DOE-ID NEPA CX DETERMINATION
Idaho National Laboratory

CX Posting No.: DOE-ID-INL-21-102

SECTION A. Project Title: Irradiation Testing of Uranium Oxide Fuel with Silicon Carbide Cladding in ATR and Transient Testing in TREAT

SECTION B. Project Description and Purpose:

The objective of this project is to assist in the design analysis and execution of fuel (UO_2) and cladding (SiC/SiC) irradiation testing at the conditions required to represent General Atomic (GA) reactor concept. The Advanced Test Reactor (ATR) is located at INL and boasts multiple capabilities for irradiation testing of materials and fuels for various reactor designs by utilizing a variety of engineering designs for manipulating neutron energy spectrums and temperatures. One such method for testing fuel is the Fission Accelerated Steady-state Testing (FAST) approach where reduced scale fuel rodlets can significantly improve the rate of irradiation. INL has developed a standard capsule to support FAST tests in multiple ATR positions called the Irradiation System for High-throughput Acquisition (ISHA) capsule. This capsule will be used in the project to test materials of interest for GA's Fast Spectrum Modular Reactor (FMR) concept. Additionally, INL can support investigations of FMR fuel within TREAT via the Dry In-pile Fracture Test (DRIFT) and Temperature Heat-sink Overpower Response (THOR) modules. The project will be done at Materials Fuels Complex (MFC) TREAT reactor and ATR.

The FMR fuel is designed for high temperature and high burnup operation with the system temperature higher than ~500˚C and the fuel burnup greater than ~10%, respectively. These operating conditions determine the fuel integrity affected by deformation of the fuel pellet and degradation of SiC-SiC properties. The performance of the ceramic cladding is expected to be driven by:

- Hermiticity of the SiC-SiC composite cladding
- Pellet-cladding mechanical interaction (PCMI)
- Pellet-cladding chemical interaction (PCCI)
- Internal pressure buildup
- Strain energy deposition during irradiation and transient

As the fuel irradiation in ATR is limited by the peak temperature of the material and irradiation time, it may not be possible to test the as-designed fuel rod under prototypic operation conditions. As such, it would be necessary to verify the fuel integrity for selected operating conditions and scalable configuration. Two different rod sizes are considered: one for the nominal design and the other for accelerated irradiation. Two different fuel gaps are also considered: one for nominal design and the other for pellet-cladding mechanical interaction.

Task 1. Irradiation Performance Model Support

INL will provide support for implementing BISON material models and performance codes to analyze the test fuel design and irradiation behavior of the test fuel. INL will collaborate with GA and Argonne National Laboratory (ANL) to develop the BISON model of UO fuel pellet for safety and performance analysis and further analyze the fuel behavior during FAST irradiations.

Task 2: Steady State Irradiation in ATR

Task 2.1 Experiment Design - GA will provide irradiation design requirements and INL will use the designs to determine the target fuel dimension, enrichment, and test capsule geometry. Tentative design requirements are listed in Appendix A. The completion of this effort will be validated by the issuance of the following documents:

- Functional and Operational Requirements (design basis)
- Technical, Functional, and Operational Requirements (analyses basis)
- Engineering Calculations and Analysis Reports (ECARs);
  - Thermal-hydraulic analysis
  - Neutronics analysis
- Design drawings
- Experiment Safety Analysis (ESA) report

Task 2.2 Uranium Supply and Experimental Materials - INL will down blend uranium metal to the target enrichment and ship to GA for fuel fabrication. The amount of uranium metal and enrichment level needed will be determined during the development of the experiment.

Task 2.3 Fabrication and Assembly - INL will fabricate test capsule materials and assemble the experiments using fueled rodlets (cladding and fuel) provided by GA. A final as-built design and analysis report will document the completion of this effort.

Task 2.4 Scheduling and Irradiation Test in ATR - INL will conduct a steady state experiment in ATR and provide as-run neutronics reports for each cycle. It assumed that there will be at least six full power cycles.

Task 2.5 Test History Summary Report - INL will summarize the irradiation history and compile a final report to support model evaluation and post-irradiation examination (PIE) of the irradiation experiments. This will not include PIE data.

