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Revision 0

Overview of the Tank Focus area HLW Tank Retrieval Activities (Remote Operations)

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200
Fluor Hanford
P.O. Box 1000
Richland, Washington

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DOCUMENT NO.: HNF-7485-FP

AUTHOR'S NAME: Peter W Gibbons

ADDRESS: PO Box 1300 MS H9-91
Richland, WA 99352

PHONE: 509-372-4926 **FAX:** 509-372-6364

CO-AUTHOR(S):

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ADDRESS: PO Box 1300 MS H9-91
Richland WA 99352

PHONE: 509-372-4926 FAX: 509-372-6364

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P.W. Gibbons
Numatec Hanford Corporation

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Peter W. Gibbons (Numatec Hanford Corporation)
PO Box 999, MS: K9-91, Richland, WA 99352/USA
e-mail: Peter_W_Gibbons@rl.gov
Tel: 1-509-372-4926

ABSTRACT

Several U.S. Department of Energy (DOE) sites are currently retrieving or preparing to retrieve radioactive waste from underground storage tanks with technical assistance from the Tanks Focus Area. The Tanks Focus Area is a national program that provides information and technologies to safely and effectively remediate radioactive waste stored in DOE's underground tanks. Funding for the Tanks Focus Area is provided by the DOE Offices of Science and Technology, Environmental Restoration, and Waste Management. This paper provides an overview of recent remote waste retrieval activities as well as recent successes sponsored by the Tanks Focus Area.

1.0 INTRODUCTION

The Tanks Focus Area (TFA) is dedicated to providing technical assistance to six radioactive waste tank sites. These sites are Oak Ridge Reservation, Savannah River Site, Hanford Site, Idaho National Engineering and Environmental Laboratory, Fernald Site, and West Valley Demonstration Project. A brief history of each site follows. For more detailed information on the sites, see http://www.pnl.gov/tfa/. The Oak Ridge Reservation, in Tennessee, was created during World War II and has a long and involved nuclear history. Part of the site's original work was to develop and run the pilot plant for the high-level waste separation process used in Savannah River Site and Hanford Site nuclear material production operations. Now, the Oak Ridge Reservation is serving as a pilot-scale project for tank remediation. In the early 1950s, the Savannah River Site was established in South Carolina. The site's primary mission was to produce special nuclear materials to support U.S. defense, space, and medical programs. These missions generated highly radioactive waste. Today, the Savannah River Site is working on converting their tank waste to a glassified form and saltstone. Created in the 1940s, the Hanford Site's primary mission was to create plutonium for nuclear weapons. Since 1989, the site's mission has been environmental cleanup. The site, located in Washington State, is preparing to vitrify tank sludge and supernate. Idaho National Engineering and Environmental Laboratory was built in the late 1940s as a test site for nuclear reactors. Fifty-two reactors were built at this site. The spent nuclear fuel from these reactors as well as other site projects is stored in tanks. Today, the site is working on removing this waste and converting it to safer forms. The Fernald Environmental Management Project (or Fernald Site) was built in 1951 in Ohio to produce uranium metal as part of the Cold War effort. The site contains four silos built to hold uranium

residues, which need to be retrieved, treated, and transported to the Nevada Test Site for disposal. The West Valley Demonstration Project, a former commercial nuclear fuel reprocessing facility, was operated from 1966 to 1972 and generated liquid high-level waste, which is stored in tanks. The West Valley Demonstration Project is nearly finished with waste retrieval from its sludge tanks but a stubborn zeolite heel remains in one tank.[1]

Table 1. Summary of U.S. Department of Energy Tank Sites

	Fernald Environmental Management Project	Hanford Site	Idaho National Engineering and Environmental Laboratory	Oak Ridge Reservation	Savannah River Site	West Valley Nuclear Project
Number of tanks	4 silos	177	11 7 calcine vaults	40	51	3
Waste volume (Mgal)	10,645 cubic meters	54	1.4 (tanks) 1 (calcine)	0.6	34	0.6
Total curies	9.3 kCi	198 MCi	0.5 MCi (tanks) 24 MCi (calcine)	0.2 MCi	470 MCi	0.6 MCi

Under the TFA's retrieval program, robotic and remote systems are being successfully applied to mobilize and remove radioactive sludge, saltcake, and supernate from underground tanks. The TFA is directly assisting the Hanford, Oak Ridge, Idaho, Savannah River, and West Valley sites through technology teaming and co-funded deployment of new technologies. The Fernald Site is receiving indirect assistance in the form of lessons learned, transfer of technical data, and crosscutting program (i.e., Robotics) assistance. For these six sites, this paper briefly reviews remote technology applications being funded under collaborative projects that are sponsored by the TFA and/or DOE waste remediation programs. For additional information on retrieval technologies, see the TFA Technical Team Web Site (http://www.pnl.gov/tfa/).

