Project Title: Condition monitoring of dry storage canisters by helical guided ultrasonic waves

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ABSTRACT:

Over 90% of dry cask storage systems in the United States are welded dry storage canisters (DSC). Currently, the service performance of DSC relies on periodic visual inspections (VI) which are time-consuming and depend heavily on the skills of the inspectors. We need to transition from periodic VI established on the basis of limited-to-no knowledge of likely component degradation to an automated real-time condition-based inspection method that could be performed on a daily basis. With a paradigm shift into condition-based inspection, the main objective of this project is to develop a technology to enable the next generation of "intelligent dry storage canisters (DSC)", that is, canisters with integrated sensing and processing capabilities to enable real-time state awareness. Overall, it is proposed to use a novel class of low-cost sensing system, helical guided ultrasonic waves (HGUW) and advanced data processing techniques for interrogating the DSC internal conditions. The crux of this proposal is to generate helical waves into the external surface of the canister, and detect its multiple echoes, generated from its cylindrical geometry, at a receiving transducer. Therefore, instead of monitoring only the direct path connecting two transducers (i.e., first echo arrival), multiple paths taken by each helical wave (i.e., late echo arrivals) can be monitored. The solution represents a change in paradigm – multiple wave reflections, considered undesirable in current inspection techniques, will be used to enable real-time state awareness from only a few monitoring points. This reduces the number of sensors needed and number of robotic deployments required to perform an inspection. A wall-climbing robot (the "vehicle") will be developed to enter the canister annulus and deploy sensors along the canister wall. The vehicle will be loaded with one or more sensors prior to deployment, enter the annulus, and then affix the sensors to the deployment points using a mechanism. The proposed technology will be able to operate in a dual monitoring mode: 1) real-time continuous (or *passive mode*), and 2) in-situ routine periodic inspections (or *active mode*). The research is a collaborative effort between the University of Texas at Austin (UTA), the Idaho National Laboratory (INL), and Orano TN. The project team offers a complete and balanced skill set for the proposed work. The proposed project can have positive impacts in terms of technical and policy aspects. Technical impacts include the development of a novel condition monitoring (CM) technology that will close a critical gap in the inspection and monitoring of dry cask storage systems, improving public confidence in nuclear waste storage and nuclear power in general. In addition, the research outcome will impact various plant management policies. The automatic diagnosis will help facility managers and policy makers to strategically allocate labor and resources for management plans.