Contract No:

This document was prepared in conjunction with work accomplished under Contract No. DE-AC09-08SR22470 with the U.S. Department of Energy.

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Technology Needs and Status on Closure of DOE Radioactive Waste Tank Ancillary Systems - 9312

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ABSTRACT

This paper summarizes the current state of art of sampling, characterizing, retrieving, transferring and treating the incidental waste and stabilizing the void space in tank ancillary systems and the needs involved with closure of these systems. The overall effort for closing tank and ancillary systems is very large and is in the initial stages of being addressed in a systematic manner. It was recognized in doing this effort, that gaps in both technology and material application for characterization and removal of residual waste and closure of ancillary systems would be identified. Great efficiencies are to be gained by defining the technology need areas early in the closure process and providing recommendations for technical programs to improve the closure strategies. Therefore, this paper will not only summarize the state of closure of ancillary systems but also provide recommendations to address the technology gaps identified in this assessment.

INTRODUCTION

This paper summarizes the current state of art of closure of ancillary systems. In the process of conducting this assessment, needs or gaps in the existing technologies for characterizing, removal of residual waste and grouting for final closure of ancillary systems were identified. From these identified technology needs, recommendations in each of the closure tasks were provided to improve upon the closure strategies for ancillary systems. The objective of this report is to use information gained from subject matter experts, literature, and workshops to: 1) document the current state of knowledge regarding tank ancillary system closure, 2) identify information gaps and technology needs, and 3) provide recommendations to improve the closure programs for tank ancillary systems.

IDENTIFICATION OF TANK ANCILLARY SYSTEMS

The DOE Complex tank farms all contain ancillary systems and equipment in addition to the tanks with residual radiological inventories that must be accounted for as part of facility closure. Ancillary systems were used to both transfer waste (e.g., transfer lines, pump tanks and pits, diversion boxes and valve boxes) and reduce waste volume though evaporation (e.g., the evaporator systems). Collectively, these are referred to as ancillary systems. In Figure 1, a waste transfer system of pipelines and other miscellaneous structures that support the transfer and storage of waste within the tank farms at SRS is shown (1).

Fig. 1. SRS Tank Transfer Piping Construction

The DOE Complex tank farms at INEEL, Hanford, and SRS all contain tank ancillary systems and equipment with residual radiological inventories that must be accounted for as part of facility closure. A summary of the ancillary systems that need closure at these various sites is shown in Table I (2).

Table I: Summary of Ancillary Systems Requiring Closure

	INEEL	Hanford	SRS
Tank Annulus	Yes	Yes	Yes
Cooling Coils	Yes	Yes	Yes
Transfer Piping	Yes	Yes	Yes
Miscellaneous Structures*	Yes	Yes	Yes

* Small waste tanks, reactor disassembly basins, pumps, etc.

ANCILLARY SYSTEM CLOSURE TASKS

Safely closing ancillary systems, as with waste tanks, involves an intricate set of steps that includes removing as much of the residual waste as possible through various technologies and techniques. After completing ancillary equipment cleaning operations, a small amount of residual radioactive waste that cannot be removed remains. As with the tanks, these residuals will need characterization to confirm that radionuclide and hazardous constituent concentrations meet performance objectives to ensure protection of the public and the environment. After cleaning activities are completed for individual vaults and other ancillary systems, DOE will consider stabilizing each of these components by filling or encapsulating them with grout. Other priority considerations in closure are necessary such as coordination of the many regulatory requirements, performance assessments, accessing the waste or components and secondary waste minimization considerations. In summary, the major remediation and closure activities that will be conducted for ancillary systems are summarized in Table II.

Table II: Ancillary System Closure Strategy Tasks

Task	Subtask
Sampling & Characterization	Ancillary System Piping Walls
	Residual Wastes in Large Ancillary Systems
Waste Retrieval/Transfer/Conveyance	Residual Waste Removal & Transfer
	Ancillary Component/System Removal
Stabilization/Contaminant Immobilization	Immobilization/ Internal
	Encapsulation/ External
Other Considerations	Regulations and Risk Assessments
	Waste Access
	Secondary Waste Treatment

Site closure plans for ancillary systems vary based on the type or size of ancillary systems. In conducting this assessment, it was necessary for ancillary components with similar attributes to be optimally grouped to better evaluate the range of closure and corrective actions that may need to be performed as progress is made toward final closure at the DOE sites. Therefore, ancillary systems were divided into the following four categories based on how they are addressed in the site closure plans or performance assessments: 1) Large or "significant" systems, 2) transfer piping, 3) cooling coils, and 4) small piping (< 1 in.) and equipment.

