Evaluation of Economic Benefits of Accident Tolerant Plants Through Risk-Informed Approaches

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Program: RC-6: Evaluation of Potential Improvements to Risk and Economics Resulting from Accident Tolerant Plant Designs

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ABSTRACT:

The objective of the proposed work is to explore the economic benefits brought upon by the implementation of practical Accident Tolerant Fuels (ATFs) concepts and FLEX-type systems in current Light Water Reactors (LWRs). By reducing the O&M cost of selected components, Risk-Informed Approaches (RIAs) have gained significant traction by the nuclear industry in the 21st century. RIAs have also found acceptance by the regulator since they have demonstrated an increase in safety and a decrease in worker dose. At the same time the total operating cost of the current nuclear fleet has increased by 20% since 2002. Thus, future adoption of ATFs and current implementation of FLEX following the 2011 Fukushima disaster, motivates a fresh look at RIAs to LWR safety systems in order to offset this increase in the operating cost. The advanced ATF designs have the potential to minimize clad oxidation and hydrogen generation for a longer time period while maintaining or improving the reactor performance during normal operation. As more time is made available for operator actions, ATF provides a better opportunity for a successful implementation of portable FLEX equipment to ensure long-term core cooling during severe accidents.

The proposed work will focus on two near term ATF cladding concepts: coated clad and steel-based clad along with FLEX type equipment such as backup batteries and emergency feedwater makeup pumps. We will focus on the thermal-hydraulic and fuel performance response of the reactor safety systems in accident scenarios up to the initiation of fuel damage. We will then adopt the Risk-Informed Margins Management (RIMM) approach within the Risk-Informed Safety Margin Characterization (RISMC) methodology to quantify the impact on key figures-of-merit like the peak cladding temperature by primarily utilizing the system code TRACE. TRACE's relative modern architecture and Multiphysics capability allows readily translation of our system models to Nuclear Energy Advanced Modeling and Simulation (NEAMS) toolkit in the future. We will leverage the existing implementation of the mentioned ATFs and availability of reference plant models in the TRACE code. This allows us to focus our efforts on development of optimized strategies to increase coping time in conjunction with new proposed FLEX-type systems. In order to successfully demonstrate our methodology, the scope of work will be focused on loss of coolant inventory type accident, since it is one of the risk-significant contributors to plant core damage frequency. Generic Probabilistic Risk Assessment (PRA) plant models will be utilized to identify risk-significant pathways for a reference Pressurized Water Reactor. The acquired information from risk analysis will then be used for decision-making and margin management, driven by INL's tool RAVEN. The ultimate outcome of the proposed work is to take credit for the safety improvements of the "accident tolerant plant" to reduce the cost of LWRs operation. This will be done by leveraging existing RIAs such as 10CFR50.69 and recommending new RIAs to revise current regulation (e.g. 10CFR50.46) in context of the study.