DOE-ID NEPA CX DETERMINATION
Idaho National Laboratory

CX Posting No.: DOE-ID-INL-13-018

SECTION A. Project Title: ZIRCEX Nuclear Fuel Dissolution Testing

SECTION B. Project Description:

Battelle Energy Alliance (BEA) has a Department of Energy-Nuclear Energy (DOE-NE) project to perform proof-of-concept testing for a nuclear fuel processing method on naval nuclear fuel. A non-radioactive portion of the test will be performed at Central Facilities Area (CFA)-625. To conduct the portion of testing with irradiated nuclear fuel, a hot cell facility at Idaho Nuclear Technology and Engineering Center (INTEC) that is owned by DOE- Environmental Management (EM) and operated by CH2M-WG Idaho, LLC (CWI) will be used. BEA will conduct the required tests in the Remote Analytical Laboratory (RAL) facility (Chemical Process Plant [CPP]-684) as a tenant in the CWI-operated facility. Included in this scope, CWI will prepare the facility in accordance with Statement of Work (SOW)-11050 "RAL Upgrades and PMs" (i.e., reestablishment of steam heat) and SOW-10972 "CWI Support for BEA Tenant Use of RAL" (i.e., CWI will perform landlord [facility condition, facility maintenance, and facility safety] operations). A larger pilot-scale equipment test will be performed by BEA in CPP-653. This EC covers the work on unirradiated materials at CFA and all work at INTEC.

This project provides proof-of-concept for the Zircex process on naval fuels. The Zircex process utilizes hydrochlorination or chlorination of the fuel with hydrogen chloride (HCl) or chlorine (Cl_2) gas at approximately 350-450°C. This vaporizes Zr (which is > 90% of the fuel mass) as ZrCl4 (g) and other constituents of Zircaloy (tin, etc.) from the solid, fuel product material. The zirconium is either desublimed to a solid ZrCl4 product or converted to the oxide by steam pyrohydrolysis. The uranium and most of the fission products do not form volatile compounds and are left in the reaction vessel. The remaining solid uranium/fission product material may then be oxidized with O_2 gas or NO_2 at 300-450°C. The off-gas, containing hydrogen (if HCl gas used), nitrogen or other diluent gas, and excess hydrochloric acid or chlorine gas, is treated by scrubbing with water, caustic or a solid soda-lime column to remove chlorine and then high-efficiency particulate air (HEPA) filtered. It is possible on some of the experiments that the chlorine/HCl gas may be recovered and recycled, instead of just removed.

The portion of this project planned for CFA-625 would use ~5 g pieces of non-radioactive (non-uranium bearing) zircaloy which would be contacted with Cl2 or HCl gas at 350-450°C in a glass vessel. These reactions are exothermic and will be monitored with thermocouples and controlled by the rate of gas flow and concentration into the system. The vaporized zirconium and any other vaporized materials will be routed to a room temperature glass vessel where it will condense (sublimation temperature is 330°C). Weights and reaction rates will be noted for various operating conditions/temperatures. The reaction rates will be measured by monitoring temperature with thermocouples in various locations and by monitoring any H_2 gas released. Approximately 5 tests will be run with this set-up. Each 5 g test will use (flow) about 0.9 ft^3 of HCl gas (or ~ 0.2 ft^3 Cl_2) over approximately a one hour period and will release 0.1 ft^3 H_2 and scrub out 0.7 ft^3 HCl at 20% utilization. A small fluidized bed (1 ½" dia) using alumina oxide as the bed, will then be used with 200-300 gram pieces of zircaloy for the same reaction for approximately 5 tests. A 300 g test will use (flow) about 53 ft^3 of HCl gas (or ~ 13 ft^3 Cl_2) over approximately a 4-8 hour period, releasing about 5.3 ft^3 H_2 and scrubbing out 43 ft^3 HCl. This portion of the test will help check out the equipment/procedures and narrow-down the testing conditions that will be used for the irradiated set of tests (at CPP-684).

