

# Plug-in Solutions for Medium & High Voltage Applications

Air is the oldest and still most widely used insulation material in high voltage applications. Since introduction of other insulation including oil and SF<sub>6</sub>, however, a growing number of HV applications are being integrated into housings filled with these materials. Pluggable cable accessories are a perfect example of this trend and were developed to allow

easy connection to such integrated devices while at the same time keeping the device separate from the application itself. This overview, contributed by Robert Ströbl of TE Connectivity, discusses plug-in solutions now being used to connect medium and high voltage apparatus to power cables.

Modern plug-in systems consist of basically two main components: the insulator or bushing and the plug itself. The bushing provides the insulation containment of the equipment (e.g. the switchgear) and keeps the insulation gas in a separate vessel. Consequently, it has to be able to withstand the pressure of the insulation gas while also transferring the power. Moreover, the defined interface of the bushing and the electrical element of the plug part must provide the insulation performance required.

The plug part of the system is made up of components typically found in almost every cable accessory, i.e. an electrical connection, a stress control element and the insulation body. Electrical contact between the cable conductor and the bushing is then provided by the mechanical connection with the bushing, which is the link to the live part of the apparatus.

Stress control systems these days are usually based on insulating and conductive silicones. The deflector within the plug body controls the electric field by means of shape and capacitance whereas the surrounding silicone provides the required insulation thickness according to the operating voltage. The combination of compressive force and silicone allows superior operating performance and also leads to an oil-free connection.

## Medium Voltage Plug-in Solutions

There are two widely-accepted and standardized bushing designs – outer and inner cone – each having its own advantages. For example, the inner cone system normally provides higher mechanical stability whereas the outer cone system offers greater flexibility for installation on different cable constructions. Plug-in type bushings are used for liquid filled transformers and all other types of medium voltage systems with the relevant standards for these applications being EN 50180 and EN 50181.

In recent years, the Type C outer-cone bushing has become the most common connection on distribution networks. Increasing energy density on such network has required some modification to extend the range of this type of bushing from 630 A to 1250 A rated current. As a result, the separable connector must be designed to cope with this new requirement so as to avoid becoming the 'bottleneck' of the

connection between cable, bushing and separable connector.

## High Voltage Plug-in Solutions

In the case of HV applications, the overall arrangement remains similar to what is used at MV except that the insulator is limited to the inner cone version. The outer cone version of the insulator is defined within IEC 62271-209 such that the system can be used in any application that complies with this standard (e.g. switchgear, transformer, back-to-back configurations, etc.). The inner shape, which is the counterpart of the stress control element, is however not defined. That means that the insulator and plug-in part basically have to be supplied by the same manufacturer but can still be changed 'as a system'. Moreover, this standardization allows for not only connection of power cables but also different applications such as blind plugs, test connectors and other apparatus.

