



# Gas-Insulated Switchgear up to 245 kV, 50 kA, 3150 A Type 8DN9

Power Transmission and Distribution

**SIEMENS**

# Gaining from Experience



Our switchgear ensures extraordinarily high availability with low operating costs.



Our 8D range of gas-insulated switchgear represents a highly successful product concept. Since its introduction back in 1968, Siemens has installed more than 17,000 bays worldwide. More than 230,000 years of bay operation have been recorded since. Intensive research work and continuous innovative improvement of the prototypes have ultimately led to today's generation of gas-insulated metal-encapsulated switchgear, a world leader in terms of:

- Economic efficiency
- High reliability
- Safe encapsulation
- High degree of gas-tightness
- Long service life
- Low life-cycle and maintenance costs
- Good accessibility and ergonomics
- High availability
- Safe operation even under extreme environmental conditions.

All those requirements, which are nowadays usually specified for modern and advanced switchgear with respect to performance and reliability, are met by our switchgear type 8DN9 for rated voltages of up to 245 kV. They are among the most compact designs available worldwide. This compact design has been made possible by use of improved insulating materials, optimization of the enclosure form and utilisation of computer-aided design methods in conjunction with modern casting techniques and improved manufacturing technology.

The space-saving design, low weight, and the long operating life associated with low operating costs contribute to making this switchgear extremely economical. Since the levels of noise and field emission (EMC) are extremely low, it is possible to integrate them even in sensitive environments, residential quarters, and city centers. By virtue of these characteristics, our 8DN9 switchgear fulfills all the requirements for environmentally compatible high-voltage switchgear.



Easily comprehensible, user-friendly operating front, optimally installed on the feeder.

# Flexibility due to **Modular Design**

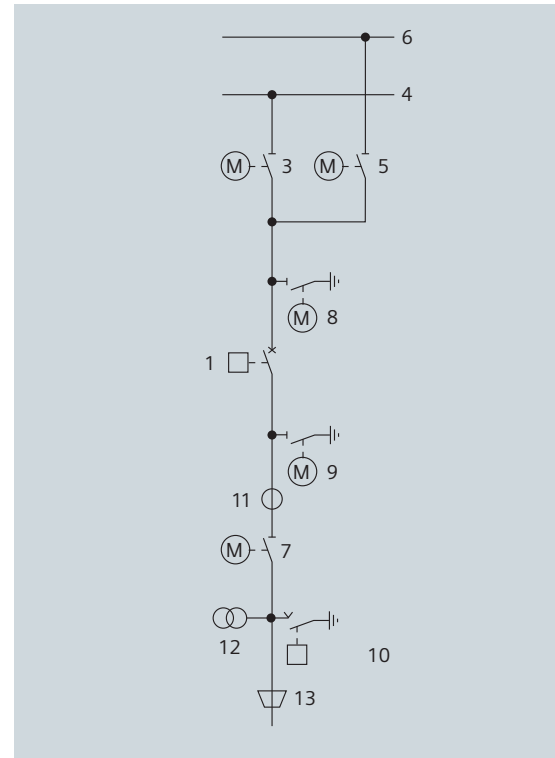


A fundamental feature of our gas-insulated switchgear is the high degree of versatility provided by a modular system. According to their respective functions, the components are housed in compressed gas-tight enclosures. With a remarkably small variety of active and passive modules, it is possible to meet all customary bus schemes.

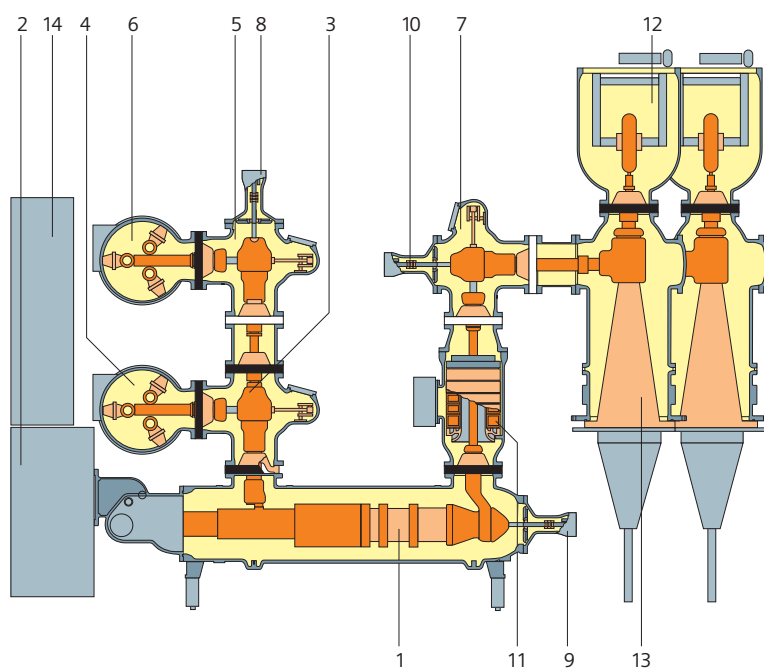
The 8DN9 type switchgear benefits from the advantages offered by single-phase and three-phase encapsulation. Single-phase encapsulation in the feeder and three-phase encapsulation in the busbar enables an extremely compact design with reduced space requirements.



