Gas-insulated switchgear up to 145 kV, 40 kA, 3150 A type series 8DN8

Answers for energy.
Benefiting from experience

Our 8D series of gas-insulated switchgear represents a highly successful product concept.

Since its introduction in 1968, Siemens has installed more than 24,000 bays worldwide. A total of well over 285,000 years of bay operation have since been recorded.

Intensive research work, many years of system experience, and continuous further development of the first system types have ultimately led to today's generation of gas-insulated, metal-enclosed switchgear – a world leader when it comes to

- economic efficiency
- high reliability
- long service life
- safe encapsulation
- very high degree of gas-tightness
- low life cycle and maintenance costs
- easy access and ergonomic design
- high availability
- reliable operation even under extreme environmental conditions
Our type series 8DN8 switchgear for all voltage levels from 72.5 kV to 145 kV represents one of the most compact systems of its kind available worldwide, and meets all of today’s requirements for modern, pioneering switchgear in terms of efficiency and economy. Its space-saving design and its low weight help make this switchgear extremely economical.

Since the levels of noise and field emission (EMC) are extremely low, it is possible to easily integrate 8DN8 switchgear even in sensitive environments, residential quarters, and city centers. They feature high energy efficiency over the entire process chain – from production and commissioning to recycling – and meets all current requirements for environmentally compatible high-voltage switchgear.

Switchgear type series 8DN8 145 kV combines technical expertise with all standards and advantages of the Siemens 8D type series. It also offers a number of distinct advantages:

- Rapid availability thanks to time-saving delivery and installation concepts
- Independence from atmospheric and external influences
- Suitability for indoor and outdoor installation
- Convincingly space-saving system configurations (e.g. H configuration, 1½ breaker, ring, etc.)
- High flexibility of switchgear arrangement for optimized system management
- Adaptable to all predecessor models of the same voltage level

Switchgear type series 8DN8 72.5 kV corresponds to switchgear 8DN8 145 kV with regard to construction and technical design but it is significantly smaller. The extremely small component dimensions allow it to be deployed wherever space is at a premium.
A fundamental feature of our gas-insulated switchgear is the high degree of versatility made possible by its modular system. Depending on their respective functions, the components are housed either individually and/or combined in pressure-resistant, gas-tight enclosures. With a remarkably small number of active and passive modules, all customary bus schemes are possible. Standard adapters ensure compatibility with all predecessor models of the same voltage level.

Three-phase enclosures are used for type series 8DN8 switchgear in order to achieve extremely low component dimensions. This concept allows a very compact design with minimum space requirement. The ergonomic modular principle makes for easy access to control elements.

Aluminum is used for the enclosure. This guarantees freedom from corrosion and ensures lightweight equipment. The use of modern construction methods and casting techniques makes it possible to optimize the enclosure’s dielectric and mechanical characteristics. The low bay weight ensures minimal floor loading and eliminates the need for complex foundations.

All the modules are connected to one another by means of flanges. The gas-tightness of the flange connections is assured by O-ring seals that have been proven in operation since 1968.

Temperature-related changes in the length of conductors are compensated by coupling contacts. Where necessary, the joints are accessible via openings sealed with gas-tight covers. Sulfur hexafluoride (SF₆) is used as the insulating and arc-quenching medium. It is contained in an extremely gas-tight enclosure so that it cannot pollute the environment.

Gas-tight bushings allow subdivision of the bay into a number of separate gas compartments, each of which is provided with its own gas monitoring equipment. The static filters in the gas compartments absorb moisture and decomposition products. The use of rupture diaphragms reliably prevents shattering of the enclosure in the case of buildup of abnormally high pressure. Diverter nozzles on the rupture diaphragms ensure that the gas is expelled in a defined direction in the event of bursting, thus ensuring that the operating personnel are not endangered.
Three-phase enclosure allows compact design:
8ND8 145 kV, cable bay with double busbar

1. Integrated local control cubicle
2. Support for control cubicle
3. Current transformer
4. Busbar II with disconnector and earthing switch
5. Interrupter unit of the circuit-breaker
6. Busbar I with disconnector and earthing switch
7. Stored-energy spring mechanism with circuit-breaker control unit
8. Voltage transformer
9. High-speed earthing switch
10. Outgoing feeder module with disconnector and earthing switch
11. Cable sealing end
Circuit-breaker module

The central element of the gas-insulated switchgear is the three-pole encapsulated circuit breaker comprising the following two main components:

- interrupter unit
- operating mechanism

The design of the interrupter unit and of the stored-energy spring mechanism is based on proven and in most cases identical designs which have often been used for outdoor switchgear installations worldwide.

