

Modeling and Test Validation of a Reactor Cavity Cooling System with Air

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ABSTRACT

NGNP safety analysis research focuses on providing practical tools to analyze the reactor thermal-hydraulics, system performance, and reactor gas-coolant helium thermal fluids behavior during transients, postulated accidents, and safety evaluations. The RCCS is a key safety system that is important to the NGNP passive safety concept. The air-cooling option for the RCCS design is in line with the anticipated design for the Prismatic Modular Reactor. This work will support the expected final design and safety analysis of the RCCS for the NGNP.

The air-cooled RCCS has advanced in design detail to allow the NSTF ½-scale integral facility to be built. The combination of NSTF data and the proposed scaled experiments (¼-scale) will allow NGNP designers and national laboratory staff, as well as regulators, to examine and validate the effects of variable heating conditions and geometric asymmetry on the ability to remove the NGNP vessel decay heat levels without deleterious instabilities or local hot spots.

We plan to conduct scaled, air-cooled RCCS experiments that are coordinated with the larger scaled NSTF experiments, as well as develop computational models describing key phenomena that occur during passive natural convection in the RCCS. Our tasks will be:

[1] RCCS Test Facility with scaled plena, downcomer, risers (smaller scale): Experiments will be conducted in a scaled facility (¼- to 1/6-scale of the full-scale RCCS) to examine the integral effect of flow from an inlet chimney, through a common downcomer, to a set of risers and into a common hot plenum and chimney. This facility will be complementary to a larger scale NSTF facility and will investigate the effects of spatially variable heat fluxes on flow distribution between a common cold plenum and multiple heated risers, hot outlet plenum and chimney.

[2] Separate effect riser and hot plenum testing and modeling: Separate effects tests will be conducted with differentially heated risers into an instrumented hot plenum. The focus will be on the effect of large temperature differences on the stability of flow in the risers, and associated local mixing in the hot plenum. Because these experiments may be done at even smaller scale, simulant gases will be considered to better match the needed scaling laws and parameters [2].

[3] Model development and validation from the scaled experiments: Computational modeling of these test facilities, along with coordination of the modeling of the larger scale Argonne Lab experiments at NSTF, will be directed by our research team. Models will include system models (e.g., RELAP5-3D, MELCOR) and CFD tools (e.g., FLUENT, Star-CCM+). The intent is to validate the models at these various empirical scales for use in the full-scale analysis.