In Table III, a generalization of the current strategies for ancillary system closure is shown. The DOE sites are making progress in preparation of their closure documents which will specify specific strategies for ancillary system closure. Closure strategies for larger or "significant" ancillary equipment/systems such as the tank annulus space and evaporators may be similar to those used in the tanks as shown in Table III. These strategies include requirements of sampling, waste removal, cleaning, and grouting and should be able to leverage off the tank closure efforts. Plans for transfer piping and cooling coils have normally been addressed in the site closure plans or risk and performance assessments and require flushing three times and grouting. Smaller ancillary systems such as piping and transfer equipment (e.g., pumps) require internal grouting or grouting in-place.

Table III: Generalization of Current Closure Strategies for Ancillary Systems/Components

Closure Task	Current Closure Strategy for Ancillary Systems/Components			
	Large or "Significant" Equipment	Transfer Piping	Cooling Coils	Small Systems/ Equipment
Sampling, Charac-terization,	Planned	Not Planned - Estimation of Inventory	Not Planned - Estimation of Inventory	Not Planned Estimation of Inventory
Waste Retrieval/ Cleaning	Planned: Bulk & Residual Waste Removal Planned	Flush 3X or Pipe Removal	Flush 3X or Removal of Coils	Not Planned or Removal
Stabilization	Planned to minimize infiltration of water and subsidence	Planned – Internal Grouting	Planned – Internal Grouting	Planned – Grouted-In-Place
Other	Above grade ancillary structures, utilities that could interfere with closure cap construction will be removed. Closure of ancillary systems will be addressed in closure documentation.			

DOE sites are at various stages of progress in their ancillary system closure programs, as the focus has generally been on tank waste retrieval. Considerable progress in closure of ancillary systems has occurred at INEEL which has completed closure of eleven tanks in their tank farm. Between 2007 and 2008, INEEL was completing the final closure task for associated ancillary systems to those tanks by grouting the tank cooling coils and transfer piping. Site progress in implementing closure strategies are impacted by several factors including: physical properties of the waste, regulatory requirements and commitments, ancillary system configuration/ obstructions/conditions and occupational radiological exposure risks.

SUMMARY OF SITE CLOSURE NEEDS AND CHALLENGES FOR ANCILLARY SYSTEMS

Future closure plans and strategies are developed based on identified challenges and needs in closure of DOE waste tank farms. The needs and challenges discussed in this section do not encompass all the needs required in closure of the ancillary systems, but are considered the more challenging or significant needs that are required for successful closure of ancillary systems/components. These needs, challenges, and technology gaps shown in Table IV have been assembled from various sources that include: 1) previous DOE site surveys regarding closure (2), 2) subject matter experts (SMEs) (3) and 3) closure workshops. Many of these needs and issues were identified at the 2008 Waste Retrieval Workshops conducted at Hanford and SRS where experts in tank closure made assessments of the highest challenges in tank and ancillary system closures. Table IV also includes issues arising from "lessons learned" that were identified by SMEs in research and technology development, as well as, closure operations at the workshops (4, 5). These "lessons learned", both successes and improvements, can be applied to improve future tank and ancillary system closure strategies. Needs and challenges in large ancillary systems can "dovetail" or leverage off tank closure efforts. Needs and challenges for other smaller categories of ancillary systems such as piping and cooling coils have also been identified in Table IV.

