DOE-ID NEPA CX DETERMINATION
Idaho National Laboratory

CX Posting No.: DOE-ID-INL-20-012

SECTION A. Project Title: Advanced Post-Irradiation Examination (PIE) of Proliferation Resistant U-7Mo/Mg Dispersion Fuels

SECTION B. Project Description and Purpose:

The U.S. Department of Energy (DOE) established the Reduced Enrichment for Research and Test Reactors (RERTR) in 1978. In 2004, DOE's National Nuclear Security Administration (NNSA) created the Global Threat Reduction Initiative (GTRI), which incorporated the RERTR. Under RERTR and GTRI, Idaho National Laboratory (INL) supports research and development (R&D) programs aimed at eliminating the use of Highly Enriched Uranium (HEU) in research and test reactors. INL collaborates with international partners to develop high-density Low Enriched Uranium (LEU) fuel concepts to allow research reactors to convert from using HEU to LEU.

As part of these global efforts to develop proliferation resistant nuclear fuels, Canadian Nuclear Laboratories (CNL) and INL propose to perform Post Irradiation Examination (PIE) on high burnup U-Mo/Mg fuel samples to assess fuel performance. The proposed action evaluates the effect of changes in microstructure with burnup on fuel performance. The proposed PIE characterizes 1) the growth of fission gas bubbles, which can accelerate swelling of the fuel, 2) the radiation stability of the Mg matrix, and 3) the interaction layer at U-Mo fuel particle/Al Cladding or Mg/Al cladding interfaces and compares these characteristics with that observed in other U-Mo fuel designs.

CNL fabricated aluminum clad U-7Mo/Mg and U-10Mo/Mg pin-type mini-elements with a LEU loading of 4.5 g/cm^3 and found no evidence of chemical interaction between the U-Mo fuel particle and Mg matrix during fabrication. CNL irradiated the mini elements in the National Research Universal (NRU) reactor at linear power ratings of 100 kW/m up to 80 at% 235U burn up. Researchers removed four mini elements from each fuel composition at each interim inspection (10, 30, and 60 at% 235U burnup). Four mini-elements of each fuel composition reached a final design burnup of 80 at% 235U burn up in March 2018.

CNL completed detailed PIE on the mini elements that achieved 30 at% 235U burn up and investigated the microstructure and phase composition of the irradiated U-7Mo/Mg and U-10Mo/Mg fuel cores using optical microscopy and neutron diffraction analysis. CNL also completed in-bay visual examinations on the 10, 30, 60 and 80 at% burnup mini-elements. Recent hot cell macroscope images of the discharged fuel elements at 80 at% 235U burn up indicate that both U-7Mo/Mg and U-10Mo/Mg fuel pins remain intact.

Under the proposed action, CNL will prepare and ship an initial fuel sample to INL followed by two future samples. CNL will cut fuel pieces measuring about 1 mm^3 from selected regions that include the following features: 1) interior of U-Mo fuel particle, 2) U-Mo fuel particle/Mg interface, 3) U-Mo fuel particle/Al clad, and 4) Mg/Al clad interface. CNL will embed the fuel piece in epoxy in a scanning electron microscope (SEM) dish pin mounted in a polishing jig.

INL will receive the SEM dish pin at the Irradiated Materials Characterization Laboratory (IMCL) at the Materials and Fuels Complex (MFC) to quantitatively map the elemental distribution of Mo, U and Mg using the Electron Probe Micro-Analyzer (EPMA). INL will identify areas for single spot analysis and for obtaining samples using focused ion beam milling (FIB) for SEM and transmission electron microscope (TEM) characterizations. In addition, INL may also investigate the microstructure of U-10Mo/Mg fuel at 80% at% 235U burn up, if needed, to confirm the effect of Mo content on the irradiation performance of U-Mo fuel. EPMA results regarding Mo concentration and distribution in U-7Mo/Mg fuel may reveal a connection between low Mo content (lower than the target concentration of 7 wt. %) and high concentration of fission gas bubbles.

After characterizing the samples, INL will polish and coat the samples for EPMA mapping and elemental quantitative analysis. When fuel characterization, mapping, and analysis are complete, INL will ship the TEM samples back to CNL. All shipments, from CNL to INL and from INL to CNL, will be standard Type A packages.

Packaging, repackaging, transportation, receiving, and storing used nuclear fuel and R&D for used nuclear fuel management is covered by DOE's Programmatic Spent Nuclear Fuel (SNF) Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement (EIS) 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 (February 1996). The analyses include those impacts related to transportation to, storage of, and research and development related to used nuclear fuel at the INL (see Tables 3.1 of the SNF Record of Decision (May 30, 1995) and Table 1.1 of the Amended Record of Decision [February 1996].

The environmental impacts of transferring LLW from the INL Site to the Nevada National Security Site were analyzed in the 2014 Final Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada (DOE/EIS-0426) and DOE's Waste Management Programmatic EIS (DOE/EIS-200). The fourth Record of Decision (ROD) (65 FR 10061, February 25, 2000) for DOE's Waste Management Programmatic EIS established the Nevada National Security Site as one of two regional LLW and MLLW disposal sites.

The potential for transportation accidents was analyzed in the SNF EIS (Section 5.1.5 and Appendix I-5 through I-10).

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

PIE will be performed at IMCL. Air emissions could include minor amounts of radionuclides and toxic air pollutants. All work will be controlled using gloveboxes and hot cells with installed ventilation.

Generating and Managing Waste

Small amounts of low-level, mixed low-level, industrial waste and hazardous waste may be generated (estimated at ~2 ft^3) from personal protective equipment and towels used for cleaning and polishing.

Releasing Contaminants

Very small amounts of radioactive material may be emitted during this work. Airborne and liquid releases will not exceed those for normal IMCL operations.

Using, Reusing, and Conserving Natural Resources

All materials would be reused and recycled where economically practicable. All applicable waste would 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"

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 Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada (DOE/EIS-0426, December 2014).

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."

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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: 03/09/2020