The cast-aluminum enclosures ensure a lightweight and corrosion-resistant system. Through use of modern forming and casting techniques, it has been possible to optimize the dielectric and mechanical characteristics of the enclosure. The low bay weight results in minor floor loading. The flanges at all inter-module joints are equipped with high pressure O-ring seals to ensure high gas-tightness.

The conductors are linked by coupling contacts capable of absorbing movements due to thermal expansion. Where necessary, the joints are accessible via openings which are closed with gas-tight and pressure-resistant covers. Sulphur hexafluoride ( $\text{SF}_6$ ) is used as insulating and arc-quenching medium. Any moisture or decomposition products are completely absorbed by static filters in the gas compartments, which are attached to the inside of the covers of the access openings. Rupture diaphragms prevent build-up of an impermissible high pressure in the enclosure. A diverter nozzle on the rupture diaphragm ensures that the gas is expelled in a defined direction in the event of bursting, thus ensuring that the operating personnel are not endangered.  $\text{SF}_6$  is completely sealed in and will not be consumed. Thus, with proper use there is no environmental danger.



With only a few modules, all typical switching configurations can be created.



 gas-tight bushings  
 gas-permeable bushings

1. Circuit-breaker interrupter unit
2. Spring-stored energy mechanism with circuit-breaker control unit
3. Busbar disconnector I
4. Busbar I
5. Busbar disconnector II
6. Busbar II
7. Outgoing-feeder disconnector
8. Work-in-progress earthing switch
9. Work-in-progress earthing switch
10. Make-proof earthing switch (high-speed)
11. Current transformer
12. Voltage transformer
13. Cable sealing end
14. Integrated local control cubicle



## Circuit-breaker module

The central element of the gas-insulated switchgear is the single-phase encapsulated circuit-breaker module with its two main components:

- Interrupter unit
- Stored-energy spring mechanism

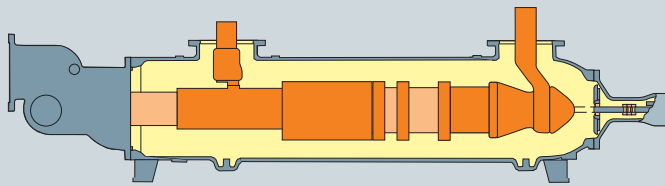
For air-insulated switchgear (AIS) and gas-insulated switchgear (GIS), the same interrupter units and operating mechanism are used. The use of this platform concept in a wide range of applications has provided us with decades of comprehensive experience. The circuit-breaker is suitable for single-pole autoreclosure.

### Stored-energy spring mechanism

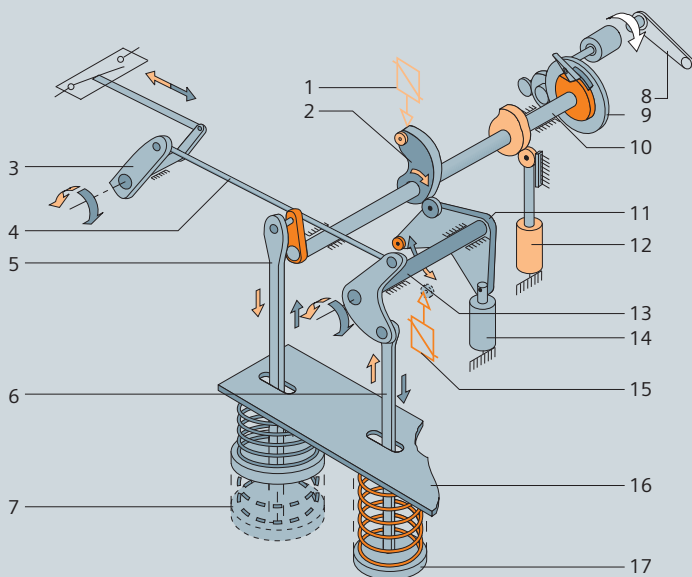
State-of-the-art production techniques allow using compact housing. Since the closing and opening springs are housed in the operating mechanism, the structure is compact and sturdy. This design results in a small number of moving parts. The use of roller bearings and the maintenance-free spring mechanism are a prerequisite for decades of reliable operation. Proven design principles, such as vibration-isolated latches and load-free isolation of the charging mechanism, are retained.

The advantages of the stored-energy spring mechanism:

- One principle for rated voltages from 72.5 to 550 kV
- High reliability due to low operating energy
- Simple principle of operation
- Switching state controllable at all times
- Low maintenance, economical with a long service life
- Low environmental impact



Circuit-breaker module



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



### Interrupter unit

The interrupter unit used in the circuit-breaker for arc-quenching operates according to the dynamic self-compression principle. This principle requires only low operating energy and, thus, keeps the mechanical stresses on the whole circuit-breaker to a minimum.