2.0 OAK RIDGE RESERVATION

Recently, three significant retrieval operations occurred at the Oak Ridge Reservation, in Tennessee. First, the remaining waste heel was removed from gunite Tank W-9, marking eight gunite tanks passage from "retrieval" to "final cleaning and closure." Second, the alternative sluicing technology -- Russian Pulsating Mixer Pump -- was prepared for installation and plans call for it to begin retrieval shortly. Finally, the pulsejet mixer was deployed in the Melton Valley Capacity Increase Tanks, showing the commitment to the future by planning for retrieval today.

2.1 Waste from Eight Gunite Tanks Retrieved

The eight cleaned gunite tanks at Oak Ridge mark a significant retrieval milestone for DOE. These cleaned tanks are proof that remote retrieval technologies effectively remove radioactive waste under real, full-scale conditions. The 50-foot-diameter tanks were built using concrete and rebar in 1943 and 1944. These tanks have since been removed from service because of their age and changes in onsite waste needs. In the early 1980s, 90 percent of the waste was pumped from these tanks. This left behind thousands of gallons of radioactive supernate. In addition, lightweight and heavier sludge was left behind.[1]

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The sludge and supernate from seven of the tanks were transferred to Tank W-9. The waste in Tank W-9 was then transferred to the Melton Valley Storage Tanks. The waste was transferred from the other tanks to W-9 using the Radioactive Tank Waste Cleaning System. This is an integrated system composed of the Modified Light-Duty Utility Arm, the Houdini vehicle, and the Waste Dislodging and Conveyance System. With the waste consolidated, the PulseAir™ technology and the Flygt (pronounced "flight") mixer were used to mobilize the lightweight sludge and supernate and suspend the solids in Tank W-9. Keeping the solids in suspension was a critical issue, because the solids could plug the 1-mile-long, 2-inch-diameter transfer line. Plugging the transfer line would be costly and lead to schedule delays. In pulsed air mixing, large bubbles were produced periodically by gas-pulsing valves that feed air through horizontal, circular plates positioned just above the tank floor. The rapid growth of the pulsed air bubbles near the tank floor and their subsequent rise through the fluid lifted the solids and maintained them in a uniform suspension. Pulsed air mixing required only minor additions of water, involved no moving parts, and did not add heat to the waste slurries. The 15-horsepower Flygt mixer used a motor and propeller (similar to an outboard motor) to set up long-range currents that suspended the solids in the waste solutions. A Flygt mixer was used because it was smaller and less expensive than conventional slurry mixer pumps.[1]

The heavier sludge in Tank W-9 was removed with the Heavy Waste Retrieval System (HWRS). This system was added to Tank W-9 to allow the Modified Light-Duty Utility Arm and Confined Sluicing End Effector to move the heavier sludge to an in-tank receiver. The HWRS provided a means of maintaining continuous flow to the transfer line while receiving discontinuous discharges from the jet pump used with the Confined Sluicing End Effector. This system used a small surge tank to capture effluent from the sluicing system. An air-operated double-diaphragm pump was used to pump waste from the surge tank to the active system. A second pump was used to feed supernate to the surge tank. This allowed a steady flow to be maintained through the transfer system when cleaning the tank bottom, or when operations in heavy sludge resulted in low or discontinuous discharge from the confined sluicing system. From this receiver, the heavy sludge was pumped a short distance (500 feet) to the Bethel Valley Evaporator Service Tanks. From these tanks, the AEA Technologies pulsejet mixer was used to mix the waste in the tanks and pump it to the Melton Valley Storage Tanks.[1]

2.2 Final Preparations for Russian Pulsating Pump Deployment

Another significant retrieval accomplishment at the Oak Ridge Reservation was the final preparations for deployment of the Russian Pulsating Pump (Figure 1), an alternative technology for smaller waste tanks that cannot manage the larger retrieval equipment. The Russian Pulsating Pump was designed to mobilize and retrieve sludge waste using a jet pump, mixing pump, and transfer pump. Once in the tank, a vertical drive-screw system will raise and lower the pump to effectively mix the waste at various levels in the tank. An important benefit of the pulsating mixer pump is that additional liquids are not introduced into the tank during the mobilization and retrieval efforts. This technology was developed by the American Russian Environmental Services through a contract with the National Environmental Technology Laboratory. It will begin retrieving sludge in Tank TH-4 in December 2000. This tank contains radioactive and hazardous chemical waste produced as part of normal operations at the Oak Ridge Reservation.[1]

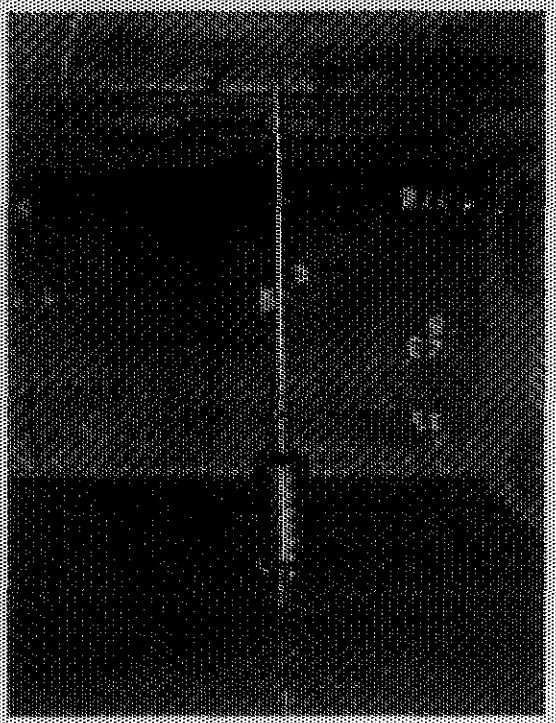


Figure 1. The Russian Pulsating Pump is an alternative technology for waste retrieval in smaller tanks where the larger equipment cannot function.

