CH2M-36346-FP
Revision 0

Tank Waste Retrieval Lessons Learned at the Hanford Site

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

Contractor for the U.S. Department of Energy
Office of River Protection under Contract DE-AC27-99RL14047

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Date Published
January 2008

To Be Presented at
WM 2008 Conference

Waste Management Symposia, Inc.
Phoenix, Arizona

February 24-28, 2008

Published in
Proceedings of 2008 Waste Management Conference

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WM2008 Conference, February 24 - 28, 2008, Phoenix, AZ

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ABSTRACT

One of the environmental remediation challenges facing the nation is the retrieval and permanent disposal of approximately 90 million gallons of radioactive waste stored in underground tanks at the U. S. Department of Energy (DOE) facilities. The Hanford Site is located in southeastern Washington State and stores roughly 60 percent of this waste.

An estimated 53 million gallons of high-level, transuranic, and low-level radioactive waste is stored underground in 149 single-shell tanks (SSTs) and 28 newer double-shell tanks (DSTs) at the Hanford Site. These SSTs range in size from 55,000 gallons to 1,000,000 gallon capacity. Approximately 30 million gallons of this waste is stored in SSTs. The SSTs were constructed between 1943 and 1964 and all have exceeded the nominal 20-year design life. Sixty-seven SSTs are known or suspected to have leaked an estimated 1,000,000 gallons of waste to the surrounding soil. The risk of additional SST leakage has been greatly reduced by removing more than 3 million gallons of interstitial liquids and supernatant and transferring this waste to the DST system. Retrieval of SST saltcake and sludge waste is underway to further reduce risks and stage feed materials for the Hanford Site Waste Treatment Plant.

Regulatory requirements for SST waste retrieval and tank farm closure are established in the Hanford Federal Facility Agreement and Consent Order (HFFACO), better known as the Tri-Party Agreement, or TPA. The HFFACO was signed by the DOE, the State of Washington Department of Ecology (Ecology), and U. S. Environmental Protection Agency (EPA) and requires retrieval of as much waste as technically possible, with waste residues not to exceed 360 ft^3 in 530,000 gallon or larger tanks; 30 ft^3 in 55,000 gallon or smaller tanks; or the limit of waste retrieval technology, whichever is less. If residual waste volume requirements cannot be achieved, then HFFACO Appendix H provisions can be invoked to request Ecology and EPA approval of an exception to the waste retrieval criteria for a specific tank.

Tank waste retrieval has been conducted at the Hanford Site over the last few decades using a method referred to as Past Practice Hydraulic Sluicing. Past Practice Hydraulic Sluicing employs large volumes of DST supernatant and water to dislodge, dissolve, mobilize, and retrieve tank waste. Concern over the leak integrity of SSTs resulted in the need for tank waste retrieval methods capable of using smaller volumes of liquid in a more controlled manner.

Retrieval of SST waste in accordance with HFFACO requirements was initiated at the Hanford Site in April 2003. New and innovative tank waste retrieval methods that minimize and control the use of liquids are being implemented for the first time. These tank waste retrieval methods replace Past Practice Hydraulic Sluicing and employ modified sluicing, vacuum retrieval, and in-tank vehicle techniques.

Waste retrieval has been completed in seven Hanford Site SSTs (C-106, C-103, C-201, C-202, C-203, C-204, and S-112) in accordance with HFFACO requirements. Three additional tanks are currently in the process of being retrieved (C-108, C-109 and S-102) Preparation for retrieval of two additional SSTs (C-104 and C-110) is ongoing with retrieval operations forecasted to start in calendar year 2008.

Tank C-106 was retrieved to a residual waste volume of 364 ft^3 using oxalic acid dissolution and modified sluicing. An Appendix H exception request for Tank C-106 is undergoing review. Tank C-103 was retrieved to a residual volume of 351 ft^3 using a modified sluicing technology. This approach was successful at reaching the TPA limits for this tank of less than 360 $ft^3$and the limits of the technology. Tanks C-201, C-202, C-203, and C-204 are smaller (55,000 gallon) tanks and waste removal was completed in accordance with HFFACO requirements using a vacuum retrieval system. Residual waste volumes in each of these four tanks were less than 25 ft^3. Tank S-112 retrieval was completed February 28, 2007, meeting the TPA Limits of less than 360 cu ft using saltcake dissolution, modified sluicing, in-tank vehicle with high pressure water spray and caustic dissolution . Tanks C-108 and C-109 have been retrieved to 90% and 85% respectively. Modified sluicing was no longer effective at retrieving the remaining 5,000 to 10,000 gallons of residual. A Mobile Retrieval Tool (FoldTrac) is scheduled for installation early in 2008 to assist in breaking up chunks of waste and mobilizing the waste for transfer.

Lessons learned from application of new tank waste retrieval methods are being documented and incorporated into future retrieval operations. They address all phases of retrieval including process design, equipment procurement and installation, supporting documentation, and system operations. Information is obtained through interviews with retrieval project personnel, focused workshops, review of problem evaluation requests, and evaluation of retrieval performance data.

