Advanced Fogging Technologies Demonstration

PARTNERS

National Nuclear Laboratory (NNL)
UNITED KINGDOM

Idaho National Laboratory (INL)
Florida International University (FIU)
U.S. DOE EM

Red tinted FX2 fogging solution has thoroughly penetrated the initially white talcum powder in 42 m³ test at FIU.

Technical Summary

Radiological contamination control is crucial during decommissioning and demolition (D&D) activities, as well as during modifications to existing radiological systems. Normally, radiological fixatives are applied directly by workers to allow subsequent D&D operations. The application of a remote process (i.e., fixative and delivery system) that can reliably reduce airborne radiological or mercury (Hg) contamination and affix loose contamination in a large (i.e., industrial scale) space would significantly benefit these D&D efforts. Since 2012, the INL and the NNL have collaborated to demonstrate that remotely-operated large scale application of a contamination affixing fog formulation was possible. In 2014, INL conducted pilot scale testing (9 m³ space) of the fogging process and optimized the fogging solution recipe, referred to as FX2. In 2015, the INL/NNL team engaged FIU to conduct a room scale (42 m³ hot cell mockup) cold demonstration. A test sample from the FX2 fogging demonstration at FIU is shown in the figure. Additionally, NNL conducted a very large room scale (450 m³ enclosure) cold test in the UK. In addition to demonstrating the FX2 process on scales realistic for D&D uses, bench scale work was undertaken on developing fogging formulations to capture Hg vapor and liquid Hg contamination. The Hg capture solution, referred to as FX Hg, shows great promise for containing Hg contamination in residential and industrial facilities. Test results indicate that, for Hg vapor, the FX Hg fixative will be able to achieve the 8-hour weighted average exposure limit of 0.1 mg/m³ imposed by the Occupational Safety and Health Administration.

Path Forward

- Identify appropriate opportunity and demonstrate the FX2 fogging process in a radioactively contaminated facility that is part of an actual D&D closure project.
- Alternatively, the demonstration may employ the FX Hg contamination abatement product in a Hg contaminated facility.

Funding FY2012 -2014 - $710K | FY2015 - $250K | Outyears - $250K

Key Accomplishments

- Developed a solution that effectively affixes radiological contamination to surfaces.
- Successfully demonstrated practicality of remote fogged delivery of the fixative solution using commercially available technology (i.e., Curtis Dyna-Fog, Ltd.)
- Optimized the fogging solution composition, resulting in the current FX2 formulation.
- Demonstrated the FX2 fogging process at multiple scales (i.e., 9 m³, 42 m³, and 450 m³), validating its practicality for large room sized spaces, and thus applicability to many DOE EM D&D needs.
- Demonstrated, at bench scale, the efficacy of the FX Hg fixative/abatement agent for reducing Hg vapors.

Key Benefits

- Minimizing airborne and loose radiological contamination significantly reduces risk to employees, as well as decreases cost and schedule, for D&D. Providing a reliable, unmanned method of introducing a coating that captures and fixes contamination in place within facilities further reduces risk, cost, and schedule for these challenging conditions.
- Mercury poses significant health risk to D&D workers. Development and demonstration/validation of a new Hg vapor fixative/abatement agent for facilities with Hg contamination will also provide significantly improved safety and cost benefits to the EM mission.

For more information on this project or the EM International Program

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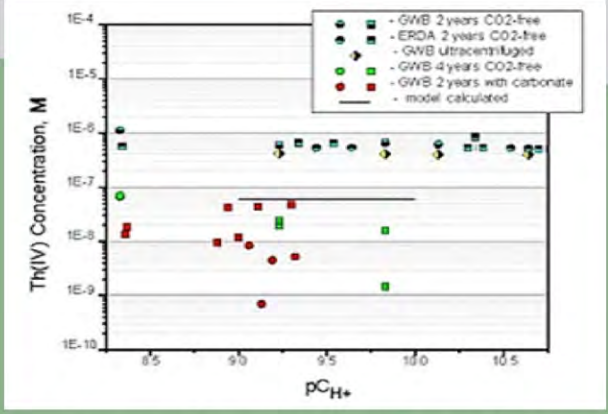
U.S. DEPARTMENT OF ENERGY

Assesment of Mp(IV) and U(IV) as Improved Analogues for Pu(IV) in High Ionoic Strength Brine Systems

PARTNERS

Kalsruhe Institute of Technology (KIT)
Institute of Nuclear Waste Disposal (INE)
GERMANY

Los Alamos National Laboratory (LANL)
U.S. DOE EM



Concentration of thorium measured in WIPP simulated brines.

Technical Summary

LANL and KIT/INE are collaborating to assess neptunium (IV) [Np(IV)] and uranium (IV) [U(IV)] as improved and more realistic analogues for plutonium (IV) [Pu(IV)] in high Ionic-strength brine systems. The planned work will address the multiyear metastability of the thorium (IV) [Th(IV)] analogue, illustrated in the figure, which leads to the over-prediction of initial solubility, does not define a clear equilibration point, and cannot be used to evaluate either complexation or colloidal behavior.