Table IV. Significant Needs & Challenges for Ancillary System Closure

Needs	Large Ancillary Systems	Other Ancillary System & Components
Regulatory & Other Priority Needs	**Regulatory:** • Coordination of all Regulations regarding Closure • Definable Closure Criteria; *"How Clean is Clean?" and "Are 3 flushings sufficient?"*	
	Technology Transfer: • Better Understanding and Integration of What has been done Complex Wide in Closure	
	Cold Demonstration Testing: • Need to conduct more Robust Testing/Demonstration Prior to Deployment	
Sampling & Characterization & Access to Waste	**Sampling and Characterization Needs:** • Representative Sample of Residual Waste • Minimize Turn-around Time • Adequate Measurement of Physical Properties (Large/Dense Particles; Rheology) and Volume • Monitor Real-Time Measurements	• Representative Sample of Pipeline and Residuals
	Waste Access Needs: • Waste Access: External and Internal (i.e., tank risers, internal obstructions)	• Access to pipelines; Exposure risk
Waste Retrieval & Transfer	**Secondary Waste:** • Minimize Secondary Waste Generation (e.g., continuous recycle of supernate)	
	Waste Retrieval Equipment Needs: • Need Equipment that is Removable, Maintainable, Disposable, Repairable, Waste Compatible • Easily Navigated; Navigate Internal Obstructions; Maximize Access to Waste and to Conveyance System • Able to Remove Difficult Waste (i.e., Large, Dense Particles) **Improved Understanding of Chemical Cleaning & Waste Residual Removal**	
	Transfer Equipment Needs: • Need Design to Minimize System/Line Plugging • Equipped with Recovery Systems (e.g. Flushing) • Compatible with Receipt System (e.g., Retrieval Rate)	
Stabilization/ Contaminant Immobilization	• Need Grout Design Mixes to Meet Requirements (e.g., self-leveling, etc.) and Confirm PA • Need Development and Demonstration of Tools for Unique Challenges (e.g., void spaces in ancillary systems in tanks or removed ancillary piping); Wall and Grout Interface and Cold Joints to Characterize the Moisture Transport (i.e., potential fast flow-paths) • Need Grout to Immobilize Contaminants in the Vadose Zone Surrounding Tanks as a result of Past Leaks • Revised Specification for Ancillary System Closure Utilizing Supplier Experience • Characterize/verify concrete properties and pore fluids and to understand the evolution of these properties as function of time under the exposure conditions • Verify Heat of Hydration and Shrinkage on Current Mixes	

Regulatory and "Other Priority" Needs & Challenges

Coordination of Closure Regulations - An understanding of the regulatory drivers for the individual sites is necessary to give an understanding of the specific nature of the requirements and needs of the site closure programs. Tank and ancillary system closures at the DOE sites are under different and changing regulations requiring closure efforts to be coordinated between the regulating agencies. Many of these plans and strategies for closure of ancillary systems (and tanks) are in the development state and have not been approved by regulators with the exception of INEEL. There have been significant regulatory changes that impacted the tank closures at SRS and INEEL that were addressed in a paper by Langton and Cook (6) in 2008. INEEL and SRS both of which have high level waste are currently regulated by Section 3116 of the National Defense Authorization Act (NDAA) of 2005. "Section 3116 of the NDAA states that the term 'high-level radioactive waste' does not include radioactive waste resulting from reprocessing of spent nuclear fuel if several requirements are met including the requirement that 'radionuclides are removed to the maximum extent practical'. Consequently, since late 2004 tank closures at INEEL and SRS are being conducted under the Waste Determination (WD) process defined under 3116 of the NDAA, whereas, tank closure at Hanford and West Valley are being conducted under the DOE-WIR process defined under DOE Order 435.1.(6)"

DOE tank closure activities must also comply with other regulatory requirements. For example high-level waste tank sites at Hanford, Idaho and the SRS have been identified as Superfund Sites by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which requires the sites to develop Federal Facility Agreements (FFA) or Interagency Agreements. FFAs include binding solutions and time lines for disposition of these facilities. The HLW tanks at West Valley are not a CERCLA site and much of the clean up is being performed as National Environmental Policy Act (NEPA) activities under a Cooperative Agreement." (6)

Definable Closure Criteria - It has been recognized the need to have consistent, definable closure criteria that the sites can conduct their retrieval efforts. Even the National Academies of Science (NAS) after evaluation of DOE's plans for waste retrieval at the sites indicated that the the essential question of, "How clean is clean enough?" applies to all cleanup activities and does not have a unique, numerical solution (6).

Technology Transfer - Previously, retrieval and other closure technologies have been deployed on a tank by tank basis across the DOE complex with little synergy and sharing of detailed information to assist with future development activities. Technology transfer has been recognized as a element of success for past tank and ancillary system closures. Therefore, the need to better integrate closure efforts and share lessons learned will be a priority for future closure efforts.

