Dry-Type Outdoor Terminations 145 kV and 245 kV – Criteria of Design and Electrical Layout

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ABSTRACT

XLPE cables have become widely accepted for HV and EHV cable lines and connections. These cables are dry systems without any insulating liquid. Especially outdoor terminations are still using insulation liquids or gases. This paper presents design criteria for the use of a flexible silicone stress cone instead of liquids for dielectric field control.

KEYWORDS

cable accessories; cable termination; overhead lines; power cables;

INTRODUCTION

Nowadays, cable systems with XLPE insulation are widely accepted in HV and EHV grids. This applies to both, AC and increasingly to DC technology. The main benefit of XLPE cables is the avoidance of insulating fluids like oil. In contrast to the solid cable insulation, accessories still use oil or gas as an insulation medium. In case of GIS cable terminations, dry-type designs using silicone stress cones as dielectric field control element are successfully in service.

Nevertheless, especially outdoor terminations are still designed using insulation liquids like oils or gases like SF_6. The cable is mounted in a hollow core insulator for the required mechanical support. The field control is realized with a pre fabricated stress cone made of liquid silicone rubber (LSR). After the cable installation, the insulator is filled with the insulation liquid or dielectric gas. These non solid insulation mediums are well known designs, but have some drawbacks, which has to be dealed with durig operation.

Oil insulated outdoor terminations have a high fireload in case of a damage or breakdown inside the termination. Therefore, several standards consider safety regulations for oil filled cable terminations. In case of a leakage, the oil is released to the environment with dramatic consequences. Also the temperature range is limited, due to the pour point of the liquid. Especially during powering up of the cable system, this can cause problems. The maximum inclination of the termination is limited by the electrical dimensioning of the termination itself. Gas insulated cable terminations also show several of these drawbacks. Even though this insulation medium has no fireload, in case of a breakdown the danger of an exploding insulator still exists. Due to the boiling point of the dielectric gas, the minimum operating temperature is still limited. To ensure proper functionality even at low ambient temperatures an external heating system is necessary. Furthermore, gas insulated cable terminations require a gas monitoring system to detect leakage.

To deal with these drawbacks, several other designs are available at the market:

AVAILABLE SOLUTIONS

One solution is to replace the liquid oil with a high viscosity gel. This technology allows the prefabrication of accessories, and the process of oil handling during the installation is avoided. One difficulty of this technology is to ensure the adhesion between the gel and the insulator surface over the load cycles. The thermal expansion and shrinkage of the material is causing mechanical stress in this interface. The adhesion needs to be ensured over the whole lifetime. Otherwise, air voids along this interface can cause PD, which leads to a dielectric failure of the termination.

Another design uses the plug-in technique of the dry-type GIS termination in an epoxy resin insulator for outdoor purposes. This termination has some benefits during installation. The stress cone can be prepared on the ground while the termination itself is mounted on a pole. Then the cable is plugged into the termination. Thus, a lifting of the termination including the installed cable is not necessary. The maximum tolerable inclination of the termination is not limited, due to the avoidance of an insulating liquid. Nevertheless, such an epoxy resin outdoor termination has a high weight presenting a significant drawback during assembly. Furthermore, the large amount of epoxy resin makes this solution expensive.

DRY-TYPE SOLUTION

An alternative to gel filled or epoxy resin outdoor terminations are products using only silicone rubber as an insulating material. These dry outdoor terminations can be separated into flexible products, which need an external insulator for mechanical stabilization, and self supporting products, where an enlarged stress cone is inserted in a hollow core insulator. These self supporting dry-type outdoor terminations have been introduced in [1] - [3].

The avoidance of dielectric fluids, liquids or gases allow a large operating temperature range as well as an excellent behaviour during internal arc faults [2]. The environmental compatibility is improved, there is no fire load in case of a failure of the accessory, and complex oil or gas seals are not required. This reduces the risk of installation faults. Nevertheless, the realization as a dry-type solution brings some new challenges for the design, which are introduced more in detail.

Mechanical Layout

The mechanical layout of the dry type outdoor termination is based on the layout of the conventional fluid filled product. This layout is shown in Fig. 1. For the transition of