Prequalification test program for 525 kV DC underground and submarine cable systems

Frank **DE VRIES**, Sergei **SCHENNINK**, Ron **VAN DEN THILLART;** TenneT T.S.O., (The Netherlands), frank.de.vries@tennet.eu, sergei.schennink@tennet.eu, ron.van.den.thillart@tennet.eu

Roland **ZHANG** TenneT T.S.O., (Germany), roland.dongping.zhang@tennet.eu

Sander **MEIJER**, EP-ICS, (The Netherlands), sander.meijer@ep-ics.nl

ABSTRACT

As part of a large 2 GW development program TenneT started a prequalification test program for 525 kV DC extruded cable systems with eight cable suppliers. The program involved underground and submarine cables, including factory joints and accessories. The test program included special mechanical tests, long duration voltage tests under different loads, super imposed impulse tests and examination.

This prequalification test program for 525 kV DC extruded cable systems is considered to be a success. In time, before the award of the first 2 GW projects, multiple suppliers have successfully performed the prequalification test program.

KEYWORDS

Prequalification test, PQ test, Extruded submarine cable, Extruded underground cable, 2 GW, 525 kV, Bipole with metallic return, Impulse test, Accelerated aging test, Mechanical preconditioning.

INTRODUCTION

The EU ambitions for developments of offshore wind are challenging and demands for further developments in cable technology. In order to cope with these ambitions and to accelerate the role out of offshore wind, TenneT has launched a large 2 GW program that includes the development and realization of 2 GW offshore and onshore converter stations including HVDC equipment and 2 GW DC cable systems. With respect to cable systems TenneT had the following focus points.

- Cable systems with bulk power transport
- Standardisation of technology
- Clustering of projects

The paper will present how TenneT came to the best technological solution, taking into account voltage classes and mass impregnated and extruded insulation material. The paper will continue with the prequalification program that TenneT initiated with eight cable manufacturers in order to push the development of 525 kV DC extruded cable systems, for underground and submarine applications. The prequalification test program, test setup, specific test items and the introduction of an accelerated aging test (as an alternative) will be presented. Furthermore the test results and some technical experience during the tests will be described.

DESIGN CONSIDERATIONS

In order to connect 2 GW of wind power to the shore, multiple grid connection system concepts were assessed, including AC and DC, bipole with and without metallic return and different voltage levels. Besides system voltage also extruded and mass impregnated cable insulation was evaluated. It soon became clear that the amount of power infeed in combination with the distance to shore would point into the direction of DC links.

525 kV DC voltage class

During the initiation phase of the 2 GW program, 320 kV DC symmetrical bipole was the standard system technology for power up to 1000 MW. Connecting 2 GW of power with 320 kV DC would lead to at least two cable systems for each grid connection. There was an interest to look for higher operating voltages for multiple reasons

- Efficient use of space (permits)
    - Smaller cable corridors (one cable system for 2 GW)
- Better environmental footprint
    - Less materials
    - Less environmental disturbance
    - Less losses
- Efficient use of resources
    - Less people
    - Less production capacity

Bipole with metallic return

The standard 2 GW HVDC grid connection system consists of a bipole with metallic return configuration. The metallic return facilitates a higher availability because the system can still operate on half capacity (as asymmetrical monopole) during a pole outage, either due to a fault or during scheduled maintenance. When compared to a rigid bipole or symmetrical monopole topology of the same capacity, it reduces the probability of occurrence of a high impact (2 GW) outage extremely, thanks to the virtually decoupled operation of HVDC poles, where the imbalance current between the poles flow through the metallic return.

Last but not least, being the most technically flexible HVDC scheme, bipole with metallic return provides distinct advantages to enable extension towards a future multi-terminal DC (MTDC) grid [9].