Gas Insulated Switchgear ELK-0
for stations up to 170 kV, 4000 A, 63 kA
# Content

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### Version examples
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## Technical data

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Since the presentation of the first SF₆-insulated 110-kV-switchbay in the year 1965, ABB has been among the pioneers of this technology.

Nowadays the range of high-voltage applications includes several series of modular gas-insulated substations (GIS) for rated voltages of between 52 kV and 800 kV.

Over 2,000 stations with more than 10,000 switch bays demonstrate their value every day in 70 countries. Extensive experience in plant operation in a wide variety of conditions and with many different requirements forms the valuable basis of the needs-oriented development and production of our gas-insulated substations, with their recognized high quality.

Characteristic advantages of the ELK-0 substations are

- Space saving, compact design
- High availability
- Low maintenance and repair requirements
- Short delivery and commissioning period
- Consistent modular technology
An ingenious modular system makes possible a variety of solutions

Gas-insulated switchgear (GIS) ELK-0 is created by the combination of standardized function modules such as circuit breakers, disconnectors and earthing switches, instrument transformers, supplementary modules, etc. These 3-phase modules are connected together by means of carefully machined flange connections.

The dimensions of these flanges are the same with all modules, so that various components can be combined very freely. This facilitates the design of a substation and its planning.

The individual modules are connected in such a way that subsequent expansion or the conversion of a substation can be carried out easily. Gas-tight barrier insulators ensure that any effect on adjacent substation components is kept to a minimum.
The ingenious modular system offers the planning and project engineer great flexibility for optimization. He can thus easily realize his concepts of the optimum configuration for the substations. Various criteria such as basic circuit, routing of lines and cables, building size, accessibility, and provisions for extensions and rapid fault rectification are evaluated individually and taken into consideration accordingly.

During the project planning of substations, all basic circuits used in classic substation construction can be realized also with our fully encapsulated GIS. Substations with single or multiple busbars – optionally with transfer busbar also – can be created with standard modules just as well with disconnectable or switchable busbars and bus couplings.
The function of the individual components, and thus also of the substations, is dependent on the increasingly strict system requirements for electrical networks and their equipment, e.g. economy, safety, and quality. Here, an appropriate solution is GIS EXK-0: compact design, flexible application, extremely reliable primary and secondary technology.

Uniform, standard modules, which are type-tested and manufactured in large numbers, are joined to form individual systems. Structures with great functional complexity are created by the combination of clearly defined elements. This concept is a precondition for effective, comprehensive quality assurance.

The busbar is made by adjoining busbar components. The length of these elements corresponds to the bay width of 1200 mm.

Gas-tight barrier insulators in every switch bay avoid time consuming gas filling and emptying of large gas compartments. Telescopic transverse assembly elements facilitate tasks necessary for on-site assembly and plant extensions or conversions.

The busbar phase conductors are fastened bay by bay to gas-tight barrier insulators. These insulators are each combined with a telescopic transverse assembly element, which facilitates the work necessary in event of station extensions or conversions. Plug-in contacts in the transverse assembly element connect the busbar conductors. Alternations in length caused by temperature fluctuations are thereby flexibly compensated.

Mechanical strain on the insulators due to differing heating of the individual conductors and the enclosures are thus completely avoided. A combination of busbar disconnector and maintenance earthing switch for subsequent switchgear extension, maintenance, etc. is an integral part of each busbar module. The common operating mechanism for the
combined disconnector and earthing switch is mounted at the front, and acts via bevel gears and an insulating shaft on the three parallel contact pins. Depending on the direction of movement the contacts act as disconnector or earthing switch (maintenance earthing switch). By means of a crank handle, manual operation of the combined disconnector and earthing switch is also possible.

Two separate position indicators and auxiliary switches are positively connected to the operating mechanism. Furthermore, as the switching does not take place until immediately before the contact end positions are reached, an accurate overview of the contact position is therefore always assured.
The circuit breaker is equipped with two or three connection flanges. Their position and form is determined by the station layout. As all other modules can be connected directly, by means of appropriate project planning very compact and thus inexpensive stations can be formed.

The circuit breaker works as a single-pressure breaker according to the auto puffer principle with one break per pole, and therefore requires very little maintenance.

