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Retrieval of Underground Storage Tank Wastes: The Hanford Challenge

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RETRIEVAL OF UNDERGROUND STORAGE TANK WASTES: THE HANFORD CHALLENGE

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ABSTRACT

The U.S. Department of Energy has accepted the challenge of recovering, by the year 2018, all defense byproduct wastes now stored in the single-shell tanks (SSTs) located at the Hanford Site in southeastern Washington State. Approximately 140,000 m^3 (37 Mgal) of waste material now resides in 149 SSTs, which range in size from 208 m^3 (55,000 gal) to 3,785 m^3 (1 Mgal) in capacity. These tanks are of an early design that consists of a carbon-steel liner surrounded by a reinforced structural concrete shell. Originally designed for a 20-year life, the first of those constructed are surpassing that expectation. Many have lost confinement integrity, and leaks to the environment have been detected.

In a cooperative agreement with the Washington State Department of Ecology and the U.S. Environmental Protection Agency, the U.S. Department of Energy, through its prime operating contractor, Westinghouse Hanford Company, has established a comprehensive and aggressive program to remove, treat, and dispose of the wastes stored in these underground tanks. A systems-engineering approach is being used to establish the basic elements of the program for the ultimate disposal of the wastes. The overall system is referred to as the Tank Waste Remediation System. The system contains several subelements that will

- Characterize the waste
- Retrieve the waste
- Treat the waste in preparation for disposal
- Vitrify the waste for disposal as low-level or high-level waste.

This paper discusses the long-term strategy that has been developed to support the waste retrieval efforts of the Tank Waste Remediation System program.

INTRODUCTION

The wastes stored in the underground SSTs at the Hanford Site present a significant recovery challenge.[1] The goal is to develop and field retrieval systems with the capability to remove wastes from these tanks and transfer those wastes for further downstream processing. The application of existing technologies has been the foundation of the retrieval strategy. However the aggressive schedules and complexity of the wastes to be recovered have required the search for and the development of more advanced technologies.

The Waste Retrieval Challenge

High-level radioactive waste has been produced at the Hanford Site since 1944 as a byproduct of processing spent nuclear fuel for the recovery of plutonium and uranium.[2] Approximately 140,000 m^3 (37 Mgal) of waste are being stored in 149 SSTs, which range in size from 208 m^3 (55,000 gal) to 3,785 m^3 (1 Mgal) in capacity. These tanks are of an older design and were placed into service between 1943 and 1964. No wastes have been added to the SSTs since November 1980. Recognizing the need for higher integrity waste containment systems, a new design, consisting of a tank-within-a-tank construction (double-shell tank), has been implemented to support current operational needs.

The SSTs are constructed of structural concrete that has been lined with carbon steel. They range in size from 22.9 m (75 ft) in diameter, with depths of between 5.5 to 9.7 m (18 ft to 32 ft), to 6.1 m (20 ft) in diameter and approximately 7.6 m (25 ft) in depth. The tanks are typically buried from 1.7 m (5 ft) to 4 m (12 ft) beneath the surface to provide radiation shielding.

Currently, 67 of the SSTs are known to have leaked or are suspected of leaking. In an effort to reduce the environmental impacts, a program to remove the pumpable interstitial liquid and supernate wastes was started in 1968. The liquids removed through this program are transferred to the double-shell tanks for interim storage in preparation for further processing.

The waste volumes in the tanks vary from 5% to 95% of the tanks' capacities. These wastes consist primarily of sodium hydroxides; sodium salts of nitrate, nitrite, carbonate, aluminate, and phosphate; and hydrous oxides of iron and manganese. The primary radioactive components in the waste are the radionuclides ^{90}Sr and ^{137}Cs, along with quantities of uranium, plutonium, and americium. The wastes in the SSTs exist primarily in two solid forms: sludge and salt cake.

Sludge is comprised of precipitates of iron, manganese, and aluminum of varying physical consistencies. Analogies used to describe its properties range from gruel on the thin side to thick peanut butter for the heavier sludges. Some sludge also exists as dried mud or clay.

