

Gas-Insulated Switchgear for Substations



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Introduction

Common characteristic features of switchgear installation

Because of its small size and outstanding compatibility with the environment, SF₆-insulated switchgear (GIS) is gaining constantly on other types. Siemens has been a leader in this sector from the very start.

The concept of SF₆-insulated metal-enclosed high-voltage switchgear has proved itself in more than 70,000 bay operating years in over 6,000 installations in all parts of the world. It offers the following outstanding advantages.

Minimal space requirements

The availability and price of land play an important part in selecting the type of switchgear to be used. Siting problems arise in

- Large towns
- Industrial conurbations
- Mountainous regions with narrow valleys
- Underground power stations

In cases such as these, SF₆-insulated switchgear is replacing conventional switchgear because of its very small space requirements.

Full protection against contact with live parts

The all-round metal enclosure affords maximum safety for personnel under all operating and fault conditions.

Protection against pollution

Its metal enclosure fully protects the switchgear interior against environmental effects such as salt deposits in coastal regions, industrial vapors and precipitates, as well as sandstorms. The compact switchgear can be installed in buildings of uncomplicated design in order to minimize the cost of cleaning and inspection and to make necessary repairs independent of weather conditions.

Free choice of installation site

The small site area required for SF₆-insulated switchgear saves expensive grading and foundation work, e.g. in permafrost zones. Other advantages are the short erection times and the fact that switchgear installed indoors can be serviced regardless of the climate or the weather.

Protection of the environment

The necessity to protect the environment often makes it difficult to erect outdoor switchgear of conventional design, whereas buildings containing compact SF₆-insulated switchgear can almost always be designed so that they blend well with the surroundings.

SF₆-insulated metal-enclosed switchgear is, due to the modular system, very flexible and can meet all requirements of configuration given by network design and operating conditions.

Each circuit-breaker bay includes the full complement of disconnecting and grounding switches (regular or make-proof), instrument transformers, control and protection equipment, interlocking and monitoring facilities commonly used for this type of installation (Fig. 39).

Beside the conventional circuit-breaker bay, other arrangements can be supplied such as single-bus, ring cable with load-break switches and circuit-breakers, single-bus arrangement with bypass-bus, coupler and bay for triplicate bus. Combined circuit-breaker and load-break switch feeder, ring cable with load-break switches, etc. are furthermore available for the 145 kV level.

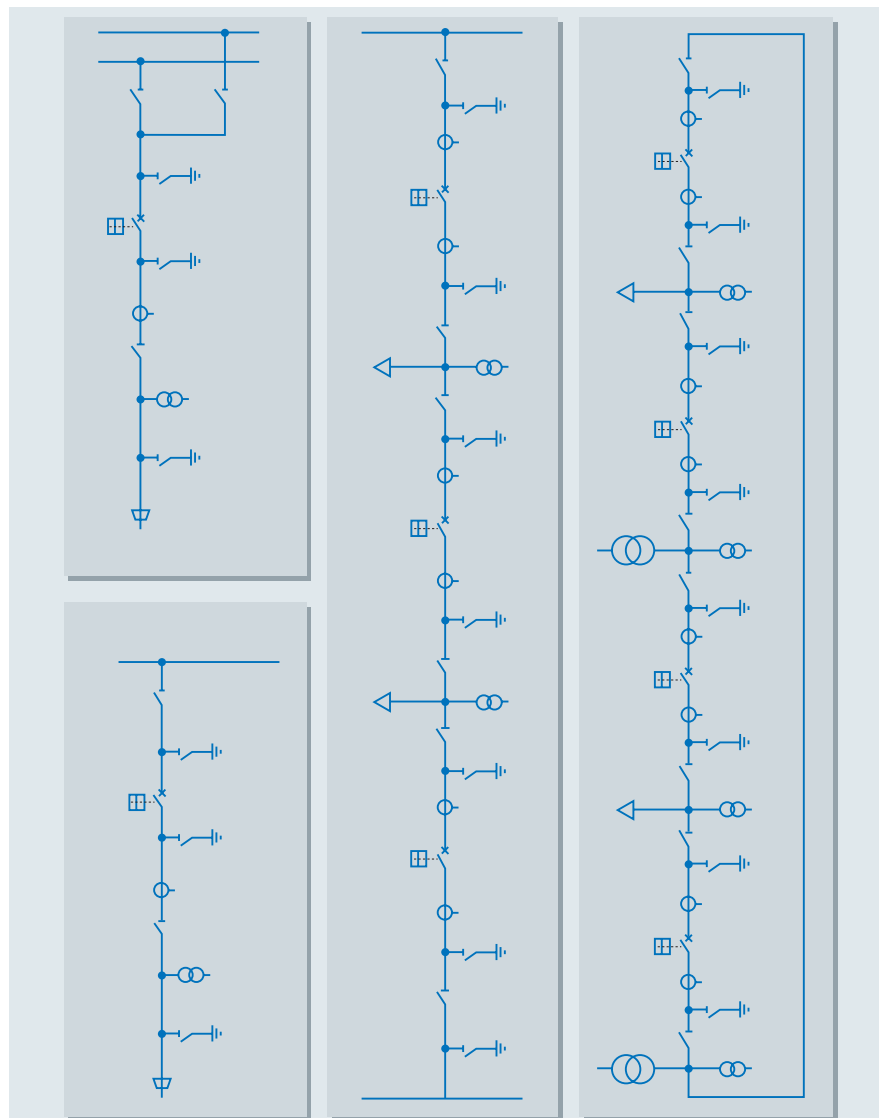
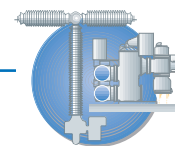


Fig. 39: Typical circuit arrangements of SF₆-switchgear



Gas-Insulated Switchgear for Substations

Main product range of GIS for substations

SF₆ switchgear up to 550 kV (the total product range covers GIS from 66 up to 800 kV rated voltage): Fig. 40.

