Kinectrics AES
partnered with
Pacific Northwest National Laboratory

NE-21-26492: Extension of Cable Electrical Assessment Techniques to Detect and Discriminate Radiation Aging on Cable Insulation Systems

YEAR AWARDED: 2021

TOTAL PROJECT VALUE: $595,700

STATUS: Completed

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DESCRIPTION: Kinectrics AES, a company located in Naperville, Ill., supports nuclear, transmission, and distribution cable business areas throughout the United States. As nuclear plant operating lives are increased from their original 40-year licenses to 60 or 80 years, low voltage (LV) cables may experience degradation, from radiation or heat or both combined. Although methods for monitoring the physical-chemical impacts of aging on most cable materials have been relatively well developed, diagnostic methods for assessing the impact of radiation on cable systems have not been sufficiently demonstrated. This work uses electrical test methods to close the gap in the detection and quantification of radiation aging and combined thermal and radiation aging in nuclear cable applications.

BENEFIT: Kinectrics' ability to electrically characterize changes affecting cables, and discriminate between sources of degradation to provide an accurate assessment of cable condition, will assist plant operators in their repair, mitigation, or replacement efforts.

IMPACT: This study involved diagnostic testing of cross-linked polyethylene (XLPE)- and ethylene propylene rubber (EPR)-insulated cables subjected to high doses of cobalt-60 gamma radiation following thermal aging. It is anticipated that this exercise will produce information needed to support the extension or expansion of electrical assessment techniques for electrical cables at nuclear power plants.

SIGNIFICANT CONCLUSIONS: With a Co-60 source of sufficiently high activity, a passive dosimetry system of sufficient dose range, and the appropriate protocols, uniform doses can be delivered to 12 cable mandrels (roughly 300 feet of total cabling) within approximately 100 days. Electrical diagnostic and material testing showed the following effects or trends: Although both aging regimes (thermal + radiation and radiation only) created a decrease in elongation-at-break values at each subsequent aging interval, the combined thermal and radiation created a stronger decrease for both XLPE and EPR samples. The indenter results for EPR show that radiation aging did not create a trend in insulation hardness, whereas an increasing trend in hardness was clear for samples subjected to progressive thermal aging. A clear decreasing trend was observed for the oxidation induction temperature (OITP) tests on XLPE, which experienced thermal and radiation aging, while no clear trend was measured for the radiation-only samples.

With respect to electrical testing, the observed changes caused by radiation and thermal aging mechanisms resulted in differing electrical responses across insulation types tested in this program. Additionally, when thermal aging and radiation aging are combined, they result in competing effects in material and electrical characteristics of the cables. From these observations it was determined that condition assessment metrics and criteria will vary depending on the type of insulation being investigated and the stressor, or combination of stressors, affecting it. The data also suggest that for radiation aging metrics obtained in the higher frequency region of the dielectric response are more sensitive to the level of insulation degradation than the lower frequency regions.

NEXT STEPS: The effort confirmed that radiation aging and combined radiation and thermal effects can be detected in low voltage cables using novel electrical test methods. The results of this study enable the extension or expansion of electrical assessment techniques for nuclear power plant electrical cables, providing operators more complete information to support repair, mitigation, or replacement decisions. In some cases where combined effects are material, the behavior is more complex and results in material specific responses. In more limited cases, further investigation is needed to determine the most effective metrics and criteria to be applied to frequency domain dielectric spectroscopy and polarization depolarization current responses.