Operating mechanism

The stored-energy spring mechanism provides the force for opening and closing the circuit-breaker. It is installed in a compact corrosion-free aluminum housing. The closing spring and the opening spring are arranged in order to ensure good visibility within the drive unit. The entire drive unit is completely isolated from the SF₆ gas compartments. Roller bearings and a maintenance-free spring mechanism ensure decades of reliable operation.

Proven design principles of Siemens circuit-breakers are used, such as vibration-isolated latches and load-free isolation of the charging mechanism. The operating mechanism offers the following advantages:

- defined switching position which is securely maintained even if the auxiliary power supply fails
- tripping is possible irrespective of the status of the closing spring
- high number of mechanical operations
- low number of mechanical parts
- compact design
- choice of single-pole or common drive design. The single-pole version allows single-pole automatic reclosing.
Interrupter unit

The interrupter unit used in the circuit-breaker for arc quenching operates on the proven self-compression principle. Since this requires only minimal operating energy the mechanical stresses involved are low. Stressing of both the circuit-breaker and the housing is reduced.

The current path

In the case of a self-compression circuit-breaker, the current path is formed by the contact support (1), the base (6), and the moving contact cylinder (5). In the closed position, the operating current flows through the contact finger (3) and the arcing contact (4) which is also closed.

Interruption of operating current

During the breaking operation, the contact finger (3) opens first and the current continues to flow via the arcing contact (4), which is still closed. This prevents erosion of the main contacts. As the breaking operation progresses, the arcing contacts (4) open and an arc develops between them. Simultaneously, the contact cylinder (5) moves into the compression volume (6) and compresses the remaining arc-quenching gas. The compressed arc-quenching gas flows through the contact cylinder (5) into the contact gap and extinguishes the arc.

Interruption of fault currents

If the short-circuit current is high, the arc-quenching gas at the arcing contact is heated considerably by the arc's energy. This leads to a strong, additional rise in the pressure in the contact cylinder and builds up the necessary arc-quenching energy. Consequently, this energy does not have to be supplied by the operating mechanism. As the switching operation progresses, the fixed arcing contact releases the outflow from the nozzle (2). The gas now flows out of the contact cylinder and through the nozzle, thus extinguishing the arc.
Variations are possible with switchgear type series 72.5 kV

### Three-position switching device

The functions of a disconnecting switch and an earthing switch are combined in a three-position switching device.

The moving contact either closes the gap or connects the high-voltage conductor to the mating contact of the earthing switch. Integral mutual interlocking of the two functions is achieved as a result of this design, thus eliminating the need for providing corresponding electrical interlocking. An insulated connection to the mating contact of the earthing switch is provided outside the enclosure for test purposes. In the third, neutral position, neither the disconnector contact nor the earthing switch contact is closed. The three poles of a bay are mutually coupled and all three poles are operated at once by a motor drive. Force is transmitted into the enclosure via gas-tight rotating shaft glands. The alarm switches and the on/off indicators are friction-locked and are connected directly to the drive shaft. Manual emergency operation is possible. The enclosure can be provided with generously sized view ports, through which the switching position of all three phases is visible.

The three-position switching device is contained in a number of different modules:

#### Outgoing feeder module

The outgoing feeder module connects the basic bay with various termination modules (for cable termination, overhead line termination, and transformer termination). It contains a three-position switching device, which combines the functions of an outgoing feeder disconnector and of a bay-side earthing switch (work-in-progress type). Installation of a high-speed earthing switch and of a voltage transformer is also possible where required. The high-voltage site testing equipment is generally connected to this module.

#### Busbar module

Connections between the bays are effected by means of busbars. The busbars of each bay are enclosed. Adjacent busbar modules are coupled by means of expansion joints. The module contains a three-position switching device, which combines the functions of a busbar disconnecting switch and of a bay-side earthing switch (work-in-progress type).

The busbar can also be of the passive type.