Task 3: Transient Testing at TREAT

Transient irradiation testing will be conducted using TREAT to characterize the fuel-cladding mechanical behavior under initial power ramp. The objectives will be to understand the strain on the cladding as a result of initial fuel swelling and heating as well as to capture high temperature fuel cracking behavior. This can help inform the understanding of behaviors such as pellet-cladding-mechanical-interactions.

Task 3.1 TREAT Design Modifications and Analysis - INL will perform a design modification of the TREAT test to accommodate the conditions needed by GA for the FMR fuel design. This test will use either modified version of the DRIFT or THOR capsules. The DRIFT capsule was originally designed for UO_2 at light water reactor temperatures (~300°C) but will be modified to support more prototypic temperatures of gas cooled reactor (~800-900°C). The THOR capsule was originally designed to support metal fuel overpower tests but can also support the needs of the FMR fuel. INL and GA will work to determine the most appropriate test. This focus will be on ensuring capsule geometry (i.e., accommodate FAST dimensions) and temperature needs (FMR conditions) are sufficient. The completion of this effort will be validated by the issuance of the following documents:

- Functional and Operational Requirements (design basis)
- Technical, Functional, and Operational Requirements (analyses basis)
- Engineering Calculations and Analysis Reports (ECARs);
  - Thermal-hydraulic analysis
  - Neutronics analysis
- Design drawings
- Experiment Safety Analysis (ESA) report

Task 3.2 Perform Fresh Fuel Test - INL will perform a TREAT test on unirradiated fuel.

Other TREAT capsules may also be explored for their ability to improve the understanding of the fuel-cladding system under transient conditions. Fuel will be fabricated and provided by GA.

Task 3.3 Perform Irradiated Fuel Test - INL will perform a TREAT test on irradiated fuel. This work will also include engineering work for transfer of rodlets from ISHA capsules into a TREAT capsule within the Hot Fuel Examination Facility (HFEF) hot-cell. The capsule will be shipped to TREAT. There will be no further irradiations of the capsule. Fuel will be fabricated and provided by GA via Task 2 ATR irradiations.

Task 3.4 Transient Test Report - INL will provide GA with a summary report of the transient test results. The results will be limited to supporting analysis (e.g., neutronics) and any data collected from capsule instrumentation. This will not include PIE data. PIE efforts are not currently funded as part of this effort but are expected to be completed when funding becomes available.

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

Experiment irradiation and PIE will be performed at the ATR and MFC facilities. Air emissions would include minor amounts of radionuclides and toxic air pollutants. The irradiation in the ATR is not a modification in accordance with Idaho Administrative Procedures Act (IDAPA) 58.01.01.201 and 40 Code of Federal Regulation (CFR) 61 Subpart H. ATR radionuclide emissions are sampled and reported in accordance with Laboratory Wide Procedure (LWP)-8000 and 40 CFR 61 Subpart H.

The irradiated specimens will be delivered to the MFC HFEF for disassembly and then undergo routine PIE before being sent to the AL for analysis. The PIE examination in HFEF and the analysis completed in the Analytical Lab is not a modification in accordance with Idaho Administrative Procedures Act (IDAPA) 58.01.01.201 and 40 Code of Federal Regulation (CFR) 61 Subpart H.

Packaging in HFEF is not a modification in accordance with Idaho Administrative Procedures Act (IDAPA) 58.01.01.201 and 40 Code of Federal Regulation (CFR) 61 Subpart H.

Releases of radioactive airborne contaminants from the proposed action are not expected to increase to the annual dose to the Maximum Exposed Individual (MEI).

Discharging to Surface-, Storm-, or Ground Water

N/A

Disturbing Cultural or Biological Resources

ATR (TRA-670 and (TREAT (MFC-720) are both over 50 years old. No structural or aesthetic changes are planned for either building.

Generating and Managing Waste

Hazardous/Radioactive Material or Waste Handling and Transportation: Project personnel would work with Waste Generator Services (WGS) to properly package and transport regulated, hazardous or radioactive material or waste according to laboratory procedures. Low-Level Waste Generation: The proposed action could generate Personal Protective Equipment (PPE) and towels used for cleaning and polishing. Project activities would likely result in the generation of small amounts of industrial waste. Irradiated sample debris and PIE waste are expected to generate TRU waste and mixed TRU waste. The amount of TRU waste that will be generated is less than 1 cubic meter.