This paper presents current retrieval successes and lessons learned from retrieval of tank waste at the Hanford Site and discusses how this information is used to optimize retrieval system efficiency, improve overall cost effectiveness of retrieval operations, and ensure that HFFACO requirements are met.

INTRODUCTION

The Hanford Site covers approximately 560 square miles of arid land in southeastern Washington State. The radiochemical processing of spent nuclear fuels and other waste management operations conducted over the past six decades has left us with roughly 53 million gallons of radioactive waste. This waste is currently stored in 149 SSTs and 28 DSTs located in the 200 East and 200 West Areas of the Hanford Site (commonly referred to as the Central Plateau). The SSTs were constructed from 1943 to 1964 and contain roughly 30 million gallons of waste. All of the SSTs have exceeded their 20-year design life by several decades.

The SSTs are constructed with steel-reinforced concrete outer shells and carbon steel liners along the sidewalls and tank bottoms. The SSTs were constructed in 12 tank farms containing 4 to 18 tanks each. Sixteen SSTs are 200-Series tanks with capacities of 55,000 gallons each. The remaining 133 SSTs are 100-Series tanks with capacities ranging from 530,000 gallons to 1 million gallons each. Many of the tanks were built in cascades of three or four tanks. The cascading tank configuration allowed solids to separate and settle while less radioactive liquids flowed from one tank to another.

The SSTs contain mostly radioactive saltcake and sludge waste. The waste is primarily sodium nitrate and sodium nitrate salts; and metal phosphate, carbonates, oxides, hydroxides, and sulfates. About 75 percent of the radioactivity is attributed to Strontium-90 while 24 percent of the radioactivity is associated with Cesium-137. The remaining 1 percent of the waste is a mixture of other radionuclides (primarily actinides). The majority of the Strontium-90 is found in the sludge while Cesium-137 tends to concentrate in the saltcake and interstitial liquids.

Sixty-seven of the 149 SSTs are known or suspected to have leaked an estimated 1 million gallons of waste into the surrounding soil. The number of tanks that actually leaked is estimated to be 50 percent less based on results of recent investigations attributing some suspected tank leaks to pipeline ruptures and near-surface spills.

In March 2004 the Hanford Site completed the interim stabilization saltwell pumping in all 149 SSTs in accordance with HFFACO requirements. Roughly 3 million gallons of drainable and pumpable liquid waste was removed from the SSTs and transferred into the environmentally sound DSTs between 1997 and 2004. Completion of interim stabilization salt-well pumping was an important first step in retrieving waste from the SSTs and greatly reduces the potential risk associated with leakage of waste while the SSTs await completion of retrieval operations.

SELECTION OF 241-C SINGLE SHELL TANKS FOR RETRIEVAL

The C Tank Farm was chosen as the first Hanford tank farm to focus on retrieving all the waste from the single shell tanks for several reasons.

- Early retrieval of C Farm high heat tanks, primarily C-106, resolved high heat safety concerns regarding the addition of water for cooling in a tank that might develop a leak.

- C Farm tanks rank high relative to other tanks for curie to volume ratio. C Farm retrieval maximized the curies retrieved for the volume of waste transferred as well as containing 35% of the total Single Shell Tank inventory of transuranic radionuclides.

- Sludge waste material in C Farm was needed in the Double Shell Tanks to stage for efficient and sustained high level waste vitrification plant operation in the future.

- The close proximity of C Farm to the Double Shell Tank Farms reduced the cost of infrastructure for transferring the waste.

- Focused initiative on retrieval of C Farm waste would result in early opportunities to close a Hanford Tank Farm facility and early opportunities to begin learning and applying lessons learned to future tank closure activities.

Through teaming with the Washington Department of Ecology, EPA, U.S. Department of Energy, Office of River Protection (ORP) and CH2M Hill Hanford Group, Inc., agreement was reached on this focused retrieval plan.

The C Tank Farm was constructed during 1943 and 1944 with twelve tanks having a nominal capacity of 530,000 gallons each and four tanks with a nominal capacity of 55,000 gallons. These tanks received metal waste sludges primarily from PUREX plant operations. Several tanks within the C Farm have had waste sludge temperatures in the tank increase to above 212 degrees Fahrenheit due to the quantities of Strontium-90. Active ventilation and periodic raw water additions were used to facilitate evaporative cooling. As a result of high-heat safety issues and concerns over addition of raw water to control waste temperatures, the decision was made to retrieve the waste from tank C-106. The first retrieval method, termed "past-practice" hydraulic sluicing was initiated in November 1998 and completed in October 1999. This method introduced high-pressure, high-volume DST supernatant in the tank to dislodge, dissolve, and mobilize the waste for removal by the retrieval pumping system. This system was successful at retrieval of about 187,000 gallons of sludge and resolving high-heat safety concerns with tank C-106. About 36,000 gallons of supernatant and hard sludge were left in the tank following this initial retrieval campaign.