#### Bus sectionalizers

Bus sectionalizers are used for isolating the busbar sections of a substation. They are integrated in the busbar in the same manner as a busbar module. The module contains a three-position switching device which combines the functions of a bus sectionalizer and of an earthing switch (work-in-progress type).
**High-speed earthing switch**

The high-speed earthing switch used is of the so-called “pin-type.” In this type of switch, the earthing pin at earth potential is pushed into the tulip-shaped mating contact. The earthing switch is equipped with a spring-operated mechanism, charged by an electric motor.

**Instrument transformers**

Current and voltage transformers are used for measuring, protection, and monitoring purposes and can be integrated at any point within the substation. The secondary connections are led out of the enclosure through gas-tight bushings and brought into contact with terminals. They are supplied in a number of variants – ranging from conventional instrument transformers of different classes and standards to advanced current and voltage sensors.

**Current transformer**

As a general rule, conventional induction type current transformers are used which are individually matched to the different requirements of measurement and protection systems. The high-voltage conductor forms the primary winding. The individual cores with the secondary windings constitute independent measurement circuits. Changeover to a different transformation ratio is possible by means of secondary-side tab connections. The current transformer should preferably be arranged in the bay directly downstream of the circuit-breaker.

**Voltage transformer/voltage divider**

Conventional induction type voltage transformers, which are individually matched to the different requirements of measurement and protection systems, are predominantly used. Voltage transformers should preferably be provided on the busbar and in the outgoing circuit. Optional insulating clearances at the primary terminal enable the transformer to be switched on and off in the high-voltage test.

Voltage transformers of the “Power VT” design provide a convenient interface for carrying out high-voltage tests effortlessly, not only during commissioning but also over the entire life cycle of a GIS system, for example after expansions.

R/C voltage dividers are designed to match advanced digital measurement and protection systems. They map high voltage in linear form over a wide frequency range and are therefore suitable, for example, for monitoring voltage quality, especially for networks in which semiconductor technologies are used to an increasing extent.
Variations are possible with switchgear type series 72.5 kV

Connection modules

Connection modules join system components within a bay. They are also used for pipework penetrations and form the connection between switchgear components situated far apart. They also provide a means of connecting equipment such as transformers or overhead lines located some distance away. Both single-pole and three-pole encapsulated connection modules are available depending on the circuit and the spatial layout of the bay.

Extension modules

Extension modules connect switchgear components that are a long way away from each other in a straight line.

T-modules

T-modules are used as branch-off points or for attaching a surge arrester, voltage transformer, earthing switch, or outgoing feeder module. Their basic design is always the same in every version.

Angular modules

Angular modules are used for splitting the conductors in outgoing leads. They are available in designs with angles of 30°, 45°, 60°, and 90°. With the three-pole 90° module it is also possible to implement offset system designs and long outgoing leads.

Splitting module, single-pole/three-pole

Splitting modules are used for connecting three-pole switchgear components to single-pole components. As a rule, they form the connection between the outgoing feeder module and various termination modules (for example, overhead line termination, transformer termination).

Surge arrester

If required, encapsulated surge arresters can be connected directly. They serve to limit overvoltages that may occur. Their active part consists of metal-oxide resistors with strongly non-linear current/voltage characteristics. The arrester is generally flange-jointed to the switchgear via a gas-tight bushing. The arrester housing incorporates an inspection hole, through which the internal conductor can be accessed for inspection purposes. There are connections for gas monitoring and arrester testing on the underside.
Termination modules

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

- overhead line
- transformer or reactor
- cable

They thus form the transition between the SF$_6$ gas insulation within the enclosure and other insulating media.

Cable termination

This three-pole module links the metal-enclosed gas-insulated switchgear with the high-voltage cables. All customary types of high-voltage cables can be connected without problem via conventional cable sealing ends or plug-in types. The primary conductor between the cable sealing end and the switchgear can be removed in the neighboring outgoing feeder module to perform a high-voltage withstand test.

SF$_6$/air termination

The single-pole SF$_6$/air termination module forms the transition from the gas-insulated switchgear to air-insulated components or overhead lines. This termination is a combination of single-pole connection modules and an outdoor/SF$_6$ bushing. Length, shed form, and creepage distance of the outdoor/SF$_6$ bushing are determined in line with insulation coordination, minimum clearance, and degree of pollution. The outdoor termination module is suitable for air-insulated connections between GIS and

- overhead lines
- outdoor bushings of outdoor transformers or reactors
- outdoor sealing ends of high-voltage cables.