Saltcake constitutes the majority of the waste found in the SSTs. These wastes have formed through the crystallization of saturated solutions of sodium salts. The dried saltcake is a hard, abrasive, brittle material that has been modeled as a weak concrete. Photos (Figure 1) have shown the presence of very large monolithic crystals in some of the tanks. Simulants that have been employed in the past to physically model these saltcakes include fertilizers that have been wetted down, compacted, and allowed to dry and hard salt blocks used in the cattle industry.

The recovery of the sludge and saltcake wastes from the SSTs could be envisioned to be a relatively straightforward material retrieval problem that has been accomplished numerous times in the past. However, the retrieval task has been complicated significantly by the presence of unusual, unique hardware and discarded solid material collectively known as in-tank hardware. The presence of in-tank hardware introduces an additional element of complexity, in that the recovery of the waste must be preceded by the removal of the hardware or a mine-around strategy developed. It is likely that a combination of the above options will be required to successfully remove wastes in the presence of these physical obstructions.

Figure 1. Salt Cake Waste.

In-tank hardware falls into two general categories. The first category consists of items that were originally installed in the tanks to monitor the conditions within the tank environment or that were used to process or transfer the waste, such as pumps that remove free liquids. These items are usually pipes and pump shafts that extend from the entry risers in the tank top down into the waste. The numbers of these vertical obstructions, Figure 2, along with fact that many are significant in size, present a retrieval system challenge. The second category of in-tank hardware consists of items that have been discarded into the tanks. Typical in this category are lead bricks, discarded stainless steel measuring tapes, sample bottles, spent fuel elements, rocks, and reactor poison balls. The quantity and location of these types of in-tank hardware are largely unknown, and in some cases they could present significant radiation sources. The disposal of in-tank hardware is also a significant cost consideration. The recent experience with disposal

Figure 2. In-tank Obstructions.

of similar hardware at the Hanford Site required substantial financial resources to comply with current environmental and statutory mandates.

The Single-Shell Tank Retrieval Program

A comprehensive plan has been established and the implementation initiated to remove, treat, and dispose of the wastes stored in the underground SSTs. The major elements of this plan include the characterization of the wastes and the tanks, recovery of the wastes within the tanks, treatment of the wastes in preparation for final disposal, and finally the vitrification of the wastes as either low-level or high-level wastes. The system that has been established to accomplish these functions is known as the Tank Waste Remediation System.

Driving the Tank Waste Remediation System are the goals that have been established by key stakeholders. The U.S. Department of Energy, Washington State Department of Ecology, and the U.S. Environmental Protection Agency have laid out a comprehensive schedule of goals and milestones that constitute a schedule for accomplishing the cleanup mission at the Hanford Site.[3] The following are some of the key dates from this Hanford Federal Facility Agreement and Consent Order, known as the Tri-Party Agreement, that specifically govern the waste retrieval activities, which are the intended focus for the remainder of this paper.

October 1997: Initiate sluicing retrieval of tank 241-C-106 to resolve the high-heat safety issue and demonstrate waste retrieval.

September 2003: Initiate and complete a full scale demonstration of SST retrieval technology. This demonstration will be considered complete when no less than 99% of the waste inventory is removed from the tank.

December 2003: Initiate tank waste retrieval from one single-shell tank.

September 2018: Complete waste retrieval from all remaining single-shell tanks.

The schedule dictated by the milestones described above requires an aggressive retrieval program of considerable flexibility to be able to recover the wastes from all 149 SSTs in an approximately 15-year window.

SST Waste Retrieval Strategy

The strategy for SST waste retrieval is to implement the best available demonstrated technology in a time frame that will support overall Tank Waste Remediation System objectives and minimize the need for follow-on tank-cleanup actions that may be required by regulatory constraints. Retrieval operations will be initiated with known technology to support rapid closure of tank safety issues and statutory commitments. In parallel, advanced technology will be developed, demonstrated, and deployed as available to meet the aggressive schedule established by the Tri-Party Agreement and to address the complexity of recovering wastes from all SSTs.

