

# DOE-ID NEPA CX DETERMINATION

## Idaho National Laboratory

**SECTION A. Project Title:** R&D Activities for the Microreactor Applications Research Validation and Evaluation (MARVEL) Project

**SECTION B. Project Description and Purpose:**

Revision 1

The revision of this ECP includes both changes in scope to the original ECP (Activities 3 and 7) and an addition to the scope (Activity 8).

Activity 3: Primary Coolant System Testing- This task designs, constructs, and tests an electrically heated test loop similar to the reactor reference design to investigate the thermal performance of the primary coolant system and to support validation of the numerical modeling and simulation tools used in development of the final reactor design. This scope involves developing a full scale reactor simulator which will simulate nuclear fission using electrical cartridge heaters, with a natural convection liquid sodium or NaK flow path and a single Stirling engine in each of four loops to remove heat to produce power. This test will demonstrate the capability of the primary coolant system to remove heat from the core. The test skid will be initially operated at a vendor's alkali metal system test facility in Pennsylvania but may later be relocated to a suitable alkali metal facility at INL once such a facility can be prepared and qualified for this operation.

Activity 7: To enable successful production of critical Beryllium Oxide (BeO) components for nuclear microreactors and the Idaho National Lab MARVEL® Microreactor program, design, general tooling and fixtures must be designed, fabricated and tested for manufacturability. Under the scope of this proposal, Materion will provide engineering and staff resources required for the design of all tooling and fixtures necessary to manufacture BeO components for nuclear reactors. Materion Corp is a multinational company specializing in high-performance engineered materials where they specialize in beryllium and specialty engineered beryllium. As a deliverable, Materion will have fabricated these critical tools and fixtures and fabricate BeO parts to assure fabricated parts can meet manufacturing specifications. Materion will manufacture the following items, execute the following tasks, and/or perform the following services: (i) Engineering (ii) Project Management (iii) Purpose-built consumable tooling, e.g., mills, bits, grinding wheels, adhesives, molds, etc. (iv) Purpose-built durable tooling, e.g., fixtures, vices, chucks, base plates, firing setters, inspection mounts, etc. (v) Purpose-built transport fixtures (vi) Travel expenses. The aforementioned scope does not include fabricating any reactor parts, rather reduces manufacturability risks.

Activity 8: Detector test in TREAT - The purpose of the detector test in TREAT is to use the electronics and detectors that will go into MARVEL at TREAT, to the extent possible, to identify any potential issues. The detectors to be used are the TREAT spares and have similar specifications to the startup and steady state detectors in the TREAT reactor. TREAT has an electronics port on the North side which should be available to place the chambers inside. The chambers would be in symmetrical locations to the startup and steady state detectors on the south side and should have similar ranges for the power levels. The test will exercise the count rate range of the pulse detector system and the test will verify the operation of the Femto current amplifier. An attempt will be made to be able to get two cables that must be able to withstand temperatures >100°C and be resistant to radiation fields. One of the cables must be able to handle >2kV high voltage and the other cable must be a low-noise cable since the signal for the ion chambers operates at very low currents. Testing of the cables will verify if the cables are suited or if compromises need made. The tests will require preparation of a simple work package and will be performed during concurrent transient tests at TREAT.

Original ECP

Through engagement and outreach with end-users and stakeholders, Idaho National Laboratory (INL) has identified the need to perform research and development (R&D) on the integration of microreactors with a range of anticipated applications such as load following electricity demand, process heating, hydrogen production, and water purification. To meet this need, INL proposes to investigate issues and challenges related to the fabricating, assembling, installing, deploying, and operating microreactors to facilitate end-user adoption. The proposed R&D investigates the operational features of microreactors and their integration with end-user applications with the end goal of developing a small-scale reactor having a simple design and full operational capabilities for R&D purposes.

