UPISC UNIVERSITY OF PITTSBURGH INFRASTRUCTURE SENSING

COLLABORATION WORKSHOP

NATIONAL ENERGY TECHNOLOGY LABORATORY

Fusion of Distributed Fiber Optics, Acoustic NDE and Physics-Based AI for Spent Fuel Monitoring

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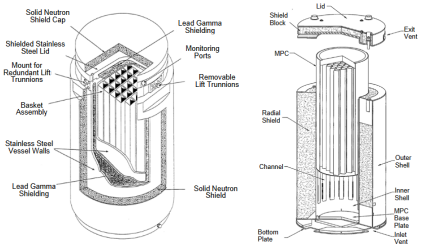
Project Outline:

Motivation:

Current status: *Dry Casks Storage Systems (DCSS) for nuclear waste storage poses challenges for traditional structural health monitoring methods due to hard and limited access, creating a demand for less intrusive techniques of easy installation.*

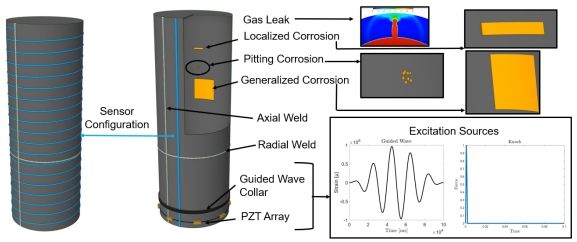
Improvement: *Combine Acoustic nondestructive evaluation (NDE) based on ultrasonic guided waves will be combined with distributed fiber optic sensing enhanced by artificial intelligence (AI) frameworks to quantitatively characterize the internal state of dry cask storage systems (DCSS). Physics-based simulations and reduced order modeling will be coupled with targeted experiments to train and apply AI-classification to distributed acoustic data acquired with fiber optics*

CASTOR® V/21 casks at Surry Powerstation, Virginia/USA

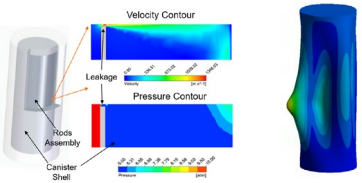


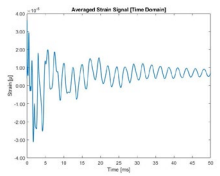
O.K., Chopra, Diercks D.R., Fabian R.R., Han Z.H., and Liu Y.Y. "Managing Aging Effects on Dry Cask Storage Systems for Extended Long-Term Storage and Transportation of Used Fuel." Technical. Argonne National Laboratory, September 30, 2014.

Structural Health Evaluation and Monitoring Enabled by Distributed and Quasi Distributed Optical Fiber Sensor Configuration

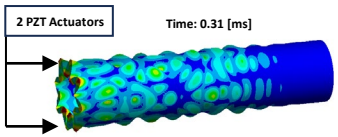


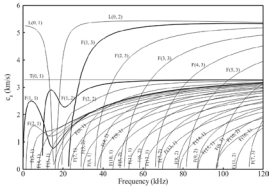
Canister Passively Excited by Internal Leaking Fuel Rod:



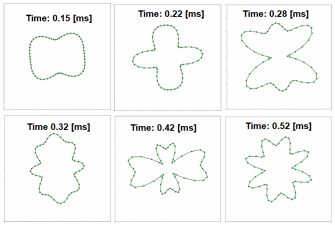


Non-Axisymmetric Guided Wave Excitation

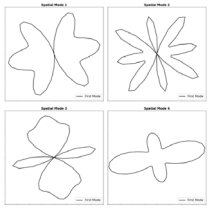


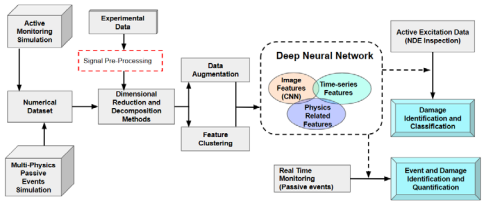


Angular Strain Profiles at 15" in Length



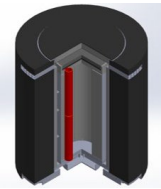
Principal SVD Spatial Modes (Discrete Basis):





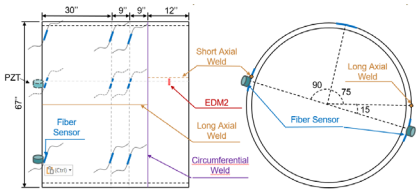
Future Field-Testing Plans

PNNL Facility



Hanford Waste Facility

Field Test Plan Schematic



Future Objectives: 1) Field testing of sensor system in more realistic canister structures at PNNL and Hanford Waste Facility. 2) Development of initial AI classifier for specific structural defects, based on signal from distributed or quasi-distributed optical fiber sensor upon excitation sources 3) Physics-based simulation of real size structure subjected to active excitation sources, and development of reduced order model to assist in data augmentation.

Publications:

[1] Zhang, P., Venketeswaran, A., Wright, R. F., Lalam, N., Sarcinelli, E., and Ohodnicki, P. R., 2023, "Quasi-Distributed Fiber Sensor-Based Approach for Pipeline Health Monitoring: Generating and Analyzing Physics-Based Simulation Datasets for Classification," Sensors, **23**(12), p. 5410.

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