The best available demonstrated technology is hydraulic sluicing, a mining technology that has been successfully used for the recovery of wastes from the Hanford Site's SSTs since the 1950's. Sluicing employs low-pressure, high-volume water jets to mobilize wastes through a process of dissolution and erosion. The mobilized wastes are then removed from the tank via slurry transfer pumps (see Figure 3). A total of 54 sludge-waste tanks have been recovered in the past using this approach. However concerns over the integrity of the tanks' liners and the ability of this technology to recover all waste types have prompted the need for advanced technologies.

The most promising of the advanced technologies is the arm-based retrieval systems that will deploy specialized retrieval tools (called end effectors) to

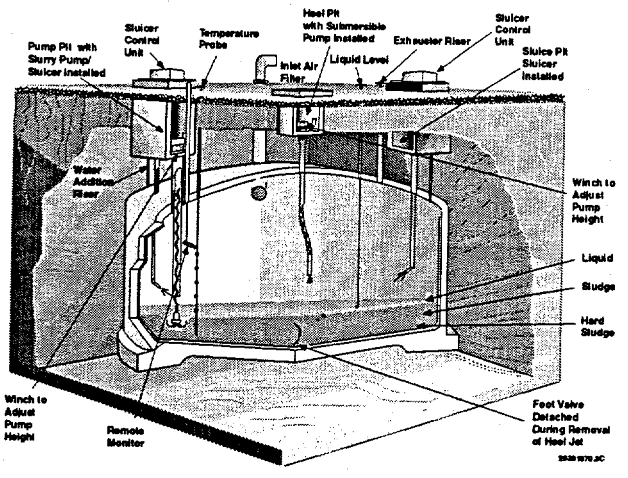

Figure 3. Single-shell Tank 241-C-106 (with Sluicing Equipment Installed).

mobilize SST wastes (see Figure 4). A wide range of waste types and forms can be mobilized and removed through the deployment of specialized end effectors that utilize a number of different technologies, such as high-pressure water jets, and mechanical impact devices. Though not as mature as the sluicing retrieval systems, the arm-based retrieval systems promise the ability to address a wider range of wastes and tank conditions. Development and demonstration testing to date has shown arm-based retrieval systems to be feasible. The procurement of the first system to employ this technical approach is in progress.

The combination of sluicing and arm-based retrieval systems, known as reference systems, forms the basis for completing the initial milestones established by the Tri-Party Agreement.[3] Tank 241-C-106 (a high-heat safety tank), the first major waste retrieval milestone, will begin the waste recovery demonstration using sluicing and complete the cleanup task with an arm-based retrieval system. A two system approach has been chosen because Tank C-106 contains a layer of hardened sludge on the tank bottom, which may not be recoverable using sluicing technology and therefore requires a different technology to complete the job.

Between the two technologies of sluicing and arm-based retrieval, there is a high degree of confidence that the wastes from any of the 149 SSTs can be recovered. Nevertheless, the development of additional advanced retrieval approaches is continuing because of a need to educe the overall costs of the retrieval program and to tackle the more difficult tanks that follow tank C-106. The spectrum of waste types and forms in the presence of in-tank hardware requires enhancements to the existing hydraulic sluicing and arm-based retrieval designs. Already costly, the enhanced systems are anticipated to increase the flexibility and complexity of the reference technologies and therefore drive costs higher. A further consideration is the large number of retrieval systems that will be required during the height of the retrieval campaign.

