



Fig. 11: SPS2/3AP1 DT 72.5 kV



Fig. 12: SPS2/3AP1 DT 145 kV

Dead-Tank Circuit-Breakers for 72.5 kV up to 550 kV

Circuit-breakers in dead-tank design

In contrast to live-tank circuit-breakers, dead tanks have a metal-enclosed interrupter unit and the housing is always earthed. They are therefore called dead-tank circuit-breakers. For certain substation designs, dead-tank circuit-breakers might be required instead of the standard live-tank circuit-breakers. The dead-tank circuit-breaker offers particular advantages if the protection design requires the use of several current transformers per pole assembly. For this purpose, Siemens can offer dead-tank circuit-breaker types suitable for different voltage levels (*fig. 11, fig. 12, fig. 13*).

Most important characteristics of a dead-tank circuit-breaker:

- A compact construction due to toroidal-core current transformers on bushings
- High short-circuit breaking currents (up to 63 kA with one interrupter unit)
- Low impulse load of the bases
- Higher seismic withstand capability due to low center of gravity of the bases
- Gas mixture or heating system for lowest temperature applications
- Gas-insulated components ensure highest availability with minimum maintenance effort
- Metal-enclosed interrupter unit (earthed housing).



Fig. 13: SPS2/3AP1 DT 362 kV (two cycles)

Current transformers (CT)

The dead-tank circuit-breakers can be equipped with bushing current transformers for measurement or protection purposes, fulfilling the requirements of international standards such as IEC, ANSI, etc. The current transformers are mounted in weatherproof housings onto both sides of each circuit-breaker pole, and are located at the base of the bushings. The current transformer leads terminate in the control cubicle at short-circuiting-type terminal blocks. A standard housing provides space for up to three current transformers per bushing.

The 3AP DT high-voltage circuit-breaker operates safely and is capable of bearing high loads. Extra-strong porcelain bushings and an optimized circuit-breaker design give it very high seismic stability while in operation. The circuit-breaker covers the whole temperature range from -60 °C up to 55 °C with pure SF₆, which makes it suitable for all climate zones.

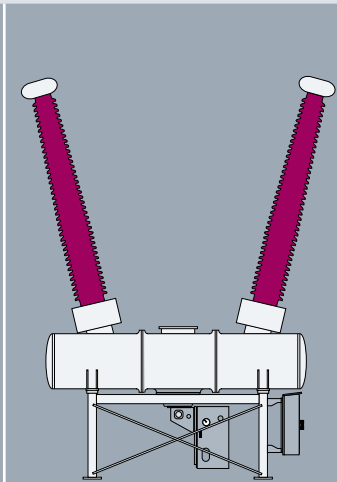
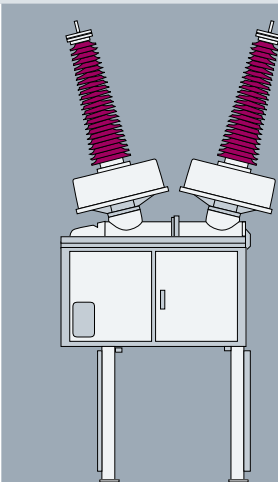
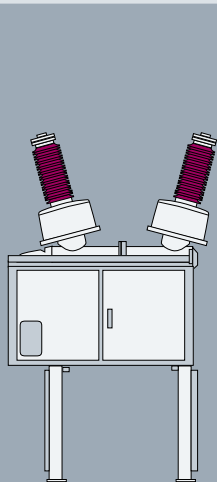
Like the other circuit-breakers, the Siemens dead tanks are based on a proven modular design using a patented self-compression arc-quenching system and the stored-energy spring drive mechanism. They ensure a consistent quenching performance with rated and short-circuit currents – even after many switching operations.

Dead-tank circuit-breaker

Type SPS2 and 3AP DT

The type SPS2 power circuit-breakers are used for the US and ANSI markets, and the 3AP DT circuit-breaker types are offered in IEC markets. Both types are designed as general, definite-purpose circuit-breakers for use at maximum rated voltages from 72.5 kV up to 550 kV (*table 2*). In 2012, two new DT breakers with two-cycles interruption for 245 kV and 362 kV complemented the Siemens DT portfolio, and have been established on the market with great success (*fig. 13*).

