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Categorical Exclusion Posting No.: DOE-ID-INL-23-063 R1

Project Title: XPeRT R1

Project Description and Purpose:

Revision 1:

Idaho National Laboratory (INL) is supporting X-energy in the development and licensing of the Xe-100, a 200 MWth high-temperature gas-cooled pebble-bed reactor. As part of this effort, INL will design, fabricate, and irradiate a second fueled pebble experiment, XPeRT-2 (X-energy Pebble Reactor Test 2), in the Advanced Test Reactor (ATR). The objective of XPeRT-2 is to generate irradiation performance data for TRISO-fueled pebbles under prototypic conditions to support the Xe-100 licensing basis and inform fuel qualification. This effort also serves as a precursor to a follow-on post-irradiation examination (PIE) campaign to further characterize fuel behavior that will be an additional revision to this ECP.

The INL will lead the design of the fueled experiment in collaboration with X-energy. The experiment will then be fabricated and assembled, with the completed test train transferred to ATR for reactor insertion. During irradiation, the experiment will be operated to meet specified test conditions, with active monitoring of key parameters such as fission gas release and temperature to ensure compliance with design requirements. Operational adjustments will be made as necessary to maintain target conditions. Upon completion of the irradiation campaign, INL will perform an as-run analysis and provide lead-out data via the Nuclear Data Management and Analysis System (NDMAS), along with a detailed as-run report. The project will conclude with the preparation of a comprehensive final report jointly developed by INL and X-energy, documenting experiment design, execution, and results.

The Experiment Requirements are as follows:

- The irradiation shall take place in the Advanced Test Reactor (ATR).
- The fuel form will be reduced diameter pebbles.
- A minimum of 55,000 triso particles shall be irradiated.
- Maximum particle packing fraction in the reduced size pebbles: 15% (X-energy prefers using their prototypical packing fraction of 9.5%).
- 15.5 wt% or 4.95 wt% U-235.
- The test shall be equipped with active temperature control. Thermocouples shall be used to measure temperature and a He/Ne gas blend system shall be used to control temperature.
- Temperature measurements shall be taken by using thermocouples around the graphite holders surrounding the pebbles.
- Temperature control will be managed using gas gaps, gas He/Ne mixture, and/or burnable neutron poisons to maintain 1000 +/- 150 °C for at least 1 pebble for the length of the experiment.
- The maximum fast fluence 8.00 E+25 n/m² with an average target of 7.00 E+25 n/m² fast fluence for neutrons with E > 0.18 MeV. It is recommended to use some type of neutron poison, such as B4C, within the test train design.
- Achieve Fissions Per Initial Metallic Atom (FIMA) of 18.2% on at least 2 pebbles.
- Experiment target temperature is T > 600 °C for all pebbles for the length of the experiment.

The expected waste generated during this project can be see in the original project scope.

The used fuel and waste will be managed and dispositioned during the PIE process at the INL. This ECP will be revised before the PIE phase begins.

Original ECP:

The Idaho National Laboratory, the lead nuclear laboratory for the DOE, nuclear engineering expertise draws upon multiple disciplines required to analyze, design, demonstrate, deploy, and operate nuclear systems. These include capabilities in neutronics, thermal hydraulics, structural-design analyses for small- and large-scale experiments, mechanistic and probabilistic safety and other risk analyses, development of robust materials for nuclear environment, and development of destructive and nondestructive nuclear materials detection and safeguards technologies. IN order to take advantage of these capabilities X-Energy, LLC is developing a 75 MWe pebble-bed reactor known as the Xe-100 project. The Xe-100 project requires the testing of fuel to support the development of the reactor. To that end, INL will support nuclear irradiation testing and analysis. DOE proposes to support the Xe-100 project by performing the following:

- Irradiate TRISO-X Fuel in the ART South Flux Trap Position (67 mm).
- The fuel form will be reduced diameter pebbles. Pebble diameter shall be maximized to the extent possible for the south flux trap position.
- A minimum of 75,000 triso particles shall be irradiated.

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- Maximum particle packing fraction in the reduced size pebbles: 15% (X-energy prefers using their prototypical packing fraction of 9.5%).
- U-235 Fuel enrichment: 15.5%
- The test shall be equipped with active temperature control. Thermocouples shall be used to measure temperature and a He/Ne gas blend system shall be used to control temperature.
- Temperature measurements shall be taken by inserting thermocouples into the graphite holders surrounding the pebbles. X-energy would like INL to evaluate the feasibility of inserting thermocouples into the graphite rinds of two pebbles.
- Temperature control gas gaps shall be sized to achieve a beginning of life (BOL) fuel meat volume average temperature of $1000 \pm 75^\circ\text{C}$ for all pebbles, except for a single designated high temperature pebble. The volume average temperature of the high temperature pebble at BOL shall be $1200 \pm 75^\circ\text{C}$. To the greatest extent possible, these volume averaged temperatures shall be maintained within $\pm 125^\circ\text{C}$ throughout the duration of the irradiation. It is expected that this will be achieved through the use of burnable neutron poisons.
- The test shall be equipped with at least one fission product monitoring system similar to that used for the AGR-1 and AGR-2 tests. If the pebble stack can be separated into more than one chamber with sweep gases going to separate fission product monitors, this will be beneficial so as to help localize any observed fuel particle failures (and to provide better temperature control across the pebble stack).
- The maximum particle power is 400 mW
- The fuel burn up goal is as follows: Achieve maximum Fissions Per Initial Metallic Atom (FIMA) given schedule constraints of ATR, with an extraction date no later than 08/01/26 (Est. 200 Irradiation Days). Note that if only 3 ATR cycles can be accomplished, then less than 200 irradiation days will be achieved to meet the extraction deadline.
- The fuel goal is as follows:
 - Achieve maximum Fissions Per Initial Metallic Atom (FIMA) given schedule constraints of ATR, with an extraction date no later than 08/01/26 (Est. 200 Irradiation Days).
 - Note that if only 3 ATR cycles can be accomplished, then less than 200 irradiation days will be achieved to meet the extraction deadline.
- The fuel fast fluence goal is as follows: All pebbles to receive fast fluence between 2×10^{25} and 5×10^{25} n/m² (> 0.18 MeV).