The development of the switchgear is always based on an overall production concept, which assures the achievement of the high technical standards required of the HV switchgear whilst providing the maximum customer benefit.

This objective is attained only by incorporating all processes in the quality management system, which has been introduced and certified according to DIN EN ISO 9001 (EN 29001).

Siemens GIS switchgear meets all the performance, quality and reliability demands such as:

Compact space-saving design

means uncomplicated foundations, a wide range of options in the utilization of space, less space taken up by the switchgear.

Minimal-weight construction

through the use of aluminum alloy and the exploitation of innovations in development such as computer-aided design tools.

Safe encapsulation

means an outstanding level of safety based on new manufacturing methods and optimized shape of enclosures.

Environmental compatibility

means no restrictions on choice of location through minimal space requirement, extremely low noise emission and effective gas sealing system (leakage < 1% per year per gas compartment).

Economical transport

means simplified and fast transport and reduced costs because of maximum possible size of shipping units.

Minimal operating costs

means the switchgear is practically maintenance-free, e.g. contacts of circuit-breakers and disconnectors designed for extremely long endurance, motor-operated mechanisms self-lubricating for life, corrosion-free enclosure. This ensures that the first inspection will not be necessary until after 25 years of operation.

Reliability

means our overall product concept which includes, but is not limited to, the use of finite elements method (FEM), three-dimensional design programs, stereolithography, and electrical field development programs assuring the high standard of quality.

Smooth and efficient installation and commissioning

transport units are fully assembled and tested at the factory and filled with SF₆ gas at reduced pressure. Plug connection of all switches, all of which are motorized, further improves the speediness of site installation and substantially reduces field wiring errors.

Routine tests

All measurements are automatically documented and stored in the EDP information system, which enables quick access to measured data even if years have passed.

For further information please contact:

Fax: ++49-9131-7-34498

e-mail: evhgis@erls04.siemens.de

Switchgear type	8DN8	8DN9	8DQ1
Details on page	2/30	2/31	2/32
Rated voltage [kV]	up to 145	up to 245	up to 550
Rated power-frequency withstand voltage [kV]	up to 275	up to 460	up to 740
Rated lightning impulse withstand voltage [kV]	up to 650	up to 1050	up to 1800
Rated switching impulse withstand voltage [kV]	–	up to 850	up to 1250
Rated (normal) current [A] busbar	up to 3150	up to 3150	up to 6300
Rated (normal) current [A] feeder	up to 2500	up to 3150	up to 4000
Rated breaking current [kA]	up to 40	up to 50	up to 63
Rated short-time withstand current [kA]	up to 40	up to 50	up to 63
Rated peak withstand current [kA]	up to 108	up to 135	up to 170
Inspection [Years]	> 25	> 25	> 25
Bay width [mm]	800	1200/1500	3600

All dimensions in mm

Fig. 40: Main product range

Gas-Insulated Switchgear for Substations

SF₆-insulated switchgear up to 145 kV, type 8DN8

Three-phase enclosures are used for type 8DN8 switchgear in order to achieve extremely low component dimensions. The low bay weight ensures minimal floorloading and eliminates the need for complex foundations. Its compact dimensions and low weight enable it to be installed almost anywhere. This means that capital costs can be reduced by using smaller buildings, or by making use of existing ones, for instance when medium voltage switchgear is replaced by 145 kV GIS.

The bay is based on a circuit-breaker mounted on a supporting frame (Fig. 41). A special multifunctional cross-coupling module combines the functions of the disconnecter and earthing switch in a three-position switching device. It can be used as

- an active busbar with integrated disconnecter and work-in-progress earthing switch (Fig. 41/Pos. 3 and 4),
- outgoing feeder module with integrated disconnecter and work-in-progress earthing switch (Fig. 41/Pos. 5),
- busbar sectionalizer with busbar earthing.

For cable termination, a cable termination module can be equipped with either conventional sealing ends or the latest plug-in connectors (Fig. 41/Pos. 9). Flexible single-pole modules are used to connect overhead lines and transformers by using a splitting module which links the 3-phase encapsulated switchgear to the single pole connections.

Thanks to the compact design, up to three completely assembled and works-tested bays can be shipped as one transport unit. Fast erection and commissioning on site ensure the highest possible quality.

The feeder control and protection can be located in a bay-integrated local control cubicle, mounted in the front of each bay (Fig. 42). It goes without saying that we supply our gas-insulated switchgear with all types of currently available bay control systems – ranging from contactor circuit controls to digital processor bus-capable bay control systems – for example the modern SICAM HV system based on serial bus communication. This system offers

- Online diagnosis and trend analysis enabling early warning, fault recognition and condition monitoring.
- Individual parameterization, ensuring the best possible incorporation of customized control facilities.
- Use of modern current and voltage sensors.

This results in a longer service life and lower operating costs, in turn attaining a considerable reduction in life cycle costs.

