SECTION A. Project Title: Transient Reactor Test (TREAT) Facility Irradiation of a EBR-II High Burnup Mixed Oxide (MOX) Fuel Pin R2

SECTION B. Project Description and Purpose:

Revision 2:

This revision involves work between Idaho National Laboratory (INL) and the Japan Atomic Energy Agency (JAEA). The goal is to develop a threshold for fuel-cladding mechanical interaction (FCMI) in irradiated oxide fuels. These thresholds will be used for designing future irradiation experiments in the Japanese experimental fast reactor, JOYO, and for qualifying oxide fuels for future commercial Sodium Fast Reactors (SFRs). This work will also contribute to the "Advanced Fuels" efforts under the Civil Nuclear Energy Research and Development Working Group (CNWG) collaboration.

Location

The work will take place primarily at the following INL Facilities:

- Hot Fuels Examination Facility (HFEF)
- Transient Reactor Test (TREAT) facility
- Radioactive Scrap and Waste Facility (RSWF)

Tasks during this project

Fuel Pin Selection and Evaluation

- INL, with JAEA's assistance, will evaluate Experimental Breeder Reactor (EBR)-II mixed oxide (MOX) fuel pin specimens and select one pin for testing and one for destructive characterizations. These test specimens are currently stored at the INL.
- Additional pins may be reserved for future testing.
- Evaluation includes recovering irradiation history in EBR-II.

Transport and Pre-Test Characterization

- INL will transport selected pins from RSWF to HFEF for installation into the Temperature Heat-sink Overpower Response (THOR) capsule.
- Non-destructive examination (NDE) will be performed on fuel pins, including neutron radiography, contact profilometry, axial gamma scanning, and visual inspection.
- Destructive characterization of a sister pin will validate fuel conditions.

Experiment Design and THOR Capsule Development

- INL and JAEA will design the experiment and develop THOR capsule specifications.
- The THOR capsule test protocol will be document, allowing for various power events to be simulated on the test fuel pin.
- Preliminary test description includes rapid power increase followed by a slow ramp to melting conditions.

Capsule Fabrication and assembly

- INL will fabricate and assemble the THOR capsule.
- The test pin will be loaded into the THOR capsule at HFEF, the readiness checks completed, and transported to TREAT.

Irradiation Test and Post- Irradiation Examination (PIE)

- INL will conduct the irradiation test in the TREAT facility and transport the experiment back for disassembly and examinations.
- PIE will include both non-destructive and destructive examinations to assess the condition and integrity of the fuel pins.

Final Reporting

- INL will prepare a final report documenting the results, including summaries for each experimental phase.

Waste Details

- Hazardous Waste: Approximately 1 cubic meter.
- Radioactive Waste: Up to 20-30 kg of irradiated sample debris and secondary waste.
- Low-Level Waste: Approximately 1 cubic foot of remote-handled low-level waste.
- Mixed Low-Level Waste: Approximately 1 cubic foot of sodium-contaminated waste.
- Transuranic (TRU) Waste: Less than 1 cubic meter.

All waste will be generated at the INL and will be handled in accordance to facility specific requirements with the assistance of Waste Generation Services (WGS).

The offsite work will only consist of data review, design, and technical assistance. No waste will be generated off-site.

Revision 1:

This ECP has been revised to include the following changes to the Scope of Work (SOW):

1. Points of Contact
2. The Preliminary Test description: The preliminary test description includes two transient tests, mixed oxide (MOX)TOP-1 and MOXTOP-2. The goal of the tests is to simulate the temperature increase from an initial cladding temperature of 600 ºC at 43 kW/m (normal operating condition) under the Transient Overpower (TOP) conditions in a fast reactor. Given the constraints of the Temperature Heat-sink Overpower Response (THOR) capsule and available energy in the INL's Transient Reactor Test (TREAT) facility, "window" power histories will be considered to avoid overheating the specimen cladding. Descriptions of the proposed power histories are:

- MOXTOP-1: Max linear power will increase to 120.4 kW/m (280% of 43 kW/m) in 1 second at startup stage, and then increase to 125.56 kW/m (292% of 43 kW/m) in 12 s, corresponding to the power rising rate of 1%/s.
- MOXTOP-2: Max linear power will increase to 120.4 kW/m (280% of 43 kW/m) in 3 second at startup stage, and then increase to 125.56 kW/m (292% of 43 kW/m) in 12 s, corresponding to the power rising rate of 1%/s.

