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Project Execution Plan

Project Number: 33645

Environmental Management Spent Nuclear Fuel Technology Development

Idaho National Laboratory

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ACRONYMS

ASNF	Aluminum clad spent nuclear fuel
ATR	Advanced Test Reactor
CFD	Computation fluid dynamics
DCR	document change control
DOE	Department of Energy
DOE-EM	DOE Office of Environmental Management
DOE-NE	DOE Office of Nuclear Energy
EBR	Experimental Breeder Reactor
EDMS	Electronic Document Management System
FASB	Fuels and Applied Science Building
FERMI	Enrico Fermi Power Plant Unit 1
FY	Fiscal year
GA	General Atomics
HFIR	High Flux Isotope Reactor
INL	Idaho National Laboratory
MEDE	Melt-drain evaporate
MPO	Memorandum Purchase Order
NEPA	National Environmental Policy Act
PEP	Project Execution Plan
QAP	Quality Assurance Program
RCMS	Remote Canister Monitoring System
R&D	Research and development
SGE	Selective gas extraction
SNF	Spent nuclear fuel
SNFWG	Spent Nuclear Fuel Working Group
SRNL	Savannah River National Laboratory
TD	Technology Development

1. PROJECT SCOPE, AND COST OVERVIEW

This revised Project Execution Plan (PEP) sets forth plans, organizations, and systems to be employed for managing the Environmental Management Spent Nuclear Fuel (SNF) Technology Development (TD) Project (project #33645). This project was created as an organizational structure to plan, manage, control, and coordinate individual activities funded by the National Spent Nuclear Fuel (NSNF) Program through the U.S. Department of Energy (DOE)-Office of Environmental Management (EM).

The format of this report is based on that of the PEP for the Aluminum Clad Spent Nuclear Fuel (ASNF) Long Term Dry Storage Technical Issues Project (project #32855). [1] The activities of the ASNF project were incorporated as an individual task (Task 1). In total, the Environmental Management SNF TD Project currently includes the following ten tasks listed in Table 1, though not all are presently active.

Table 1. Project task list and status.

Task	Title	Status	Notes
Task 1	ASNF laboratory technical and engineering studies	Active	This task includes the activities of former project #32855
Task 2	Technical and engineering analyses to address spent fuel management	Merged	Due to overlapping scope, this task was merged with Task 6
Task 3	Spent fuel data management and analysis	Merged	Due to overlapping scope, this task was merged with Task 6
Task 4	ASNF validation/verification	Active	–
Task 5	Disposition of sodium-bonded SNF – Technical risks and uncertainties	Active	–
Task 6	Reducing SNF management technical risks and uncertainties	Active	Includes activities of Tasks 2 and 3
Task 7	Disposition options for fuel debris at Savannah River National Laboratory (SRNL)	Never initiated	–
Task 8	Project controls and integration	Active	–
Task 9	Evaluation of SNF packaging	Active	–
Task 10	High Flux Isotope Storage (HFIR) ASNF dry storage concept	–	–

The activities of these ten tasks have been gradually initiated since fiscal year (FY) 2017. Parts of these activities have been completed, and the scopes of some of the tasks were adapted due to the identification of additional research and development (R&D) needs, project management needs, or funding prioritizations. To be specific:

- Task 1 includes six subtasks (see Section 1.2.1), with Subtasks 1.1 and 1.4 having been completed successfully.
- The activities of the original standalone Tasks 2 and 3 were merged with the activities of Task 6. Thus, Tasks 2 and 3 will not be discussed in detail within this PEP.
- Task 7 has not been initiated and there are no plans for funding this task. Thus, this task will not be discussed in detail within this PEP.

At the time of developing this PEP revision, the DOE-EM funding for project #33645 was approximately $27 million (FYs 2017–2022). Additional funding of approximately $2 million will be requested before the end of FY 2022.

With the development of a technical basis for extended (>50 years) dry storage of ASNF [2], the development of conceptual monitoring systems of dry storage canisters [3, 4], and the completion of the melt-drain evaporate (MEDE) TD of sodium-bonded SNF and evaluation of treatment alternatives such as selective gas extraction (SGE) [5, 6], the goal of completing key fundamental research activities was achieved. Based on the findings of this work, key FY 2022 and FY 2023 follow-on activities are currently being pursued or were identified to strengthen the technical basis for extended dry storage of ASNF, to move from conceptual designs to deployable canister monitoring systems, and to evaluate MEDE treatment for use on irradiated material. Activities within the scope of the remaining tasks are expected to continue beyond FY 2022, should additional funding become available. The structure of this project will be continuously adapted if new R&D needs are identified.

This PEP also establishes and documents the methods and controls for managing the project. It will be a controlled document, effective throughout the life of the project (i.e., after completion of all current and future activities), and reviewed and updated both annually and as needed (i.e., whenever significant changes occur).

1.1 Mission Need

The Environmental Management SNF TD Project was tailored to address DOE-EM mission needs [7, 8], and its activities are funded through the annual U.S. congressional budget, specifically, through passing the Energy and Water Development and Related Agencies Appropriations Bill (e.g., in FY 2022) [9, 10]: "Within Technology Development and Deployment, $5,000,000 is provided for the National Spent Nuclear Fuel Program to address issues related to storing, transporting, processing, and disposing of Department-owned and managed SNF. Within these amounts, the Department shall use funding to address the need for additional assessments into material degradation that may occur as a result of multiple decades of Environmental Management SNF storage facilities, nuclear material measuring and monitoring in the Department's storage systems, and other activities recommended by the U.S. Nuclear Waste Technical Review Board in its 2017 report on the "Management and Disposal of U.S. Department of Energy Spent Nuclear Fuel."

1.2 Project Description

In the following sections, activities within the scope of each individual task of the Environmental Management SNF TD Project are described in detail.

1.2.1 Task 1 – ASNF Fuel Laboratory Technical and Engineering Studies

This task was created to help develop an improved understanding of ASNF behavior during extended dry storage, as well as a technical basis for the continued storage of this type of DOE SNF, using laboratory experimental work on surrogate materials and simulations. This task is critical for ensuring safe, extended dry storage in both current and future ASNF configurations, and for providing information for the future transportation, conditioning, and disposal of ASNF.

1.2.1.1 Task 1 – Activities

The DOE Spent Nuclear Fuel Working Group's (SNFWG) report on technical considerations and challenges for extended dry storage of ASNF (DOE/ID RPT-1575) [11] identified five knowledge gaps and technical data needs. The report also made several recommendations, including the development of an action plan (INL/EXT-17-93408) [12] to identify needed technical and engineering activities/analyses for addressing these gaps/needs. The activities in Task 1 represent the R&D work that enabled the development of a technical basis for extended dry storage of ASNF (see Figure 1).

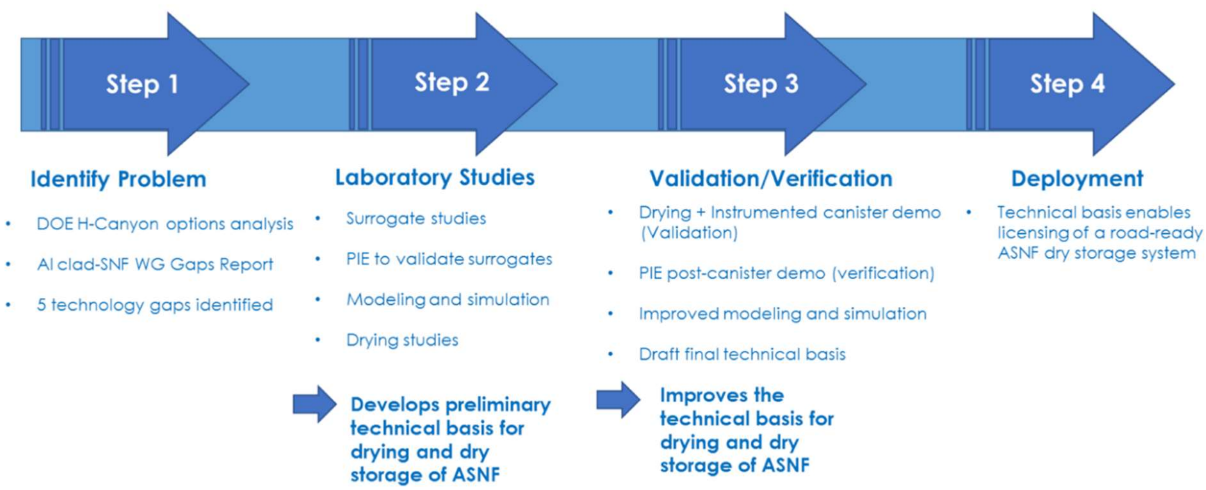

Figure 1. Necessary steps for developing the technical basis for extended dry storage of ASNF. [1]

Within this process, the five data/knowledge gaps identified in the SNFWG report had to be filled in order to help decision-makers better understand the environmental, safety, and long-term programmatic risks associated with a management strategy for ASNF placed in extended (i.e., greater than 50 years) dry storage. These gaps are the following:

1. Behavior/chemistry of oxyhydroxide layers for the broad range of ASNF fuel designs and dry storage configurations.

2. Resolution of radiolytic gas generation data regarding ASNF oxyhydroxide layers.

3. Combined effect of episodic breathing and the radiolytic generation of potentially corrosive gases in sealed and vented systems.