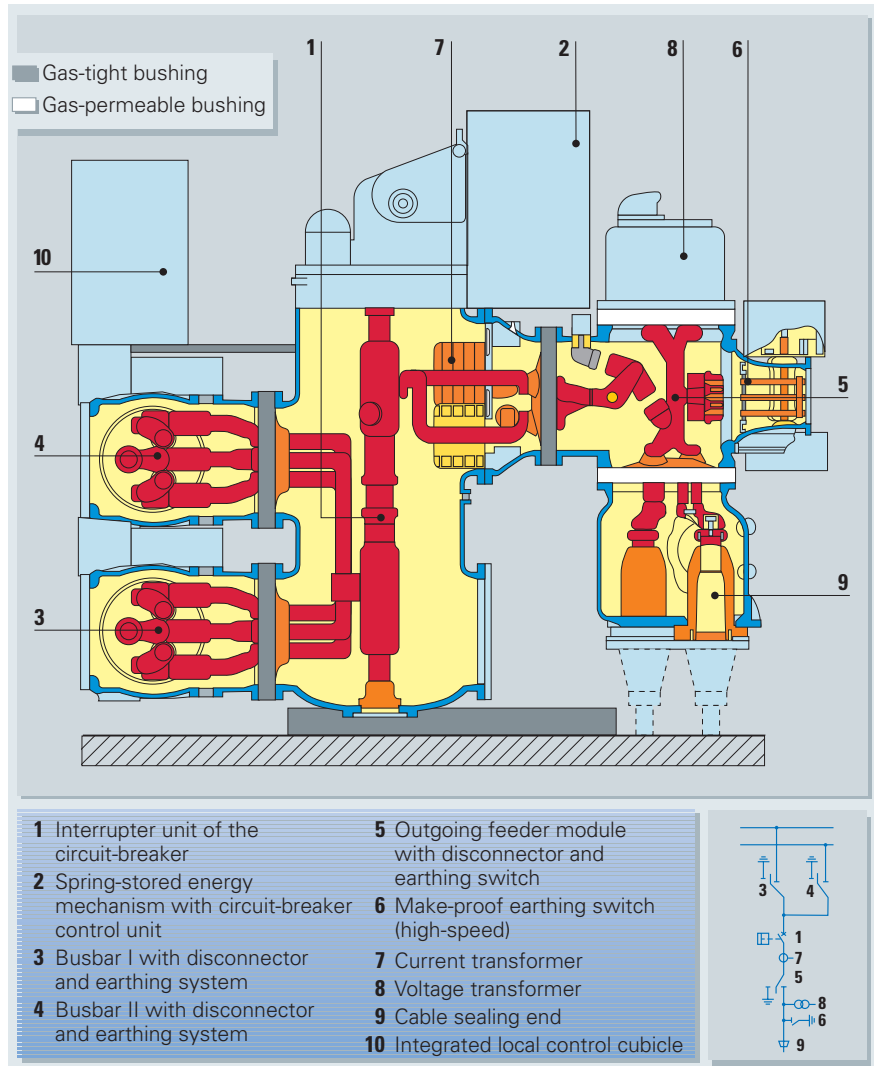


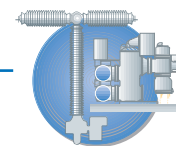
Fig. 41: Switchgear bay 8DN8 up to 145 kV



Fig. 42: 8DN8 switchgear for rated voltage 145 kV



Fig. 43



Gas-Insulated Switchgear for Substations

SF₆-insulated switchgear up to 245 kV, type 8DN9

The clear bay configuration of the light-weight and compact 8DN9 switchgear is evident at first sight. Control and monitoring facilities are easily accessible in spite of the compact design of the switchgear.

The horizontally arranged circuit-breaker forms the basis of every bay configuration. The operating mechanism is easily accessible from the operator area. The other bay modules – of single-phase encapsulated design like the circuit-breaker module – are located on top of the circuit-breaker. The three-phase encapsulated passive busbar is partitioned off from the active equipment.

Thanks to “single-function” assemblies (assignment of just one task to each module) and the versatile modular structure, even unconventional arrangements can be set up out of a pool of only 20 different modules.

The modules are connected to each other by a standard interface which allows an extensive range of bay structures. The switchgear design with standardized modules and the scope of services mean that all kinds of bay structures can be set up in a minimal area.

The compact design permits the supply of double bays fully assembled, tested in the factory and filled with SF₆ gas at reduced pressure, which assures smooth and efficient installation and commissioning.

The following major feeder control level functions are performed in the local control cubicle for each bay, which is integrated in the operating front of the 8DN9 switchgear:

- Fully interlocked local operation and state-indication of all switching devices managed reliably by the Siemens digital switchgear interlock system
- Practical dialog between the digital feeder protection system and central processor of the feeder control system
- Visual display of all signals required for operation and monitoring, together with measured values for current, voltage and power
- Protection of all auxiliary current and voltage transformer circuits
- Transmission of all feeder information to the substation control and protection system

Factory assembly and tests are significant parts of the overall production concept mentioned above. Two bays at a time undergo mechanical and electrical testing with the aid of computer-controlled stands.

