Development of a gas-filled plug-in type HVDC cable termination

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ABSTRACT

HVDC cable terminations and joints are key components in DC cable systems. As cable terminations differ in structure and materials among manufacturers, this paper presents the development process of a ± 200 kV gas-filled plug-in type HVDC cable termination. This type of termination has the advantages of lightweight, short installation time and low explosion risk. In the design process of this cable termination, we rely on multiphysics simulation modeling for performing electrical-thermal coupling and mechanical stress simulation. The system has successfully passed the type test. Extended tests have shown the system has a comfortable safety margin, suggesting the possibility of further size reduction and application at higher voltage levels.

KEYWORDS

HVDC; Gas-filled plug-in DC cable termination; Dry-type termination; ± 200kV; Interface; FEM simulation; R&D Test; Type Test

INTRODUCTION

Cable terminations are critical components in cable systems, and their reliability is essential for the proper operation and longevity of the system. In this paper, we present the development process of a novel gas-filled plug-in type high-voltage direct current (HVDC) cable termination.

The gas insulated plug-in type termination has a number of advantages due to its unique structural characteristics over traditional types as follows:

- **Lightweight**: The gas-insulated termination is considerblely lighter than the oil-filled terminations, making it easier to handle, transport and install.
- **Easy installation**: The plug-in type termination requires a shorter cable length for installation, which shortens the time required for straightening, peeling, and polishing. This also lowers the possibility of human error during the installation process and reduces the time and labor forces required for installation.
- **No risk of oil leakage**: The gas-insulated termination is a dry type termination, so there is no risk of oil or other insulation liquid leakage. It is an ideal solution for offshore platforms. However, it is still necessary to avoid the leakage of SF6, which is a greenhouse gas.
- **The possibility of using SF6-free insulation gas**: This termination is designed to be able use SF6-free insulation gas in the future, which will reduce the environmental impact of the termination.
- **Application in gas insulated system (GIS)**: The design and experience gained from this project can easily be further exploited in a GIS system.

STRUCTURE

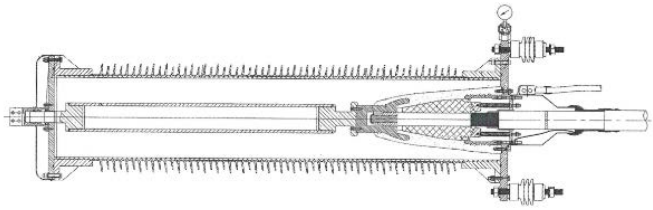

Fig. 1: Structure of the designed cable termination

The gas-filled plug-in type HVDC cable termination is a complex system consisting of multiple components designed to ensure good performance and reliability. These components include, but not limited to, a gas-filled insulator, epoxy socket, stress cone, supporting disk, springs, and more (Fig.1).

The gas-filled insulator housing provides the insulation and mechanical supports for the high-voltage electrode. It is filled with SF6 gas, which has excellent insulation properties and is chamically stable under high-voltage conditions.

The stress cone in the design is made of silicone rubber material which has been modified for DC applications. This particular silicone rubber material has been successfully used in multiple our previous projects, and its performance has been proven suitable for direct current cable accessories up to ± 500kV.

DIELECTRIC INTERFACES

One of the critical challenges in designing cable terminations are the dielectric interfaces, where the cable insulation meets the termination material or the interfaces between different components of termination. The interface's performance is essential for the termination's reliability and safety, as it determines the dielectric strength and the risk of partial discharge.

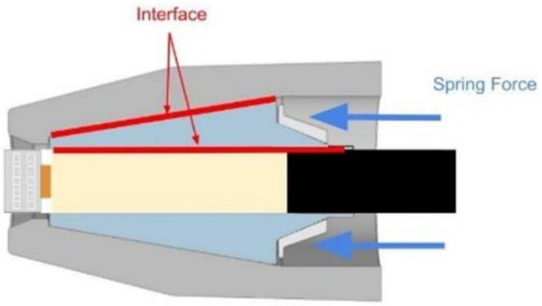

Fig. 2: Two critical interfaces in a gas insulated plug-in type cable termination

The relationship between the mechanical pressure and dielectric strength of such interfaces is illustrated in Fig.3 [1]. The state of art approach is to achieve the required