Integral Fuel Rod Real-Time Wireless Sensor & Transmitter Irradiation Test and Post Irradiation Examination

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Program: NSUF-2.3, Advanced In-Reactor Instrumentation

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ABSTRACT:

Description: The objective of the program proposed is to continue the nuclear-environmental evaluation of a radiation and temperature tolerant remotely interrogated (magnetic coupling) in-core wireless sensor capable of measuring critical parameters such as fuel pellet center line temperature, fuel pellet elongation and fuel rod pressure, and wirelessly transmitting these parameters without a penetration of the fuel rod. The receiving antenna located in the instrument thimble will receive the signal and route it to the receiver and signal processing system.

Major tasks (phases, planned approach, etc.) and methods to be employed

Experiment design, assembly: HFIR and Westinghouse project teams will collaborate to define the sensor package design and the test vehicle required.

Sensor assembly and test verification: The Westinghouse team will modify the existing sensor package based on inputs from Task#1, assemble a test vehicle specific for the HFIR environment and perform a validation test prior to shipment.

Sensor irradiation at HFIR: Two independent sensors (temperature and pressure) to be tested. Tungsten rod through gamma radiation will simulate fuel pellet temperatures.

Sensor PIE: Sensor and selected components. SEM and XRD will be performed.

Scope and objectives: The proposed project will assess the accuracy and reliability of the Westinghouse developed wireless sensor under typical PWR conditions. The Oak Ridge National Laboratory (ORNL) High Flux Isotope Reactor (HFIR) facility will enable the installation of two independent sensors that measure local temperature and pressure change.

Major Deliverables: The program deliverables include (1) radiation and temperature effects on the electronic components, (2) reliability and accuracy assessment of measured parameters (temperature and pressure) when exposed to typical PWR conditions, (3) the evaluation of wireless signal transmission through metal, and (4) post irradiation examination results of the sensor and selected components.

Potential impact: This non-intrusive system would make a critical contribution to the rapid development of advanced fuel by providing real-time data from fuel under test as opposed to the current methodology of irradiation followed by cooling and post-irradiation examination (PIE). Real-time monitoring of fuel properties during operation reduces the need for post cycle fuel analysis using gamma tomography, saving operators cost while improving plant operations and safety. The existing methodology for testing advanced fuel cladding materials requires fuel rods to be tested over several fuel cycles and examined at the end of the irradiation test. This is a lengthy process, taking anywhere from several months to several years during which time performance data is not available. Another potential application of this technology is in the Reactor Protection System (RPS). In current RPS System designs, critical state variables such as Fuel Rod Centerline Temperature (TM) and Peak Clad Temperature (TC) are inferred from fuel fission rate distribution, and bulk indications of reactor vessel coolant temperature and coolant flow rate. The lack of detailed fuel rod internal temperature information imposes the need for conservative assumptions on the relationships between the nuclear radiation distribution, reactor vessel temperature distribution, and the corresponding peak TM and TC values in the reactor. This conservatism can be eliminated or improved by placing non-intrusive in-rod sensors.

Participants: The program collaborators and test facility will include the ORNL HFIR, Irradiated Fuels Examination Laboratory (IFEL), Irradiated Materials Examination and Testing (IMET) and Low Activation Materials Development and Analysis (LAMDA) Testing Facility.