4. Performance of research test reactor ASNF in existing dry storage systems.

5. Effects of high-temperature (i.e., greater than 100°C) drying on the chemistry and behavior of oxyhydroxide layers.

Task 1 includes six subtasks. Figure 2 illustrates how Subtasks 1.1–1.6 interfaced with each other in order to close the five data/knowledge gaps listed above.

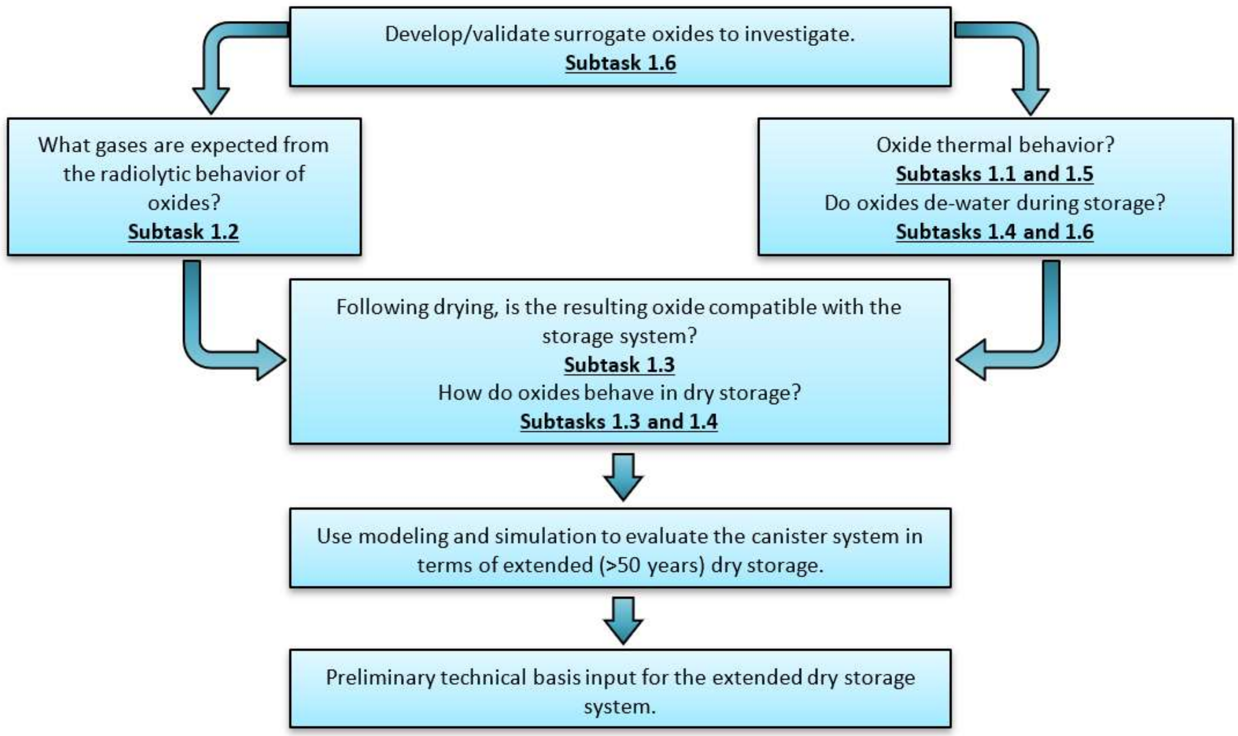

Figure 2. Illustration of the technical questions to be answered, and the interfaces between the activities of Task 1 (adapted from [1]).

The work included in Task 1 was initiated in FY 2017. Subtasks 1.1, 1.4, and 1.6 are complete (although may be continued depending on the identification of additional research needs). The fundamental research of Subtasks 1.2, 1.3, and 1.5—needed to develop the technical basis for extended dry storage of ASNF—was completed by the end of FY 2021. This allowed for publication of INL/EXT-21-65214, "Technical Basis for Extended Dry Storage of Aluminum Clad Spent Nuclear Fuel," [2] in December 2021, which summarizes the findings that form the foundation of the technical basis for extended dry storage of ASNF. Currently ongoing activities within Subtasks 1.2, 1.3, and 1.5 are focused on strengthening the technical basis by addressing research needs identified throughout the project execution. Details on the Task 1 activities are summarized in the following paragraphs, and additional information can be found in the Technical Task Plan. [13]

Subtask 1.1 – Oxyhydroxide layer behavior and chemistry

The first step in building an understanding of how ASNF will perform over extended storage periods was to develop a complete understanding of the behavior of oxide/oxyhydroxide films created during in-reactor operations and out-of-reactor storage, with a focus on how temperature affects those films.

Completion of Subtask 1.1 in early 2020 answered several questions, such as whether mechanisms exist that could alter the aluminum oxide/oxyhydroxide layers during extended storage, whether (and under what conditions) these layers decompose, and whether this decomposition process could lead to SNF storage canister integrity issues. Within the scope of this subtask, oxide layer thicknesses and growth rates were evaluated based on fuel history. Both thermal effects and corrosion behavior in different oxide layers were characterized. Based on these experiments, no hydrogen is expected to be produced due to corrosion of the oxyhydroxide layers under the range of temperatures used in testing—temperatures representative of those anticipated in dry storage. The results obtained via the work in Subtask 1.1 informed the modeling activities regarding DOE SNF dry storage systems (Subtask 1.3) and drying (Subtask 1.5).

Subtask 1.2 – Oxide layer radiolytic gas generation

While the results of Subtask 1.1 provide information regarding the amount of gas generated due to thermal effects on, or corrosion of, the oxide/oxyhydroxide layer, the activities of Subtask 1.2 focus on radiolysis of the oxide/oxyhydroxide layer and the gaseous sources present within a storage canister.

This subtask was tailored to answer questions on the types of important gases (e.g., hydrogen, oxygen, and NO_x) that may be produced inside sealed and vented ASNF canisters, questions on radiolytic gas generation rates, questions on the radiolytic degradation mechanisms, and the question of whether in-canister conditions can be predicted based on these mechanisms. Fundamentally, this subtask supports the development of storage models (Subtask 1.3) by providing information on maximum gas generation rates.

Ongoing Subtask 1.2 activities are designed to strengthen the developed technical basis for extended dry storage of ASNF, and include in-situ surface characterizations. The work will explore the micromechanical effects in aluminum oxide/oxyhydroxide layers in strong gamma radiation fields, track the oxygen generation, and further, identify alloy type dependencies of the hydrogen generation rate.

Subtask 1.3 – Sealed and vented system episodic breathing and gas generation prediction

Subtask 1.3 modeled the combined effects of episodic breathing (in the vented canisters stored within INL's CPP-603 facility) and radiolytic gas generation on the ASNF cladding, oxide layers, canister, and other system components. Additional activities included the comprehensive modeling of sealed and inert canister storage systems, using the DOE Standard Canister [14] as an example.

Diffusional and convective exchanges of reactive gaseous species and heat inside the canister, with ambient air induced by episodic breathing in both the vented and unsealed storage systems, will shift the chemical equilibrium conditions and affect the level of radiolytic production of corrosive gases. The modeling activities within this subtask applied insights gained from Subtasks 1.1 and 1.2 in order to identify the primary gas generation reactions and kinetics in both sealed and vented systems, and to implement the reactions in the canister-scale multiphysics computational fluid dynamics (CFD) models for predicting the long-term evolution of concentrations of corrosive gases and moisture contents inside/outside the canisters. The simulation results were continuously coordinated with the technical leads and research staff of Subtasks 1.1 and 1.2, and used to guide their experimental designs.

Ongoing Subtask 1.3 activities are designed to strengthen the developed technical basis for extended dry storage of ASNF and include modeling of the roll-over hydrogen generation point (i.e., reaching a steady state), Subtask 1.5 drying experiment modeling, and model updates using the latest experimental data collected within the scope of Subtasks 1.2 and 4.1.

Subtask 1.4 – Performance of ASNF in dry storage

Subtask 1.4 was completed by the end of FY 2019. It was focused on predicting the long-term integrity of stored ASNF, and included collecting baseline information about the fuel's passive oxide/oxyhydroxide surface characteristics at various stages during its lifecycle.

Corresponding activities were completed within the scope of Subtask 1.4. These activities included visual inspections of ASNF, with a priority focus on Advanced Test Reactor (ATR) ASNF stored at INL's CPP-603 facility, evaluations of ATR endboxes from the ATR canal, and evaluations of corrosion layers from actual ATR SNF in dry storage in the CPP-603 facility.

At the end of reactor service, the end boxes are removed from each ATR element before transferring the elements out of the ATR canal. These end boxes provided opportunities to obtain limited ASNF sample material post-irradiation and before the dry storage stage of the fuel's lifecycle. Inspection of ASNF in dry storage established a baseline understanding of how ASNF performs over its storage lifetime. The primary criteria in selecting ATR elements for inspection were a long storage duration and a high burnup for fuel of the selected vintage.

The utilized evaluation techniques were coordinated with Subtask 1.6 research activities of Savannah River National Laboratory (SRNL) to allow for more consistent comparisons between SRNL and INL sample materials. Part of the reason for inspecting the ATR ASNF and end boxes was to address concerns about expected corrosion and radiolytic phenomena, and to ensure that storage conditions do not introduce new, unexpected fuel behaviors. The analyzed samples indicate there is minimal change in the oxide and associated hydration of the surface of the aluminum ATR fuel elements that can be attributed to dry storage. Note that, within Subtask 1.4, an ATR fuel-handling tool for handling individual elements was designed and procured.