### The current path

In the closed position, the operating current flows through the main contacts (2, 10). The arcing contacts (1, 7) are plugged in parallel to the main contacts.

### Interruption of operating current

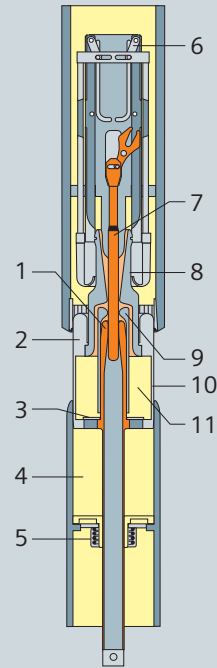
During the breaking operation, the main contact (10) opens and the current commutates to the arcing contacts (1, 7), which are still closed. This avoids erosion of the main contact. As the breaking operation continues, the arcing contact opens and an arc forms between the contacts (1) and (7). At the same time, the contact cylinder (10) compresses the SF<sub>6</sub> gas located in the compression volume (4). The compressed arc-quenching gas flows through the heating volume (11) into the contact gap and extinguishes the arc.

### Interruption of fault current

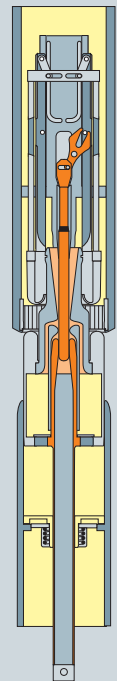
In the case of large short-circuit currents, the gas between the arcing contacts (1) and (7) is heated by the arc energy and is driven into the heating volume (11) with high pressure. When the current passes through zero, the gas flows back from the heating volume through the nozzle (9) and quenches the arc. The valve (3) of the contact cylinder (10) prevents the high-pressure gas from entering the heating volume. Thus, the arc-quenching energy does not have to be supplied by the operating mechanism.

## Arc-quenching principle

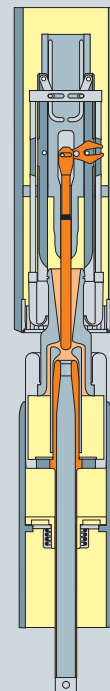
- |                          |                                  |
|--------------------------|----------------------------------|
| 1. Moving arcing contact | 7. Counter moving arcing contact |
| 2. Contact finger        | 8. Insulating nozzle             |
| 3. Valve                 | 9. Auxiliary nozzle              |
| 4. Compression volume    | 10. Contact cylinder             |
| 5. Valve                 | 11. Heating Volume               |
| 6. Steering gear         |                                  |



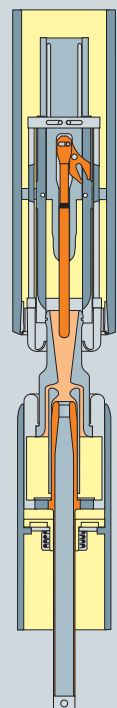
Breaker in  
"On" position



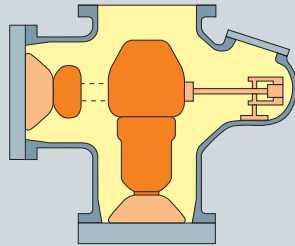
Breaking:  
Main contact  
opened



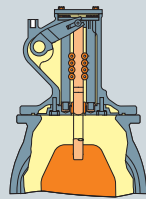
Breaking:  
Arcing contact  
opened



Breaker in  
"Off" position



Disconnecting switch



Pin-type earthing switch

## Disconnecting switches

Disconnecting switches assure a dielectrically safe gap between both contacts for secure isolation of system areas with different potential, e.g., busbar disconnecting switches isolating a whole feeder from the busbar. Cast-resin bushings keep the contact system in place, and the pressurized gas serves as the isolating medium between live parts and the metal housing.

The module is available with up to two earthing switches and the necessary connectors for different types of adjacent modules. Disconnecting switches can be built as separate gas compartments by themselves with their own monitoring or be combined with surrounding modules.

## Earthing switches

Earthing switches (e.g., work-in-progress earthing switches or busbar earthing switches) are used for properly connecting deenergized live parts of the high-voltage system to the ground. On the outgoing side of the feeders, a make-proof version (high-speed) is frequently used to eliminate risk to the GIS system, e.g., if the opposite side was not switched off properly. In the insulated design they are used for measuring purposes and for testing protection relays.

In 8DN9 switchgear, the earthing switches are of a pin-type design. They are preferably used in conjunction with disconnecting switches, but can also be supplied as separate modules with their own housing. With the pin-type earthing switch, the earthing pin at earth potential is pushed into the mating contact. Make-proof earthing switches are equipped with a stored-energy spring mechanism. The spring, which stores the required switching energy, can be recharged either with a motor or manually in an emergency.

