

# DOE-ID NEPA CX DETERMINATION

## Idaho National Laboratory

**SECTION A. Project Title:** Advanced Reactor Technologies (ART) Tristructural Isotropic (TRISO) Fuels - Safety Testing and Post-Irradiation Examination (PIE)

**SECTION B. Project Description:**

The purpose of this Environmental Checklist (EC) is to add scope to activities originally detailed in INL-08-082 (OA 7) as Very High Temperature Reactor (VHTR) Technology Development. The program name has been changed to Advanced Reactor Technologies (ART) tristructural isotropic (TRISO) Fuels as a result of a reorganization at DOE-NE HQ. The previous EC covered installation of a high temperature furnace system in the Hot Fuel Examination Facility (HFEF) at Window 6M of the main cell to support qualification of Advanced Gas Reactor (AGR) fuel for a High Temperature Gas-Cooled Reactor (HTGR) at the Materials and Fuels Complex (MFC) at Idaho National Laboratory (INL). The furnace was designed to subject irradiated fuel specimens to thermal conditions that could be encountered during postulated reactor accident conditions (typically 1,600 to 2,000°C). The furnace system includes an INL-designed fission gas monitoring system capable of measuring volatile fission gases released during the fuel heating tests. The original EC also covered furnace accident testing of the Advanced Gas Reactor (AGR)-1 experiment and briefly discussed processing of 8 test trains through HFEF. This EC is needed to capture extended project scope.

Experiments AGR-1 through AGR-8 are planned for the AGR Fuel Development and Qualification Program which supports the development of TRISO fuel under the HTGR program. The goals of these experiments are to: 1) provide irradiation performance data to support fuel process development; 2) qualify fuel for normal operating conditions; 3) support development and validation of fuel performance and fission product transport models and codes; and 4) provide irradiated fuel and materials for post-irradiation examination (PIE) and safety testing. This series of planned experiments is designed to test TRISO coated, low enriched uranium oxycarbide (LEUCO) fuel.

The proposed action involves experiments to develop an understanding of how well the fission products (i.e., the elements produced when uranium fissions) stay inside or move outside of the coated fuel particles and through the graphite reactor core and to study moisture and air ingress. Development of modeling and simulation tools to analyze and predict this behavior an objective of the proposed action. The proposed action would conduct irradiation, safety testing, and post-irradiation examination (PIE) to support fuel development and qualification for the HTGR program and to evaluate the behavior of the fuel under reactor accident conditions.

Equipment has been built and qualified for disassembly, inspection, and metrology of AGR test trains (1 and 2). This portable equipment is installed in the main cell of HFEF. The AGR-1 test train was disassembled and characterized without incident in 2010, although follow-on post-irradiation examinations (e.g., sample preparation) continue. Similar equipment would be designed and fabricated for the remaining AGR test trains. A total of 4 test trains would be processed through HFEF (FY 2010 through FY 2022). The AGR-2 test train (very similar to AGR-1) and AGR-3/4 test train (less fuel) are being irradiated in the Advanced Test Reactor (ATR). The AGR-5/6/7 test train is in the early stages of design.

The AGR-1 test train was transported from ATR to MFC in 2010. Shipment of the AGR-2 test train to MFC is anticipated in early FY2015. Shipment of the AGR-3/4 test train to MFC is tentatively scheduled in the winter of FY2014-15.

The proposed action involves the following five major elements:

1. Experiment Fabrication
2. Experiment Irradiation
3. Post-Irradiation Examination and Safety Testing
4. Performance Modeling.

The following discussion provides a more detailed discussion of the proposed action:

### **1. Experiment Fabrication**

The details of test train internals, test articles, and control parameters would vary depending on the requirements for a given irradiation as defined in the applicable test specification, but the basic tasks remain the same. The following tasks have been identified:

- Test specification: Test articles to be included in the test train, required operating conditions, and data to be produced by the test would be defined.
- Test train and supporting system's technical and functional requirements: The general design and functional requirements of the test train and its supporting systems would be included in this step. Experiment fabrication includes requirements necessary to meet technical specifications and safety analysis requirements for ATR.
- Test train and supporting systems design: The design and procurement specifications necessary to fabricate and assemble the test trains and establish needed supporting systems would be completed.
- Test train and supporting systems fabrication/assembly: Fabrication and assembly would include procurement or fabrication of test train components and assembly of the test train, including the test articles, for insertion into ATR. The AGR experiment test trains would be assembled at the Test Train Assembly Facility (TTAF) located at the ATR Complex.