Plutonium is the key actinide of concern for the Waste Isolation Pilot Plant (WIPP), as well as other DOE-EM near-surface contaminant sites. Understanding the fate and mobility of the Pu(IV) oxidation state is a key aspect of understanding the overall fate of plutonium in the environment. Advancing the understanding of the fate and transport of Pu(IV) will allow for better prediction and control of its release and related risk for many nuclear waste considerations important to DOE-EM. The technical focus of this effort is on understanding the solubility, complexation, and colloid formation/stability of the specific actinides [i.e., An(IV)] oxidation state. This work will significantly improve the modeling of Pu(IV) solubility and mobility that, in contrast to our current reliance on Th(IV) as chemical analogue, will enhance the credibility and accuracy of long-term performance assessment predictions of this actinide's mobility.

Path Forward

- A literature survey will be completed on Np(IV) and U(IV) chemistry in salt brine solutions, including oxidation-state stabilization approaches, thermodynamic data and solubility studies, and generating a report on available Pitzer model data.
- Np(IV) and U(IV) solubility studies will be performed and initiate the development and validation of key Pitzer parameters with a focus on hydrolysis and colloid formation.

Funding FY2014 - $0K | FY2015 - $103K | Outyears - $200K

Key Accomplishments

- After several months of negotiations and iterations a contract has been agreed to and signed.
- The initial activities have been identified and agreed upon, as described in the Path Forward.

Key Benefits

- This work will create Np(IV) and U(IV) system data to complement past Th(IV) analog studies to lead to a more "realistic" degree of conservatism in future WIPP regulatory compliance demonstrations, by enhancing both the realism and credibility of less conservative approaches. This may provide a basis for establishing more efficient packaging and emplacement configurations, thus increasing the overall efficiency of the available volume in the WIPP facility.
- This collaborative effort between the U.S. and Germany complements other joint activities related to studies of salt formation behavior, brine characteristics under various conditions (e.g., higher heat loads), etc., which are focused on establishing the technical basis for expanding the use of salt formation deep geologic disposal in the U.S. to other types of waste forms (e.g., high level radioactive waste).

For more information on this project or the EM International Program

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U.S. DEPARTMENT OF ENERGY

Correlating Aging and Durability of Ancient Glasses to Predicted Long-Term Performance of Vitrified Waste

PARTNERS

Division of Waste Science and Technology at the Lulea University of Technology
SWEDEN

Pacific Northwest National Laboratory (PNNL),
Idaho National Laboratory (INL),
Washington State University (WSU), and
Smithsonian Institute's Museum Conservation Institute
U.S. DOE EM

The ruins of a Swedish hillfort site.

Technical Summary

This effort is looking to the past to help with its future by studying how ancient glass has fared through the centuries and how it compares to the results of accelerated aging tests on various types of low-activity waste (LAW) glass. The investigation of the alteration of natural and archeological analogues is a critical aspect of understanding the long-term performance of nuclear waste glasses. Specifically, the collaborative effort will evaluate the long-term corrosion behavior of the Swedish hillfort glasses that date back to as early as the first millennium. This will provide a science-based foundation from which the long-term corrosion behavior of LAW glasses can be assessed. While laboratory executed glass alteration experiments can provide insight into the short-term corrosion, only natural and archeological glasses can be used to determine the long-term, i.e., over the course of thousands of years, mechanism(s) that drive the glass corrosion process. These mechanisms are of particular interest to the nuclear waste glass community as their vitrified products will need to withstand internment on a geological time scale.

Path Forward

- The International team will work with various organizations (including the Swedish National Heritage Board, the Geoarchaeological Laboratory, Swedish County Administrative Boards, and other research institutes to obtain samples for characterization.
- Once samples are obtained, a series of non-destructive, semi-destructive, and destructive testing will be conducted, as defined in the Statement of Work, and in accordance with the ruling of the cognizant Swedish authority(ies).

Funding FY2014 - $0K | FY2015 - $100K | Outyears - $350K

Key Accomplishments

- A joint statement of work has been agreed to for the initial phases and the contract with the Division of Waste Science and Technology at the Lulea University of Technology in Sweden has been awarded.
- Scoping tests based on the anthropologists analytical/compositional data for 10 glass compositions (even after aging) have indicated that 4 of the glasses produce homogeneous glass products. The remaining glasses lacked the desired viscosity for pouring which could be indicative of alkali corrosion during the aging process.

Key Benefits

- The DOE Office of River Protection (ORP) has undertaken an Immobilized LAW (ILAW) Durability and Leaching Test Development that seeks to develop a more meaningful accelerated aging test for ILAW (i.e., similar to leach testing for disposal of hazardous waste). Results of the Swedish hillfort glass work can establish the effectiveness of short-term accelerated aging test methods, and potentially lead to improved waste loadings and/or expanded operational envelopes.
- In addition to supporting ORP's mission of vitrifying LAW, this effort will also provide further insight into the long-term preservation and historical interpretation of the vitrified hillfort materials, much of which Is still under debate among archeologists.

