




SIEMENS



High-Voltage
Compact Switchgear

3AP1 DTC for 145 kV and 245 kV

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How the hybrid concept fulfills our customers' requirements

Meeting customer demands with high voltage switching technology has become a story of success for Siemens. Our decades of experience are the basis for the design and production of our high-voltage circuit breakers and disconnectors, and we have used our knowledge to satisfy our customers in the best way we know possible. Our goal is to offer premium products at competitive prices, and we have fulfilled our mission with a wide range of high voltage products.

Circuit breakers are the central part of air-insulated (AIS) and gas-insulated switchgear (GIS). By combining the best of both worlds, we have used the hybrid concept to create the highly versatile DTC (Dead Tank Compact) circuit breaker.

The DTC is a compact arrangement of several functions needed in a substation, and is composed of a dead tank circuit breaker fitted with several components just according to your individual substation requirements. The DTC switchgear is available for rated voltages for 145 and 245 kV.

The core components are adopted from our high voltage circuit breakers, disconnectors, and GIS product family:

- Self-compression arc-quenching interrupter unit of the AIS 3AP-circuit breaker
- Stored-energy spring drive mechanism
- SF₆ insulated disconnector/earthing switch from the GIS type 8DN9
- Outdoor earthing switch from the Ruhrtal-designed range of disconnectors

Our products are made to accommodate the needs of each of our customers. With the compact design and flexible use of the components, different layouts can be created with minimal engineering effort.

The level of encapsulation and the design of the DTC module can be easily adjusted to accommodate the needs of individual substation layouts and system operator's project budget.

Russia, 145 kV



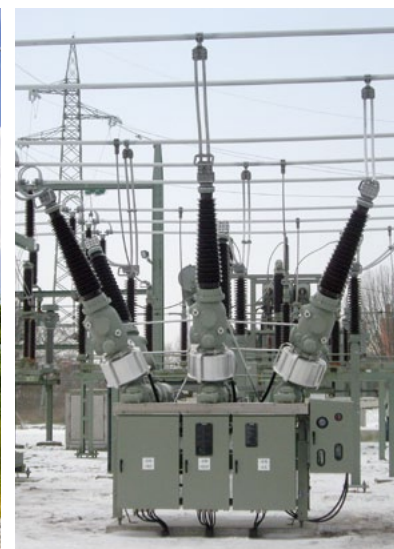
Spain, 145 kV



Thailand, 145 kV



Germany, 145 kV



The hybrid concept enhances safety

by combining SF₆ gas-insulated and air-insulated components. According to CIGRE analyses, gas-insulated components are four times more reliable than air-insulated components.

By increasing the safety of our product through the separation of gas compartments (e.g. between the circuit breaker and disconnecter), we increase availability of switchgear in the market.

Deliveries of more than 1,000 DTC circuit breakers to over 30 countries provide our customers with safety and competitive advantages worldwide, which equates to greater success for their own businesses.

Benefit from the hybrid idea!

The hybrid concept enhances security of investments

The concept of our product is to provide an economical compact design while providing our customers with a variety of options. The 3AP1 DTC offers you:

- Proven SF₆ gas-insulated and air-insulated components that can be combined in new and different ways
- Optimized investments according to the requirements of individual substation layouts
- Gas-insulated components that ensure the highest possible availability with minimum maintenance effort
- Flexibility in confined spaces and extreme environmental conditions (e.g. low temperature applications)
- Easy installation and commissioning

References from around the world

China, 245 kV



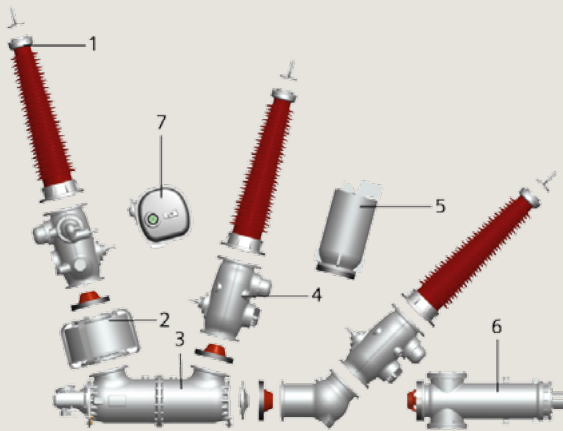
Romania, 245 kV



Poland, 245 kV



Versatile and flexible with the modular concept



Possible components for the 3AP1 DTC compact switchgear

1. Bushing
2. Current transformer
3. Circuit breaker with self-compression principle
4. Three-position disconnecter / earthing switch
5. Voltage transformer
6. Cable connection assembly
7. High speed earthing switch