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- Approval of test articles: This would include the receipt, inspection, and QA acceptance of all test articles to be incorporated into the test train.
- Review/approval of final design and fabrication data packages: This task would include review and concurrence by program participants.

Fuel for AGR experiments consists of TRISO coated particles that are slightly less than 1 mm in diameter. Each particle has a central kernel containing the fuel material, a porous carbon buffer layer, an inner pyrolytic carbon (IPyC) layer, a silicon carbide (SiC) barrier coating, and an outer pyrolytic carbon (OPyC) layer. The test trains would be fabricated from raw materials at one or more INL machine shops and assembled at the TTAF.

### **2. Experiment Irradiation**

Experiment irradiation includes all activities associated with irradiation of the test train, including insertion into and removal from the reactor, operation of the fission product monitoring system, technical support, operation of data acquisition systems, documentation of conditions and results of irradiation (including a near real-time remote data acquisition capability), and placement of the test train in the ATR canal for cooldown once irradiation (estimated at 90 days).

The number and type of test trains to be irradiated were planned based on the needs of the fuel manufacturing, fuel performance modeling, and fission product transport activities. The AGR-1 “shakedown” test train contained six capsules independently controlled for temperature and separately monitored for fission product gas release, with each capsule containing twelve 1-inch-long compacts. The AGR-2 test train contained six capsules independently controlled for temperature and separately monitored for fission product gas release with four capsules containing United States-made UCO fuel in three capsules, and UO<sub>2</sub> fuel in one capsule. The fifth capsule contained French UO<sub>2</sub> fuel, and the sixth capsule contained South African UO<sub>2</sub> fuel. The AGR-3/4 test train was designed to increase the capacity for irradiation of fuel and decrease the duration of the irradiations and for a different location within the ATR. This design would be used for the AGR-5/6/7 experiments as well. The AGR-3/4 test train contains 12 capsules with each capsule containing four ½-inch-long compacts. The AGR-3/4 test train capsules are independently controlled for temperature and separately monitored for fission product gas release. The designs and configurations for the AGR-5/6/7 experiments are presently being studied.

### **3. Post-Irradiation Examination and Safety Testing**

Post-irradiation examination (PIE) and safety testing would provide feedback on the performance of kernels, coatings, and compacts. Data from PIE and safety testing, in conjunction with the in-reactor measurements, are necessary to demonstrate that the fuel system has sufficient performance capability to meet reactor design requirements.

All PIE tasks may not be required depending on results as the proposed action proceeds. The PIE would primarily address metallic fission product release fractions, distributions within the fuel, and coating layer behavior, but would also capitalize on available capabilities to locate and examine all failed fuel particles.

Proposed PIE falls under existing capabilities of HFEF. Samples would be sent to the Analytical Lab for analysis. The following paragraphs discuss the general operations to be performed in HFEF to support PIE:

#### **Cask Transfer from ATR to HFEF**

Following removal from ATR and after at least 90 days of decay time in the reactor canal, each AGR test train would be loaded into a shipping cask for transfer to HFEF. HFEF routinely receives casks such as the GE 2000 cask, and standard procedures would be used to mate the cask to the hot cell and open the cask. The shielded liner would be removed from the cask and opened, and each test train would be transferred to a shielded window location within the HFEF hot cell to be externally inspected and disassembled for PIE.

The GE-2000 cask was leased for AGR-1, and is planned for AGR-2 and AGR-3/4 test trains. An alternative shipping plan could be used for the AGR-5/6/7 test train.

#### **Photo-visual Inspection of Test Train**

After unloading from the shipping cask, the exterior of the intact test train would be visually inspected by photo (using a digital camera via periscope or through a hot cell window) to identify any significant damage or degradation.

#### **Neutron Radiography**

Prior to disassembly, neutron radiography may be performed on the intact test train to establish the general condition of fuel compacts, graphite holders, and graphite spacers which may degrade during irradiation and transportation. Each test train would be lowered beneath the HFEF main cell and positioned in a beam from the NRAD reactor to reveal features of both fuel-bearing and graphite components.

#### **Gamma Scanning of Test Train**

The intact test train would be examined by precision (isotopic) gamma scanning for information on both fission product migration and shifting of fuel compacts within the capsules.

#### **Disassembly of Test Train**

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The test train would be disassembled to extract capsule components, including fuel compacts and graphite fuel holders. The individual fuel compacts and other components from the irradiation capsules would be photographed and measured. Some compacts would be sent to the Analytical Laboratory for analysis, some to the containment box for sectioning and mounting, and others to the FACS furnace for safety testing. Other hardware associated with disassembly of the test train would have various exams done within HFEF and the Analytical Laboratory.

