An Experimental Study of Design and Performance for the Water-based Reactor Cavity Cooling System

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ABSTRACT:

Passive heat removal systems are one of the primary technological goals of the Generation IV program, since they can guarantee their functionality also in the event of an accident, when power is lost, requiring no human intervention. Natural circulation is one of the most promising passive heat removal mechanisms, already implemented in new reactor systems of the latest generations (III and III+), being also integral part of typical Small Modular Reactor (SMR) designs. The Reactor Cavity Cooling System (RCCS) is a new passive safety system designed for the next generation of nuclear power plants and it will be incorporated into proposed reactor designs for VHTR. This system is designed to guarantee the integrity of the fuel, the reactor vessel and the structures inside the reactor cavity by passively removing heat from the reactor vessel and transport the heat out of the reactor cavity both during normal operation and accident scenarios.

As remarked in the current FOA, there is a relevant focus on providing high quality experimental data for validation of existing and new system codes and computational fluid dynamics (CFD) codes, and models of high temperature gas-cooled reactors, and to support the validation matrix of the RCCS performances.

Within the framework of previous NEUP awards, two scaled water-cooled RCCS test facilities were designed, constructed, and operated in close collaboration with the Natural convection Shutdown heat-removal (NSTF) RCCS facility at Argonne National Laboratory: The small scale (1/20th) at TAMU, and the medium scale (1/4th) at UW. The scaling methodology and design applied for these facilities was similar to the one adopted for the original NSTF and the modified water-cooled NSTF (1/2 scale). Our team has conducted a large variety of tests under different conditions using the experimental facility mentioned above and developed construction, measurements, and flow visualization techniques successfully applied during the past experimental activity.

The objective of this proposal is to extend and enhance the experimental tests previously conducted using the existing water-cooled RCCS at TAMU and UW, in close collaboration with water-cooled NSTF research team at ANL. Phenomena of particular interest such as the flow split through multiple risers (up to 18 risers) and the behavior of the flow through the upper collector system will be investigated. A unique set of high quality experimental data will be produced to contribute to the validation of existing system codes (such as RELAP5 and MELCOR), system codes under development (RELAP7), and computational fluid dynamics (CFD) codes. The proposed experimental work will also satisfy the need for data to support the validation matrix of RCCS performances, and will provide valuable insights into RCCS operation and important phenomena that contribute to the behavior and performance of these systems. The data produced will be valuable to system designers and safety analysts,