HG 11.01 · 2007

Vacuum Switching Technology and Components for Medium Voltage

Your Guide

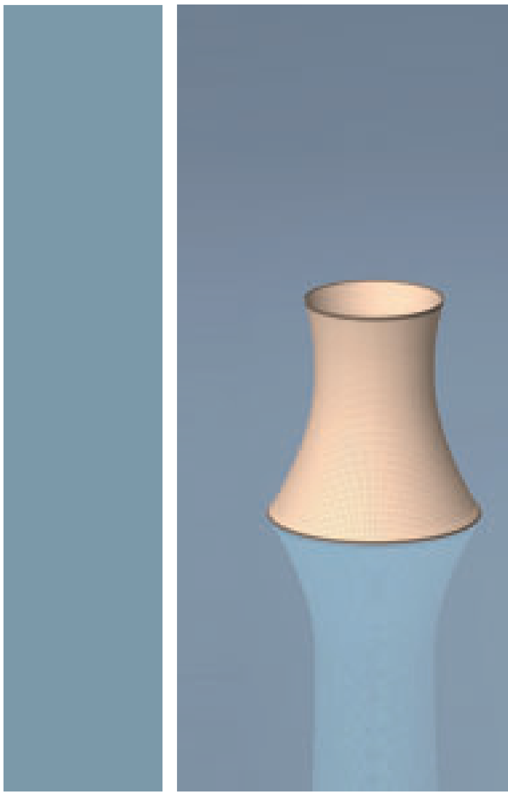
Power Transmission and Distribution

SIEMENS

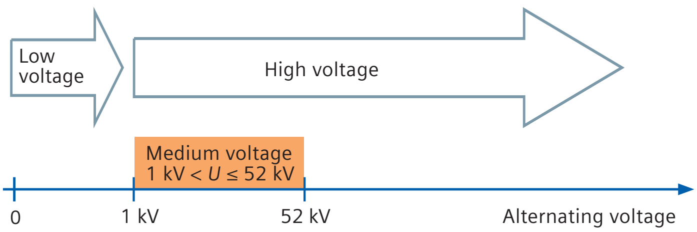
Proven vacuum switching technology from Siemens meets all requirements placed on circuit-breakers and contactors in medium-voltage switchgear up to 40.5 kV.

Contents

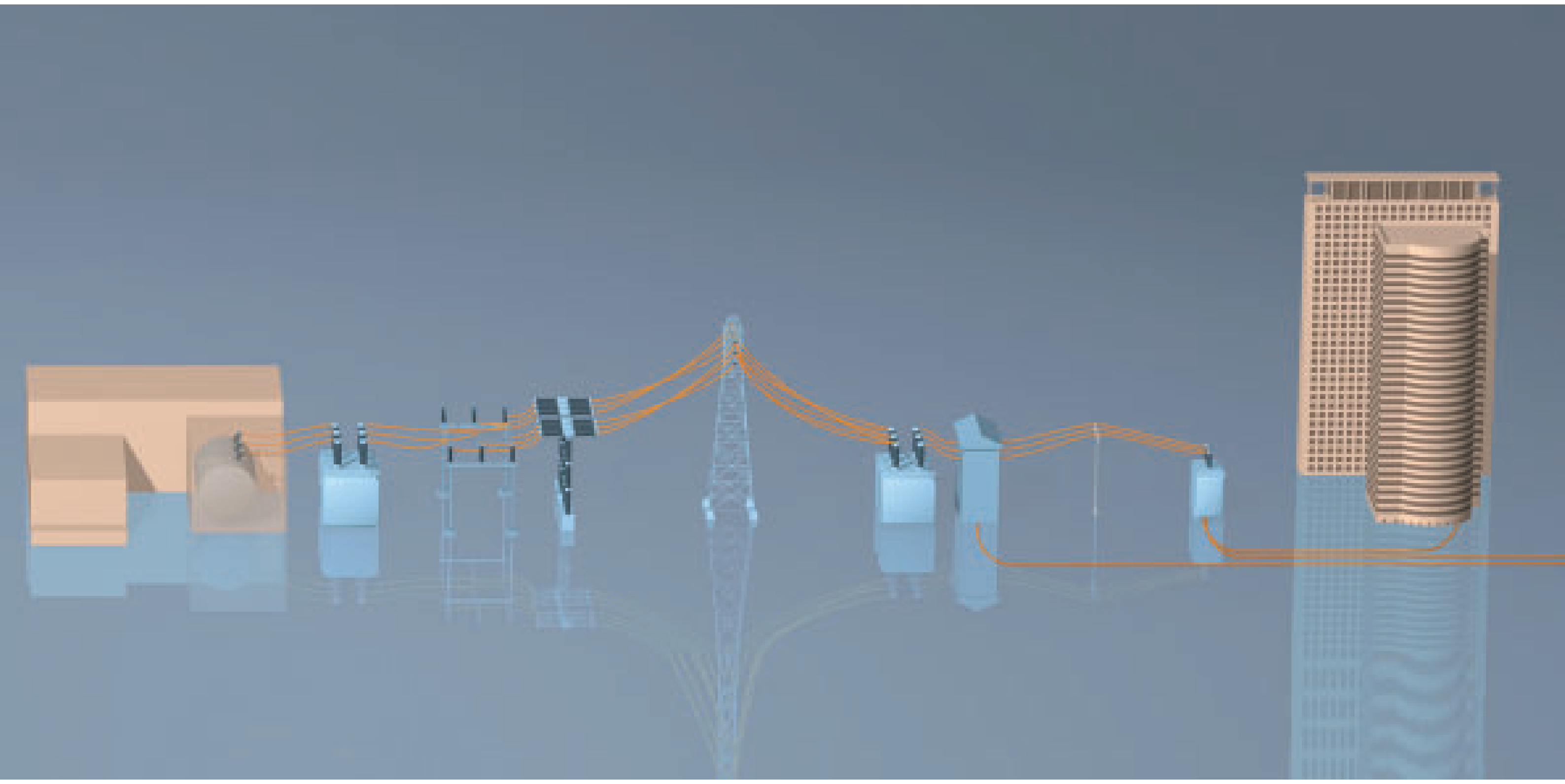
Medium voltage is defined as the range above 1 kV and up to and including 52 kV (alternating voltage). This term refers to a section of the high-voltage range, as there are only two voltage levels available according to international rules: Low voltage up to and including 1 kV alternating or 1.5 kV direct voltage, and high voltage greater than 1 kV alternating or 1.5 kV direct voltage.



Voltage levels from the generator to the consumer



Introduction to the world of medium-voltage components



High voltage is used to transport electrical power over very long distances and to distribute it regionally into the load centres. The term "medium voltage" has been established as a result of the various high-voltage levels which have developed in the field of power transmission and distribution.

Power station locations follow the availability of primary energy sources, cooling systems and other environmental conditions, and are therefore often located away from the power consumption centres. The power transmission and distribution systems not only interconnect power stations and consumers, but also create a supraregional backbone with reserves for the reliability of supply and the compensation of load differences. To keep the losses of power transmission low, high operating voltages (and thus, smaller currents) are preferred. The voltage is not transformed down to the customary values of the low-voltage system – which are required for operation of most electrical devices in households, trade and industrial applications – until it reaches the load centres.

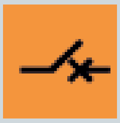
In public power supply, most medium-voltage systems are operated in the range between 10 kV and 40 kV. Due to the historical development and the local facts, the ratings differ a lot from country to country. The supply radius of a medium-voltage system is about 5 to 10 km long at 10 kV in urban areas, and about 10 to 20 km at 20 kV in rural areas. In practice, the supply area depends to a large degree on local influences, for example, on the consumer structure (load) and the geographical situation.

Apart from the public supply, there are still other voltages fulfilling the needs of consumers in industrial plants with medium-voltage systems; in most cases, the operating voltages of the motors installed are decisive. Operating voltages between 3 kV and 15 kV are frequently found in industrial systems.