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U.S. DEPARTMENT OF ENERGY

Demonstration and Implementation of Novel UK 3-D SONAR Technology for Surveying and Mapping of Tank Sludges

PARTNERS

NuVision Engineering (NVE) **and Fortis**
UNITED KINGDOM

Savannah River Remediation (SRR)
U.S. DOE EM

3-D SONAR demonstration with members of NVE, Fortis, SRR and DOE EM

Technical Summary

This project is focused on demonstrating the capability of a three-dimensional (3-D) sonar mapping technology to provide an accurate estimate of residual solids in a tank without first removing the tank's liquid contents. This approach may allow effective, efficient, and targeted strategies for bulk waste removal (BWR), such as localized waste retrieval of an identified mound or mass of solids during mixer operations. As envisioned, when the 3-D SONAR mapping shows negligible solids, BWR can be declared complete and further waste removal activities deemed unnecessary, thereby accelerating the overall tank closure process. If proven to be reliable, implementation of the UK-developed 3-D SONAR technology within DOE EM could likely be considered a High-Impact Technology, as defined in the recently issued Secretary of Energy Advisory Board Report on Technology. The 3-D SONAR technology has reached a high level of maturity in the UK and DOE EM is taking advantage of these prior efforts to accelerate deployment for US applications. As a result, the technology will be demonstrated on an actual tank (Tank 4 at Savannah River Site [SRS]) in the near term, which will serve as a test bed to assess its suitability for widespread use across the DOE complex. If successful, this technology will address a key challenge in the DOE complex, especially at SRS and Hanford, related to effective management of radioactive sludges/tank closure in million gallon tanks.

Path Forward

- Procure and fabricate equipment for deployment at SRS Tank 4.
- Conduct field deployment and demonstration at SRS.
- Work with Hanford (DOE Office of River Protection) to develop and implement a plan for field demonstration in a Double Shell Tank.
- Procure / build equipment for Hanford deployment ensuring optimum re-use of equipment from SRS deployment.

Funding FY2014 - $0K | FY2015 - $200K | Outyears - $750K

Key Accomplishments

- Developed a plan for deployment in SRS Tank 4 as the initial application. This included identifying necessary equipment based on results from 3-D SONAR modeling analysis.
- Conducted multiple modeling campaigns to determine ideal deployment methodology based on available risers, interferences and water level, thereby ensuring optimum operations. Created shadow maps to indicate coverage.
- Completed a detailed design of the 3-D SONAR equipment, controls, interface, deployment mast and over-canning necessary for initial deployment.

Key Benefits

- Successful demonstration and deployment of the technology, will help address a widely acknowledged high priority need in the DOE complex (i.e. effective management of sludges/tank closure in million gallon tanks at both SRS and Hanford).
- Integration and close collaboration of the HQ technology program with the SR and Hanford sites respective technology development efforts provides focused resources such that near term deployment of this innovative technology can be realized.
- DOE EM leveraging of UK investment (Government and private) and operational experience with these 3-D SONAR systems will help EM achieve tank closures as cost effectively, safely and quickly as possible through elimination of multiple 'mix, settle, pump, mix' cycles.

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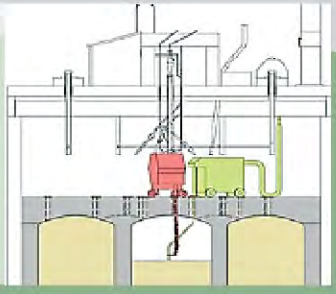
U.S. DEPARTMENT OF ENERGY

Demonstration of UK Snake Arm Robotic Technology for Calcine Retrieval

PARTNERS

NuVision Engineering (NVE) **and OC Robotics**
UNITED KINGDOM

CH2M Washington Group Idaho (CWI)
U.S. DOE EM



Conceptual Model of Planar Snake Arm and Hose Management System on CSSF 2

Technical Summary

There are approximately 4,400 m^3 of radioactive calcined solids material, which was generated from processing high level radioactive liquid waste in a fluidized bed calcination system. The resulting material is stored in six Calcine Solids Storage Facilities (CSSFs) at the DOE Idaho site. Each CSSF contains from three to twelve stainless steel tanks, referred to asbins, surrounded by a concrete vault. The design of each is different, with the earlier binsets having substantially different configurations than the later designs (i.e., vault geometry, bin geometry.). Additionally, access to each is different and very limited, having access risers of only six-inches or eight-inches in diameter. In accordance with the Idaho Settlement Agreement (ISA), this waste has to be retrieved and immobilized by December 31, 2035. No decisions have yet been made on how the calcine wastes are going to be retrieved from the CSSF's. The objective of this project is to demonstrate that the OC Robotics-developed Snake Arm system can be adapted for this unique application such that it can meet the access and retrieval challenges associated with the unique physical constraints of the calcine binsets, in compliance with the regulatory and technical requirements of the ISA. In this task, NVE has collaborated with CWI, DOE EM and OC Robotics to develop a conceptual design (see figure) of an integrated remote solution to retrieve calcine material from the binset feed tubes, remove the feed tubes, install additional risers on the bins and then retrieve the calcine material using a snake arm robot.