Subtask 1.5 – Oxide layer response to drying

Within the scope of Subtask 1.5, the effects of drying on the development and composition of oxide layers on ASNF were investigated. The underlying goal of the completed work was to develop an understanding of how effectively different drying procedures (e.g., temperature, vacuum, and forced helium) remove the chemically bound water in parts of the oxide layers, as well as the impact of drying procedures on the formation/transformation of those layers. The selection of specific drying temperatures and types of oxide layers for analysis was heavily informed by the results of Subtask 1.1. Furthermore, Subtask 1.5 activities were conducted by INL in collaboration with its partners in academia (University of South Carolina) and industry (Holtec).

Ongoing Subtask 1.5 activities are designed to strengthen the developed technical basis for extended dry storage of ASNF, and include the development and evaluation of specific drying recipes for ASNF. This work will inform the recommendation of ASNF drying processes planned for FY 2021.

Subtask 1.6 – Surrogate sample preparation and validation

Subtask 1.6 was completed in 2021. It included investigations into knowledge gaps and technical data, which were supported by the evaluation of laboratory-grown oxide/oxyhydroxide layers on surrogate material. Subtask 1.6 was led by SRNL and was designed to validate the accurate representation of ASNF oxide/oxyhydroxide layer composition (e.g., gibbsite, bayerite, and boehmite) by surrogate materials. The activities of this subtask included characterization of the oxide/oxyhydroxide layers on actual Savannah River Site SNF materials, as well as preparation and characterization of representative surrogate materials for use in other activities.

1.2.2 Task 4 – ASNF Validation/Verification

The intent of Task 4 is to move the ASNF work of Task 1 from the laboratory scale to a verification/validation stage. The focus of this work is on the development and utilization of an instrumented lid, along with associated instrumentation to monitor the internal conditions of SNF canisters currently used to store DOE SNF at INL's CPP-603 facility. Data collected within the scope of Task 4 will help quantify and reduce the technical risks and uncertainties associated with a DOE SNF packaging evaluation (Task 9).

1.2.2.1 Task 4 – Activities

The TD for the SNF canister internal-condition monitoring of Task 4 includes activities such as determining the phenomena to be monitored, down-selecting the appropriate monitoring and data collection technologies, and working through the logistical, operational, and regulatory concerns relating to the deployment of the developed canister lids. As part of the transition from the ASNF laboratory studies of Task 1 to larger demonstrations, research staff and technical leads will closely coordinate to ensure that the latest data and physical behavior of ASNF is understood and appropriately incorporated into planning activities. Task 4 includes two subtasks described in the following paragraphs.

Subtask 4.1 – Development of a DOE Standard Canister lid

Subtask 4.1 is led by SRNL. Within the scope of this subtask, an instrumented lid for the DOE Standard Canister was developed to collect data on the internal conditions of the canister during extended dry storage of DOE SNF. The DOE Standard Canister is a leak-tight (i.e., not vented) system usable for continued dry storage of the various DOE SNF types, including the ASNF currently stored at INL's CPP-603 facility. Subtask 4.1 further includes the selection of parameters to be monitored within the DOE Standard Canister, based on the results of the experimental work in Task 1. The data collected using the developed canister lid to date helped verifying the experimental and predictive modeling work conducted within the scope of Task 1.

Ongoing experimental work on surrogate and actual ASNF specimens, complementary to the activities of Task 1, is continuously conducted in order to complete and verify INL's radiolytical gas generation data collection. This process utilizes the developed instrumentation to measure hydrogen release rates (i.e., G-values) for unirradiated and irradiated aluminum coupons.

Subtask 4.2 – Development of a CPP-603 Canister Lid

Within the scope of Subtask 4.2, a remote canister monitoring system (RCMS) is under development that will enable interrogation of the atmosphere within INL CPP-603 dry storage canisters. A variety of DOE SNF types, including ASNF, have been stored in these vented (i.e., non-leak-tight) canisters for years—in some cases, even decades. The canisters are located within CPP-603's fuel storage area, a highly radioactive environment enclosed by thick concrete walls. The technical challenges posed by the completed activities of Subtask 4.2 involved selecting the appropriate sampling parameters and the development of a reliable sampling system to support determining the condition of SNF stored within the CPP-603 canisters and verifying the experimental and predictive modeling work conducted in Task 1. Different candidates for suitable RCMS instrument components were evaluated. Feasibility studies were conducted by industry partners (i.e., Westinghouse) and partners in academia (Idaho State University [ISU]) that included testing of the different components in simulated conditions, including radioactive environments. Further, evaluations of available wireless data transfer technologies were needed to ensure reliable transfer of sampling data from within the fuel storage area to the outside.

Future steps within Subtask 4.2 include the involvement of the CPP-603 facility operator to enable the development of functional and operational requirements. Based on these requirements, the plan is to design and order an RCMS prototype, and to extensively test it throughout FY 2023.

1.2.3 Task 5 – Disposition of Sodium-bonded SNF – Technical Risks and Uncertainties

DOE high-level waste and SNF repository requirements specifically exclude hazardous materials as identified in the Resource Conservation and Recovery Act. Experimental Breeder Reactor (EBR)-II and Enrico Fermi Power Plant Unit 1 (FERMI) SNF utilized sodium to bond fuel pins to the cladding. Because this sodium has the potential to react violently with water, it must be removed or passivated prior to repository disposal.

DOE activities necessary for meeting the Idaho Settlement Agreement's 2035 deadline [15] include identification and evaluation of potential sodium-bonded SNF treatment technologies, followed by technology down-selection of a preferred option, completion of National Environmental Policy Act (NEPA) and Record of Decision requirements, and retrieval and treatment of 34 metric tons of heavy metal FERMI SNF over the next 17 years. Based on the disposition timeline and the long lead time for the required DOE-EM activities, it is critical to execute these studies in a timely manner.

1.2.3.1 Task 5 – Activities

The DOE Office of Nuclear Energy (DOE-NE) has been processing EBR-II fuel at INL using electrometallurgical technology since the early 2000s, and aims for completing processing of both driver and blanket materials in 2035. This is a very costly and time-consuming process. EBR-II driver fuel is challenging to treat since sodium diffused into the metal fuel core during fuel irradiation. However, EBR-II and FERMI blanket materials experience much less irradiation, and sodium does not migrate into the heavy metal core to nearly the same extent as in the driver fuel. This difference in SNF characteristics makes EBR-II and FERMI blanket materials amenable to heat treatment alternatives such as MEDE or SGE, another alternative treatment option for sodium-bonded SNF.

Based on these evaluations, alternative treatment options for FERMI blanket materials could be recommended. Additional sodium-bonded SNF or blanket material treatment R&D work will be conducted as needs are identified and additional funding becomes available. Task 5 includes two subtasks described in the following paragraphs.

Subtask 5.1 – Evaluation of MEDE as a Treatment Alternative for Sodium-bonded SNF

Within the scope of Subtask 5.1, review and analyses of results from preliminary studies on DOE-EM-funded FERMI and DOE-NE-funded EBR-II MEDE studies were performed, and new FERMI MEDE R&D work was initiated. This includes staging several unirradiated FERMI blanket elements and a single blanket assembly and subjecting them to MEDE processing. Figure 3 depicts the FERMI MEDE treatment development process using a high-level simplified flow chart.

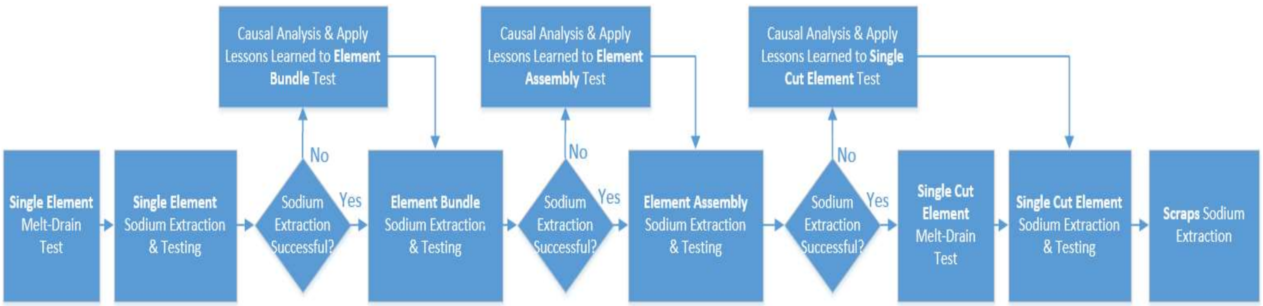

Figure 3. Simple flow chart of MEDE testing. [16]

The MEDE research plan started with extracting sodium at the individual element scale, expanded to bundles (nine elements), and ultimately, to a full assembly (25 elements), followed by analyses of each step before proceeding to the next step.

Prior to MEDE heat treatment, cut points along the blanket elements had to be identified. Cutting the elements allows liquid and gaseous sodium to escape the elements during heating. To identify these cut points, original, non-irradiated FERMI blanket assemblies provided by the Henry Ford Museum were analyzed using radiography. Additional tests of the MEDE process were conducted that involved cutting open only one end of the blanket elements for venting.