The hybrid concept enhances flexibility

exactly in accordance with your individual substation configurations:

- Circuit breaker with one or three-pole operating mechanism
- Disconnecter, earthing switch, high-speed earthing switch
- Current transformer, voltage transformer and voltage detection system
- Cable connections possible at various positions
- Bushings available as porcelain or composite insulators
- Additional separation of gas compartment, with SF₆ density monitor on request
- Double breaker modules for ultra-compact substation designs
- Possibility for stand-alone components, e.g. disconnecter module with voltage transformer

DTC-components and the modular design

Our decades of experience in manufacturing and operating have allowed us to create a modular platform concept that is applied to all of our high-voltage circuit breakers, including our Dead Tank Compact. This concept leads to high diversity of circuit breaker types and allows for flexible variations for different applications according to customer needs. The main components of our modular design include:

- operating mechanism
- control system
- kinematic chain
- insulator designs

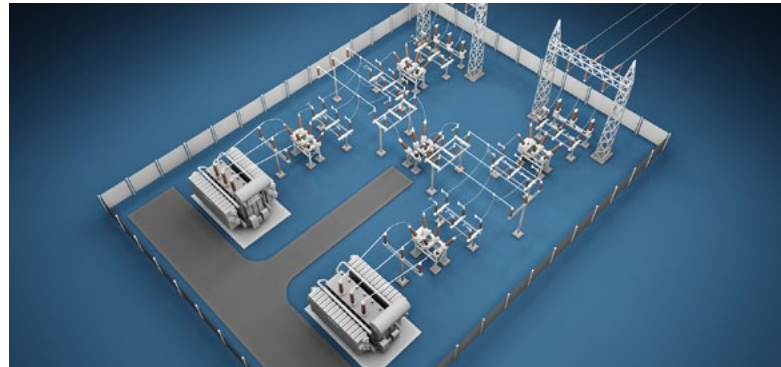
By applying our modular design within our global manufacturing network, we are able to fulfill the highest expectations regarding availability and reliability at eminently competitive prices.

Bushings

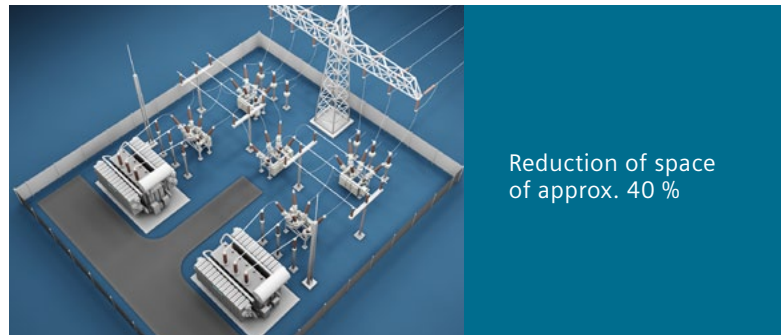
DTC switchgear is connected to the overhead lines or bus bars by SF₆ insulated bushings. A conductor and a shield electrode are fixed inside the bushing. For both voltage levels – 145 kV and 245 kV – the insulator is available in either porcelain or composite (epoxy impregnated fiber glass tube with silicon rubber sheds) materials. The variants with outdoor earthing switches are equipped with porcelain bushings.

The hybrid concept enhances the space efficiency of your substation

H-layout of a conventional 145 kV AIS using 5 Dead Tanks



compared to a DTC solution with 5 DTC switching modules



Reduction of space of approx. 40 %

Current transformer

Current transformers for DTC are conventional types. The existing CT housing enables the placement of ring type cores in many combinations with different ratings. Cores for measuring and protection are available. The current transformer can be located at various positions, e.g. between the circuit breaker and the disconnector/earthing switch. This is equivalent to the location of current transformers in Air Insulated Switchgear (AIS).

