



**UNITED STATES
NUCLEAR REGULATORY COMMISSION**
WASHINGTON, D.C. 20555-0001

Grant # 31310022M0005

Grantee: University of Texas -Austin

Title of Grant: **Advanced Condition Monitoring of Dry Storage Canisters by Helical Guided Ultrasonic Waves**

Period of Performance: 10/29/2021-10/28/2024 (FY21 Notice of Funding Opportunity NOFO)

Executive Summary

The objective of this research program is to develop a technology to enable the next generation of “intelligent spent nuclear fuel dry storage canisters (DSCs),” that is, canisters with integrated sensing and processing capabilities to enable real-time state awareness. It is proposed to use a novel low-cost sensing system based on helical guided ultrasonic waves (HGUW) and advanced data processing techniques for interrogating the outer surface of the canister. 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. We hypothesize that these echoes carry valuable information about the containment function of the canister, and the ability to monitor and analyze these signals can yield a completely new inspection modality that can be used to identify and track the onset of conditions conducive to component degradation (e.g., stress corrosion cracking, internal temperature and pressure). 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 to perform an inspection. The key advantages of the proposed HGUW-based monitoring technology include: (1) the ability to interrogate the internal conditions of the canister from only a few monitoring points, thus increasing the inspection cost effectiveness, (2) the ability to monitor simultaneously the entire circumferential area of the canister, (3) the increased sensitivity to many parameters (e.g.: internal pressure and temperature, helium leakage, stress corrosion cracking) owing to the wave structure choice, (4) the capability to detect onset of damage (e.g., leaks, or cracks) and to estimate internal parameters (e.g., temperature and pressure) by toggling between the modes of “passive” acoustic emission testing and “active” ultrasonic testing. Furthermore, the sensing system based on HGUW can be integrated with existing robotic vehicle(s) to remotely apply the HGUW technology on in-service DSCs.

Principal Investigator: Salvatore Salamone, salamone@utexas.edu

Presentations and Publications

The list of publications was submitted with the final report after grant expiration.

- Lee G., Livadiotis S., Salamone S., “Helical paths based two-dimensional source discrimination of acoustic emission waveforms from hollow cylindrical structures using

variational autoencoder”, Published in Health Monitoring of Structural and Biological Systems XVII 12488, 265-271.

- *Lee G., Livadiotis S., Salamone S., “Applicability of data augmentation through variational autoencoder for two-dimensional acoustic emission source discrimination on hollow cylindrical structures”, Published in Structural Health Monitoring 2023.*
- *Peruvazhuthi S., Sohn J., Salamone S., “Tracking growth of crack-like defects in hollow cylindrical structures from the stepped-wavelength scattering of helical guided ultrasonic waves”, Under review in Mechanical Systems and Signal Processing Journal.*
- *Wilson N., Livadiotis S., Lee G., Salamone S., “Structural Integrity Assessment of Nuclear Spent Fuel Canisters Using Guided Waves”, Presented at International Workshop of Structural Health Monitoring, Stanford, CA, September 2023.*
- *Wilson N., Lee G., Salamone S., “Condition Monitoring of Dry Storage Canisters by Helical Guided Ultrasonic Waves”, Presented at 2023 Graduate Student Symposium, Austin, TX, February 2024.*
- *Wilson N., Salamone S., “Condition Monitoring of Dry Storage Canisters by Helical Guided Ultrasonic Waves”, Presented at Department of Energy Office of Spent Fuel and High-level Waste Disposition Program Meeting, Las Vegas, NV, July 2024.*

Patents

N/A