Cold Demonstration Testing - Cold demonstration testing of sampling, waste retrieval and grouting methods has been attributed as the key factor in the success of many of the closure successes to date (4, 5). Testing allows closure methodologies to be perfected and operations to improve their knowledge base. A few examples of closure task successes in waste retrieval and grouting have been attributed to prior testing at INEEL with the "test ring" (7) and the SRS slurry (Flgyt) pumps which are recognized in the clean out of Tank 19.

Sampling and Characterization and Waste Access Needs

Ancillary components within the systems have been in contact with radioactive waste over the operating life of the facility. The amount of contamination on these components depends on such factors as the service life of the component, its materials of construction, and the contaminating medium in contact with the component. The radionuclide inventory in the ancillary components at the DOE waste tanks may be more substantial than realized due to the relative number of components within the tank systems.

Table V gives specific needs in characterization and access for pipelines and other ancillary components. Even though the table is based primarily on piping, it is recognized that pipelines are closely related to other ancillary systems and equipment such as diversion boxes and pump pits since these are used to access pipelines (8). Access to residual waste in both waste tanks and large ancillary systems including the tank annulus space was identified as a significant need at the 2008 Waste Retrieval Workshops at Hanford and SRS (4, 5). Waste access is the first pre-requisite to characterization of the waste and subsequent identification of waste retrieval technologies to be utilized in closure preparation at the DOE sites. Several needs in sampling and characterization of the residuals remaining in ancillary systems and tanks were also identified at the 2008 workshops. Improvements in analytical capabilities should be focused on the following four key activities: improved detection limits, faster turnaround on sample analysis, reduction of cross contamination, and real-time data.

Table V: Access & Characterization Needs for Pipelines & Ancillary Components

Primary Need	Description
Evaluate Removal or Decontamination Approaches	Evaluate the nature and likely current state of pipelines to determine where removal or decontamination activities might be necessary and what contaminants might drive subsequent treatment and disposal requirements (for removal approaches) and decontamination approaches.
Evaluate Optimum Access to Pipelines	Consider how best to access pipelines, such as through diversion boxes or pump pits, or direct excavation.
Demonstration of Characterization Approaches	Demonstrate characterization approaches including in situ sampling techniques to ensure that the nature and extent of contamination in pipelines can be determined and, if decontamination activities are carried out, to explore how decontamination media might be delivered and how their performance can be documented.
Develop Template for Conducting Future Pipe Characterization	Develop and demonstrate a process for how pipeline characterization might be accomplished and establish a template for conducting future pipe sampling and characterization.
Evaluate Waste Constituents	Evaluate and demonstrate the types of waste constituents in pipelines through review of past efforts and new sampling to identify drivers for risk and future decision-making.
Develop Test Plan for Sampling and Characterization	Develop a test plan for sampling and characterization of pipelines (informed by review and consideration of the history/status of ancillary equipment). Subsequent sampling and analysis plans for pipeline characterization need to be developed.

Waste Retrieval and Transfer Needs

Improved Removal of Waste Residuals

Improved removal of waste residuals during the closure process is another area for focus in tank and large ancillary systems. With the Department of Energy's cleanup program wrapping up its second decade, long-term research and development of remediation technologies should continue to be a top priority. Assistant Secretary for Environmental Management James Rispoli told the National Academies' Nuclear and Radiation Studies Board in 2008, the need for better technologies to help retrieve high-level waste from underground storage tanks, primarily at Hanford, is an example of the technical challenges in closure programs (9).

In 2008, DOE issued a technology "roadmap" intended to help guide the development of new technologies over the next decade to address a number of challenges. Implementation of the roadmap is being led by SRNL, which serves as the corporate lab for the DOE cleanup program. Deputy Assistant Energy Secretary for Engineering and Technology Mark Gilbertson indicated that DOE's new emphasis on technology development was already producing results. Among the examples he listed was the development of interim technologies to help process radioactive salt waste taken from tanks at the SRS for eventual on-site disposal (9).