### Common features of disconnecting and earthing switches

- The three poles of a bay are coupled mechanically.
- All three poles are commonly operated by one motor mechanism.
- Auxiliary switches and ON/OFF indicators are friction-locked.
- Identical motor operating mechanisms are used for disconnecting and earthing switches.
- Manual emergency operation is integrated.
- Enclosures can be fitted with inspection windows on request.



## Instrument transformers

Both current and voltage transformers are used for measuring and protection purposes.

### Current transformer

The current transformers are of the single-phase inductive type and preferably located on the outgoing side of the circuit-breaker. They can, however, be located at any point within the bay or substation. The high-voltage conductor forms the primary winding. The cores with the secondary windings are designed for the specific project to comply with the requirements for accuracy, rating, etc. Different ratios can be achieved via taps in the secondary winding. Secondary connections are routed through a gas-tight bushing plate to a terminal box. The pressurized SF<sub>6</sub> gas in the module serves as the primary insulation. The encapsulated design provides very high reliability in terms of electromagnetic compatibility (EMC).

### Voltage transformer

Each single-phase inductive voltage transformer is encapsulated in its own housing forming a separate gas-tight module. Each voltage transformer consists of the following main components:

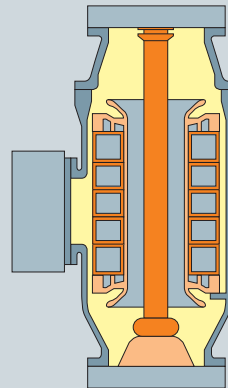
- The primary winding
- One or more secondary windings (forming one coil)
- An iron core

The pressurized gas inside the enclosure together with the film insulation provides insulation against high voltage. The high-voltage connection to the switchgear is established by means of the primary conductor, which is supported by a gas-tight bushing. The secondary connections are routed by means of a gas-tight bushing plate to the terminal box.

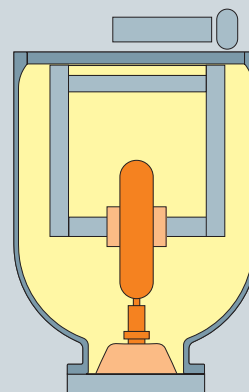
## Surge arrester

If required, encapsulated surge arresters can be connected directly. Their purpose is to limit any overvoltages.

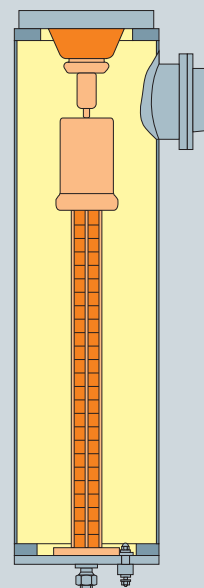
Their active parts consist of metal-oxide resistors with a strongly non-linear current/voltage characteristic. The arrester is generally flange-jointed to the switchgear via a gas-tight bushing. In the tank of the arrester module, there is an inspection hole, through which the internal conductor can be inspected. At the bottom there are the connections for gas monitoring, arrester testing, and an operation counter.



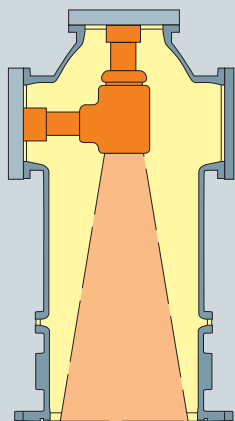
Example: Conventional current transformer



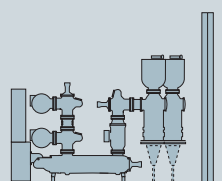
Example: Conventional voltage transformer



Surge arrester



Cable termination



## Termination modules

The termination modules connect the bays of the gas-insulated switchgear to the following items of equipment:

- Overhead lines
- Transformer or reactor
- Cables

They form the transition between the GIS with SF<sub>6</sub> gas insulation and other high-voltage systems with different insulating media.

### Cable termination

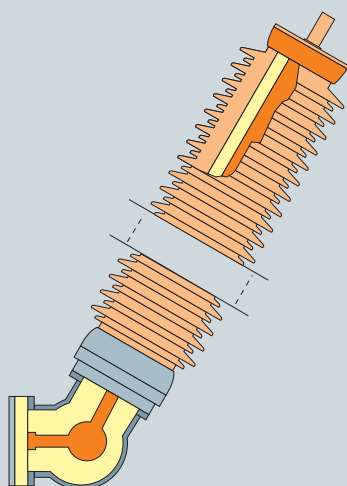
This module acts as a link between the metal-enclosed gas-insulated switchgear and the high-voltage cable. All types of standard high-voltage cables can be connected. The inspection hole also provides the connecting flange for the high-voltage cable-testing set. During high-voltage cable testing, the primary conductor between the cable sealing end and the switchgear can be removed.

