PROGRESS IN RETRIEVAL AND CLOSURE OF FIRST HIGH-LEVEL WASTE TANK AT HANFORD: SINGLE-SHELL TANK C-106

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ABSTRACT

One of the most challenging environmental remediation activities facing the United States is the retrieval and permanent disposal of approximately 90 million gallons of radioactive waste stored in underground tanks at Department of Energy (DOE) facilities. The Hanford Site stores roughly 60 percent of this waste. Successful retrieval, treatment, and disposal of this waste represents a significant step towards eliminating potential threats to human health and the environment, and reducing the nations stockpile of radioactive waste.

The Hanford Federal Facility Agreement and Consent Order (HFFACO) establishes, among other things, regulatory requirements for single-shell tank (SST) waste retrieval and SST farm closure. The HFFACO requires retrieval of as much waste as technically possible, with waste residuals not exceeding 360 cubic feet in 530,000 gallons or larger tanks; 30 cubic feet in 55,000 gallons or smaller tanks; or the limit of waste retrieval technology, whichever is less.

In fiscal year (FY) 2002, the DOE Office of River Protection (ORP) commissioned the Accelerated Tank Closure Demonstration (ATCD) Project at the Hanford Site to establish and demonstrate the technical, regulatory, and administrative aspects of tank waste retrieval and interim closure. Tank C-106 was the first SST retrieved and will be the first SST closed under the auspices of the ATCD Project.

Tank C-106 was built during the early 1940's with a nominal capacity of 530,000 gallons. It is the third tank in a cascade series of three tanks and contained 10 million curies of radioactivity prior to initiation of waste retrieval operations. As a result of high-heat safety issues during the 1990's and concerns regarding the addition of raw water to control waste temperatures in a SST that exceeded its design life by several decades, a decision was made to retrieve the waste from Tank C-106.

Initial retrieval of waste from Tank C-106 was conducted during the late 1990's to successfully resolve the high-heat safety concerns. Final retrieval of waste from Tank C-106 was completed in December 2003 using oxalic acid dissolution and modified sluicing methods. Efforts are underway to initiate closure of Tank C-106 in accordance with approved closure plans and in a manner consistent with the future Record of Decision for the Tank Closure Environmental Impact Statement.

This paper describes the background, methods, accomplishments, and issues associated with retrieving waste from Tank C-106 to the limits of technical feasibility. In addition, future plans for interim and final closure of Tank C-106 are discussed.

INTRODUCTION

On August 6, 1945, an atomic bomb was dropped on Hiroshima, Japan, and President Harry S. Truman told the world about the Manhattan Engineer District (MED) and the once secret "Manhattan Project." Three days later a second atomic bomb exploded over Nagasaki, Japan, bringing an end to World War II.

Hanford Engineer Works (HEW), now the Hanford Site, was constructed along a remote stretch of the Columbia River in southeastern Washington State to produce plutonium for the Manhattan Project. Between initial ground breaking in March 1943 and the end of World War II in August 1945, the MED and HEW built over 1,000 structures on the Hanford Site including nuclear reactors, radiochemical processing plants, underground single-shell tanks (SSTs), and supporting infrastructure. In addition, the government city of Richland, Washington was born.

Over the next two decades the Hanford Site expanded in response to national and international events that included explosion of the first former Soviet Union atomic bomb, victory of the Communist Chinese over the Nationalist Army, the "space race" between the United States and former Soviet Union, and the beginning of the Korean War. The mid-1960's to mid-1980's ushered in a phase-down of nuclear weapons production at the Hanford Site and elsewhere.

Today, the vast majority of the DOE's 90 million gallons of radioactive waste (approximately 97 percent) is stored underground in 177 tanks at the Hanford Site and 51 tanks at the Savannah River Site in South Carolina. The Hanford Site stores roughly 60 percent of this waste.

One of the most important challenges facing the nation is the cleanup and permanent disposal of DOE's radioactive legacy wastes. Many cleanup activities have been completed and more are underway across the DOE-Complex to address these legacy wastes to ensure adequate protection of human health and the environment, and closure of waste sites in a cost-effective, timely, and regulatory compliant manner.

Hanford Site Single-Shell Tanks and Waste

The Hanford Site covers approximately 560 square miles in southeastern Washington State. The radiochemical processing of spent nuclear reactor fuels and other waste management operations conducted over the past six decades resulted in the generation of roughly 55 million gallons of radioactive waste. This waste is currently stored in 149 SSTs and 28 double-shell tanks (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 "dished" 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 100-Series tanks were built in cascades of three or four tanks. The cascading tank configuration allowed solids to separate and settle while less radioactive liquids over-flowed from one tank to another.