Technical data



Type	3AP1 DT / SPS2					3AP2/3 DT / SPS2	
Rated voltage [kV]	72.5	123	145	245	362	362	550
Rated power-frequency withstand voltage [kV]	140 / 160	230 / 260	275 / 310	460	520	520	800 / 860
Rated lighting impulse withstand voltage [kV]	325 / 350	550	650	1,050	1,380	1,380	1,865 / 1,800
Rated switching impulse withstand voltage [kV]	–	–	–	–	950	950	1,175
Rated nominal current up to [A]	3,150	3,150	3,150	3,150	5,000	4,000	4,000 / 5,000
Rated breaking current up to [kA]	40	40	63	90	63	80	63
Operating mechanism type	Stored-energy spring mechanism						

Table 2: Technical data of dead-tank circuit-breaker

The design

Dead-tank circuit-breakers (except for the 550 kV version) consist of three identical pole units mounted onto a common support frame. The opening and closing spring of the FA-type operating mechanism is transferred to the moving contacts of the interrupter unit through a system of connecting rods and a rotating seal at the side of each phase.

The connection to the overhead lines and busbars is established by SF₆-insulated air bushings. The insulators are available in either porcelain or composite (epoxy-impregnated fiberglass tube with silicone rubber sheds) materials.

The tanks and the bushings are charged with SF₆ at a rated pressure of 6.0 bar. The SF₆ is used for insulation and arc-quenching purposes.

The 3AP2/3 DT for 550 kV (fig. 14, fig. 15) consists of two interrupter units in a series that features a simple design. The proven Siemens arc-quenching system ensures faultless

operation, a consistently high arc-quenching capacity, and a long service life, even at high switching frequencies.

Thanks to ongoing further development, optimization, and consistent quality assurance, Siemens self-compression arc-quenching systems meet all the demands placed on modern high-voltage technology.

A control cubicle mounted at one end of the circuit-breaker houses the spring operating mechanism and circuit-breaker control components. The interrupter units are located in the aluminum housing of each pole unit. The interrupters use the latest Siemens self-compression arc-quenching system.

The stored-energy spring mechanism is the same design as used for the Siemens 3AP live-tank circuit-breakers, GIS, and compact switchgear. This design has been in service for more than ten years, and has a well-documented reliability record.