Waste Retrieval Equipment Needs

Results from the 2008 workshops identified important needs for waste retrieval equipment needed in cleaning of large ancillary systems such as miscellaneous tanks and the tank annulus space (4, 5). The equipment must be removable, maintainable, disposable, repairable, and waste compatible. The equipment must be able to easily navigate the internal obstructions. It must also be designed to maximize access to waste and to the conveyance system. It must also be able to remove difficult waste that is coarse with large, dense particles. The transfer piping and equipment must minimize system and line plugging. The equipment and piping must be equipped with flushing and other recovery systems. It must also be compatible with the receipt systems (i.e., the retrieval rate). Key needs in waste retrieval in pipelines and small ancillary components are to demonstrate piping removal technologies, including proper treatment and disposition of removed pipelines. Ancillary systems such as catch tanks presents an important opportunity to field test a number of technologies and approaches that may be needed for the larger waste tanks. Hanford will prepare an engineering study to evaluate potential removal technologies for the waste in the catch tank and select a technology for waste removal. Lessons learned including cost and exposure data will be incorporated into the waste removal demonstrations (8).

Secondary Waste Minimization

Secondary waste volume can exceed that of the waste being removed in the waste retrieval efforts. Previous tank retrieval campaigns have reduced water consumption through "lessons learned" from previous retrieval efforts. For example, SRS continuously recycled supernate to reduce the consumption of water, and therefore, minimized secondary waste generation. Another example was during Hanford's retrieval efforts of the C-200 series tanks where transfer line flushes were decreased. The reduction was made after trends in operating data showed that the waste was sufficiently diluted to minimize the risk of line plugging. Transfer line flushes accounted for about 1/5 of the water used for waste retrieval (10).

Stabilization /Contaminant Immobilization Needs

DOE site closure plans at SRS, Hanford, and INEEL indicate that closure of ancillary systems may require grouting for final closure. In the past several years, some test work for ancillary systems has been conducted (11, 12, 13). Even though progress has been made in this final task of ancillary system closures, several key grouting needs have been identified for future ancillary system closures by subject matter experts in cementitious materials (3). These grouting needs for ancillary systems include:

- Grout design mixes to meet requirements and improve properties and durability,
- Development and demonstration of tools for unique challenges (e.g., void spaces in ancillary systems in tanks),
- Grout mixes to immobilize contaminants in the vadose zone surrounding tanks as a result of past tank leaks,
- Revised specification for ancillary system closure utilizing supplier experience, and
- Testing grout methodologies for removed ancillary components.

The current closure concept for the waste tanks and large ancillary systems is to fill the majority of each tank with a chemically reducing cementitious grout. Piping that can extend for miles within the associated tank systems need grouts that are highly flowable. Cooling coils need grouts that can remain adhesive underwater. Many of these grout mixes have been designed and used in tank and ancillary system closures at both SRS and INEEL. Therefore, one of the primary needs beyond testing the properties of the grout formulations is to design and test alternate test grout mixes to improve hydraulic properties (i.e., reduce the permeability and porosity), to reduce water and contaminant transport and improve durability. Additional testing is recommended to demonstrate that further improvements can be made with respect to permeability by changing the requirement of a single point placement of grout in the large tanks and transfer piping. If more than single point placements are allowed, then the flow property requirements can be reduced. Highly flowable grouts or concretes are on the edge of physical stability where slight variations in water content can result in higher permeabilities and increased bleed water. Many considerations are required in the development of alternate test grout mixes. Several competing factors must be balanced in the design of a low permeability, flowable grout or concrete suitable for large ancillary systems and transfer piping. These requirements include: highly flowable material, no bleed water, low permeability, low heat of hydration for mass pour application, low water/cement ratio, and set time that can be adjusted to minimize cold joints assuming daily pours (11).

RECOMMENDED PATH FORWARD FOR TECHNOLOGY GAPS

The improvements needed to mitigate the needs and challenges, collectively referred to as "technology gaps," have been identified for each of the tasks necessary to improve closure strategies of ancillary systems. A path forward/test program to address the technology gaps in each of the closure tasks for ancillary systems has been recommended in Table VII.

