Novel NDE Sensors, Waveforms, Models, and Algorithms for Cable Health Monitoring

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ABSTRACT:

Long-term exposure to radiation, thermal and other adverse environmental conditions is known to cause damage and embrittlement of cable insulation, which could lead to economic and safety concerns for the reliable operation of nuclear power plants (NPPs). Sensitive nondestructive evaluation (NDE) techniques to determine the useful life left in a power cable is important because it allows replacement of aged and degraded cables at the proper time, which saves cost while assuring the cable system performance under a design-basis-event. The proposed research introduces several innovative new concepts that do not exist today. These include new sensing, waveforms and diagnostic methods for insulation defect testing, probabilistic algorithm development and statistical decision thresholds for cable fault determination. These will be accomplished in collaboration with and guidance from two national labs one with expertise in cable health monitoring algorithms and experimental methods and the other with radiation related cable health damage estimation.

Under the **Sensing and Waveforms Thrust** two types of sensing and diagnostic techniques are proposed. New distributed stick-on interdigitated sensors will be designed, developed, instrumented and tested for insulation damage detection when cables or cable sections are specifically subjected to significant stresses, e.g. high temperature and or humidity. New surface wave sensors and Joint Time-Frequency Domain Reflectometry (JTFDR) waveforms will be developed to detect insulation damage in cables with existing damage and cables that are subjected to accelerated aging tests. The primary focus will be to develop novel sensors and waveforms that can maximize the length of propagation along the cable and then detect insulation damage. Sensitivity of the proposed approach will be evaluated.

Under the Algorithms, Modeling, and Tests Thrust the focus will be on cable model development to understand defects in cable insulation, probabilistic algorithm development, and tests. Modeling and analysis will also be performed to understand radiation related insulation damage. To accurately estimate and predict the remaining service life of a cable, a particle filtering-based approach is proposed which offers a compromise between data-driven and model-based techniques. Note that signal processing approaches, such as Hilbert-Huang transform (HHT), will be used to remove the effects of noises and artifacts to make the diagnosis and prognosis more accurate. Future improvement of this effort and commercialization has the potentials for in-situ stand-alone sensing and processing.

Major milestones include (1) interdigitated sensors and their efficacy evaluation in cable insulation damage detection, (2) JTFDR in conjunction with signal processing and probabilistic algorithms to determine decision thresholds of damage, (3) comparative study of obtained results with existing data, and (4) the understanding of radiation related effects on cable and how to incorporate that into future NDE efforts.