Subsequent retrieval operations were performed in C-106 in 2003, using a combination of modified sluicing, with oxalic acid dissolution. During this retrieval, a total of 142,000 gallons of 0.9 molar Oxalic Acid were added to C-106 in 6 batches. After each batch, the acid was allowed to fully react with the sludge material, pumped to the receiving DST and sluicing operations were performed to remove the loosened sludge. This process was repeated until no additional waste was being removed. [1]

At the conclusion of these retrieval operations, the residual waste volume on the C-106 tank bottom was estimated to be about 348 ft^3 using the Video Camera/CAD Modeling System (CCMS). For C-106 the 95% confidence interval (CI) was 364 ft^3. Because this volume exceeded the 360 ft^3 residual volume goal, an Appendix H exception request has been written in accordance with the HFFACO and is being reviewed.

Tank C-103 retrieval using a modified sluicing technology was initiated on November 6, 2005. The tank contained about 77,000 gallons of sludge. Two sluice nozzles were positioned on either side of the tank with a Gorman Rupp adjustable height slurry pump located in the center of the tank. Supernatant from the double shell tank (DST) was pumped to C-103, introduced through the sluice nozzles to mobilize the sludge, and then pumped back to the DST. Fig. 1 shows the percent of C-103 volume retrieved per day of operation in comparison to the predicted retrieval rates.

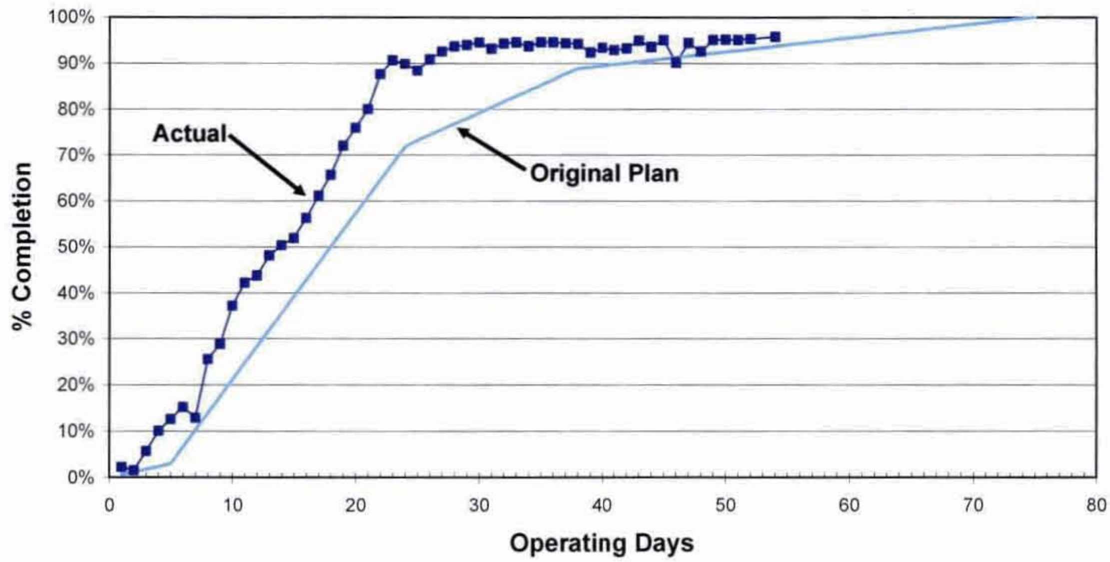

Fig. 1. Comparison of Predicted and Actual Waste Retrieval Rates from Tank C-103

Two critical equipment failures occurred during the retrieval. The slurry pump used for C-103 was an off-the-shelf 10-hp, bottom suction, top discharge, centrifugal pump commercially manufactured by the Gorman Rupp Company. After approximately 24-hours of operation in the waste tank, the C-103 pump failed with a dead short to ground in all three of the motor phases. Although high radiation levels prevented the failed pump from being disassembled/inspected, shop testing of identical spare pumps and disassembly/inspection identified a common failure mechanism characteristic of the pumps (primary and secondary seal failure occurring early in the operating life of the pump which allowed moisture to enter the air filled winding cavity). To improve the pump reliability, CH2M HILL worked with Gorman Rupp to enhance pump manufacturing and testing procedures for pumps supplied to Hanford. Additionally, extensive testing following mounting of the pump on the pump assembly was conducted prior to installation. This pre-installation testing included a 96-hour challenge test, with periodic megger testing, oil removal and inspection, and seal cavity vacuum testing. The enhanced pump manufacture Quality Control measures combined with the extensive on site testing has greatly improved pump reliability. To date, no additional pump failures have been experienced during subsequent retrievals. A comprehensive evaluation of the C-103 pump failure is documented in RPP-RPT-28451. The hydraulic sluicers used for C-Farm tank retrieval are hydraulic actuated sluicers commercially manufactured for removal of waste sludge from petroleum tanks with minor modifications performed to interface with Hanford's waste tanks. During C-Farm sluicing two sluicer failures have occurred (one failure during C-103 retrieval and one failure during C-108 retrieval). Both sluicers experienced identical failure mechanisms which resulted in the loss of the sluicer nozzle vertical angle positioning and both were replaced with identical sluicers. High radiation levels associated with the failed sluicers prevented post failure evaluation to determine the exact cause of failure, however, troubleshooting identified both failures were associated with the hydraulic motor gear drive or linkage connection. Prior to installing replacement sluicers, the sluicer manufacturer was consulted and extensive pre-installation testing and inspection was performed. To understand the exact failure mechanism, a spare sluicer was provided to the sluicer manufacturer and subjected to a 300-hour continuous run test.

