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Final Summary Report on the Feasibility and the Benefits of the Advanced Nuclear Fuel Pellet Designs with Radially Varying Fuel Zoning and Burnable Poison Concentration

Oak Ridge National Laboratory:
Mehdi Asgari
Eva Davidson
Jake Hirschhorn
Dave Kropaczek
Andrew Godfrey
Ryan Sweet

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Nuclear Energy and Fuel Cycle Division
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OAK RIDGE NATIONAL LABORATORY
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ACRONYMS AND ABBREVIATIONS

ANFPD	advanced nuclear fuel pellet design
CASL	Consortium for Advanced Simulation of LWRs
CRADA	Cooperative Research and Development Agreement
DOE	US Department of Energy
FCT	fuel centerline temperature
FGR	fission gas release
GAIN	Gateway for Accelerated Innovation in Nuclear
LWR	light-water reactor
NE	Nuclear Energy (DOE)
ORNL	Oak Ridge National Laboratory
PCMI	pellet-cladding mechanical interaction
VERA	Virtual Environment for Reactor Applications

1. INTRODUCTION

As part of the work supported by the US Department of Energy (DOE) Office of Nuclear Energy (NE) Gateway for Accelerated Innovation in Nuclear (GAIN) FY 2021 Voucher, Exelon Generation, now Constellation, and Oak Ridge National Laboratory (ORNL) entered into a cooperative research and development agreement (CRADA) to evaluate and assess the feasibility and impact of various conceptual advanced nuclear fuel pellet designs (ANFPDs). The objective of this project was to perform modeling and simulation and analyses using the advanced modeling and simulation capabilities of VERA/BISON, developed by DOE, to determine the viability and benefits of numerous advanced nuclear fuel pellet design concepts in terms of fuel cycle costs, operational safety, and margin improvement. Whereas the detailed coupled neutronic and thermal hydraulic analyses performed using VERA provided in-depth knowledge in terms of fuel cycle performance, the detailed VERA results were used in subsequent fuel performance analyses using BISON. These subsequent analyses focused on several key fuel performance criteria, such as peak fuel centerline temperature (FCT), fission gas release (FGR), gap closure, plenum pressure, and cladding hoop stress. These key fuel performance criteria were analyzed for some of the conceptual fuel designs and were compared with the results obtained for UO_2 fuel. The results provided detailed information to enable better understanding of the performance of the fuel types analyzed. Understanding the advantage of loading these conceptual fuel designs into the core is important not only to Constellation but also to the entire light-water reactor (LWR) fleet in the United States.

Asgari et al. [1] present the detailed design characteristics of the different fuel design concepts evaluated under this CRADA. The content of the report is protected under CRADA and prohibited for public release because it contains export-controlled information and potential intellectual property. The purpose of this memo is to document the completion of the project and provide a record of the full report generated under this project.

2. TECHNICAL DISCUSSION OF WORK PERFORMED

In the effort pursued through this GAIN voucher, various accident-tolerant fuel concepts were identified and evaluated to assess the viability, performance, and benefits of such intricate fuel design concepts. Understanding the advantage of loading these fuel designs into the core is important not only to Constellation but to the entire fleet, as well as to nuclear fuel vendors. The advanced modeling and simulation capabilities developed by DOE, VERA/BISON, were utilized to perform a series of coupled neutronic and thermal hydraulic as well as fuel performance calculations to better understand performance and benefits of such advanced fuel design concepts in terms of fuel cycle costs, operational safety, and margin improvement. The report by Asgari et al. [1] presents the list of the advanced fuel design concepts evaluated, detailed analyses performed, results feasibility, benefits, and potential oppertunities.

3. REFERENCES

1. Asgari, M., et al. 2022, “Neutronic and Fuel Performance Evaluations of Advanced Nuclear Fuel Pellet Designs for LWR Applications.” Technical Report, ORNL/TM-2022/2502, CRADA/NFE-21-08637.

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