2.3 Pulsating Mixer Deployed in Capacity Increase Tanks

Finally, the AEA Technologies pulsating mixer was deployed in the Melton Valley Capacity Increase Tanks for long-term retrieval capability. By using the exterior tank portion of the system from Tanks C-1 and C-2 and adding new in-tank charge vessels and nozzles, the plan is to move the in-tank units from tank to tank as needed. This system is a follow-on to the fluidic mixers deployed successfully in five Bethel Valley Evaporator Service Tanks in FY99. Inserted into a tank, the mixer system uses a partial vacuum to pull waste into a charge vessel. When the charge vessel is filled to the correct level, air pressure is applied to the charge vessel, forcing the waste back into the tank and mixing it. When the correct ratio of solids is achieved, the system pumps the waste out of the tank to a local treatment or storage facility.[2]

3.0 SAVANNAH RIVER SITE

At the Savannah River Site, alternatives to the baseline retrieval methods are needed to remove hard sludge and heavy, fast-settling slurries. The baseline method is to use long-shaft mixer pumps to retrieve this waste and transfer it to the Defense Waste Processing Facility for vitrification. However, these pumps are costly and often leave behind tens of thousands of gallons of heavy, fast-settling materials. Westinghouse Savannah River Company and TFA are working together to demonstrate alternative technologies for waste removal and tank closure in Tank 19. This tank contains a waste heel of hard-to-remove zeolite and other materials, a remainder from previous mixer pump retrieval operations. Flygt mixers are one of the alternative retrieval technologies. Flygt mixers are being considered because they offer a lower cost alternative to the baseline technology.[1]

3.1 Flygt Mixers Deployed in Tank 19

For two years, scale up and verification testing were conducted on the Flygt mixers. As part of the testing, Pacific Northwest National Laboratory conducted long-duration tests for the full scale. After 67 hours of run time, the newly configured mixer propeller and shaft appeared to work well; however, three of six brackets holding the prototype shroud to the motor broke. Project staff determined that the shroud material used for the mockup, in conjunction with strong dynamic loading, led to the breakage. After sending the mixer back to the Savannah site, project staff ran a structural analysis on the final redesigned shroud and mixer based on the impact loading during the full-scale test. The final design with a stronger shaft propeller and shroud was tested with clay slurry. Structural analysis showed that running three Flygt mixers at 500 rpm (lower than originally planned) was safe.[1]

Based on the test results, in August 2000, three Flygt mixers were installed in Tank 19 (Figure 2). In September, the retrieval process began with the addition of 87 inches of water. To mobilize the settled solids, the mixers first pushed the material to the center and then to the periphery. During the mixing cycle, the tank was pumped to the 48-inch level (with waste transferred to Tank 18). Decanted liquid was returned to Tank 19, re-establishing the 87-inch liquid level. This cycle was repeated. Periodic full pump-downs were used to gauge progress.[1]