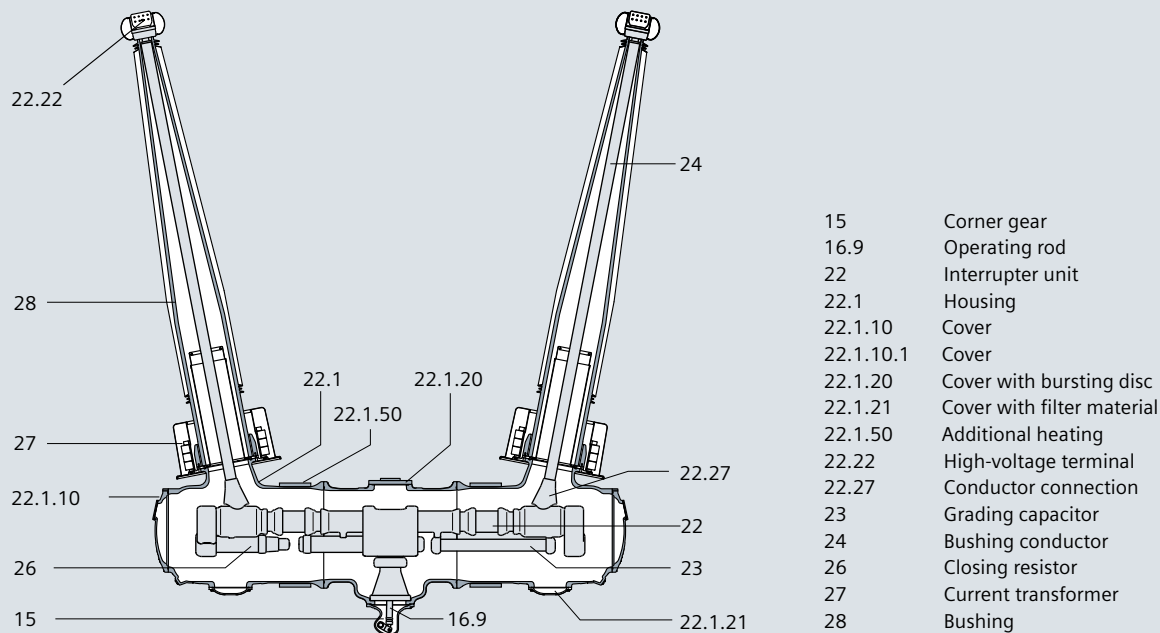


Fig. 14: Sectional view of a 3AP2/3-DT circuit-breaker pole

Operators can specify up to four (in some cases, up to six) bushing-type current transformers (CT) per phase. These CTs, mounted externally on the aluminum housings, can be removed without dismantling the bushings.

Operating mechanism

The mechanically and electrically trip-free spring mechanism type FA is used on type SPS2 and 3AP1/2 DT circuit-breakers. The closing and opening springs are loaded for "O-C-O" operations.

A weatherproof control cubicle (degree of protection IP55) has a large door sealed with rubber gaskets for easy access during inspection and maintenance. Condensation is prevented by heaters that maintain a difference between inside/outside temperature, and by ventilation.

The control system includes all the secondary technical components required for operating the circuit-breaker, which are typically installed in the control cubicle. The current transformer connections are also located in the control cubicle.

There is a wide selection of control, tripping, motor and heating power supplies. Depending on customer requirements, two standard control versions are available.

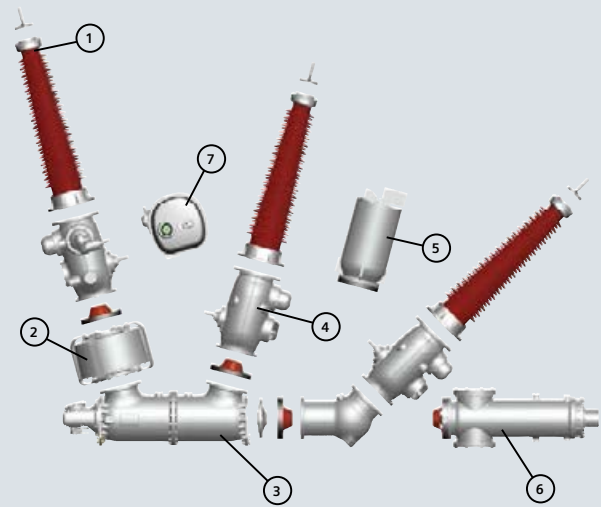
Basic version

The basic variant includes all control and monitoring elements that are needed for operation of the circuit-breaker. In addition to the elementary actuation functions, it features:

- 19 auxiliary switch contacts (nine normally open, nine normally closed, one passing contact)
- Operations counter
- Local actuator.



Fig. 15: 3AP2 DT 550 kV



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

Fig. 16: Possible components for the 3AP1 DTC

Compact version

In addition to the basic version, this type includes:

- Spring monitoring by motor runtime monitoring
- Heating monitoring (current measuring relay)
- Luminaire and socket attachment with a common circuit-breaker to facilitate servicing and maintenance work
- Overvoltage attenuation
- Circuit-breaker motor
- Circuit-breaker heating.

The 3AP1 DTC – Dead-Tank Compact – a Compact Switchgear up to 245 kV

The hybrid concept

The hybrid concept combines SF₆-encapsulated components and air-insulated devices. The application of gas-insulated components increases availability of switchgear. According to CIGRE analyses, gas-insulated components are

four times more reliable than air-insulated components. The level of encapsulation can be defined in accordance with the requirements of the individual substation layout and the system operator's project budget. This leads to optimized investments and can be combined with further air-insulated devices.