The equipment needed for MEDE evaluation was developed and procured. This includes a furnace to heat the FERMI blanket materials, a retort for condensation of the vaporized sodium released from the fuel, a programmable logic controller for the furnace, and handling tools. The furnace and retort were installed in the pyro-chemistry glovebox at INL's Fuels and Applied Science Building (FASB). Mockup FERMI blanket assemblies and elements were also designed and tested. To complete the work on unirradiated material, actual FERMI blanket material was subjected to MEDE treatment.

In the MEDE demonstration process, the furnace heaters were de-energized after each round of sodium extraction, and the system pressure was equalized. The MEDE apparatus was positioned horizontally for disassembly and unloading. Separation of element slugs from its cladding was assessed, and samples of the separated element, cladding, and bond sodium were taken for elemental and isotopic analyses at INL's Analytical Laboratory. The MEDE test apparatus was then reloaded for subsequent operations. Results from each analysis were applied as lessons learned to the subsequent test.

The achieved degree of removal of reactive sodium metal from the unirradiated material is promising. Follow-on activities within Subtask 5.1 could include a demonstration of MEDE on actual (i.e., irradiated) FERMI blanket assemblies.

Subtask 5.2 – Evaluation of SGE as a Treatment Alternative for Sodium-bonded SNF

As part of the activities of Subtask 5.2, R&D work was conducted that included evaluating SGE as an alternative treatment option for sodium-bonded SNF. General Atomics (GA) was contracted to lead these efforts. GA has developed proprietary techniques for the chemical separation of materials that showed the potential for being applied in the field of nuclear waste treatment, and was previously awarded a patent for related SGE technology (U.S. 9,076,561 B2) for Mo-99 recovery. GA's specific focus in SGE TD included both consultations on and design, construction, and testing of required preliminary equipment for EBR-II fuel separation, among other activities.

Subtask 5.2 was completed. An evaluation of the data and results provided by GA to INL did not demonstrate any significant advantage of SGE over other treatment options such as vacuum distillation. [6] Thus, project management decided to discontinue TD activities pertaining to SGE.

1.2.4 Task 6 – Reducing SNF Management Technical Risks and Uncertainties

The research work in Task 6 continues to support DOE-EM's mission by developing a better understanding of the diversity and unique characteristics of the various types of DOE SNF. These activities include development of specific research that addresses a number of cross-cutting considerations in order to ensure safe, long-term management of the broad range of SNF types.

1.2.4.1 Task 6 – Activities

The activities in Task 6 address unique needs by providing technical studies, evaluations, and option analyses, as identified and prioritized by DOE-EM strategic planning initiatives and the SNFWG. Some of the identified technical risks involve complying with criticality safety requirements for highly enriched fuels, age-related SNF degradation, and design issues associated with packaging DOE SNF for storage, transportation, and eventual disposal. Further, the activities include providing data and analyses for SNF processing TD, and for feasibility studies and evaluations such as those performed by the DOE SNFWG, the Idaho Integrated Product Team, and other DOE and governmental oversight groups. Specifically, the central goals of Task 6 are to support R&D efforts for achieving a DOE SNF configuration that enables safe transportation and disposal after long-term dry storage (i.e., a road-ready condition). Furthermore, Task 6 continuously provides data and technical support to the DOE Standard Canister Packaging Demonstration Project (Task 9) and to the SNFWG on related strategic initiatives.

1.2.5 Task 8 – Project Controls and Integration

To meet DOE-EM mission needs within the scope of the Environmental Management SNF TD Project, oversight is necessary for steering any collaborative efforts toward the desired outcomes.

1.2.5.1 Task 8 – Activities

Task 8 includes management, control, coordination, and integration activities for this project, with the understanding that data and information obtained over the course of these activities may be used in future DOE R&D activities. The project control and integration activities will ensure successful implementation of the Environmental Management SNF TD Project. The goal of this task is to foster communication among the technical leads by holding regular meetings to align the various research activities conducted within the scope of the individual tasks and subtasks, track deliverable developments, control project costs, identify technical and financial risks, and coordinate additional funding. Additional activities within this task include reporting the project progress to DOE-EM, developing project control/management-related documents such as this PEP, and presenting results/findings to the scientific community.

1.2.6 Task 9 – Evaluate SNF Packaging

Task 9 supports DOE-EM's mission to evolve road-ready SNF dry storage. It includes DOE SNF packaging TD.

1.2.6.1 Task 9 – Activities

Task 9 includes DOE Standard Canister packaging demonstration activities. The DOE Standard Canister [14] is a standardized canister system developed to store, transport, and potentially, dispose various types of DOE SNF. The packaging demonstration aims to successfully transfer DOE SNF stored in CPP-603 canisters into one or more DOE Standard Canister(s). Subsequently, the canister(s) will be loaded into the dry storage overpack(s).

An important Task-9 TD step, planned for completion within FY 2021, is the completion of a DOE Standard Canister remote closure system design, including procurement of the required equipment. Due to the global supply chain problems caused by the COVID-19 pandemic, this process was delayed. The current schedule aims for a completion by the end of calendar year 2022. The current design state of the welding technology is an orbital tool platform with a rotating, modular head that carries a welding tool, eddy-current and ultrasonic non-destructive examination equipment, tools for weld repair, and hammer peening equipment for weld stress relief. Besides design and equipment procurement, qualification testing of the closure system and safety analyses of the required SNF packaging procedures are also planned.

The understanding developed throughout the activities of Tasks 1, 4, and 9 will support the design of procedures and equipment for DOE SNF canister loading, conditioning, and sealing. Furthermore, canister transfer procedures and equipment could be developed, and a dry storge overpack model selected and procured. This additional R&D work would allow for moving a loaded and sealed DOE Standard Canister from within CPP-603's fuel-handling cave to an external storage location for continued dry storage. Funding provided by DOE-EM in coordination with DOE-NE beyond FY 2022 levels is needed to initiate the development and procurement of the remaining system procedures and components.

1.2.7 Task 10 – HFIR ASNF Dry Storage Concept

The general scope of this task includes the preparation of a conceptual plan for a demonstration of dry storage of HIFR ASNF.

1.2.7.1 Task 10 – Activities

This task was initiated in FY 2022. It is led by a research team at SRNL and includes limited development of a preliminary concept describing a process to retrieve HFIR ASNF from SRS L-basin to load, dry, and close a dry storage canister with HFIR ASNF. Further, monitoring of the ASNF will utilize the instrumented lid technology developed at SRNL and INL. FY 2023 follow-on activities could include moving from a preliminary concept design to the development of a HFIR dry storage concept demonstration plan.

1.3 Work Scope

INL, SRNL, and INL’s industry and academia partners will continue working together to ensure that the overall objectives of this work are met. INL will continue to lead the tasks and be supported by its partners, as appropriate. The technical leads for each task will continue developing and documenting the activities within their scope of work, including experimental configuration, testing matrixes, results documentation approach, and quality assurance approach.

1.4 Schedule

This project was formed from R&D activities ongoing since FY 2017. It will be continued throughout FY 2022 and beyond. Since the initiation of these R&D activities, a significant number of milestones have been completed, and additional ones will be completed throughout FY 2022. Table 2 summarizes the project milestones as they exist at the time of writing this PEP, and provides the date of completion for some of the milestones.

Table 2. Schedule and milestones.

TASK 1 – ASNF Laboratory Technical and Engineering Studies[a, b]	**Completion**	**Reports**
Milestone 1.1[c]: Final report on ASNF technical evaluations	9/23/2021	INL/EXT-21-01417 Rev. 0
Milestone 1.2[c]: Draft report on preliminary technical basis for extended dry storage for aluminum clad SNF	12/15/2021	INL/EXT-21-65214 Rev. 0

SUBTASK 1.1 – Oxyhydroxide Layer Behavior and Chemistry	Completion	Reports
Milestone 1.1.1[d]: Aluminum oxidation experimental design and system assembly	6/28/2018	INL/EXT-18-45857
Milestone 1.1.2: Model of aluminum/water reactions	12/1/2018	INL/EXT-18-51694
Milestone 1.1.3: Calculation of hydrogen generation from Al 1100	12/18/2018	INL/EXT-18-52249
Milestone 1.1.4: Calculation of hydrogen generation from other aluminum alloys	5/17/2019	INL/EXT-19-53964
Additional Report[e]: Vapor phase corrosion of pretreated aluminum alloys: Final Report	1/1/2020	INL/EXT-19-56497 Rev. 1
Milestone 1.1.6: Comprehensive analysis of hydrogen generation	8/30/2019	INL/EXT-19/55558

Table 2 (cont.). Schedule and milestones.