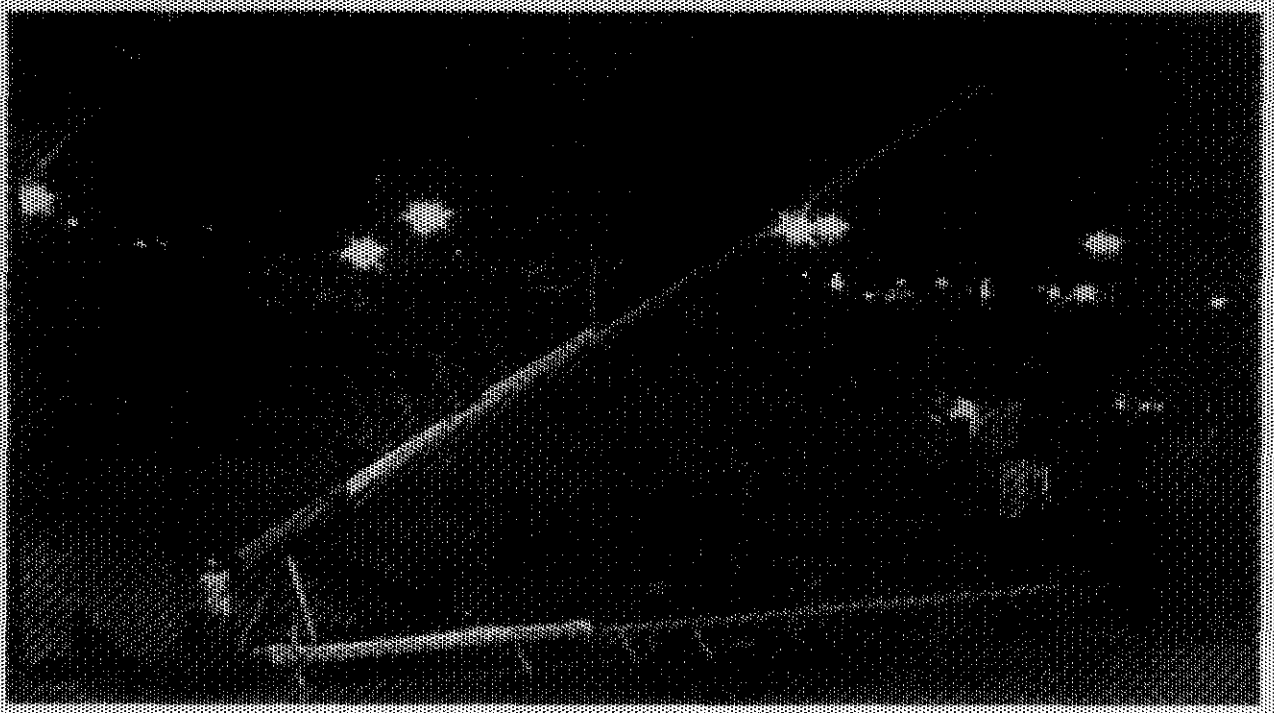
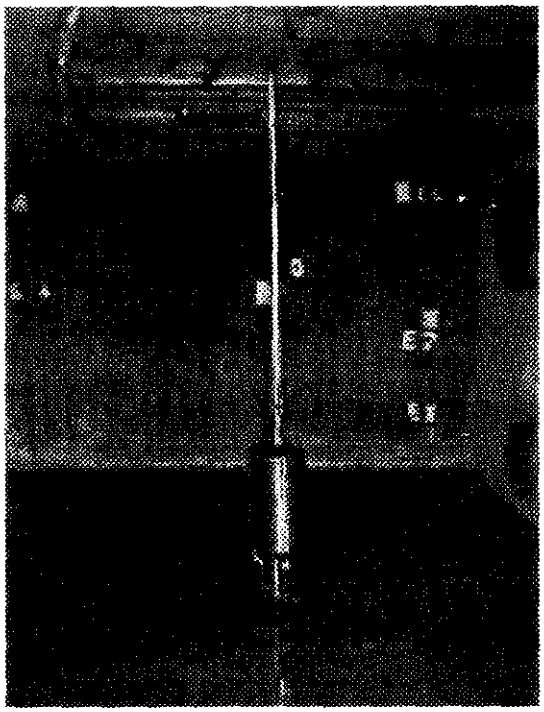


Figure 2. The Flygt mixer, being positioned in a Savannah River Site tank, uses a motor and propeller (similar to an outboard motor) to set up long-range currents that suspended the solids in the waste solutions.

Operators determined that a mound of solids, probably zeolite added after the 1980s mixing campaign, kept the transfer pump approximately a foot above the tank floor. Future mixing may clear the landing spot, if not, further steps will be taken to lower the pump for optimum retrieval results.[1]

3.2 Disposable Crawler Development Continues

Residual tank heel can take a variety of forms in Savannah River Site tanks. In Tank 18, a flat-bottomed tank, hard zeolite deposits exist on the tank floor. To remove these deposits, work



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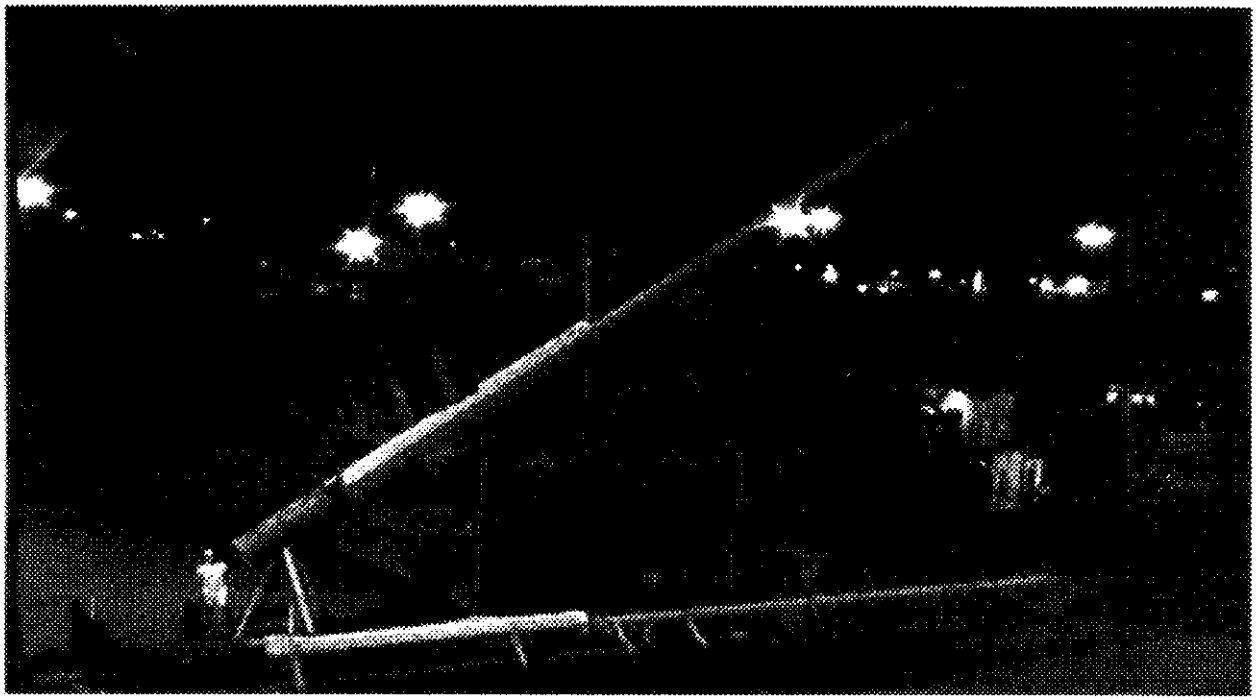

