DOE-ID NEPA CX DETERMINATION

CX Posting No.: DOE-ID-17-082

SECTION A. Project Title: Performance of SiC-SiC Cladding and Endplug Joints Under Neutron Irradiation with a Thermal Gradient – General Atomics

SECTION B. Project Description

General Atomics, in collaboration with Oak Ridge National Laboratory (ORNL), proposes to obtain critical performance data for SiC joints under irradiation in representative thermal conditions and in representative joint geometries. The work will provide material property data to enable more accurate modeling of joints in SiC-based components for nuclear applications.

The work will be accomplished through a combination of out-of-pile testing and post-irradiation examination (PIE) of joint samples. The three main tasks are:
• Specimen Fabrication and Out-of-pile Testing: SiC joint specimens will be fabricated in representative cladding tube-endplug geometries using three leading candidate SiC joint formulations. The specific endplug and joint geometry will be selected to be compatible with fabrication requirements for all joint types. Out-of-pile SiC joint strength, permeability, and thermal properties will be characterized as a function of temperature, filling critical gaps in the knowledge base. In addition, the use of custom test fixtures will be demonstrated to facilitate the mechanical and thermal property testing of SiC joints in representative geometries.
• Capsule Design, Irradiation, and PIE : SiC joint specimens in representative geometries will be irradiated in a capsule designed to replicate realistic temperature and thermal gradient conditions. Two irradiation temperatures will be used, with one set of samples irradiated at LWR temperatures and another set under conditions relevant to advanced high-temperature reactors. Mechanical and thermal properties of irradiated SiC joints will be measured during PIE, as well as hermeticity, swelling, and microstructural changes. The capsule design, irradiation, and PIE will be performed using the resources available at the High Flux Isotope Reactor (HFIR) facility and supporting NSUF resources at ORNL.
• Material Property Database Development: SiC joint properties will be incorporated into a material property database suitable for more accurate representation of joint materials. The nuclear fuel performance code BISON will be used to simulate stresses of representative SiC cladding geometries, with validation against commercial FEM codes and comparison with out-of-pile and PIE characterization results.

SECTION C. Environmental Aspects / Potential Sources of Impact

Radioactive Material Use – This project is to perform a neutron irradiation under high radial heat flux on prototypical SiC-based fuel cladding relevant to practical light water reactor fuel operation. Various test specimens of monolithic SiC and SiC composites will be irradiated in the High Flux Isotope Reactor.

Radioactive Waste Generation – To accommodate these samples, 12 rabbit capsules are required for the tube irradiation with each capsule accommodating 1 tube specimen with two of each joint type. Two rabbit capsules are required to be built with each capsule accommodating eight torsion specimens. ORNL has capabilities and procedures to handle all radioactive waste generated.

Chemical Use/Storage – Flammable solvent and corrosive usage includes: Methanol – less than 5 gallons; Isopropyl alcohol – less than 5 gallons; 2-Butanone – less than 5 gallons; Acetone – less than 5 gallons; Nitric acid (70wt%) – less than 1 gallon

Several silicon carbide (SiC)-based additives will be used, including nano- and micro-meter sized powder; and whiskers of various diameters, lengths, and fibers and combinations thereof. Polymer binders will be used, including polyethylenes and polypropylenes. Carbide based powders and nanopowders: Carbon fiber – less than 1 kg; SiC fiber – less than 1 kg; SiC nanopowder – less than 2 kg; Propylene carbonate – less than 10 kg; SiC whiskers – less than 1 kg; Alumina nanopowder; Yttira nanopowder

All work will be conducted at laboratory-scale using existing facilities. Training is required annually for all employees in Hazard Communication and Hazardous Waste Management.

The Low Activation Materials Design and Analysis Laboratory (LAMDA) laboratory at ORNL will perform any cleaning/decontamination activities using laboratory supplies on hand and follow a disposition path according to its internal laboratory processes.

Chemical Waste Disposal – The following chemical waste, to be generated by the project, will be characterized, labeled, and otherwise profiled appropriately, and managed as hazardous waste through a licensed hazardous waste management contractor currently under contract with GA: Mixed solvent waste containing carbide or oxide nano-particles, polycarbosilane slurry (Acetone, 2-butanone, isopropyl alcohol) – less than ten gallons per month; Corrosive laboratory debris – less than 10 pounds per month; Corrosive liquid – less than 1 gallon per month

The project will strictly adhere to Federal, State, and local Environmental Protection Agency (EPA) regulations regarding the identification and management of hazardous waste.

The LAMDA laboratory at ORNL will perform any cleaning/decontamination activities using laboratory supplies on hand and follow a disposition path according to its internal laboratory processes.

Hazardous Waste Generation – Chemical waste generated by the project will be managed as hazardous waste. GA follows the most stringent EPA regulations for hazardous waste management enforced by local Certified Unified Program Agencies.

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). Not included in this category are demonstration actions, meaning actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial development.

Justification: The activity consists of research aimed at obtaining performance data for SiC joints under irradiation in representative thermal conditions and in representative joint geometries.

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

Approved by Jason Sturm, DOE-ID NEPA Compliance Officer on 09/13/2017