Wet designs for HV submarine power cables

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Wet designs of XLPE cables, meaning cables without any impervious water barrier, have been frequently used for MV applications. However, past experience revealed that water treeing were attributed to these types of XLPE cables, contributing to a faster electrical degradation and shorter lifetime compared to dry designs. During time and intensive research, there was consensus about that the major contribution to water treeing depended on the quality of the insulation system and vulcanization process used.

Experienced cable manufacturers of today have the latest 10-20 years improved both vulcanization processes, material handling systems and quality of materials to a degree far better the level which was prevailing 30 years ago or more. Today MV cables are normally designed without water barriers but with longitudinal water tight materials in conductors. Since good operating experiences have been seen one could therefore ask if wet designs are mature to be introduced also at HV (52 - 170kV).

To answer this question, a test and modelling program has been implemented at Sintef and Nexans in Norway. There is no standardized test method for water aging tests at HV but aging tests according to Cenelec-500 Hz has been scaled up and slightly modified for HV. Using high-quality materials and processes good results have been obtained for HV cables. In addition, several tests of small cable samples have been put in water baths at different temperatures and for different durations to establish a good estimate of water saturation and water content levels in different layers of a specific wet design to be used in a HV dynamic application in North Sea. These data in combination with accurate characterization of cable materials have been put into a water diffusion model taking into account also temperature drops across different cable layers etc. It has been seen that only a small temperature drop across an outer plastic sheath is sufficient to effectively prevent the water content to exceed RH99%, thus reducing the rate of growth of water trees from the outer semicon layer.

The tests and computation models presented in this paper give confidence that wet designs could be introduced at low risk in certain applications for HV cables. However, the conditions for such a direction are high quality control in materials and processes and a thorough test and quality plan how to verify such an approach to be confident. Water trees are developed under certain types of conditions. However, if the effect of some conditions are reduced or even eliminated for both MV and HV applications, it is very likely that past comprehended risks of water treeing, need a reevaluation conditioned by the high quality materials and processes used today.

Key words

Wet design, water barrier, Cenelec, water aging test, 500 Hz, power cables,