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Capacitive Sensing for Nuclear Power Plant Cable Insulation Assessment

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The ability to evaluate, nondestructively, the material state of insulation polymers widely employed in aged control and power cables has been identified as important In the process of routine safety inspection and safety inspection for license renewal of aging Light Water Reactor Nuclear Power Plants (NPPs) in the United States [1]. The present industry standard is that the insulation polymer breaking strain (or elongation-at-break, EAB) should be no less than 50% of that value measured on the pristine material, for the aged insulation polymer to be fit for service. Measurement of EAB is destructive, the method requires a relatively large quantity of sample material, and the results exhibit large uncertainty, however. Here, the ability of a capacitive sensor to indicate, nondestructively, the state of the insulation polymer is explored. The insulation material most commonly employed in U.S. NPPs, cross-linked polyethylene (XLPE), is aged simultaneously at elevated temperature and by exposure to gamma radiation. XLPE- coated wire samples are aged at 90 °C or 115 °C with a combination of three dose rates (0, 19, or 54 krad/h) and two exposure durations (10 or 25 days) to give different total doses that range between 0 Mrad, for a pristine sample, and approximately 32 Mrad, for the most severely aged sample in this set. An inter-digital capacitive sensor that conforms to the curved surface of the insulated wire [2] is used to assess the dielectric properties of the samples. The breakdown voltage of the wire insulation is measured by means of a custom-designed electrode setup. Correlation values are computed between capacitance, dissipation factor, breakdown strength, and EAB measured on the aged samples, in order to assess the effectiveness of the nondestructive capacitive method for indicating the state of the wire insulation after aging.

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References:

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