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Figure 3. The sluicer on the disposable crawler can be easily positioned to move residual waste to more convenient areas for retrieval. In this photo, the sluicer is aimed at a set of motorized treads.

continues on a disposable crawler (Figure 3). This crawler uses off-the-shelf motorized treads from Inuktun® to sweep up the residual waste. The top-mounted sluicer uses a water jet to move the remaining waste into convenient areas for retrieval. This low-cost system uses less water than a tank-mounted top sluicer and can be disposed of with the other in-tank equipment, avoiding expensive decontamination activities. However, further development will be done on the disposable crawler to increase ease deployment and to add tools, such as a scavenging system, for more effective bottom cleaning.[1]

Another use of this technology may be final in-tank cleaning. Final cleaning involves removing residual waste on the tank floor. Because the residual waste is a thin layer spread on the tank floor, a method is needed to "sweep" the waste into piles that could be easily removed. When an evaluation of the performance is completed, a recommendation report containing data and lessons learned will be incorporated into the Retrieval Technology Guide (see http://www.tanks.org/).[1]

3.3 Exhaust System Modifications Mitigate Entrainment Concern

Use of air-operated pumps at Savannah River Site triggered a safety concern regarding the tank exhaust system. The vacuum system that draws water into the pumps could entrain liquids and release them through the tank's exhaust system, which is located inside the tank near to the top. The exhaust system was not prepared to handle such a burden and was not a safety class item (a quality assurance certification). The TFA and its partners mitigated the problem by adding safety class valves and a flow-restricting orifice to reduce air velocity below entrainment speeds.

4.0 HANFORD SITE

Retrieval efforts at the Hanford Site are focused on eliminating special safety concerns identified in Public Law 101-510, Section 3137, commonly called the Wyden Bill after its sponsor, U.S. Representative Ron Wyden. This law requires DOE to identify and monitor tanks that require special safety precautions (for example, tanks that generate excessive amounts of heat). These tanks are referred to as the Watch List tanks. In addition, retrieval efforts are concerned with removing waste from aging single-shell tanks, some of which have leaked waste to the surrounding soil.[3]

4.1 Retrieval Technologies Remove Tank from Watch List

Sluicing is an effective way to remove sludge from some single-shell tanks. Using the recycled supernate sluicer, 95 percent of the sludge (188,000 gallons) was removed from single-

shell Tank C-106. Because of the physical and chemical complexity of the sludge, a sluicing strategy was developed for use in the tank. The strategy was based upon sluicing tests performed using the Hanford nozzle with full-scale pressure, flow rates, and stand-off range in a 30-foot-diameter tank filled with simulated sludge. Combined with full-scale operations studies, a successful strategy for retrieving soft sludge was developed and implemented. This is the first completed retrieval of radioactive waste from a single-shell tank at Hanford. This effort is particularly significant, given the history of Tank C-106. Over the years, a high concentration of fission products in this tank generated temperatures as high as 235 degrees Fahrenheit. This heat was controlled by routinely adding 6000 gallons of water to the tank. The high heat measured within the tank sometimes raised fears about tank failure and leakage. These fears caused the tank to be listed on the "Watch List." Now that the waste has been removed with sluicing, site managers now can turn their attention to tank closure issues (such as hard heel removal or fixation).[1]

4.2 Studies Continue Regarding Retrieval from Leaking Tanks

At the Hanford Site, retrieval work is focused on removing sludge and salt from the aging single-shell tanks. These tanks are a significant issue at the Hanford Site because some will continue to be used after they have exceeded their 50-year design life. As the tanks exceed their design life, they are more prone to developing leaks, allowing waste to seep to the surrounding soil. For retrieval efforts, this poses a significant set of challenges, specifically how to remove waste from leaking tanks without exacerbating the leak. Based on preliminary studies of leaking tanks, three efforts are planned or under consideration for retrieval from Tank C-104: 1) a cold feasibility test of a crawler-based retrieval system, 2) testing of an additional sluicing system, and 3) exploration of new technologies that could remove damp sludge and salt without adding water. These studies are not only critical to developing retrieval technologies, they are also critical to protecting the surrounding environment.[1]

5.0 IDAHO NATIONAL ENGINEERING & ENVIRONMENTAL LABORATORY

Retrieval efforts at INEEL are focused on waste heel and closure requirements. Recently, the site has completed sampling efforts in Tank WM-182 that support the development of a closure plan, a critical step in closure. In addition, the site is working on retrieving viscous waste discovered clinging to the cooling coils and floors of several tanks.

