Gas-insulated switchgear up to 245 kV, 50 kA, 4000 A
Type 8DN9

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Gaining from experience

Our switchgear ensures extraordinarily high availability with low operating costs.
The Siemens gas-insulated switchgear (GIS) is an extremely successful product concept. Since its introduction back in 1968, Siemens has installed more than 28,000 indoor and outdoor switchgear bays worldwide, and well over 300,000 bay-years of operation have been recorded. Intense research and continuous further development of the first system types have 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 gastightness
- Long service life
- Low life-cycle and maintenance costs
- Easy access and ergonomic design
- High availability
- Reliable operation even under extreme environmental conditions

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

The space-saving design, low weight, and long operating life plus 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 this switchgear even in sensitive environments, residential quarters, and city centers. Thanks to its excellent characteristics, our 8DN9 switchgear fulfills all the requirements for environmentally compatible high-voltage switchgear.
Flexibility thanks 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 arranged in pressure-resistant gastight enclosures. With a remarkably small variety of active and passive modules, it is possible to meet all customary bus schemes.

8DN9 type switchgear benefits from the advantages of 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. Modern forming and casting techniques made possible the optimization of the dielectric and mechanical characteristics of the enclosure. The low bay weight results in minor floor load. The flanges at all module joints are equipped with high pressure O-ring seals to ensure high gastightness.

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 gastight and pressure-resistant covers. Sulphur hexafluoride (SF₆) 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. SF₆ 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.

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

Gastight bushings
Gas-permeable bushings
Circuit-breaker module

The central element of a switchgear bay within the gas-insulated switchgear is the single-phase encapsulated circuit breaker. The circuit breaker is designed for single-pole automatic reclosure. It consists of two main components:

- Interrupter unit
- Stored-energy spring mechanism

The design of the interrupter unit and the spring mechanism is based on time-tested identical constructions widely used in air-insulated as well as gas-insulated switching technology for many years. This design, decades of experience, and high quality guarantee the surpassing reliability of our switchgear.

Stored-energy spring mechanism

The stored-energy spring mechanism provides the force required to operate the circuit breaker. It has a compact, corrosion-free aluminum housing. Both the opening and the closing spring are visibly arranged within the drive unit. The complete drive unit is strictly separated from the SF₆ compartment. Roller bearings and the maintenance-free spring mechanism ensure decades of reliable operation. Proven technology, such as vibration-isolated latches and load-free isolation of the charging mechanism, improve the reliability of the mechanism.

The advantages of the stored-energy spring mechanism:

- Identical construction principle for rated voltages from 72.5 to 550 kV
- Low operating energy
- Simple principle of operation
- Switching state controllable at all times
- Low maintenance, economical with a long service life
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 little operating energy, which keeps the mechanical stresses on the circuit breaker and its housing as well as the foundation loads to a minimum.

Current path
In the closed position, the operating current flows through the contact finger (2) and the contact cylinder (10). The arcing contacts (1, 7) are connected in parallel to the main contacts.

 Interruption of operating current
During the breaking operation, the contact finger (2) with the contact cylinder (10) opens and the current commutates to the arcing contacts (1, 7), which are still closed. This avoids erosion of the main contacts. As the breaking operation continues, an arc forms between the contacts (1) and (7). At the same time, the contact cylinder (10) compresses the SF$_6$ 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 currents
In the case of large short-circuit currents, the gas between the arcing contacts (1) and (7) is heated by the arc energy. Thus, the pressure in the heating volume (11) increases. When the current passes through zero, the gas flows back from the heating volume (11) through the nozzle (9) and quenches the arc. The valve (3) of the contact cylinder (10) prevents the high-pressure gas from entering the compression volume (4). Thus, the operating mechanism does not have to supply the arc-quenching energy.

