Pre-qualification test of 525 kV extruded HVDC XLPE subsea and underground cable system

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ABSTRACT

To investigate the technical feasibility and capability of a 525 kV extruded high voltage direct current (HVDC) cross-linked polyethylene (XLPE) cable system, a parallel prequalification (PQ) test is conducted. The cable system consists of the following parts: subsea cable and underground cable with a maximum DC voltage of 550 kV and a rated current up to 2000 A, outdoor terminations, and various types of joints. To simulate the practical conditions, different installation schemes are employed i.e. direct buried, buried in ducts etc. The test is successfully carried out according to CIGRE TB 496 as well as some additional tests are also performed for research purpose.

KEYWORDS

Prequalification tests, 525 kV Extruded HVDC XLPE cables, subsea cables, underground cables, Joints, Terminations, VSC

INTRODUCTION

To meet the energy demand of ever-increasing world population, the installed capacity of off-shore power plants has significantly increased in the recent years. For power transfer over long distances, high voltage direct current (HVDC) transmission is preferred over high voltage alternating current (HVAC) technology due to minimized power losses and reactive power capacity [1]. Figure 1 demonstrates the breakeven distance beyond which HVDC is the most feasible technology for power transmission. The performance of insulation material determines the efficiency and life of the cable. Previously, fluid filled and mass impregnated cables have been widely used for power transmission. However, XLPE now has been adopted as potential insulation material for HV cables for the past several decades as it is more environmentally friendly. Initially, AC XLPE had been used for both AC and DC power cable applications. However, AC XLPE suffers severe space charge accumulation when subjected to HVDC stress. In 1990's, researchers put significant efforts to develop DC XLPE material [2].

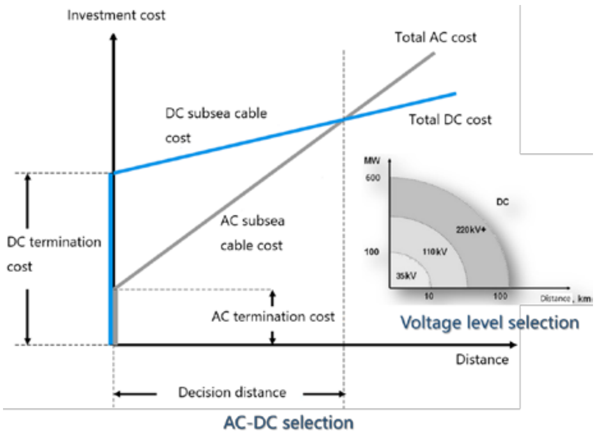

Figure 1: Relationship between transmission distance and cost of HVAC and HVDC system

The advanced voltage source convertor (VSC) technology allows flexible bidirectional power flow without changing the voltage polarity of the system. This interesting feature of VSC technology further encourages the use of XLPE extruded HVDC cables. During the last decade, the applications of XLPE extruded HVDC cable have significantly increased and the existing voltage level is 400 kV for XLPE HVDC cable system [3]. However, to efficiently transmit the large power from continuously increasing installed capacity of renewables, it is essential to further upgrade the voltage level of the HVDC cable transmission system. However, due to the lack of experience of power transmission with HVDC cables of voltages above 400 kV, there is a stringent demand to carefully develop the state-of-the-art new HVDC cable systems and also rigorous qualification testing is urgently required.

This technical paper presents the successful completion of PQ test for a newly developed 525 kV extruded HVDC XLPE cable system. CIGRE TB 496 [4] is completely followed during the test. The cable system includes both subsea/submarine and land cables with joints as well as terminations. The temperature of the whole cable system is carefully monitored throughout the test. During the test, the temperature profiles of the different sections of the cable system and the leakage current are carefully recorded. Also, the space charge profiles also measured on the full-sized cable before the PQ test, and expected to be carried as well after the PQ test. This development further helps to realize the HVDC grid vision, encourages mutual cooperation of energy markets and better use of renewable energy resources.

DEVELOPMENT OF CABLE AND ACCESSORIES

Submarine and Land Cable

A high-quality assurance during cable production and its strict consistency is indispensable to produce an efficient and flawless cable of a hundred of kilometers. Besides the quality requirements for HVAC cable production i.e. to avoid any voids, pollution particles, cracks, scorch etc., additional care is required for HVDC cable production. For example, some by-products may not be detrimental for HVAC cable but may deteriorate the DC conductivity of HVDC cable which should be avoided/minimized. Hence, the cable production facility assures the state-of-the-art quality from insulation material preparation to the cable