The modular design

Based on the well-proven modular design, the core components of the main units apply the same technology that is used in the well-established high-voltage circuit-breakers, disconnectors, and GIS product family from Siemens.

These components are (fig. 16):

- Self-compression arc-quenching interrupter unit of the AIS 3AP circuit-breaker
- Stored-energy spring mechanism
- SF₆-insulated disconnecter/earthing switch from the GIS type 8DN8
- Outdoor earthing switch from the disconnecter product range.



Fig. 17: 3AP1 DTC 145 kV



Fig. 18: 3AP1 DTC 245 kV

This enables flexible solutions according to different substation configurations (fig. 17, fig. 18, fig. 20):

- Circuit-breaker with single-pole or three-pole operating mechanism
- Disconnect, earthing switch, high-speed earthing switch
- Current transformer, voltage transformer, and voltage detecting system
- Cable connections possible at various positions
- Bushings available as porcelain or composite insulators
- Additional separations of gas compartment, with SF₆ density monitor on request
- Double-breaker modules for ultra-compact substation designs
- Option to combine with stand-alone components, e.g., disconnect module with voltage transformer.

Highlights and characteristics

- Simple SF₆ filling and monitoring, one gas compartment possible (separation optional)
- Flexibility in confined spaces and extreme environmental conditions, e.g., low temperature applications to –55 °C

- Single-pole encapsulation: no three-phase fault possible, and fast replacement of one pole (spare part: one pole)
- Safety can be enhanced by separated gas compartments, e.g., between circuit-breaker and disconnect
- Complete module can be moved with a fork-lift truck
- Fast installation and commissioning: easy assembly of fully manufactured and tested modular units
- Less maintenance effort: first major inspection after 25 years
- Service life minimum 50 years
- Single-pole and three-pole operated drive system for 145 kV and 245 kV (fig. 19).

Standard

The international IEC 62271-205 standard treats compact switchgear assemblies for rated voltages above 52 kV. The used terminology for the hybrid concept is the so-called mixed technology switchgear (MTS).

The Siemens compact switchgear is fully type-tested in accordance with this standard (table 3).

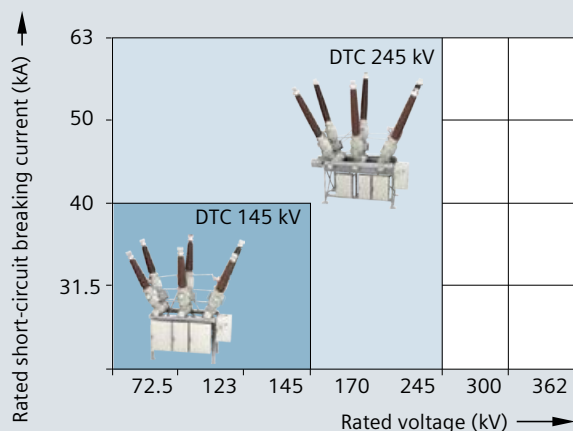


Fig. 19: DTC product range, one-pole or three-pole operation



Fig. 20: 3AP1 DTC 145 kV with voltage transformer and cable connection

Siemens has one of the most modern testing laboratories available, which is certified and part of the European network of independent testing organizations (PEHLA). Additional international testing laboratories (KEMA, CESI) also certify the high quality standards of the Siemens circuit-breakers.

Accessories for 3AP1 DTC

To enhance the possibility of circuit-breaker monitoring, the Siemens voltage detecting system (VDS) or SIVIS camera systems can be used.

The VDS is an economic alternative to a voltage transformer if the measurement of voltage values is not required. Up to three VDS systems can be integrated into 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.

High-voltage compact switchgear		3AP1 DTC	
Rated voltage	[kV]	145	245
Rated normal current	[A]	3,150	4,000
Rated frequency	[Hz]	50/60	50/60
Rated lightning impulse withstand voltage	[kV]	650	1050
Rated power-frequency withstand voltage	[kV]	275	460
Rated short-time withstand current (3 s)	[kA]	40	63
Rated peak withstand current	[kA]	108	170

Table 3: Technical data of 3AP1 DTC