The arcing chamber used in this breaker arises from the outdoor circuit breaker, which is tested under the most stringent conditions. It is characterized by the consistent separation of the continuous-current contacts and the auxiliary contacts for the arc extinction.
Long-life auxiliary contacts for arc extinction and the absence of contact erosion at the continuous-current contacts make the need for inspection and maintenance rare and in most cases even superfluous.

The puffer piston connected to the contact nozzle generates the SF₆ gas flow necessary for arc extinction during the switch-off movement. The gas suppresses the operating currents and small short-circuit currents. Compression volume and contact geometry are optimized with regard to low-overvoltage, soft extinction behavior.

In the heat-up volume, the energy present in the short-circuit arc is used to heat the SF₆ gas. The pressure thus created serves to extinguish short-circuit currents up to the rated breaking current.

The compression power to interrupt the short-circuit currents is thus not performed by the breaker operating mechanism. The operating mechanism – a spring-assisted hydraulic mechanism is used – can therefore be made especially simple and reliable.

The majority of the switching operations are normal-load operations; most switching operations are thus performed with the lower mechanical load from the compression volume. Reaction forces and wear are accordingly low.
The hydraulic stored-energy spring mechanism of the circuit breaker forms an ideal connection for the wear-free power transmission of the hydraulics system, with the robustness of a mechanical energy accumulator. A Belleville spring assembly serves as an energy accumulator. Its excellent qualities include reliability, long-term stability and independence of temperature.

The drive for three-pole switch actuation comprises four functional modules: recharging module with hydraulic pump and low-pressure tank, accumulator module with Belleville spring assembly, working module with drive piston and integrated end-position damping and a monitoring and control module with open-close control coils. In the version for single-pole actuation, there are three working and control modules respectively.

Tripping and enabling of the drive energy is by means of tried and tested hydraulic drive technology components. In accordance with the accepted safety philosophy, the close-open changeover valve is equipped with two redundant open coils.

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Tripping and enabling of the drive energy is by means of tried and tested hydraulic drive technology components. In accordance with the accepted safety philosophy, the close-open changeover valve is equipped with two redundant open coils.
The drive has no pipe or screw connections. The number of sealed points to the outside is kept to a minimum. Pressurized sliding gaskets are arranged so that unavoidable leaks can only reach the low-pressure chamber and never reach the outside.

The high- and low-pressure chambers are hermetically sealed, excluding the possibility of long-term change to the hydraulic fluid caused by oxidation.
Cross unit with combined disconnector and earthing switch

The line disconnector is located in a cross-shaped module. It is composed of the same active elements as the busbar disconnector. Integral component of the disconnector is a motor-driven earthing switch.

In addition, this disconnector provides the possibility of connecting a voltage transformer. Here, the electrical connection is made either before or after the isolating distance, so that the voltage is either displayed for the station side or the line side. The connecting flange for the voltage transformer also serves as a test flange for the high-voltage test of the substation or the cable.

In general this module is combined with a voltage transformer, a make-safe earthing switch, and a cable sealing end or a pipe outlet line.
The make-safe earthing switch is fitted with a spring operating mechanism which makes contact switching very fast. It is therefore particularly suitable as a line earthing switch, as any conceivable effects in the case of incorrect switching are thus small.

The closed earthing switch can be isolated from the operational earthed enclosure during an inspection. There is therefore the possibility of creating an electrical connection from outside via the housing of the earthing switch and the movable contact pins, which are insulated from each other, to the main circuit. This considerably facilitates the adjustment and checking of the protective relays, cable checking, and locating cable faults. During operation, the insulation is short-circuited.
Current and voltage transformer

For measurement and protection purposes inductive, single-phase current and voltage transformers are used. For both transformers the primary insulation consists of SF₆ gas. The transformers are particularly operationally safe, as this insulation material is not subject to any aging. Feeder current transformers are arranged in the junction flange of the circuit breaker. The available core volume was determined to allow installation of up to four cores.

The voltage transformer has a so-called SF₆ film insulation. Here, the individual layers of the winding are insulated from each other by means of plastic film and the intermediate spaces have been impregnated in a special process with SF₆ gas.