3. Destructive examination: Destructive examination (DE) of both failed and unfailed fuel pins will be performed. A sectioning diagram based on the non- destructive examination (NDE) will be developed to inform the subsequent examinations. DE will include ceramography of the fuel and metallography on the cladding of sections taken from locations defined in the sectioning diagram. A minimum of one section will be taken from each fuel pin. Additional sectioning might be performed based on the results of the NDE and mutual interest between the parties (a potential breached site on the MOXTOP pins would likely require at least one more section on a given pin). These additional sections will be pursued if budget and schedule allow.

Original ECP:

The purpose of the proposed action is to develop a threshold for fuel-cladding mechanical interaction (FCMI) in irradiated oxide fuels needed to design future irradiation experiments in the Japanese experimental fast reactor, JOYO, and to qualify oxide fuels for future commercial Sodium Fast Reactors (SFRs). The proposed action is a Cooperative Research and Development Agreement (CRADA) between Idaho National Laboratory (INL) and the Japan Atomic Energy Agency (JAEA). The parties propose to select two PNC1520 clad MOX fuel pins from the Operational

Reliability Testing (ORT) experiment program performed in the Experimental Breeder Reactor (EBR)-II currently stored at INL. The proposed action subjects the pins to simulated off normal transients in INL's TREAT facility using the THOR capsule. The proposed action also completes pre-test characterization of the test pins as a reference for post irradiation examination (PIE).

The following tasks make up the proposed action:

1. INL and JAEA evaluate the EBR-II MOX fuel specimens and select two pins for testing and one for destructive characterization. Evaluation includes recovering irradiation history in EBR-II.

2. INL transports the selected pins from storage at the Radioactive Scrap and Waste Facility (RSWF) to the Hot Fuels Examination Facility (HFEF) for installation into the THOR capsule. Task 2 has two subtasks described below. a. Prior to experiment assembly, project personnel perform non-destructive examination (NDE) of the fuel pins to characterize the pre-test conditions. NDE includes neutron radiography, contact profilometry, axial gamma scanning, and visual inspecting all irradiated MOX fuel pins to be used for the transient tests in TREAT.

The project will complete destructive characterization of a single sister pin of similar design and irradiation history to validate fuel condition relative to historic destructive examinations.

3. INL, with assistance from JAEA, designs the experiment and develops the THOR capsule specifications. Task 3 has two subtasks described below. a. The final test protocol for the THOR capsule test in TREAT will be documented in the TREAT Data Package. The THOR capsule allows test pins to be irradiated in a heat sink capsule that is thermally bonded by stagnant sodium. This configuration allows for a variety of shaped events.

The preliminary test description includes a two-stage transient. The first phase centers on driving the fuel at a linear heat rating and the cladding temperature of approximately 430 W/cm and about 600 °C before initiating the overpower transient in TREAT. During the transient, the reactivity insertion rate should be controlled (within a range between 50C/s and 3$/s) and increased successively until cladding failure is anticipated or indicated by in-situ instrumentation. The detailed conditions including +/- tolerances will be decided in the design phase of this experiment.

4. INL fabricates and assembles the two THOR capsules plus a backup capsule.

5. INL loads the two test pins into the THOR capsule at HFEF (or equivalent), completes readiness checks, and transports to TREAT.

6. INL completes high burnup annular MOX fuel pin testing in the TREAT facility and transport samples to hot cell facilities for examination.

7. INL completes PIE including non-destructive and destructive examination. Task 7 has two subtasks described below.

Prior to experiment disassembly, the project performs neutron radiography to assess the condition of the fuel. If the pin is effectively intact (minor disruption that allows routine handling), the fuel pin will be extracted and subjected to NDE including visual examination, contact profilometry, gamma scanning, and visual inspection. If the pin is not breached, the plenum will be punctured using the Gas Assay, Sample and Recharge (GASR) system to measure gas plenum pressure and composition. If the pin is severely damaged, NDE will consist of visual inspection of the experimental debris.

Destructive examination (DE) of both failed and unfailed fuel pins will be performed. A sectioning diagram based on the NDE will be developed to inform the subsequent examinations. DE will include ceramography of the fuel and metallography on the cladding of sections taken from locations defined in the sectioning diagram. It is assumed that two sections will be taken from each fuel pin.

8. INL prepares a final report documenting the results. A series of summary reports for each experimental phase will be completed including: 1) fuel pin selection, 2) summary of EBR-II irradiation history, 3) pre-transient characterization, 4) irradiation test conditions and in-pile instrumentation results, and 5) post irradiation examination data.

The Department of Energy (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 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...". In addition, 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) 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 transuranic (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 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.