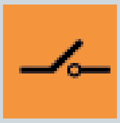
Medium-voltage equipment is therefore available in power stations (in generators and station supply systems), in transformer substations (of public systems or large industrial plants) of the primary distribution level – which receive power from the high-voltage system and transform it down to the medium-voltage level – as well as in secondary, transformer or transfer substations (secondary distribution level), where the power is transformed down from medium to low voltage and distributed to the end consumer.

Overview of medium-voltage components

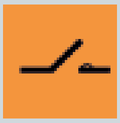
Switching devices



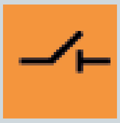
Circuit-breakers (see page 12)
Circuit-breakers must make and break all currents within the scope of their ratings, from small inductive and capacitive load currents up to the short-circuit current, and this under all fault conditions in the power supply system such as earth faults, phase opposition, etc. Outdoor circuit-breakers have the same applications, but are exposed to weather influences.



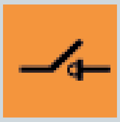
Switches (see page 18)
Switches must make and break normal currents up to their rated normal current, and be able to make on existing short circuits (up to their rated short-circuit making current). However, they cannot break any short-circuit currents.



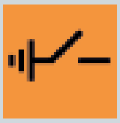
Contactors (see page 20)
Contactors are load breaking devices with a limited making and breaking capacity. They are used for high switching rates, but can neither make nor break short-circuit currents.



Disconnectors (see page 22)
Disconnectors are used for no-load closing and opening operations. Their function is to “isolate” downstream equipment so they can be worked on.



Switch-disconnectors (see page 23)
A switch-disconnector is to be understood as the combination of a switch and a disconnector, or a switch with isolating distance.



Earthing switches (see page 24)
Earthing switches earth isolated circuits. Make-proof earthing switches earth circuits without danger, even if voltage is present, i.e. also in the event that the circuit to be earthed was accidentally not isolated.

Switching devices are components used to connect (close) or interrupt (open) electrical circuits.

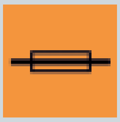
Stress

- No-load switching
- Breaking of normal currents
- Breaking of short-circuit currents

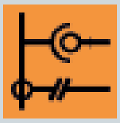
Requirements

- In closed condition, the switching device has to offer minimum resistance to the flow of normal and short-circuit currents.
- In open condition, the open contact gap must withstand the appearing voltages safely.
- All live parts must be sufficiently isolated to earth and between phases when the switching device is open or closed.
- The switching device must be able to close the circuit if voltage is applied. For disconnectors, however, this condition is only requested for the de-energized state, except for small load currents.
- The switching device shall be able to open the circuit while current is flowing. This is not requested for disconnectors.
- The switching device shall produce as low switching overvoltages as possible.

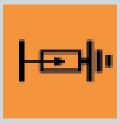
Non-switching devices



Fuses (see page 25)
Fuses consist of a fuse base and a fuse link: With the fuse base, an isolating distance can be established when the fuse link is pulled out in de-energized condition (like in a disconnector). The fuse link is used for one single breaking of a short-circuit current.



Instrument transformers (see page 26)
Instrument transformers are electrical components which transform normal currents and operating voltages into proportional and phase-identical measured values that are suitable for the connected devices – measuring instruments, meters, protection relays and similar equipment.



Surge arresters/limiters (see page 27)
Surge arresters and limiters protect components and switchgear by discharging overvoltages caused by lightning strikes, switching operations or earth faults.

Selection of components by switching applications

Switching applications with undisturbed operation

Appearing load / Switching application	① cos φ	② Current	③ Main problem	④ Comment	Circuit-breaker	Switch	Contactor	Disconnector	Switch-disconnector	Earthing switch	Make-proof earthing switch	Fuse
Switching duties in inductive circuits												
Trans-formers – unloaded (neutral earthing transformer)	< 0.3	≤ 0.03 I_r	–	–	■	■	■	–	■	–	–	–
Trans-formers – loaded	0.7 to 1.0	≤ I_r	–	**Generally no protective circuit required**	■	■	■	–	■	–	–	–
Trans-formers – overloaded	0.7 to 1.0	≤ 1,2 I_r	–	**Generally no protective circuit required**	■	■	■	–	■	–	–	–
Trans-formers – in rush	0.15	≤ 15 I_r	Breaking up to 15 I_r at cos φ ≤ 0.15; overvolt. poss.	**Protection relay with rush stabilization required**	■	–	■	–	–	–	–	–
Furnace transformers	0.2 to 0.9	≤ 2 I_r	High switching rate	**Overvoltage protection circuit to be configured individually**	■	–	–	–	–	–	–	–
Earth-fault reactors	0.15	≤ 300 A	–	**Surge arresters are common practice**	■	■	–	–	■	–	–	–
Compensation reactors	0.15	≤ 2000 A	Transient recovery voltage with rate of rise ≤ 6 kV / µs	**Overvoltage protection circuit to be configured individually**	■	■	–	–	–	–	–	–
Motors – in operation	0.8 to 0.9	≤ I_r	–	–	■	■	■	–	–	–	–	–
Motors – during start	0.2 to 0.3	≤ 7 I_r	Breaking up to 7 I_r at cos φ ≤ 0.3	**For motors with I_{start} ≤ 600 A,** 3EF surge limiters are suitable as protective circuit. For the 12 kV level, surge limiters type 3EF3 120-1 should be used. Individually compensated motors need no protective circuit.	■	■	■	–	–	–	–	–
Generators	0.8 to 1.0	≤ I_r	Transient recovery voltage with high rate of rise	**Overvoltage protection is common practice**	■	–	–	–	–	–	–	–
Static converters	0.1 to 1.0	≤ I_r	–	**Overvoltage protection is common practice**	■	–	–	–	–	–	–	–
Switching duties in capacitive circuits												
Capacitor banks	capacitive	≤ 1.4 I_r	High recovery voltage	–	■	■	■	–	■	–	–	■
Filter circuits	capacitive	≤ 1000 A	High recovery voltage	–	■	■	–	–	–	–	–	–
Parallel connection of capacitor banks	capacitive	≤ 100 I_r	High amplitude and high rate of rise of the inrush current	Permissible inrush current: ≤ 5 kA: for NXACT vacuum circuit-breaker ≤ 10 kA: for 3AH vacuum circuit-breaker > 10 kA: reactor required	■	■	–	–	–	–	–	–
Unloaded cables	capacitive	≤ 100 A	High recovery voltage	–	■	■	–	–	■	–	–	–
Unloaded overhead lines	capacitive	≤ 10 A	High recovery voltage	–	■	■	–	–	■	–	–	–
Ripple control systems	capacitive	≤ 20 A	High recovery voltage	–	■	■	–	–	–	–	–	–
Switching duties for other cases of operation												
Ring opening	0.3 inductive	≤ I_r	–	–	■	■	–	–	■	–	–	–
Changeover to differently loaded busbars	0.7 to 1.0 inductive	≤ I_r	–	–	■	■	–	–	■	–	–	–
Earthing and short-circuiting	–	–	–	–	■	–	–	■	■	■	■	–
Synchronizing	–	–	–	–	■	–	–	–	–	–	–	–
Disconnecting	–	–	–	–	–	–	–	■	■	–	–	–

① This column defines guide values for the power factors arising in the individual cases.

② This column defines currents which must be switched on or off in the worst case for:
- Overloaded and loaded transformers: This does not refer to transformers with special loads such as motors, generators, converters and arc furnaces.
- Earth-fault reactors: In case of earth fault, full operating voltage may be present at the open contact gap of the open switching device.
- Compensation reactors: Due to the high TRV frequency of compensation reactors, high rates of rise are to be expected for the transient recovery voltage.
- Motors: For frequently operated motors it is more cost-efficient to use contactors instead of circuit-breakers or switches.
- Generators: Generators generally behave like an inductance, regardless of the fact whether they are operated with overexcitation or underexcitation.
- Filter circuits: Capacitors with current-limiting reactors are filter circuits as well.

