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NEPO Cable System Aging Management Programs

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Cable polymer aging and condition monitoring is being studied in detail under the Nuclear Energy Plant Optimization Program (NEPO) that is co-sponsored by the U.S. Department of Energy and EPRI. Significant advances in modeling of polymer aging and condition monitoring have occurred and continue to be developed. The activities include:

- Analysis of the linearity of the Arrhenius model to room temperature
- Development of a wear-out technique for determining remaining life of cable polymers
- Determination of the aging fragility point for composite EPR/CSPE insulation with respect to LOCA function
- Development of visual/tactile training aids for cable assessment
- Development of a totally new nuclear magnetic resonance condition monitoring technique
- Assessment of existing techniques with regard to repeatability, accuracy and ease of use.

Through use of highly precise oxygen consumption experiments, the linearity of the Arrhenius model is being evaluated. In these experiments, polymer is placed in vials with a known amount of oxygen and aged at much lower temperatures than is possible with standard accelerated aging techniques. Aging results are possible at room temperature. The technique is being applied to commonly used insulation and jacket polymers.

The wear-out technique allows highly non-linear aging behavior to be made linear. The wear-out point of a polymer is determined through high-rate aging and use of a condition monitoring technique to establish the end point. Then, micro-samples of cable that have been naturally aged are subjected to high rate aging to the same end point. The ratio of the remaining high rate aging period to the total high rate aging time provides a linear indication of the remaining service time.

Initial screening of nuclear plant cable systems can use visual/tactile techniques to identify cable that has aged significantly. Training aids [1] have been developed by developing sets of specimens with accelerated aging ranging from none through four steps of aging. The change in individual insulated wires and overall cables can be experienced by the user of the training aids allowing plant cables to be assessed to determine if they are like new or have aged significantly and need to be replaced.

If large numbers of cables have aged perceptibly, then more sophisticated condition assessment techniques will be needed to discriminate between degrees of aging to allow planning and scheduling of replacements. The program is both evaluating a number of existing techniques to determine their ease of use and accuracy and is developing a totally new technique based on nuclear magnetic resonance testing. The NMR technique [2] is proving to be easy to perform and interpret and can be performed on as little as 1 mg of material.

REFERENCES:

[1] Toman, G., L. Duncan, "Training Aids for Visual/Tactile Inspection of Electrical Cables for Detection of Aging," EPRI 1001391, March 2002

[2] Harris, D.J., M. Celina, R. A. Assink, "Oxidative Degradation Analyisis of HTPB/IPDI Polyurethane Using ^{17}O and ^{13}C NMR," Sandia National Laboratories, Albuquerque, NM. Polymer Preprints, 2001