Path Forward

- Based on the final conceptual design, a remotely-operated integrated large-scale test bed will be constructed to demonstrate multiple aspects of the technology.
- Testing will be performed that demonstrate performance for the most challenging calcine retrieval scenarios, as well as adaptability to various CSSF configurations.

Funding FY2014 - $0K | FY2015 - $250K | Outyears - $880K

Key Accomplishments

- Developed a detailed Conceptual Design for an integrated remote system that can be used to remove obstacles from the in-vault area, gain access to each bin, and remove material and obstacles from inside each bin.
- Worked in close collaboration with CWI and DOE-Idaho to ensure the design approach took advantage of key site experience and met the general requirements and could achieve approval and acceptance from stakeholders and regulators, as well as DOE HQ.

Key Benefits

- Successful demonstration of the technology, especially related to its effective adaptation to the various configurations for the CSSFs, will provide a proven alternative technology for consideration during planned investigation of options and conduct of Analysis of Alternatives (AoA) for the calcine retrieval challenge. This is compliant with requirements of DOE O 413.3B, as well as recent direction from the Secretary of Energy regarding application of the AoA process.
- DOE EM leveraged significant investment by the UK in developing the Snake Arm retrieval technology. Although some adaptation to the application for retrieval from the CSSFs is necessary, this approach provides a more cost-effective and accelerated strategy for evaluation of technology options for addressing a recognized DOE EM challenge.
- This effort provides an opportunity to demonstrate the importance of the DOE National Robotics Initiative through a near-term application.

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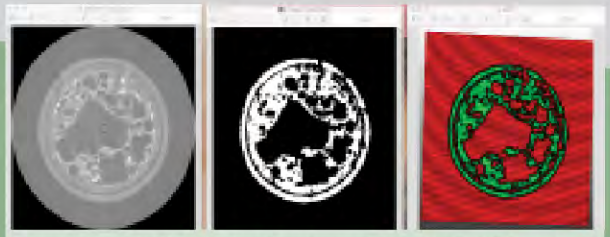
U.S. DEPARTMENT OF ENERGY

In-Situ 3-D Mapping of Cold Cap Utilizing X-Ray Computed Tomography



Sample x-ray CT image of molten surrogate waste glass (a) cross-sectional image, (b) thresholding applied, (c) meshed for modeling..

PARTNERS

Tokyo Institute of Technology
JAPAN

Pacific Northwest National Laboratory (PNNL)
Idaho National Laboratory (INL)
U.S. DOE EM

Technical Summary

Three-dimensional (3-D) non-destructive evaluation (NDE) may be used to improve the understanding of cold cap structure. This is important because changes in the concentration of nuclear waste components in solution can greatly affect the size and spatial distribution of bubbles/voids in the quenched simulated cold cap, which impacts the melt rate and overall efficiency of the melter. Researchers at PNNL and INL are collaborating with the Tokyo Institute of Technology to apply x-ray computed tomography (CT) scanning and ultrasonic techniques to produce a 3-D map of the cold cap glass-gas topography during melting.

In this effort, select glass samples with compositions of interest will be examined at temperatures ranging from ambient to 1100°C. A series of 2-D "slices" will be developed which can then be reconstructed to represent the cold cap structure in 3-D (see figure). This information can then be used to create a layered, temperature-stratified model of the cold cap.

The first application of the x-ray CT technique was found to have high potential to reveal the thermal properties of the cold cap in a liquid-fed-ceramic-melter system. Beamline experiments have been proposed to examine structural and chemical heterogeneities in the quenched glass for several different glass compositions.

Path Forward

- Testing will be completed and the results documented.
- The complete set of x-ray diffraction (XRD) and extended x-ray adsorption fine structure (EXAFS) data will be compiled. Image reconstruction for visualization of the CT results will also be completed. If successful, this could result in an in-service inspection tool for the melter refractory at Waste Treatment and Immobilization Plant and Defense Waste Processing Facility.

Key Accomplishments

- Samples were shipped to Japan and the laboratory work initiated.
- Modeling methodology development was initiated using sample datasets. Initial results show promise in the approach being able to predict the thermal properties of the cold cap.
- A strategy for conducting beamline experiments to further understand the structural and chemical heterogeneities has been implemented.

Key Benefits

- Successful demonstration and application of a 3-D x-ray CT NDE technique for evaluation and understanding of the cold cap structure will be useful for predicting melt behavior and overall characteristics due to operational conditions and feed chemistry. This can allow in-situ monitoring, prediction, and control of cold cap behavior to optimize melter performance through improved melt rate.
- The proposed technique, when coupled with other data, may be capable of providing a real-time in situ capability for monitoring the condition of the melter refractory lining, particularly at the interface between the cold cap and molten glass and vapor above the cold cap. This could lead to increased melter performance by allowing operation at higher temperatures, improved waste loading (i.e., relieving restrictions on chemically aggressive constituents), etc.