Circuit breaker

The self-compression arc-quenching principle is applied in the DTC circuit-breakers. The arc energy is used to interrupt the fault circuit breaking current. The required energy does not need to be provided by the operating mechanism. The components of the interrupter unit and the stored-energy spring drive mechanism are adopted from the well established 3AP circuit-breaker family. The circuit breaker can be provided in one- or three-pole operation design.

Three-position disconnector / earthing switch

The DTC disconnector/earthing switch is based on the design of GIS components with the same function. The main parts contain movable contacts, shafts and levers from GIS components. They have proved their reliability in operation over many years. The motor drive is an established reliable component from the GIS range of products.

Voltage transformers

The voltage transformer lowers the operating voltage of the substation down to values suitable for connected measuring instruments and protective equipment. The implementation of the voltage transformers on each pole allows the individual measurement for each phase. Inductive voltage transformers are used in the Dead Tank Compact circuit breaker. The separate gas compartment is monitored by an additional density monitor.

Cable connections

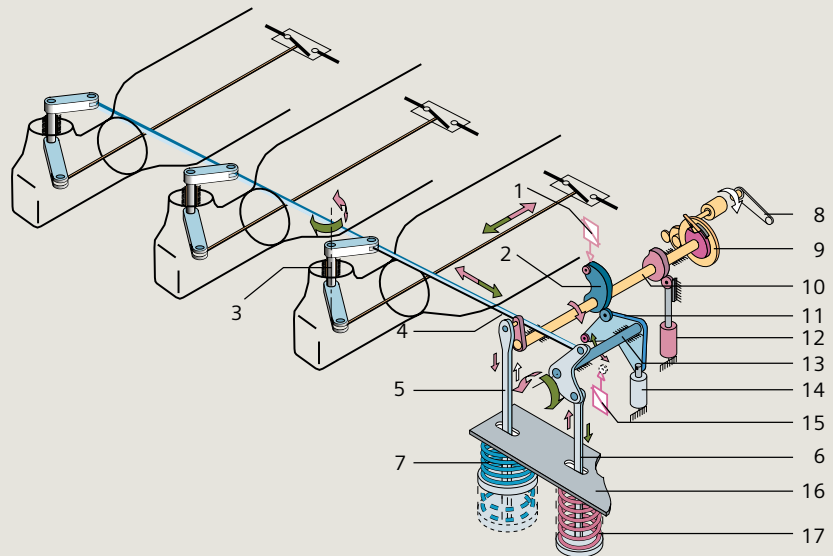
As an alternative to the bushings the DTC can also be offered with a cable connection assembly. The cable connections are SF₆ insulated and delivered with cable terminals according to IEC.

High-speed earthing switch

With the additional spring snap mechanism, the high-speed earthing switch allows for the fault making capacity. That means the earthing of the overhead line can be conducted without the help of the circuit breaker. The high speed earthing switch has the option of being mounted at the disconnector/earthing switch or at the cross connection module. The separate operating mechanism is connected with the spring snap mechanism by coupling rods. Coupling rods connect the separate operating mechanism to the spring snap mechanism.

Proven and reliable drive technology

- 1 Trip coil CLOSE
- 2 Cam plate
- 3 Corner gear
- 4 Connecting rod
- 5 Connecting rod for closing spring
- 6 Connecting rod for opening spring
- 7 Closing spring
- 8 Emergency hand crank
- 9 Charging gear
- 10 Charging shaft
- 11 Roller lever
- 12 Damper (for closing)
- 13 Operating shaft
- 14 Damper (for opening)
- 15 Trip coil OPEN
- 16 Drive mechanism housing
- 17 Opening spring



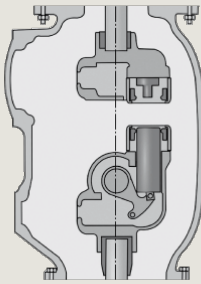
Stored-energy spring drive mechanism

The operating mechanism is a central part of high-voltage circuit breakers. The drive concept of the 3AP circuit breaker family is based on the patented stored-energy spring principle and is identical on all types. The use of such an operating mechanism for voltage ranges of up to 800 kV became appropriate as a result of the development of a self-compression interrupter unit that requires minimal actuating energy. The compact design of this operating mechanism makes it possible to place the stored-energy spring mechanism within the control cubicle in a compact housing.