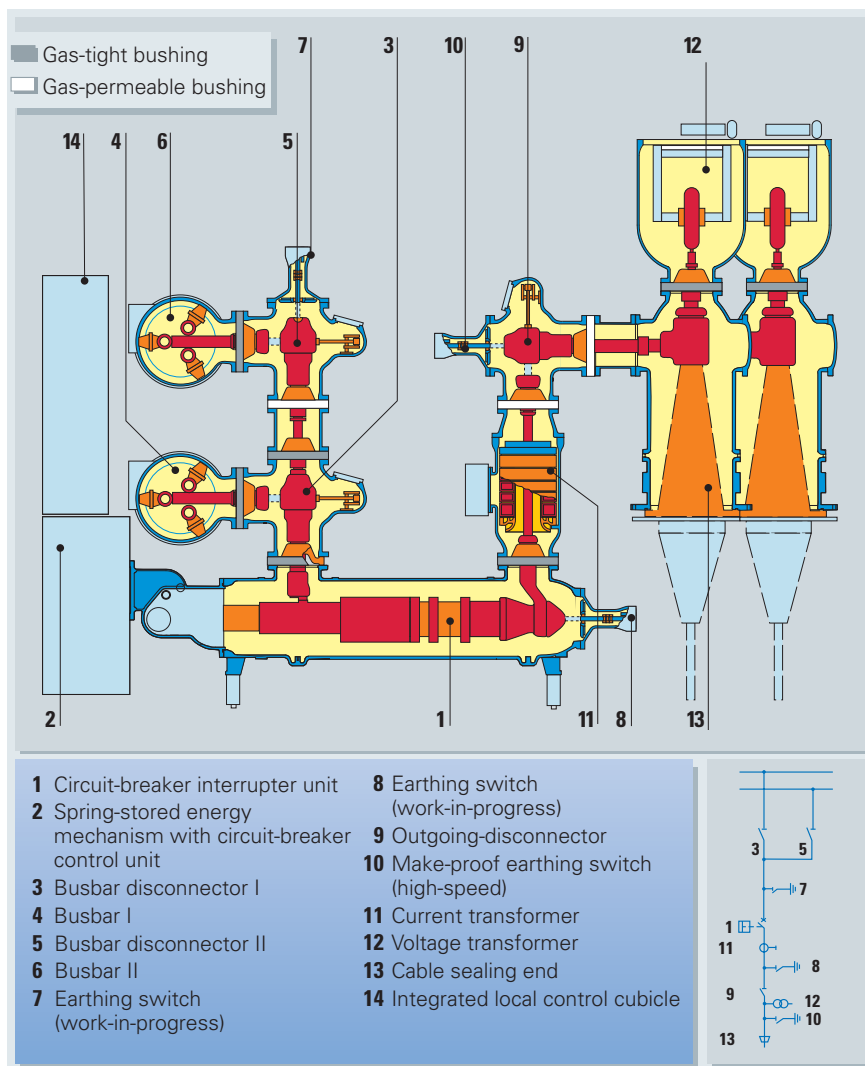


Fig. 44: Switchgear bay 8DN9 up to 245 kV



Fig. 45: 8DN9 switchgear for rated voltage 245 kV

Gas-Insulated Switchgear for Substations

SF₆-insulated switchgear up to 550 kV, type 8DQ1

The GIS type 8DQ1 is a modular switchgear system for high power switching stations with individual enclosure of all modules for the three-phase system.

The base unit for the switchgear forms a horizontally arranged circuit-breaker on top of which are mounted the housings containing disconnectors, grounding switches, current transformers, etc. The busbar modules are also single-phase encapsulated and partitioned off from the active equipment.

As a matter of course the busbar modules of this switchgear system are passive elements, too.

Additional main characteristic features of the switchgear installation are:

- Circuit-breakers with two interrupter units up to operating voltages of 550 kV and breaking currents of 63 kA (from 63 kA to 100 kA, circuit-breakers with four interrupter units have to be considered)
- Low switchgear center of gravity by means of circuit-breaker arranged horizontally in the lower portion
- Utilization of the circuit-breaker transport frame as supporting device for the entire bay
- The use of only a few modules and combinations of equipment in one enclosure reduces the length of sealing faces and consequently lowers the risk of leakage

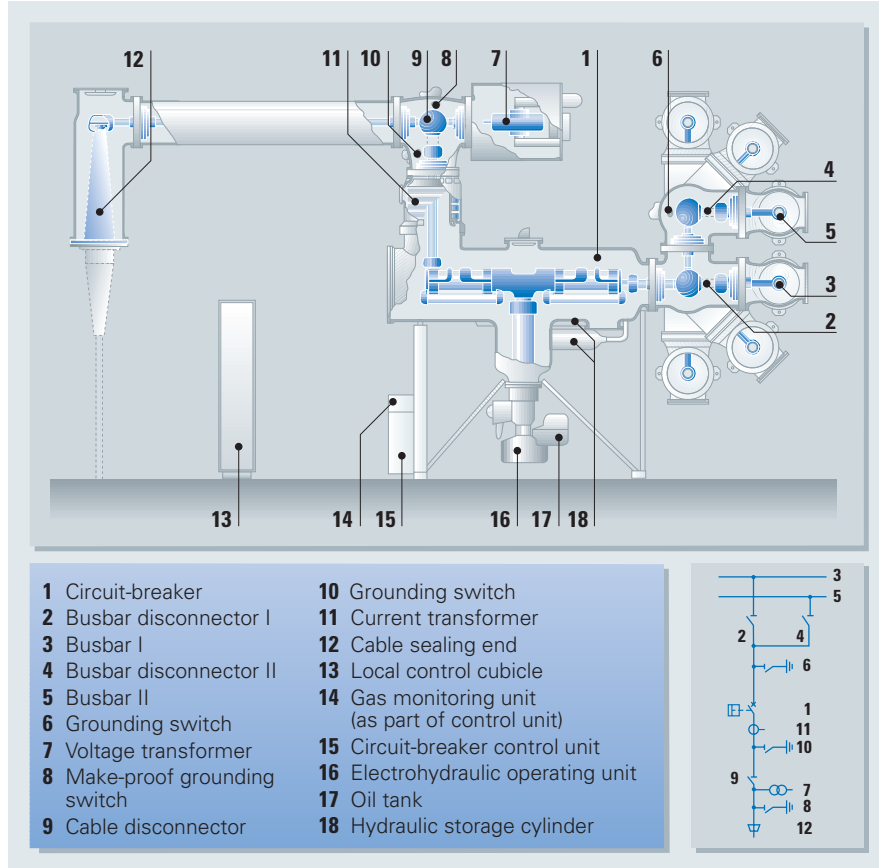
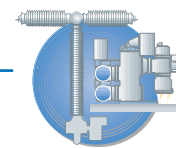


Fig. 46: Switchgear bay 8DQ1 up to 550 kV



Fig. 47: 8DQ1 switchgear for rated voltage 420 kV



Gas-Insulated Switchgear for Substations

Some examples for special arrangement

Gas-insulated switchgear – usually accommodated in buildings (as shown in a tower-type substation) – is expedient whenever the floor area is very expensive or restricted or whenever ambient conditions necessitate their use (Fig. 50, page 2/34).

For smaller switching stations, or in cases of expansion when there is no advantage in constructing a building, a favorable solution is to install the substation in a container (Fig. 49).

