

DOE-ID NEPA CX DETERMINATION Idaho National Laboratory

SECTION A. Project Title: Joint Fuel Cycle Studies (JFCS) Program Revision 2

SECTION B. Project Description and Purpose:

Idaho National Laboratory (INL) analyzed the environmental impacts from implementing activities in CRADA 11-CR-13 for the Joint Fuel Cycle Studies (JFCS) program in environmental checklist (EC) INL-14-044. This revision to EC INL-14-044 clarifies project scope and proposed utilization of used commercial nuclear fuel.

INL is performing an ongoing kilogram-scale test of electrochemical recycling of used nuclear fuel, known as the Integrated Recycling Test (IRT), at the Materials and Fuel Complex (MFC) to study flowsheet options and the technical and economic feasibility and nonproliferation acceptability of electrochemical recycling of commercial light water reactor (LWR) fuel. The JFCS program includes fuel procurement, the IRT, critical gap research and development (R&D), and fuel rodlet fabrication and irradiation. These components are discussed below:

Fuel Procurement

The IRT process requires about 45 kilograms of used high-burnup LWR fuel or use as feedstock. This feedstock is not available at INL or other sites in the DOE complex. The original CRADA for the IRT proposed to use 25 individual pressurized water reactor (PWR) rods from the Byron Nuclear Generating Station in Illinois shipped to INL in a Nuclear Assurance Corporation legal-weight truck (NAC-LWT) cask and stored in the Hot Fuels Examination Facility (HFEF) hot cell.

In April 1995, DOE completed the Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement (DOE/EIS-0203) (hereafter, 1995 EIS) (DOE 1995a). The 1995 EIS contains an analysis of the potential environmental impacts associated with managing DOE's complex-wide Spent Nuclear Fuel (SNF) Program from 1995 until 2035, and includes an analysis of a broad spectrum of fuel element designs. In the June 1995 Record of Decision (ROD) for the 1995 PEIS, DOE selected Alternative 4a (Regionalization by Fuel Type) and decided to transport 165 Metric Tons of Heavy Metal (MTHM) in 1,940 planned shipments of SNF (including 575 Navy shipments) to the INL Site through the year 2035 [60 Federal Register (FR) 28680, June 1, 1995]. DOE issued an amended ROD in June 1996 for the 1995 PEIS, which lowered the number of planned shipments of SNF to the INL Site to 1,133 (575 shipments for the Navy and 558 planned shipments for DOE) (61 FR 9441, March 8, 1996).

At present, INL cannot accept irradiated fuel subject to the Idaho Settlement Agreement. It is anticipated that noncompliance issues will be resolved before this project begins, and INL will be able to accept the irradiated materials. If INL cannot accept the irradiated materials, the JFCS program proposes to complete project activities using about 35 kg of DOE-owned LWR fuel in dry storage at the Irradiated Fuel Storage Facility at Chemical Processing Plant (CPP) building 603 (CPP-603). The LWR fuel is low to intermediate burnup and does not meet the full requirements of the JFCS collaboration. Fluor Idaho will retrieve the fuel from storage and ship the material to MFC in the Nuclear Assurance Corporation (NAC) legal-weight truck (LWT) (NAC-LWT) cask using the Multi-purpose Haul Road on the INL Site. Shipments will not use public transportation routes. Table 1 describes the fuels proposed for shipment from CPP-603 to MFC.

Table 1. Summary of interim LWR fuel from CPP-603.

Current Container ID	Old Container ID	LWR Fuel Description	Burnup	Discharge Date	Enrichment
CAN-GSF-106-23	A-7	7 Saxton MAPI fuel rods	5 GWd/MT	1972	5.7%
		3 Saxton fuel rods	16.8, 15.6, 10.4 GWd/MT	1972	12.5%
CAN-GSF-106-19	I-1	16 Dresden rod sections from approx. 5 fuel rods	28 GWd/MT	1994	3.1%
CAN-GSF-107-29	I-8	3 Saxton MAPI fuel rods	5 GWd/MT	1972	5.7%
		2 Saxton fuel rods	16.0, 18.5 GWd/MT	1972	12.5%
CAN-GSF-107-21	J-4	15 Dresden rod sections from approx. 5 fuel rods	28 GWd/MT	1994	3.1%
CAGSF-106-13	J-7	4 Saxton fuel rods	16.7, 17.4, 16.7, 17.6 GWd/MT	1972	12.5%
CAN-GSF-107-03	K-4	2 HB Robinson fuel rods sectioned	28 GWd/MT	1974	3.1%
		2 Peach Bottom fuel rods sectioned	11.9 GWd/MT	1976	2.5%