The splitting of the connection points for the three phases with the necessary clearance in air for conductor insulation is taken into account in the design of the switchgear.

Transformer tube-termination

Similar to the outdoor termination module, the single-pole transformer termination module is connected to the three-phase encapsulated basic bay via a combination of connection modules. It effects the transition from the GIS directly to the bushing of oil-insulated transformers or reactors. The transformer bushing must be oiltight and resistant to gas pressure. Temperature-related movements and non-uniform settling of the switchgear and transformer foundations are absorbed by expansion joints.
Control and monitoring – consistent and flexible control and protection

Proven switchgear control

All the elements for the auxiliary and control circuits are accommodated in a decentralized arrangement in the high-voltage switching devices. The complete drive mechanisms for the switchgear are factory-tested. Only tried and tested Siemens technology is used in the auxiliary and control circuits.

Switchgear is usually supplied complete with bay-internal cabling, for example all the way to the integrated local control cubicle. This minimizes the time required for installation and commissioning and reduces the possibilities of error.

Additional sensors and interfaces can be provided optionally for diagnostics systems or modules for permanent monitoring of the precise current data condition.

Gas monitoring

Each switchgear bay is divided into a number of gas compartments. These gas compartments are constantly monitored by means of density monitors with integrated indicators; any deviations are indicated as soon as they reach the defined response threshold. The optionally available density sensors allow remote indication and further processing of the current measured value for each gas compartment in digital control and protection systems.

Flexible and reliable 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 reduces the amount of space needed and the time required for commissioning. Alternatively, a version of the local control cubicle for installation separate from the switchgear is available as a flexible solution for meeting different requirements with respect to the arrangement of the control and protection components. The cabling between the local control cubicle and the high-voltage switching devices is effected via coded plugs, which minimizes both the installation cost and the risk of cabling errors.

Of course, type series 8DN8 switchgear is available on request with any commonly available bay and substation control and protection systems as well as uniform systems to meet your individual requirements. Standard interfaces in the switchgear control allow interfacing of

- conventional control systems with protective interlocking and control panel
- digital control systems with user-friendly bay controllers and substation automation with PC operator station (HMI)
- intelligent, fully networked digital control and protection systems with supplementary monitoring and remote diagnostic functions.

The wide range of Siemens control and protection systems enables us to provide customized concepts from a single source.
Transport, installation, commissioning, operation, and maintenance

Transport

The 8DN8 is optimized for transport and on-site installation. Thanks to the compact dimensions of the 8DN8 it can be shipped in standard containers and by road, and is transported in the largest possible units that are still easy to handle. It is thus possible to dispatch up to six single or three double switchgear bays, completely assembled and tested, as a single transport unit. In transport units containing 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 against corrosion and sealed with transport covers. All items are packed according to the specific transport conditions. Special sealed packing is used for shipments to countries outside Europe, allowing transport overseas and combined transport and storage durations of 12 months or more.

Installation and assembly

The delivery of complete factory-assembled and tested single and double bays reduces the time and effort required for installation on-site. It only needs simple devices to move the transport unit to its installation position and align it for assembly with the other bays. A mounting frame facilitates movement and rapid alignment of the bays. Only few anchorings and hardly any additional steel supports are required for securing the switchgear to the foundation. Depending on the bay design, only the bay termination needs to be assembled. On the secondary side, only bay-to-bay cabling and interfacing to the substation control and protection system are required.

Siemens provides complete installation and commissioning on site. Uncomplicated work procedures, detailed installation instructions, and the use of relatively few special tools allow easy and rapid installation of the switchgear by your own personnel under the guidance of an experienced supervisor from Siemens. If required, your personnel can acquire the necessary know-how in a special training program.

Commissioning

After assembly, the entire switchgear undergoes final testing for gas-tightness. At the same time, all switching devices and all electrical circuits for control and monitoring are tested to ensure their proper function in both mechanical and electrical terms. All tests are performed in conformity with IEC and the results documented in reports.