Table VII. Recommended Path Forward to Mitigate "Technology Gaps" in Ancillary System Closure

Closure Technology Gap	Recommendations to Mitigate "Technology Gaps"
Regulatory & Other Priority Gaps	**Technology Transfer :** - Develop Centralized Data Base on Ancillary System Closure Strategies/Tools
	Cold Demonstration Testing: - Develop and Demonstrate Adequate Scale Cold-Testing of Tools/ Strategies/Grout Design Mixes
	Regulatory Need To Define Closure Criteria: - Develop Methodologies to Prove Completion of Waste Retrieval to Regulators (i.e., Definable and Maintainable Criteria); Complex-Wide Consistency - Assign Long-Term Management Champions for Closures
	Post Closure/Risk Assessment: - Improve Understanding of Radionuclide Release (e.g., Corrosion Studies, Leaching of Radionuclides, Cap Degradation)
Sampling/ Characterization	**Sampling and Characterization Improvement Program:** - Develop Methods to Refine and Confirm Assumed Radionuclide Inventories - Improve Analytical Methods - Develop Universal Waste Sampling & Characterization Strategies/Tools
Waste Retrieval	**Residual Waste/Heel Removal Improvement Program:** - Improve Understanding on Chemical Cleaning Methodologies (e.g. Gas Generation Rates, Dissolution) - Invest in New or Modified Tools/Equipment/Strategies (with Adequate Cold-Testing/Mock-ups)
	Secondary Waste Minimization Program: - Develop Cleaning Strategy based on Treatment of Cleaning Solutions - Testing Support to Determine the Minimum Quantity of Flush Water - Minimize High Airborne Contaminants During Cleaning
Stabilization & Contaminant Immobilization	**Stabilization Improvement Program:** - Develop Tank Ancillary System Specific Requirements - Develop and Demonstrate Tools for Unique Challenges in Grouting in Ancillary Systems - Improved Understanding of Grout Properties and Evolution over Time (e.g., Degradation and Improved Methods of Measurement)

Regulatory & Other Priority Strategies

Technology Transfer

Issue/Gap: Technologies for retrieval, cleaning, sampling, etc. have been deployed on a site by site basis across the DOE Complex with very little synergy and sharing of detailed information to assist with future development activities.

Recommendation: A team of technical experts is needed to collect and manage a database for closure technologies and lessons learned. It is recommended that the FY08 effort on the EM-21 funded Retrieval Knowledge Center for the waste retrieval database be expanded to include: 1) closure tasks for ancillary systems and 2) sampling, characterization and grouting closure tasks in addition to the waste retrieval tasks for both ancillary systems and tanks.

Cold Demonstration Testing

Issue/Gap: Successes in previous tank closure strategies point to cold testing of the closure tools and strategies prior to radioactive deployment. Needs have been identified to build, test and deploy new technology and tools to remove and stabilize remaining waste from tanks and ancillary systems to successfully execute site specific waste disposition plans.

Recommendation: Ancillary system closure tasks including characterization, cleaning, and grouting may need to be assessed through additional testing to quantify the system's ability to safely meet the performance requirements established in the risk/performance assessments. The cold tests will provide a low-risk environment in which the project team can evaluate the performance of the selected systems components.

Regulatory Program to Define Closure Criteria

Issue/Gap: DOE's approach for closure was considered workable by the NAS but an important technical challenge remains: to answer the question, "How clean is clean enough?" Currently, the cleanup activities do not have a unique, numerical solution to answer that question (6).

Recommendation: A program is needed to pursue a more risk informed, consistent, participatory, and transparent process for making decisions about how much waste to retrieve from each of its tanks and large ancillary systems. This program should also include a method to justify the characterization of ancillary systems based on the "3 flushings" assumption. DOE sites will also need to demonstrate if closure by removal or decontamination is practicable for ancillary systems and components such as pipelines. To support closure planning, historical documents and other closure and waste retrieval information from other DOE sites should be evaluated. A Complex-wide closure database with characterization, sampling, waste retrieval and grouting information would be invaluable to this process. The DOE sites must consider a range of technical and non-technical factors, including technical capabilities for waste retrieval, worker doses, cost and the potential risks from other wastes to be left onsite.