The project will be conducted at ATR TTAf, HFEF, AL, FCF, IMCL. The project will generate air emissions from the gases used to control the temperature in the experiment as part of a once-through system and discharged to the atmosphere. The temperature control system will use helium-neon gas mixture with a ratio varying from 100% helium to 100% neon. The maximum expected flow rate discharged will be 250 cc/min. The expected annual gas discharge is given below, assuming maximum ATR operating performance (80%) and maximum expected flow rates for all test assemblies.

GAS: Helium/neon 105 m³/yr.

Chemical Use/Storage - Isopropyl alcohol and acetone will be used as a cleaning agents in the assembly process.

Solid Waste - Some project activities will generate small quantities of solid waste such as machining chips, also waste in the form of personal protective equipment (PPE), gloves, etc.

Radioactive Waste Generation - The proposed project will generate approximately 9 cubic yards of low level radioactive waste, such as anti-contamination clothing, gloves, rags, stainless tubing, flux wires, etc.

Equipment will be purchase and will included, but is not limited to materials to buy/develop/build fixtures to do PIE.

Environmental Aspects or Potential Sources of Impact:

Air Emissions

The project will generate air emissions from the gases used to control the temperature in the experiment as part of a once-through system and discharged to the atmosphere. The temperature control system will use helium-neon gas mixture with a ratio varying from 100% helium to 100% neon. The maximum expected flow rate discharged will be 250 cc/min. The expected annual gas discharge is given below, assuming maximum ATR operating performance (80%) and maximum expected flow rates for all test assemblies.

GAS: Helium/neon 105 m³/year

Discharging to Surface-, Storm-, or Ground Water

NA

Disturbing Cultural or Biological Resources

Cultural: Pursuant to the 2023 Programmatic Agreement, this federal undertaking does not trigger Section 106 review as the proposed activity has no potential to cause effects to historic properties.

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Generating and Managing Waste

When wastes are generated, how they are disposed can adversely affect the environment. Managing wastes appropriately and responsibly and implementing recycling or reuse practices, where feasible, during project activities can reduce the potential impact on the environment.

Releasing Contaminants

When chemicals are used during the project there is the potential for spills that could impact the environment (air, water, soil).

Using, Reusing, and Conserving Natural Resources

Project description indicates materials will need to be purchased or used that require sourcing materials from the environment. Being conscientious about the types of materials used could reduce the impact to our natural resources.

Determination:

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

Justification: The proposal fits within the classes of actions listed in Appendix B to 10 CFR Part 1021 or Appendix B and C of DOE's NEPA Implementing Procedures and satisfies the conditions that are integral elements of the classes of actions therein. The proposal does not: (1) threaten a violation of applicable statutory, regulatory, or permit requirements for environment, safety, and health, or similar requirements of DOE or Executive Orders; (2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment facilities (including incinerators), but the proposal may include categorically excluded waste storage, disposal, recovery, or treatment actions or facilities; (3) disturb hazardous substances, pollutants, contaminants, or CERCLA-excluded petroleum and natural gas products that preexist in the environment such that there would be uncontrolled or unpermitted releases; (4) have the potential to cause significant impacts on environmentally sensitive resources, including, but not limited to, those listed in paragraph B(4) of 10 CFR Part 1021, Appendix B; (5) involve genetically engineered organisms, synthetic biology, governmentally designated noxious weeds, or invasive species, unless the proposed activity would be contained or confined in a manner designed and operated to prevent unauthorized release into the environment and conducted in accordance with applicable requirements, such as those listed in paragraph B(5) of 10 CFR Part 1021, Appendix B.

There is no extraordinary circumstance related to the proposal that is likely to cause a reasonably foreseeable significant adverse effect or for which DOE does not know the environmental effect. Extraordinary circumstances are unique situations presented by specific proposals, including, but not limited to, scientific controversy about the environmental effects of the proposal; uncertain effects or effects involving unique or unknown risks; and unresolved conflicts concerning alternative uses of available resources.

The proposal has not been segmented to meet the definition of a categorical exclusion. Segmentation can occur when a proposal is broken down into small parts in order to avoid the appearance of significance of the total action. However, segmentation does not include proposals that are developed and potentially implemented over multiple phases where each phase results in a decision whether to proceed to the subsequent phase.

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

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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.

Based on my review of the proposed action, I have determined that the proposed action fits within the specified class(es) of action, the other regulatory requirements set forth above are met, and the proposed action is hereby categorically excluded from further NEPA review.

Approved by Robert Douglas Herzog, DOE-ID NEPA Compliance Officer on: 6/4/2026