Characteristics of Water Trees in Submarine Cables (Wet-Design) for Offshore Wind Power Generation

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ABSTRACT

We have developed a 66 kV-class submarine cable without a water impervious layer, which meets IEC 63026 and CIGRE TB 722, by determining an insulation material resistant to water trees. Notably, long-term water tree resistance is greatly affected by the amount of supersaturated moisture, which is part of the moisture that permeates into the cable insulation due to temperature heat cycles. We studied a new technique to evaluate the long-term characteristics of water trees. This technique can make evaluations based on conditions close to aged deterioration of cables in service by analyzing the amount of supersaturated moisture in the cable insulation.

KEYWORDS

Offshore wind power generation, submarine cables, water trees

INTRODUCTION

Recently, it has become an imperative issue for the global community to reduce greenhouse gas emissions. In 2020, the Japanese government made a declaration to attain "carbon neutrality by 2050." The Green Growth Strategy, which was formulated in line with this declaration, sets out a policy to introduce renewable energy as far as possible with top priority placed on decarbonization of the electricity sector. Notably, a goal has been set for the offshore wind power industry to increase its capacity to 10 GW by 2030 and to 30 to 45 GW by 2040.[1] Thus, offshore wind power generation will become more important than before. Power cables, which are used to transmit the electricity generated, will play a key role. This paper reports the results of a study on new power cables for offshore wind power generation and an evaluation technique suitable for the conditions of cables in service with future developments in offshore wind power generation in mind.

STRUCTURAL CHANGES TO SUBMARINE CABLES FOR OFFSHORE WIND POWER GENERATION

In offshore wind power generation, electricity is generated using offshore wind turbines. Power cables for harvesting electricity are laid on the sea bed to transmit electricity back to an onshore substation. The development of wind power generation technology has been accelerating in recent years. As shown in Fig. 1, the size and output of wind turbines have increased. Thus, the voltage and power capacity of power cables for wind power generation have been increased accordingly. Previously, mainly 22 kV- to 33 kV-class cables were used. Recently, there has been a shift to 66 kV-class cables. The increased size of cables to meet the higher voltage has brought about issues in terms of manufacturability, cost, and in particular, site workability. To cope with these issues, cables with a structure without a water impervious layer (hereinafter referred to as "submarine cables without a water impervious layer"), are expected to play a key role in the market in place of cables with a conventional structure, as shown in Fig. 2.

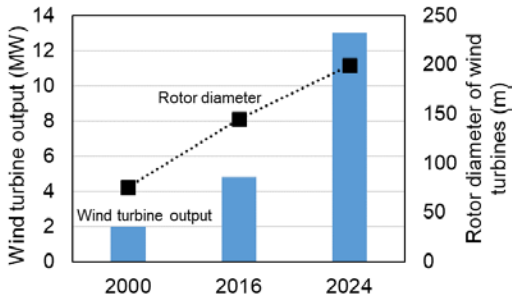

Fig. 1: Changes in size and output of wind turbines[2]

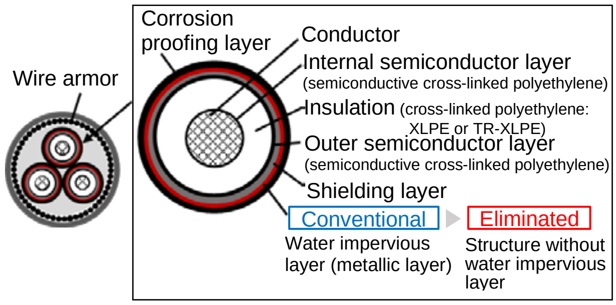

Fig. 2: Submarine cable structure

STANDARDS FOR SUBMARINE CABLES

In line with market developments to eliminate the water impervious layer in cables, a standard for submarine cables without a water impervious layer (CIGRE TB 722: Recommendations for Additional Testing for Submarine Cables) was established in 2018. One of the biggest risks of eliminating the water impervious layer is a deterioration phenomenon known as a "water tree," which progresses in cable insulations during constant operation of cables in a submerged condition, as discussed below. CIGRE TB 722 also describes a submerged voltage endurance test for evaluating water tree characteristics.

Submarine cables without a water impervious layer for offshore wind power generation are currently required to meet the general submarine cable standard (IEC 63026) and have their water tree resistance evaluated to meet the standard of CIGRE TB 722, which was mentioned above, as shown in Fig. 3 and Table 1. It should be noted that CIGRE TB 722 is a standard for up to 66 kV-class cables (maximum voltage: 72.5 kV). At present, the structure without a water impervious layer is only applicable up to 66 kV-class cables.