

DOE-ID NEPA CX DETERMINATION

Idaho National Laboratory

SECTION A. Project Title: Irradiation Testing of Boise State University Nuclear Science User Facilities (BSU-NSUF) Experiment

SECTION B. Project Description and Purpose:

Several key issues associated with fuel performance of U3Si2 need to be addressed before it can be qualified and licensed as a nuclear fuel for commercial reactors. The purpose of the proposed action is to investigate the fuel clad chemical interaction behavior of U3Si2 and various candidate cladding materials to multiple burnups (2 rodlets). This drop-in test experiment will test U3Si2-SiC U3Si2-FeCrAl and U3Si2-Zr diffusion couples to evaluate pellet cladding interaction of U3Si2 pellets coupled with plates of cladding samples.

The proposed experiment will evaluate the following:

- Swelling behavior of U3Si2-based fuels during irradiation
- Irradiation induced microstructural evolution and densification prior to swelling
- Thermal creep, mechanical integrity, and fuel pellet cracking
- Hardness of the outside of the irradiated U3Si2 pellet
- Fission gas release during irradiation
- Changes in stoichiometry of U3Si2 after irradiation.

Idaho National Laboratory (INL) will lead the planning, designing, and analysis of experiments in coordination with Boise State University (BSU) and Westinghouse. Westinghouse will provide U3Si2 fuel qualified by the INL.

The BSU-National Scientific User Facility (NSUF) experiment will be irradiated in the Advanced Test Reactor (ATR), and post-irradiation examination (PIE) will be performed at the Hot Fuel Examination Facility (HFEF) at the Materials and Fuels Complex (MFC). Selected samples may be shipped to other hot cell facilities or laboratories for complimentary or additional examinations, contingent on the availability of an acceptable shipping cask/container. This environmental checklist (EC) will be reviewed and revised prior to any off-site sample shipments.

The following activities will be performed by INL in support of the proposed action:

- Conduct experiment design review and obtain ATR design acceptance
- Fabricate basket assemblies for irradiation of BSU-NSUF capsules in the ATR
- Perform neutronic analyses of the aggregate capsules
- Perform thermal-hydraulic analyses of the experiment assembly
- Perform structural analyses of the capsules and the test rodlets
- Fabricate stainless steel capsules
- Encapsulate test rodlets in the stainless steel capsules
- Prepare and obtain approval for the Experiment Safety Analysis
- Irradiate capsules to specified burnup levels in the ATR
- Handle experiment and basket change-outs during ATR outages as needed
- Store discharged experiments in the ATR canal for cooling
- Ship discharged capsules to HFEF at MFC
- Perform PIE at HFEF and supporting laboratories at MFC
- Coordinate the shipment of selected samples to other examination facilities as appropriate, contingent on the availability of an acceptable shipping cask/container and review and revision of this EC.

The BSU-NSUF experiments irradiation test assembly design will be based on a design used since the late 1990s to test fueled rodlets in the ATR under conditions of temperature and power prototypic of light water reactors (LWRs). This design was originally developed to test mixed-oxide (MOX) fuels for the Department of Energy (DOE) Fissile Materials Disposition Program, and it continues to be referred to as the "MOX hardware" by ATR designers and experimenters.

The irradiation test assembly consists of an aluminum experiment basket that contains 316L stainless steel capsule(s) that serve as the primary safety (i.e., pressure) boundary. Each capsule contains a single test rodlet made of test specimens inside cladding. The experiment basket is designed to hold multiple, vertically stacked capsule assemblies. Each capsule assembly is independent, meaning it can be introduced into, or removed from, an experiment basket during any ATR outage.

The test rodlet represents a miniature length pressurized water reactor (PWR) fuel rod, nominally prototypic in the radial dimension. The design accommodates a fuel column of ~ 6.0-in., although this height is likely to be reduced as needed for certain BSU-NSUF concepts. The fuel outer diameter and cladding inner diameter will be determined on a case-by-case basis for each BSU-NSUF concept.

