

Ultra Safe Nuclear Corporation (USNC)
partnered with
Oak Ridge National Laboratory

NE-20-23742, Graphite Finite Element Model Verification

TOTAL PROJECT VALUE: \$512,500 (DOE: \$410,000, USNC: \$102,500)

STATUS: Completed

PRINCIPAL LAB INVESTIGATORS: José D Arregui Mena (ORNL), Aaron Selby (USNC)

DESCRIPTION: Ultra Safe Nuclear Corporation -- Technologies (USNC) is a technology development subsidiary of Ultra Safe Nuclear Corporation dedicated to identifying and enabling the commercial development of advanced nuclear technology for terrestrial- and space-based applications. It has developed a finite element model (FEM), the Nuclear Graphite Interactive Material Model and Simulation Environment Model and released it as open-source software. To optimize the design and lifetime estimates of the graphite components, it was necessary to create a benchmark and analytical solution to verify the FEM. This GAIN-supported project employed Oak Ridge National Laboratory's random fields finite element model (RFEM) and expertise in graphite to generate independent, confirmatory analytical solutions.

BENEFIT: Graphite components are subjected to various degradation mechanisms, including irradiation-induced dimensional change, oxidation, thermal stresses and irradiation creep. These degradation mechanisms created by the reactor environment cause stress concentrations and changes in the microstructure that may eventually lead to cracking and damage to the graphite core. To understand and predict the effects of degradation mechanisms of graphite under the reactor environment, it is necessary to create modeling tools that are supported by mechanical properties and microstructural characterization.

IMPACT: The benchmarks for USNC -- Tech's graphite FEM will ultimately be used in the company's final Micro Modular Reactor (MMR™) design and licensing submissions. The benchmarks, analytical solutions, and failure criteria are to be used to evaluate the current graphite core design of the MMR™ reactor, resulting in an optimized core and a down-selection of the graphite used for the core. The USNC FEM code verification will enhance the fidelity of the modeling and support the safety cases of MMR™ reactor applications.

SIGNIFICANT CONCLUSIONS: Graphite-moderated reactors have not been operated in the United States since 1989, when Colorado's Fort St. Vrain Generator Station closed. This has resulted in limited public data and a lack of expertise. For the effective and reliable use of graphite in advanced reactors, the United States must identify the state of knowledge and the potential effects of graphite source variability in advanced reactors must be discerned.

NEXT STEPS: USNC plans to locate a pilot fuel manufacturing facility near ORNL to have easy access to the lab's world-class scientists and facilities. The company is also scaling up the production of specialty components for nuclear and industrial applications.