Development and engineering application of ±160kV XLPE to three-terminal VSC HVDC project in China

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The world's first ever multi-terminal voltage source converter (VSC) high voltage direct current system was put into operation at the end of 2013 for the connection of Nan'ao island wind farm to the onshore grid in China. The project, rated at ±160kV and 200MW, has deployed a 28.3 km-transmission system which comprises XLPE insulated HVDC land and submarine cables and overhead lines by considering the geographic condition of transmission right-of-way. XLPE insulated DC cable and its accessories was also the first ever developed at such voltage level in China by then. The configuration of the project is illustrated in Figure1.

Figure 1 Configuration of Nan'ao VSC project

This paper presents the technical issues of ±160kV XLPE insulated HVDC cable development and its engineering application in this three-terminal VSC project. For the material development and cable insulation design, a good effort has been made on conductivity characteristic of insulation material with temperature and electric field, insulation material breakdown tests, and space charge behavior.

Submarine cable is made of swelling tape for water blocking, and an 18-core fiber-optic is buried between lead sheath and armor steel wires for monitoring and communication. The prefabricated joint and termination were developed by optimizing interface material properties to decrease the space charge accumulation.

The cable system was tested by referring to CIGRE TB 496 "Recommendations for Testing DC Extruded Cable Systems for Power Transmission at a Rated Voltage up to 500kV". Due to the connection of cable system and overhead line, the maximum potential lighting and switching impulse voltage were calculated by PSCAD/EMTDC simulation to determine the insulation coordination parameters. Superimposed impulse voltage tests have been successfully conducted on this basis. Apart from the development test, routine test and sample test suggested by CIGRE TB 496, a new testing procedure of AC-DC-AC withstand tests with partial discharge measurement in AC test was agreed between manufacturer and user to check the insulation integrity after manufacture and DC voltage test respectively, which has been proved to be an effective testing method to ensure the quality of XLPE insulated HVDC cables.

The cable system has been put into operation for almost a year and its conditions and system characteristics are presented and analyzed as well based on the data obtained from Nan'ao on-line monitoring system.