HVDC XLPE CABLE SYSTEMS APPLICABLE FOR HIGHER TEMPERATURE AND POLARITY REVERSAL OPERATION

Yoshinao **MURATA**, Kazutoshi **ABE**, Makoto **SUIZU**, Shoji **MASHIO**, Osamu **MATSUNAGA**, Shinya **ASAI**, Shoshi **KATAKAI**, J-Power Systems Corporation, (Japan), murata.yoshinao@jpowers.co.jp, abe.kazutoshi@jpowers.co.jp, suizu.makoto@jpowers.co.jp, mashio@jpowers.co.jp, matsunaga.osamu@jpowers.co.jp, asai.shinya@jpowers.co.jp, katakai.shoshi@jpowers.co.jp

ABSTRACT

HVDC XLPE cables we have developed have excellent properties under DC voltage application, especially very low accumulation of space charge. Therefore, the HVDC XLPE cables can be applied to DC link lines with not only VSC technology but also LCC technology with polarity reversal operation. The HVDC XLPE cables and accessories were subjected to long term tests according to the test conditions of CIGRE TB 219. The long term tests were conducted at a conductor temperature of 90°C including polarity reversal test. In this paper, fundamental characteristics of the HVDC XLPE and results of long term tests are described.

KEYWORDS

HVDC; XLPE cable; polarity reversal operation; permissible operating temperature, space charge.

INTRODUCTION

High Voltage Direct Current (HVDC) transmission technology is employed for long distance electrical power transmissions such as international and intercontinental power transmissions. There is a tendency for power stations to be built in rural areas far from urban cities, so the necessity of long distance bulk power transmission technology will increase in the future. On the other hand, in order to increase renewable energy sources, off-shore wind farms have been increasingly employed, especially in Europe. This has made the distance from the wind farm to the shore longer and longer as the available space near the shore reaches its limits. Therefore, HVDC technology is likely to be applied in long distance off-shore wind power transmissions to the shore.

Recently, HVDC link projects using extruded insulation cables have increased because extruded cables have some advantages compared to the technology of conventional cables such as Mass Impregnated paper cables (MI cables). The principal advantages of the extruded insulation cables against MI cables are that no oil is used in insulation and the permissible conductor temperature is higher in normal operation. However, the extruded cables have been only applied for DC link projects with Voltage Source Converter (VSC) technology, never with Line Commutated Converter (LCC) technology. It is believed that the space charge is likely to be accumulated in the extruded insulation material rather than the oil impregnated paper. Therefore, generally speaking, it is difficult to apply the extruded insulation cables in the polarity reversal operation conducted in LCC line.

The HVDC cross linked polyethylene (XLPE) cables we developed have excellent properties under DC voltage application, especially a very low accumulation of space charge. These excellent DC properties are due to the special technique on XLPE insulation material. Therefore, the HVDC XLPE cables can be applied to DC link lines with not only VSC technology but also LCC technology with polarity reversal operation. In addition, the HVDC cables can be operated at a conductor temperature of 90 degrees centigrade in normal operation.

In order to qualify the HVDC cable systems with LCC at an operating temperature of 90°C, long term tests according to the test conditions of CIGRE Technical Brochure 219 [1] (TB 219) were conducted. In this paper, the fundamental properties of the HVDC XLPE insulating material are reviewed and the long term test results of the HVDC cable systems are described.

HVDC XLPE INSULATION

Conventional XLPE insulating materials, which are generally used for AC cables, have insufficient properties for DC cable application. The authors have developed HVDC XLPE insulating materials, and found that the problem in the DC properties of conventional XLPE can be solved by the mixing of special additives to XLPE. The HVDC XLPE's major advantages against conventional XLPE are as follows:

- Volume resistivity is higher.
- Space charge accumulation is lower.
- DC breakdown strength is higher.

These fundamental properties are described below. In this paper, the HVDC XLPE insulating material we developed is called "DC-XLPE", and the conventional one is called "AC-XLPE".

Volume resistivity

Volume resistivities of a pressed sheet specimen were investigated. The volume resistivity was evaluated from the leakage current value ten minutes after the measurement started. The thickness of the sheet specimen was about 150μm. A three-terminal electrode system was used, and the main electrode diameter was 65mm. The measurement temperature was 90°C, and the applied electric fields were 40, 60 and 80kV/mm.

Figure 1 shows the dependence of the volume resistivity on the electrical field at 90°C. In Figure 1 both volume resistivities of DC-XLPE and AC-XLPE are shown. As shown in Figure 1, the volume resistivity of DC-XLPE is approximately a hundred times that of AC-XLPE. DC-XLPE has an extremely higher volume resistivity than AC-XLPE at high temperatures.