③ This column defines the main problems that may appear. If nothing is stated, this switching application represents no problem for the switching devices to be used.

④ This columns gives general information about the measures to be observed for the application.

Switching applications with disturbed operation

Appearing load Switching application	① cos φ	② Current	③ Main problem	④ Comment	Circuit-breaker	Switch	Contactor	Disconnector	Switch-disconnector	Earthing switch	Make-proof earthing switch	Fuse
Switching duties in case of short-circuits												
Closing	0.15 inductive	I_{ma}	–	–	■	■	–	–	■	–	■	–
Terminal short-circuit	0.15 inductive	I_{sc}	–	–	■	–	–	–	–	–	–	■
Generator-fed short-circuit	0.15 inductive	I_{sc}	Transient recovery voltage with rate of rise ≤ 6 kV / μs	**Overvoltage protection for generators with I''_k ≤ 600 A**	■	–	–	–	–	–	–	–
Auto-reclosing	0.15 inductive	I_{sc}	–	–	■	–	–	–	–	–	–	–
Transformator-fed short-circuit	0.15 inductive	I_{sc}	Transient recovery voltage with rate of rise ≤ 4 kV / μs	–	■	–	–	–	–	–	–	■
Short-circuit current limiting reactors	0.15 inductive	I_{sc}	Transient recovery voltage with rate of rise ≤ 10 kV / μs	–	■	–	–	–	–	–	–	–
Double earth fault	0.15 inductive	0.87 I_{sc}	–	–	■	–	–	–	–	–	–	■
Blocking motors	0.2 inductive	≤ 6 I_r	Breaking 6 I_r at cos φ < 0.2	**For motors with I_{start} ≤ 600 A,** 3EF surge limiters are suitable as protective circuit. For the 12 kV level, surge limiters type 3EF3 120-1 should be used. Individually compensated motors need no protective circuit.	■	■	–	–	–	–	–	–
Phase opposition	0.15 inductive	0.25 I_{sc}	–	–	■	–	–	–	–	–	–	–
Switching duties under earth-fault conditions												
Unloaded cables/overhead lines (fault on supply side)	capacitive	≤ 5 A	High recovery voltage	–	■	■	■	–	–	–	–	–
Loaded cables/overhead lines (fault on supply side)	variable	≤ I_r	High recovery voltage	–	■	■	■	–	–	–	–	–
Breaking of earth-fault current (fault on load side)	variable	≤ I_r	–	–	■	■	■	–	–	–	–	–
Switching duties for other applications												
Protective disconnection (disconnecting under load)	0.7 to 1.0 inductive	≤ I_r	–	–	–	–	–	–	■	–	–	–
Rapid load transfer	0.7 to 1.0 inductive	≤ I_r	Changeover in < 150 ms	–	■	–	–	–	–	–	–	–

① This column defines guide values for the power factors arising in the individual cases.
② This column defines currents which must be switched on or off in the worst case of a transformer-fed short-circuit: This applies to all transformers regardless of the load.
③ This column defines the main problems that may appear. If nothing is stated, this switching application represents no problem for the switching devices to be used.
④ This columns gives general information about the measures to be observed for the application.

Abbreviations and symbols for pages 6 and 7
■ Application of component is useful
– Application of component is not useful

I_{start} Motor starting current
I''_k Initial symmetrical short-circuit current
I_{ma} Rated short-circuit making current
I_r Rated normal current
I_{sc} Rated short-circuit breaking current

Selection of components by ratings

The switching devices and all other equipment must be selected for the system data available at the place of installation. This system data defines the ratings of the components.

Component designation	Rated insulation level	Rated voltage	Rated normal current	Rated peak withstand current	Rated breaking current	Rated short-circuit breaking current	Rated short-circuit making current
Switching devices							
Circuit-breaker	■	■	■	–	–	■	■
Switch	■	■	■	–	■	■ 1)	■
Switch-disconnector	■	■	■	–	■	–	■
Disconnector	■	–	■	■	–	–	–
Earthing switch	■	–	–	■	–	–	–
Make-proof earthing switch	■	■	–	–	–	–	■
Contactor	■	■	■	–	■	■ 1)	■ 1)
Non-switching components							
Fuse link	–	■	■	–	–	■	–
Fuse-base	■	–	■	–	–	–	–
Surge arrester	■	■	–	■ 2)	–	■ 3)	–

■ Influence on selection of component
— No influence on selection of component

1) Limited short-circuit making capacity
2) Rated discharge current of arresters
3) Short-circuit current strength in case of overload of arresters

Rated insulation level

The rated insulation level is the dielectric strength from phase to earth, between phases and across the open contact gap, or across the isolating distance. The dielectric strength is the capability of an electrical component to withstand all voltages with a specific time sequence up to the magnitude of the corresponding withstand voltages. These can be operating voltages or higher-frequency voltages caused by switching operations, earth faults (internal overvoltages) or lightning strikes (external overvoltages). The dielectric strength is verified by a lightning impulse withstand voltage test with the standard impulse wave of 1.2/50 µs and a power-frequency withstand voltage test (50 Hz/1 min).

Rated voltage

The rated voltage is the upper limit of the highest system voltage the device is designed for. As all high-voltage switching devices are zero-current interrupters – except for some fuses –, the system voltage is the most important dimensioning criterion. It determines the dielectric stress of the switching device by means of the transient recovery voltage and the recovery voltage, especially while switching off.

Rated normal current

The rated normal current is the current the main circuit of a device can continuously carry under defined con-ditions. The heating of components – especially of contacts – must not exceed defined values. Permissible temperature rises always refer to the ambient air temperature. If a device is mounted in an enclosure, it is possible that it may not be loaded with its full rated current, depending on the quality of heat dissipation.

Rated peak withstand current

The rated peak withstand current is the peak value of the first major loop of the short-circuit current during a compensation process after the beginning of the current flow, which the device can carry in closed state. It is a measure for the electrodynamic (mechanical) load of an electrical component. For devices with full making capacity, this value is not relevant (see rated short-circuit making current).

Rated breaking current

The rated breaking current is the load breaking current in normal operation. For devices with full breaking capacity and without a critical current range, this value is not relevant (see rated short-circuit breaking current).

Rated short-circuit breaking current

The rated short-circuit breaking current is the root-mean-square value of the breaking current in case of short circuit at the terminals of the switching device.

Rated short-circuit making current

The rated short-circuit making current is the peak value of the making current in case of short circuit at the terminals of the switching device. This stress is greater as that of the rated peak withstand current, as dynamic forces may work against the contact movement.

Standards

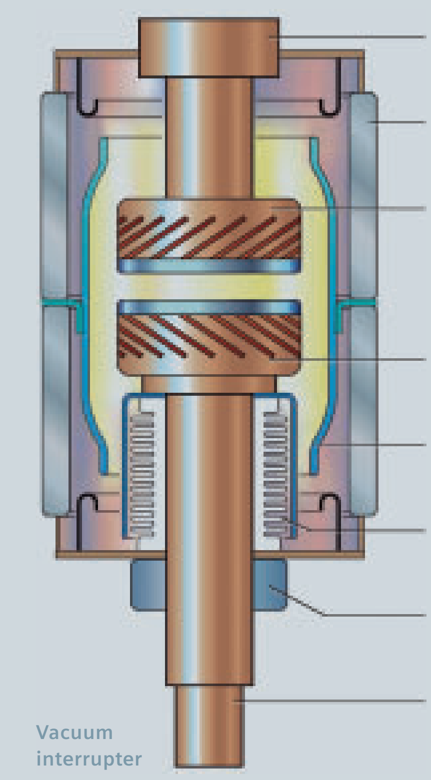
The switching devices and non-switching components are subject to national and international standards. The following table shows the different international standards and their German correspondence.

