

145kV Cable Connection Systems for High-Voltage Switchgears



THE POWER CONNECTION

CABLE SYSTEMS | COMPONENTS | OVERHEAD LINES | RAILWAY CATENARY SYSTEMS

The authors describe one of the interfaces in high-voltage gas-insulated switchgears (GIS), the cable connection module, from the viewpoint of the switchgear manufacturer and the cable connection manufacturer and with respect to standardisation.

High-voltage switchgear with cable connection

It is increasingly important to take into account the costs and time involved in assembling and commissioning high-voltage switchgears right from the planning stage. Relocating assembly work from the construction site to the factory, using prefabricated and pre-inspected components, is one way of cutting down on assembly times while raising product quality levels.

In the case of voltage levels of up to 145 kV, a switchgear panel often consists of up to three 'delivery units' (depending on design and transport limitations) that have to be fitted together on site. In the case of small switchgears, e.g. for unit-type power stations or wind farms, no additional work is carried out on the gas compartment on site except for installation of the cable connector sockets.

If the cable connector sockets are already fitted and tested in the factory and the test voltage is 275 kV at a nominal voltage of 145 kV, then this work is performed under much better operating and ambient conditions. This gas compartment then no longer has to be opened on the construction site. This procedure is reflected in the quality of the entire system.

On-schedule installation in the factory requires reliable logistics to be in place between the cable connection system supplier and switchgear manufacturer. When installing in the factory, the sockets will be required four to eight weeks earlier than if installing on the construction site. This places stricter requirements on the planning accuracy of all partners and the ability of the cable termination system manufacturer to supply.

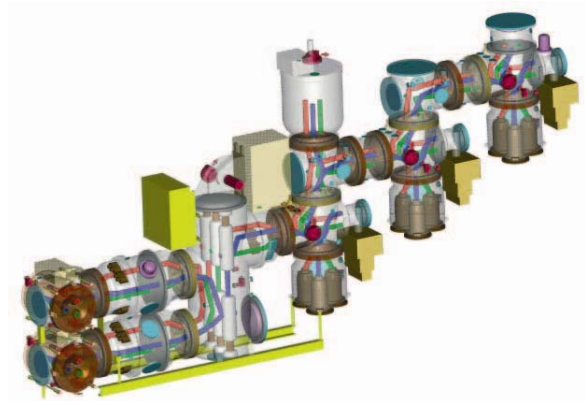


Figure 1: Example of a switchgear panel with three cable ducts

Current standardisation

For medium voltage applications, the specified measurements for device assemblies and interfaces for all kinds of transformer bushings are specified in DIN EN 50 180 for liquid-filled transformers and in DIN EN 50181 for all other transformers. These cover bushings for overhead line connections and bushings for cable connections. Six types of the latter are defined for the outside cone and four types for the inside cone system.

In terms of power cables, the same definitions can be found in DIN 47 636 for the outside cone and in DIN 47 637 for the inside cone, which includes applications in GIS.

An installed device connection cannot be voltage-powered as a 'half bushing' without a cable connection. On the other hand, this standardised interface, routed out of the device, allows suitable cable connection accessories from any manufacturer to be fitted. The user is free to select a suitable plug connection system.

When project planning the system, the manufacturer does not need to know which cable is ultimately going to be connected up. This method has proved to be a success for more than 15 years thanks to the clear distinction between device end and cable end parts. At this real interface, not only do the right systems provide complete compatibility but there is also a decoupling in the system production process because the areas of responsibility are clearly demarcated. To date, we have had no comparable rules for the interface in plug-in type bushings for cable connections in high voltage applications. For around 20 years, technical specification IEC 60 859 has defined the installation dimensions for two models. A distinction is made between the wet cable

terminators and the dry plug-in cable connections. The dimensions are only specified for some of the contact elements while there are none for the dielectric areas. There is therefore no interchangeability or compatibility: device end and cable end parts must be obtained from one and the same manufacturer. Unfortunately, the current revision of IEC 60 859 has not managed to rectify this problem.

The standard which is published under the new IEC number (IEC 62 271-305, Ed. 1: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages of 72.5 kV and above – Fluid-filled and extruded insulation cables – Fluid-filled and dry type cable-terminators) will again only contain specifications of installation dimensions for the connection compartments in GIS. Attempts to define a real interface between device end and cable end parts of the bushing have failed. Various manufacturer solutions will continue to compete for shares of the market while interchangeability and compatibility have fallen by the wayside.

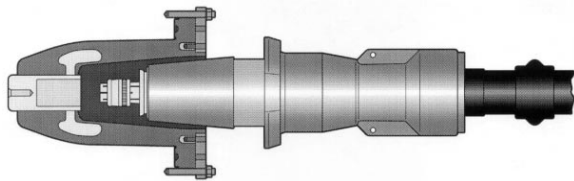


Figure 2: Cable connection system during the plug-in process

Description of the cable connection system

The HV- CONNEX cable connection system is used to connect plastic-insulated single-core cables to electrical equipment such as gas-insulated switchgears and transformers. As can be seen in Figure 2, the system consists of a cable end and device end part.