5.1 Sampling Brings Tank WM-182 Closer to Closure

Remote inspection work moved INEEL closer to closure of Tank WM-182, which contains a 6-inch layer of liquid and precipitated solid waste. Using the LDUA Stereo Viewing System, INEEL staff inspected the tank walls and interior. They found much of the tank wall interior and piping was covered with a milky colored residue. They also found several inches of precipitated solids in the heel layer. Using the LDUA Heel Sampling End Effector, four heel samples were taken from different locations on the tank floor with volumes ranging from 480-830 milliliters and gamma radiation contact readings of 9-24 rad/hr. A fifth sample was obtained but was too small for a full suite of analyses.[1]

The samples were sent to the Remote Analytical Laboratory at Idaho Nuclear Technology and Engineering Center. The solid and liquid phases of each heel sample will be analyzed. With

the sampling information and the data from analysis conducted last year, the TFA plans to submit a tank closure plan to DOE-Idaho Operations Office by the end of FY00, and to begin closure of Tank WM-182 in FY03.[1]

5.2 Retrieval Spray Ball Sluicer Tested

In the past several years, sampling in three of the INEEL tanks discovered a viscous waste layer on the bottom of the tanks and adhering to the cooling coils on the tank walls. To help the site meet agreed-upon waste treatment schedules, a retrieval spray ball sluicer with a steam jet eductor was tested as a possible retrieval option. On September 13 and 14, 2000, testing was conducted using a test bed was a full-size mockup of half of a 50-foot-diameter tank (Figure 4). The rotating spray ball was placed in a shroud that caught the jets as they pointed away from the mockup half. A steam jet pump was placed in the requisite location, and cooling coils installed on the tank floor. The mockup was located at a private vendor facility. This has allowed for rapid construction and testing (that is, four to six weeks for construction, equipment setup, and initiation of the first test). Solid simulant and water were placed in the test bed to a depth of 11 inches, with 8 inches of settled solids. The solids at INEEL have a slow settling rate and will stay in suspension several minutes after agitation. Using the spray ball sluicer, 90-95% of the solid material was removed, leaving a 3/4-inch-deep slurry layer, on average. Subsequently, two directable sluicing nozzles were added to systematically move the remaining sludge toward the pump. The directable nozzles resulted in excellent recovery, leaving only a 1/16-inch-thick layer across the floor. A hot demonstration is planned for 2001.[1]

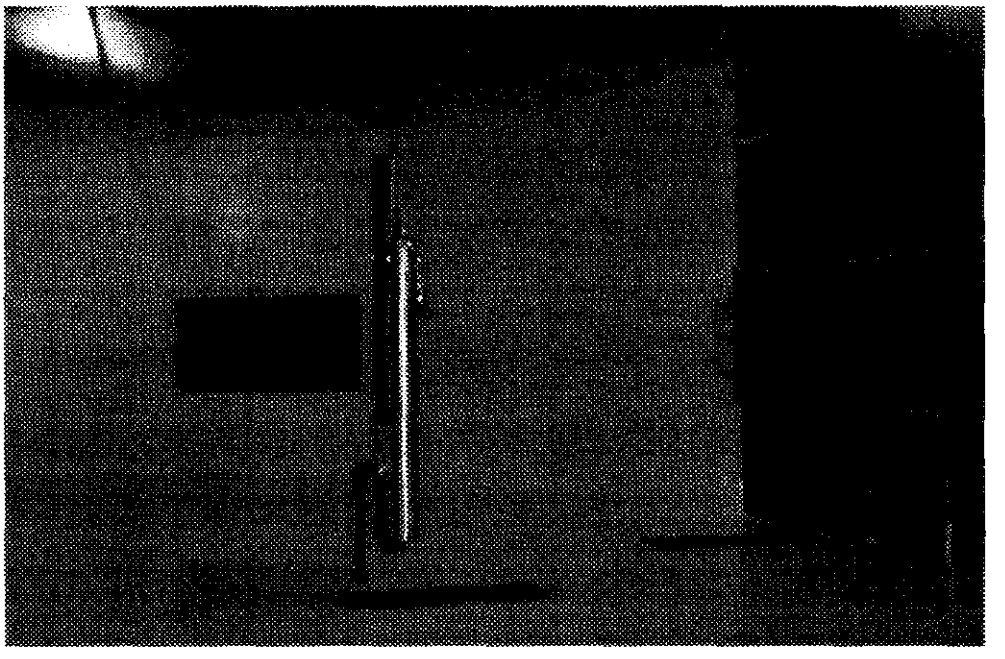

Figure 4. Mock-tank testing of the combined sluicing sprayball and steam jet eductor was conducted at INEEL in September 2000. (Photo provided by INEEL.)