### SF<sub>6</sub>/air termination

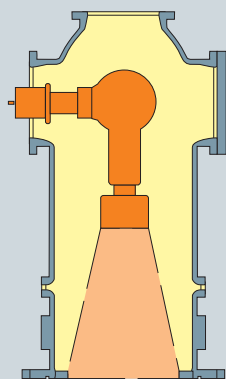
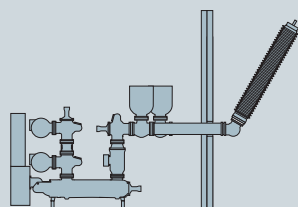
The SF<sub>6</sub>/air termination module enables the connection of the gas-insulated switchgear to air-insulated components or overhead lines. This termination is a combination of an angle-type module and an outdoor/SF<sub>6</sub> bushing. The length, shape-form, and creepage distance of the outdoor/SF<sub>6</sub> bushing can be adapted to various requirements regarding insulation coordination, minimum clearance, or degree of pollution.

### Transformer tube-termination

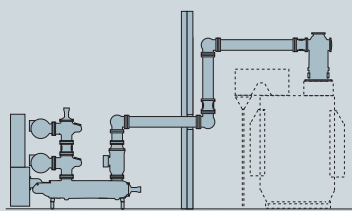
The transformer termination module enables a direct tube connection from the GIS to an oil-insulated transformer or reactor. For this purpose, the transformer bushing must be oil-tight, gas-tight, and pressure-resistant. Temperature-related movements of the switchgear and the transformer as well as the settling of foundations are absorbed by expansion joints in the tube connection.



SF<sub>6</sub>/air termination



Transformer tube-termination



## Busbar module

Busbars have a three-phase encapsulation. The busbar modules of adjacent bays are connected with expansion joints which absorb constructional tolerances and temperature-related movements in longitudinal as well as transverse direction to the busbar. Axially guided sliding contacts between the conductors compensate temperature-related expansions in conductor length. A sectionalizer (to increase the availability of the switchgear) can be fitted without any additional measures.

## Connecting modules

These single-pole enclosed modules are used for connections required within a bay and/or for gas-insulated busducts. The following connection modules can be employed depending on the circuit and the special layout of the bay:

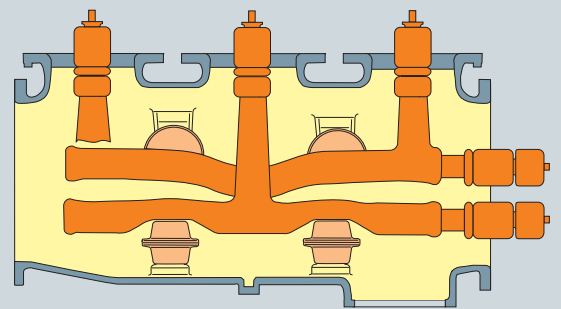
- Extension modules
- T-modules
- Angle-type modules
- Expansion-joint modules

### T-module

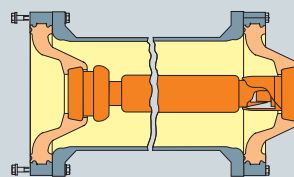
T-modules are used as a junction or for the connection of an earthing switch. Although they are available in different designs, the basic structure is always the same.

### Angle-type module

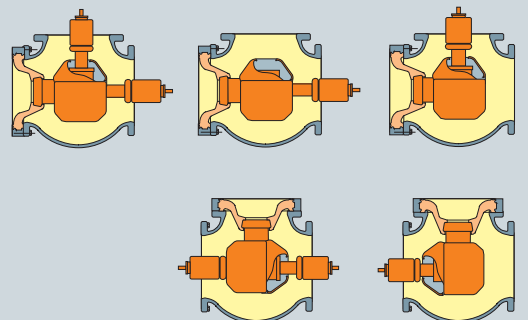
Angle-type modules are used for the splitting of the conductors into terminal leads. They are available with 30°, 45°, 60°, and 90° angles.



Busbar module



Extension module



Design versions T-modules



Design versions angle-type modules



# Control and Monitoring – Reliable and Flexible Control and Protection System

## Proven switchgear control

Robust electrical components are used to control and monitor the circuit-breaker as well as other switchgear components.

All elements necessary for the control and monitoring of circuit-breaker, disconnecting, and earthing switches are incorporated in the respective control unit. The switching device control systems are factory-tested and the switchgear is usually supplied with bay-internal cabling all the way to the integrated local control cubicle to reduce commissioning time to a minimum and to avoid any failures on-site.

## Gas monitoring

Gastight insulating partitions subdivide each switchgear bay into separate gas compartments (e.g., circuit-breakers with current transformer, disconnecting switches, voltage transformers, surge arresters, and termination modules). The gas compartments are constantly monitored by density monitors providing alarm and blocking signals via contacts. Monitoring takes place on a triple-pole decentralized basis.