INL is researching and developing a potential design for the Microreactor Applications Research Validation and Evaluation Project (MARVEL) that is capable of meeting the demand for reliable power and heat at remote installations. MARVEL is a small nuclear power generator (less than 100KWe), and the core, heat removal, power conversion, heat rejection and controls are integrated into a single packaged unit. The proposed action uses facilities at INL to support proposed R&D activities. Research and development activities for this effort integrate individual R&D activities to develop an operating low power (100 kWt) reactor based on the SNAP-10A reactor design and technology. The SNAP 10A FS-3 was a complete reactor-based electric generating plant that operated for more than 10,000 hours at full power under simulated space-flight conditions. The program launched a duplicate system, the 10A Flight System (FS)-4, into orbit from Vandenberg Air Force Base on April 3, 1965 in a flight test named SNAPSHOT. SNAP 10A and SNAPSHOT provided a firm, proven basis for designing, fabricating, and testing more advanced reactor power systems.

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Because a final design has not been developed or tested, reactor construction and testing are beyond the scope of this environmental checklist (EC). If the proposed R&D activities determine the proposed design is feasible, additional analysis in compliance with the National Environmental Policy Act (NEPA) will be performed to evaluate constructing and testing of the MARVEL design to disclose the environmental impacts. To gather the data needed to demonstrate that the requirements for the microreactor design can be met, INL proposes to complete non-fuel R&D and fuels R&D. The activities for each are described below:

### Non-Fuels (R&D)

This work scope involves designing a very small microreactor to perform R&D associated with decentralized generation applications and testing new reactor operational aspects, such as semi-autonomous and remote operation. In addition to design, the scope of work includes building and testing prototypes of major systems by INL and Los Alamos National Laboratory (LANL). The proposed action involves the following activities:

**Activity 1: Project Management-** This task develops an integrated Project Plan, Schedule and Budget for executing the project, including requirements and detailed scope, and managing the project.

**Related Activity: Reference Design-** This activity develops the point design of the nuclear reactor portion of the test bed including determining the fuel system, reactor controls, decay heat removal, primary heat exchanger, and power conversion. INL provides support for the point design.

**Activity 2: Power Conversion Demonstration-** Under this activity, the project installs and operates a commercially available power conversion system to learn the startup sequence, operation, control algorithm of the power conversion and heat rejection system. This scope enables the team to engineer the power conversion interface to the reactor vessel. This involves using propane tank to supply heat to operate a commercial Stirling engine genset for training, research and operations perspective. Air emissions involve the formation of combustion products similar to automobiles, i.e., primarily carbon dioxide and water, which will be released to the atmosphere. The test skid will be located outside the Research Collaboration Building (RCB) at MFC.

**Activity 3: Primary Coolant System Testing-** This task designs, constructs, and tests the proof of principle of a sub-scale electrically heated test setup using the reference design to verify the thermal performance of the primary coolant, especially in terms of critical heat flux. This scope involves developing a subscale (1/4th scale) reactor vessel, which will simulate nuclear fission using electrical cartridge heaters, with a natural convection liquid sodium flow path and a single Stirling engine to remove heat to produce power. This test will demonstrate the capability of the primary coolant system to remove heat from the core. The test skid will be located at a lab space, located in the first floor of the RCB at MFC.

**Activity 4: Reactor Control Systems Development-** The project will also develop the reactor control system based on reactor design and safety requirements and design the control systems and Instrumentation and Control (I&C) logic per requirements. After design is complete, procure control system and assemble prototype to test basic functions with designed control algorithms. This activity involves the creation of a control drum system prototype and will be operated to demonstrate functions using a developed instrumentation and control system. The test skid will be located at a lab space, located at the RCB at MFC.

**Activity 5: Shutdown Rod System Development-** Develop the shutdown rod system based on reactor design and safety requirements. Perform design of the shutdown rod system and I&C logic per requirements. After design is complete, the project will procure a shutdown rod system and assemble a prototype to test basic functions with designed control algorithms. This activity involves creating a shutdown rod system prototype and will be operated to demonstrate functions using a developed I&C system. The test skid will be located at a lab space on the first floor of the RCB at MFC.

