On-Site Testing of 66 kV Subsea Array Cables for Off-Shore Windfarms

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ABSTRACT

Off-shore windfarms with extruded XLPE inter array cables with ratings up to 66 kV will be more and more common. IEC is anticipating the situation with a new standard IEC 63026 (under development) to guide manufacturers, test service providers and operators is under development. This paper discusses the kind of application of this standard and the practical implication in the field. A test system to cover the requirements is proposed and the test methodology analyzed and discussed in depth.

KEYWORDS

Inter-array cable, 66kV- cables, offshore wind farm, test after installation

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INTRODUCTION

Off-shore windfarms are moving towards higher generation power per wind turbine. To connect the wind turbines in the most efficient way, the voltage level of the connecting array cables is more and more moved to 66 kV, with reference to U_m = 72.5 kV. Regarding cable technology, it can be stated that extruded XLPE cables are state of the art and a cost-efficient solution. Nevertheless EPR insulated cables are type- tested and ready for use. This allows the increase of the power capacitance, leading to an increase of the number of connected wind turbines and therefore the maximum length of the string. Utilizing 66 kV cables off-shore, the experience regarding failures and failure mechanisms during installation and operation is limited. To guide manufacturers, test service providers and operators, a new standard is under development: IEC 63026. As the standard is not published yet, there is no doubt that a dielectric on-site test for commissioning will be recommended.

For the practical application two different set of requirements can be defined: The installation of an individual wind turbine and its connection to the wind farm and the connection of a complete string of wind turbines to the collector platform for full operation. To ensure the quality of the cable system, it is important to apply a test voltage in such a way, that potential partial discharges (PD) and therefore potential failures can be detected safely.

In a first step the physical background how PD in a cable system can be initiated and measured will be discussed. Based on that background the different methods to generate a suitable test voltage to ensure the dielectric integrity of the cable as well as the sufficient amount of energy to initiate PDs in wrongly mounted cable joints and terminations are compared.

As a solution a resonant test circuit shows the preferred performance to detect PD in cables and cable accessories. The structure of such a test system is explained, especially the necessary adaptations for offshore applications for cable systems with rated voltages up to 66 kV. These adaptations are covering the test circuit as such and also the infrastructure for the transportation, installation and application of the resonant test system. The integration of the PD measurement is one of the key discussion points.

TESTING OF CABLES

Cable systems with U_r above 36 kV should be tested to evaluate their technical integrity and performance. Whereas the cable as such has passed the factory test, the cable systems includes joints and terminations. There assembly takes place on-site and deviations and failures cannot be excluded (Figure 1; [1]). For the typical length of array cables, joints will be not expected or only for a few special layouts. Nevertheless, terminations are mounted at each connection on the collector platform and at all wind turbines.

To test the integrity of terminations, the cable should be applied with a test voltage and partial discharges (PD) should be measured at each termination. To increase the probability to find the failures, the dielectric stress - based on electric field as well as shape and distribution of test voltages - should be as similar as possible to the operational stresses. A preferred solution to generate an applicable test voltage is a resonant test circuit.

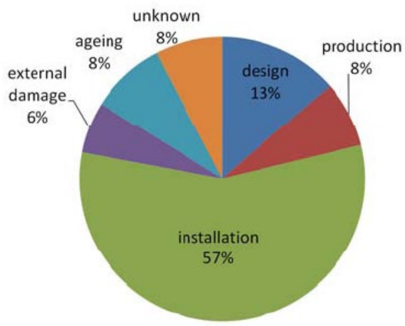

Figure 1: Statistic of failure cause of cable accessories [1]

Resonant Test Circuit

Resonant test systems use the resonance effect to generate a high AC test voltage [2]. The capacitance C of the test object (cable system) and the inductance L of a reactor (part of the test system) form an oscillating circuit. The reactive energy oscillates between these two elements and does not have to feed from the power source again in each period. While energy in a capacitor is stored in the electrical field between its electrodes, energy in an inductor is stored in its magnetic field. If an oscillating circuit is excited, energy swings between the two elements L and C. For the generation of a constant AC voltage an additional feeding source has to deliver active power only to