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ABSTRACT

Passive Safety Optimization in Liquid Sodium-Cooled Reactors

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A three-year collaboration is proposed between Argonne National Laboratory (ANL) and the Korea Atomic Energy Research Institute (KAERI) to identify and quantify the performance of innovative design features in metallic-fueled, sodium-cooled fast reactor designs. The objective of the work is to establish the reliability and safety margin enhancement provided by design innovations offering significant potential for construction, maintenance, and operating cost reductions. The targeted cost reductions and safety performance improvements are directly responsive to the goals for Generation IV nuclear energy systems.

The proposed work includes a combination of advanced model development, analysis of innovative design and safety features, and planning of key safety confirmation experiments. The model development task provides for required improvements in prediction of reactor thermal-hydraulic performance; reactor fuel, cladding, coolant, and structural material temperatures; and resulting reactivity feedback effects. The safety analysis task provides for evaluation of the effectiveness and safety performance impacts of specific design features, with emphasis on passive safety mechanisms that augment and replace costly engineered safety systems. The third task investigates the safety and operational performance implications of a Brayton power conversion cycle utilizing supercritical carbon dioxide, and incorporating an innovative heat exchanger design. This cycle offers the potential for a significant increase in operating efficiency, and the new heat exchanger design allows elimination of the intermediate heat transfer loop. Finally, the fourth task provides for planning of a series of experiments designed to verify the safety margins available in metallic-fueled, sodium-cooled reactors for in-vessel retention of core melt debris and mitigation of the consequences of extremely low probability severe accidents. Verification of material behavior provided by these experiments will provide a basis for containment design simplification, and corresponding cost reduction.

Each of the tasks proposed here is thus specifically aimed at identifying and accurately quantifying the safety and operational performance benefits of innovative design features in metallic-fueled, liquid-sodium-cooled fast reactor, with the objective of simplifying reactor and plant designs and reducing costs.