Releasing Contaminants

Although not anticipated, there is a potential for spills when using chemicals

Using, Reusing, and Conserving Natural Resources

All materials will be reused and recycled where economically practicable. All applicable waste will be diverted from disposal in the landfill where conditions allow.

SECTION D. Determine Recommended Level of Environmental Review, Identify Reference(s), and State Justification: Identify the applicable categorical exclusion from 10 Code of Federal Regulation (CFR) 1021, Appendix B, give the appropriate justification, and the approval date.

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, or similar requirements of Department of Energy (DOE) or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment or facilities; (3) disturb hazardous substances, pollutants, contaminants, or Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-excluded petroleum and natural gas products that pre-exist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources (see 10 CFR 1021). In addition, no extraordinary circumstances related to the proposal exist that would affect the significance of the action. In addition, the action is not “connected” to other action actions (40 CFR 1508.25(a)(1) and is not related to other actions with individually insignificant but cumulatively significant impacts (40 CFR 1608.27(b)(7)).

References: 10 CFR 1021, Appendix B to subpart D, items B3.6, "Small-scale research and development, laboratory operations, and pilot projects."

Final Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) for the Resumption of Transient Testing of Nuclear Fuels and Materials (DOE/EA-1954, February 2014).

Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement and Record of Decision (DOE/EIS-0203, 1995) and supplemental analyses (DOE/EIS-0203-SA-01 and DOE/EIS- 0203-SA-02) and the Amended Record of Decision (1996).

Final Waste Management Programmatic Environmental Impact Statement [WW PEIS] (DOE/EIS-0200-F, May 1997) and Waste Isolation Pilot Plant Disposal Phase Supplemental EIS (SEIS-II) (DOE/EIS-0026-S-2, September 1997).

Justification: The proposed R&D activities are consistent with CX 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); 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 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 deployment."

DOE evaluated the environmental impacts of transient irradiations in the TREAT reactor, including 1) transporting experiment materials between MFC and TREAT, 2) pre- and post-irradiation radiography, 3) PIE of test components at HFEF or other MFC facilities, and 4) waste generation and disposal in the Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) for the Resumption of Transient Testing of Nuclear Fuels and Materials (DOE/EA-1954, February 2014).

After PIE, irradiated test pin segments and PIE remnants will be stored with other similar DOE-owned irradiated materials and experiments at MFC, most likely in the HFEF or the Radioactive Scrap and Waste Facility (RSWF) in accordance with DOE’s Programmatic SNF Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement (FEIS) and ROD (DOE/EIS-0203, 1995) and supplemental analyses (DOE/EIS-0203-SA-01 and DOE/EIS-0203-SA-02) and the Amended Record of Decision (February 1996). Ultimate disposal of the irradiated test pin

segments and PIE remnants will be along with similar DOE-owned irradiated materials and experiments currently at MFC. Irradiated sample debris and secondary waste could total as much as 20-30 Kg. Categorizing this material as waste is supported under Department of Energy Order (DOE O) 435.1, Att. 1, Item 44, which states "…Test specimens of fissionable material irradiated for research and development purposes only…may be classified as waste and managed in accordance with this Order...".

NEPA coverage for the transportation and disposal of waste to WIPP are found in the Final Waste Management Programmatic Environmental Impact Statement [WM PEIS] (DOE/EIS-0200-F, May 1997) and Waste Isolation Plant Disposal Phase Supplemental EIS (SEIS-II) (DOE/EIS-0026-S-2, Sept. 1997), respectively. The 1990 ROD also stated that a more detailed analysis of the impacts of processing and handling TRU waste at the generator-storage facilities would be conducted. The Department has analyzed TRU waste management activities in the Final Waste Management Programmatic Environmental Impact Statement (WM PEIS) (DOE /EIS-200-F, May 1997). The WM PEIS analyzes environmental impacts at the potential locations of treatment and storage sites for TRU waste; SEIS-II addresses impacts associated with alternative treatment methods, the disposal of TRU waste at WIPP and alternatives to that disposal, and the transportation to WIPP.

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

Approved by Jason L. Anderson, DOE-ID NEPA Compliance Officer on: 07/07/2021