The program needs a consistent methodology that represents the DOE large ancillary systems have been cleaned to the "maximum extent practical (MEP)". In waste retrieval efforts, DOE sites have shown that MEP is demonstrated by the principal of "diminishing returns". For example, during cleaning operations, MEP was considered reached when the radiation monitor indicated that radioactivity levels were no longer decreasing. Once the criteria have been defined, the site specific methodologies need to be coordinated to make the process for demonstrating closure criteria have been met is consistent among the sites. The success of this program will depend on an integrated team of site management, technical and regulatory personnel.

Post-Closure/Risk Assessment

Issue/Gap: The leaching of long-lived radionuclides is a primary influence on the PA calculations for the tank farms. Limited data is available for grout utilized for ancillary system (and tank) closure. Extreme bounding values from literature are often used to support the PA.

Recommendation: Laboratory support is needed to support these properties used in the PA. A systematic study is needed to collect data and place in a database for complex-wide use.

Issue/Gap: A key prediction used in the PA to evaluate the release of radionuclides after closure is the failure rate of the stainless steel liners/housings of ancillary systems/equipment (and tanks).

Recommendation: Predictions for failure of significant ancillary systems such as the stainless steel transfer line core piping are based on literature values and modeling. The results of the modeling studies need to be confirmed by laboratory testing. This need is further substantiated by the NRC who recommended that DOE should provide support for the empirical models used to estimate pitting corrosion commensurate with the risk-significance of the failure modeling. There is also a need to provide additional technical justification for the assumption that 25% of the surface area of the transfer lines needs to be breached to constitute failure. Experimental studies are needed to derive a more complete understating of corrosion mechanisms to make better predictions in the PA.

Sampling & Characterization Technology Strategies

Confirm Characterization Assumptions/ Improve Analytical Methods

Issue/Gap: The PA recommended future work in the area to refine and confirm the existing radionuclide inventories that will be present in the HLW tanks and ancillary systems at site closure. This work includes additional sampling and analysis of existing waste and refinement of potential waste estimates for un-sampled areas, such as the piping and other ancillary equipment.

Recommendation: Methods to refine and confirm assumed radionuclide inventories and improve analytical methods are needed. This work should consider additional sampling and analysis of existing waste and refinement of potential waste estimates for un-sampled areas, such as the piping and other ancillary equipment. Sampling of the waste tanks and ancillary systems after cleaning and improving the analytical methods before grouting will be necessary to evaluate the inventory to ensure that the groundwater protection performance objectives are met.

Sampling and Characterization Tools

Issue/Gap: Characterization of residual waste in ancillary systems from both a volume and chemical/radionuclide content is difficult and subjective. Even though determination of the amount of waste trapped inside pump, coils and lines is challenging, it is critical to selecting the most efficient waste retrieval/cleaning methods. Remote tooling concepts and strategies are currently deployed as component and waste specific.

Recommendation: An effort is needed to develop universal waste sampling & characterization strategies/tools. The set of tools should be adaptable that are not required to be component/waste specific. This effort should include generating a list of tools and methods for characterizing the amount of residual waste inside pumps, coils and transfer lines. Adaptable or universal remote sampling tools and strategies for deployment for ancillary systems should be developed.

Waste Retrieval Technology Strategies

Residual Waste/Heel Removal Improvement Program – Chemical Cleaning Strategies

Issue/Gap: In tank annulus spaces, wastes have leaked over the years and left dried salt residues. Chemical cleaning strategies have been selected as a key waste retrieval technology for these components. Chemical cleaning in combination with mechanical cleaning has become a necessity within the DOE complex particularly at SRS.

Recommendation: A cleaning strategy based on waste retrieval using chemicals (i.e., oxalic acid) and mechanical technologies needs to be developed. A link between the two efforts and a complete understanding of the impacts of chemicals (including the use of water) on various waste types (salt, sludge, etc.) is needed. A team of technical experts is needed to collect information, data, and lessons learned from chemical cleaning studies and deployments and provide recommendations for future studies.

Evaluate Gas Generation Rates During Chemical Cleaning

Issue/Gap: One of the baseline processes for chemical cleaning of residues in the HLW tank annulus space and HLW tanks involves the use of oxalic acid. In contact with carbon steel, the acid generates hydrogen gas during corrosion. The rate of hydrogen production is key to safe processing and control strategies.

Recommendation: A designed study is needed to obtain a mechanistic understanding of gas generation rates and speciation during chemical cleaning that can be utilized across the tank farm to potentially aid in chemical cleaning.