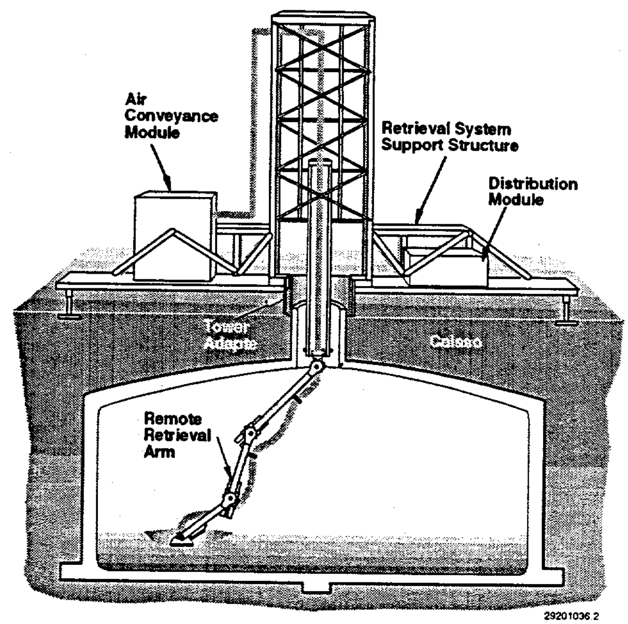

Figure 4. Single-shell Tank Retrieval Baseline Concept (Confined Sluicing).

A major thrust in the retrieval program is aimed at the reduction of the overall costs of the program through the development of alternative approaches. The premise of the alternative program is the development of advanced retrieval approaches that will be allowed to focus upon specialized niches for which a particular technical approach may be uniquely suited. The expected result is the identification of retrieval approaches that are simpler and may only be suitable for a subset of tanks or waste forms. The remaining tanks will be addressed by other specialized systems using different technological approaches or by the reference approaches that are broader in capability and flexibility. In the past, several promising approaches have been rejected because of their inability to tackle all conditions that can be found in the tanks. Following the alternative technology route, these limited capability systems will be reconsidered in hopes of reducing the costs to the retrieval program.

Current Status

The U.S. Department of Energy is aggressively moving forward with the design and deployment activities that will lead to the hot demonstration of the two reference technologies, hydraulic sluicing and arm-based retrieval, in Tank 241-C-106. Hydraulic-sluicing retrieval equipment will be deployed and waste retrieval initiated before the October 1997 milestone date to resolve high-heat safety concerns. The 241-C-106 tank demonstration will be completed when an arm-based retrieval system has successfully recovered 99% of the wastes or whatever percentage is technically feasible using this technology.

The hydraulic-sluicing project for tank C-106 is in the detail design phase for the retrieval campaign. Several of the major system procurements are in progress in tandem with the tank inspections and field modifications required to support the effort.

Arm-based retrieval completed the initial phase of the technology program, and efforts now focus upon enlisting the support of industrial partners to complete the design, development, and fabrication of the first arm-based retrieval system. The solicitations for industrial support released in the fall of 1994 sought vendors to propose and develop concepts/designs in competitive, multi-vendor, multi-option contracts in order to select the most promising design for deployment as Hanford's first arm-based waste retrieval system.

In parallel with the design, fabrication, and deployment of hydraulic-sluicing and arm-based retrieval systems, a program has been established to identify and develop alternative retrieval systems to be deployed into downstream SSTs. Once again, industrial partners have been sought to bring out new concepts with the intention of completing the design and fabrication efforts leading to deployment of the most promising ideas. The academic community has organized a concept/design competition to identify and initially develop waste-retrieval approaches that would be applicable to SST waste retrieval. The competition brings together university teams from across the nation and presents them with the same waste retrieval challenge that was given to industry.

CONCLUSIONS

The U.S. Department of Energy, through its operating contractor, Westinghouse Hanford Company, is actively pursuing a long-term course that will lead to the recovery of wastes from 149 SSTs located at Hanford, Washington. The approach strives to move ahead with early retrieval actions using known technology but continues the search for advanced technology to reduce overall costs and improve performance for future tank recovery actions. It is an integral part of the strategy to enlist the support of private industry and the academic community to assist with the design and development of the equipment and systems needed to retrieve wastes from the SSTs. The first of these interactions with industry and the academic community is well underway. Using a combination of reference and advanced technologies, the hope is for a comprehensive yet cost-effective method for completing one of Hanford's major challenges: retrieval of the SST wastes.

REFERENCES

[1] *Tank Waste Retrieval Issues and Options for Their Resolution*, WHC-SA-1697-FP, Waste Management '93, Tucson, AZ (1993).

[2] *A Description of the Hanford Single-shell Tanks and Their Contents*, WHC-SD-TD-TI-001, Westinghouse Hanford Company, Richland, WA (1992).

[3] ECOLOGY, EPA, and DOE, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, WA (1994).

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