SECTION A. Project Title: Reusable Building-Type Material Containing Isotopes for Simulating Radioactive Contamination Environments

SECTION B. Project Description and Purpose:

The Idaho National Laboratory (INL) Nuclear/Radiological Search & Response Training (N/RS&RT) Program conducts training for radiological incident response organizations in controlled environments utilizing radioactive materials. Radiological training and/or testing activities are conducted under various scenarios using:

1. Dispersed radioactive material,
2. Contained (unsealed) radioactive sources,
3. Sealed radioactive sources, and/or
4. Certified special form sealed radioactive sources.

Radiological materials are packaged and transported to the designated training area and placed or dispersed according to approved plans. Activities may include contamination control and decontamination operations; evaluation of command and control protocols; collection of samples; and/or site characterization using hand-held instrumentation, vehicles, aerial surveys or remote radiation measurements, etc. After each exercise, the radiological sources are returned to storage in accordance with the applicable procedures and the dispersed material is left in place to decay.

The proposed scope of this project includes the incorporation of select radioisotopes into a building-type material (e.g., floor tile) that will be used to create a simulated contamination environment, providing the participants opportunity to practice radiation detection and contamination control techniques in known radiation fields without actual removable contamination. Initial designs will be based around a standard 12” x 12” floor tile. However, other designs are in consideration. The floor tile (or other similar building material) will be transported and used as a sealed source in accordance with approved procedures and plans. There will be no dispersal activities utilizing this material.

The tiles will be configured as a single item or placed in a grid pattern to represent small local area contamination incidents and/or large-scale contamination incidents. The tiles will be customizable in terms of appearance, size, and isotopic composition to align with training objectives and requirements and can be reused for multiple events.

The proposed research has six primary objectives:

1. Sol-gel encapsulation and irradiation of europium powder
2. Investigation of suitable external structure material (epoxy, epoxy/carbon fiber, etc.)
3. Investigation of radiolysis effects of chosen external material and sol-gel glass
4. Production of five prototypes
5. Investigation of prototype to incorporate long-lived alpha/beta emitting isotopes

6. Feasibility study on prototype qualification and designation as a certified special form source

Development Phase:

The development phase will take place at Washington State University (WSU). The initial tasks will focus on the incorporation of europium-152 (Eu-152) (^{152}Eu) and europium-154 (Eu-154) (^{154}Eu) into a building-type material. Eu-152/154 both have multiple gamma energies that are useful for training and testing purposes. Other radioisotopes including potassium bromide, sodium nitrite and copper may also be considered for use.

The high purity europium powder will be prepared into a sol-gel glass form with the end product of the sol-gel synthesis process being dense glass particulate in defined particle sizes. The sol-gel glass will then be irradiated and particle sizes greater than 100 µm will be used for incorporation into the selected building material to eliminate any respiratory concerns and control the spread of contamination during production. The sol-gel glass encapsulation of the powder will create a secondary layer of protection with the selected building material providing the primary layer, resulting in the final product being double-encapsulated or sealed to prevent any removable contamination.

The building material will be selected based on several factors including the need to have a non-brittle, ruggedized material to aid in ease of handling, transport and storage and also to minimize the effects of attenuation and allow for uniform distribution of the radioisotopes (as sol-gel glass). The suggested building materials that will be utilized are an epoxy or epoxy combined with carbon fiber which will be molded/formed into the desired structural shape (i.e., floor tile).

Production and Evaluation Phase:

The production and evaluation phase will begin with the evaluation of radiological or radiolysis effects on sol-gel glass encapsulated within epoxy and/or epoxy combined with carbon fiber coupons. The composite coupons will be exposed to a controlled radiation source consisting of 22,500 Ci (340,000 R/hr @ 30cm) of Co-60 to test the durability and rates of degradation of the fibers. The test will be conducted in a controlled environment where radiation dosage, exposure time and temperature will be carefully monitored and recorded. The objective is to assess how the radiation interacts with these materials and changes their physical properties, structural integrity, or chemical composition. Post exposure, the coupons will undergo a thorough analysis using various techniques such as mechanical testing and microscopy to determine the extent of the radiological effects. The findings from these tests will provide valuable data relative to radiation resistance and stability for long-term use.