During the testing, the sluicer failed after approximately 200 hours of operation with conditions identical to those previously experienced during sluicing operations. The failed sluicer was disassembled and inspected which identified the hydraulic motor gear drive had failed. Further investigation into the cause of the failure identified the drive linkage (over center cam linkage) was creating unacceptable load conditions during full extension of the sluice nozzle. To resolve the problem, the sluicer nozzle elevation position linkage was redesigned and replaced with a chain and sprocket assembly which eliminated excessive loading at full extension. Following modification, the sluicer successfully completed over 300-hours of continuous operation with no failure or signs of excessive wear. Sluicers planned for future installation are currently undergoing modification.

In addition to the major equipment failures, the in-tank camera had to be removed and cleaned several times. Mist generated in the tank from the sluice nozzles created a film over the camera lenses limiting the visibility. A lens shield constructed out of an empty drink bottle, kept mist off of the lens and significantly decreased the maintenance required on the camera. In total, about 50 days of sluicing was performed with about 2.3 million gallons of DST supernatant recycled to complete retrieval. Retrieval was stopped when the limits of the technology had been achieved and a residual waste volume in C-103 was measured to be 338 ft^3, with a 95% upper confidence limit (UCL) of 351 ft^3. This tank met the criteria for completion of retrieval per the TPA.

Tank C-108 retrieval was initiated in December 2006, with an estimated 66,000 gallons of waste sludge. This tank is considered to be sound, so modified sluicing with recycled supernatant was again chosen as the retrieval technique. The 96 hour slurry pump operational testing was used and the hydraulic motor used to rotate the sluicer was reinforced as improvements due to the C-103 experience. One of the sluicers located in C-108 again failed in a similar manner about 2 months into retrieval, requiring replacement. The sluicer was replaced and retrieval resumed. With approximately 1.8 million gallons of DST waste recycled and about 90% of the waste retrieved, sluicing was halted in C-108. No additional solids were being removed from the tank with the installed modified sluicing system. The decision was made to procure a mobile retrieval tool, referred to as the Foldtrac which could be installed in the tank and mechanically break-up and push the waste to the slurry pump. Water jets installed on the tool would also aid in mobilizing the solids. The installation of the Foldtrac in C-108 is scheduled for mid 2008. Fig. 2 plots the waste retrieval rate versus the gallons of total slurry pumped from C-108. This plot shows that the actual retrieval rate is faster at the start of retrieval than predictions, but quickly diminishes. This plot also identifies a disparity between the retrieved volume and the starting volume. The gallons of waste retrieved is measured at the receiving double shell tank as a function of the net increase in level. Inaccuracies in the starting volume due to an uneven surface and dry sludge porosity account for the difference between the starting volume and the volume of sludge retrieved.

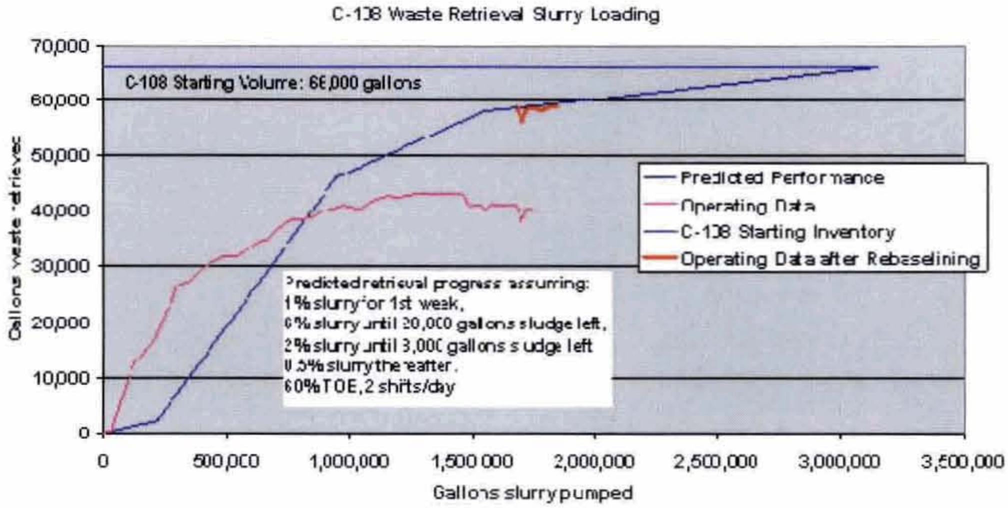

Fig. 2. C-108 Waste Retrieval Slurry Loading

Retrieval of tank C-109 was started in June of 2007 with a starting volume of about 63,000 gallons. Retrieval of 85% of the waste was achieved by August 2007. No significant equipment issues occurred during the retrieval sluicing operations, however the retrieval efficiency again significantly reduced (see Fig. 3) making it necessary to install a new piece of equipment to achieve the TPA goals. Similar to C-108, waste chunks on the bottom of the tank that were too cohesive to break up and/or too heavy to move with the sluice nozzles remain. The volume of waste residuals is about 10,000 gallons, well in excess of the 360 cu ft (2700 gallon) goal for retrieval. The Foldtrac appears to be best suited for deployment in this tank to meet the retrieval goals. Foldtrac deployment in C-109 is scheduled for early 2008.

