Wireless Reactor Power Distribution Measurement System Utilizing an In-Core Radiation and Temperature Tolerant Wireless Transmitter and a Gamma-Harvesting Power Supply

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ABSTRACT:

PROJECT OBJECTIVES

Develop a self-powered, wireless transmitter that uses highly radiation and temperature resistant vacuum micro-electronic (VME) technology capable of operating inside a Light Water Reactor (LWR) vessel for use in continuously measuring neutron flux and/or coolant temperature distribution. Other potential applications of the technology within a LWR containment environment will also be investigated.

PROJECT SCOPE/DESCRIPTION

The proposed project will develop the technology necessary for a wireless reactor power distribution measurement system. This novel power distribution measurement system utilizes highly radiation-and temperature-resistant vacuum micro-electronics technology that continuously broadcasts Self-Powered Detector signals and reactor coolant temperature sensor signal measurements to a receiving antenna. The temperature and radiation sensitivity performance of the VME device, which is the key component of the system, will be evaluated as well as the supporting passive components of the circuit. The project will also include the design, construction, and testing of the gamma radiation harvesting power supply.

EXPECTED OUTCOMES/BENEFITS

Significant improvement in power distribution measurements: The proposed project would enable 100% of fuel assemblies to be instrumented by placing a VME wireless transmitter in the top nozzle of each fuel assembly, which represents a significant increase from the existing 33% of fuel assemblies. It is expected that this technology would enable the plant to increase the reactor operating margin due to reduced reactor power distribution measurement uncertainty.

Reduced number of penetrations through primary coolant boundary: The proposed system can generate the required state variable measurements without the need for additional penetrations in the reactor coolant system boundary. From a safety standpoint, this is particularly beneficial for all LWR.

Potential for reduction in O&M costs: While it is true that the VME wireless transmitters would allow for reduction or elimination of the vessel penetrations used for core instrumentation, thus reducing plant capital cost, the main impact is on O&M cost because of the elimination of inspection, maintenance, and all the measures related to the instrumentation wiring that are typically taken during outages.

COLLABORATOR: PENN STATE RSEC

The Penn State RSEC facilities include the Penn State Breazeale Reactor (PSBR). The PSBR is the nation's longest continuously operating university research reactor. The PSBR is a 1 MW TRIGA Mark III reactor with moveable core located in ~71,000 gallon, 24 ft. deep pool of demineralized water. A variety of dry tubes and fixtures are available in or near core irradiation positions. The irradiation performance features of the PSBR allow the rapid simulation of in-core radiation conditions in a commercial LWR environment.