SUBTASK 1.2 – Oxide Layer Radiolytic Gas Generation Resolution	Completion	Reports/Notes
Milestone 1.2.1[d]: Experimental design	7/30/2018	INL/EXT-18-45858
Milestone 1.2.2: Material characterization	2/1/2019	INL/EXT-19-52738 Rev. 1
Milestone 1.2.3: Gamma irradiation	2/1/2019	INL/EXT-19-52738 Rev. 1
Milestone 1.2.4: Demonstration of oxide layer radiolytic gas generation	2/1/2019	INL/EXT-19-52738 Rev. 1
Milestone 1.2.5: Multi-dimensional irradiation test matrix	9/1/2019	INL/EXT-19-55202 Rev. 2
Milestone 1.2.6[f]: Complete Round-robin hydrogen gas analysis capability comparison	12/14/2020	INL/EXT-20-00810 Rev. 1
Milestone 1.2.7[b]: Evaluate molecular hydrogen gas measurement techniques	12/14/2020	INL/EXT-20-60008
Milestone 1.2.8[c, g]: Complete additional radiolytic gas generation analysis including helium-backfilled samples	2/17/2021	INL/EXT-21-61404
Milestone 1.2.9[c]: Complete additional radiolytic gas generation analysis for AA6061 samples including data analysis	12/15/2021	INL/EXT-21-01823
Milestone 1.2.10[c]: Steady-state H2 ‘roll-over’ point data for aluminum alloys 1100 and 6061	–	–
Milestone 1.2.11[c]: Report on expanded ASNF hydrogen generation and surface characteristics data collection	–	–

Table 2 (cont.). Schedule and milestones.

SUBTASK 1.3 – Sealed and Vented System Episodic Breathing and Gas Generation Prediction	Completion	Reports/Notes
Milestone 1.3.1: Canister-scale conceptual models	4/3/2018	INL/EXT-18-45860
Milestone 1.3.2: 3D canister-scale Multiphysics CFD models for sealed canisters	6/30/2018	INL/EXT-18-51683 Rev. 0
Milestone 1.3.3: 3D canister-scale Multiphysics CFD models for vented systems	9/30/2018	INL/EXT-18-51681 Rev. 0
Milestone 1.3.4: Improve CFD models including comprehensive sensitivity studies	1/31/2019	INL/EXT-19-52650
Milestone 1.3.5: Develop 3D facility-scale coupled Multiphysics CFD model	9/30/2019	INL/EXT-19-55185, Rev. 1
Milestone 1.3.6[c]: Complete temperature and dose rate calculations for relevant SRNL fuel geometry	3/31/2020	INL-EXT-20-57893
Milestone 1.3.7[c]: Evaluate effect of helium G-values on radiolytic chemistry model	4/14/2021	INL-EXT-21-62306
Milestone 1.3.8[c]: Evaluate effect of neutron poison corrosion on DOE Standard Canister	10/15/2020	INL/EXT-20-59994
Milestone 1.3.9[c]: Revise INL/EXT-18-51683 with grid convergence study	12/23/2020	INL/EXT-18-51683 Rev. 1
Milestone 1.3.10[c]: Revise INL/EXT-18-51681 with vented lid details	3/3/2021	INL/EXT-18-51681 Rev. 1
Milestone 1.3.11[c]: Revise INL/EXT-20-58578 with time stepping and G-value discussion	3/3/2021	INL/EXT-20-58578 Rev. 1
Milestone 1.3.12[c]: Modeling summary of ASNF in DOE sealed standard canisters	10/4/2021	INL/EXT-21-64413 Rev. 0
Milestone 1.3.13[c]: Report on mini-canister modeling with roll-over effects	3/31/2022	INL/RPT-21-66504 Rev. 0
Milestone 1.3.14[c]: Report on longer-term (100 to 200 year) modeling of DOE Standard Canister	_	_
Milestone 1.3.15[c]: Report on modeling of 1/3 canister model	_	_

SUBTASK 1.4 – Performance of ASNF in Dry Storage	Completion	Reports/Notes
Milestone 1.4.1: Characterize aluminum from the ATR canal	10/11/2018	INL/EXT-18-51230
Milestone 1.4.2: Develop individual ATR element handling capability for use in CPP-603	9/20/2019	CCN 245627
Milestone 1.4.3: ATR element visual inspection	9/20/2019	CCN 245627
Milestone 1.4.4: Surface oxide sampling technique	9/20/2019	CCN 245627
Milestone 1.4.5: Canister monitoring evaluation	9/30/2019	INL/EXT-19-55950

Table 2 (cont.). Schedule and milestones.

SUBTASK 1.5 – Additional Drying Studies[h]	Completion	Reports/Notes
Milestone 1.5.1: Issue ASNF Subtask 5 experiment test plan	8/1/2019	INL/EXT-19-54019 Rev. 1
Milestone 1.5.2: Issue engineering scale experiment design document	8/31/2019	INL/EXT-19-56017
Milestone 1.5.3: Successful completions of system operability testing	8/11/2020	INL/MIS-58841 Rev1
Milestone 1.5.4: Issue final report on ASNF drying	11/3/2021	INL/EXT-62416_Rev0
Milestone 1.5.5[c]: Letter report on alternative drying recipes test plan	_	_
Milestone 1.5.6[c]: Conceptual description of the loading, drying, closure welding of ASNF in the DSC	_	_

SUBTASK 1.6 – Surrogate Sample Preparation and Validation	Completion	Reports/Notes
Milestone 1.6.1: Growth/characterization of oxides on 1100 alloy	8/1/2018	SRNL-STI-2018-00427
Milestone 1.6.2: Characterization of oxides on dry Uruguay fuel plate	8/1/2018	SRNL-STI-2018-00449
Milestone 1.6.3: Growth/characterization of oxides on 6061 alloy	10/1/2018	SRNL-STI-2018-00428
Milestone 1.6.4: Growth/characterization of oxides on 5052 alloy	11/20/2018	SRNL-STI-2018-00646
Milestone 1.6.5: Characterization of oxides on wet Uruguay fuel plate or L-basin aluminum materials	3/14/2019	SRNL-STI-2019-00058
Milestone 1.6.6[c]: Complete test plan for radiolysis testing of ASNF L-basin materials	3/20/2020	SRNL-RP-2020-00187
Milestone 1.6.7[c]: Complete irradiation of as-is L-basin samples	11/30/2021	SRNL-STI-2021-00625
Milestone 1.6.8[c]: Complete irradiation of dried L-basin samples	11/30/2021	SRNL-STI-2021-00625
Milestone 1.6.9[c]: Document results of gas generation on as-is and dried ASNF L-basin materials	11/30/2021	SRNL-STI-2021-00625

TASK 2 – Technical and Engineering Analyses to Address Spent Fuel Management	**Completion**	**Reports/Notes**
No milestones planned	NA	NA

TASK 3 – Spent Fuel Data Management and Analysis	**Completion**	**Reports/Notes**
No milestones planned	NA	NA

Table 2 (cont.). Schedule and milestones.

TASK 4 – ASNF Fuel Validation/Verification		
SUBTASK 4.1 – Development of a DOE Standard Canister Lid[i]	Completion	Reports/Notes
Milestone 4.1.1: Finalize instrumented Canister test plan	3/31/2019	SRNL-RP-2019-00225
Milestone 4.1.2: Complete system detailed design	5/31/2019	SRNL-L2240-2019-00002
Milestone 4.1.3: Complete lid detail design	6/30/2019	SRNL-L2240-2019-00003
Milestone 4.1.4: Obtain/fabricate basket and canister	12/9/2019	SRNL-L2240-2019-00006
Milestone 4.1.5: Assemble lid components	8/1/2019	SRNL-L2240-2019-00024
Milestone 4.1.6: Complete initial full system qualification testing	9/1/2019	SRNL-L2240-2019-00004
Milestone 4.1.7: Perform full system testing	20/02/2020	SRNL-L2240-2019-00005 Rev. 1
Milestone 4.1.8: Issue final report	2/21/2020	SRNL-L2240-2019-00007 Rev. 1
Milestone 4.1.9: Complete test plan for real-time measurement of hydrated oxide specimens under irradiation	4/6/2020	SRNL-RP-2020-00219
Milestone 4.1.10: Fabricate hydrated oxide specimens for testing	8/5/2020	SRNL-L6000-2020-00034
Milestone 4.1.11: Initiation irradiation and measurement of as-is hydrated oxide specimens (large coupons)	9/1/2020	SRNL-L6000-2020-00038
Milestone 4.1.12: Initiate irradiation and measurement of dried hydrated oxide specimens (large coupons)	9/18/2020	SRNL-L6000-2020-0046
Milestone 4.1.13: Draft document of results of irradiated hydrated oxide specimens	3/19/2021	SRNL-L6000-2021-00006
Milestone 4.1.14: Complete irradiation of as-received large coupons	11/30/2021	SRNL-STI-2021-00625
Milestone 4.1.15: Initiate irradiation of large coupon assembly and update drying recipe	11/30/2021	SRNL-STI-2021-00625
Milestone 4.1.16: File report of irradiated as-received and dried large coupon testing	11/30/2021	SRNL-STI-2021-00625
Milestone 4.1.17: Report on mini-canister testing campaigns, MURR surrogate testing, including predictive modeling and simulation (M&S) work	–	–
Milestone 4.1.18: Report on interim results from the alternate drying condition, including predictive M&S work	–	–

Table 2 (cont.). Schedule and milestones.