Mobile containerized switchgear – even for high voltage

At medium-voltage levels, mobile containerized switchgear is the state of the art. But even high-voltage switching stations can be built in this way and economically operated in many applications.

The heart is the metal-enclosed SF₆-insulated switchgear, installed either in a sheet-steel container or in a block house made of prefabricated concrete elements. In contrast to conventional stationary switchgear, there is no need for complicated constructions; mobile switching stations have their own “building”.



Fig. 49: 8DN9 switchgear bay in a container

Mobile containerized switching stations can be of single or multi-bay design using a large number of different circuits and arrangements. All the usual connection components can be employed, such as outdoor bushings, cable adapter boxes and SF₆ tubular connections. If necessary, all the equipment for control and protection and for the local supply can be accommodated in the container. This allows exten-

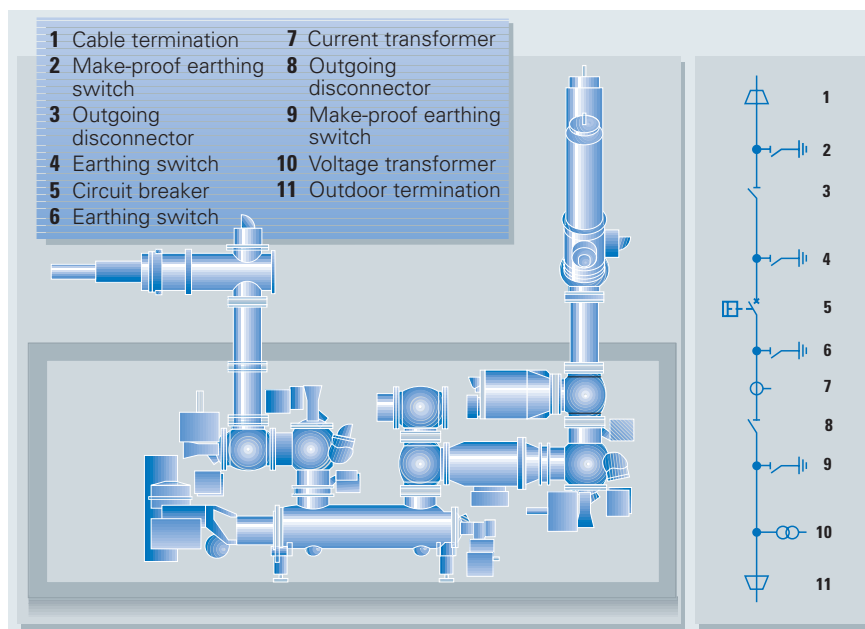


Fig. 48: Containerized 8DN9 switchgear with stub feed in this example

sively independent operation of the installation on site. Containerized switchgear is preassembled in the factory and ready for operation. On site, it is merely necessary to set up the containers, fit the exterior system parts and make the external connections. Shifting the switchgear assembly work to the factory enhances the quality and operational reliability. Mobile containerized switchgear requires little space and usually fits in well with the environment. Rapid availability and short commissioning times are additional, significant advantages for the operators. Considerable cost reductions are achieved in the planning, construction work and assembly.

Building authority approvals are either not required or only in a simple form. The installation can be operated at various locations in succession, and adaptation to local circumstances is not a problem. These are the possible applications for containerized stations:

- Intermediate solutions for the modernization of switching stations
- Low-cost transitional solutions when tedious formalities are involved in the new construction of transformer substations, such as in the procurement of land or establishing cable routes
- Quick erection as an emergency station in the event of malfunctions in existing switchgear
- Switching stations for movable, geothermal power plants

GIS up to 245 kV in a standard container

The dimensions of the 8DN9 switchgear made it possible to accommodate all active components of the switchgear (circuit-breaker, disconnector, grounding switch) and the local control cabinet in a standard container.

The floor area of 20 ft x 8 ft complies with the ISO 668 standard. Although the container is higher than the standard dimension of 8 ft, this will not cause any problems during transportation as proven by previously supplied equipment.

German Lloyd, an approval authority, has already issued a test certificate for an even higher container construction.

The standard dimensions and ISO corner fittings will facilitate handling during transport in the 20 ft frame of a container ship and on a low-loader truck.

Operating staff can enter the container through two access doors.

Rent a GIS

Containerized gas-insulated high voltage substations for hire are now available. In this way, we can step into every breach, instantly and in a remarkably cost-effective manner.

Whether for a few weeks, months or even 2 to 3 years, a fair rent makes our Instant Power Service unbeatably economical.

