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GAIN Gateway for Accelerated Innovation in Nuclear

OAK RIDGE National Laboratory

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Nuclear Energy and Fuel Cycle Division

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1. INTRODUCTION

As part of the work supported by a US Department of Energy (DOE) Office of Nuclear Energy Gateway for Accelerated Innovation in Nuclear FY 2020 Voucher, Holtec International subsidiary SMR LLC (hereinafter referred to as *Holtec*) and Oak Ridge National Laboratory entered into a cooperative research and development agreement (CRADA) to develop coupled multiphysics core models of the Holtec-developed small modular reactor (SMR), SMR-160. A rendering of the SMR-160 plant is shown in Figure 1.

Figure 1. SMR-160 plant rendering.

The scope of the 1 year project was to use the DOE–developed tool set, VERA, to analyze several aspects of a representative SMR-160 core design. The goals of the project were to perform the code-to-code benchmarking and to provide Holtec with a confirmatory calculations to compare against the results with the codes used in the SMR-160 design, identify and resolve areas of discrepancy between the two models to give Holtec a basis for selecting certain tool and model options, and develop a workflow so that the VERA model could be adapted easily to any future changes in the design of the SMR-160 core.

The work proceeded in four phases:

1. Developing the initial VERA model based on Holtec-provided core design information
2. Comparing VERA results with Holtec-provided calculations for the first five cycles
3. Developing a VERA transient model based on the prior model
4. Training Holtec personnel on VERA and hand-off the developed models

This report summarizes at a high level the completed tasks. Details of the tasks and results are reserved for the full report, which will not be publicly released for 5 years per the terms of the CRADA. The report is titled “Coupled Neutronic and Thermal Hydraulic Analysis of a Natural Circulation Based Small Modular Reactor (SMR) using VERA-CS” and has the ORNL technical report number ORNL/TM-2021/2303 (NFE-20-08305).

2. TECHNICAL TASKS

2.1 TASK 1: VERA MODEL DEVELOPMENT

The VERA model was created using information that Holtec provided in technical reports and a SIM5 input deck via email and teleconference. The model uses the VERA common input format. For this first task, most of the effort involved ensuring that the fuel assembly compositions and reflector geometry

match those provided. Additionally, the amount of error introduced by various approximations was quantified as part of this task to determine which approximations could be made without negatively affecting solution accuracy.

2.2 TASK 2: CODE-TO-CODE COMPARISONS

For this task, comparisons between VERA and the Holtec tools were conducted. These comparisons included hot zero power and hot full power comparisons for the beginning of cycle 1. These comparisons were used to determine whether there were any shortcomings in the Holtec modeling tools.

2.3 TASK 3: CYCLE VERA SIMULATIONS

The third task was to compare VERA with the Holtec tools for cycles 1 through 5 depletion calculations. Again, these calculations were intended to validate the Holtec modeling tools for the SMR-160. Comparisons between the two tool sets were made at various points throughout each cycle for boron concentration, control rod worth, and power distribution.

2.4 TASK 4: TRANSIENT SIMULATIONS

2.4.1 Main Steam Line Break

The fourth task had two parts. The first was to simulate a main steam line break with VERA. This was compared with the system analysis code that Holtec used. VERA was then used to generate pin-level data that could not be generated by the system analysis tool. The pin-level data are useful for determining whether there is any potential for fuel failure during the transient.

2.4.2 Reactivity Insertion Accident

The second part of task 4 was performing a rod ejection accident with VERA and the Holtec tools to confirm the accuracy of the Holtec tools for a rapidly evolving transient. It also provided pin-wise data from VERA that are not readily available in the Holtec tools.

2.4.3 BISON Calculations

For each of these two accidents, detailed BISON calculations were conducted using the VERA results. These calculations provided a much more detailed look at the fuel performance to ensure that there is no risk of fuel failures in either transient.

3. NONTECHNICAL TASKS

Several nontechnical tasks were conducted as part of this project.

1. VERA models and results were handed off to the Holtec team.
2. Training was provided to the Holtec team concerning the VERA tools and capabilities.
3. The aforementioned final report was generated.

The hand-off and training were combined into one all-day meeting that occurred on April 5, 2022. The final report was generated throughout the project and was completed and submitted to Holtec on April 29, 2022, to conclude the project.

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