Integrated Recycling Test
Modular Workstations

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Modular workstations in the HFEF Argon Cell support equipment for the IRT. Two large workstations and a smaller intermediate table furnish operating space and power and instrumentation connections for replaceable equipment. Bins below the workstation operating surfaces supply storage for equipment not in use. Each workstation includes one integrated balance for mass tracking purposes.

Fuel Decladding Equipment

INL processes used nuclear fuel rods as feedstock for the IRT. Processing requires used nuclear fuel rod storage, handling, sectioning, and de-cladding. The de-clad fuel is sieved to remove fines, and some fines are manipulated to demonstrate and test processing methods. Some higher burnup cladding sections will be processed to demonstrate methods to reduce fuel holdup.

Oxide Reduction System

The project electrochemically reduces de-clad used fuel to metallic form in the oxide reduction system. The reduction process tests the 'universal' basket concept, i.e. a loaded basket is processed through the oxide reduction, distillation, and electrorefining systems without unloading. The reduction system is designed to allow testing of scalability features such as multiple electrodes and variations in basket thickness or electrode spacing. The anode system has the flexibility to test materials, geometries, immersion depths, and off-gas capture settings. An oxide reduction system has been designed, constructed, tested, and installed, and operates as a part of the (IRT).

Electrorefining System

The project electrorefines processed fuel from the oxide reduction system to recover purified low-enriched uranium (LEU). Transuranic elements accumulate in the electrorefining salt, and a liquid cadmium cathode (LCC) extracts a uranium/transuranic/rare earth product to acquire feedstock to manufacture fuel rodlets. The electrorefining vessel also allows the project to test features important to scalability.

Distillation Systems

After oxide reduction and electrorefining, INL separates salts from metallic products and cadmium and salt from the uranium/transuranic/rare earth products via vacuum distillation. HFEF has two remote distillation systems to maintain the IRT processing schedule.

Sampling/Casting Furnace

Casting transuranic fuel slugs is an objective of the IRT, and a variety of metallic products require sampling. Material losses, remote reliability, and scalability are important for long-term success of electrochemical recycling processes. The project samples and casts fuels in HFEF, and fabricates fuel in a glovebox at the Fuel Manufacturing Facility (FMF).

Critical Gap Research and Development

Head End Processes

The method for processing used fuel is important to subsequent processes. Critical gap studies evaluate and select fuel preparation methods used in the IRT and include design development, testing, cutting methods, and handling fuel pieces. Potential measurement methods to determine input accountancy are important to determine nonproliferation acceptability. R&D includes additional studies for processing fuel fines, such as agglomeration or sintering, or the examination of off-gasses produced from processing. Prior research indicates high burnup fuels may display increasing fuel hold up in the cladding. Proposed research also evaluates methods to reduce fuel hold-up.

Current technology for electrolytic reduction utilizes platinum anodes, but other materials, such as iridium or conductive ceramics, have the potential to deliver cost and durability advantages. Anode material testing focuses on the performance of iridium electrodes in surrogate salt systems.

Experiments support system design and troubleshoot oxide reduction system operations in the IRT. This research evaluates construction materials and system behavior and characteristics during different operating scenarios. Testing uses non-radioactive surrogates and depleted uranium (DU).

Electrorefining & Liquid Cadmium Cathode Operations

This activity tests a scaled-up prototype electrorefining system with molten salt and uranium dendrites. This allows challenges and performance limitations to be identified before remote equipment fabrication and installation and allows trouble-shooting of remote process operations. Testing includes evaluating the impact of process parameters, system design, and construction materials. Testing uses non-radioactive surrogates and DU.