Operation and maintenance

Our gas-insulated switchgear is designed and manufactured so as to achieve an optimal balance of design, materials used, and maintenance required. The hermetically sealed enclosures and automatic monitoring ensure that the assemblies are practically maintenance-free under normal operating conditions. We recommend that the first major inspection be carried out after 25 years.
A consistent quality management system supported by our employees ensures the production of gas-insulated switchgear of the highest quality. 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. Naturally, the Siemens QM system has been successfully re-certified at regular intervals according to DIN EN ISO 9001. As early as 1994, a DIN EN ISO 14001-compliant environment management system was implemented as an addition to the existing management system and successfully certified.

One of the major milestones in developing testing expertise 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 and environment management systems cover every single process in our products’ life cycles, from marketing to after-sales service.

Regular management reviews and audits of all processes ensure that the system is effective and up-to-date at all times and that appropriate measures are taken to continuously improve it. The audits are based on the consistent documentation of all processes relevant to quality and the environment. The quality of our switchgear consequently 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 complete modules all ensure reliable operation of the overall product. Routine mechanical tests and final high-voltage testing of the complete bay or complete shipping units verify that the manufactured quality complies with the standards.

The expert packing concept is optimized along ecological lines and provides for the switchgear’s safe arrival at its destination. Design aspects also play a crucial role in the outstanding ecological balance of type series 8DN8 switchgear. The exceptionally compact construction results in low consumption of materials and energy in production, a relatively small requirement for SF₆, resource-saving transport options without wood packaging and finally lower space requirement for installation of the switchgear.
Typical bay arrangements

All the standard circuit configurations can be realized using our type series 8DN8 switchgear.

Variations are possible with switchgear type series 72.5 kV
Ring busbar

Variations are possible with switchgear type series 72.5 kV
Variations are possible with switchgear type series 72.5 kV

Typical configuration with H-configuration
Technical data

<table>
<thead>
<tr>
<th>Switchgear type series</th>
<th>8DN8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>72.5/145 kV</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Rated power frequency withstand voltage (1 min)</td>
<td>140/275 kV</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage (1.2/50 μs)</td>
<td>325/650 kV</td>
</tr>
<tr>
<td>Rated normal current busbar</td>
<td>2500/3150 A</td>
</tr>
<tr>
<td>feeder</td>
<td>2500/3150 A</td>
</tr>
<tr>
<td>Rated short-breaking current</td>
<td>31.5/40 kA</td>
</tr>
<tr>
<td>Rated peak withstand current</td>
<td>85/108 kA</td>
</tr>
<tr>
<td>Rated short-time withstand current</td>
<td>31.5/40 kA</td>
</tr>
<tr>
<td>Leakage rate per year and gas compartment</td>
<td>≤ 0.5% routine test</td>
</tr>
<tr>
<td></td>
<td>≤ 0.1% type test</td>
</tr>
<tr>
<td>Bay width</td>
<td>650/800/1200 mm</td>
</tr>
<tr>
<td></td>
<td>25.59/31.50/47.24 inches</td>
</tr>
<tr>
<td>Height, depth</td>
<td>see typical bay arrangements</td>
</tr>
<tr>
<td>Circuit-breaker operating mechanism (single-pole or common drive)</td>
<td>stored-energy spring</td>
</tr>
<tr>
<td>Rated operating sequence</td>
<td>O-0.3 s-CO-3 min-CO</td>
</tr>
<tr>
<td></td>
<td>CO-15 s-CO</td>
</tr>
<tr>
<td>Rated supply voltage</td>
<td>48–250 V DC</td>
</tr>
<tr>
<td>Expected lifetime</td>
<td>&gt; 50 years</td>
</tr>
<tr>
<td>Ambient temperature range</td>
<td>–30°C to +40°C</td>
</tr>
<tr>
<td>Standards</td>
<td>IEC/IEEE</td>
</tr>
</tbody>
</table>

Other values on request

For further information

Phone: +49 9131 / 7-3 34 88
Fax:  +49 9131 / 7-3 44 96
E-mail: h-gis.ptd@siemens.com
www.siemens.com/energy/hv-substations

Please send me information on the following topics:

- Gas-insulated switchgear product range
- Gas-insulated switchgear up to 245 kV
- Gas-insulated switchgear up to 300 kV
- Gas-insulated switchgear up to 550 kV
- HIS – Highly Integrated Switchgear up to 145 kV
- HIS – Highly Integrated Switchgear up to 550 kV
- container-type switchgear
- rent a GIS – temporary leasing of switchgear
- Gas-insulated transmission lines (GIL)
  the superior solution for special requirements
- further copies of this brochure