After the CFA-625 testing is complete, the equipment will be moved into the CPP-684 (RAL) hot cell and set up for the same reactions only using irradiated naval fuel pieces with a maximum of 5 g of irradiated fuel (at 1.86% U this is about 0.1 g U per test) in the glass vessel and 250-300 g of fuel (about 5.6 g U) in the fluidized bed. Samples of the $ZrCl_4$ and remaining fuel "ash" will be taken and analyzed by gamma, beta, and Ion Coupled Plasma (ICP) spectrometry in addition to obtaining weights and (potentially) photographs of the materials. After the chlorination reactions are complete and samples are obtained, the remaining uranium "ash" may be contacted with O_2 or NO_2 gas to oxidize the uranium to uranium oxide. Sampling and analysis of the remaining uranium oxide and contaminates will be completed at the RAL. Each 5 g sample of fuel will contain a maximum of 1.46 Ci fission products (0.003 Ci Actinides). Each 300 g of fuel will contain a maximum of 87.5 Ci fission products (0.18 Ci actinides).

The RAL facility will require modifications to support the testing described. Most modifications will be minor and include maintenance activities. Steam isolation reconfiguration, exhaust blower motor replacement, and the hot cell cleanout actions are examples of more complex modifications that will be performed to support testing. The modifications will be performed by CWI personnel.

A larger pilot-scale equipment test (6 inch diameter fluidized beds) of the same process will be done with zirconium and unirradiated highly enriched, uranium bearing fuel (maximum 300 g U per test; 16-20 kg total zircaloy mass) in CPP-653. This would use approximately 2850 ft^3 HCl (710 ft^3 Cl2) over a 10-20 hour period with release of 285 ft^3 H_2 and scrubbing out 2274 ft^3 of HCl from off-gas.

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions - At INTEC the chlorination process is expected to release small amounts of radioactive species and hydrogen chloride or chloride gas vapor and hydrogen gas when using HCl as the chlorinating gas. The diluent gas, probably nitrogen will also be released. When doing the oxidation process, NO_2 and O_2 could be released. The work at CFA-625 will not be radioactive and will be covered under the existing Air Permit Applicability Determination (APAD) 04-09. The work at CPP-653 and CPP-684 will require new determinations to be completed by BEA.

Generating and Managing Waste - Radioactive liquid and solid materials (both low level waste [LLW] and mixed low level waste [MLLW]) from enriched uranium, radioactively contaminated zirconium chloride (or oxide), scrub solutions and/or caustic solids will be generated during the INTEC tests. Small amounts of industrial waste and hazardous waste may be generated from activities at CFA. At the RAL approximately 64 ft^3 of mixed low level waste will be required to be removed from the cell prior to installation of new equipment (hot cell cleanout activity). This waste stream will be managed and dispositioned through the CWI Waste Generator Services personnel.

At CFA-625 the project will be working with Zircaloy only. Wastes will be 1-5 liters of scrub solution (low concentration caustic or water containing some chlorides), solid soda lime containing chloride, and small amounts of dissolved solids ($ZrCl_4$ and ZrO_2 dissolved with corrosives) from the analysis. The actual $ZrCl_4$ solids will mostly be consumed in the analysis. In addition personal protective equipment (PPE) and glassware will be required to be disposed of. The CFA waste would be hazardous only, characteristic due to acids/bases or non-hazardous if not acidic or basic (or non-hazardous [non-haz] if elementary neutralization is performed).

At RAL small amounts of irradiated fuels will be used. Small amounts of scrub solutions, soda lime, minor amounts of uranium and dissolved solids from the analysis (contaminated with fission products) will be disposed of. The amount of uranium used in the cell will be limited. In addition, a small amount of equipment will need to be disposed of as radioactive waste as well as any remaining $ZrCl_4$ that was not dissolved for analysis at the end of the project. The RAL waste will be LLW and MLLW (due again to acids/bases, or non-haz if elementary neutralization is performed). It may be remote handled due to high radiaton fields due to fission products. Approximately 10-20 ft^3 total will be generated. The RAL has a waste loadout system for disposition of remote handled waste from which waste is then placed in a shielded container which is expected to be below 200 mr/hr at the surface of the container, then shipped off-Site for disposal.