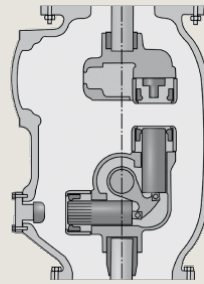
The mechanism types differ in terms of the number, size and arrangement of the opening and closing springs. Both the closing and opening springs are located inside the operating mechanism, thereby achieving a simple and sturdy device. This design minimizes the number of required moving parts. The use of roller bearings and of the maintenance-free charging mechanism is a prerequisite for reliable operation over decades. Proven design principles such as vibration-isolated latches and load-free isolation of the charging mechanism were retained.

Advantages:

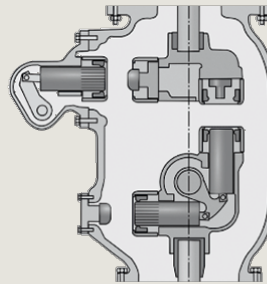
- Same principle for all circuit breaker types rated from 72.5 kV up to 800 kV
- High reliability thanks to low operating energy (10,000 operating cycles guaranteed)
- Fail-safe, economical and persistent due to uncomplicated and robust construction with few moving parts
- Controllable switching state at all times
- Easy access to springs as they are not integrated in SF₆ compartments
- Maintenance-free for 25 years or 6,000 operation cycles



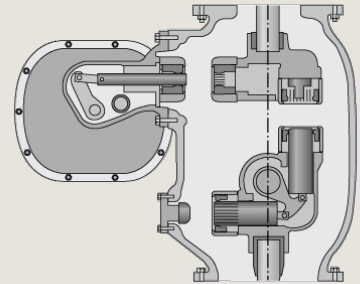
disconnector



disconnector/ earthing switch



disconnector/ earthing switch
with additional earthing switch



disconnector/ earthing switch
with high-speed earthing switch

Drive variants of disconnector/earthing switch

Disconnection and earthing of the Dead Tank Compact circuit breaker is achieved by combining the functions of the disconnector/earthing switches, additional earthing switches, and high-speed earthing switches. When the respective part of the system is turned off and isolated, the isolation distance requirements for safe working conditions on electrical systems and earthing are met. Additional rupture discs and filter attachments increase the safety and lifetime during operation. Optional inspection windows allow monitoring of the switching positions.

Due to its design as a three-position unit, the disconnector/earthing switch functions are mechanically interlocked. The additional earthing switch or the high speed earthing can be operated independently from the disconnector/earthing combination. In the unlikely event of a technical failure, each operating mechanism can be operated manually. The variants and combination possibilities offer numerous earthing options.

Advantages:

- The drive variant can be defined according to individual substation requirements or designs
- Disconnector/earthing switch can be mounted at different positions of the DTC module
- Position indicator at operating mechanism for monitoring of the disconnector/earthing switch position
- An integrated high-speed earthing switch increases the fault making capacity of the DTC

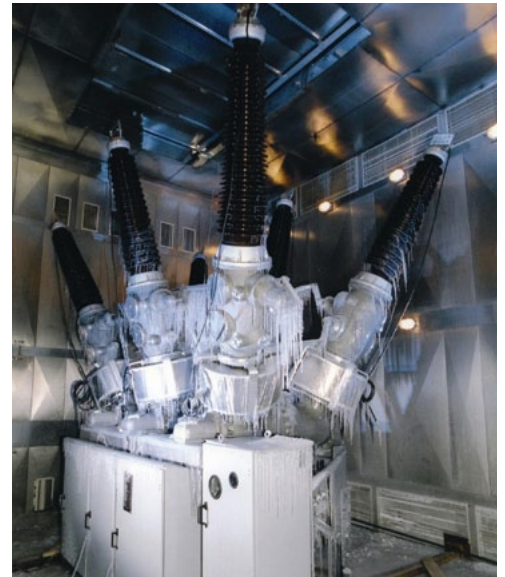
We invest in Quality



high-voltage test



secondary technology test



temperature rise test

Type Testing

All our circuit breakers are completely type-tested in accordance with latest international standards before their market launch. In our Berlin factory, we have one of the most modern testing laboratories available which are accredited to EN 45001 and part of the European network of the independent testing organization, PEHLA.