Develop Cleaning Strategy based on Treatment of Cleaning Solutions

Issue/Gap: Minimize secondary waste generation; develop cleaning strategy based on downstream treatment of cleaning solution (i.e., secondary waste).

Recommendation: There is a need for the integration of ancillary system decontamination and cleanout technologies with treatment of solutions downstream. Minimizing this waste by simple treatment (neutralization or volume reduction) is far better than delivering millions of gallons of extra solution to the final process, which may not even be capable of handling those wastes. There is a need to investigate treatment methods (including obtaining information from industry) and recommend one that can be effectively applied under the requirements of the DOE sites.

Testing Support to Determine the Minimum Quantity of Flush Water for Cleaning Pipes

Issue/Gap: The current practice for flushing transfer lines is to use 3 volume flushes and is independent of flush velocity, length of piping, or physical properties of the fluid being flushed. This quantity of flush water may be excessive or not adequate for flushing prior to closure.

Recommendation: There is a need to define the requirements and perform actual tests to support the assumptions of residual waste left in the piping.

Minimize High Airborne Contaminants During Cleaning

Issue/Gap: During waste processing campaigns, waste retrieval and closure, the pump pits and other ancillary facilities become contaminated with high airborne contaminants and often work must be stopped until decontamination has been completed.

Recommendation: Methods should be developed and tested to reduce airborne contamination in work areas such as pump pits such as fixing the contamination using fogging techniques.

Stabilization Technology Strategies

Develop Grout Mixes That Meet System Specific Requirements

Issue/Gap: Final decision is still pending for various grout techniques and recipes to be used for ancillary equipment that can be specified in the future closure modules.

Recommendation: Alternative fill materials need to be evaluated to obtain a preferred grout mix for closure of the tank ancillary systems. Future studies need to focus on improving grout production and batching, grout flow, and hydraulic properties.

Develop and Demonstrate Tools for Unique Challenges in Grouting in Ancillary Systems

Issue/Gap: Following cleaning, all ancillary equipment of a significant size located under the tank farm closure cap and in the tank will require grout filling. The tank farm performance assessment requires that any significant void spaces be grouted to minimize subsidence of the closure cap. The definition of "significant" as stated in the tank farm performance assessment has not been defined. Also, ancillary systems provide unique challenges to ensure that all the voids are filled.

Recommendation: Modeling is needed to define the potential subsidence propagation if a structure collapses and the impact to the soils above. Also, techniques and tools to fill the ancillary equipment in the tank that do require grouting need to be developed and demonstrated.

Improved Understanding of Grout Properties and Evolution of these Properties over Time

Issue/Gap: Closure systems may degrade over time, eventually releasing contaminants to the environment. The physical and chemical mechanisms that control the release or leaching of residual contamination from the grouted waste tanks and ancillary equipment need to be better defined, studied, and tested to support the assumptions used in the PA. Specifically, the permeability (hydraulic conductivity) of grouts that will be used in ancillary system closure (and tank closure) is an important input parameter in the tank farm performance assessment. The impact of concrete degradation over time on hydraulic conductivity has only been assumed in the PA and not determined in the laboratory.

Recommendation: Need test programs that conduct further testing of grout properties under closure conditions and determine the changing parameters over time. The primary purpose of alternative grout testing is to improve the hydraulic performance (i.e., reduce permeability and porosity) to reduce water and contaminant transport and improve durability. While reduced permeability is certainly important, there are other properties of the grout that may be important to radionuclide retention (e.g., chemical attributes) that may compete with the optimization of hydraulic properties. It is important to recognize how the grout formulations impact the overall long-term performance of the cementitious materials—their resistance to chemical and physical attack and ultimately their ability to retain radionuclides over long time periods relied on radioactive waste disposal.

Improve Methods of Measurement

Issue/Gap: Currently, the hydraulic conductivity is reported as a single value and the variation has not been assessed over time. The NRC indicated that DOE should assess the important factors leading to variability in measured hydraulic properties of cementitious materials, attempt to reduce this variability, and evaluate uncertainty in hydraulic properties in its performance assessment.

Recommendation: There is a need to demonstrate a measuring technique in which the results are reproducible and accurate for permeability.

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