Fuel fabrication for the rodlet assembly, capsule fabrication and final assembly, baseline characterization, and final inspections will be performed at MFC in the Fuels and Applied Science Building (FASB) (MFC-787), Experimental Fuels Facility (EFF) (MFC-794), and the Electron Microscopy Laboratory (EML). Fuel chemistry for the Westinghouse fuel will be analyzed in the MFC Analytical Laboratory.

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The U₃Si₂ and UN/U₃Si₂ pellets will be stacked in three different capsules filled with different compositions of Ar/He gas. Through enrichment adjustment, the fuel pellets will be irradiated at various power rates from 5 to 30 kW/ft. The initial safety analysis evaluation by ATR will be used to set the test operating envelope. The target fission density is anticipated to be between 7.59 and 9.49x10²⁰ fissions/cm³, which is equivalent to the burnup of a typical LWR fuel at the end of life. The number of effective full power days will be calculated based on this fission density, fuel enrichment and thermal neutron flux once the irradiation position is assigned for this project.

To study the irradiation effect on the water corrosion resistance of U₃Si₂, a double encapsulated capsule rig will be used to allow water to contact U₃Si₂ and UN/U₃Si₂ pellets of 4 mm diameter. The capsule will be loaded in ATR and irradiated for one cycle. The proposed double encapsulated capsule rig uses an INL design, and capsules have been analyzed up to 350 psi internal pressure. Therefore, experiment parameters fall within a current safety boundary. Westinghouse will provide baseline results from their studies on the out-of-pile water corrosion resistance of U₃Si₂ and UN/U₃Si₂ at 300 and 350°C.

Finally, two capsules will be loaded with pairings containing U₃Si₂ and Zr, FeCrAl and SiC. This test will be carried out at ~800°C in order to analyze interactions between the U₃Si₂ and these potential cladding materials.

Following irradiation in the ATR and cooling in the ATR canal, the following PIE activities would be conducted at HFEF:

- Visual Examination
- Disassembly
- Gamma Scanning
- Immersion Density
- Eddy Current (Oxide)
- Profilometry
- NRAD
- Metallography
- Microhardness
- Blister Anneal Testing
- Burn-up and Scanning Electron Microscope (SEM)/Transmission Electron Microscope (TEM) Sample Preparation
- Fission Product Release

In addition, some samples may be sent to the EML for visual analysis or the Analytical Laboratory or Radiochemistry Laboratory at MFC for chemical or radiological analyses.

After PIE, irradiated sample segments and PIE remnants would 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). Ultimate disposal of the irradiated sample segments and PIE remnants would be along with similar DOE-owned irradiated materials and experiments currently at MFC generated from other research and development activities. Categorizing this material as waste is supported under 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..."

Additionally, to complete the proposed action, it is necessary for the project to use the HFEF hot cell which contains both defense and nondefense related materials and contamination. Project materials will come into contact with defense related materials. It is impractical to clean out defense related contamination, and therefore, waste associated with project activities is eligible for disposal at the Waste Isolation Pilot Plant (WIPP). NEPA coverage for the transportation and disposal of waste to WIPP are found in 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 transuranic (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.

Packaging, repackaging, transportation, receiving, and storing used nuclear fuel and research and development for used nuclear fuel management is covered by DOE's Programmatic Spent Nuclear Fuel (PSNF) 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 (February 1996). The analysis includes 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]).

While the research test specimens described in the EC are not spent nuclear fuel, they are similar in environmental hazards, except the test specimens contain less radiological material than a normal spent nuclear fuel shipment. Therefore, the potential environmental impact of transportation of the test specimens can be conservatively estimated to be equal to or less than a spent nuclear fuel shipment. The potential for transportation accidents was analyzed in the 1995 PSNF EIS (Section 5.1.5 and Appendix I-5 through I-10).

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Finally, the record of decision for the 1995 PSNF EIS, DOE determined and stated "the evaluated potential impacts resulting from all alternatives were found to present no significant risk to potentially affected populations." Based on DOE's statement for the entire DOE SNF program, the proposed action would not have the potential for significant impact or have any unique or unknown risks.