On the secondary side of the voltage transformers, two measurement windings and one open delta winding may be provided for earth fault detection.

The current transformer is designed as a low-voltage transformer. The available transformation ratios, secondary outputs, accuracy classes, etc., of the transformers correspond to the usual requirements of modern protection and measurement technology.
By means of the cable sealing end, cables of any kind can be connected. For the XLPE-insulated cables mostly in use today, there is a cable sealing end with a short installation length and a completely dry solid insulation.

The main elements of the plug-in sealing ends are the plug-in sockets made of epoxy resin and the cable connectors with the pre-manufactured stress-cones made of silicone rubber. An advantage is the consistent separation of the substation and cable system installations.

For other types of cable, a sealing end is selected of which the main component is the longer cable insulator for liquid-filled sealing ends.
SF₆ outdoor bushing

The outdoor bushing allows the transition from the enclosed substation to overhead lines or the bare connection of transformers.

Plastic compound bushings are preferably used. They are characterized by a fiber-reinforced support pipe made of epoxy resin with vulcanized shields made of silicone rubber. These bushings are fracture- and explosion-proof, easy to handle and have excellent pollution layer characteristics on account of the hydrophobic insulation material. Upon customer request, traditional capacitor bushings can also be provided with porcelain insulation.

Supplementary modules

With regard to station layout various connection modules may be required for combination of the equipment. These are primarily:
- Pipe connections
- Elbow pieces
- T-pieces

The components are equipped with a support or barrier insulator. Plug-in and tulip contacts serve for connecting the conducting paths. Occasionally, station sections are combined with a transverse assembly element in order to facilitate subsequent station modifications, extensions or repairs.
SF₆ gas system

In accordance with the dual function of the SF₆ gas as arc extinction and insulating medium we differentiate between the extinguishing gas compartments, and the insulating gas compartments of the busbars, disconnectors, instrument transformers, etc. The gas compartments are segregated by gas barrier insulators and the gas pressure is monitored by temperature compensated pressure relays (density related relays).

All gas compartments have their own automatic vacuum coupling, so that all maintenance jobs, like drawing a gas sample or topping-up the SF₆ gas can be carried out without difficulty.

Control cubicle

The auxiliary electrical units required for command input, warning, locking, etc. are accommodated in their own individual control cubicles.

The units are connected to the control cubicles by means of control cables with coded multiple connectors. These connections are already manufactured and tested in the factory. The electrical connections between control cubicle and control room are routed on terminal strips.

The door is fitted with the mimic diagram with the position indicators, associated control switches and visual alarm indicators. By means of key-switches, the units’ locks are released or switched to local or remote control.

As an alternative to the conventional electromechanical control system, a microprocessor-controlled bay control and protection device REF542plus can be used. It combines the basic functions control, protection, communication and monitoring. Standardized digital interfaces permit easy connection to the substation control system.
Transportation, assembly, and maintenance

**Factory-assembled and -tested substations**

Thanks to the low weight of the ELK-0 components, transportation and assembly of a substation is easy. Preferably, ELK-0 substations are supplied in completely assembled and tested bays with the relevant control cubicles.

Here, the following advantages may be applicable:
- The assembly period at the installation site is very short and the work for substation commissioning is uncomplicated.
- The insulating capacity has been proven in the factory by means of routine tests of the complete bays. As here a partial-discharge measurement was also carried out, impairment of the insulating capacity due to material or manufacturing faults can be safely ruled out.
- On account of the small bay dimensions and weights, ELK-0 substations can also be delivered by air freight without problem. Complicated packaging and preservation are not required, so commercial use of the station can start earlier.

After the station has been set up, the gas compartments are filled with $\text{SF}_6$ gas. For this purpose, special service trolleys are available. As all gas compartments are provided with valve couplings which can be opened without gas or pressure loss, these operations are very simple to perform. Gas losses and emissions are therefore almost completely eliminated. After the switchgear has been checked for perfect mechanical operations, the results of the commissioning tests are recorded.
On-site assembly of complete bays

High voltage test
The operational safety of fully encapsulated SF₆ insulated substations is subject to no external influence resulting from dirt, moisture or similar. The GIS ELK-0 therefore requires extremely low-maintenance.

