Structural Health Monitoring of Nuclear Spent Fuel Storage Facilities

PI: Dr. Lingyu Yu,
University of South Carolina

Collaborators: Dr. Adrian E. Mendez-Torres,
Savannah River National Laboratory

Program: FCR&D: Used Nuclear
Nuclear Fuel Disposition, Storage

ABSTRACT:

Following the issuance of the Blue Ribbon Commission (BRC) on America's Nuclear Future Final Report in 2012, interim storage of spent nuclear fuel from reactor sites has gained additional importance and urgency for resolving waste-management-related technical issues. In response to the BRC report and the Joint Explanatory Statement accompanying the Consolidated Appropriations Act, to develop a strategy for the management of used nuclear fuel and nuclear waste, the Department of Energy issued on January 2013 a Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste. The document established a framework for moving toward a sustainable program to deploy an integrated system capable of transporting, storing, and disposing of used nuclear fuel and high-level radioactive waste from civilian nuclear power generation, defense, national security and other activities. To ensure that nuclear power remains as clean energy, safe, long-term management of used nuclear fuel and high level radioactive waste "remains a national priority".

In response to the program *Fuel Cycle Technologies Used Nuclear Fuel Disposition (FC-4)*, we propose to develop a nuclear structural health monitoring (SHM) system based on embedded piezoelectric sensing technologies that monitors material degradation and aging for nuclear spent fuel dry cask storage system (DCSS) and similar structures. The proposed SHM technology uses permanently installed low-cost low-profile sensors to perform on-demand interrogation that monitor the structural integrity from material level degradation (micro scale) to structural level damage (macro scale) using ultrasonic guided waves. Our unique "multi-mode" sensing strategy combines the advantages of several sensing methods with the employment of a single sensor network. Such a sensory system stays tuned for acoustic emission (AE) events resulting from crack (case for study in this project) and evaluate the damage evolution; when significant AE is detected, the sensor network switches to the active mode to perform damage interrogation and quantification as well as probe "hot spots" that are prone to damage for material degradation evaluation using impedance approach. Toward DCSS applications, long term nuclear environmental influences investigation will be conducted to verify and validate the proposed sensor and sensing system. Consequently, the developed technology will provide timely information regarding the structural integrity for condition assessment of components important to safety (ITS) at any time.

The outcome of this project will be a safety assurance approach that can evaluate degradation and aging phenomena of used nuclear fuel containers and storage facilities under extended storage. These advanced piezoelectric sensors will decrease the measurement uncertainty and provide the basis for demonstrating integrity and dependability (i.e., safety, reliability, and robustness to faults) of intermediate spent fuel disposition equipment over long period.