Performance evaluation and failure mode analysis of a long-term ageing test on HV submarine cables with tree-retardant XLPE insulation and factory joints

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ABSTRACT

The use of TR-XLPE for the insulation of a wet design submarine cable has been a widely adopted design, however CIGRE TB 722 requires a long-term ageing test to qualify wet design insulation.

Currently very few information is available in the literature regarding the long-term performance of cable systems combining factory joints and wet design.

This paper presents the results of a wet ageing test preformed according to the recommendations of CIGRE TB 722 at 500 Hz in salt water (Regime B). The acceptance criteria were met, no breakdown during the water ageing occurred. In the final AC breakdown test, three samples out of six experienced a breakdown of the insulation above the set target, the remaining reached the testing equipment working limits.

KEYWORDS

Wet ageing; CIGRE TB 722;TR-XLPE wet cable; inter array cable; factory joints.

INTRODUCTION

Inter array cables (IAC) are submarine connections for electricity transmission generated by the offshore wind turbines in an offshore wind farm. This segment of cables is used to transmit electricity generated by each turbine in the so-called array to an offshore substation; which collects all the arrays and where electricity is converted to higher voltages either alternated or direct current (AC or DC) and finally transmitted to shore. Inter array cables are therefore a very valuable asset in an offshore wind farm and considering the trend of increasing the offshore wind capacity to reach the decarbonisation targets, it is of fundamental importance for cable manufacturers to provide both reliable and cost-effective solutions in the next future.

The consolidated state of art for inter array cable is represented by 66 kV static cables (i.e. laid on the seabed with limited movements). Due to emerging interest in large scale floating offshore wind farm, the development and demand for dynamic cables is increasing in the market. These types of cables are not laid on the ground and, thanks to special accessories, are free to move to follow the movement of floating turbines.

For European applications, the main reference standard for submarine cables up to 66 kV is now the IEC 63026 (2019) [2].

IEC 63026 bases itself on existing standard and recommendations well known in the industry for several years such as IEC 60502-2 [3], IEC 60840 [4], TB 490 [5] and TB 623 [6]. However, not all the topics have been covered by IEC 63026 which has to be integrated by other standards and recommendations. CIGRE TB 722 [1] aims at standardising and assess the suitability of a dielectric insulation intended to operate without a radial water barrier. Indeed, the technical brochure provides guidance and additional tests for the qualification of designs not covered by IEC 63026.

Inter array commonly used design is three-core cables, copper or aluminium conductors with cross-linked polyethylene (XLPE) or ethylene propylene rubber (EPR) insulation. For metal screen, several alternatives are possible.

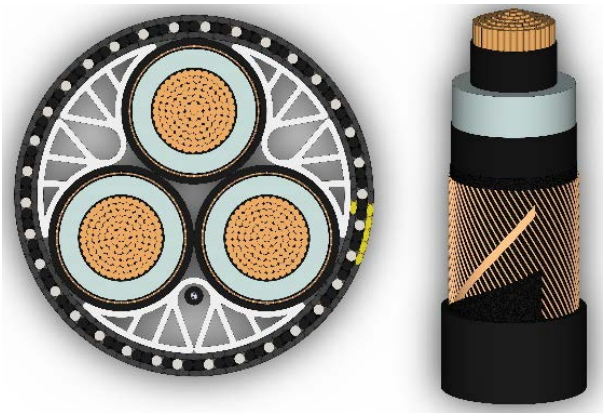

Fig. 1: Indicative section and 3D drawings of 3-core inter array cable

The metal screen design chosen can be classified either as dry or wet according to TB 722. The latter has a metal screen with only electrical function (i.e., no radial water blocking is guaranteed). In seek of cost-effective solution and for benefit of the application in case of dynamic cables, the use of wet design solution is adopted.

Though, for water ageing test to prove insulation performance in wet environment, TB 722 has done a work of survey and review of existing standards and recommendations (for several topics, water ageing is one) ending up with protocols to be adopted for additional tests to IEC 63026. The proposed regimes for accelerated water ageing test have been outlined to guarantee safe performance of the system for the lifetime of the offshore windfarm.

Achieving the proposed qualification for wet design can be also a plus in terms of risk mitigation for standard dry designs. In this scenario, in case of failure of the radial water barrier, the system is still proved to perform without any additional risk.

To tackle cost reduction of cable system, factory flexible joints are present in the inter array cables. Although, length