International	German	Designation
EN 50110	VDE 0105-100	Operation of electrical equipment
IEC 60044	VDE 0414	Instrument transformers
IEC 60099	VDE 0675	Surge arresters
IEC 60265-1	VDE 0670-301	High-voltage switches – Part 1: Switches for rated voltages above 1 kV and less than 52 kV
IEC 60282	VDE 0670-4	High-voltage fuses – Part 1: Current-limiting fuses
IEC 60470	VDE 0670-501	High-voltage alternating current contactors and contactor-based motor-starters
IEC 60644	VDE 0670-401	Specification for high-voltage fuse-links for motor circuit applications
IEC 60694	VDE 0670-1000	Common specifications for high-voltage switchgear and controlgear standards
IEC 60787	VDE 0670-402	Application guide for the selection of high-voltage current-limiting fuse-links for transformer circuits
IEC 62271-100	VDE 0671-100	High-voltage alternating-current circuit-breakers
IEC 62271-102	VDE 0671-102	Alternating current disconnectors and earthing switches
IEC 62271-105	VDE 0671-105	Alternating current switch-fuse combinations

The numbers of the standards for switching devices and switchgear will change in the coming years or have already been partly changed. In future, IEC will summarize all standards of one commission under one group number, so that the standards of a specific technical field will be easy to locate.

Medium-voltage components in detail

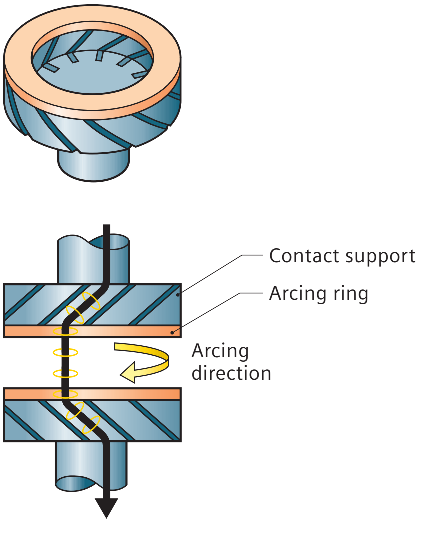
Vacuum switching technology



Vacuum interrupter

Arc quenching

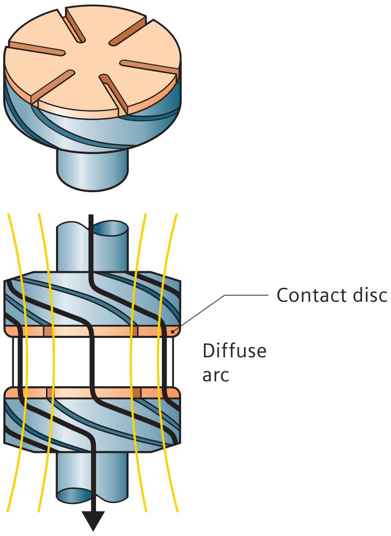
During the galvanic separation of the contacts, the current to break produces a metal-vapour arc discharge. The current flows through this metal-vapour plasma until the next current zero. Near the current zero, the arc extinguishes. The metal vapour loses its conductivity after few microseconds already – the insulating capability of the contact gap recovers quickly. To maintain the metal-vapour arc discharge, a specific minimum current is required. If this minimum current is not reached, it will chop before the natural current zero. To prevent unpermissible switching overvoltages while switching inductive circuits, the chopping current must be limited to the lowest possible values. Using a special contact material, the chopping current in vacuum circuit-breakers is just 2 to 3 A. Due to the fast recovery of the contact gap, the arc is safely quenched even if the contacts separate right before a current zero. Therefore, the arcing times in the last-pole-to-clear are 15 ms as a maximum. Depending on the breaking current and the interrupter dimensions, different contact geometries are used.



Radial magnetic-field contact

- In radial magnetic-field contacts, the arc burns diffusely until approx. 10 kA (momentary value). Higher currents burn across a contracted arc. In this case, local overheating of the contacts must be avoided. An additional magnetic field produces a force which makes the arc rotate on the arcing rings of the contacts. Thus, contact erosion at the base point of the arc is distributed over the entire ring surface.
- In axial magnetic-field contacts, the arc remains diffuse even with high currents due to the axial magnetic field. The disc-type contact surfaces are uniformly stressed, and local melting is avoided.

In alternating-current circuit-breakers, the actual function of the quenching system is to de-ionize the contact gap immediately after current zero. For all conventional quenching systems, this means that the arc must already be cooled before reaching the minimum quenching distance and the following current zero. Involuntarily, this increases the arc power a lot. In vacuum circuit-breakers, however, the arc is not cooled down. The metal-vapour plasma is highly conductive.



Axial magnetic-field contact

This results in a very small arc voltage ranging between 20 and 200 V. For this reason, and due to the short arcing times, the energy converted in the contact gap is very low. Because of this relatively low stress, the quenching system is maintenance-free. In stationary condition, the pressures in the interrupter are very low – less than 10^{-9} bar –, so that contact distances of just 6 to 20 mm are required to reach a very high dielectric strength. Apart from circuit-breakers, the vacuum switching technology can also be used in contactors and switches. Today, more than 70% of all circuit-breakers installed in medium-voltage systems are based on vacuum switching technology.

Vacuum circuit-breakers

Application

- Universal installation in all customary medium-voltage switchgear types
- As single-pole or multi-pole medium-voltage circuit-breaker for all switching duties in indoor switchgear
- For breaking resistive, inductive and capacitive currents
- For switching generators
- For switching contact lines (single-pole traction circuit-breakers)

Switching duties

The switching duties of the circuit-breaker are dependent – among others – on its type of operating mechanism:

- Stored-energy mechanism
  – for synchronizing and rapid load transfer
  – for auto-reclosing
- Spring-operated mechanism (spring CLOSED, stored-energy OPEN)
  – for normal closing and opening

Designs

SION – the innovative

Standard circuit-breaker for variable application

- As standard circuit-breaker or complete slide-in module
- Up to 10,000 operating cycles

Switching duties

Synchronizing

The closing times during synchronizing are so short, that – when the contacts touch – there is still sufficient synchronism between the systems to be connected in parallel.

Rapid load transfer

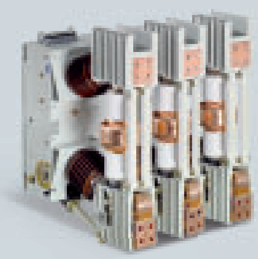
The transfer of consumers to another incoming feeder without interrupting operation is called rapid load transfer. Vacuum circuit-breakers with stored-energy mechanism feature the very short closing and opening times required for this purpose. Beside other tests, vacuum circuit-breakers for rapid load transfer have been tested with the operating sequence O-3 min-CO-3 min-CO at full rated short-circuit breaking current according to the standards. They even control the operating sequence O-0.3 s-CO-3 min-CO up to a rated short-circuit breaking current of 31.5 kA.

Auto-reclosing

This is required in overhead lines to clear transient faults or short-circuits which could be caused by e.g. thunderstorms, strong wind or animals. Even at full

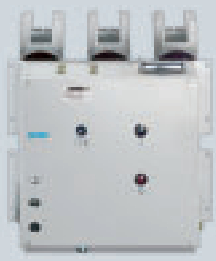
3AH5 – the economical

Standard circuit-breaker for small switching capacities
- Up to 10,000 operating cycles



3AH3 – the powerful

Circuit-breaker for high switching capacities
- Rated short-circuit breaking currents up to 63 kA
- Rated normal currents up to 4000 A
- Up to 10,000 operating cycles



3AH4 – the persistent

Circuit-breaker for a high number of operating cycles
- Up to 120,000 operating cycles

3AH37/3AH38 – the strong

Circuit-breakers for high-current and generator applications
- Rated normal currents up to 6300 A
- Up to 10,000 operating cycles
- According to IEEE Std C37.013

short-circuit current, the vacuum circuit-breakers for the switching duty K leave such short dead times between closing and opening that the de-energized time interval is hardly appreciable for the power supply to the consumers. In case of unsuccessful auto-reclosing, the faulty feeder is shut down definitively. For vacuum circuit-breakers with auto-reclosing feature, the operating sequence O-0.3 s-CO-3 min-CO must be complied with according to IEC 62 271-100, whereas an unsuccessful auto-reclosing only requires the operating sequence O-0.3 s-CO.