6.0 FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Staff members at the Fernald Environmental Management Project have placed two private contracts for retrieval of damp soil-like wastes from Silos 1 and 2 as well as the dry retrieval of a radon-containing powder from Silo 3 (Silo 4 is empty). The TFA provided data regarding retrieval technologies and tests to assist the Fernald staff in placing the contracts. Both contractors are planning to use bridge-mounted long-reach manipulators to deploy retrieval systems. In the Silo One and Two Project, the goal is to remove and transfer the contents to a temporary storage facility or tanks. This project will use a Gray Pilgrim Easily Manipulated Mechanical Armature (EMMA) coordinated cable-operated system. This system is a simple, exceptionally lightweight deployment system that requires less support structure than more conventional arms. The arm can reach up to 30 feet with a potential for a 40-foot reach, the maximum reach required to retrieve waste. To retrieve waste from the silos, the arm will be deployed down a single riser; when it emerges from the riser, it will grasp and then position the Silo Retrieval End Effector, which has been deployed down a separate riser (Figure 5). The end effector uses rotating jets to direct a short-range pressurized spray of water to effectively mobilize the waste (Figure 6). Simultaneously, the water and dislodged tank waste are aspirated using a jet pump-driven conveyance system. The material is pumped outside of the tank where it can be stored. The Silo Retrieval End Effector is a direct descendant of the Confined Sluicing End Effector, developed by the TFA to remove waste from the gunite tanks at the Oak Ridge Reservation. [1]

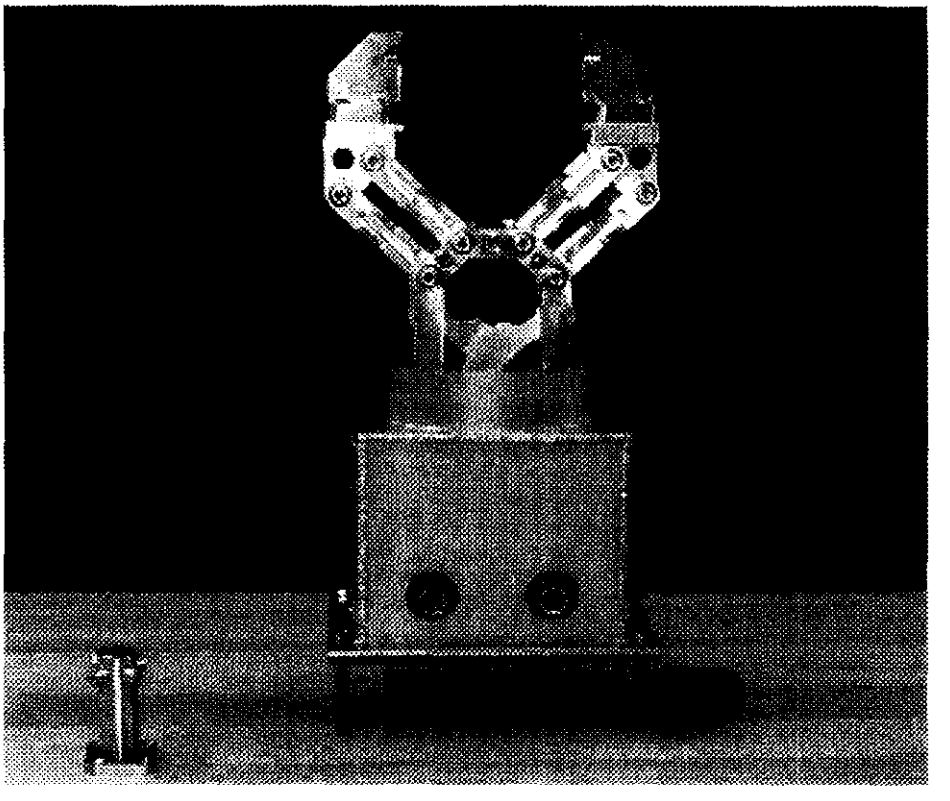

Figure 5. With this specially designed clamping system, the EMMA grasps the Silo Retrieval End Effector and positions it to remove mobilize waste inside the tank.

The goal of the Silo Three Project is to remove and treat the powder without adding water. The plan is to use Framatome Technologies Revolving Turret Reeled Cable Incremental Link Extending Vacuuming Robot (ReTRIEVR) to remove waste. This system consists of a 60-foot-reach

Figure 6. The Silo Retrieval End Effector (SREE), shown here in the hydraulic test bed, uses rotating jets to direct a short range pressurized spray of water to effectively mobilize the tank waste.

segmented-link platform and a six degree-of-freedom dexterous master-slave robotic arm. The arm can hold a variety of retrieval tools.[4] For more information, see http://www.framatech.com/marketing/retrievr.htm.