Gas-Insulated Switchgear for Substations

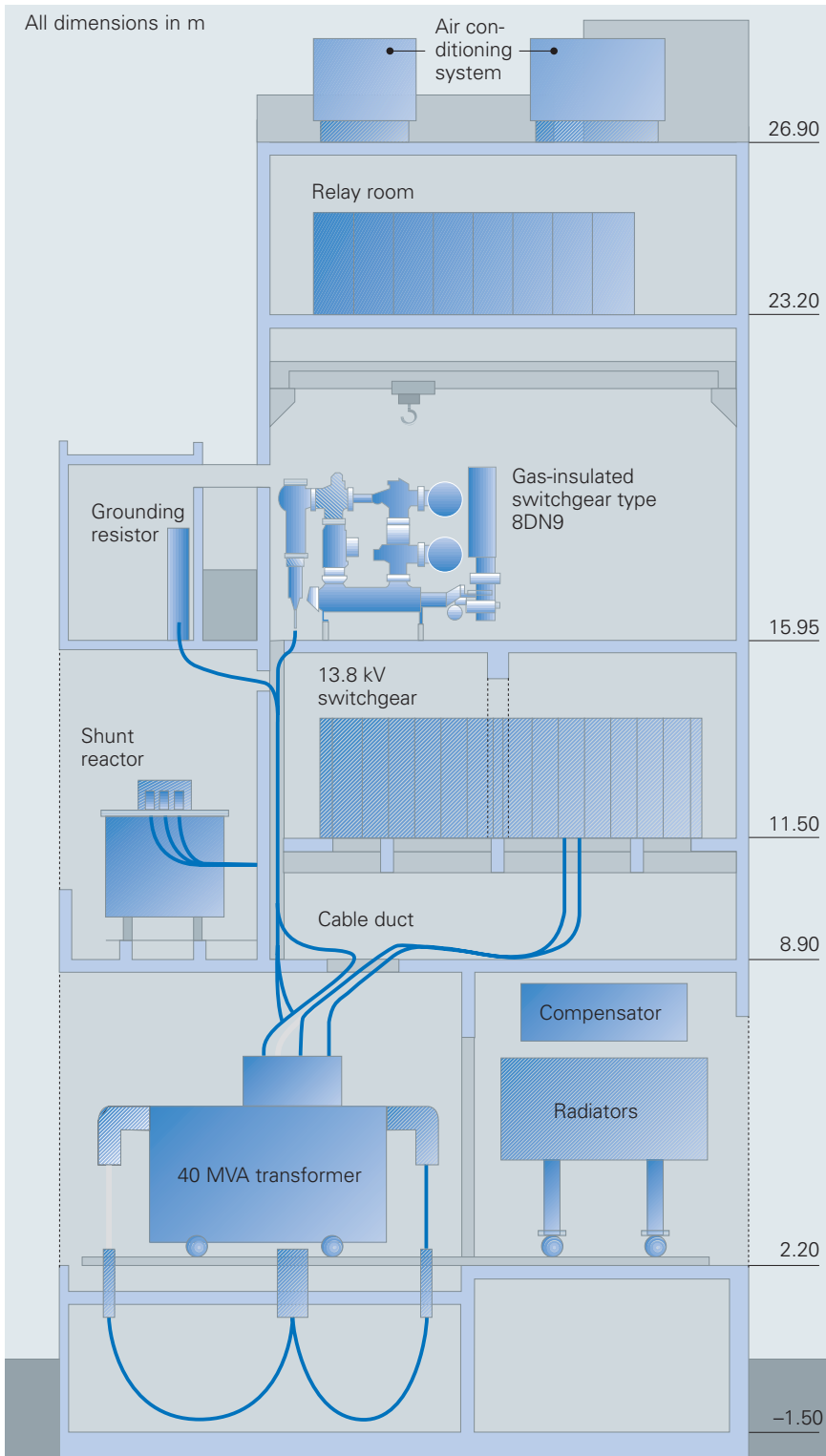


Fig. 50: Special arrangement for limited space. Sectional view of a building showing the compact nature of gas-insulated substations

Specification guide for metal-enclosed SF₆-insulated switchgear

The points below are not considered to be comprehensive, but are a selection of the important ones.

General

These specifications cover the technical data applicable to metal-enclosed SF₆ gas-insulated switchgear for switching and distribution of power in cable and/or overhead line systems and at transformers. Key technical data are contained in the data sheet and the single-line diagram attached to the inquiry.

A general "Single-line diagram" and a sketch showing the general arrangement of the substation and the transmission line exist and shall form part of a proposal.

The switchgear quoted shall be complete to form a functional, safe and reliable system after installation, even if certain parts required to this end are not specifically called for.

Applicable standards

All equipment shall be designed, built, tested and installed to the latest revisions of the applicable IEC 60 standards (IEC Publ. 60517 "High-voltage metal-enclosed switchgear for rated voltages of 72.5 kV and above", IEC Publ. 60129 "Alternating current disconnectors (isolators) and grounding switches", IEC Publ. 60056 "High-voltage alternating-current circuit-breakers"), and IEC Publ. 60044 for instrument transformers.

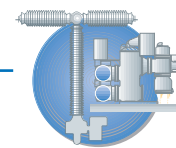
Local conditions

The equipment described herein will be installed indoors. Suitable lightweight, prefabricated buildings shall be quoted if available from the supplier.

Only a flat concrete floor will be provided by the buyer with possible cutouts in case of cable installation. The switchgear shall be equipped with adjustable supports (feet). If steel support structures are required for the switchgear, these shall be provided by the supplier.

For design purposes indoor temperatures of -5 °C to +40 °C and outdoor temperatures of -25 °C to +40 °C shall be considered.

For parts to be installed outdoors (overhead line connections) the applicable conditions in IEC Publication 60517 shall also be observed.



Gas-Insulated Switchgear for Substations

Work, material and design

Aluminium or aluminium alloys shall be used preferably for the enclosures.

Maximum reliability through minimum amount of erection work on site is required. Subassemblies must be erected and tested in the factory to the maximum extent. The size of the subassemblies shall be limited only by the transport conditions.

The material and thickness of the enclosure shall be selected to withstand an internal arc and to prevent a burn-through or puncturing of the housing within the first stage of protection, referred to a short-circuit current of 40 kA.

Normally exterior surfaces of the switchgear shall not require painting. If done for aesthetic reasons, surfaces shall be appropriately prepared before painting, i.e. all enclosures are free of grease and blasted. Thereafter the housings shall be painted with no particular thickness required but to visually cover the surface for decorative reasons only. The interior color shall be light (white or light grey).

All joints shall be machined and all castings spotfaced for bolt heads, nuts and washers.

Assemblies shall have reliable provisions to absorb thermal expansion and contractions created by temperature cycling. For this purpose metal bellows-type compensators shall be installed. They must be provided with adjustable tensioners.

All solid post insulators shall be provided with ribs (skirts).

For supervision of the gas within the enclosures, density monitors with electrical contacts for at least two pressure levels shall be installed. The circuit-breakers, however, might be monitored by density gauges fitted in circuit-breaker control units.