All required facilities are available:

- Physics laboratory
- High-voltage testing laboratory
- High-power testing laboratory
- Mechanical testing laboratory
- Temperature rise testing laboratory

Other testing laboratories that we work together with are KEMA, CESI, IPH and FGH, which are also part of the European network of independent testing organizations.

Routine Testing

The main components of the Compact Switchgear are subject to complete preacceptance pressure testing before assembly. Based on this high quality level, it is possible to guarantee a

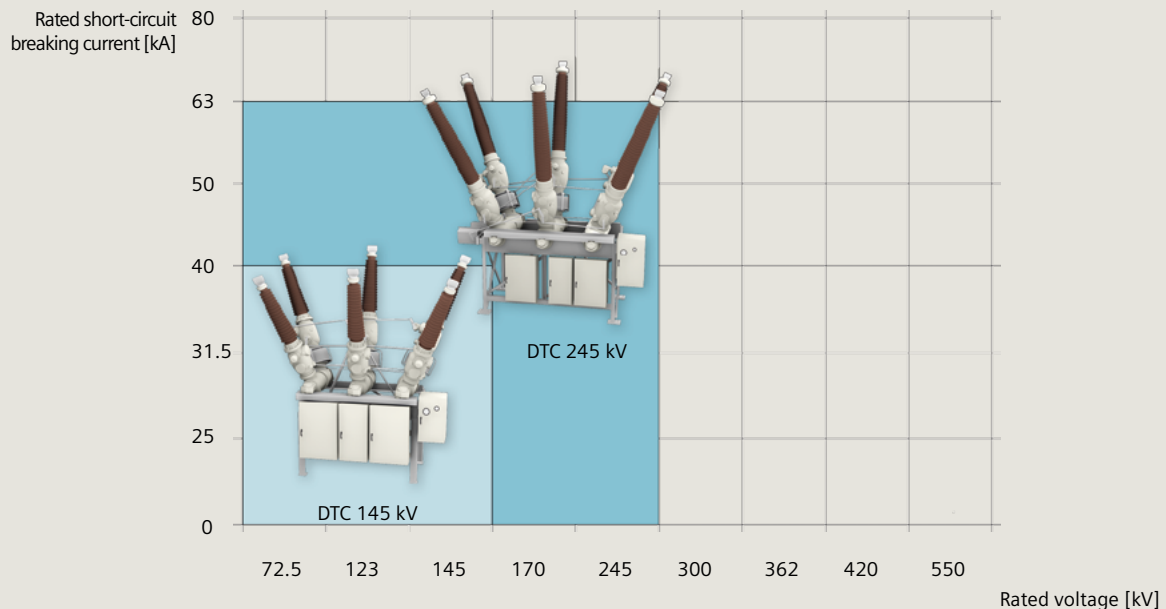
leakage rate of less than 0.1% per year

for the switchgear modules.

Routine testing is performed in accordance with the latest IEC- or ANSI-standards which includes at least the following operations and measurements:

- Series of 100 mechanical switching cycles
- Switching time determination
- Tripping and motor currents
- Gas monitoring
- Testing of control circuits in accordance with the circuit diagram
- Voltage drop of the main conducting path
- High-voltage tests

Two types – many applications



Technical data		3AP1 DTC	
Rated voltage	kV	145	245
Number of interrupter units per pole		1	
Rated power-frequency withstand voltage/min	kV	275	460
Rated lightning impulse withstand voltage/min	kV	650	1050
Rated normal current, up to	A	3150	4000
Rated short-time withstand current (1s-3s), up to	kA _(rms)	40	63
Rated short-circuit breaking current, up to	kA	40	63
Temperature range	°C	-55 up to +55	
Rated operating sequence		O-0.3 s-CO-3 min-CO or CO- 15 s-CO	
Rated break time		3 cycles	
Rated frequency	Hz	50 or 60	
Maintenance after		25 years	

All values in accordance with IEC; other values on request

Competitive and safe with DTC accessories

Voltage Detection System (VDS)

The Voltage Detection System (VDS) is yet another intelligent device of the DTC component portfolio.