Next, five prototypes will be produced. Two of the prototypes will consist of sol-gel glass (with no radiological components) incorporated into an epoxy and/or epoxy combined with carbon fiber outer material to validate the fabrication process. If successful, three additional prototypes containing varying quantities of Eu-152/154 will be produced. Production will also include the fabrication of shielding and shipping containers for transportation and use in training and testing activities.

The five prototypes will then be evaluated for the ability to incorporate alpha/beta emitting radioisotopes. High attenuation of alpha/beta energies when encapsulated in sol-gel glass along with the outer epoxy layer is anticipated.

The last objective will be to evaluate the prototype for potential qualification as a certified special form source. The final prototype design will be assessed for its ability to pass tests as described in 49CFR 173.469 "*Tests for special form Class 7 (radioactive) materials*." Testing will include physical integrity tests such as impact, puncture, and thermal to ensure the product can withstand harsh conditions and maintain containment of the incorporated radioisotopes under specified accident scenarios. Assessment will also include the prototype's resistance to crushing and compression forces. Finally, the prototype will be evaluated for the ability to pass leak testing to validate that there are no pathways for radioactive materials to escape.

All physical integrity tests will be completed at the INL using INL material scientist experts.

Radiation Exposure and Risk:

The proposed scope of research includes the incorporation of radioisotopes (Eu-152/154) that will be physically embedded in both sol-gel glass and an epoxy or epoxy/carbon fiber matrixes, there are no environmental pathways that require Engineering Calculations and Analysis (ECAR) for assessment of potential dose and environmental impacts. The end state matrixed material, anticipated to be in the form of a floor tile, will be handled in a similar fashion to sealed radioactive sources produced commercially or normal form sources regularly used throughout the INL. Conservative dose estimates for Eu-152/154 is approximately 1 mR/hr at 2 inches from the external material surface.

The floor tile will be placed to simulate varying levels of radioactive contamination throughout a test or training area. Upon completion of the test or training event, the tiles will be collected and placed in storage for future use. There will be no dispersal activities utilizing this material. Current research plans include the evaluation of this material for long-term use under varying environmental conditions and radiolysis.

The proposed scope will be performed in conjunction with WSU – Nuclear Science Center (NSC) under Contract 280838.

WSU-NSC: The NSC reactor facility serves a critical need for reactor-produced radioisotopes utilized in DOE-funded research, including europium for the proposed action. The environmental impacts of the WSU reactor programs have been evaluated in Facility Operating License No. R–76; Washington State University Modified TRIGA Nuclear Radiation Center Reactor (NRCR); Environmental Assessment and Finding of No Significant Impact."

Testing at WSU NSC will include the irradiation of blank sol-gel glass and glass with varying loadings of europium oxide and potentially potassium bromide, sodium nitrite and copper. This will be done to evaluate impurities within both the glass and active materials. Once fully decayed, post irradiated materials will be evaluated for changes in appearance and structural integrity.

Waste may be associated with the WSU portion of the project. WSU activities are covered under the following programs/protocols:

- Isotope production:
    - NSC Standard Operating Procedures, Rev. 0.6 are the most current
    - SP-1-101714, Rev. 5-2021

- SP-2-101714, Rev 6-2021
- Quality Management Plan QMP-101714 Rev. 5-2021

- Waste handling (although all waste in the direct production scheme for this project is shipped to INL (sample can only)
  - NSC Standard Operating Procedures, Rev. 0.6 are the most current
  - WSU Radiation Protection Plan
  - NSC Radiation Protection Plan, Rev. 8-2018
- Shipping procedures are handled with the following:
  - SP-2-101714, Rev 6-2021
  - HazMat Radioactive material shipping training completed as required by DOT through HMTC

Deliverables:

The proposed work will require the use of laboratory space, equipment, and time contributions from a multitude of subject matter experts including health physicists, nuclear engineers, radiochemists, etc. With the INL being the lead nuclear research lab in the United States, the infrastructure to successfully complete this project are already in place. Furthermore, previous research including the irradiation other radioisotopes utilized in support of similar training and testing activities has resulted in a longstanding partnership with Washington State University.

