DOE-ID NEPA CX DETERMINATION

CX Posting No.: DOE-ID-21-071

SECTION A. Project Title: Development of Novel Corrosion-Responsive Buffer Materials for Long-Term Immobilization of High-Level Nuclear Waste – The Pennsylvania State University

SECTION B. Project Description

The Pennsylvania State University (PSU) proposes to develop a novel cementitious buffer material (CBM) to extend the safe disposal and isolation of high-level nuclear waste (HLNW) over long timescales. The innovative CBM is sought to address the waste package corrosive failure modes and immobilize fugitive radionuclides in generic mined disposal concepts in salt, crystalline rock, or clay/shale. The primary aim of this project is to identify and develop novel magnesium aluminophosphate (Mg-Al-P) CBMs, complete with assessments of their repository material stability as well as their transport and immobilization capacity of radionuclides. Hence, supporting DOE's program efforts to design, develop, and characterize the performance of engineered barrier technologies. Given the accelerated corrosion of HLNW canisters, the secondary aim of this project is to employ advanced in-situ monitoring systems to understand the corrosive failure modes at the canister-CBM interface. New digital twin models will lead to improved models of the waste container-package long-term performance leveraging Mg-Al-P CBMs. Thus, the project will provide a sound technical basis for the development and assessment of the Mg-Al-P CBM potential to isolate waste. The project aims will be accomplished through four main research objectives, namely: 1) characterization of phase assemblage time-based (0-12 months) and thermal evolution (100-1000 °C) in Mg-Al-P CBMs via x-ray diffraction, thermogravimetric analysis, and pore solution chemical analysis; 2) assessment of the physio-chemical reactive transport of radionuclides (i.e., ^{137}Cs, ^{90}Sr, ^{243}Am, ^{237}Np, ^{99}Tc, ^{129}I) and of high-risk repository geochemical conditions (i.e., brine and groundwater flow) within Mg-Al-P pore networks via micro-tomography (μ-CT); 3) in-situ monitoring of the corrosive degradation at the canister steel-CBM interface through bespoke ultrasound and electrochemical impedance spectroscopy (EIS) non-destructive measurements; and, 4) near-field reactive transport modeling (i.e., digital twins) for long timescale performance predictions of disposed HLNW packages in mined geological repositories with novel Mg-Al-P CBMs. The project research objectives will be accomplished leveraging a unique combination of validated multi-physics simulations and data-driven experimentation (hybrid analytics) to deliver improved models of the waste container's long-term performance.

SECTION C. Environmental Aspects / Potential Sources of Impact

The project involves the utilization of acid/base chemistry employing non-hazardous polymers (polyvinyl alcohol polymers) and ammonium salts (ammonium phosphate trihydrate, ammonium aluminate nonahydrate) as well as colloidal silica (TM50 LUDOX). These main chemicals will generate acid/base chemical disposal (>500 ml total per month) to be handled and treated in accordance with The Pennsylvania State University Environmental Health and Safety office (EH&S). More specifically, University procedures and standards will be followed to safely handle, process, and dispose of the generated chemical waste by following both Hazardous Waste Disposal Policy (SY20) and Disposal of Pollutants in University Sanitary Systems (SY40) procedures. Similarly, radioactive simulants (i.e., CsCl, SrCl, $EuCl_2$, $EuCl_3$, $Ce(SO_4)_2$, $NaTCO_4$, and $Ca(IO_3)_2$) will generate hazardous waste (irritant, caustic) of nearly 5L total that will be safely disposed in accordance with EH&S Hazardous Waste Disposal Policy (SY20). These procedures, standards, and policies are compliant with 25 PA Code Ch. 260(a) - 262(a) and the Environmental Protection Agency regulation 40 CFR 260-262. Lastly, all chemicals will be safely stored in accordance with the University Safety Policy SY39 - Hazardous Chemical Inventory Management, which requires that all work areas maintain a chemical inventory in the Chemical Inventory Management System (CHIMS). The Re-AIM Laboratory facilities have recently been upgraded to comply with all EH&S requirements for chemical use/storage, disposal, and waste generation.

SECTION D. Determine the 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.

Note: 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, including requirements of DOE orders; 2) require siting and construction or major expansion of waste storage, disposal, recovery, or treatment 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) adversely affect environmentally sensitive resources. 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: 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 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). For purposes of this category, "demonstration actions" means actions that are undertaken at a scale to show whether a technology would be viable on a larger scale and suitable for commercial deployment. Demonstration actions frequently follow research and development and pilot projects that are directed at establishing proof of concept.

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Justification: The activity leverages hybrid physics and data-driven experimentation to achieve a new understanding of corrosive package failure and high-risk repository geochemical conditions affecting the near-field physio-chemical reactive transport of fugitive radionuclides in novel Mg-Al-P CBMs.

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

Approved by Jason Anderson, DOE-ID NEPA Compliance Officer, on 09/07/2021.