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Using TR-XLPE Insulation for Wet High Voltage Array Cables

The special reporter raised questions about the limits of current technical guidance documents and on possible areas that need to be enhanced to support the expanding industry for insulated power cables.

This contribution would like to address the need to develop an industry consensus extending the test protocols in CIGRE TB722 to higher voltages and acceptance that meeting these recommendations would indicate a reliable solution.

The increased application of submarine cables, to support the growing usage of offshore wind energy, is expanding the industry for insulated power cables. To improve the energy generated by offshore wind farms there is a drive to larger turbines which can lead to needing to increase the array cable voltage higher than today's 66 kV, the current standard. For cost effective array cables, a wet cable design is preferred. For wet high voltage cables greater than 66 kV, the insulation material would not be a limiting factor as today's water tree retardant crosslinked polyethylene has a demonstrated excellent performance in wet cable applications and it is capable for at least 150 kV wet cables.

The inherent high dielectric strength and low electrical loss characteristic of crosslinked polyethylene (XLPE) insulation make it the preferred insulation for dry high voltage cables such as used in the export cables for offshore wind farms. This enables the energy generator to maximize the electrical power delivered to the energy user. A dry cable design involves water swellable tapes, a (metallic) moisture barrier layer as well as other water blocking components. A common metallic mositure barrier is lead which anticipated environmental regulations would discontinue. Additionally, to avoid ingress of water, the installation of a dry high voltage cable requires appropriate precautions to ensure the outer layers of the cable are not damaged during transport and installation. These additional precautionary steps to exclude water from an extruded dielectric high voltage cable lead to extra effort and cost in cable installation.

Wet cable designs simplify the cable process by eliminating the need for the water swellable tapes, metallic moisture barrier and other water blocking components. Additionally, wet cable designs also improve the overall system economics. When exposed to moisture, electrical and mechanical stress, XLPE insulation is susceptible to water treeing, which has been associated with cable failures. It is anticipated that conventional XLPE would not meet expectations for a long life in a wet submarine cable application for offshore wind farms. Over 40 years ago, water tree-retardant crosslinked polyethylene (TR-XLPE) insulation was introduced to reduce the impact of water treeing on the life performance of wet cable designs.

TR-XLPE insulated cables have an excellent robust performance in highly accelerated, wet cable tests across the globe as well as has a 40-year history of excellent performance in wet land cable applications. As TR-XLPE insulation has a low electrical loss characteristic, similar to XLPE, under submarine conditions and high voltage stresses, it is capable to maximize power delivery. As wet offshore wind farms would operate in a saline environment, studies have shown the ionic concentration of ocean water has minimal impact on the water tree retardance performance. In highly accelerated, wet cable testing per North American and European wet cable qualification test protocols, TR-XLPE has shown excellent retention of dielectric strength. Additionally, in cable life testing, where the cables are aged under high voltage stresses until failure, TR-XLPE insulation has shown industry leading life performance.

Currently, the only industry guidance for wet high voltage cables is CIGRE TB 722 that outlines recommendations for additional testing for wet high voltage submarine cables to 60 kV. There is no industry guidance for wet high voltage cables at voltages higher than 60 kV. We propose wet high voltage cables for operating greater than 60 kV, can be demonstrated by extending of the current recommendations in CIGRE TB 722. We suggest there needs to be consensus about extending these test protocols to higher voltages and acceptance that meeting these recommendations would indicate a reliable solution.