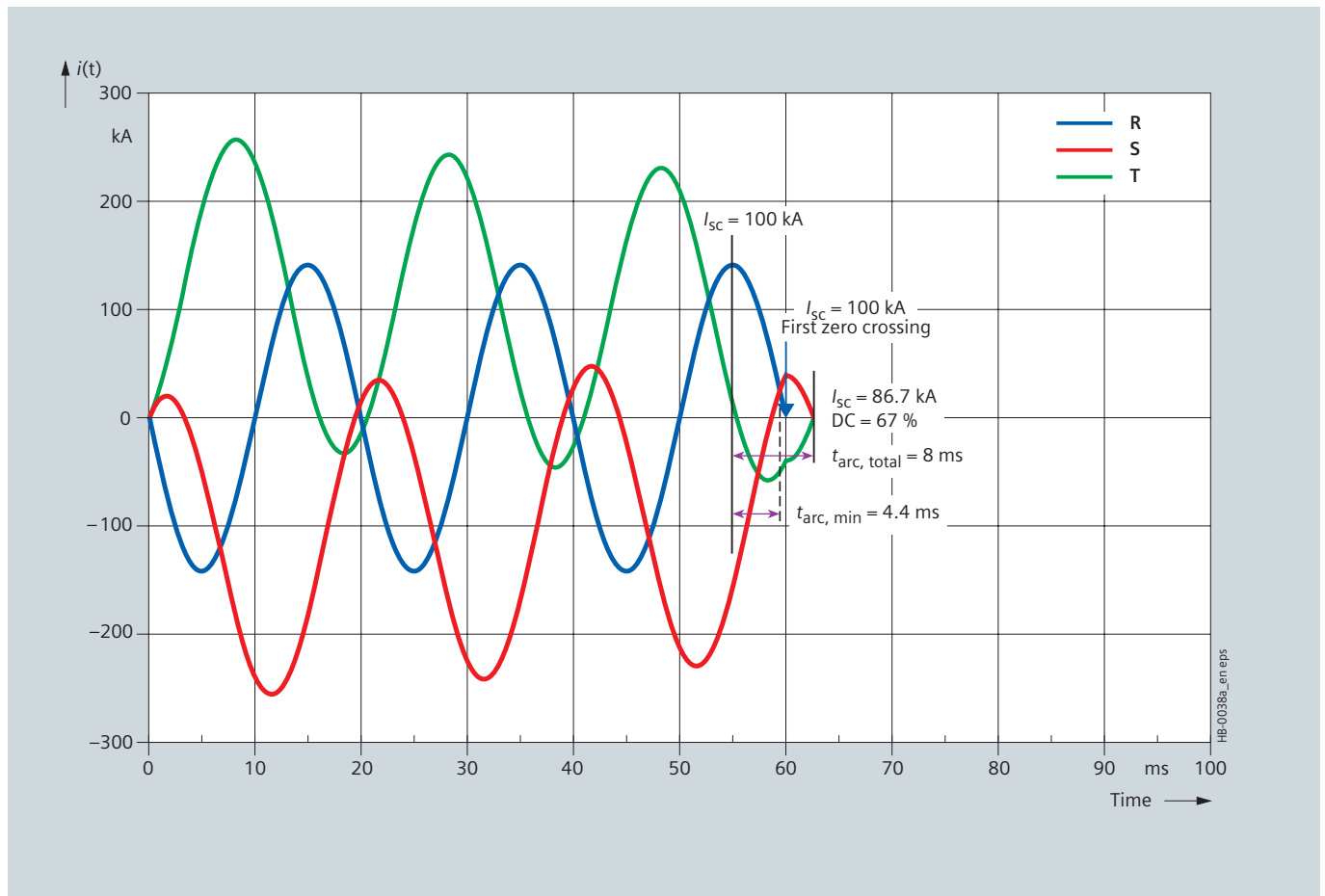


Fig. 55 Example of short-circuit simulation to confirm the breaking capacity

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