On a larger scale, work to be done in CPP-653, will use unirradiated fuel (i.e., no fission products) but will contain highly enriched uranium (HEU). The HEU will be a product of the process and each run (of 5-10) will be limited to 300 g of HEU. The wastes will mostly include scrub solutions, soda lime columns, $ZrCl_4$, ZrO_2, and dissolved solids possibly contaminated with uranium, as well as PPE, sample bottles, and a HEPA filter (from the enclosure and off-gas), etc. Since this is larger scale, the scrub solution may be on the order of 50 liters instead of 5.

There is expected to be no high-level waste (HLW) generated in this process. HLW is a title given to that high radioactivity (fission product) waste separated from fuel and disposed of via reprocessing. The ZIRCEX process differs in that the fission products are not separated in this process, but the zirconium is separated from the uranium (and fission products) by hydrochlorination. The fission products remain with the fuel for eventual (potential) reprocessing, though that activity is not included in this project. This product will be retained for future study and stored by CWI at FAST.

It is unlikely the proposed action would generate TRU waste. The overwhelming mass of the product (HEU with fission products and actinides), the Zr waste (potentially recycled with very small amounts of fission product) and any "scrubbing" waste from the off-gas are projected to contain less than 100nCi/g TRU. If any of these products or wastes are found to be TRU contaminated, (only in the case of the few grams of irradiated HEU product material is this possible) through subsequent chemical analysis, it would be managed by mixing with cementatious grout to reduce below TRU concentrations--only if deemed waste and not product.

HEU would be retained after the project for further study. In the case of the unirradiated material (pilot scale testing in CPP-653), the HEU would be returned to the supplier, B&W in Lynchburg, VA, for recycling into their fuel production facility. The few grams of irradiated HEU material would be retained and subsequent tests of small scale separations could be performed. Such separations are not funded at this time, but the ZIRCEX product would be valuable and not a waste for scientific purposes. If it were determined to dispose of it as waste, it could be returned to the Navy Spent Fuel Disposition Project that is just beginning at INTEC or grouted and disposed of separately.

Project personnel would work with CWI Waste Generator Services (WGS) to properly package and transport regulated, hazardous or radioactive material or waste according to existing or specially approved INL and/or ICP laboratory procedures at the RAL. At other facilities (CFA or CPp-653) the direction for waste management will come from BEA WGS. At the present time contact and remote handled LLW will likely go to Nevada National Security Site; Class A MLLW to Energy Solutions in Clive, Utah; greater than class A waste to Perma-Fix Northwest; and hazardous waste to Clean Harbors.

The proposed action would not create new, unique waste streams, and the disposition activities associated with project related waste are currently conducted at the INL.

Releasing Contaminants - Project activities have the potential to release potentially hazardous contaminants into the air. Refer to Air Emissions above.

Using, Reusing, and Conserving Natural Resources - All materials would be reused and recycled where economically practicable. All applicable waste will 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 recycle 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 http:/www.sftool.gov/GreenProcurementCategory/14).

SECTION G. 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 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 which would affect the significance of the action, and the action is not “connected” nor “related” (40 CFR 1508.25(a)(1) and (2), respectively) to other actions with potentially or cumulatively significant impacts.

References: National Environmental Policy Act (NEPA) Implementing Procedure, Final Rule, 10 CFR 1021 Appendix B to Subpart D, Categorical Exclusion B3.6 "Small-scale research and development, laboratory operations, and pilot projects."

Justification: Project activities in this Environmental Checklist (EC) are consistent with 10 CFR 1021 Appendix B to Subpart D, Categorical Exclusion 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); and small-scale pilot projects (generally less than two years) frequently conducted to verify a concept before demonstration action, 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 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 Jack Depperschmidt, DOE-ID NEPA Compliance Officer on: 8/12/2013