# Quantifying Properties for a Mechanistic, Predictive Understanding of Aqueous Impact on Ageing of Medium and Low Voltage AC and DC Cabling in Nuclear Power Plants

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**ABSTRACT:**

## PROJECT OBJECTIVES

The project objective is to develop a mechanistic, predictive model of medium and low voltage cable failure based on the primary environmental degradation parameters of *aqueous immersion time*, *temperature* and the *oxidation extent*. The fundamental properties of cable materials under accelerated ageing conditions will be quantified and developed into an equivalent circuit model, which considers multiple mechanisms of degradation including the hypothesized advance of pores. The measurement protocol will determine the response of intrinsic physical properties of the cable including the water reaction-diffusion coefficient, water volume fraction, strain to break, modulus and impedance to the three primary controlled degradation factors.

The specific aims are:

- Quantify the degradation of prevalent medium power cables as a function of:
  - Immersion time
  - Temperature
  - Oxidation
- Develop a mechanistic, predictive model for probabilistic failure of cables due to arcing.

## SUMMARY OF THE PROPOSED PROJECT

Given that the number of cables in submerged environments for a period of greater than 30 years is growing and the majority of reported failures range from 20 to 40 years, this proposal to develop a *mechanistic understanding* of the degradation process is critical to confidently predict functional properties and safety margins for dielectric breakdown over timeframes of 80 years. Two common polymers for use in cable and jacket material are cross-linked polyethylene (XLPE) and propylene rubber (EPR) will be used in this investigation. The commercial versions of these cable materials will be compared to neat polymer samples lacking processing additives to decouple the impact of the risk associated with the loss of additives from the polymer versus the risk due to degradation of the matrix itself.

The potential for degradation of polymer jackets and insulation of medium and low voltage power cables represents a concern for lifetime extension of nuclear power plants. A growing concern especially for medium voltage cables is failures that have been observed in submerged environments. According to a NEI survey, over 50 circuit failures have been reported in 21 nuclear power plants (NPPs), perhaps as the result of aqueous impact. The culmination of the degradation simulation will be prediction of the electrical treeing structure at failure as an integral model validation. Therefore, this proposal will emulate aggressive environments and measure polymer physics properties for *mechanistic understanding* of the degradation and dielectric breakdown properties to predict catastrophic failure.