The LCC approach recovers a product combined of uranium, transuranic, and residual rare earth materials during the IRT. Ongoing studies explore the impact of process parameters, system design, and construction materials. Studies use non-radioactive surrogates, DU, and transuranic (TRU) elements and utilize equipment and materials already on-Site at MFC. Studies also analyze anode residue.

Product Conditioning

In the recovery of the uranium/TRU/rare earth product via LCC technology, the rare earth contamination may be higher than the desired concentration in the metal fuel. Ongoing, jointly-planned experiments explore the feasibility of ways to reduce the concentration of rare earths in uranium/TRU/rare earth products. Studies use non-radioactive surrogates, depleted uranium, and TRU elements and utilize equipment and materials at MFC.

The IRT requires four distillation operations. Distillation system design issues require confirmation, including evaluating the performance of stainless steel for the pressure boundary for distillation up to 1200°C. Ongoing investigations confirm the design and materials for the distillation system and test the performance of advanced crucible materials for distillation operations. Initial screening uses uranium, and final testing uses uranium/transuranic/rare earth products.

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A high-temperature distillation furnace separates salt and consolidates the dendritic uranium product into an ingot. Initial scoping experiments have been successful at separating salt and metals at atmospheric pressure by a porous bed, with a short residence time. These characteristics and system compactness have the potential to improve product purity, process monitoring, and safeguards opportunities. These tests use non-radioactive surrogates and DU.

Fuel Fabrication

Engineering-scale fuel fabrication is critical to commercialization of electrochemical recycling. Weld inspection is a challenging technology that must be perfected for remote application. The project tests ultrasonic and laser weld inspection systems and evaluates alternative approaches to qualify the welding process based on statistical analysis of process parameters. These tests utilize only non-radioactive materials.

The properties of some metal fuel alloys need to be characterized. The project performs fuel alloy fabrication and analysis in the MFC Casting Laboratory. Casting studies use several fuel variations to evaluate potential products in the IRT. These studies use non-radioactive surrogates, DU, and TRU elements and use equipment and materials at MFC. Cast fuel sample characterization methods include dilatometry, differential scanning calorimetry, and laser flash thermal diffusivity.

Studies also evaluate in-reactor cladding performance. Metal fuel integrity could be limited by the interaction of fuel constituents and fission products with the cladding, commonly described as fuel cladding chemical interaction (FCCI). Studies are needed to verify the performance of barrier materials that mitigate FCC, especially in the case of TRU and rare-earth-bearing metal fuel. The project produces, irradiates, and evaluates barrier cladding samples.

Fundamental Properties and Waste Forms

Activities to increase fundamental knowledge of molten salt systems include studies to evaluate 1) electrochemical or thermophysical characteristics of molten solutions and 2) technology to monitor process conditions inside molten salt electrochemical systems. These studies use non-radioactive surrogates, DU, and TRU elements and equipment and materials at MFC.

Identification and demonstration of waste forms is critical to the feasibility of electrochemical recycling. The IRT evaluates the most feasible and cost effective options for fission product concentration and immobilization from the electrochemical recycling of used LWR fuel. These evaluations involve waste experts from INL, KAERI, Pacific Northwest National Laboratory (PNNL), and Argonne National Laboratory (ANL). Once processes have been defined, laboratory-scale waste forms may be fabricated, if necessary, from fission product streams for characterization and testing. Fission product concentration and waste form processes would be optimized for application to the IRT.

In the IRT, some iodine enters the oxide reduction vessel with used fuel. Experiments have shown that I₂ has the potential to be released with O₂ during the reduction process. Improved understanding of how to capture this iodine, either as a gas or by capture within the molten salt, is critical to understanding the mass balance of fission product in a real process. Studies evaluate methods to better understand I₂ release during the reduction process and quantitatively capture the iodine from the off-gas stream in a surrogate salt system. The project also examines methods to extract iodine and tellurium from the molten salt. The feasibility of getter materials to selectively absorb reactive fission products will be tested in a surrogate salt system.

These studies use non-radioactive surrogates, DU, and TRU elements and equipment and materials at MFC.

