Demonstration of Self Powered Neutron Detectors Performance and Reliability

PI: Joe Palmer (INL)

Collaborators: Troy Unruh, Pattrick Calderoni, Kevin Tsai (INL), David Carpenter (MIT-NRL)

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ABSTRACT:

The unique fuel arrangement of the Advanced Test Reactor (ATR) provides great operation flexibility—power may be "tilted" to one of four lobes. But this flexibility also results in a measure of uncertainty in the neutron flux at any one experiment location. To remedy this situation, an effort to develop and deploy reliable neutron flux sensors based on Self-Powered Neutron Detector (SPND) technology has been initiated as part of the Nuclear Energy Enabling Technology Advanced Sensor and Instrumentation program.

Although SPNDs are used routinely in commercial power reactors, they have not been effectively deployed in ATR experiments. Considerable engineering and confirmatory testing are required for each reactor, and also for each experiment type. This is because the response of an SPND is dependent upon the neutron spectrum at the sensing point, and the spectrum is, in turn, based on the temperature of the surrounding neutron moderating materials. In addition, SPND output can be affected by the activation of the surrounding materials because an SPND's output results from both neutron and gamma ray absorption. To help calibrate and validate the data obtained from the SPNDs, they will be paired with a set of Micro-Pocket Fission Detectors, tuned for both thermal and fast neutron fluxes, and a set of passive dosimetry wires, again tuned for both thermal and fast neutron detection.

The proposed collaboration with Massachusetts Institute of Technology's Nuclear Reactor Laboratory (MIT-NRL) provides an excellent opportunity to qualify sensors for use in ATR experiments at greatly-reduced cost. One of the prime experiment locations in ATR is the Loop 2A pressurized water loop. To date, the experiments conducted in this position have not been instrumented because of the difficulty in incorporating instrumentation in such a harsh environment. The Massachusetts Institute of Technology Research (MITR) reactor is equipped with a high-pressure water loop which is capable of providing approximately the same thermal flux and pressure/temperature environment as ATR Loop 2A, but at a much lower flow rate. Additionally, the MITR loop is a materials-only loop (no fissile), and thus contamination is very low. The simple design and low contamination of the MITR loop allows experiments to be conducted at a greatly-reduced cost (< 20% of the cost of a similar experiment in ATR Loop 2A), making it a perfect vehicle for instrumentation development and demonstration prior to being installed in a high-value ATR Loop 2A experiment, or any other position in ATR.

In summary, the objectives of this project are as follows:

- Stand up a reliable domestic supplier of Self-Powered Neutron Detectors
- Perform the engineering required for installation in a high-power test reactor, particularly the engineering required to install in a high-pressure water loop
- Demonstrate proper response and calibration by comparing the SPND signals against a set of Micro-Pocket Fission Detectors, and a set of passive instrumentation.

Having accomplished these objectives, the instruments will be ready for deployment in ATR experiments.