Arc-quenching principle
1. Moving arcing contact
2. Main contact
3. Check valve
4. Compression volume
5. Check valve
6. Steering gear
7. Moving arcing rod
8. Insulating nozzle
9. Auxiliary nozzle
10. Contact cylinder
11. Heating volume
Disconnecting switches

In the open position, disconnecting switches assure a dielectrically safe gap between system parts at different potentials; for example, the busbar disconnector isolates the feeders from the busbar. Cast-resin bushings keep the contact system in place, and the pressurized gas serves as the high-voltage insulating medium between live parts and the metal housing.

The conductor terminals vary for different types of adjacent modules. Up to two earthing switches can be installed simultaneously. The disconnecting switches can be built as separate gas compartments with their own monitoring or be combined with surrounding modules.

Earthing switches

Earthing switches (work-in-progress earthing switches or busbar earthing switches, for example) are used for properly connecting de-energized live parts of the high-voltage system to the grounding system. On the outgoing side of the feeders, a make-proof version (high-speed) is frequently used to dissipate inductive and capacitive currents from parallel cables or overhead lines or to reduce the risk to the GIS system in case of faulty connections. In the insulated design they are also used for measuring purposes and for testing protection relays.

In the switchgear type 8DN9 up to 245 kV, the earthing switches are of a pin-type design. Depending on the switchgear design, they are either incorporated in a common housing with the disconnection switches or installed in a separate housing. With the pin-type earthing switch, the earthing pin at earth potential is pushed into the matching 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.

Surge arrester

If desired, 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 gastight bushing that is included with the delivery. An inspection hole in the arrester housing allows opening the internal conductor when inspecting the switchgear. The connections for gas monitoring, arrester testing, and a surge counter are at the bottom.
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 with one or more cores 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 located on a grounded electrode and are designed to comply with the requirements in terms of accuracy, class, and power rating. Different ratios can be achieved via taps in the secondary winding. Secondary connections are routed through a gastight bushing plate to a terminal box. The pressurized SF₆ gas in the module serves as the primary insulation. The encapsulated design provides very high reliability in terms of electromagnetic compatibility (EMC).

Voltage transformer/RC-voltage divider
Each single-phase inductive voltage transformer is encapsulated in its own housing and thus forms 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 in combination with the film insulation provides insulation against high voltage. The high-voltage connection to the switchgear is established via the primary conductor, which is supported by a gastight bushing. The secondary connections are routed via a gastight bushing plate to the terminal box.

Resistive-capacitive voltage dividers (RCVD) consist of oil-impregnated capacitive elements with parallel mounted resistors in hermetically-sealed glass-fiber-reinforced plastic tubes (GRP). The RCVD has a common gas compartment with the neighboring gas compartment. It is also available in another version with a separate gas compartment. The secondary connection can either be designed as a single or as a double unit (redundant version). The RCVD has a smaller size and weight in comparison to inductive voltage transformers. It is a ferroresonance-free technology with no saturable cores. The RCVD maps high voltage in linear form over a wide frequency range from DC up to 20 kHz and has an excellent transient characteristic. The power output is low but sufficient for the demands of modern protection and energy counting systems (e.g. SiPROTEC 5).
Termination modules

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

- Cables
- Overhead lines
- Transformer or reactor

They form the transition between the GIS with SF₆ 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 high-voltage cables complying with IEC 62271-209 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.

SF₆/air termination

The SF₆/air termination module enables the connecting of the gas-insulated switchgear to air-insulated components or overhead lines by means of a bushing, which is available either as a porcelain or a composite insulator. This termination is a combination of an angle-type module and an SF₆ bushing. The length, shed form, and creepage distance of the outdoor/SF₆ bushing can be adapted to various requirements with regard to insulation coordination, minimum clearance, or degree of pollution.

Transformer 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, gastight, 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 (acc. to IEC 61639/IEC 62271-211).
Busbar module

The switchgear type 8DN9 up to 245 kV has a three-phase encapsulated passive busbar. 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 for 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.
Control and monitoring – a 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
Gas-tight 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.
Transport
To facilitate easy transport and on-site installation, our switchgear assemblies are split into optimized shipping units with emphasis on ease of handling. Standard switchgear bays are usually shipped in one transport. All shipping units are mechanically and dielectrically tested before dispatch. In the case of modules that contain switching devices, all operating-mechanism attachments are preset at the factory prior to shipment. All flanges where the modules join to other equipment are protected against corrosion and sealed with transport covers.