The manufacturer assures that the pressure loss within each individual gas compartment – and not referred to the total switchgear installation only – will be not more than 1% per year per gas compartment.

Each gas-filled compartment shall be equipped with static filters of a capacity to absorb any water vapor penetrating into the switchgear installation over a period of at least 25 years.

Long intervals between the necessary inspections shall keep the maintenance cost to a minimum. A minor inspection shall only become necessary after ten years and a major inspection preferably after a period exceeding 25 years of operation, unless the permissible number of operations is met at an earlier date.

Arrangement and modules

Arrangement

The arrangement shall be single-phase or three-phase enclosed.

The assembly shall consist of completely separate pressurized sections designed to minimize the risk of damage to personnel or adjacent sections in the event of a failure occurring within the equipment. Rupture diaphragms shall be provided to prevent the enclosures from uncontrolled bursting and suitable deflectors provide protection for the operating personnel. In order to achieve maximum operating reliability, no internal relief devices may be installed because adjacent compartments would be affected.

Modular design, complete segregation, arc-proof bushings and “plug-in” connection pieces shall allow ready removal of any section and replacement with minimum disturbance of the remaining pressurized switchgear.

Busbars

All busbars shall be three-phase or single-phase enclosed and be plug-connected from bay to bay.

Circuit-breakers

The circuit-breaker shall be of the single pressure (puffer) type with one interrupter per phase*. Heaters for the SF₆ gas are not permitted.

The arc chambers and contacts of the circuit-breaker shall be freely accessible. The circuit-breaker shall be designed to minimize switching overvoltages and also to be suitable for out-of-phase switching.

The specified arc interruption performance must be consistent over the entire operating range, from line-charging currents to full short-circuit currents.

The circuit breaker shall be designed to withstand at least 18–20 operations (depending on the voltage level) at full short-circuit rating without the necessity to open the circuit-breaker for service or maintenance.

The maximum tolerance for phase disagreement shall be 3 ms, i.e. until the last pole has been closed or opened respectively after the first.

A standard station battery required for control and tripping may also be used for recharging the operating mechanism.

The energy storage system (hydraulic or spring operating system) will hold sufficient energy for all standard IEC close-open duty cycles.

The control system shall provide alarm signals and internal interlocks, but inhibit tripping or closing of the circuit-breaker when there is insufficient energy capacity in the energy storage system, or the SF₆ density within the circuit-breaker has dropped below a minimum permissible level.

Disconnectors

All isolating switches shall be of the single-break type. DC motor operation (110, 125, 220 or 250 V), completely suitable for remote operation, and a manual emergency drive mechanism is required.

Each motor-drive shall be self-contained and equipped with auxiliary switches in addition to the mechanical indicators. Life lubrication of the bearings is required.

Grounding switches

Work-in-progress grounding switches shall generally be provided on either side of the circuit-breaker. Additional grounding switches may be used for the grounding of bus sections or other groups of the assembly.

DC motor operation (110, 125, 220 or 250 V), completely suitable for remote operation, and a manual emergency drive mechanism is required.

Each motor drive shall be self-contained and equipped with auxiliary position switches in addition to the mechanical indicators. Life lubrication of the bearings is required.

* two interrupters for voltages exceeding 245 kV

Gas-Insulated Switchgear for Substations

2

Make-proof high-speed grounding switches shall generally be installed at cable and overhead-line terminals. DC motor operation (110, 125, 220 or 250 V), completely suitable for remote operation, and a manual emergency drive mechanism is required.

Each motor drive shall be self-contained and equipped with auxiliary position switches in addition to the mechanical indicators. Life lubrication of the bearings is required.

These switches shall be equipped with a rapid closing mechanism to provide fault-making capability.

Instrument transformers

Current transformers (CTs) shall be of the dry-type design not using epoxy resin as insulation material. Cores shall be provided with the accuracies and burdens as shown on the SLD. Voltage transformers shall be of the inductive type, with ratings up to 200 VA. They shall be foil-gas-insulated.

Cable terminations

Single or three-phase, SF₆ gas-insulated, metal-enclosed cable-end housings shall be provided. The stress cone and suitable sealings to prevent oil or gas from leaking into the SF₆ switchgear are part of the cable manufacturer's supply. A mating connection piece, which has to be fitted to the cable end, shall be made available by the switchgear supplier.

The cable end housing shall be suitable for oil-type, gas-pressure-type and plastic-insulated (PE, PVC, etc.) cables as specified on the SLD, or the data sheets.

Facilities to safely isolate a feeder cable and to connect a high-voltage test cable to the switchgear or the cable shall be provided.

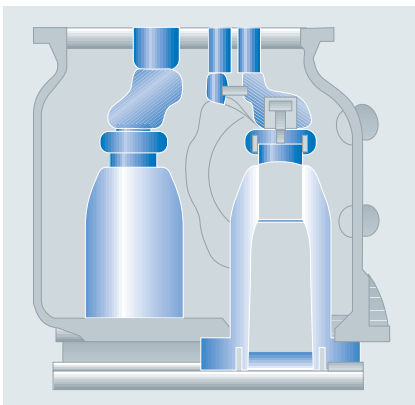


Fig. 51: Three phase cable termination module. Example for plug-in type cables.

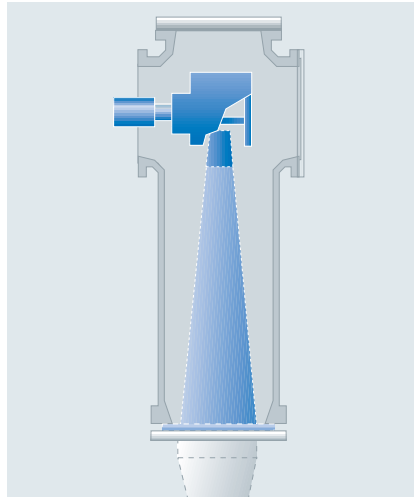


Fig. 52: Cable termination module – Cable termination modules conforming to IEC are available for connecting the switchgear to high-voltage cables. The standardized construction of these modules allows connection of various cross-sections and insulation types. Parallel cable connections for higher rated currents are also possible using the same module.

