Wirelessly Powered Sensing Platform to Interrogate and Report Spent Nuclear Fuel Dry Storage Canister Conditions

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ABSTRACT:

Due to the absence of defined spent nuclear fuel (SNF) disposal/reprocessing pathways, extended dry storage systems may need to operate for several decades. The U.S. Nuclear Regulatory Commission (NRC) requires dry storage canister (DSCs) to maintain fuel retrievability, limit component temperatures, confine materials, minimize external radiation, and maintain subcritical configurations [?]. Analysts employ experimental and computational methods to ensure the integrity of the fuel during storage and transport. However, the experimental methods are usually conducted for separate or limited combined effects in laboratory settings that are not fully representative of all the conditions in DSCs. Monitoring the internal conditions of DSCs during long periods of storage and after transport can provide better assurance that these safety requirements are met, and validate methods to predict internal conditions. Also, understanding the actual conditions inside a DSC would help operators to decide if a DSC that needs to be reopened could be handled as a normal or off-normal evolution, based on the condition of the fuel rods (intact vs. breached).

The objective of the proposed research is to develop a proof-of-concept sensing platform that may be safely and compactly integrated into a wide variety of DSC designs. The researchers will use experimental and computational methods to develop and optimize magnetic-resonance systems to (a) wirelessly power the platform from an external source, and (b) reliably transmit the measured data from the platform to an external receiver. The researchers will also use experimental techniques to assess a variety of novel and existing gas composition (oxygen, hydrogen, water vapor, and xenon) and radiation spectra measurement technologies (in addition to measuring pressures and temperatures). The electronics will be shielded, sealed, and inert, to minimize their interference with normal DSC materials and operations. The University researchers will work with researchers from Pacific Northwest National Laboratory (PNNL) to develop sensors that can be integrated within DSC's high temperature and radioactive environment. They will also work with the industrial partner, Orano/TN America, to determine and mitigate degradation mechanisms, including any incompatibilities with DSC components/operations, for each candidate technology. The University researchers will also use their advanced computational fluid dynamics (CFD) capabilities to determine if leakage of the inert gas from the DSC (and replacement by air) can be practically detected by measuring temperatures on the DSC external surface. This work will allow the researchers and partners to develop a proof-of-concept platform that will reliably operate during long periods of extended dry storage and after transport, and be available for future development.