All components are packed according to means, duration, and route of transport as well as the conditions and duration of storage. Shipments within Europe are normally sent by road. Switchgear supplied to countries overseas are sealed in appropriate shipping units with seaworthy packing, taking into account any temporary storage that may be necessary.

On-site installation
Dividing the switchgear into a few, easy-to-handle shipping units reduces the time and effort required for installation on site. Detailed installation instructions and relatively few special tools allow easy and rapid installation of the switchgear. It can even be performed by your own personnel under the supervision of an experienced supervisor from Siemens. Our training facilities are at your disposal if needed.

Commissioning
After completion of the assembly work on-site, all switching devices and electrical circuits for controlling and monitoring are tested to ensure the accurate electrical and mechanical functioning of the entire system. All flanges are double-checked for tightness. Commissioning work on the primary section ends with the high-voltage test on site to verify that all installation work has been conducted correctly. All tests are performed in accordance with IEC standards and the results are documented in the final test reports.

Maintenance
Our gas-insulated switchgear installations are designed and manufactured to provide an optimal balance of design, materials used, and maintenance measures. Thanks to the hermetically sealed enclosure, a minimum of maintenance is needed and the GIS system can even be regarded as maintenance-free under normal operating conditions. Depending on environmental conditions, visual inspections are recommended. A visual inspection is performed bay by bay, with no need for an outage or opening the gas compartments. The first major inspection is not due for 25 years.
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 subject to continual 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 and the accreditation as an independent PEHLA test lab.

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 continually 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 to the high quality of our gas-insulated switchgear.

Comprehensive manufacturing inspections and routine testing of individual components, subassemblies, and entire modules all play an important role in ensuring the 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. Appropriate packing ensures the switchgear’s safe arrival at its destination.
Switchgear bay examples

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

<table>
<thead>
<tr>
<th>Switchgear type</th>
<th>8DN9</th>
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<tbody>
<tr>
<td>Rated voltage</td>
<td>up to 245 kV</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Rated short-duration power-frequency withstand voltage (1 min)</td>
<td>up to 460 kV</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage (1.2 / 50 μs)</td>
<td>up to 1,050 kV</td>
</tr>
<tr>
<td>Rated normal current busbar</td>
<td>up to 4,000 A</td>
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<tr>
<td>Rated normal current feeder</td>
<td>up to 4,000 A</td>
</tr>
<tr>
<td>Rated short circuit-breaking current (&lt; 3 cycles)</td>
<td>up to 50 kA</td>
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<tr>
<td>Rated peak withstand current</td>
<td>up to 135 kA</td>
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<tr>
<td>Rated short-time withstand current (up to 3 s)</td>
<td>up to 50 kA</td>
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<tr>
<td>Leakage rate per year and gas compartment (type-tested)</td>
<td>&lt; 0.1%</td>
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<tr>
<td>Driving mechanism of circuit breaker</td>
<td>stored-energy spring</td>
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<tr>
<td>Rated operating sequence</td>
<td>0-0.3 s-CO-3 min-CO</td>
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<td></td>
<td>CO-15 s-CO</td>
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<tr>
<td>Bay width</td>
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<tr>
<td>Bay height, depth (depending on bay arrangement)</td>
<td>3,700 mm x 5,100 mm</td>
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<tr>
<td>Bay weight (depending on bay arrangement)</td>
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<tr>
<td>Ambient temperature range</td>
<td>–25 °C up to +55 °C</td>
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<tr>
<td>Installation</td>
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<td>First major inspection</td>
<td>&gt; 25 years</td>
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<tr>
<td>Expected lifetime</td>
<td>&gt; 50 years</td>
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<td>Standards</td>
<td>IEC / IEEE / GOST</td>
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Other values on request