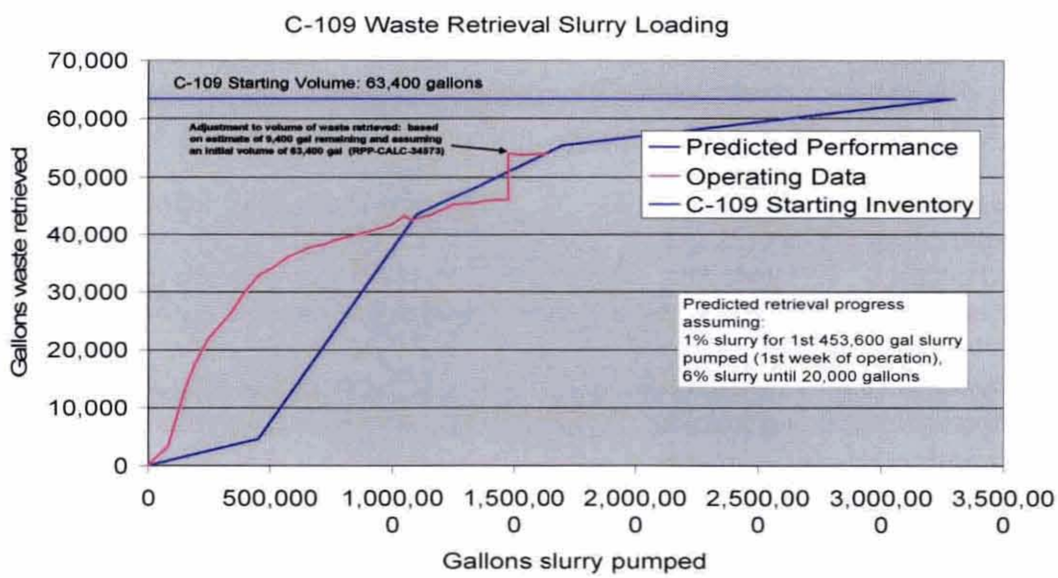

Fig. 3. C-109 Waste Retrieval Efficiency

A comparison of these retrieval efficiencies is shown in Fig. 4. An increase in retrieval efficiency from 45% to 85% reflects the improvements that have been achieved. This represents the days that the system was operated versus the days it was planned for operation. This data shows that the lessons learned and implementation of corrective actions has resulted in a significant increase in the retrieval efficiency. The key to implementation of the lessons learned has been to maintain the majority of the system simple, largely unchanged, and target specific failure mechanisms to limit the introduction of new failures. The major equipment failures and replacement time significantly impacted the time required to complete the retrieval. As shown in each tank specific retrieval plots, the first 50% to 75% volume retrieval is achieved quickly, however the final 15% to 25% is time consuming to break-up, move to the pump and mobilize the waste for transfer. Debris, obstacles, monolithic layers and waste chunks are not visible at the start of retrieval, therefore planning for those specific issues is difficult. However a wide variety of tools and techniques is being developed for use on Hanford waste tanks, many of which have been successfully deployed and used to meet the TPA goals.

Fig. 4. Comparison of Modified Sluicing Efficiencies

The Lessons Learned from retrieval operations included:

- The slurry pump is best located in the center of the tank if risers are available for access. In this manner, the dish- shaped tank bottom can be used most effectively to allow pumping to the lowest point in the tank and minimize residuals.

- Permanently installed stainless steel pipe-in pipe transfer piping was used for transferring waste from C-106 to the DST receiver during past practice sluicing operations. While it was effective for use, materials and installation were very expensive in this application.

During oxalic acid dissolution and modified sluicing, an above-ground Hose-in-Hose Transfer Line was utilized which provided high performance at a significantly reduced cost.

- During the bulk retrieval operations in the late 1990s, DST supernatant was recycled during the retrieval operations and used as the sluicing media. This was very effective at mobilizing the tank sludge and reducing the total waste generated during the retrieval operations. About 10 million gallons of supernatant has been recycled during the retrieval of waste from the C Farm Tanks saving important DST space and eliminating the need for additional tank evaporation campaigns.

- The initial methods for determining the residual volumes at a 95 percent confidence interval resulted in very large upper bounds and largely overstated the residual volumes. This methodology was revised, resulting in a smaller residual volume estimate at a 95 percent confidence interval.

- More extensive slurry pump testing is necessary to fully identify potential pump problems. A 96-hour run-in at vendor prior to delivery and pre-installation testing increased confidence in operability of pump.

- Adjustable height slurry pump minimizes plugging and shutdown, and increases sluicing efficiency.

- New sluice controls (electric to hydraulic) allow faster response at sluice nozzle. Removal of ~4000 Ft. of hydraulic hose negated need for glycol heating system.