The SSTs contain mostly radioactive salt-cake and sludge waste. The waste is primarily sodium nitrate and sodium nitrite salts; and metal phosphates, 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) and chemicals. The majority of the Strontium-90 is found in the sludge while Cesium-137 tends to concentrate in the salt-cake 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 interim stabilization salt-well pumping in all 149 SSTs in accordance with HFFACO requirements. A total of roughly 3 million gallons of drainable and pumpable liquid waste was removed from the SSTs and transferred into environmentally sound DSTs. 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.

Single-Shell Tank C-106 History

Tank C-106 was constructed during 1943 and 1944 with a nominal capacity 530,000 gallons. It is the third tank in a cascade series of SSTs that include Tank C-104 and Tank C-105. Tank C-106 is one of twelve 100-Series SSTs located in 241-C Tank Farm. It received Metal Waste (MW) from the Bismuth Phosphate Process during the second quarter of 1947 as a cascade from Tank C-105. The MW contained all the uranium, 90 percent of the original fission products, and 1 percent of the plutonium. The MW was stored in Tank C-106 until 1953 when sluice-mining was started for uranium recovery. Virtually no solids remained in the tank after the last transfer of slurry from the sluice-mining operation.

Tank C-106 was filled to capacity during 1954 with Tri-butyl Phosphate Waste (TBP). During the second quarter of 1957, the tank was pumped to a small residual heel and began receiving Coating Waste (CW) from the Plutonium/Uranium Extraction Plant (PUREX). The tank remained full and static until 1963 when it was pumped to the 241-B Tank Farm.

During the last quarter of 1963 the tank began receiving PUREX Supernatant Waste (PSN). Tank C-106 was filled with PSN waste and no further transfers were made until 1968. After being pumped to a minimum liquid heel in 1968, the tank was used to support PUREX sludge processing. This process included a step for washing slurry with water to remove soluble constituents. The wash solution, termed PUREX Sludge Wash Waste (PSS), was routed to Tank C-106. The tank was subsequently pumped to B-Plant for cesium recovery.

Tank C-106 continued to receive PUREX wastes until 1971 when sludge temperatures increased to above 212 degrees Fahrenheit. It was determined that unacceptable quantities of Strontium-90 were transferred with PSS waste as indicated by temperature increases and boiling of the waste due to radiolytic heat generated from the decay of Strontium-90. Since Tank C-106 was not equipped for storing self-boiling waste, the use of the tank as a PSS waste receiver was

discontinued and the tank was placed on an active vessel ventilation system. Raw water was periodically added to the tank to facilitate evaporative cooling and keep the waste from boiling and drying out.

Retrieval of Tank C-106 Waste

There are no indications that Tank C-106 has ever leaked. However, as a result of high-heat safety issues and concerns over the addition of raw water to control waste temperatures in a SST that exceeded its design life, a decision was made to retrieve the waste from Tank C-106. Two retrieval methods were deployed in the late 1990's and early 2000's to remove the waste.

Past Practice Hydraulic Sluicing – 1998/1999

The first waste retrieval method, termed "past-practice" hydraulic sluicing, was initiated in November 1998 and completed in October 1999. This method introduced high-pressure, high-volume liquids into the tank to dislodge, dissolve, and mobilize the waste for removal by the retrieval pumping system. Figure 1 depicts the Tank C-106 past-practice hydraulic sluicing system.