Funding FY2014 - $0K | FY2015 - $100K | Outyears - $100K

For more information on this project or the EM International Program

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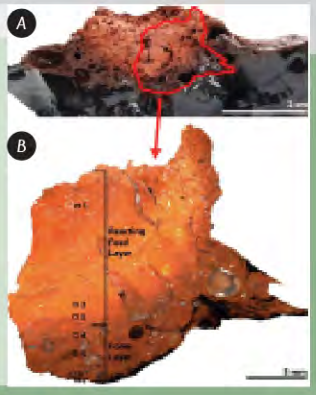
U.S. DEPARTMENT OF ENERGY

In-Situ Monitoring of Cold Cap/Melt Utilizing X-Ray Computed Tomography and Ultrasound

PARTNERS

Tokyo Institute of Technology
JAPAN

Pacific Northwest National Laboratory (PNNL)
U.S. DOE EM



Present evaluation of cold cap from HLW melt. X-ray CT allows in situ measurements in reacting cold cap.

Technical Summary

Three-dimensional (3-D) non-destructive evaluation (NDE) may be used to improve the understanding of cold cap structure. This is important because changes in the concentration of nuclear waste components in solution can greatly affect the size and spatial distribution of bubbles/voids in the quenched simulated cold cap, which impacts the melt rate and overall efficiency of the melter. Researchers at PNNL are collaborating with the Tokyo Institute of Technology to apply x-ray computed tomography (CT) scanning and ultrasonic techniques to produce a 3-D map of the cold cap glass-gas topography during melting, and to relate these observations to what has been observed with isothermal measurements (see figure).

Changes in the concentration of nuclear waste components and glass forming additives in the melt greatly affect the size and spatial distribution of bubbles/voids in the quenched simulated cold cap. The first application of the x-ray CT technique revealed dynamic movement and changes within the cold cap. Measurement of bubble and liquid formation and movement within the melt will be important in predicting and controlling cold cap behavior and characteristics. Interpretation of the x-ray CT scans and applying them to our present understanding of the cold cap will provide new information for developing more comprehensive and representative cold cap models.

Path Forward

- Measurements of the x-ray CT data will be completed. Interpretation of this data through measurement of bubbles, volume expansion and calculated density are necessary to develop correlations for addition of new information and data to existing cold cap models.
- Additional samples will be prepared and measured to validate current work and to examine Low Activity Waste Feeds with additional data compiled in the model.

Funding FY2014 - $0K | FY2015 - $100K | Outyears - $125K

Key Accomplishments

- Seven feeds of high-level waste were made at PNNL, shipped to Japan and are presently being tested. Cooperation with Tokyo Institute of Technology began in May 2015
- Existing reports of quartz particles dissolving in the melt, reactions of nuclear waste components, the production of gas phases and their encapsulation as bubbles/voids, together with homogenization, were clearly seen in the three-dimensional image data.

Key Benefits

- Successful demonstration and application of a 3-D x-ray CT NDE technique can allow in-situ monitoring, prediction, and control of cold cap behavior to optimize melter performance through improved melt rate.
- The proposed technique, when coupled with other data, may be capable of providing a real-time in situ capability for monitoring the condition of the refractory, particularly at the interface between the cold cap, vapor above the cold cap, and the refractory wall of the melter. This could lead to increased melter performance by allowing operation at higher temperatures, improved waste loading (i.e., relieving restrictions on chemically aggressive constituents), etc.

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U.S. DEPARTMENT OF ENERGY

Leveraging International Experience in the Implementation of Characterization Technologies to D&D in the DOE Complex

PARTNERS

NuVision Engineering (NVE)
UK Nuclear Decommissioning Authority (NDA), **Sellafield Ltd., and Cogentus Consulting Ltd.**
UNITED KINGDOM

Office of D&D and Facility Engineering (EM-13)
U.S. DOE EM

Technical Summary

Characterization technologies have been identified as one of the three key themes for future development in decontamination and decommissioning (D&D). Before investing limited research and development (R&D) funding in developing new systems, it is important to understand what is already available and what other organizations such as UK NDA, Tokyo Electric Power Company (TEPCO), Canada Nuclear Laboratory (CNL) and Sellafield Ltd are developing and/or testing such that their efforts can be leveraged for DOE EM benefit. This project is focused on engaging the international D&D community to identify available characterization technologies and where they can be used within the DOE complex to ensure best practice. This information is loaded into a web-based searchable repository that can then be readily accessed and used by a wide audience within DOE that have identified the need for characterization technologies for planned or ongoing D&D efforts. Such a program helps to ensure DOE R&D funds are spent on characterization technologies which do not currently exist rather than 'reinventing the wheel'. This project is modeled on the successful remote systems review project recently completed by NVE and Cogentus.

Path Forward

- Assess characterization technologies in the database against DOE needs and challenges.
- Develop, manage and facilitate a workshop to demonstrate how the database can be used to identify solutions to DOE characterization challenges.