SUBTASK 4.2 – Development of a CPP-603 Canister Lid[j]	Completion	Reports/Notes
Milestone 4.2.1: Select and fabricate candidate's sensors	5/1/2020	INL/EXT-20-58149
Milestone 4.2.2: Feasibility study for wireless/spatial data system and point data system	9/30/2021	INL/EXT-21-64564
Milestone 4.2.3: Separate testing of radiation sensor and data acquisition and transmission	9/30/2021	INL/EXT-21-64564
Milestone 4.2.4: Draft report on selected CPP-603 instrumentation for canister monitoring technology	12/22/2021	INL/EXT-21-65501
Milestone 4.2.5[c]: Draft report on roadmap to final CPP-603 integrated lid system	12/16/2021	INL/EXT-21-65431
Milestone 4.2.6[c]: CPP-603 instrumented lid system - F&ORs	–	–
Milestone 4.2.7[c]: CPP-603 instrumented lid system - Conceptual design report	–	–
Milestone 4.2.8[c]: CPP-603 instrumented lid system prototype - Placement of engineering, design and procurement contract	–	–

TASK 5 – Disposition of Sodium-Bonded SNF - Technical Risks and Uncertainty		
SUBTASK 5.1 – Evaluation of MEDE as a treatment alternative for sodium-bond SNF[k]	Completion	Reports/Notes
Milestone 5.1.1: Finalize FERMI MEDE study test plan and analytical chemistry plan	7/29/2019	INL/EXT-19-54148
Milestone 5.1.2: Complete MEDE furnace design	12/9/2019	–
Milestone 5.1.3: Fabricate or procure equipment used to extract sodium	4/30/2020	–
Milestone 5.1.4: Determine element cut points using radiography	5/14/2020	–
Milestone 5.1.5: Complete Phase I MEDE furnace construction	5/21/2020	–
Milestone 5.1.6: Complete Phase I MEDE furnace qualification testing	6/22/2020	–
Milestone 5.1.7: Complete MEDE furnace construction in FASB glovebox	8/27/2020	–
Milestone 5.1.8: Operational readiness completion	11/3/2020	–
Milestone 5.1.9: Complete blanket elements testing	12/16/2021	–
Milestone 5.1.10: Complete blanket assembly testing	1/13/2022	–
Milestone 5.1.11: MEDE project finish	3/11/2022	–
Milestone 5.1.12: End-of-year summary report on MEDE results and proposed Na-bonded blanket material path forward	2/17/2022	INL/RPT-22-66033

Table 2 (cont.). Schedule and milestones.

SUBTASK 5.2 – Evaluation of SGE as a treatment alternative for sodium-bond SNF[l]	Completion	Reports/Notes
Milestone 5.2.1: Cladding Hull Waste - Data needs and test rigs designs	6/21/2021	–
Milestone 5.2.2: Cladding Hull Waste - Experimental test rig construction	8/31/2021	–
Milestone 5.2.3: Cladding Hull Waste - Final report on advancement of DOE nuclear waste separation technologies – GA support	11/12/2021	39863R00003 Rev. 1
Milestone 5.2.4: Evaluation and Recommendations on SGE for Cladding Hull Waste - Letter report	2/17/2022	–
Milestone 5.2.5: Follow-up contract placement for SGE optimization for cladding hull waste treatment	–	–
Milestone 5.2.6: SGE technology optimization for treatment of sodium-bonded SNF including roadmap for tests of technology on hot material – Report	–	–

TASK 6 – Reducing SNF management technical risks and uncertainties	**Completion**	**Reports/Notes**
Milestone 6.1: Bounding calculations for hydrogen generation and pressurization of DOE Standard Canister loaded with ASNF	–	–

TASK 7 – Disposition of Sodium-Bonded SNF - Technical Risks and Uncertainties	**Completion**	**Reports/Notes**
No milestones planned	NA	NA

TASK 8 – Project Controls and Integration	**Completion**	**Reports/Notes**
Milestone 8.1: Environmental Management TD ASNF dry storage final report	12/16/2021	INL/EXT-21-65214 Rev. 0

TASK 9 – Evaluate SNF packaging	**Completion**	**Reports/Notes**
Milestone 9.1: Delivery of circumferential welding device for DOE Packaging Demonstration for testing to INL	–	–

TASK 10 – HFIR packaging concept	**Completion**	**Reports/Notes**
Milestone 10.1[c]: Draft report on HFIR packaging demo conceptual plan	–	–

Table 2 (cont.). Schedule and milestones.

a.	Milestone numbering changed from X.X to 1.X.X to reflect the incorporation of the ASNF Long Term Dry Storage Technical Issues under Task 1. Internal milestone number remains unchanged.
b	It was determined that Milestones 1.5, 1.7, 2.6 did not provide value to the project. Thus, these milestones were dismissed or replaced.
c	New milestone.
d	Not for external release!
e	Intermediate, draft deliverable.
f	Replaces original milestone.
g	Includes intermediate milestones.
h	Milestone numbering for DOE dissemination only. Internal milestone numbering deviates and includes intermediate deliverables.
i	Milestone numbering changed from to reflect the incorporation under Subtask 4.1. Internal milestone number remains unchanged.
j	Milestone numbering changed from to reflect the incorporation under Subtask 4.2. Internal milestone number remains unchanged.
k	Milestone numbering changed from to reflect the incorporation under Subtask 5.1. Internal milestone number remains unchanged.
l	Milestone numbering changed from to reflect the incorporation under Subtask 5.2. Internal milestone number remains unchanged.
m	Scope was reduced and milestone was removed.

1.5 Cost Baseline

The current cost baseline for this project is $29M: $24M in FY 2017–2021 funds and $5M in FY 2022 funds, as illustrated in Table 3.

Table 3. Project budget.

Task	Description	FY 2017-FY 2021 ($K)	FY 2022* ($K)
1	ASNF laboratory technical and engineering studies (includes three subtasks described in attachment 1)	$8,890	$730
2	Technical and engineering analyses to address spent fuel management	$600	$0
3	Spent fuel data management and analysis	$800	$0
4	ASNF validation/verification	$3,300	$1,060
5	Disposition of sodium-bonded SNF – technical risks and uncertainty	$3,532	$360
6	Reducing SNF management technical risks and uncertainties	$3,518	$710

Table 4 (cont.). Project budget.

7	Disposition options for fuel debris at SRNL	$0	$0
8	Project controls and integration	$860	$310
9	Evaluate SNF packaging	$2,500	$1,720
10	High Flux Isotope Reactor ASNF dry storage concept	$0	$110
	Totals	**$24,000**	**$5,000**
	Estimated carryover from FY 2021	–	**$2,030**
	Total available for expenditure in FY 2022, including carryover	–	**$7,030**
	Estimated expenditures in FY 2022	–	**$6,732**
	Estimated carryover from FY 2022 into FY 2023*	–	**$298**
NOTE:	*Some FY 2022 tasks are new starts or tasks where the sub-contracts are still being placed. Therefore, the timelines and expenditures for those tasks are subject to change depending on funding availability and negotiations with sub-contractors.*		

2. PROJECT ORGANIZATION AND INTERFACES

The project manager has approval authority over any action that will impact the project schedule, cost, scope, milestones, or commitments. The integration lead will coordinate with the technical leads and project manager to ensure that all project planning, execution, and oversight are appropriately conducted to meet the project objectives. Each technical lead is responsible for the development and execution of a task-specific test plan.

2.1 Roles and Responsibilities

The key project personnel are identified in the following list. The project manager is responsible for maintaining a current list of key project personnel in the event of any changes made prior to a revision of this PEP.

- Project Manager – Josh Jarrell (INL)
- Integration Lead – Elmar Eidelpes (INL)
- Technical Leads – Task 1:
  - Subtask 1.1: None (Closed)
  - Subtask 1.2: Greg Horne (INL)
  - Subtask 1.3: Alex Abboud (INL)
  - Subtask 1.4: None (Closed)
  - Subtask 1.5: Rebecca Smith (INL)
  - Subtask 1.6: Robert Sindelar (SRNL)

- Technical Leads – Task 4:
  - Subtask 4.1: David Herman (SRNL)
  - Subtask 4.2: Evans Kitcher (INL)
- Technical Leads – Task 5:
  - Subtask 5.1: Brian Preussner (INL)
  - Subtask 5.2: Robert Buckingham (GA)
- Technical Lead – Task 6: Brett Carlsen (INL)
- Technical Lead – Task 8: Josh Jarrell (INL)
- Technical Lead – Task 9: Dan Thomas (INL)
- CPP-603 Technical Support Staff: Kristen Mortensen (IEC)
- DOE-EM Project Manager: Jomaries Rovira (EM-4.23)

Battelle Energy Alliance support organizations such as Environment, Safety, and Health and Quality Assurance will be employed as well.

3. PROJECT CONTROL AND REPORTING

3.1 Project Authorization

Funding of this project is requested by INL through Work Authorization and Task Change Requests. In accordance with LWP-7390, "Project Management Process," initial work authorization was given by DOE-EM on September 6, 2017, and the approved Work Authorization and Task Change Requests are included as Appendix A of this PEP. The initial fund authorization form from October 31, 2017, is included as Appendix B of this PEP.

3.2 Activity Work Authorization

All work authorizations will be conducted in accordance with LWP-7390. The project manager will, as needed throughout the project lifecycle, continue authorizing work activities in accordance with the work breakdown structure. Task Baseline Agreements, Memorandum Purchase Orders (MPOs), and Work Orders will be issued, as needed, and approved by the project manager prior to starting work.

3.3 Performance Baseline Measurement

Project earned value will be measured by assessing the milestones completed for designated project activities. The milestone completion will be evaluated in agreement between the project manager and principal investigator. Spending plans on the activity level will be developed, and spending-based progress tracking will be employed to control the project's financial performance. Performance measurement begins when the formal baselines (scope, schedule, and cost) in this PEP have been approved, and as work is authorized.