Tasks and deliverables for both the Development Phase and Production/Evaluation Phase are shown in Tables 1 and 2.

Table 1. Development Phase.

Task	Deliverable	Date
Sol-gel encapsulation and irradiation of europium powder	Preliminary report	09/2024
Investigation of external structure materials	Preliminary report	09/2024
Investigation of radiolysis effects	Preliminary report	09/2024

Table 2. Production and Evaluation Phase

Task	Deliverable	Date

Prototype development gamma reusable structures	Production confirmation	04/2025
Investigation of suitable alpha/beta reusable structures	Final report	09/2025

SECTION C. Environmental Aspects or Potential Sources of Impact:

Air Emissions

The proposed scope of research includes the incorporation of radioisotopes (Eu-152/154) that will be physically embedded in both sol-gel glass and an epoxy or epoxy/carbon fiber matrixes, there are no environmental pathways that require Engineering Calculations and Analysis (ECAR) for assessment of potential dose and environmental impacts.

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.

Generating and Managing Waste

This work will take place at WSU. No waste be generated at INL.

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.

Environmental Justice

NA

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: B1.2 "Training exercises and simulations", B2.4 "Equipment qualification", B3.6 "Small-scale research and development, laboratory operations, and pilot projects", B3.11 "Outdoor tests and experiments on materials and equipment components", DOE/EA-1776 "Idaho National Laboratory Radiological Response Training Range, Idaho", DOE/EA-2063 "Final Environmental Assessment for Expanding Capabilities at the National Security Test Range and the Radiological Response Training Range at Idaho National Laboratory"
Washington State University Modified TRIGA Nuclear Radiation Center Reactor (NRCR); Environmental Assessment and Finding of No Significant Impact” Facility Operating License No. R–76. NRC–2011–0083.

Justification: B1.2 Training exercises and simulations (including, but not limited to, firing-range training, small-scale and short-duration force-on-force exercises, emergency response training, fire fighter and rescue training, and decontamination and spill cleanup training) conducted under appropriately controlled conditions and in accordance with applicable requirements.

B2.4 Activities undertaken to (1) qualify equipment for use or improve systems reliability or (2) augment information on safety-related system components. These activities include, but are not limited to, transportation container qualification testing, crane and lift-gear certification or recertification testing, high efficiency particulate air filter testing and certification, stress tests (such as "burn-in" testing of electrical components and leak testing), and calibration of sensors or diagnostic equipment.

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). 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.

B3.11 Outdoor tests and experiments for the development, quality assurance, or reliability of materials and equipment (including, but not limited to, weapon system components) under controlled conditions. Covered actions include, but are not limited to, burn tests (such as tests of electric cable fire resistance or the combustion characteristics of fuels), impact tests (such as pneumatic ejector tests using earthen embankments or concrete slabs designated and routinely used for that purpose), or drop, puncture, water-immersion, or thermal tests. Covered actions would not involve source, special nuclear, or byproduct materials, except encapsulated sources manufactured to applicable standards that contain source, special nuclear, or byproduct materials may be used for nondestructive actions such as detector/sensor development and testing and first responder field training.

DOE/EA-1776 Idaho National Laboratory Radiological Response Training Range, Idaho

DOE/EA-2063 Final Environmental Assessment for Expanding Capabilities at the National Security Test Range and the Radiological Response Training Range at Idaho National Laboratory

The environmental impacts of the WSU reactor programs have been evaluated in Facility Operating License No. R–76; Washington State University Modified TRIGA Nuclear Radiation Center Reactor (NRCR); Environmental Assessment and Finding of No Significant Impact."

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

Approved by Robert Douglas Herzog, DOE-ID NEPA Compliance Officer on: 4/1/2024