Main objectives and results of the EU project ADVANCE with focus on aging assessment of cable insulation used in nuclear power plants through electrical measurements

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Extending the lifetime of a Nuclear Power Plants (NPPs) to 60 years or more is among one of the most important concerns in the global nuclear industry. As electric cables are one of the long life items that have not been considered for replacement during the design life of NPPs (typically 40 years), assessing their degradation state and predicting their remaining lifetime are very critical issues. Many of these cables are installed in the containment area, where the harshest environmental conditions, characterized by high temperature and gamma-radiation, can stress significantly cable insulations.

This paper presents the main objectives and results of the European project ADVANCE (Aging Diagnostics and Prognostics of low voltage I&C cables), a 3 years collaborative R&D project co-funded by the European Commission that ended in 2013. It addressed issues regarding the assessment of safety-related cables that are required to operate not only during normal operating conditions but also under accident conditions, like in the case of the Loss Of Coolant Accident (LOCA).

The main goals of the project were to adapt, optimize and assess promising electrical condition monitoring (CM) techniques for nuclear cables that are non-destructive and to establish acceptance criteria by correlating physical cables properties to electrical properties in order to evaluate the degree of degradation.

So, a particular issue of the project was dedicated to investigate electrical aging markers which can provide information on the state of the cable by non-destructive testing methods. This would improve significantly the present diagnostic techniques based on destructive testing: measurement of chemical properties, such as OIT, OITP, TGA, and/or measurement of mechanical properties, such as elongation at break.

A few techniques were investigated, e. g. LIRA, TDR, Voltage Return, loss factor. The search of aging markers coming from electrical properties like, e.g., electrical conductivity and dielectric spectroscopy, to assess the state of low voltage cable insulation, has also been investigated. For this purpose, electrical property measurements on EPR, XLPE and EVA insulations used for power cables of NPPs have been carried out during the project. These cables were aged under thermal and radiation stresses: in order to obtain significant results in a reasonable time, the dose rate and the temperature chosen were higher than the values usually found inside NPPs. These measurements have been performed using dielectric spectroscopy, which allow the real and imaginary part of the permittivity in the frequency domain to be obtained. The change of electrical properties with aging was correlated to variation of elongation-at-break and chemical properties (density and gel fraction). For most cables, a good correlation was found, in particular, between imaginary part of the permittivity at 100 kHz and density measurements, which indicated oxidation as the main degradation mechanism. Therefore, the imaginary part of permittivity at high frequency, could be an interesting non-destructive property to assess the degradation state of NPP cable insulation.

Guidance and propositions for future work built on the analysis of results are suggested.