Triple Jumps of XLPE Insulated HVDC Cable Development in China: - from 160kV, 200kV to 320kV

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ABSTRACT

HVDC transmission technology has been well recognized due to its significant advantages over the HVAC in terms of transmission capacity, transmission distance and transmission losses. With the technology advancement of VSC (Voltage Sourced Converter) and engineering application, research and development on HVDC cable has been initiated since 2012 because of the first industry application including the research of the insulation materials , design, manufacture and tests of DC submarine power cable and factory flexible joint and cable accessories as well. Under the specification of TICW (National Quality Supervision and Inspection Center of Wire and Cable) for DC power cable, Zhongtian Technology (ZTT) as a pioneer in China has succeeded in ±160kV, ±200kV and ±320kV DC power cables for domestic and oversea commodity market. In December 2013, ±160kV DC submarine and land cable with a total length of 37km was put into operation in a three-terminal VSC DC transmission project for the connection of Nan'ao island wind farm to the onshore grid of China Southern Power Grid. In June 2014, 294km ±200kV DC submarine power cable also came into service in Zhoushan multi-terminal VSC DC transmission project owned by State Grid . Another VSC project at the voltage level of ±320kV is under construction in Xiamen within State Grid of China, in which a cable with the length of 21km will be deployed and the relevant prequalification test is in progress. The project is expected to come into service in December 2015. On the completion of three projects within three years of time China has realized triple leap in its HVDC submarine and land cable development. The paper presents the technical achievement of XLPE insulated HVDC cable development in details of material characterization, space charge behavior, degassing processing and testing considerations. Their application in three projects is briefed as well to illustrate the insulation and coordination design by considering each individual transmission system.

KEYWORDS

DC Cable； flexible DC Project； prequalification test

0 PREFACE

Along with continuous expansion of exploit scale of the offshore wind power, solar, tidal and other renewable energy, the new energy power transmission capacity and transmission distance increase more and more. The intermittent and periodic characteristics of the renewable energy make the AC transmission technology or the traditional DC transmission technology for the network is not economical and reliable. In addition, with the rapid increase in electricity need load, it is required to keep expanding the network capacity and reduce the loss of transmission lines, which shall be realized by means of new transmission technology. In recent years. China grid has used conventional DC transmission technology for the construction of ±800kV UHV, ±660kV and ± 500kV EHV overhead transmission lines with length of nearly ten thousands of kilometers. And in these projects, the conventional HVDC transmission tecnology takes use of overhead conductor or paper insulated power cable, oil-filled power cables for the whole system, which not only produces a greater side impact on the environment but also causes a huge investment. Compared with that, flexible DC transmission technology based on voltage source converter generally chooses XLPE as cable insulation type and has the advantages of excellent electrical performance, high operating temperature and no aging oil spill risk. Flexible HVDC technology has the characteristics of monopole operation, simple power control, low line loss, long transmission distance and so on. Also it can realize the back-to-back connection of AC power and the phased engineering construction and capacity expansion, especially suitable for AC system linking with different frequency or same frequency of non periodic operation (wind energy, tidal energy and other new energy) and long-distance power transmission under the sea. With the successful development of Chinese flexible DC converter technology, DC power cable technology and products, flexibe HVDC transmission demonstration projects started from 2012 in China. DC submarine and land cables with a total length of 37km used in the Nan'ao ±160kV flexible multi-terminal HVDC transmission project undertaken by southern power grid has been put into operation in December 2013. In June 2014. 294km ±200kV DC submarine power cable also came into service in Zhoushan multi-terminal VSC DC transmission project owned by State Grid. In 2014, another VSC project at the voltage level of ±320kV is under construction in Xiamen within State Grid of China, in which a cable with the length of 21km will be deployed and the relevant prequalification test is in progress. The project is expected to come into service in December 2015.

1 BASIC WORK OF DC CABLE RESEARCH AND DEVELOPMENT CHINA

XLPE insulated cable is the key technology to realize the flexible HVDC transmission. With the successful development of Borealis 4253DC insulation materials and its open application to China market, the DC cable system research and development is accelerated. Chinese colleges and universities, research institutes and manufacturer including Shanghai Jiao Tong University, Xi'an Jiao Tong University, Harbin University of Science and Technology and the Shanghai Electric Cable Research Institute, China Southern Power Grid and