Auto-reclosing in traction line systems

To check the traction line system via test resistors for absence of short circuits after a short-circuit shutdown, the operating sequence is O-15 s-CO.

Multiple-shot reclosing

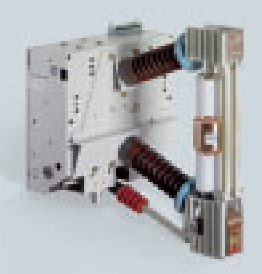
Vacuum circuit-breakers are also suitable for multiple-shot reclosing, which is mainly applicable in English speaking countries, for example, operating sequence O-0.3 s-CO-15 s-CO-15 s-CO.

Switching of transformers

In the vacuum circuit-breaker, the chopping current is only 2 to 3 A due to the special contact material used, which means that no hazardous overvoltages will appear when unloaded transformers are switched off.

Breaking of short-circuit currents

While breaking short-circuit currents at the fault location directly downstream from transformers, generators or current-limiting reactors, first, the full short-circuit current can appear, and second, the initial rate of rise of the transient recovery voltage can be far above the values according to IEC 62 271-100. There may be initial rates of rise up to 10 kV/µs – and while switching off short circuits downstream from reactors, these may be even higher. The circuit-breakers are also adequate for this stress.



3AH47 – the special

Circuit-breaker for applications in traction systems
- System frequency 16 2/3, 50 or 60 Hz
- 1-pole or 2-pole
- Up to 60,000 operating cycles

Switching of capacitors

Vacuum circuit-breakers are especially designed for switching capacitive circuits. They can switch off capacitors up to maximum battery capacities without restrikes, and thus without overvoltages. Capacitive current breaking was tested up to a rated voltage of 12 kV with up to 600 A, for 24 kV up to 300 A, and for 36 kV up to 200 A. These values are technically conditioned by the testing laboratory. Operational experience has shown that capacitive currents are generally controlled up to 70% of the rated normal current of the circuit-breaker. When capacitors are connected in parallel, currents up to the short-circuit current can appear, which may be hazardous for parts of the system due to their high rate of rise. Making currents up to 10 kA (peak value) are permissible; higher values on request.

Switching of overhead lines and cables

When unloaded overhead lines and cables are switched off, the relatively small capacitive currents are controlled without restrikes, and thus without overvoltages.

Switching of motors

When small high-voltage motors are stopped during start-up, switching overvoltages may arise. This concerns high-voltage motors with starting currents up to 600 A. The magnitude of these overvoltages can be reduced to harmless values by means of special surge limiters. For individually compensated motors, no protective circuit is required.

Switching of generators

When generators with a short-circuit current of ≥ 600 A are operated, switching overvoltages may arise. In this case, surge limiters or arresters should be used.

Switching of filter circuits

When filter circuits or inductor-capacitor banks are switched off, the stress for the vacuum circuit-breaker caused by the recovery voltage is higher than with mere capacitors. This is due to the series connection of the inductor and the capacitor, and must be observed for the rated voltage when the vacuum circuit-breaker is selected.

Switching of arc furnaces

Up to 100 operating cycles are required per day. The vacuum circuit-breaker type 3AH4 is especially adequate for this purpose. Due to the properties of the load circuit, the currents can be asymmetrical and distorted. To avoid resonance oscillations in the furnace transformers, individually adjusted protective circuits are necessary.

Vacuum circuit-breaker portfolio

Rated short-circuit breaking current	Rated normal current	Rated voltage and frequency 7.2 kV 50/60 Hz	12 kV 50/60 Hz		15 kV 50/60 Hz	17.5 kV 50/60 Hz		17.5 kV 16 2/3 Hz	24 kV 50/60 Hz			27.5 kV 50/60 Hz	36 kV 50/60 Hz	
12.5	800 A					SION			SION					
	1250 A					SION			SION					
13.1	800 A		3AH5											
16	800 A	SION	SION	3AH5		SION			SION	3AH5				
	1250 A	SION	SION			SION			SION				3AH5	
	2000 A					SION			SION					
	2500 A					SION			SION					
20	800 A	SION	SION	3AH5					SION					
	1250 A	SION	SION	3AH5					SION	3AH5				
	2000 A		3AH5						SION	3AH5				
	2500 A								SION	3AH5				
25	800 A	SION	SION	3AH5		SION	3AH5		SION					
	1250 A	SION	SION	3AH5		SION	3AH5		SION		3AH5	3AH47	3AH5	
	2000 A	SION	SION			SION		3AH47	SION			3AH47	3AH5	
	2500 A		SION	3AH5		SION	3AH5		SION		3AH5	3AH47		
31.5	800 A	SION	SION			SION								
	1250 A	SION	SION	3AH5		SION	3AH5					3AH47	3AH3	3AH4
	2000 A	SION	SION			SION		3AH47				3AH47	3AH3	3AH4
	2500 A	SION	SION	3AH5		SION	3AH5					3AH47	3AH3	3AH4
40	1250 A	SION	SION			SION								
	2000 A	SION	SION			SION								
	2500 A	SION	SION			SION		3AH47	3AH3	3AH4			3AH3	3AH4
	3150 A	SION	SION		3AH1	SION								
50	1250 A	3AH3	3AH3		3AH3	3AH3								
	2500 A	3AH3	3AH3		3AH3	3AH3		3AH47						
	3150 A	3AH3	3AH3		3AH3	3AH3	3AH38							
	4000 A	3AH3	3AH3		3AH3	3AH3	3AH38							
	5000 A					3AH37								
	6300 A					3AH37								
63	1250 A	3AH3	3AH3		3AH3	3AH3								
	2500 A	3AH3	3AH3		3AH3	3AH3								
	3150 A	3AH3	3AH3		3AH3	3AH38								
	4000 A	3AH3	3AH3		3AH3	3AH38								
	5000 A					3AH37								
	6300 A					3AH37								
72	3150 A					3AH38								
	4000 A					3AH38								
	5000 A					3AH37								
	6300 A					3AH37								

Outdoor vacuum circuit-breakers

Application

Outdoor vacuum circuit-breakers have been especially designed for outdoor installation. The design comprises a minimum of moving parts and a simple structure in order to guarantee a long electrical and mechanical service life, offering all advantages of indoor vacuum circuit-breakers at the same time.

In live-tank circuit-breakers, the vacuum interrupter is housed inside a weatherproof insulating enclosure, e.g. made of porcelain. The vacuum interrupter is at electrical potential, which means live.

The significant property of the dead-tank technology is the arrangement of the vacuum interrupter in an earthed metal enclosure, thus defined as dead.

Live Tank

Outdoor vacuum circuit-breaker portfolio

Type	3AG0	3AF034	3AF014	3AF015
Rated voltage	12 kV	17.5 kV	36 kV	36 kV
Rated short-duration power-frequency withstand voltage	28 kV	38 kV	70 kV	70 kV
Rated lightning impulse withstand voltage	75 kV	95 kV	170 kV	170 kV
Rated normal current	1600 A	1600/2000 A	1600/2000 A	1600/2000 A
Rated short-circuit breaking current	25 kA	25 kA	25 kA	31.5 kA
Rated short-circuit making current	63 kA	63 kA	63 kA	80 kA
Design	Live Tank	Live Tank	Live Tank	Live Tank

Switching duties

Dead Tank

Outdoor vacuum circuit-breakers fulfil the same functions as indoor circuit-breakers and cover a similar product range. Due to their special design they are preferably used in power systems with a large extent of overhead lines. When using outdoor vacuum circuit-breakers it is not necessary to provide for closed service locations for the installation of circuit-breakers.

