Project Title

Pre-Application License Review of Silicon Carbide Composite Clad Uranium Carbide Fuel for Long-Life Gas-Cooled Fast Reactor Cores

PI: John Bolin, General Atomics (GA) **Collaborators**: N/A (GA will be the sole participant)

Program: Advanced Reactor Technologies

ABSTRACT:

Project Objectives: Silicon carbide composite (SiC-SiC)-clad uranium carbide (SiC/UC) is a new type of nuclear reactor fuel and does not have a history of licensing and operation. GA will work with the Nuclear Regulatory Commission (NRC) to determine the requirements for licensing SiC/UC for use in a gas-cooled fast reactor long-life core. The licensing requirements would include the experimental database, validated performance and safety codes, and approach to licensing a prototype core.

Project Description: The SiC/UC fuel concept was developed by GA for its Energy Multiplier Module gas-cooled fast reactor (known as EM^2: a GA service mark), but is applicable to a wide variety of advanced reactor concepts. It consists of a SiC-SiC cladding around cylindrical porous UC fuel pellets. The cladding is composed of a matrix of high-density β-phase SiC deposited around a β-SiC fiber framework, similar to the cladding GA developed for the U.S. Department of Energy Accident Tolerant Fuel Program. It is also resistant to chemical reactions with air, water, and molten salts at high temperatures and potentially resistant to reactions with sodium with an appropriate coating. UC is a desirable fuel because of its high uranium content and high thermal conductivity. The UC pellet is chemically compatible with SiC for temperatures over 2000ºC. The porous UC pellet accommodates swelling and fission product deposits for high burnups (e.g., 25%). GA has built bench-scale fabrication facilities for both UC and SiC-SiC cladding and can produce high-quality pellets and cladding.

A major question relevant to the commercialization of advanced reactors is the strategy and required data for NRC licensing of a new fuel type. Therefore, before embarking on an extensive and potentially costly development campaign, it would be highly beneficial to have an initial interaction with the NRC to lay out the requirements for licensing as well as a strategy for accomplishing it. This would include SiC/UC test requirements for demonstration and prototype reactors, requirements for a validated predictive performance code, design and safety requirements, and overall licensing plan for use in long-life cores.

In order to accomplish this, GA will engage the NRC to execute a one-year program for a pre-licensing review of GA's SiC/UC fuel system. GA will submit a white paper to the NRC that describes SiC/UC and its use in a gas-cooled fast reactor with a long-life core. The paper will include the status of fabrication and testing to date and a preliminary set of analyses of SiC/UC in both steady-state and severe accident cases. It will identify potential SiC/UC failure modes and recommend tentative safety limits. It will include a proposed test plan for obtaining the necessary data to validate a fuel performance code for both steady-state and transient conditions. It will also include a draft plan for licensing the fuel through test, demonstration, and/or and prototype reactors. Time will be scheduled for responding to questions, and unresolved issues will be documented. The expected result will be written commentary and recommendations by the NRC on the four points identified above, which will reduce uncertainty relative to fuel licensing schedule and cost. GA will then modify the white paper to serve as the roadmap for an efficient SiC/UC fuel qualification program with potential application to other advanced reactor fuel forms such as SiC/uranium nitride and SiC/uranium dioxide.