## Reliable and flexible control and protection system

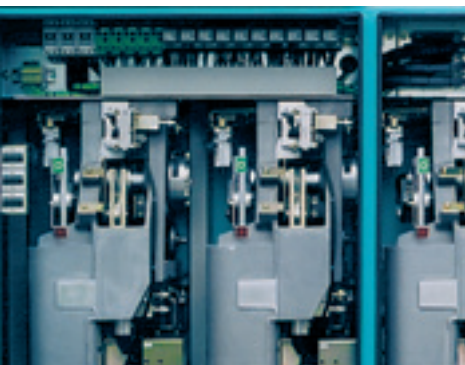
Control and feeder protection are generally accommodated in the local control cubicle, which is itself integrated in the operating panel of the switchgear bay. This substantially reduces the amount of space required and also the time needed for commissioning. If requested, a version of the local control cubicle is available for installation separate from the switchgear. The cabling between the separately installed local control cubicle and the high-voltage switching devices is connected up via coded plugs, which minimizes both the costs of installation and the risk of cabling failures.

On request, we can supply our high-voltage switchgear with any of the commonly available digital control and protection systems.

Standard interfaces in the local control allow the connection of

- Conventional control systems with protective interlocking and control panels
- Digital control and protection systems with user-friendly bay controllers and station automation with PC workstations (HMI)
- Intelligent, fully networked digital control and protection systems with additional monitoring and remote diagnostic functions.

Thanks to the extensive range of Siemens control and protection systems, we can offer you a wide range of customized concepts from a single source.



Example: Conventional control of the circuit-breaker



Bay with integrated local control cubicle



# Transport, Installation, Commissioning, Maintenance

## Transport

To facilitate easy transport and on-site installation, our switchgear assemblies are split into optimized shipping units with emphasis on ease-of-handling. In the case of type 8DN9, a completely assembled and tested bay prefilled with SF<sub>6</sub> gas is shipped as one transport. In the case of modules which contain switching devices, all operating-mechanism attachments are preset at the factory prior to shipment. All flanges where the modules are to be joined to other equipment are protected and sealed with transport covers. All goods are packed according to means, duration, and route of transport as well as in line with conditions and duration of storage. Shipments within Europe are normally done by road. Switchgears supplied to overseas countries are sealed in suitable shipping units with seaworthy packing taking into account any temporary storage that may be necessary.

## Installation and erection

The delivery of complete factory-assembled bays significantly reduces the effort required for installation at site. Detailed installation instructions and the use of relatively few special tools allow easy and rapid installation of the switchgear. It can even be effected by your own personnel under the supervision of an experienced supervisor from Siemens. Our training facilities are at your disposal.

## Commissioning

After completion of the assembly work on site, all switching devices and electrical circuits for controlling and monitoring are tested to ensure proper electrical and mechanical function of the whole system. All flanges are double-checked for tightness, especially those fitted on site. Commissioning work on the primary section ends with the high-voltage test to verify that all installation work, including the work done inside the enclosure, has been done correctly. All tests are performed in accordance with IEC standards and the results are documented in the final test reports.

## Maintenance

Our SF<sub>6</sub>-insulated switchgear installations are designed and manufactured to provide an optimum balance in design, manufacturing, operation, and maintenance. Due to the tightly-sealed enclosure, a minimum of maintenance is needed and the GIS-system can even be regarded as maintenance-free under normal operating conditions. Subject to environmental conditions, visual inspections are recommended. A visual inspection is carried out bay by bay without any need for outages or the opening of gas compartments. A major inspection is not recommended before 25 years of operation.



Seaworthy packing is ensured for overseas shipment



Short, uncomplicated erection and commissioning times enhances the attractiveness of the 8DN9



High-voltage test at site

# Quality Assurance

A consistent quality management system supported by our employees makes sure that we produce high-quality gas-insulated switchgear. The system was certified in 1983 in accordance with CSA Z299 and again in 1989 according to DIN EN ISO 9001. The quality management system is process-oriented and subject to continuous improvement. Certification according to DIN EN ISO 9001:2000 was passed with flying colors in 2003. As early as 1994, the environmental protection system according to DIN EN ISO 14001 was implemented as an addition to the existing quality management system and successfully certified. One of the fundamental milestones in developing testing competence was the certification of the test labs according to ISO/IEC 17025 (previously EN 45001) in 1992. From that point on, they have been considered independent.

The quality management and environmental protection systems cover every single process in our products' life cycles, from marketing to after-sales service. Regular management reviews and internal audits of all processes based on the consistent documentation of all processes relevant to quality and environmental protection ensure that the system is efficient and up-to-date at all times and that appropriate measures are taken to continuously improve it. Consequently, the quality of our switchgear meets even the highest requirements.

In addition to consistent quality management and environmental protection, the special "clean" areas set up in the production workshops are an important contribution towards the high quality of our gas-insulated switchgear.

Comprehensive manufacturing inspections and routine testing of individual components, sub-assemblies, and modules all ensure reliable operation of the overall product. Mechanical routine and high-voltage tests of the complete bay or complete shipping units verify that the manufactured quality complies with the standards. Suitable packing provides for the switchgear's safe arrival at its destination.