Advantages:

- Economic alternative to a voltage transformer if there is no requirement for voltage values to be measured
- High reliability due to use of an optical interface
- Guaranteed high level of safety created by an integrated surge arrester which protects electronic components and staff
- Opportunity for simple integration of switching error protection, such as closing the earthing
- Switch under live conditions

Up to three VDS systems can be integrated in the outgoing units to monitor the voltage. The system is attached directly to the disconnecter and earthing switch component of the DTC and enables the voltage condition of the compact switchgear to be checked. The three sensor attachments are mounted directly on the housing of the disconnecter and earthing switch element.

The integrated electrical components guarantee for long service life through the use of a splash-proof housing and surge arrester. The electrode is responsible for decoupling a capacitive current that behaves proportionally to the high voltage connection. It is mounted on a cover which includes a gas-tight bushing. The measured signal converter transforms the capacitive current into an optical signal and supplies an optical output signal from a minimum threshold current of $5 \mu\text{A}$, which corresponds to a primary-side voltage in the range of 10 % and 35 % $U_R/\sqrt{3}$.

The control cabinet unit evaluates the signals from all three phases. The voltage condition is displayed via LEDs on the front side of the unit and made available by means of relay outputs. As a result of the VDS displaying the voltage condition, an electrical interlocking device can be used to prevent the disconnecter and earthing switch component from switching when voltage is applied. This switching error protection affords you a greater level of safety during operation. The optical fiber transmission link eliminates the possibility of influence from external interference which ensures that the voltage condition is always displayed correctly.



Sensor attachment with VDS

Protective corrugated conduit with optical fiber cable



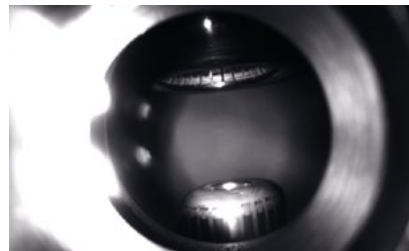
Control cabinet units for the monitoring

SIVIS Stationary and Mobile Camera Systems

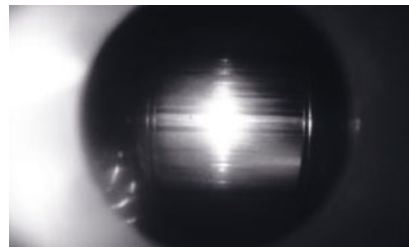
SIVIS camera systems for the 3AP1 DTC make it possible to quickly and easily check the disconnecting earthing switch module positions. The systems are a complementary solution for preexisting position indicators on earthing disconnector operating mechanisms. With these camera systems, we have made it

easy for your maintenance and service personnel to monitor the disconnector, earthing switch, and high-speed rating positions during maintenance

which further improves the safety standards of your switchgear. According to your individual requirements you have the choice between a stationary and a mobile camera system.



Opened disconnector contact



Closed earthing switch contact

Stationary Camera

- Up to 6 cameras per pole (up to 18 cameras total)
- Cameras are mounted directly on the inspection window of the disconnector and earthing switch modules
- Cable connection between cameras and control system in the control cabinet
- Switching between camera images with rotary selector switches
- LCD display in the control cabinet for camera image visualization

- Simple and quick visual monitoring of the disconnector and earthing switch position at any time (of up to 18 positions)
- Integrated galvanic separation on the camera control board protects the secondary equipment of the compact switchgear



Fixed mounted cameras on the disconnector and earthing switch module

Mobile Camera

- Telescope bar for hazardous-free placement on heavily reachable locations
- Contactless monitoring of the switching position inside the disconnector/earthing unit
- Universal interface by using a USB connection for Windows Notebook
- Shipment in a robust carrying case including documentation and software
- Adapter for 245 kV compact switchgear (optional)

- High flexibility - camera system can be attached on every inspection window of the 3AP1 DTC
- High mobility - applicable in assembly, maintenance and test switching
- Easy to use



- Step 1: connect the camera with laptop USB interface
- Step 2: start the operating software
- Step 3: place the camera telescope bar onto the inspection window
- Step 4: if necessary, picture can be optimized via the operating software

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