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Science-Based Development of ASTM standard tests for graphite-based fuel pebbles

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ABSTRACT:

Several advanced reactor designs developed today will utilize pebble fuel forms. For example, molten salt cooled (Fluoride High-Temperature Reactor, FHTR) reactor utilizes buoyant pebbles that are moving through the core continuously and suspended in FLiBe. High-temperature gas reactors (HTGR) also utilize pebble fuel forms with Helium as the heat transport media. In both cases, the TRistructural-ISOtropic (TRISO) fuel particles are suspended in matrix graphite, where the graphite acts as a protective measure to prevent damage to the fuel and in case of FHTRs, allows to dial in the correct buoyancy. However, in order to ensure success of these reactors one must ensure the integrity of the fuel pebbles deployed at all times. Quality control, and standardized testing suitable for the fuel pebbles must be established based on scientific principals with engineering applicability in mind.

Therefore, this work aims to establish a science-based protocol to quantify fuel pebbles degradation in extreme reactor environment. In this project, testing methodologies for mechanical (fracture, impact, etc.) as well as friction and wear tests will be developed and standardized, and the guidelines for developing statistically significant tests in line with NQA-1 quality assurance program will be established. To achieve the project goals, the program will utilize past pebble (mechanical) performance assessment methods and new testing practices, adapt wear and friction measurements (deployed in other research areas, such as coating industry) to graphite fuel pebbles, apply rigorous data analysis and statistical screening methods to the test data, and develop a best practices database for fuel pebble test methods. This proposal will not just deploy already established methods from other fields but will also develop tailored methods for the quality control problem of fuel pebbles on hand.

It is the ultimate aim of this program to obtain a fundamental understanding of the failure modes in pebble fuels during use and develop an appropriate test methodology to quantify the failure rate and condition so that to optimize the pebble design, as well as to proctor quality control and predict performance during use and reuse. At the completion of this program, we will be able to write ASTM standards for pebble fuel testing.