3.4 Reporting

INL's Planning and Financial Controls prepares monthly status reports using P6, Cobra, Discoverer and BDSIS.

The project manager will report frequently (no less than bi-monthly) the activities and status of the project to Jomaries Rovira, DOE-EM 4.23, either directly or indirectly through assigned DOE-EM program staff.

3.5 Baseline Change Control and Management

The project will use an internal trend program to record any change history. Baseline change control will be applied to the approved performance measurement baseline in accordance with INL procedures. The project manager of INL will make the final decision on changes within the project work package.

4. SAFEGUARDS AND SECURITY

Activities performed for this project will be in accordance with PDD-246, "Nuclear Materials Management, Control and Accountability Plan,". Environmental Management SNF TD Project personnel are responsible to comply with INL safeguards and security requirements and are responsible for the quality of the end products and results. Specifically, the use of export control and classification control will be required.

5. QUALITY ASSURANCE

The Environmental Management SNF TD Project work performed at INL shall be in accordance with QAP requirements as defined in PDD-13000, "Quality Assurance Program Description," and implementing procedures. This DOE Idaho-Operations-Office approved QAP invokes and implements the requirements of:

- DOE Order 414.1D, "Quality Assurance"
- Title 10 Code of Federal Regulations, Part 830, Subpart A, "Quality Assurance Requirements" (10 CFR 830, Subpart A)
- American Society of Mechanical Engineers, Nuclear Quality Assurance Standard (NQA-1-2008/1a-2009 Edition)
- NQA-1-2008/1a-2009, Subpart 2.7, "Quality Assurance Requirements for Computer Software for Nuclear Facility Applications"
- NQA-1-2008/1a-2009, Subpart 2.14, "Quality Assurance Requirements for Commercial Grade Items and Services."

Non-INL participants must comply with INL QAP requirements as they are specified in contracts, MPOs, Memorandums of Understanding, Memorandums of Agreement, or other interface agreements.

The project manager will ensure that work performed at INL is regularly evaluated to determine compliance with applicable INL QAP requirements. Each participant (e.g., INL, SRNL)'s scope of work shall be reviewed by a program/project quality engineer or procurement quality engineer to identify the appropriate NQA-1 requirements applicable thereto. Applicable acceptance criteria for participant work products shall also be specified in contracts, MPOs, Memorandums of Understanding, Memorandums of Agreement, or other interface agreements. Applicable INL requirements such as peer review and data qualification, shall be flowed down to the interface agreements.

6. HEALTH AND SAFETY

The NEPA is our basic national charter for protection of the environment. It establishes policy, sets goals, and provides a means for carrying out the policy. INL used an environmental checklist to determine the level of NEPA documentation required for the project, and to determine any required environmental evaluations, permits, or permit modification. The environmental checklist, INL-18-048, documented that the actions of the project would not individually or cumulatively have a significant effect on the human environment, and that no environmental assessment or environmental impact statement would be required.

The Environmental Management SNF TD Project is committed to doing work safely and will conduct all work in accordance with the Integrated Safety Management. [17] All employees have the obligation to stop work any time an unsafe work condition is identified. The project manager will be notified immediately if a "stop work" is initiated. Efforts will be directed to immediately fix the unsafe condition.

7. RECORDS AND CONFIGURATION MANAGEMENT

All documents and records (e.g., controlled documents, drawings, and photographs) needing to be captured, stored, and managed to support the Environmental Management SNF TD Project will be controlled in accordance with LWP-1202, "Records Management," and LWP-1201, "Document Management." The Electronic Document Management System (EDMS) is INL's approved file location for Environmental Management SNF TD Project records. Each record is given a unique identifier and retention period according to INL's Record Types List (Appendix C).

Once a record is complete, the participant will provide the record and associated documentation to Environmental Management SNF TD Project records coordinator within 60 days to be retained in accordance with INL's records management procedures.

The EDMS is used by the Environmental Management SNF TD Project for storage of controlled documents. The document change control (DCR) process in EDMS is used for release of all controlled documents and can be used for documentation of review comments and resolution. The DCR process automatically generates compliant records of all controlled documents and document changes.

Configuration management is maintained by implementing PDD-10502, "INL Configuration Management Program," and LWP-10500, "Managing the Configuration of Structures, Systems, and Components," as they apply to structures, systems, components, and all facility modifications. Experiment/equipment design configuration is managed through EDMS and DCR. Each individual who makes a change to a design or document is responsible for recording that change via the formal DCR process.

In addition, markings will be applied to project-controlled documents and INL-generated reports, except in the case of documents intended for public release (e.g., external reports, publications, presentations, and posters), as determined by the INL Derivative Classifier Review and/or project management. Controlled information markings are applied in accordance with LWP-11202, "Controlled Unclassified Information Program."

8. PROJECT CLOSURE

The project manager will ensure an orderly and timely closeout of the project, including any transfer of documents. Project closeout activities will be conducted in accordance with MCP-7001, "Management of Capital Asset Projects."

The project acceptance and closeout phase will begin once the project deliverable(s) have been accepted and transferred to the customer.

The project manager will write the project closeout report (including a lessons-learned section) and develop a final cost report.

9. REFERENCES

1. *Aluminum Clad Spent Nuclear Fuel Long Term Dry Storage Technical Issues Project Execution Plan*, PLN-5596, May 2018.

2. *Technical Basis for Extended Dry Storage of Aluminum Clad Spent Nuclear Fuel*, INL/EXT-21-65214, December 2021.

3. *Status Update on the Instrumented Lid Project*, SRNL-L2240-2019-00007, December 2019.

4. *Architecture and Components for the Remote-Canister Monitoring System*, INL/EXT-21-65501, December 2021.

5. *Removal of Bond Sodium form Full-Length Unirradiated Fermi-1 Blanket Elements and Assembly via Melt-Drain Evaporate Process*, INL/RPT-22-66033, February 2022.

6. *Response to General Atomics' Fuel Plenum Waste Final Report on Initial Study,* Interoffice Memorandum, February 17, 2022.

7. *Mission & Functions Statement for the Office of Environmental Management,* U.S. DOE-EM, https://www.energy.gov/em/downloads/mission-functions-statement-office-environmental-management, current as of March 21, 2022.

8. *Mission,* U.S. DOE-EM, https://www.energy.gov/em/mission, current as of March 21, 2022.

9. *Energy and Water Development and Related Agencies Appropriations Bill, 2022,* Full Committee Print, House of Representatives, 117th Congress 1st Session, 2021.

10. *Management and Disposal of U.S. Department of Energy Spent Nuclear Fuel,* U.S. NWTRB, December 2017.

11. *Aluminum-Clad Spent Nuclear Fuel: Technical Consideration and Challenges for Extended (>50 Years) Dry Storage*, DOE/ID RPT-1575, June 2017.

12. *Aluminum Clad Spent Nuclear Fuel Long Term Dry Storage Technical Issues Action Plan – Technical and Engineering Activities*, INL/EXT-17-93408, November 2017.

13. *Aluminum Clad Spent Nuclear Fuel Long Term Dry Storage Technical Task Plan*, INL, February 2018.

14. *Preliminary Design Specification for Department of Energy Standardized Spent Nuclear Fuel Canisters*, DOE/SNF/REP-011 Rev. 3, August 1999.

15. *1995 Settlement Agreement: Overview & FAQs*, Idaho Department of Environmental Quality, https://www.deq.idaho.gov/idaho-national-laboratory-oversight/1995-settlement-agreement/, current as of March 21, 2022.

16. *Test and Chemistry Plan for MEDE Treatment of Fermi-1 Blanket Materials*, INL/EXT-19-54148, July 2019.

17. *Integrated Safety Management (ISM),* U.S. DOE EHSS, https://www.energy.gov/ehss/integrated-safety-management-ism, current as of March 21, 2022.

APPENDIX A

OFFICE OF ENVIRONMENTAL MANAGEMENT – TECHNOLOGY DEVELOPMENT OFFICE (TDO)
WORK AUTHORIZATION/TASK CHANGE REQUEST (TCR)

Project Number:	ID101501	Date:	Sept. 2017	AFP Change Month:	Sept. 2017
Task Title:	**Spent Nuclear Fuel Technology Development**				
Site/Contractor:	INL/BEA	TDO Program Plan Focus Area:	SNF/SNM	Attachment One contains description of Tasks 1 to 3	Technical Task Plans are due by Sept. 30, 2017

Contract Number if other than National Laboratory or DOE site contractor:
Name of Principal Investigator: INL: Mike Connolly
SRNL: Bob Sindelar

Name of Budget Analyst at the site where the contract is held:
DOE-ID, Ron Ramsey
DOE-ID, Lance LaCroix

FY17 Technology Development (TD) activities include technical and engineering studies to address knowledge gaps and identify cost efficiencies in support of continued safe management of spent fuel at Idaho and Savannah River sites. These studies will require collaboration with other National Labs and universities, leveraging EM base funded spent fuel activities, and leveraging past and present EM/NE investments in research and development capabilities. The objective of these technical and engineering studies is to ensure viability/safety of extended dry storage of DOE spent fuel, help ensure viable spent fuel management options for DOE's research test reactors, and maintaining spent nuclear fuel data and conducting related analyses. Note that the indicated funding levels are approximate and may be reallocated within the available funding depending on pending programmatic decisions and development of detailed technical evaluation plans.