**Activity 6: Mechanical/Structural System Fabrication and Manufacturing-** This task investigates the design for manufacturability of key structural and mechanical components, lists and prioritizes fabrication approaches for major components and parts, estimates parts costs, and receives vendor and assembly cost quotes. This activity also performs manufacturing trials for in-house fabrication and identifies key risks and mitigation approaches for schedule, cost, resources, and scope.

**Activity 7: Electrically heated system with quad-stirlings-** The project proposes to design, fabricate and procure, assemble, construct, and test an electrically heated system that can simulate integral effects of reactor behavior during startup, normal operation and other transients. This tasks validates thermal responses using mature I&C system and develops training and startup plans. This test setup will validate overall system dynamics and

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performance of all thermo-mechanical, electrical, and I&C systems. This system will represent the entire microreactor design concept but without nuclear fuel. The test skid will be located at a lab space, located in the first floor of the RCB at MFC. -

### Fuels R&D

The R&D of advanced nuclear fuels and materials is essential for developing and improving microreactor and small modular reactor technologies. The proposed action uses existing INL facilities and equipment at the Materials and Fuels Complex (MFC) Experimental Fuels Facility (EFF) building MFC-794 and the Fuels and Applied Science Building (FASB) (MFC-787) to research and develop methods for manufacturing fuel for the MARVEL preconceptual design efforts.

INL needs to evaluate the fuel chemistry and enrichment for MARVEL, and one of the technology options being considered is a Training, Research, Isotopes, General Atomics (TRIGA) fuel design, which is known for its safety characteristics. All TRIGA type fuels are inherently safe for reactivity insertion events by virtue of the UZrHx matrix; however, there are several TRIGA fuel types that differ in cladding, enrichment, weight percent uranium, size and burnable poisons.

The proposed R&D involves pressing and sintering approximately 57 kg of fuel pellets made from Uranium hydride mixed with Zirconium Dihydride for research, development and reliability characterization. Fuel material will be processed in gloveboxes, hoods and on the floor (with suitable enclosures as necessary and appropriate) using existing process equipment designed for modifying powder characteristics such as particle size, agglomeration size, green density and sinter density. In addition to process equipment, instruments such as scales, balances, a moisture analyzer, characterize the feedstock and product materials from the process equipment.

The proposed action needs to fabricate and test about 22 fuel pins for quality assurance and to validate the selected technology. INL anticipates these R&D activities will require the following materials:

- Mass of uranium (R&D + 22 pins for reliability) = 1kg (depleted for R&D) + 17Kg (enriched at 19.75% U-235)
- Mass of sintered pellets (R&D + 22 pins for reliability) = ~57kg
- Mass of estimated waste generated from this effort =<2kg mostly depleted U-ZrH2

Testing activities include dimensional and visual inspection for both fuel compacts and welds, along with inspecting the stainless-steel tubes and endcaps, and any other components that may be placed in the pins

The proposed action investigates two fuel compacts—1) Uranium Hydride mixed with Zirconium hydride and 2) Uranium Zirconium metal powder mixed with Zirconium hydride. The proposed action uses up to 1 kg depleted Uranium (DU) feedstock currently stored in EFF, FASB, the Fuels Manufacturing Facility (FMF) or ZPPR. INL purchases the zirconium hydride powder feedstock, mixes the materials together in the general ratio of 20% Uranium to 80% remainder, and presses the material into pellets, which are then sintered at high temperature in partial pressure hydrogen atmosphere. INL then characterizes the pellets, primarily evaluating density, homogeneity, and physical integrity.

The proposed action seeks only to demonstrate a successful fuel fabrication process. Irradiation testing and post irradiation examination (PIE) of fuels is not proposed. INL will not produce fuel for a reactor under the proposed action. Fabricating and using the fuel will be evaluated under the National Environmental Policy Act (NEPA) during the NEPA review for a reactor proposing to use the fuel.

The proposed R&D will generate low level waste (LLW). 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.

## **SECTION C. Environmental Aspects or Potential Sources of Impact:**

### **Air Emissions**

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: If this project or activity produces or causes air emissions, and it is not stated in this ECP how those emissions caused by this project or activity are exempt, then an APAD is required for documentation.