Funding FY2014 - $0K | FY2015 - $175K | Outyears - $0K
(from international program)

Screen shot from web-based D&D database..

Key Accomplishments

- Developed a web-based, user-friendly, searchable database structure that can be used as a repository for D&D-related characterization technologies, approaches, and lessons-learned. The information can be filtered at multiple levels to allow quick identification of available technologies and systems to meet specific requirements. Filters include overall Technology Readiness Level (TRL), TRL for nuclear application, industry, role in D&D, size/scale of system, and which industry currently uses the technology/system.
- Worked with the International D&D community to identify nearly 250 characterization technologies from countries including US, UK, Canada, Japan and Spain, which were subsequently documented in the web-based D&D database and are now available to support DOE EM projects.

Key Benefits

- Use of the database can help accelerate identification and implementation of applicable technologies, providing schedule and cost benefits.
- It can also minimize duplicated efforts between various sites that are conducting D&D within the DOE complex.
- It allows leveraging investments by others in developing technologies, such that DOE EM can focus limited R&D budgets on actual technology needs.

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U.S. DEPARTMENT OF ENERGY

Nuclear Facility Decommissioning/ In-Situ Decommissioning Collaboration

PARTNERS

Canadian Nuclear Laboratory (CNL)
CANADA

Savannah River National Laboratory (SRNL)
U.S. DOE EM

Examples of D&D Collaborations Opportunities:

A *Legacy Process Tanks,*

B *Deactivated Chemical Hot Laboratory showing General Contamination*

Technical Summary

The SRNL is collaborating with CNL to create a technical exchange forum for deactivation and decommissioning (D&D) technical knowledge and applications to implement state of the practice and defensible nuclear facility decommissioning methods. This international partnership allows the hands-on D&D knowledge acquired throughout the DOE and Canadian nuclear complexes to be jointly leveraged to strengthen both the Canadian Nuclear Legacy Liabilities Program and DOE-EM D&D Operations. Key applications will be pursued that provide opportunities to combine CNL's innovative remote system hardware platforms with DOE-EM sponsored sensor systems and other D&D technologies to develop flexible remote systems to support D&D operations.

The initial area of focus involved demonstration of the SRNL 3-D GrayQb™, Radiation Contamination Mapping system at Chalk River Laboratories, to determine its operability in the harsh winter conditions for Canadian facilities. The GrayQb™ device was deployed in sub-zero weather conditions for a large area application, and field test results were promising for characterization and location of contamination hot spots in these conditions. Combination of the GrayQb™ system with CNL hardware platforms will lead to the ability to remotely capture facility configuration in high hazard environments.

Path Forward

- Collaborative efforts between SRNL and CNL will continue to formulate a 3-D Visualization Framework focused on the capture and preservation of process knowledge for an excess nuclear facility in a standardized framework.
- Field testing will be conducted at SRS test bed facilities with follow-on pilot field demonstration at CNL locations; Chalk River Laboratories and/or Whiteshell Decommissioning Project.
- Other opportunities will also be identified through ongoing Technical Exchange Forums.

Funding FY2014 - $325K | FY2015 - $200K | Outyears - $250K

Key Accomplishments

- A Technical Exchange Forum between CNL Chalk River Laboratory and SRNL to identify Innovative D&D Solutions and Approaches was held December 3-4, 2014, at the Chalk River facility.
- Based on the results of the Technical Exchange Forum, a cold field test of the SRNL 3-D GrayQb™, Radiation Contamination Mapping technology, was conducted at the Chalk River facility during February 23-27, 2015. This field test demonstrated successful deployment of the GrayQb™ device in sub-zero weather conditions for a large area application with promising results.

Key Benefits

- Creating a technical exchange forum between the US and Canada for D&D technical knowledge and applications provides a mechanism for both country's clean-up programs to identify and implement state of the practice and defensible nuclear facility decommissioning technologies and methods. This will provide more cost-effective and operationally efficient D&D technologies and approaches.
- This will also provide technical platforms to showcase application of DOE-EM sponsored technologies and approaches, while providing further access to CNL decommissioning methods and approaches (e.g., hardware platforms) for potential DOE Complex application.

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U.S. DEPARTMENT OF ENERGY

Treatment of Problematic/Orphan Wastes Using a Novel Technology from the UK

PARTNERS

NuVision Engineering (NVE) **and Arvia**
UNITED KINGDOM

URS/CH2M Oak Ridge (UCOR) **and Materials and Chemistry Laboratory** (MCL)
U.S. DOE EM