Specific FY17 TD Tasks

Task#	Description	Funding
1.	Technical & engineering studies to address knowledge gaps regarding dry storage of Al-Clad fuel	$ 2,600K
2.	Technical & engineering evaluation and analysis to address spent fuel management options and challenges	$ 600K
3.	SNF data management and analysis	$ 800K

The Technical Task Plans for each FY-17 TD Task are due by 30 September, 2017. NOTE: Until the details for Technical Task Plans for each task are completed, no more than 25% of the proposed funding for any of the 4 Tasks noted above can be spent.

The minimum information to be included in the Technical Task Plans is:

a. Brief description of the problem being addressed
b. How the research addresses the need and technical approach
c. ID of Lead laboratory and/or Principal Investigator
d. Duration of total effort (if a multi-year effort)
e. Total funding needed for FY-17 (and carryover into FY-18)
f. Funding apportionment
g. Timeline
h. Deliverables along that timeline

The Office of Nuclear Materials Management (EM-4.23) commits to supplying necessary information to the Office of Technology Development (EM-3.2) to help them prepare the TD-related reports noted in the FY-17 Omnibus Budget language and Senate report 114-236.

New BA ($K) Requested	Prior Funding ($K) in this FY	Total Uncosted ($K) as of Beginning of this FY	Total Available Funding ($K) including this request (add first three columns)

Page 1 of 2

4000	0	0	4000

Spend Plan for Total Available Funding (use actual costed funds for previous quarters)

1st Quarter of FY	2nd Qtr of FY	3rd Quarter of FY	4th Quarter of FY	Projected uncosted at the end of this FY
0	0	0	500	3500

Funding Codes (To be Completed by Budget Office)

Site's	Fund	Year	Allottee	Reporting Entity	SGL	Object Class	Program	Project	Amount
INL	01250	2017	02	500003	61000000	25400	1110676	00046331	$3,000,000.00

This action obligates the remaining fiscal year 2017 funding of $3,000,000.00 for the national spent fuel program.
Refer to the attached TCR that obligates the initial $1,000,000.00.
All other approvals are provided on the attached.

Submitted by:	Genia Mckinley, TDO Program Manager John R. Shultz, Ph.D., EM-4.23 (N/A)	Date: 9/5/17
	Headquarters Project/Task Manager (Print & Sign)	
Field:	DOE-ID: Ron Ramsey (N/A)	Date:
Field DOE Representative (Print & Sign)		
Concurred by:	Hitesh Nigam, EM-4.23 (N/A) Steven P. Schneider, EM-4.2 (N/A)	Date:
TDO Program Manager (Print & Sign)		
Approved by:	Rodrigo V. Rimando, Jr.	Date: 9/6/2017
TDO Director, EM-3.2		
Submitted to:	Fatima Pashaei	Date: 9/6/2017
	EM-HQ Budget Analyst for TDD to complete AFP change	

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APPENDIX B

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                    BATTELLE ENERGY ALLIANCE              31-Oct-2017
                    FUNDS AUTHORIZATION FORM

Period Name :    OCT-FY18
Original:           Revision_number:
___________________________________________________________________________

AFP Num: 0000000018             | Non AFP Num:
Work for Others:                | WFO Control Num:
Local Use: 0502377              | WFO Proj Num:
Stars Project: 0004633          | Agreement Num:
Program : 1110676               |               :
Fund Code: 01250                |               :
Object Class: 25400             |               :
                                |               :
Oracle Project Number: 102973
Project Name: National Spent Nuclear Fuel 18
WFO Customer:
___________________________________________________________________________
Comments: This notifies the project team that carryover funds remain
          uncosted from prior years.




___________________________________________________________________________

Period of Performance:  Begin: 18-AUG-17 End: 30-SEP-18
________________________________________
FUNDING                  BA            |
                                       |
Prior Year Funding:       $3,905,282.82|
_______________________________________|
PREVIOUS                           $.00|
                                       |
OCT-FY18 CHANGE                    $.00|
_______________________________________|
TOTAL AMT                 $3,905,282.82|
_______________________________________|

Funds Assigned To
Funds Manager :  WRIGHT, CHRISTOPHER
Program Control Engineer :  LINDSAY, MARCIA
Project Manager:  CARLSEN, BRETT
Funding  Admin Signature :  JNY
FOR NON-ACCEPTANCE YOU MUST REPLY TO :  JNY

***************************************************************************
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APPENDIX C

:: Security/Privacy INL INTRANET |HOME ::WWW ::Phone:::

Records Type List
Aluminum Spent Nuclear Fuel Program

Return to Records Schedule Matrix Home

- **Plan Number:** PLN-4653
- **Point of Contact:** Mount, Judy L
- **DRSC:** EROB 3EO104
- **Comments:** Michael Connolly U003. Record retained on EDMS and \\fserob1\projects\ASNF

UFC	Record Description	Category (ies)	Disposition Authority	Destruct Moratorium (s)	Retention (Period)	Retention (Requirement/Citation)	Quality Assurance	Media Form (s)
0000	**MANAGEMENT/ADMINISTRATION**							
0250	**Controlled Documents** The master, or record copy, and the controlled document case file.							
0250	Controlled documents pertaining to operations, programmatic, safety significance, requirements roll down, or environmental aspects including Spent Nuclear Fuels (N1-434-01-3-1). This includes one record copy of each controlled document created with related instructions and documentation showing inception, scope, and purpose of the document (i.e., case file) *Comments: All controlled document to be processed through DRSC and retained in EDMS*		ENV1-b-4-a		Cut off when superseded, obsolete or canceled. Destroy 75 years after cut off.	ICP only: Retain nonpermanent WIPP QA records for ten years from the date of record generation, and then disposition according to the approved DOE schedule. New Mexico Environmental Department (NMED) Waste Isolation Pilot Plant (WIPP) Hazardous Waste Facility Permit	Sitewide / QA Lifetime	
1000	**MANAGEMENT SYSTEMS**							
1150	**Procurement**							
1151	**Request for Proposal (RFP)**							
1151	Contract, requisition, purchase order, lease, and bond and surety records, including correspondence and related papers pertaining to award, administration, receipt, inspection and payment. Procurement or purchase organization copy, and related papers. Transactions at or below the simplified acquisition threshold and all construction contracts at or below $2,000.		A3-3-a-1-b		Destroy 3 years after final payment.	For ICP records only: Legal Moratorium applies Cut off after DCAA audit. Destroy 4 years after cutoff, or 3 years after final payment, whichever is longer.		
7000	**OPERATIONS AND PROGRAMS**							
7650	**Nuclear Materials Handling** Includes (but not limited to) documentation pertaining to the receipt, storage, and handling of nuclear materials; documents retained for evidential information during the fuels lifecycle until the fuel is transferred to an off-site facility. Information may also include Criticality Control Areas (CCS) documentation such as inventories, criticality safety evaluations (CSE), criticality safety assessments, and other appropriate safety analysis documentation showing normal and abnormal conditions that may affect the nuclear material.							

7652	**Spent Nuclear Fuel** These records preserve documentary evidence for the protection provided to employees, the public, property, and the environment during activities associated with storing and handing the fuel.							
7652	Off-Site Storage Facility or Final Repository Documents - The SNF project case files include records required by DOE, DOT, EPA, and/or NRC. Spent nuclear fuel records may include, but are not limited to, the following related records: a. Documents that contain unique serial numbers for each fuel handling unit, dates received, types and conditions of fuel stored characteristics of fuel storage media, (e.g., pH, Cl-), the receipt and transfer of SNF within and between onsite or offsite facilities, fuel storage locations, and storage positions. b. Records that contain fuel information questionnaires completed by the shipper documenting fuel composition, cladding, physical description of fuel, fuel packaging, fuel-handling fixtures, and shipping containers. c. Documents that provide details sufficient to determine the requirements for and record the analytical results associated with radiation shielding, thermal performance, and basis of criticality safety for the fissile material contained in spent nuclear fuels and process systems (e.g., Criticality Safety Evaluation Reports, Origen computer code data containing radionuclide mass inventory, decay heat, and dose rate information). d. Correspondence, including management review and approval letters pertinent to receipt and shipment of spent nuclear fuel. e. Drawings, specifications, photographs, non-destructive examinations (NDE) reports or review records, contract or work agreements, statements of work, audits, event documentation, permits, personnel training and qualifications documents of individuals executing program requirements, organization charts, property lists, closure plans, final reports, and procedures. f. Documentation that describes how SNF records that require long-term retention periods are being stored, including documents and programs needed to retrieve information (i.e. indices, computer programs). g. Documents that provide evidence of the quality or describe processes associated with the characterization, conditioning, and acceptance of DOE spent nuclear fuel. *Alternate Description:* *Handling and Disposition Instructions:* *All ASNF records that have reached or exceeded the retention periods will be dispositioned as follows:* *Nonpermanent QA records shall be retained for a minimum of 3 years or as specified by procurement documents, whichever is longer.*		N1-434-01-3-1	LGL (Legal)	Destroy when 75 years old or 6 years after the demise of the repository/storage facility whichever is later.		Sitewide / QA Lifetime	

	Nonpermanent QA records shall NOT be disposed of until the following conditions are met: *1. Regulatory requirements are satisfied.* *2. Operational status permits.* *3. Purchasers requirements are satisfied.* *Program/Project Records:* *Training Records* *Development Artifacts* *Comments:* *EDMS* *TRAIN* *FSER051*							