Operations also have the potential to generate mixed waste. The project does not anticipate generating mixed low-level waste; however, it would be less than ten cubic centimeters if it did. If generated, mixed low-level waste is accumulated and stored per Federal and state regulations, treated if required, and disposed of at an off-site permitted/licensed facility. The project will produce 1 cubic meter of Hazardous waste. The proposed activities at HFEF could generate <1 m3 of transuranic (TRU) waste and < 1 liter of sodium waste.

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

The proposed action has the potential to generate radiological and chemical emissions from irradiation in TREAT and the destructive and nondestructive PIE at MFC. Air emissions are anticipated to be minor, and concentrations would not exceed the current monitored air emissions from these facilities. An Air Permit Applicability Determination (APAD) may be required as specified in the hold points.

The TREAT irradiation activities are not modifications in accordance with Idaho Administrative Procedures Act (IDAPA) 58.01.01.201 and 40 Code of Federal Regulation (CFR) 61 Subpart H. TREAT 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 Environmental Support and Services staff. All radionuclide release data (isotope specific in curies) directly associated with this proposal will be calculated and provided to the Environmental Support organization.

The irradiated specimens 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. The PIE examination 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.

For the calendar year 2021, the effective dose equivalent to the offsite maximally exposed individual (MEI) from all operations at the INL Site was calculated as 6.67E-02 mrem/yr, which is 0.67% 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, which estimated the annual cumulative doses to the maximally exposed worker, offsite 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

NA

Disturbing Cultural or Biological Resources

Cultural: Pursuant to the 2023 Programmatic Agreement, the proposed action does not meet the threshold of a federal undertaking and there is no effect to historic properties. See Hold Points and Project Specific Instructions regarding activities involving MFC-720/TREAT and MFC-785/HFEF.

Generating and Managing Waste

Operations will generate approximately 1 cubic foot of mixed low waste, (i.e. sodium contaminated), Remote handled Mixed Low Level Waste, and TRU waste. Waste is accumulated and stored per Federal and state regulations, and will be dispositioned onsite/offsite at a permitted/licensed facility. The project may also generate 1 cubic foot of Remote Handled Low-level waste.

All waste generated from this project will have an identified disposition path prior to it being generated. Project personnel will contact WGS to identify waste streams, handling, storage, and disposal requirements. All waste generated from this activity will be managed in accordance with approved Waste Manual 17 – Waste Management Program work control documents.

All materials will be reused and/or recycled where economically practicable to reduce volume and/or toxicity of waste generated. All waste will be transferred to Waste Generator Services (WGS) for appropriate disposition.

Waste for R2
Hazardous Waste: Approximately 1 cubic meter
Radioactive Waste: Up to 20-30 kg of irradiated sample debris and secondary waste
Low-Level Waste: Approximately 1 cubic foot of remote-handled low-level waste
Mixed Low-Level Waste: Approximately 1 cubic foot of sodium-contaminated waste
Transuranic (TRU) Waste: Less than 1 cubic meter

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

Environmental Justice

NA

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: B3.6 "Small-scale research and development, laboratory operations, and pilot projects", DOE/EIS-0200-F "Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste", DOE/EIS-0426 "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-0203 "Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement ", DOE/EA-1954 "Environmental Assessment for the Resumption of Transient Testing of Nuclear Fuels and Material "

Justification: Based on the purpose and need and description of the proposed action and potential environmental impacts, the proposed action fits within the class of actions that is listed in Appendix B CX B3.6. There are no extraordinary circumstances related to the proposed action that may affect the significance of the environmental effects of the proposal (10 CFR 1021.410(b)(2)). The proposed action has not been segmented to meet the definition of a categorical exclusion (10 CFR 1021.410(b)(3)). This proposal is not connected to other actions with potentially significant impacts, is not related to other actions with individually insignificant but cumulatively significant impacts, and is not precluded by 10 CFR 1021.211 concerning limitations on actions during preparation of an environmental impact statement (10 CFR 1021.410(b)(3)).

Authorizing the proposed action will not (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environment, safety, and health, including DOE and/or Executive orders; (2) require siting of new facilities or expansion of existing facilities; (3) disturb hazardous substances, pollutants, or contaminants; (4) adversely affect environmentally sensitive resources; or (5) involve genetically engineered organisms, synthetic biology, governmentally designated noxious weeds, or invasive species.

The Department of Energy (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).

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B3.6 Small-scale research and development, laboratory operations, and pilot projects. 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.

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

Approved by Robert Douglas Herzog, DOE-ID NEPA Compliance Officer on: 4/4/2025