Argonne National Laboratory Activities

Argonne National Laboratory (ANL) in Illinois performs supporting research on fundamental properties and waste forms and head-end processes, with similar work scope to that described above. These activities use only non-radioactive surrogates, DU or very limited amounts of TRU materials in authorized radiological facilities at ANL. These activities will be conducted with materials already located at ANL and will not involve shipment of any materials between ANL and INL.

Fuel Rodlet Fabrication and Irradiation

Fuel rodlet fabrication and irradiation activities focus on the production of one or more transuranic-bearing fuel rodlets, irradiation in the Advanced Test Reactor (ATR), and post-irradiation examination (PIE) at MFC. After PIE at INL, the irradiated sample segments and PIE remnants would be stored with other similar DOE-owned irradiated materials and experiments at MFC, most likely in HFEF or the Radioactive Scrap and Waste Facility (RSWF) in accordance with DOE's Programmatic Spent Nuclear Fuel (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 sample segments and PIE remnants would be along with similar DOE-owned irradiated materials and experiments currently at MFC.

Packaging, repackaging, transportation, receiving, and storing used nuclear fuel and research and development for used nuclear fuel management is within the scope of DOE's Programmatic Spent Nuclear Fuel (SNF) 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]).

To complete proposed work activities, 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). National Environmental Policy Act (NEPA)

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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.

There is the potential to generate low level waste (LLW). The environmental impacts of transferring low level waste from the INL to the Nevada National Security Site were analyzed in the 1996 Nevada Test Site (NTS) EIS (DOE/EIS-0243) and supplemental analysis (SA) (DOE/EIS-0243-SA-01) 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 mixed low-level waste (MLLW) disposal sites. The SA considers additional waste streams, beyond those considered in the 1996 NTS EIS, which may be generated at or sent to the Nevada National Security Site for management.

The impacts of transporting spent fuel, special nuclear materials, and research fuels between MFC and other INL Site facilities using the Multi-Purpose Haul Road were analyzed Final Environmental Assessment for the Multipurpose Haul Road Within the Idaho National Laboratory Site (DOE/EA-1772).

The JFCS project involves research and development work to test and refine various aspects of separations process activities. Research from the project would be used to support the development of processes to separate and recover materials such as plutonium and uranium. The project does not call for the separation of plutonium or uranium isotopes for production purposes. Because the project is for research and development of separations processes rather than for production purposes, the project does not constitute reprocessing.

Project personnel verify with the program environmental lead (PEL) that the scope, environmental aspects, and work activities are bounded by the environmental impacts analysis of this environmental checklist (EC), and revise this EC as necessary.

SECTION C. Environmental Aspects or Potential Sources of Impact:

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 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, September 1997)

Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada (DOE/EIS-0243) and supplemental analysis (SA) (DOE/EIS-0243-SA-01).

Final Environmental Assessment for the Multipurpose Haul Road Within the Idaho National Laboratory Site (DOE/EA-1772, 2010).

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Final Environmental Assessment and Finding of No Significant Impact for the Replacement Capability for Disposal of Remote-Handled Low-Level Radioactive Waste Generated at the Department of Energy's Idaho Site (DOE/EA-1793, December 2011)

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."

Transportation, receiving, and storing used nuclear fuel, as well as, research and development 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 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]. The EIS limits the number of shipments to the INL, and the proposed activities would fall within the limits of the EIS.

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

The environmental impacts of transferring low level waste from the INL to the Nevada National Security Site were analyzed in the 1996 Nevada Test Site EIS (DOE/EIS-0243) and supplemental analysis (SA) (DOE/EIS-0243-SA-01) 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 SA considers additional waste streams, beyond those considered in the 1996 NTS EIS, that may be generated at or sent to the Nevada National Security Site for management.

The impacts of transporting spent fuel, special nuclear materials, and research fuels between MFC and other INL Site facilities using the Multi-Purpose Haul Road were analyzed Final Environmental Assessment for the Multipurpose Haul Road Within the Idaho National Laboratory Site (DOE/EA-1772).

Onsite disposal of RH-LLW was analyzed in the Final Environmental Assessment for the Replacement Capability for Disposal of Remote-Handled Low-Level Radioactive Waste Generated at the Department of Energy's Idaho Site (DOE/EA-1793, 2011).

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: 10/25/2018