Overhead line terminations

Terminations for the connection of overhead lines shall be supplied complete with SF₆-to-air bushings, but without line clamps.

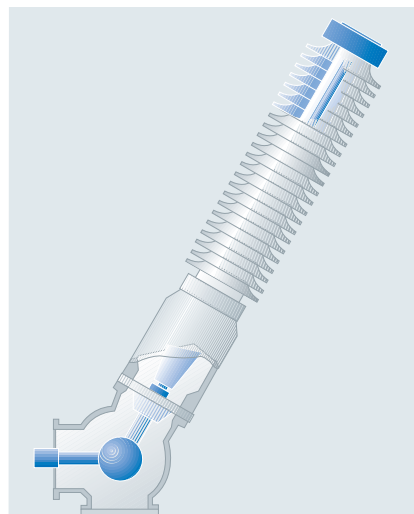


Fig. 53: Outdoor termination module – High-voltage bushings are used for transition from SF₆-to-air as insulating medium. The bushings can be matched to the particular requirements with regard to arcing and creepage distances. The connection with the switchgear is made by means of variable-design angular-type modules.

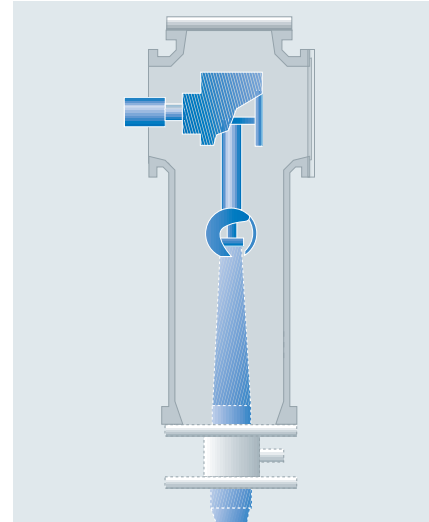


Fig. 54: Transformer/reactor termination module – These termination modules form the direct connection between the GIS and oil-insulated transformers or reactance coils. They can be matched economically to various transformer dimensions by way of standardized modules.

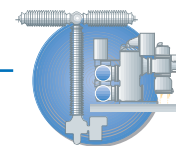


Fig. 55: Transformer termination modules

Control

An electromechanical or solid-state interlocking control board shall be supplied as a standard for each switchgear bay. This fail-safe interlock system will positively prevent maloperations. Mimic diagrams and position indicators shall give clear demonstration of the operation to the operating personnel.

Provisions for remote control shall be supplied.



Gas-Insulated Switchgear for Substations

Tests required

Partial discharge tests

All solid insulators fitted into the switchgear shall be subjected to a routine partial discharge test prior to being installed. No measurable partial discharge is allowed at 1.1 line-to-line voltage (approx. twice the phase-to-ground voltage). This test ensures maximum safety against insulator failure, good long-term performance and thus a very high degree of reliability.

Pressure tests

Each cast aluminium enclosure of the switchgear shall be pressure-tested to at least double the service pressure.

Leakage tests

Leakage tests performed on the subassemblies shall ensure that the flanges and cover faces are clean, and that the guaranteed leakage rate will not be exceeded.

Power frequency tests

Each assembly shall be subjected to power-frequency withstand tests to verify the correct installation of the conductors and also the fact that the insulator surfaces are clean and the switchgear as a whole is not polluted inside.

Additional technical data

The supplier shall point out all dimensions, weights and other applicable data of the switchgear that may affect the local conditions and handling of the equipment. Drawings showing the assembly of the switchgear shall be part of the quotation.

Instructions

Detailed instruction manuals about installation, operation and maintenance of the equipment shall be supplied by the contractor in case of an order.

Scope of supply

For all types of GIS Siemens supplies the following items and observes these interface points:

- Switchgear bay with circuit-breaker interrupters, disconnectors and grounding switches, instrument transformers, and busbar housings as specified. For the different feeder types, the following limits apply:
 - Overhead line feeder: the connecting stud at the SF₆-to-air bushing without the line clamp.
 - Cable feeder: according to IEC 60859 the termination housing, conductor coupling, and connecting plate are part of the GIS delivery, while the cable stress cone with matching flange is part of the cable supply (see Fig. 52 on page 2/36).
 - Transformer feeder: connecting flange at switchgear bay and connecting bus ducts to transformer including any expansion joint are delivered by Siemens. The SF₆-to-oil bushings plus terminal enclosures are part of the transformer delivery, unless agreed otherwise (see Fig. 54 on page 2/36)*.
- Each feeder bay is equipped with grounding pads. The local grounding network and the connections to the switchgear are in the delivery scope of the installation contractor.
- Initial SF₆-gas filling for the entire switchgear as supplied by Siemens is included. All gas interconnections from the switchgear bay to the integral gas service and monitoring panel are supplied by Siemens as well.
- Hydraulic oil for all circuit-breaker operating mechanisms is supplied with the equipment.
- Terminals and circuit protection for auxiliary drive and control power are provided with the equipment. Feeder circuits and cables, and installation material for them are part of the installation contractor's supply.
- Local control, monitoring, and interlocking panels are supplied for each circuit-breaker bay to form completely operational systems. Terminals for remote monitoring and control are provided.
- Mechanical support structures above ground are supplied by Siemens; embedded steel and foundation work is part of the installation contractor's scope.



Fig. 56: The modular system of the 8DQ1 switchgear enables all conceivable customer requirements to be met with just a small number of components

* Note: this interface point should always be closely coordinated between switchgear manufacturer and transformer supplier.