

DOE-ID NEPA CX DETERMINATION

Idaho National Laboratory

SECTION A. Project Title: Advanced Reactor Technologies TRISO Fuels - Safety Testing and PIE Revision 2

SECTION B. Project Description and Purpose:

The purpose of this revision is to add the additional scope identified in Revision 2 below.

Revision 2:

A condensable fission product monitoring system called the In-Cell Gamma Monitoring System (IC-GAMS) and an out of cell Fission Gas Monitoring System (FGMS II) will be used in support of the safety testing campaign. The IC-GAMS will be used to monitor the deposition of condensable fission products within a Thermal Gradient Tube (TGT) and Filter assembly which is coupled to the Air Moisture Ingress experiment (AMIX) furnace, and the FGMS II will monitor on-line fission gas release during fuel heating tests in oxidizing atmospheres. The IC-GAMS system is composed of LaBr detectors, control electronics and tungsten/lead/steel collimator and environmental shielding and housing assembly. The FGMS II consists of electrically cooled HPGe detectors, control electronics, electric cooled cryo-traps and associated radiation shielding/collimation to protect the system from atmospheric radiation. Some of this equipment will need to be purchased and/or fabricated.

To support design efforts, non-radioactive benchtop testing of a horizontal tube furnace, test gas preparation equipment/methodology, gas analysis instrumentation, and other supporting systems/instrumentation such as fission product monitoring will be conducted at the INL Engineering and Demonstration Facility (IEDF) and the NS&T Physics lab. Upon final design and configuration, the system is planned for installation in the radiation hot cell at the Materials and Fuels Complex (MFC).

Revision 1:

Four compacts previously irradiated in Capsule 4 of the Advanced Gas Reactor (AGR)-2 experiment will be selected for additional safety testing and examination performed by Oak Ridge National Laboratory (ORNL). Each compact will be packaged in an individual tungsten shielding container and placed within a Type A drum. The compacts would be shipped from the Hot Fuel Examination Facility (HFEF) at Idaho National Laboratory (INL) to ORNL. The irradiated shipments will be Type A radioactive material shipments in compliance with Federal regulations found at 49 CFR parts 100 to 177. Typically, Type A packages are used to transport radiopharmaceuticals and certain regulatory qualified industrial products.

Three compacts will undergo high-temperature safety tests in pure helium at ORNL and will be monitored for the release of ⁸⁵Kr gas. After safety testing, furnace components will be analyzed as needed to assess fission products. Microanalysis of particles will also be performed based on results of the preceding destructive analyses. Microanalysis may include nondestructive x-ray analysis of selected particles and analysis of particle cross sections with scanning electron microscopy and energy dispersive spectroscopy.

Furthermore, this revision also includes planning the design and use at INL of a furnace capable of testing irradiated TRISO fuels in oxidizing environments and monitoring fission product releases. To support design efforts, non-radioactive benchtop testing of a horizontal tube furnace, test gas preparation equipment/methodology, gas analysis instrumentation, and other supporting systems/instrumentation will be conducted at the INL Engineering and Demonstration Facility (IEDF). Upon final design and configuration, the system is planned for installation in the radiation hot cell at the Materials and Fuels Complex (MFC).

Original EC:

The purpose of this 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) tri-structural 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.

DOE-ID NEPA CX DETERMINATION

Idaho National Laboratory

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.
- 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 UO₂ fuel in one capsule. The fifth capsule contained French UO₂ fuel, and the sixth capsule contained South African UO₂ 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.

DOE-ID NEPA CX DETERMINATION

Idaho National Laboratory

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:

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 cryogenically 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.

Packaging, repackaging, transportation, receiving, and storing used nuclear fuel and 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]).

While the research test specimens described in the EC are not spent nuclear fuel, they are similar in environmental hazards, except the test specimens contain less radiological material than a normal spent nuclear fuel shipment. Therefore, the potential environmental impact of transportation of the test

DOE-ID NEPA CX DETERMINATION

Idaho National Laboratory

specimens can be conservatively estimated to be equal to or less than a spent nuclear fuel shipment. The potential for transportation accidents was analyzed in the 1995 PSNF EIS (Section 5.1.5 and Appendix I-5 through I-10).

Finally, the record of decision for the 1995 PSNF EIS, DOE determined and stated "the evaluated potential impacts resulting from all alternatives were found to present no significant risk to potentially affected populations." Based on DOE's statement for the entire DOE SNF program, the proposed action would not have the potential for significant impact or have any unique or unknown risks.

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 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).

All radionuclide release data associated with packaging compacts described in Revision 1 will be recorded as part of the HFEF continuous stack monitor and provided to Program Environmental Support organization. Packaging 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. 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 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.

The compacts, sent to ORNL, will be deconsolidated and leached in nitric acid to dissolve any exposed fission products (a very small fraction of the compact inventory). TRISO particles will be recovered and some (~50) will be mounted and polished to reveal a mid-plane cross section. Waste from cross-sectioning goes into the Irradiated Fuels Examination Laboratory (Building 3525) hot cell general waste stream. Waste acid will be added to the acid waste stream we already have in Building 3525 and disposed of within 2 years. The particles containing almost all of the fission products will be archived for ~5 yr in Building 3525 until no longer needed by the program and then be disposed of as solid waste (along with the mounted particles). This waste is packaged and shipped to the Waste Isolation Pilot Plant (WIPP) facility

Releasing Contaminants

Chemical use has the potential to release contaminants. All chemicals and associated Safety Data Sheets (SDS's) must be submitted in the vendor data system for approval. The Chemical Coordinator would track these chemicals in the INL Comply Plus Chemical Management System. Chemical

DOE-ID NEPA CX DETERMINATION

Idaho National Laboratory

use has a potential for small air emissions and spills. In the event of a spill, notify facility PEL. If the PEL 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 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.

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 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).

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).

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."

For the research and development activities on the INL Site, similar activities—e.g. test specimen fabrication and post irradiation examinations (PIE)—have been conducted at the INL Site for years, and those operations have been managed safely. The primary mission of the Material and Fuels Complex at the INL is to conduct both fabrication and PIE. These activities are a part of the laboratory's conventional operations for a wide variety of public and private clients. As part of this work, waste disposal paths have been identified and are available for all potential waste streams resulting from this project. Further, this project constitutes neither a significant addition to nor unique change from current or historical operating conditions at the INL. As a result, overall waste generation and air emissions estimates for the INL are not anticipated to change.

Although the project is a conventional R&D activity for the INL under B3.6, the DOE-ID NCO considered existing analysis to ensure that all aspects of the project were covered. The NCO examined the analyses in the Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement (1995 PSNF EIS) and associated supplement analyses and Records of Decision when considering the potential impacts associated with transportation of the irradiated test specimens.

While the research test specimens are not spent nuclear fuel, they are similar in environmental hazards, except the test specimens contain less radiological material than a normal spent nuclear fuel shipment. Therefore, the potential environmental impact of transportation of the test specimens can be conservatively estimated to be equal to or less than a spent nuclear fuel shipment. The potential for transportation accidents was analyzed sufficiently in the 1995 PSNF EIS (Section 5.1.5 and Appendix I-5 through I-10).

DOE-ID NEPA CX DETERMINATION
Idaho National Laboratory

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Approved by Jason Sturm, DOE-ID NEPA Compliance Officer on: 1/22/2019