Development of 350 kV and 525 kV HVDC extruded cable system

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ABSTRACT

In recent years, high voltage direct current (HVDC) power transmission lines have spread rapidly in the world's power grid. Furukawa Electric has developed the HVDC extruded cable system. For the DC 350 kV submarine cable system, a prequalification test was successfully completed without any problem. Furthermore, a DC 525 kV cable system has been developed. A DC 525 kV prequalification test is in progress and will be completed by the end of FY 2019.

Keywords

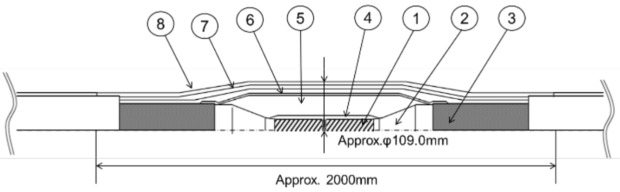
DC-XLPE, HVDC, DC 350 kV PQT, DC 525 kV PQT

Introduction

In recent years, the HVDC system has spread rapidly in the world's power grid. HVDC cables are used as land and submarine power cables. The extruded cable is superior to the OF and MI cables in terms of the environment and maintenance. Furukawa Electric Co., Ltd., has developed an HVDC CV system and has already completed the development of a DC 320 kV land and submarine cable system PQT [1]-[3]. We implemented the DC 350 kV PQT on the line, including the factory joint, which was element technology for the submarine cable system, and obtained good results. We have also developed a DC 525 kV submarine cable system to further increase the voltage. Generally, in submarine cables, the thermal conditions of the land area tend to be more severe than the sea area. In the sea, the specified temperature is expected to be low because the temperature change is small, but the base temperature will be high if it is directly buried at the landing site. Therefore, the cost of the entire system can be reduced if the size of the conductor for the portion susceptible to thermal restriction, and the portion less susceptible to thermal restrictions (for example, in the sea) can be appropriately sized. This paper reports the specifications and development test of the DC 350 kV submarine cable system, and the specifications and development test of the DC 525 kV submarine cable system including connection of 1800 mm ^{2} and 2000 mm ^{2}.

350 kV prequalification test

The tested cable had a split conductor of 2500 mm^2 for the submarine 350 kV DC-XLPE CV cable. The cable was composed of a lead sheath and a polyethylene sheath. The insulation material was DC-XLPE in which the polar group was graphed in XLPE, and the working temperature of the cable insulation was 90°C. Figure 1 shows the structure of the factory joint (FJ). The welding method was used for the conductor connections. FJ was composed of an insulating tape of the same material as the cable insulator and the reinforced insulating layer that was molded after winding the tape. The outer semiconducting layer, a lead sheath, and a PE sheath were formed on the reinforced insulation.



No.	Name of parts
1	Conductor Welding
2	Insulation of Cable
3	Insulation Screen of Cable
4	Inner Semiconducting Layer
5	Reinforced Insulation
6	Outer Semiconducting
7	Lead Sheath
8	PE Sheeth

Figure 1: Structure of factory joint (FJ)

MECHANICAL Tests

We tested the cable and the FJ that were strengthened by the wire sheath for mechanical testing in accordance with CIGRE TB 623 [4], Recommendation Electra 171 [5]. Table 1 shows the test conditions for the mechanical test. Figure 2 shows the coiling test status, and Figure 3 shows the tensile bending test status. After the coiling test, the cable with one FJ was cut, and the tensile bending test was performed at 100 kN, assuming conditions for laying a submarine cable with a conductor size of 2500 mm^2 at a water depth of 200 m. All mechanical tests were cleared without any problems.

Table 1: Test conditions for the mechanical test

item	Sample	Condition
Coiling test	Cable: 300 m FactoryJoint: Two-piece	Min bend radius: 4.5 m Time: Four cycles
Tensile bending test	Cable: 35m FactoryJoint: one piece	Tensile force: 100 kN Time: Three times bend radius: 8 m