Type	SDV6 / 8HH	SDV5
Rated voltage	15–38 kV	38 kV
Rated short-duration power-frequency withstand voltage	50–70 kV	80 kV
Rated lightning impulse withstand voltage	110–170 kV	200 kV
Rated normal current	600–2000 A	1200/2000 A
Rated short-circuit breaking current	25/40 kA	20/25 kA
Rated short-circuit making current	65/104 kA	52/65 kA
Design	Dead Tank	Dead Tank

Vacuum switches

Application

Vacuum switches are switches for indoor installations, which use the vacuum switching principle for interrupting the normal currents, thus exceeding the electrical and mechanical data of conventional switches. For example, a rated current of 800 A can be interrupted up to 10,000 times without maintenance. It is just necessary to grease the operating mechanism every 10 years. The switches are suitable for installation in withdrawable switchgear and for combination with high-voltage high-rupturing-capacity fuses.

The application of vacuum switches in combination with circuit-breaker switchgear is appropriate in order to make best use of the mentioned advantages. As they can break the rated normal current very often, it is possible, for example, to switch off unloaded transformers in industrial power systems daily in order to minimize no-load losses, thus reducing operational costs.

Short-circuit protection is taken over by fuses, just as with other switches. As switch-fuse combinations, vacuum switches can be combined with all HV HRC fuses up to maximum normal currents.

Switching duties

Switching of overhead lines and cables

Unloaded overhead lines and cables are switched off with relatively small capacitive currents without restrikes, and thus without overvoltages.

Switching of transformers

In the vacuum switch, the chopping current is only 2 to 3 A due to the special contact material used, which means that no hazardous overvoltages will appear when unloaded transformers are switched off.

Switching of motors

When small high-voltage motors are stopped during start-up, switching overvoltages may arise. This concerns high-voltage motors with starting currents up to 600 A. The magnitude of these overvoltages can be reduced to harmless values by means of special surge limiters. For individually compensated motors, no protective circuit is required.

Switching of capacitors

Vacuum switches are especially suitable for switching capacitive currents, as they break these currents without restrikes. 3CG switches can be used for current ratings up to 800 A.

Vacuum switch portfolio

Type	3CG			
Rated voltage	7.2 kV	12 kV	15 kV	24 kV
Rated frequency	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz
Rated lightning impulse withstand voltage	60 kV	75 kV	95 kV	125 kV
Rated normal current	800 A	800 A	800 A	800 A
Rated short-time withstand current (3 s)	20 kA	20 kA	20 kA	16 kA
Rated short-circuit making current	50 kA	50 kA	50 kA	40 kA
Rated closed-loop breaking current	800 A	800 A	800 A	800 A
Rated transformer breaking current	10 A	10 A	10 A	10 A
Rated capacitor breaking current	800 A	800 A	800 A	800 A
Rated cable-charging breaking current	63 A	63 A	63 A	63 A
Rated breaking current for motors with locked rotor	2500 A	1600 A	1250 A	–
Inductive switching capacity ($\cos \varphi \leq 0.15$)	2500 A	1600 A	1250 A	1250 A
Number of operating cycles at rated normal current	10,000	10,000	10,000	10,000

Switching under earth-fault conditions

These switching applications can arise in power supply systems without neutral earthing. Two cases have to be distinguished:

- Fault location downstream from the switch (rated earth-fault breaking current): The capacitive earth-fault current of the galvanically interconnected power system flows through the fault location. Depending on the size of the system, fault currents up to 500 A may appear. The full magnitude of these currents can be interrupted by the 3CG switch.
- Fault location upstream from the switch (rated cable-charging breaking current under earth-fault conditions): The fault current is not interrupted by the switch. Only the charging current of the downstream-connected cable is interrupted, but with phase-to-phase voltage as recovery voltage, because the earth-fault in one phase increases the voltage in the two healthy phases accordingly. The charging current usually only reaches a few amperes. The difficulty in this case may be that a higher load current is superimposed on the small capacitive current. In this special case, conventional switches are often overstrained. 3CG vacuum switches control this switching duty without restrictions.

3CG vacuum switch

Switching capacity under earth-fault conditions				
Rated earth-fault breaking current	630 A	630 A	630 A	630 A
Rated cable-charging breaking current under earth-fault conditions	63 A	63 A	63 A	63 A
Rated cable-charging breaking current under earth-fault conditions with superimposed load current	63 A + 800 A	63 A + 800 A	63 A + 800 A	63 A + 800 A

Vacuum contactors

Application

3TL vacuum contactors are 3-pole contactors with electromagnetic operating mechanism for medium-voltage switchgear. They are load breaking devices with a limited short-circuit making and breaking capacity for applications with high switching rates of up to 1 million operating cycles. Vacuum contactors are suitable for operational switching of alternating-current consumers in indoor switchgear, and can be used e.g. for the following switching duties:

- AC-3: Squirrel-cage motors: Starting, stopping of running motor
- AC-4: Starting, plugging and inching
- Switching of three-phase motors in AC-3 or AC-4 operation (e.g. in conveying and elevator systems, compressors, pumping stations, ventilation and heating)
- Switching of transformers (e.g. in secondary distribution switchgear, industrial distributions)
- Switching of reactors (e.g. in industrial distribution systems, DC-link reactors, power factor correction systems)
- Switching of resistive consumers (e.g. heating resistors, electrical furnaces)
- Switching of capacitors (e.g. in power factor correction systems, capacitor banks)

In contactor-type reversing starter combinations (reversing duty), only one contactor is required for each direction of rotation if high-voltage high-rupturing capacity fuses are used for short-circuit protection.

Switching duties

Switching of motors

Vacuum contactors are especially suitable for frequent operation of motors. As the chopping currents of the contactors are ≤ 5 A, no unpermissibly high overvoltages are produced when started motors are switched during normal operation. However, when high-voltage motors with starting currents of ≤ 600 A are stopped during start-up, overvoltages may arise. The magnitude of these overvoltages can be reduced to harmless values by means of special surge limiters (see page 27).

Switching of transformers

When inductive currents are interrupted, current chopping can produce overvoltages at the contact gap. In the vacuum contactor, the chopping current is ≤ 5 A due to the special contact material used, which means that no hazardous overvoltages will appear when unloaded transformers are switched off.

Switching of capacitors

3TL vacuum contactors can interrupt capacitive currents up to 250 A up to the rated voltage of 12 kV without restrikes, and thus without overvoltages.

3TL6 vacuum contactor

3TL71 vacuum contactor

3TL81 vacuum contactor

Vacuum contactor portfolio

Type	3TL81	3TL61	3TL65	3TL71
Rated voltage	7.2 kV	7.2 kV	12 kV	24 kV
Rated frequency	50/60 Hz	50/60 Hz	50/60 Hz	50/60 Hz
Rated normal current	400 A	450 A	400 A	800 A
Rated making current*	4000 A	4500 A	4000 A	4500 A
Rated breaking current*	3200 A	3600 A	3200 A	3600 A
Mechanical service life of the contactor*	1 million operating cycles	3 million operating cycles	1 million operating cycles	1 million operating cycles
Electrical service life of the vacuum interrupter (rated current)*	0.25 million operating cycles	1 million operating cycles	0.5 Million operating cycles	0.5 million operating cycles

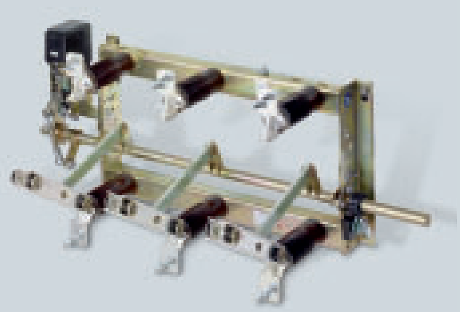
*Switching capacity according to utilization category AC-4 (cos φ = 0.35)

Disconnectors

Application

Disconnectors – also called isolators – are used for almost no-load opening and closing of electrical circuits. While doing so, they can break negligible currents (these are currents up to 500 mA, e.g. capacitive currents of busbars or voltage transformers) or larger currents if there is no significant change of the voltage between the terminals during breaking, e.g. during busbar transfer in double-busbar switchgear, when a bus coupler is closed in parallel.

