Dual External Leak Sensing and Monitoring for Dry Storage Canister

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ABSTRACT:

Dry cask storage system (DCSS) is increasingly used for extended long-term storage of spent nuclear fuel (SNF). About 90% dry storage canister (DSC) used in the U.S. are stainless-steel welded canister, which functions as the confinement boundary to retain the radioactive material under normal and accident conditions. The leak tightness of DSC is essential to ensure safe operation of dry cask storage system. Currently there are no direct methods to evaluate the leak tightness of a welded canister. Two indirect testing methods are *helium leakage* detection and *internal pressure* monitoring. The internal pressure provides a global indication of the canister's confinement integrity, and may also indicate the presence of water vapor, the formation of hydrogen and oxygen, and cladding failure.

Due to the harsh environment in DSC and strict regulation requirements, external sensing methods are preferred for practice and long-term monitoring of DCSS. This project aims to develop two complementary **external sensing methods** to evaluate the DSC integrity through monitoring the **internal pressure**, **canister surface temperature,** and **helium gas concentration** in air. An **ultrasonic** technique will be developed to continuously monitor changes of internal pressure and surface temperature; a low-cost, miniature **gas sensor** will be developed for helium leakage detection.

The following research tasks are proposed to provide a comprehensive solution to DSC monitoring.

- Task 1: We will develop an ultrasonic sensing method to monitor the internal pressure and canister surface temperature profile based on acoustoelastic and thermoacoustic effects. High sensitivity can be achieved by using ultrasonic diffuse waves.
- Task 2: We will develop a switch-type MEMS sensor that gives an alarm when the helium concentration exceeds a certain threshold. The simple design and small size of the MEMS sensor enable installation of multiple sensors without blocking air flow.
- Task 3: A laboratory-scale mockup canister will be built to simulate different DSC operation conditions. Test databases will be generated for normal and abnormal operation conditions.
- Task 4: Machine learning models will be built based on the test database to correct ambient environmental effects and improve the accuracy of decision making.

The PIs are proven experts in their specific task areas and have access to state-of-art research facilities.