Arvia Treatment Unit and members of the Arvia, UCOR, and NVE team

Technical Summary

There are a wide variety of waste streams across the DOE complex, many of which have well documented and well proven disposition pathways. However, there are also a number of waste streams, particularly those containing organics and polychlorinated biphenyls (PCBs), for which the disposition path is not clear or does not exist at all. DOE EM is collaborating with Arvia Technology and NVE, to evaluate the effectiveness of an innovative technology that combines adsorption, using a patented material called "Nyex™", with electrochemical oxidation for non-thermal destruction of organic components of radioactive liquid organic waste streams. The Arvia Organics Destruction Process is a highly efficient system to convert organic materials to carbon dioxide and water while partitioning radioactive and inorganic constituents into an aqueous stream that can be readily treated by a local active radioactive effluent treatment plant. The Nyex™ acts as a catalytic agent and is regenerated during the process, which makes the approach both environmentally friendly and cost effective. Specific waste streams with no current disposition pathway (e.g., PCBs, dioxins and furans) have been identified and non-radioactive tests conducted to demonstrate the ability of the Arvia technology to treat these wastes, removing problem organic species to below regulatory limits thereby rendering them suitable for treatment by other, more conventional means. Successful demonstration of this technology for the dioxin, furan and PCB wastes identified at Oak Ridge will enable DOE to treat these orphan wastes, allowing their final disposition.

Path Forward

- Develop the permitting strategy for application to treatment of actual radioactive orphan waste in the DOE inventory.
- Determine the necessary throughput rate versus plant size versus cost and schedule for effective processing and treatment of actual wastes at Oak Ridge.
- Develop a more detailed preliminary design for the pilot unit for radioactive waste treatment, in accordance with the permitting strategy.

Funding FY2014 - $0K | FY2015 - $245K | Outyears - $450K

Key Accomplishments

- Demonstrated the Arvia unit's ability to remove and treat target organics (i.e., PCBs, dioxins, furans) effectively to meet regulatory limits such that residual waste could be processed using existing treatment systems.
- Developed the overall conceptual design, operational parameters and protocol that will be essential in applying the technology to radioactive wastes.
- In collaboration with DOE EM, established UCOR support, engagement, and commitment to overall approach, which will help ensure effective deployment in subsequent years.

Key Benefits

- Successful demonstration and implementation of the technology will eliminate part of the DOE EM inventory of orphan wastes that have no currently identified disposition path. This will provide significant cost savings by eliminating the need for long term storage, as well as risk reduction related to handling and management of these toxic wastes.
- DOE EM leveraged significant investment by the UK in development and demonstration of the Arvia technology at Magnox Plant in the UK. Although some adaptation to the EM application is necessary, this approach provides more cost-effective and faster implementation for processing of actual waste in the DOE EM inventory.
- Similar orphan waste streams throughout the DOE complex could also eventually be treated and dispositioned.

For more information on this project or the EM International Program

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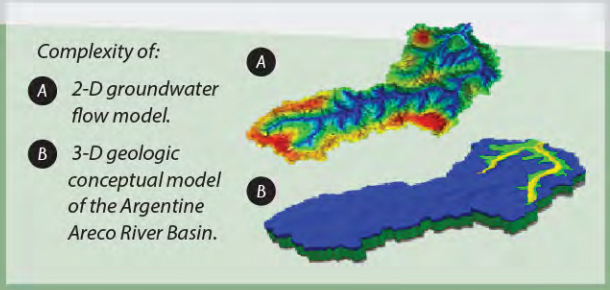
U.S. DEPARTMENT OF ENERGY

Predictive Modeling of Groundwater Flow & Transport

PARTNERS

Comisión Nacional de Energía Atómica (CNEA)
ARGENTINA

Pacific Northwest National Laboratory (PNNL)
Lawrence Berkeley National Laboratory (LBNL)
U.S. DOE EM



Technical Summary

Since September 2013, PNNL and LBNL, in collaboration with CNEA, have been building a groundwater model of the Areco River Basin in Argentina using the DOE-developed Advanced Simulation Capability for Environmental Management) (ASCEM) Toolsets. In the first year, the project focused on the analysis of published and field data, data collection and conversion of a simplified (CNEA- developed) two-dimensional (2-D) model of the site to one that more accurately represents site conditions. The resulting model (see figure part a) captures basin and stream geometry, and was calibrated against groundwater level measurements using the ASCEM Toolsets. The effort is currently in its second year, and is focused on extending the flow model to three dimensions (3-D) such that both aquifer and surface water interactions can be simulated (see figure part b). Once validated, the model will be used to establish regional baseline conditions for conducting groundwater risk analysis, enabling informed site selection of a nuclear waste disposal facility, as well as two additional nuclear reactors within the Areco River Basin. This project has provided mutually beneficial opportunities to both DOE EM and CNEA missions through targeted technology transfer and application. The initial groundwater modeling results were presented as part of the U.S. Delegation to two Joint Standing Committees on Nuclear Energy Cooperation (JSCNEC) Meetings (October, 2014 and August, 2015).

Path Forward

- Complete development of the 3-D groundwater model of the Areco River Basin.
- Execute simulations that demonstrate potential impacts of flooding from accidental releases from nuclear power plants or waste repositories using temporal and spatial flood plain analyses.
- Perform flooding analysis to assign a boundary condition to represent the surface water component of the groundwater flow model.

