DEVELOPMENT OF HVDC ±500KV XLPE CABLE SYSTEM FOR LCC AND VSC

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ABSTRACT

HVDC power transmission market is growing rapidly as inter-country power system connection and DC-based renewable energy sources such as solar, wind farm, and fuel cells increase. Under these circumstances, Taihan has been developing HVDC cable system and pass the type test successfully for both 500kV LCC and VSC XLPE insulated HVDC cable system in accordance with CIGRE TB 852 and KEPCO purchase specification in November 2022.

In this paper, we describe the development process of overcoming several technical barriers through research and development and completing development tests through special material newly developed, state-of-art design and production of accessories.

KEYWORDS

HVDC, XLPE, EPDM, Cable accessories, Space charge, type test, Volume resistance, LCC converter, VSC converter, Polarity reversal test

INTRODUCTION

HVDC XLPE cables and accessories are influenced by electric field equations different from AC cables. Therefore not only cable XLPE insulation but also the insulation material for accessories should be applied specialized new materials that minimize electric field distortion caused by space charge accumulation inside and at the interface of the accessories under DC electric fields. And much higher skills and management are required during assembly of accessories.

In particular, the 500kV HVDC cable for LCC converter adopted as the grid system of the Korea Electric Power EP project, which is the target project of this development, has a higher cable operation temperature of 90°C than VSC and includes a polarity reversal test.

We first adopted DC-XLPE material with excellent performance under these high operating temperature and polarity reversal conditions through several performance tests. In addition, by applying newly developed EPDM material and improving the structures and assembly method for cable accessories, we successfully completed the type test in order to qualify the HVDC cable system LCC with an operating temperature 90℃.

XLPE MATERIALS

In order to select the optimal XLPE material for HVDC cable, the physical properties such as volume resistance, dielectric breakdown strength, mechanical performance, and space charge of the newly introduced XLPE material for HVDC were measured.

DC-XLPE requires a significantly higher volume resistance than AC-XLPE to minimize joule heat generation due to leakage current during operation. Therefore, as shown in Figure 1, the volume resistance of DC-XLPE and AC-XLPE measured under different field and temperature conditions. As a result, the volume resistance of DC-XLPE was about 30 times higher than AC-XLPE.

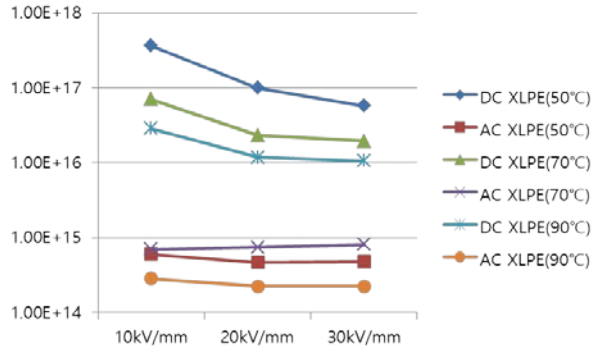

Fig.1: Volume resistance of DC & AC XLPE [Ohm-cm]

Next, as the result of DC dielectric strengths at room temperature and high temperature, respectively, the dielectric strengths at room temperature of DC-XLPE and AC-XLPE were similar as shown in Table 1, but at 90℃ high temperature, DC-XLPE was about 225% higher than AC-XLPE. [3] These results are presumed to be due to the fact that DC-XLPE has a lower accumulation of space charge at high temperatures compared to AC-XLPE.

Table 1: Result of dielectric strength test of XLPE materials

Item		Dielectric strength test [kV/mm]	
		AC XLPE	DC XLPE
DC voltage	R.T	291.3	287.4
	90℃	88.6	199.6

Space charge was measured by applying PEA measurement techniques to check the space charge characteristics according to the varied temperature condition of AC-XLPE and DC-XLPE. The experimental configuration was performed at a 30kV/mm field for 0.3mm plaques at room temperature and 70 degrees temperature conditions. The AC-XLPE is injected with Homo Charge from both electrodes under room temperature conditions, and the maximum field is distributed constantly over time. In 70 degrees, which increases the de-trapped charge than the injected charge, the Homo Charge is injected only from the ground electrode due to the relatively high electronic movement, and the field tends to be concentrated on the high voltage side.