High-voltage testing of a complete transport unit





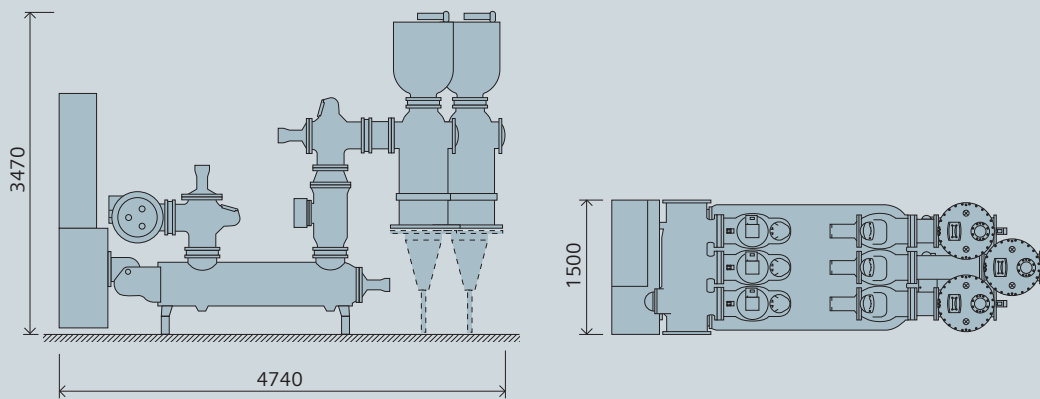
# Technical Data

Switchgear type		8DN9
Rated voltage	up to	245 kV
Rated frequency		50/60 Hz
Rated power frequency withstand voltage (1 min)		460 kV
Rated lightning impulse withstand voltage (1,2/50 µs)		1,050 kV
Rated switching impulse withstand voltage (250/2500 µs)		850 kV
Rated normal current busbar	up to	3,150 A
Rated normal current feeder	up to	3,150 A
Rated short-breaking current	up to	50 kA
Rated peak withstand current	up to	135 kA
Rated short-time withstand current	up to	50 kA
Leakage rate per year and gas compartment		≤ 0.5 %
Bay width		1,500 mm
Height, depth	see typical bay arrangements	
Driving mechanism of circuit-breaker		stored-energy spring
Rated operating sequence		O-0.3 s-CO-3 min-CO CO-15 s-CO
Rated supply voltage		60–250 V DC
Expected lifetime		> 50 years
Ambient temperature range		–25 °C to +40 °C
Standards		IEC/IEEE
Other values on request		

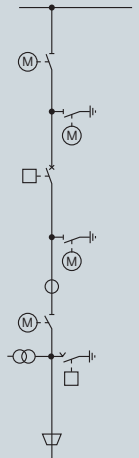
# Typical Bay Arrangements

The modular system not only allows all customary circuit arrangements but also individual solutions for specific building dimensions, system extensions, and much more.

