Space Charge Characteristics in DC-XLPE Cable after 400 kV PQ test.

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ABSTRACT

The authors have developed DC-XLPE with good DC characteristics. The first domestic application of DC extruded cable, using DC-XLPE as insulation for the HVDC link between Hokkaido and Honshu in Japan, has been completed. Operation of the HVDC link commenced in December 2012. Two years have passed since the start of operation of the HVDC link and no problems have occurred.

Pre-qualification(PQ) testing of 400kV class cable using DC-XLPE was completed. The PQ test, which includes a polarity reversal test, was conducted in accordance with the CIGRE TB 496. The conductor temperature of PQ test was 90℃.

The authors have developed the space charge measurement system of cables, and evaluated the space charge characteristics of the 400kVDC-XLPE cable which passed the PQ test. As a result, it was confirmed that the amount of space charge accumulation in cable insulator is small and the electrical field in cable insulator is similar to the calculated value on the permittivity distribution power capacity of the cable.

KEYWORDS

DC cable, cross-linked polyethylene, PQ test, cable space charge measurement

INTRODUCTION

Around the world, the main application for HVDC power transmission has been in long-distance power transmission such as intercontinental links. However, in recent years, there has been a growing trend toward its application to offshore wind power generation, which is being actively introduced in Europe as a renewable natural energy source. As its introduction has progressed, locations of wind power generation facilities have been shifted from coastal areas to offshore areas due to space constraints. As the power transmission distance has increased, HVDC power transmission technology has drawn more attention.

Previously oil-impregnated insulation cables, such as mass impregnated (MI) cable and oil-filled (OF) cable, have been applied to DC power transmission. In recent years, however, because of increasing awareness concerning environmental protection, extruded insulation cables have become more popular as they pose no risk of oil leakage.

On the other hand, cross-linked polyethylene (hereafter AC-XLPE) insulation cable, which is currently widely applied to AC power transmission, is known to have a number of problems concerning insulation when used for DC usage, i.e., prominent accumulation of space charge in AC-XLPE insulation material. Therefore, we have developed a DC-XLPE insulation material that has excellent DC characteristics. The main DC characteristics are DC breakdown strength, volume resistivity and space charge characteristics. The main DC characteristics have already been evaluated[1]. We have manufactured a DC-XLPE cable using the material and developed accessories for a cable system. The DC-XLPE cable system was installed in 2012 for the Hokkaido-Honshu DC link in Japan[2], and at the end of the year, it began operation at a voltage of 250kV. A 400 kV-class PQ test was completed under test conditions that conform to CIGRE TB 496[1],[3]. This test was carried out on a full-size cable using the DC-XLPE and cable accessories.

This paper describes operational experience of the cable using DC-XLPE, the result of long-term demonstration tests and the result of the space charge measurement in DC-XLPE cable after 400kV PQ test.

Practical Application of +/-250kVDC-XLPE Cable [2]

We have completed the first domestic application of DC extruded cable using DC-XLPE as insulation for the HVDC link between Hokkaido and Honshu.

Fig. 1 shows the external appearance of the submarine cable. Fig. 2 shows the structure of the submarine cable laid in the Hokkaido-Honshu HVDC Link. A 14-mm-thick insulator was adopted. The cable incorporates optical fiber and is armored with double layers of steel wire. Its unit weight is approximately 48 kg/m in air and approximately 33 kg/m in seawater.

Fig. 1: +/-250kV DC-XLPE cable for Hokkaido-Honshu DC link [2]