Funding FY2014 - $120K | FY2015 - $160K | Outyears - $200K

Key Accomplishments

- Successfully applied the ASCEM Toolsets to develop a 2-D groundwater model for simulating steady-state flow conditions.
- Developed and recommended to CNEA plans for model development, as well as risk and safety analyses.
- Conducted statistical meteorological analysis for evaluating net infiltration and flooding analysis.
- Developed the 3-D geologic conceptual model that is currently being implemented within the numerical modeling framework.

Key Benefits

- Use of the ASCEM Toolsets for application to modeling, investigation, and site characterization of a non-EM groundwater region offered the opportunity for independent validation data, providing a robust test case for the ASCEM Toolsets by allowing direct comparison to actual groundwater characterization data.
- Application of the resulting 2-D/3-D models for siting of nuclear facilities (i.e., radioactive waste disposal and reactors) will further establish the credibility of the ASCEM Toolset for EM needs.
- Continued international collaboration can contribute to the EM mission by providing opportunities to conduct further development work in support of a) enhancement and validation of the groundwater and groundwater-surface water models, and b) understanding performance of various waste forms (e.g., glass from vitrification).

For more information on this project or the EM International Program

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U.S. DEPARTMENT OF ENERGY

Zirconium Metal Organic Framework for Pertechnetate Removal

PARTNERS

University of Adelaide
AUSTRALIA

Pacific Northwest National Laboratory (PNNL)
U.S. DOE EM

Technical Summary

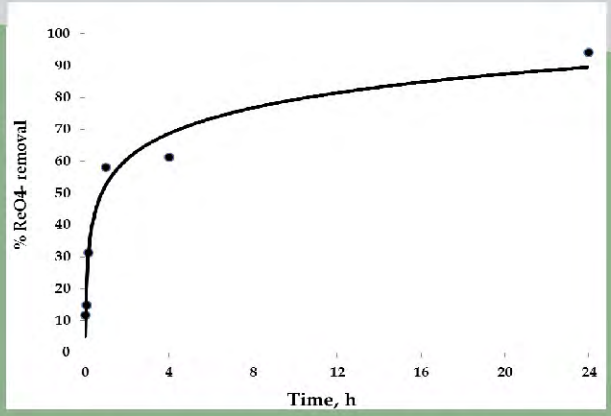
PNNL is collaborating with University of Adelaide to develop and demonstrate a new class of metal organic frameworks (MOFs) for removal of pertechnetate (TcO_4-) from liquid waste streams generated during treatment of the offgas stream resulting from vitrification of Hanford tank waste (e.g., submerged bed scrubber solutions), which are planned to be stabilized in cement for disposal. The team has synthesized and tested a new class of highly thermal and aqueous stable zirconium-based MOFs for removal of TcO_4- (Note that ReO_4- was used as a surrogate for TcO_4-). Batch experiments using quaternary ammonium functionalized MOFs suggest high adsorption capacity for ReO_4- compared to MOF without any quaternary ammonium salts (i.e., 16 wt%, with a distribution coefficient of 2,087 mL/g at room temperature). Synchrotron measurements were performed on a MOF trapped with ReO_4- to locate the adsorption sites. Results suggest that ReO_4 anions are preferentially attracted to the quaternary ammonium cations.

During this work, a porous aromatic framework (PAF) functionalized with a trimethylammonium hydroxide moiety was discovered. The functionalized PAF shows an instantaneous uptake of ReO_4 at room temperature, based on Ultraviolet and Induced Coupled Plasma analytical data. The total ReO_4- uptake is 45 wt% after 24 hours, with more than 60% of the removal of ReO_4 anions occuring within 60 minutes (see figure), suggesting faster kinetics with a distribution coefficient of 46,340 mL/g, which is much higher than the best material currently available, SuperLig 639™.

Path Forward

- Experiments will be completed to understand the selectivity of synthesized MOFs and PAFs towards other competing anions present in the liquid waste stream.
- Testing at larger scale of the best performing PAF material, to include demonstration of its ability to be readily stabilized as a cementitious waste form, as well as its performance during leaching tests.
- Efforts will be continued to further investigate and understand functionalization of PAFs and MOFs for superior performance related to TcO_4- adsorption.

Funding FY2014 - $0K | FY2015 - $175K | Outyears - $90K



ReO4 percent removal using newly discovered porous aromatic framework.

Key Accomplishments

- The first experimental evidence of the effectiveness of MOF materials for ReO_4- removal was developed and documented.
- Researchers discovered and demonstrated a new class of organic framework material called PAF that exhibits superior adsorption properties and faster kinetics, as well as increased percent removal and distribution coefficient than previously observed. The preliminary results on PAF show significantly better performance than SuperLig 639™ under similar conditions, with far less variability.

Key Benefits

- Technetium-99 is one of the most challenging radionuclides to effectively immobilize in a waste form for ultimate disposal. Successful development and demonstration of MOF-based materials for capture and immobilization of pertechnetate, will represent a "game-changing" approach to address the disposal of Tc-bearing secondary waste streams from the Waste Treatment and Immobilization Plant at Hanford.

For more information on this project or the EM International Program

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