The actual task of disconnectors is to establish an isolating distance in order to work safely on other operational equipment which has been "isolated" by the disconnector. For this reason, high requirements are placed on the reliability, visibility and dielectric strength of the isolating distance.



Disconnector in disconnected position

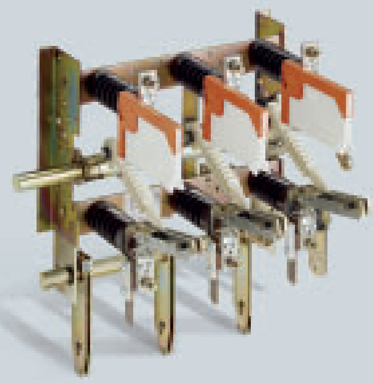
Switching duties

Disconnectors have to isolate downstream operational equipment, i.e. disconnect de-energized equipment from the connected circuits. So, disconnectors establish an isolating distance between the terminals of each pole. Therefore they have to open circuits and/or close them again after work completion, when negligible small currents have to be switched off/on, or when there is no significant voltage difference between the circuits. As they are operated very rarely, they are not designed for a high number of operating cycles like e.g. a circuit-breaker.

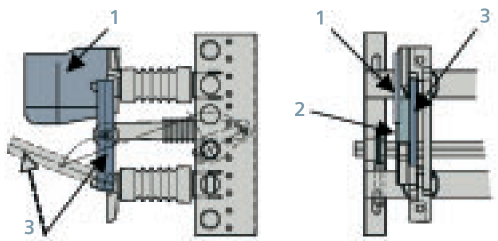
Disconnector portfolio

Rated short-time withstand current	Rated normal current	Rated voltage		
		12 kV	24 kV	36 kV
20 kA	630 A	3DC	3DC/3DA	3DC
31.5 kA	630 A	3DC		
	1250 A	3DC	3DC/3DA	3DC
	1600 A	3DC	3DC/3DA	3DA
	2500 A	3DC	3DC	3DC
	3000 A			3DC
50 kA	1250 A	3DC		
	1600 A	3DC		
	2500 A	3DC		
	3000 A	3DC		
63 kA	1250 A	3DC		
	1600 A	3DC		
	2500 A	3DC		
	3000 A	3DC		

Switch-disconnectors



Side and top view of a switch-disconnector



Switch-disconnector

Application

Switch-disconnectors combine the functions of a switch with the establishment of an isolating distance (disconnector) in one device, and are therefore used for breaking load currents up to their rated normal current. While connecting consumers, making on an existing short-circuit cannot be excluded. That is why, today, switch-disconnectors feature a short-circuit making capacity. In combination with fuses, switches (switch-disconnectors) can also be used to break short-circuit currents. The short-circuit current is interrupted by the fuses. Subsequently, the fuses trip the three poles of the switch(-disconnector), disconnecting the faulty feeder from the power system.

Arc-extinguishing principle

In switch-disconnectors, the arc is not extinguished in a vacuum interrupter, but they operate according to the principle of a hard-gas switch. This means that the arc splits off some gas from an insulating material which surrounds the arc closely, and this gas quenches the arc fast and effectively. As the material providing the gas cannot regenerate itself, the number of operating cycles is lower than that of the vacuum interrupters. Nevertheless, switch-disconnectors according to the hard-gas principle are the most frequently used ones, as they have a good cost/performance relationship.

3CJ2 switch-disconnectors operate with a flat hard-gas arcing chamber (1). During the opening movement, the contact blade (2) is separated first. As the auxiliary blade (3) guided in the arcing chamber is still touching, the current now flows through the auxiliary blade. When the switching blades reach the isolating distance, the auxiliary blade opens the connection suddenly. The opening arc burns in a small gap, and the thermal effect releases enough gas to extinguish the arc rapidly and effectively.

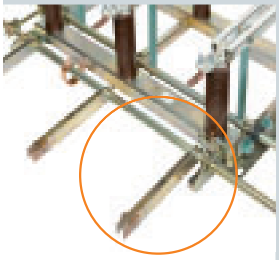
Switch-disconnector portfolio

Type	3CJ2			
Rated voltage	12 kV	17.5 kV	24 kV	36 kV
Rated short-duration power-frequency withstand voltage	28 kV/32 kV	38 kV/45 kV	50 kV/60 kV	70 kV/80 kV
Rated lightning impulse withstand voltage	75 kV/85 kV	95 kV/110 kV	125 kV/145 kV	170 kV/195 kV
Rated normal current	400 A/630 A	400 A/630 A	400 A/630 A	630 A
Rated short-time withstand current (1 sec)	25 kA	25 kA	25 kA	20 kA
Rated short-circuit making current	63 kA	63 kA	50 kA	25 kA
Rated closed-loop breaking current	400 A/630 A	400 A/630 A	400 A/630 A	630 A
Rated cable-charging breaking current	50 A	75 A	50 A	25 A
Rated earth-fault breaking current	150 A	200 A	150 A	70 A
Rated cable-charging breaking current under earth-fault conditions	86 A	100 A	86 A	40 A
Number of mechanical operating cycles	2500	2500	2500	1000
Torque of spring-operated/stored-energy mechanism	44/60	54/62	64/64	90/150
Torque of earthing switch	60	65	70	120
Standard fuse reference dimension “e”	292	362/292	442	538

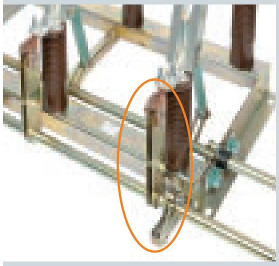
Earthing switches

Application

Earthing switches are used in order to earth and short switchgear parts, cables and overhead lines. They make it possible to work without danger on the previously earthed operational equipment. Their design is similar to that of vertical-break disconnectors. They are often mounted on disconnectors or switch-disconnectors, and then interlocked with these devices in order to prevent earthing on applied voltages. If earthing switches with making capacity (make-proof earthing switches) are used instead of the normal earthing switches, earthing and short-circuiting presents no danger even if the circuit was accidentally not isolated before.



Detail of built-on earthing switch in open position with closed disconnector



Detail of built-on earthing switch in closed position with open disconnector

Earthing switch portfolio

Earthing switches		Rated voltage		
Rated short-time withstand current	Rated peak withstand current	12 kV	24 kV	36 kV
20 kA	50 kA	3DE	3DE/3DD	3DE
31.5 kA	80 kA	3DE	3DE/3DD	3DE
50 kA	125 kA	3DE		
63 kA	160 kA	3DE		

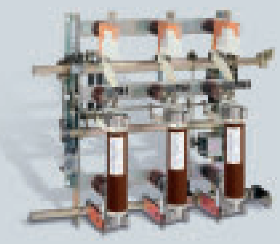
Make-proof earthing switches			Rated voltage			
Rated lightning impulse withstand voltage	Rated power-frequency withstand voltage	Rated short-circuit making current	7.2 kV	12 kV	15 kV	24 kV
60 kV	20 kV	63 kA	3CX50			
60 kV	28 kV	50 kA		3CX50		
75 kV	28 kV	50 kA		3CX50		
95 kV	38 kV	52 kA			3CX50	
95 kV	50 kV	40 kA				3CX50
125 kV	50 kV	40 kA				3CX50

Fuses

Application

Fuse link

3-phase fuse link
with fuse monitor



Switch-disconnector
with fuse links

HV HRC (high-voltage high-rupturing- capacity) fuses are used for short-circuit protection in high-voltage switchgear (frequency range 50 to 60 Hz). They protect devices and parts of the system such as transformers, motors, capacitors, voltage transformers and cable feeders against the dynamic and thermal effects of high short-circuit currents by breaking them when they arise.