In the case of inspections, the inside of the switchgear is not interfered with, so the substation can remain in operation. The condition of the gas and hydraulic oil is checked and the actuators, auxiliary contact units, density monitors are subjected to a function test.

Circuit-breakers and disconnectors should be inspected only after 5,000 mechanical operating cycles. In addition, repair of the circuit-breaker is scheduled after approx. 10-20 short-circuit cut-outs at the earliest, depending on the switched-off short-circuit current.

Experience shows that these limit values are far in excess of the requirements of practical operation. With respect to network planning, the usual precautionary measures and redundancies can therefore be considerably reduced.
Gas insulated ELK-0 substations are always the right choices when the low space requirements are an important criterion for the choice: for supplying power to cities and conurbations, industrial complexes, and when aggressive environmental conditions necessitate a sheltered location.

The following examples prove the flexibility of the system and are intended to provide stimulus for the conception and planning of new substations.

The bay width is basically 1.2 m. The required building depth is generally 7 m, the building height less than 5 m. No crane is necessary for assembling the factory-assembled and -tested switch bays and maintenance of the equipment; however, installation of a crane is recommended to facilitate the work and to save time.

All the usual station circuits can be optimally implemented on account of the modular component system. At the same time, it is possible to take into consideration the various requirements regarding building dimensions, subsequent station extensions, security of supply, comprehensive station overview, access to equipment, protection concept, etc. on the basis of a solution tailored to the individual case in accordance with its value.
**Double busbar**

This circuit is the most common circuit version for important key-point substations, power plant supply, etc.

If both busbars are operated with equal priority – instead of the operating method with main and reserve busbars – the principle of busbar separation can be applied to reduce the short-circuit current. The two busbars and their feeders belong to separate sub-networks. If required, individual feeders can be allocated to the other sub-network.

This concept relieves the stations as a result of low short-circuit loading, longer maintenance intervals and offers greater supply security.

The possible coupling versions are particularly varied: The simple bus coupling or the combined bus section-alization and coupling with six or eight disconnectors are two examples. Double disconnectors even allow subsequent high-voltage tests after station extensions or maintenance measures during partially normal operation.
Single busbar

Smaller stations or single- or double-feed stations are frequently designed with single busbars. Here, in the interest of adaptable system management, bus section couplings and bus couplings are provided. This means, for example, that part of the station can remain in operation during station extension work.

The layout of a station with simple busbar is similar to that of double busbar stations, as only the lower or upper busbar is eliminated. If the appropriate connection flanges are already provided on the circuit-breakers on the initial version, it is easy subsequently to upgrade to a double busbar.
**H-circuit**

The H-circuit is frequently used to supply industrial companies or smaller regions. Two feed lines and two step-down transformers are optimal with regard to supply reliability and network reserves. The station can be operated as a double-feed station, with closed cross connection also as a ring substation.

If subsequent possibilities for extension are not required, the especially compact version without busbar is selected.

If a subsequent station extension is under consideration, the simple busbar with section coupling is selected as basic layout. There is even subsequently the possibility of converting this to a station with double busbar and bus coupling.
The 1½-breaker method is a traditional circuit with which the non-availability of the circuit-breaker during maintenance is taken into particular consideration. It is used primarily with maintenance-intensive breakers, and where the secondary medium-voltage network does not take even a brief additional load, and a primary transmission network is not provided.

Such networks or stations are usually operated in such a way that all switches are closed. Each feeder is then fed from two sides, so that even a faulty busbar can be switched off without reducing the supply.
Mesh substation

Similarly to the 1½-breaker method, the ring bus allows uninterrupted operation of all cable and line feeders even in the event of switchgear maintenance work. With this circuit, the number of breakers and the cable and line feeders is equal, so the station is in general more inexpensive than a corresponding version with 1½ breakers per bay.
Preferentially small substations with for instance four bays are built-up with this layout. Switching of one feeder implies at least short-time interrupting the ring-busbar. This is inappropriate for big substations, because in the case of a short-circuit failure the unplanned opening of the ring busbar causes considerable load-flow variations or supply interruptions.
## Technical data

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*Higher data on request