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

Experiment irradiation and PIE will be performed at the ATR and HFEF facilities, respectively. The irradiation of sealed capsules in the ATR primary coolant 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. Normal operation of sealed experiments in ATR primary coolant is not expected to contribute to and/or cause an increase in air emissions. ATR radionuclide emissions are sampled and reported in accordance with Laboratory-wide Procedure (LWP)-8000 and 40 CFR 61 Subpart H. All experiments will be evaluated by ATR Environmental Support and Services staff, prior to insertion in the ATR. All radionuclide release data (isotope specific in curies) directly associated with this experiment will be calculated and provided to the ATR Programs Environmental Support organization by January 31 of each year for the preceding calendar year.

The irradiated experiment will be delivered to the MFC HFEF for disassembly and then undergo routine PIE. All radionuclide release data associated with the PIE portion of this experiment will be recorded as part of the HFEF continuous stack monitor and calculated and provided to the Environmental Support and Services organization by January 31 of each year for the preceding calendar year as part of the INL Annual National Emission Standards for Hazardous Air Pollutants (NESHAPs) report to Department of Energy (DOE). Releases of radioactive airborne contaminants from this process are not expected to result in an increase to the annual HFEF dose to the Maximum Exposed Individual. Therefore, no Air Permit Applicability Determination is required for the project.

Generating and Managing Waste

Irradiated sample debris and process materials used in PIE are expected to generate small amounts of both RH-LLW and RH-TRU wastes. Based on the masses and volumes of both the hardware and fuel of the Interaction Rodlet Material Components, the RH-LLW and RH-TRU waste generated from the BSU NSUF experiments would be less than 0.06 m³ (2.0 cu. ft.) and 0.1 m³ (3.5 cu. ft.), respectively. Categorizing this material as waste is supported under 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..."

In addition to the component masses this evaluation also considered the initial rodlet fuel masses, initial U-235 enrichment, actinide ingrowth as reported in the provided ORIGEN report and historical waste generation volumes for similar past experimental post-irradiation examinations.

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.

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, 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 Environmental Impact Statement for the Waste Isolation Pilot Plant (DOE/EIS-0026, October 1980) and Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant (SEIS-I) (DOE/EIS-0026-FS, January 1990)

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)

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Justification: Project activities are consistent with 10 CFR 1021, Appendix B, 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 deployment."

Although the project is a conventional R&D activity for INL under categorical exclusion B3.6, the DOE-ID NCO considered existing analysis to ensure that all aspects of the project were covered. The NCO examined the analyses in the Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement (1995 PSNF EIS) and associated supplemental analyses and respective Records of Decision when considering the potential impacts associated with transportation of the irradiated test specimens.

While the research test specimens are not spent nuclear fuel, they are similar in environmental hazards, except the test specimens contain less radiological material than a normal spent nuclear fuel shipment. Therefore, the potential environmental impact of transportation of the test specimens can be conservatively estimated to be equal to or less than a spent nuclear fuel shipment. The potential for transportation accidents to the INL was analyzed sufficiently in the 1995 PSNF EIS (Section 5.1.5 and Appendix I-5 through I-10) and in the FRR EIS (Sections 4.2.1 through 4.2.2). Finally the NCO noted that in the record of decision for the 1995 PSNF EIS, DOE determined and stated "the evaluated potential impacts resulting from all alternatives were found to present no significant risk to potentially affected populations." Based on DOE's statement for the entire DOE SNF program, the NCO determined the proposed action would not have the potential for significant impact or have any unique or unknown risks.

The impacts of transporting and disposing of waste resulting from defense activities that was placed in retrievable storage pursuant to a 1970 Atomic Energy Commission policy (see Section 1.2) and TRU waste that was reasonably expected to be generated by ongoing activities and programs was analyzed in DOE/EIS-0026 (October 1980) and the Final Supplement Environmental Impact Statement for the Waste Isolation Pilot Plant (SEIS-I) (DOE/EIS-0026-FS, January 1990).

NEPA coverage for the transportation and disposal of waste to WIPP are found in 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. DOE has analyzed TRU waste management activities in 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. (SEIS-II also includes potential transportation between generator sites.)

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: 2/27/2017