The proposed action also has the potential to generate chemical and radionuclide air emissions at EFF and FASB. Air emissions would include minor amounts of radionuclides and toxic air pollutants.

Propane engines will meet the emission standards and operating and maintenance (O&M) requirements of 40 CFR Part 60 Subpart JJJJ.

EFF is the primary manufacturing facility for the fuel pellets. Similar fuel manufacturing activities already occur in EFF.

Fuel fabrication activities in FASB (MFC-787) are 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. The dose from this facility is tracked based on inventory on a quarterly basis by Operations and Environmental personnel.

For R&D activities that are conducted at EFF, FASB, and RCB an Air Permit Applicability Determination (APAD) may be required to determine if this is an exemptible activity as defined in 40 CFR 61.96(b).

In 2018, the effective dose equivalent to the offsite maximally exposed individual (MEI) from all operations at the INL Site was calculated as 1.02 E-02 mrem/yr, which is 0.10% of the 10-mrem/yr federal standard and was calculated using all sources that emitted radionuclides to the environment from the INL site. The additional increment in emissions from the proposed action would not significantly change the total site-wide MEI dose. Therefore, the emissions are bounded by the analysis in the 1995 EIS (DOE/EIS-0203), which estimated the annual cumulative doses to the maximally exposed worker, offsite maximally exposed individual (MEI), and the collective population from DOE's decision to implement the preferred alternative (DOE/EIS-0203). The potential air emissions and human health impacts associated with the proposed action would be smaller than and are bounded by the impacts presented in the 1995 EIS.

### **Discharging to Surface-, Storm-, or Ground Water**

N/A

### **Disturbing Cultural or Biological Resources**

N/A

### **Generating and Managing Waste**

The proposed action generates LLW, industrial waste, and general laboratory waste. Generated wastes will be managed and dispositioned according to current laboratory procedures.

Currently, the majority of INL LLW is disposed at the Nevada National Security Site (NNSS). The LLW generated from the proposed action accounts for much less than 1 percent of the LLW generated by present-day INL Site operations and shipped to the NNSS for disposal. The quantity of LLW generated from the proposed action is inconsequential in comparison with the 46.7 million cubic feet NNSS anticipates receiving from activities at other DOE sites.

If project LLW is classified as remote-handled LLW (RH-LLW), it would be disposed at the RH-LLW Facility at INL as 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). The amount of RH-LLW potentially generated from the proposed action (involving up to 1 kg of fuel) would be a small fraction of the estimated average annual volume of 150 m<sup>3</sup> of remote-handled LLW analyzed in DOE/EA-1793.

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### Releasing Contaminants

Chemicals will be used and will be submitted to chemical inventory lists with associated Safety Data Sheets (SDSs) for approval prior to use. The Facility Chemical Coordinator will enter these chemicals into the INL Chemical Management Database. All chemicals will be managed in accordance with laboratory procedures. When dispositioning surplus chemicals, project personnel must contact the facility Chemical Coordinator for disposition instructions.

Although not anticipated, there is a potential for spills when using chemicals or fueling equipment. In the event of a spill, notify facility environmental staff. If environmental staff cannot be contacted, report the release to the Spill Notification Team (208-241-6400). Clean up the spill and turn over spill cleanup materials to WGS.

### Using, Reusing, and Conserving Natural Resources

All applicable waste will be diverted from disposal in the landfill when possible. Project personnel will use every opportunity to recycle, reuse, and recover materials and divert waste from the landfill when possible. The project will practice sustainable acquisition, as appropriate and practicable, by procuring construction materials that are energy efficient, water efficient, are bio-based in content, environmentally preferable, non-ozone depleting have recycled content and are non-toxic or less-toxic alternatives. New equipment will meet either the Energy Star or SNAP requirements as appropriate (see <http://www.sftool.gov/GreenProcurement>).

**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 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).

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).

### 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."

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.

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

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Approved by Jason Sturm, DOE-ID NEPA Compliance Officer on: 01/06/2021