PQ Test of Extruded HVDC 525-kV-Underground Cables: Results and Conclusion

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ABSTRACT

The German TSOs established a task force in order to launch a prequalification test for the technical feasibility and capability of EHV DC cable systems with extruded insulation. Scope of investigation were cable systems up to a maximum voltage of 550 kV DC (rated voltage of 525 kV) and a rated current of app. 2000 A.

A cable system comprises of a variety of accessories such as outdoor terminations, straight and sectionalized joints. Transition joints for different cross sections/insulation materials or from different cable manufacturers have to be tested in a separate qualification test later on if needed for the projects. All in all five cable systems from four different manufacturers were tested.

KEYWORDS

Extruded HVDC cable, Prequalification test, PQ test, Type test, Superimposed impulse voltage test, Joint, Termination, VSC, 525 kV, Visual inspection.

INTRODUCTION

To overcome the worldwide increasing demand for long distance transmission using underground cable technology, ongoing innovation is required. Especially for long distances and minimized power losses, DC is not just preferred over AC technology but often the only feasible solution.

In the 90´s intensive research and development efforts have been put into extruded DC cables. Innovation in DC insulation materials and manufacturing techniques led to the commercial deployment of extruded high voltage direct current (HVDC) cable systems. After about 15 years of commercial experience, extruded HVDC cables have become an essential part of the portfolio of HV cable products. Extruded HVDC cables are also becoming more and more attractive for the transmission of bulk power. The use of modern VSC technology enables the power flow reversal without changing the polarity of the DC system voltage. This fact encourages the use of synthetic insulated cables for long underground links.

Within about 10 years, the installed HVDC extruded cable systems passed from 150 kV to 320 kV. Throughout these years cable manufacturers and customers have gathered a considerable amount of knowledge through testing and operational experiences. Today the research on extruded cable systems for HVDC applications is focusing on increasing the voltage level in order to transmit more power.

With respect to life expectancy, it is mandatory to have a clear understanding of the cable system's performance. Especially the thermal and electrical ageing is in focus, before putting these new cable systems into service in such large power transmission projects like foreseen in Germany.

For a while, the highest voltage available on the market was 320 kV for extruded DC cable systems. In 2014 the first cable for 525 kV DC range had been announced, though none has been put into operation up to today.

HVDC cable links will be essential to connect energy markets, to integrate large amounts of green energy, to transmit vast amounts of electrical power over very long distances across or between continents and also within networks, e.g. as embedded VSC.

The PQ test undertaken by the German TSOs (GTSO)is setting a standard for the testing of extruded DC cable with a rated voltage of 525 kV. It has also proven the maturity of the HVDC cable systems at this voltage and thus is preparing a successful implementation of them into the coming projects.

MOTIVATION TO CREATE A GTSO PQ TEST SPECIFICATION SURPASSING THE CIGRE TB 496 REQUIREMENTS

With the power generation of the wind parks in the North Sea and in northern Germany, large electrical power has to be transmitted to the industrial areas in the south and west. New transmission lines over large distances are needed to stabilize and to enhance the existing German onshore EHV grid. As prescribed by law, most parts of the routes shall be realized by underground cables.

There is experience of many years with the innovative technology of extruded HVDC cables with voltages of 320 kV. However, due to the length of the lines and the energy to be transmitted, operating voltages up to 525 kV are desirable. Thereby, energy losses can be reduced as well as the number of cable systems and thus the demand of land and the level of rights of way.

To ensure the suitability and reliability of extruded 525 kV DC Cable systems, extensive prequalification procedures have to be executed. The German TSOs prepared a PQ Test Specification with enhanced requirements. The tests shall simulate realistic conditions with regard to types of cable laying and execution of the long duration voltage tests. Laying conditions that might be used in the projects, such as directly buried, tunnel and pipe installation are therefore implemented in the PQ tests.