### Safety Testing

Safety testing would be completed by placing irradiated fuel specimens in the high temperature furnace system in HFEF and heating the fuel while measuring the release of metallic and gaseous fission products as a function of time. A high purity helium sweep gas is metered past the heated fuel sample in the furnace and is routed to a fission gas monitoring system which cryrogenically traps the Kr and Xe gases for radioactive emissions counting. Following counting, the Kr and Xe gases are exhausted out to the HFEF stack.

### 4. Fuel Performance Modeling

Data obtained from the proposed action is needed to develop improved fuel performance codes under normal operating and accident conditions. As the data become available, calculations and modeling will be performed to understand the influence of the improved data on predicted fuel behavior.

In order 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 may be 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 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.

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

**Air Emissions:** Experiment irradiation and PIE will be performed at the ATR and MFC facilities. Air emissions at both facilities would be documented in an APAD. Air emissions would include minor amounts of radionuclides and toxic air pollutants. The irradiation in the ATR 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. 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 ATR Programs Environmental Support organization.

The irradiated specimens will be delivered to the MFC HFEF for disassembly and then undergo routine PIE before being sent to the Analytical Lab for analysis. All radionuclide release data associated with the PIE portion and analysis of this experiment will be recorded as part of the HFEF and Analytical Lab continuous stack monitors and provided to Programs Environmental Support organization. The PIE examination in HFEF and the analysis completed in the Analytical Lab 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. Releases of radioactive airborne contaminants from these processes are not expected to result in an increase to the annual dose to the Maximum Exposed Individual (MEI).

**Generating and Managing Waste:** Disassembly of each test train will create relatively small amounts of radioactive waste for disposal. The waste from the each test train will primarily consist of pieces of irradiated stainless steel tube less than 6 inches long and from 1.4 to 2.8 inches in diameter (total length less than 4 feet for each test train). A lathe-type tubing cutter (like that used to disassemble the AGR-1 test train and its capsules) will be used on the AGR-2 test train and a similar approach is planned for the AGR-3/4 test train. It is expected that turnings will be long ribbons, as opposed to fine chips, as is typical with lathe type turnings. These cuttings will be collected as waste. Other disassembly-related wastes will consist of gas lines and thermocouples.

Cutting, slicing, grinding, and polishing activities will create small volumes of remote handled radioactive wastes. Wastes will include the grinding and polishing residuals and the unused portions of the fuel compacts, graphite components, small pieces of thermocouple, and materials associated with decontamination of the Containment Box and Metallographic Loading Box. The whole compacts may have contact radiation fields as high as 104 rem/hr 6 months after the test irradiation. The fuel compacts that will be cut are approximately 0.5-inch diameter and from 0.5 inch x 1 to 2- inches in length. The graphite fuel holders that will be cut vary in size among specific test trains, but will be no larger than 2.6 inches in diameter and no longer than 4 inches in length for the AGR-2 and AGR-3/4 test trains are approximately 1.2-inches diameter x 4-inches long.

Project and/or HFEF personnel will work with Waste Generator Services (WGS) to properly manage and store samples. Normally, storage of samples is limited to one year in accordance with company procedures; however, in the case of samples from this HTGR

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project, select samples require archival storage to support licensing with the Nuclear Regulatory Commission. After completion of research activities, storage of samples greater than one year will require project and/or HFEF personnel to annually review sample inventory. Project and/or HFEF personnel will notify the Program Environmental Lead for post-research samples exceeding one year in storage and provide updates on sample disposition.

**Releasing Contaminants:** All chemicals utilized by the project would be managed in accordance with laboratory procedures.

**Using, Reusing, and Conserving Natural Resources:** All materials would be reused and recycled where economically practicable. All applicable waste would be diverted from disposal in the landfill where conditions allow. 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, or are non-toxic or less-toxic alternatives. New equipment will meet either the Energy Star or Significant New Alternatives Policy (SNAP) requirements as appropriate (see <https://sftool.gov/green-products/0?agency=0>).

**SECTION D. Determine the Recommended Level of Environmental Review (or Documentation) and Reference(s):** Identify the applicable categorical exclusion from 10 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 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 item B3.6 "Small-scale research and development, laboratory operations, and pilot projects"

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).

**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 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 Jack Depperschmidt, DOE-ID NEPA Compliance Officer on: 1/15/2015