

**SECTION A. Project Title: Fragmentation and Thermal Energy Transport of Chromia-doped Fuels under Transient Conditions
– University of Pittsburgh****SECTION B. Project Description**

The University of Pittsburgh proposes to provide essential data, analysis, and modeling to fill a major knowledge gap in thermal energy transport relevant to transient performance and safety of high burnup accident tolerant fuels (ATF). This project will also provide a research methodology including experimental and analysis procedures and tools for future transient reactor testing, such as TREAT, of irradiated ATF fuels for fuel safety assessment. The specific objectives of this project are: (1) Develop a model fuel system that is representative of high burnup ATF fuels, specifically, chromia-doped UO_2 with controlled grain structure, pore, and bubbles; (2) Fracture and fragment the fuel to simulate LOCA fuel fracture/fragmentation patterns, forming a microstructure descriptor (cracking patterns) for microstructure-based thermal transport; (3) Determine fuel thermal conductivity and diffusivity as functions of fuel microstructure and fracture/fragmentation characteristics and build thermophysical property correlations; and (4) Implement new property relationships in BISON and assess transient thermal transport in high burnup ATF fuels with experimental and machine learning generated microstructures and crack patterns. The proposed work consists of the following specific tasks: (1) Synthesis of chromia-doped UO_2 with controlled microstructures to mimic the microstructure evolution of the oxide fuels during irradiation including simulated high burnup structures with controlled grain structure, pores, and porosity as the model systems for fragmentation testing and heating transfer modeling; (2) Fragmentation testing of the chromia-doped UO_2 to create steady-state fuel cracking and transient fuel fragmentation under relevant thermal stress or transient power ramp (e.g., LOCA) and mechanistic understanding of the fragmentation as functions of microstructure/burnup; (3) Thermal conductivity measurements of the bulk, fractured, or fragmented fuels and the correlation with the crack pattern (e.g., numbers of cracks, size and orientation (radial or circumferential)), and the investigation of how different cracks (primary cracks or secondary micro-crack associated with transient) affect the heat transferring behavior; and (4) Implementation of the engineer-scale BISON code with the input from thermal conductivity measurements and microstructure and crack patterns, both experimentally-obtained from the model fuel system or historical data (e.g., Halden or Studsvik) and machine learning generated microstructures, for transient temperature and energy transport from fragmented fuels.

SECTION C. Environmental Aspects / Potential Sources of Impact

The university (and its partner university) has procedures in place to handle any waste that will be generated through this project. The action would not create additional environmental impacts above those already occurring at the universities.

SECTION D. Determine the Level of Environmental Review (or Documentation) and Reference(s): Identify the applicable categorical exclusion from 10 CFR 1021, Appendix B, give the appropriate justification, and the approval date.

Note: For Categorical Exclusions (CXs) the proposed action must not: 1) threaten a violation of applicable statutory, regulatory, or permit requirements for environmental, safety, and health, including requirements of DOE orders; 2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment facilities; 3) disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; 4) adversely affect environmentally sensitive resources. In addition, no extraordinary circumstances related to the proposal exist which would affect the significance of the action, and the action is not “connected” nor “related” (40 CFR 1508.25(a)(1) and (2), respectively) to other actions with potentially or cumulatively significant impacts.

References: B3.6 Siting, construction, modification, operation, and decommissioning of facilities for small-scale research and development projects; conventional laboratory operations (such as preparation of chemical standards and sample analysis); and small-scale pilot projects (generally less than 2 years) frequently conducted to verify a concept before demonstration actions, provided that construction or modification would be within or contiguous to a previously disturbed or developed area (where active utilities and currently used roads are readily accessible). For purposes of this category, “demonstration actions” means actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment. Demonstration actions frequently follow research and development and pilot projects that are directed at establishing proof of concept.

Justification: The activity consists of an investigation to develop a microstructure-based thermal transport model by considering the key microstructure features as the result of burnup, particularly fracture and fragmentation, of high burnup ATF fuels.

Is the project funded by the American Recovery and Reinvestment Act of 2009 (Recovery Act) Yes No

Approved by Jason Anderson, DOE-ID NEPA Compliance Officer, on 09/21/2021.