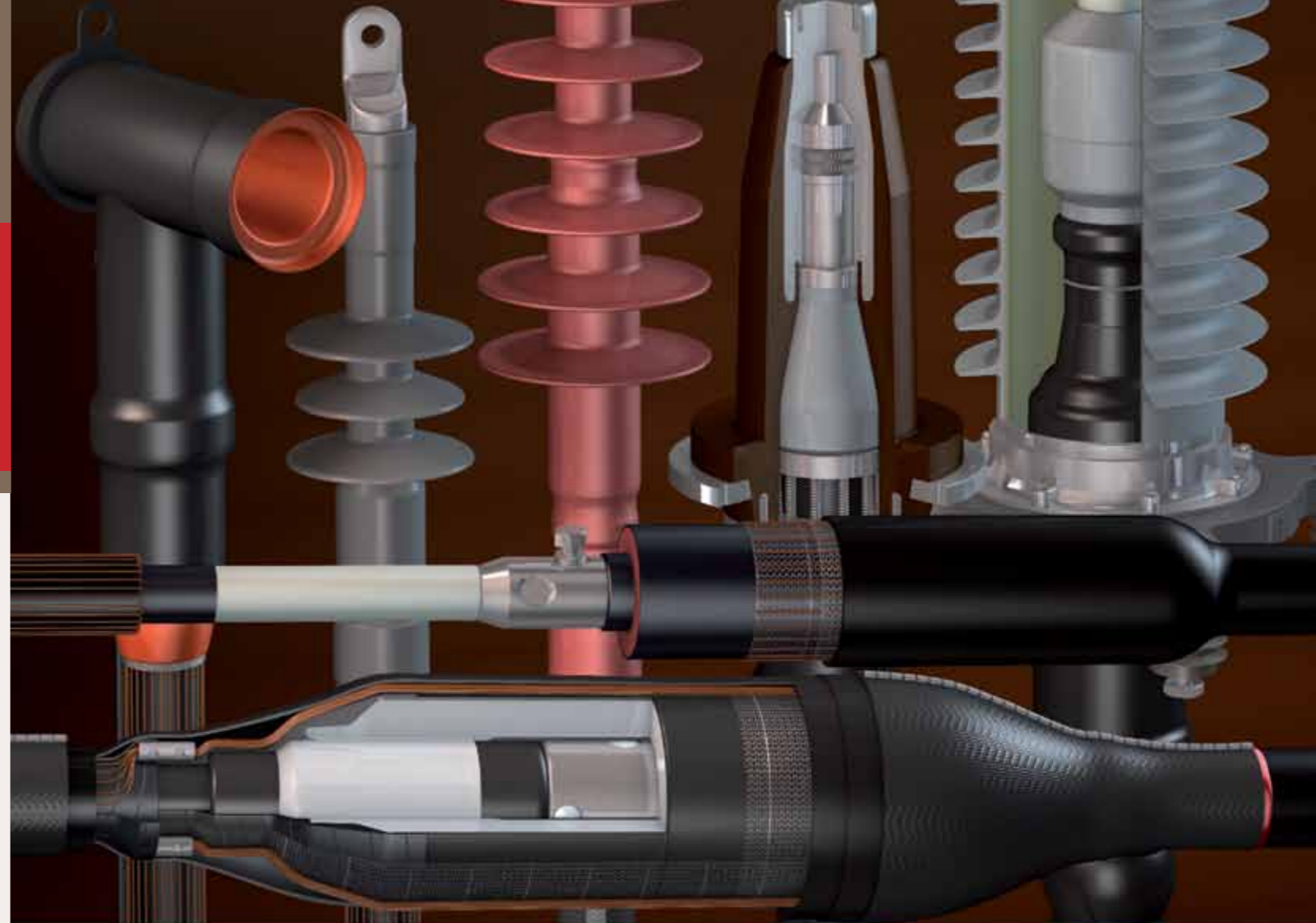
From the perspective of cable cross-section, there is no longer any practical limit and all existing HV power cables up to 2500 mm<sup>2</sup> can be connected. But at such large cross-sections there are very demanding technical requirements on the method of connection. Mechanical shear bolt technology is best suited to deal with such requirements and is therefore the current standard for plug-in solutions. A typical application is gas insulated switchgear that benefits from the fact that switchgear and cable can easily be connected yet remain separable, thus enabling a pre-test of each according to its own requirements and standards. Dry plug-in solutions are therefore now replacing old wet type equipment terminations.

## Summary

Power demand is increasing worldwide yet existing installation space remains the same. This leads to higher requirements when it comes to power density of grids and associated electrical connections. Separable plug-in solutions are increasingly becoming established in distribution and transmission applications to meet this challenge. This is because of the benefits offered compared to standard air or oil-insulated terminations and unscreened separable connection systems. Moreover, there is an ongoing evolution of these plug-in solutions and modern separable connection systems offer much higher performance to meet the growing requirements of present-day power grids. ☒



High and medium voltage plug in solutions



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