The plug-in socket is the device end part of the electrical bushing and is fitted in the switchgear or transformer. It consists of the female contact part and casting resin insulator into which the field-controlling elements are cast. The system's nominal voltage and nominal current should be taken into account when selecting a suitable size.

The cable connector part is the cable end part of the electrical bushing. It consists of the contact system, insulating and field-controlling part, made of highly flexible silicone rubber, and a metallic housing. The dimensions of the insulating and field-controlling part are coordinated to the insulating thickness of the assigned cable, are pre-fabricated, pre-inspected

and pulled on to the cable insulation during assembly. This part controls the electrical field at the stepped cable end and reliably electrically seals (by positive lock) the joints to the cable insulation and plug-in socket.

During assembly, the cable connector part is plugged into the device connector part and the electrical bushing thereby completed. The screw coupling ensures a permanent mechanical and electrical connection. The contact system ensures the zero-loss transfer of current from the system's cable conductor to its busbar. The solid insulation system ensures the necessary electrical strength during all operating and fault statuses in the network. In this assembly, the geometric fit between the cable connector part and device connector part is known as an inside cone. For medium voltage applications, there are four standard sizes of inside cone bushings for the different nominal voltages and nominal currents at the device interface between the cable end and device end parts. For high voltage systems of more than 52 kV there are currently only manufacturer-specific versions which are not interchangeable.

Compared with the conventional 'wet' cable connections according to IEC 60 859, the 'dry' plug-in cable connector systems offer many benefits. Totally new concepts will be possible in future generations of GIS and transformers thanks to the plug-in, closed, shortened cable connector compartments which can now also be positioned in any way needed.

Since the HV- CONNEX cable connector system is based on solid insulation materials, the cable entries for GIS and transformers can be spatially positioned in any way required; horizontal, vertical and angled positioning of bushings are possible, as are cable connections from above and below. Unconventional assembly window geometries for the cable connections allow systems to be adapted to the project in hand.

Gas-insulated switchgears and oil transformers can now be fitted in the factory with HV- CONNEX device connector parts up to a voltage level of 245 kV, sealed, tested and supplied ready for connection. When compared with the IEC connector currently used, this variant does not require the cable connector compartment at the usage site to be opened or any of the associated costly gas or oil work because the interface between the cable and connector compartment is routed in the bushing.

This new interface makes assembling and disassembling the cable connections on the system a fast, simple and problem-free process. Assembly times are reduced considerably compared with the conventional connection defined in IEC 60 859 Chap. 7.1, because the

HV- CONNEX plug-in system fully dispenses with liquid insulating materials. At the device end, the gas or oil compartment remains sealed at the usage site by the bushing fitted in the factory. Using prefabricated and pre-inspected components ensures a high degree of safety and reliability. Assembly errors are minimised because the HV- CONNEX plug-in system uses connectivity between the cable and system component which does justice to an innovative high voltage system. The plug-in nature of the HV- CONNEX system allows the cable to be quickly and easily disconnected for maintenance and troubleshooting in the systems.

Dr. Rolf Maier, Head of Production, Siemens AG, Power Transmission and Distribution, Berlin; Dipl.-ing. Martin Schuster and Dr. Thomas Klein are managers of Pfisterer Kontaktsysteme, Winterbach

The routine dielectric test on insulating parts of the cable plug-in system

The valid standards for switchgears and transformers prescribe routine electrical tests on components subject to electric loads. For example the IEC 60 840 standard, of relevance to cable accessories, demands an AC voltage withstand test and a partial discharge test for the insulating parts which are in direct contact with the cable insulation. In HV- CONNEX cable connector systems, the insulating part is affected by this. An automated test fixture has been designed to allow for rational, cost-effective routine testing. The insulating parts are slid onto a suitable mandrel with as little initial expansion as possible and pressed into the associated socket by pneumatic activation. The process of sliding the insulating parts on to the test mandrel is undertaken with great care to prevent any possible mechanical damage.

Alongside the routine electrical test, all the insulating parts are subject to process-orientated quality assurance tests which are individually documented to ensure clear traceability. A large number of users therefore rely on the highly developed, reproducible production process and restrict their routine testing to visual and geometric inspections of the insulating parts. After all, experts rate the risk of preliminary damage from stretching on the insulation parts during the routine electrical test as negligible.

Result

Assembling cable connector sockets in the factory and the associated high voltage test of gas-insulated switchgears, including cable sockets, is a major step towards ensuring extremely high levels of product quality and reliability for the entire switchgear. Dry plug-in cable terminators allow the manufacturer of the switchgear and the operator to implement complex spatial patterns with tiny dimensions.