- Moving camera from ventilation exhaust to ventilation inlet. To date this appears to be minimizing the amount of contamination on the cameras, hence, camera life is extended and removal/installation is easier.

- Providing two camera risers with dual ports on each riser will increase operational flexibility and should minimize downtime for camera repairs/replacement. Work platforms at camera risers will also decrease camera swap out time, and minimize retrieval downtime.

- Camera lens protectors to minimize condensate buildup on camera lens. Allows more continuous operations.

- Re-use of existing valve box, exhauster, and other ancillary equipment. This lessened the testing requirements for the new system on C-108, and reduced training time for operators and O/Es.

RETRIEVAL OF C-200 SERIES TANKS

The C-200 series tanks consist of four 55,000-gal SSTs, 20-ft diameter and built in C Tank Farm from 1944 to 1945. All four tanks are assumed to have leaked in the past. The waste in the C-

200 tanks was retrieved using a vacuum retrieval system (VRS) consisting of an articulating mast with a vacuum head, vacuum pump, slurry vessel and slurry transfer pump. A ventilation system, control trailers and associated piping and utilities make up the remaining system. Fig. 5 shows the configuration of this system. The retrieval system and its operation are described in RPP-16945, *Process Control Plan for the 241-C-200 Series Waste Retrieval System.*

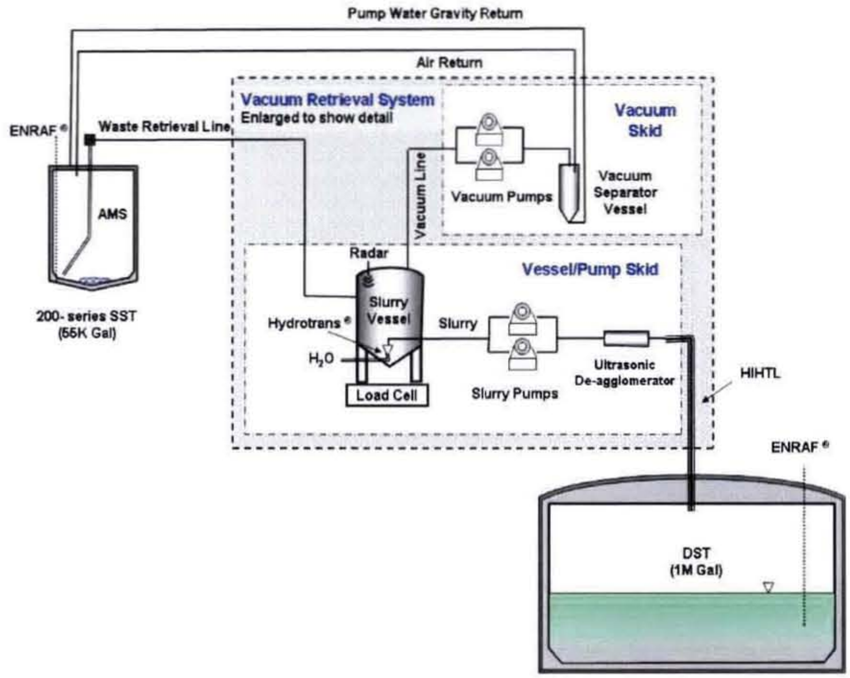

Fig. 5. Vacuum Retrieval System Configuration

The retrieval of waste from Tank C-203 started in June of 2004 and continued through March of 2005. The pre retrieval estimate of waste contained in the tank was 2,600 gallons. When retrieval completed in March of 2005, approximately 3,050 gallons of waste had been retrieved from Tank C-203. The total post-retrieval waste volume in SST C-203 is estimated to be 18.55 cu.ft (139 gallons). For the purpose of meeting the HFFACO, the total residual waste volume is the residual waste volume on the tank bottom (both liquid and solid) at the 95 percent upper control limit (14.8 cu ft) plus the residual waste volume on the stiffener rings, equipment void space, and tank walls (5.11 cu ft). Using this definition, the total post-retrieval waste volume in C-203 is estimated to be 19.9 cu ft (149 gallons) thus meeting the criteria of less than 30 cu ft.

SST C-203 retrieval was the first use of the VRS in a radiological environment for recovery of tank solids. Many lessons were learned which will improve pre-retrieval predictions and overall system performance [3]. These lessons include:

- The HFFACO established method of estimating the remaining waste volume using 3-D imaging and computer aided as-built drawings was effective in determining the waste remaining in the tank after completion of retrieval operations.
- Material balance calculations for estimating volume of waste retrieved proved useful as a general indicator of retrieval progress. Pre-retrieval volume estimates are very uncertain due to varying sludge surface heights and the waste sludge porosity and void space. The pre-retrieval estimate of 7 days was overly optimistic, though a considerable amount of waste was retrieved in the first 7 days of operation. The pre-retrieval predictions were based on performance data observed during CTF simulations prior to startup. The simulations were conducted at the CH2M HILL CTF using waste simulants derived from generator knowledge contained in RPP-14627, *Characteristics of Waste in the C-200 Series of Hanford Underground Waste Tanks*. The waste simulant resembled the sticky viscous material identified in the report. The mock retrieval system was able to suction the waste out of the tank, by adding limited quantities of water to change its consistency to a non-cohesive mud-like substance.
- Initially the waste behaved in a similar manner as observed at the CTF. As the campaign progressed; however, the waste characteristics became less favorable to retrieval. The waste, rather than resembling a mud-like substance after addition of water, broke into chunks having a gravelly appearance. This material required considerably more effort to be lifted out of the tank and remain suspended through the retrieval system process. The material had a tendency to settle quickly, requiring more water and greater agitation to suspend the particles and subsequently longer time to complete retrieval.
- The retrieval campaign used approximately 62,664 gallons of water. Water use increased during the retrieval duration as the waste behavior became more gravel-like and less mud-like. This required greater amounts of water to effectively mobilize retrieve and flush the system.
- The length and configuration of the hose connecting the AMS to the vacuum vessel was determined to be an important factor to having adequate vacuum for retrieval operations. During the retrieval activities on C-203, significantly less vacuum was observed in the AMS and vacuum head than had been demonstrated during testing at the CTF. Additional mockup operations at the CTF showed considerable improvements in vacuum by shortening the hose lengths and reducing the number and angle of bends in the piping system.
- The screen mesh size on the intake to the AMS was sized smaller than need be (3/8 in.) to protect the slurring pump and vessel equipment. This led to unnecessary plugging problems that severely slowed the vacuum retrieval rates with this system. Similar to saltcake dissolution and sluice retrieval pumps, the intake screen should be sized as large as possible to protect the pump from damage, but as large as possible to minimize plugging.

The second of the C-200 series tanks to retrieve was Tank C-202. Like C-203, Tank C-202 was assumed to have leaked in the past and utilized the vacuum retrieval system consisting of an articulating mast with a vacuum head, vacuum pump, slurry vessel and slurry transfer pump. Key lessons learned from C-203 retrieval were incorporated into the operation of C-202. These included:

- Shorter hose lengths were used between the AMS and the vacuum vessel.
- Sharp bends between the vacuum line and the top of the AMS were removed.
- Transfer line flushes were reduced from being performed after each batch, to being performed at the end of each operating day.
- Reduced water usage and air injection at the vacuum head resulted in higher vacuum and increased retrieval rates.

The retrieval efficiency was increased from 0.05 gallon waste retrieved per gallon of DST waste created for Tank C-203 to 0.07 for Tank C-202. This resulted in a 34 percent reduction in the DST space required for retrieval, however it still was greatly in excess of the goal, and if the system performed similarly on a large volume SST, retrieval would be impacted by the availability of DST space. [4]

Waste retrieval operations were initiated on tank C-201, the third of four C-200 series tanks, in October 2005. Tank C-201 contained approximately 750 gallons of solid waste prior to VRS operations. After retrieval of about 90% of the waste and the limit of retrieval ability of the VRS system was reached, the rotary union of the mast stuck. This disabled the ability to rotate the VRS mast radially, using the hydraulic controls. Due to the limited amount of waste remaining to be retrieved, the mast was manually rotated into 14 selected positions, allowing successful completion of retrieval. Using this approach, a residual waste volume of about 20 cu ft remained, meeting the goal for less than 30 cu ft. Similar to previous retrievals, the overall time required for retrieval and the total waste generated was far greater than testing and expectations. In addition, the manual rotation of the mast was time and labor intensive with no appreciable waste retrieved.

Waste retrieval operations were initiated in tank C-204, the final of the C-200 series tanks, using the vacuum retrieval system. Lessons learned from tank C-201 retrieval and the failure of the rotary union was applied to the C-204 retrieval. The rotary union in C-204, which had been installed with the mast as part of the overall system construction in the winter of 2003, was lubricated and manually rotated to prevent a failure similar to that observed in C-201. In spite of these efforts, the rotary union on C-204 became frozen in place after about 50% of the tank waste had been retrieved. A chain driven rotary system was back fit to the mast which enabled remote rotation of the mast for completion of the retrieval operation. With the modified system in place, the retrieval goal of less than 30 cu ft was again met for C-204.

Although the VRS was able to meet the TPA required retrieval goals for each of the four tanks, with residual waste volumes well below the 30 cu ft, the time necessary to retrieve small volumes of waste and the total waste generated were both excessive. The vacuum system efficiency improved significantly from tank C-203 to tank C-202 retrievals, however the major equipment failures of the mast rotation reduced the efficiency on the final two tanks. If this system is going to be used for retrieval on a larger SST for retrieval, a more reliable mast movement system must be deployed. A higher vacuum system capable of retrieving at a higher waste to water ratio must be achieved for efficient use of the limited available DST space.

GENERAL OBSERVATIONS AND LESSONS LEARNED

General lessons that have been learned and applied to subsequent retrieval operations include:

- The use of old facility systems and infrastructure should be limited. The cost of upgrading old existing systems and structures, and removing contaminated equipment far exceeds the fabrication and installation of new systems when practicable.

- The application of lessons learned from both process data and equipment design has significantly reduced the cost of retrieval from the C-106 retrieval operations to the more recent C-200 retrieval. This is demonstrated in Fig. 6.