7.0 WEST VALLEY DEMONSTRATION PROJECT

With waste retrieval nearly complete, the West Valley staff members are working with the TFA and its partners to determine the actual, residual source term in the tanks. With this determination, the staff can answer the critical questions regarding the next steps in tank closure (e.g., is more retrieval needed? can closure activities begin?). The site is planning to use a sampler developed by Oak Ridge Robotics to collect tank wall residual waste samples in FY01 on their Mast-Mounted Tool Deployment System (Figure 7). The sampler will use milling machine bits to scrape samples from carbon-steel Tanks 8D-1 and 8D-2. A vacuum and filter system will collect the dislodged material and contain it for delivery to a laboratory for analysis. From these samples, an estimate of the total contamination inside the tank can be determined.[1] This is especially timely following the identification of a "beach line" within Tank 8D-2 (this line corresponds to the location of the top of the waste when it was in the tank). This beach line contains a measurable source term. Current plans for removing the contamination at the beach line include the use of high-pressure water jet equipment mounted on a floating deployment system.

8.0 CONCLUSIONS

From simple to elaborate, the challenges of remote operations can never be underestimated as concepts are developed and deployed in the field. The TFA, working in partnership with the DOE site waste cleanup programs, private companies, and other government organizations, is successfully applying new remote technologies to retrieve waste from underground storage tanks. Valuable data from successful field operations are being effectively shared across the DOE complex to assist tank waste sites in planning for larger and more challenging retrieval problems.

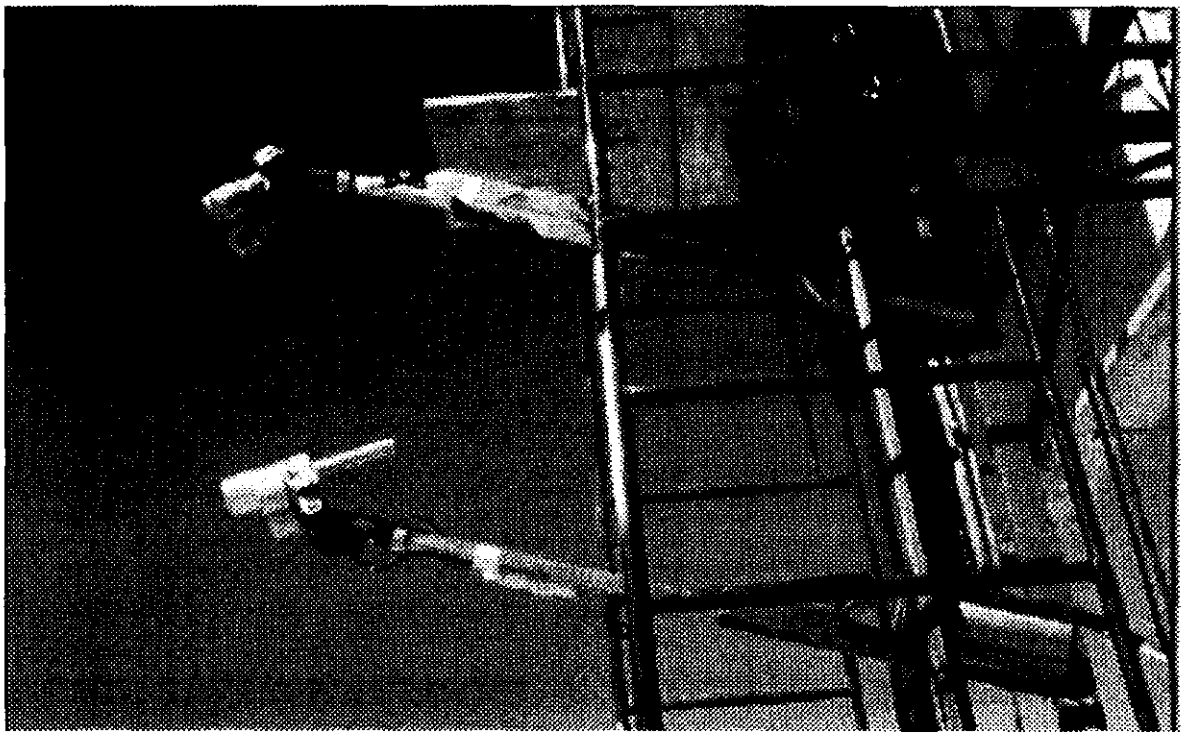

Figure 7. At the West Valley site, the Mast-Mounted Tool Deployment System will be used to deploy sampling tools to determine the actual, in-tank source term.

9.0 REFERENCES

1. Tanks Focus Area Technical Team, Tanks Focus Area Technical Team Web Site, http://www.pnl.gov/tfa/, Pacific Northwest National Laboratory, Richland, 2000.

2. Tanks Focus Area Technical Team, FOCUS ON...Applying International Technology to Solve U.S. Problems, Pacific Northwest National Laboratory, Richland, 1999.

3. Gephart, RE, Lundgren, RE., Hanford Tank Cleanup: A Guide to Understanding the Technical Issues, 11-12, Battelle Press, Columbus, 1998.

4. Framatome Technologies, Inc., ReTRIEVR, http://www.framatech.com/marketing/retrievr.htm, Framatome Technologies, Inc., Lynchburg, 1999.