Fuses consist of the fuse base and the fuse links. When the fuse links are removed, the fuse base establishes an isolating distance conforming to the standards. Fuse links are used for one single breaking of overcurrents and then they must be replaced. In a switch-fuse combination, the thermal striker pin tripping of the 3GD fuse link prevents the thermal destruction of the fuse. The fuses are suitable both for indoor and outdoor switchgear. They are fitted in fuse bases available as individual single-phase or three-phase components, or as built-on components in combination with the corresponding switching device.

Fuse portfolio

Rated voltage	Reference dimension	Rated current (A)														
		6	10	16	20	25	32	40	50	63	80	100	125	160	200	250
3.6/7.2 kV	192 mm	■	■	■	■	■	■	■	■	■	■	■				
	442 mm												■	■	■	■
12 kV	292 mm	■	■	■	■	■	■	■	■	■	■	■				
	442 mm												■	■		
24 kV	442 mm	■	■	■	■	■	■	■	■	■	■	■				
36 kV	537 mm	■	■	■	■	■	■	■								

Instrument transformers

Application

The task of instrument transformers is to transform high currents and voltages into small current or voltage values for measuring or protection purposes. So, they are used either to measure and record the transmitted power or to feed protection devices with evaluable signals, which enable the protection device to e.g. switch off a switching device depending on the situation.

In this context, **current transformers** can be regarded as transformers working in short-circuit. The full normal current flows through their primary side. Devices connected on the secondary side are series-connected. Current transformers can have several secondary windings with magnetically separated cores of the same or different characteristics. For example, they can be equipped with two measuring cores of different accuracy, or with measuring and protection cores with different accuracy limit factors.

Voltage transformers contain only one magnet core. Normally they are designed with one secondary winding only. If necessary, single-pole insulated voltage transformers are provided with an additional winding for earth-fault detection beside the secondary winding (measuring winding).

4MA7 current transformer

4MR1 voltage transformer

Instrument transformer portfolio

Current transformer type	4MA7 block-type current transformer	4MB1 block-type current transformer	4MC2 bushing-type current transformer	4MC3 bushing-type current transformer	4ME1 outdoor current transformer
Rated voltage	12 kV/24 kV/ 36 kV	12 kV/24 kV	12 kV/24 kV/ 36 kV	12 kV/24 kV/ 36 kV	12 kV/24 kV 36 kV/52 kV
Rated normal current	10–2500 A	1500–6000 A	150–3000 A	1000–10.000 A	5–1200 A
Multiratio	primary or secondary multiratio	secondary multiratio	secondary multiratio	secondary multiratio	primary or secondary multiratio
Number of cores	3	3	4	4	3

Voltage transformer type	Rated voltage	Rating of measuring winding/Class	Thermal limit rating of earth-fault detection winding
4MR1, 4MR2 indoor, single-pole and two-pole, small type	12 kV 24 kV	20 VA/0,2; 100 VA/0,5; 200 VA/1 20 VA/0,2; 100 VA/0,5; 200 VA/1	230 VA/4 A*
4MR5, 4MR6 indoor, single-pole and two-pole, large type	12 kV 24 kV 36 kV	30 VA/0,2; 100 VA/0,5; 200 VA/1 45 VA/0,2; 100 VA/0,5; 200 VA/1 50 VA/0,2; 100 VA/0,5; 200 VA/1	350 VA/6 A*
4MS3 outdoor, single-pole	12 kV 24 kV	30 VA/0,2; 100 VA/0,5; 200 VA/1 30 VA/0,2; 100 VA/0,5; 200 VA/1	230 VA/4 A* 230 VA/4 A*
4MS4	36 kV	60 VA/0,2; 150 VA/0,5; 400 VA/1	

*Higher values on request

Surge arresters and limiters

MO arrester

Application

Surge arresters and limiters protect operational equipment both from external overvoltages caused by lightning strikes in overhead lines and from internal overvoltages produced by switching operations or earth faults. Normally, the arrester is installed between phase and earth. The built-in stack of non-linear, voltage-dependent resistors (varistors) made of metal-oxide (MO) or zinc-oxide (ZnO) becomes conductive from a defined overvoltage limit value on, so that the load can be discharged to earth. When the power-frequency voltage underflows this limit value called discharge voltage, the varistors return to their original resistance value, so that only a so-called leakage current of a few mA flows at operating voltage. As this leakage current heats up the resistors, and thus the arrester, the device must be designed according to the neutral-point treatment of the system in order to prevent unpermissible heating of the arrester.

In contrast to the normal surge arrester, the surge limiter contains a series gap in addition to the MO resistor stack. If the load generated by the overvoltage is large enough, the series gap ignites, and the overvoltage can be discharged to earth until the series gap extinguishes and the varistors return to their non-conductive state. This process is repeated again and again throughout the entire duration of the fault. This makes it possible to design the device with a considerably lower discharge voltage as a conventional surge arrester, and is especially useful for the protection of motors with – normally – a poor dielectric strength. To guarantee a sufficient protective function, the discharge voltage value of the arresters or limiters must no exceed the dielectric strength of the operational equipment to be protected.

Surge arresters and limiters portfolio

	Surge arrester		Surge limiter
Type	3EF1	3EF3	3EE
Rated voltage U_r	up to 15 kV	up to 12 kV	up to 52 kV
Continuous operating voltage U_C	up to 11 kV	up to 8.2 kV	up to 42 kV
Power consumption	0.8 kJ/kV U_r	4 kJ/kV U_r	8 kJ/kV U_r / 10 kJ/kV U_r
Short-circuit current strength (duration)	–	40 kA (0.2 s)	up to 300 kA (0.2 s)

Your guide

For more information about the switching devices,
please refer to the following catalogs:

SION Vacuum Circuit-Breakers

HG 11.02

3AH5 Vacuum Circuit-Breakers

HG 11.05

3AH1/3AH3 Vacuum Circuit-Breakers

HG 11.03

3AH2/3AH4 Vacuum Circuit-Breakers

HG 11.04

3TL Vacuum Contactors

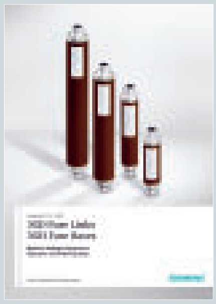
HG 11.21

3D Disconnectors and Earthing Switches

HG 11.31

3CJ2 Switch-Disconnectors

HG 12.21



3GD Fuse Links 3GH Fuse Bases

HG 12.31

3AH47 Vacuum Circuit-Breakers for Traction Applications
HG 11.52

3AF0/3AG0/SDV6/ 8HH6 Outdoor Vacuum Circuit-Breakers
HG 11.41

3CG Vacuum Switches
HG 12.11

4M Instrument Transformers
HG 24

3EE/3EF Surge Arresters and Surge Limiters
HG 21

Siemens AG
Power Transmission and Distribution
Medium Voltage Division
Nonnendammallee 104
13623 Berlin
Germany

www.siemens.com/energy

For questions concerning
Power Transmission and Distribution:
You can contact our Customer Support
Center 24 hours a day, 365 days a year.
Tel.: +49 180 / 524 70 00
Fax: +49 180 / 524 24 71
(Charges depending on provider)
E-Mail: support.energy@siemens.com
www.siemens.com/energy-support

Subject to change without notice
Order No. E50001-K1511-A011-A1-7600
Printed in Germany
Dispo 31601
KG 05.07 5.0 32 En
102085 6100/C6263