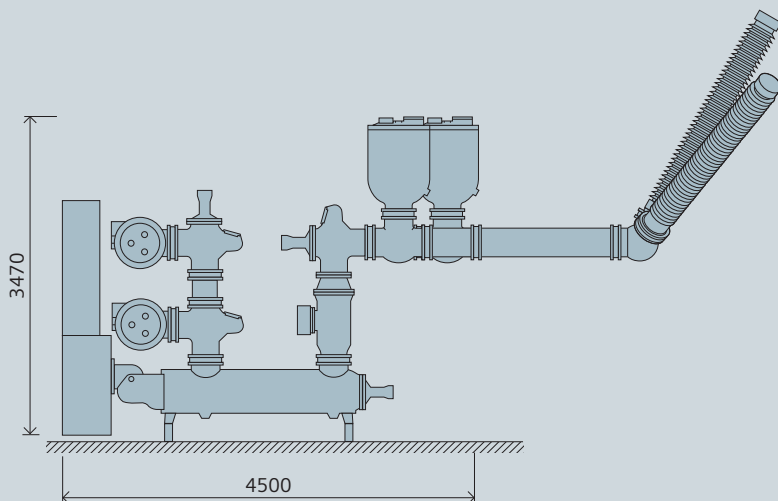
Single busbar arrangement



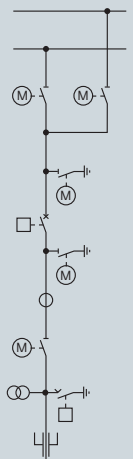
Weight of bay: approx. 5 t



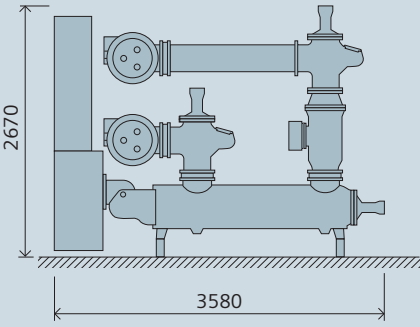
Double busbar arrangement



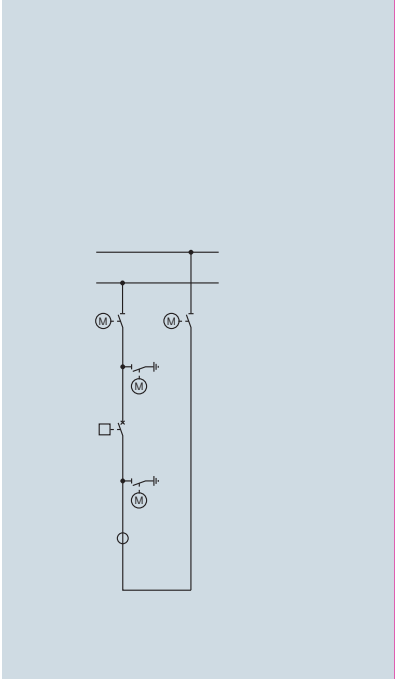
Weight of bay: approx. 5 t



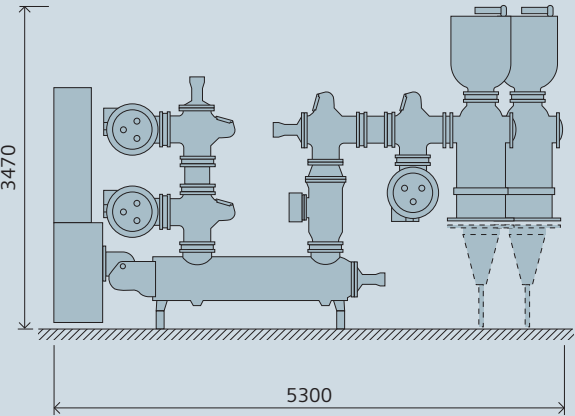
Bus coupling arrangement



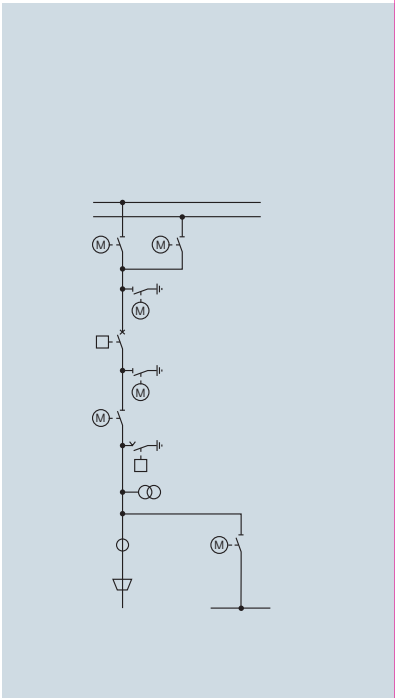
Weight of bay: approx. 4 t



Double busbar arrangement with transfer bus

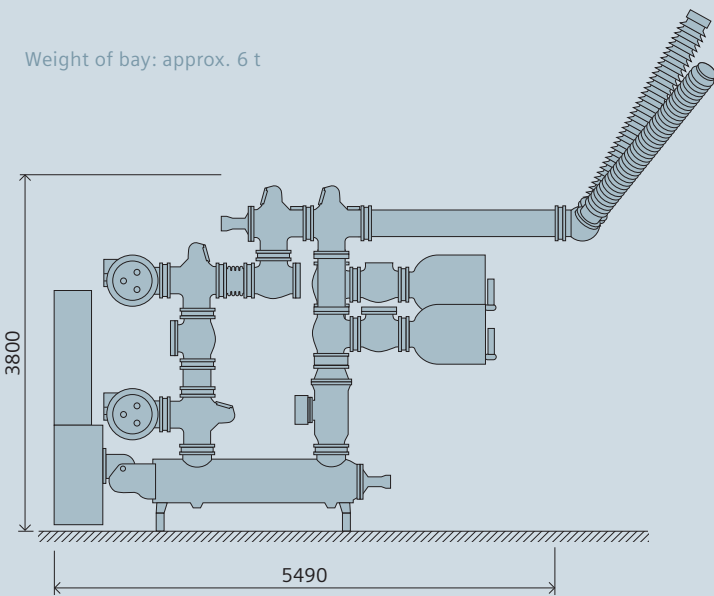


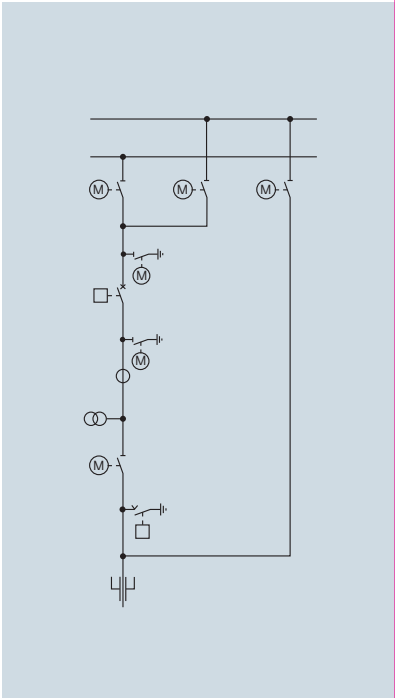
Weight of bay: approx. 6 t



Double busbar arrangement with bypass

Weight of bay: approx. 6 t







# For Further Information

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