- Significant improvement has been made in the measurement of the post retrieval residual volumes. This allows, at the 95% confidence interval, to more accurately depict the final residual volumes for use in future risk assessments and closure plans.

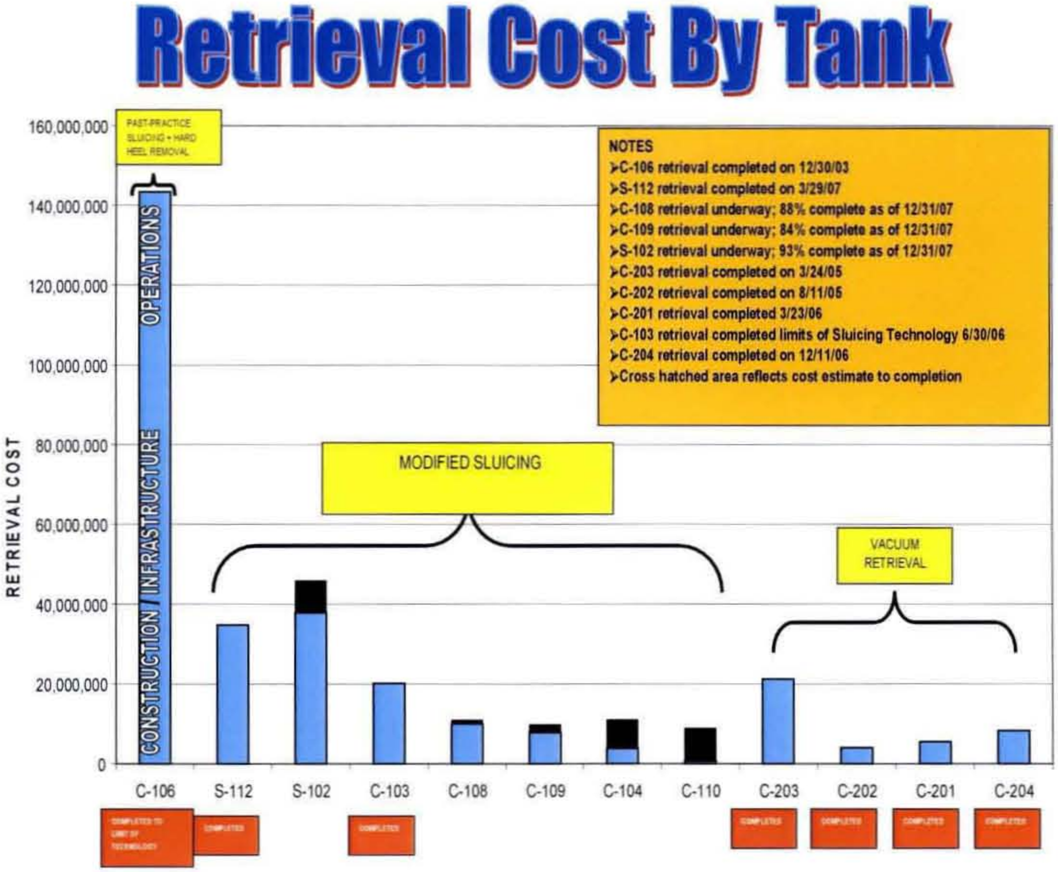

Fig. 6. Retrieval Cost by Tank

CONCLUSION

Significant accomplishments are being made in the retrieval of waste from the SSTs at Hanford. Seven tanks have been retrieved meeting the TPA goals and three more are currently underway. Three primary retrieval technologies have been deployed (modified sluicing, vacuum retrieval and saltcake dissolution) to achieve the retrieval goals. Additional processes of the salt mantis, oxalic acid dissolution, caustic dissolution, air/nitrogen sparging, high pressure mixing nozzles (rotary vipers), and variable height pumping have also been utilized. Other tools such as the Foldtrac and Sand Mantis are under various stages of testing and deployment for use in tanks. Each tank retrieved to date has exhibited different challenges and hurdles, and most of these are not revealed until many feet of waste have been retrieved. Through the application of lessons learned, the retrieval of each tank is getting more efficient and the cost of retrieval as depicted in

Fig. 6, is significantly being reduced and the end state goals for residual volumes are being achieved.

REFERENCES

1. R.A.., DODD, "Progress in Retrieval and Closure of First High-Level Waste Tank at Hanford: Single-Shell Tank C-106," WM'05 Conference, February 27 – March 3, 2005, Tucson, AZ (2005).

2. J.M. WIMETT, et al., "Calculation for the Post-Retrieval Waste Volume Determination for Single-Shell Tank 241-C-203, RPP-CALC-25672, Revision 0, CH2M HILL Hanford Group, Inc., Richland, Washington (2005).

3. T.L. SAMS,"Retrieval Data Report for Single-Shell Tank 241-C-203," RPP-RPT-26475, Revision A, CH2M HILL Hanford Group, Inc., Richland, Washington (2005).

4. CH2M-0502499, "Retrieval Report for Single-Shell Tank 241-C-202," (External letter from E. S. Aromi, CH2M HILL, to R. J. Schepens, ORP, August 25), CH2M HILL Hanford Group, Inc., Richland, Washington (2005).