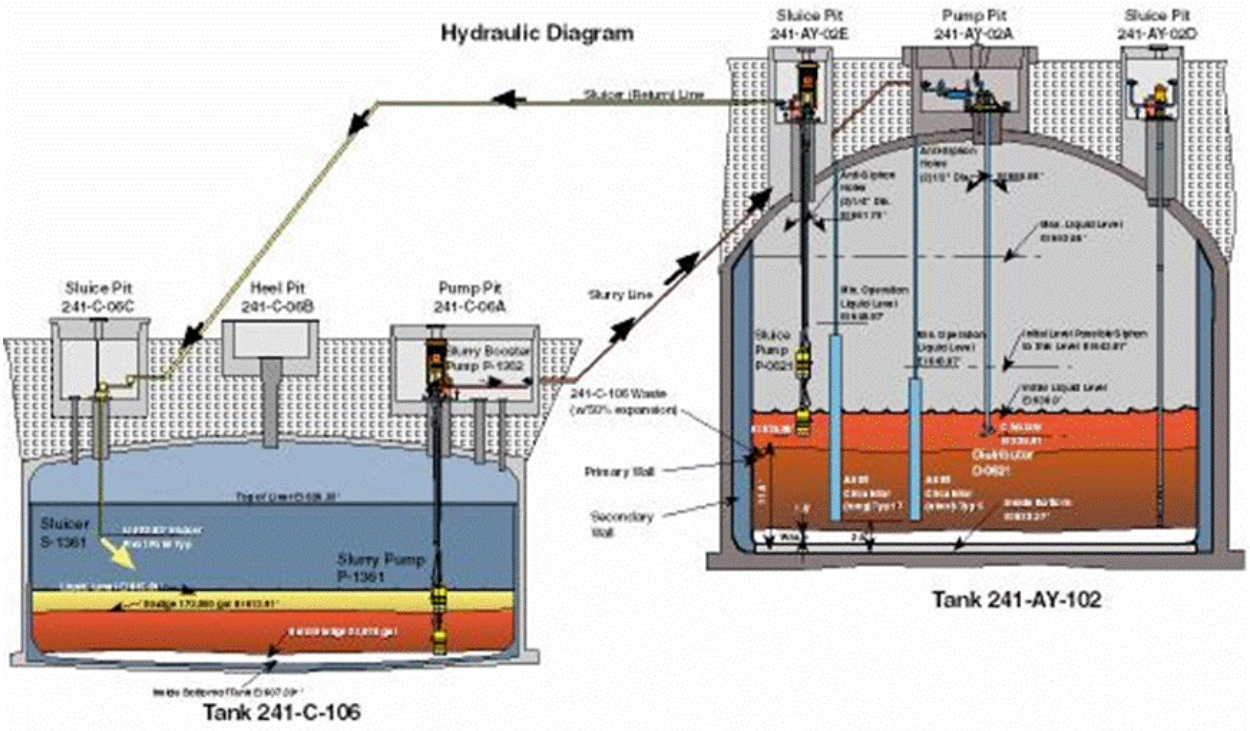

Fig. 1. Tank C-106 past-practice hydraulic sluicing system

Past-practice hydraulic sluicing was conducted using the supernatant from nearby DST AY-102. The technical limit of solids removal using past-practice hydraulic sluicing was reached in October 1999 and waste retrieval operations were discontinued. Past-practice hydraulic sluicing successfully resolved the high-heat safety issue in Tank C-106 by removing and transferring to the DST system roughly 187,000 gallons of sludge waste. In December 1999, the State of Washington, Department of Ecology (Ecology) provided the DOE with written notification that

the waste retrieval criteria and requirements had been met for this initial retrieval campaign (Fitzsimmons, 1999).

Using in-tank video imaging methods, the residual waste volume in Tank C-106 was calculated to be roughly 45,000 gallons in July 2000. This included 9,000 gallons of solids and 36,000 gallons of liquids. Residual waste calculations performed in August 2001 adjusted the total solid and liquid volume to 36,000 gallons. The reduction in residual waste volume was attributed to evaporation of 9,000 gallons of liquids resulting from continued operation of the tank vessel ventilation system.

The cost for retrieving Tank C-106 waste during the 1998/1999 campaign was $103 million or roughly $550 per gallon. A number of lessons were learned during this retrieval campaign with respect to cost, schedule, and performance baselines. These lessons were segregated into two categories (global and equipment related) and they are factored into future retrieval system designs and subsequent operations. The most significant lessons learned include (Bailey, 2000):

- Oversight reviews provide only incremental value-added for the substantial level of resources expended to support them.
- Volatile Organic Carbon (VOC) release response planning requires improvement.
- Use of continuous (rather than batch) sluicing would substantially reduce the cost of sluicing operations.
- Increasing the operational flexibility allowed by the Safety Authorization Basis and environmental permits is essential to efficient operations.
- Pump and winch modifications should be made to avoid pump priming and discharge hose kinking problems.

Modified Sluicing and Oxalic Acid Dissolution - 2003

Standard past-practice hydraulic sluicing techniques were unable to dissolve the hard heel of waste remaining in Tank C-106. This insoluble waste heel was characterized as a cobble-like, stable agglomeration with varying particle sizes up to 6 inches in diameter (May, 2003). Consequently, removal of the insoluble heel required an additional method to dissolve the waste sufficiently for entrainment in the waste slurry and subsequent removal by the retrieval pumping system.

Attempts to remove the remaining residual waste volume from Tank C-106 were initiated in April 2003 with the removal of 18,000 gallons of supernatant. A retrieval method referred to as "modified sluicing" was selected for the removal of the remaining 18,000 gallons of predominantly solid matter. The modified sluicing retrieval method utilizes an articulated, high-pressure, low-volume nozzle to dislodge, dissolve, and transport waste slurry to the retrieval pumping system for removal. The low-volume feature of the modified sluicing retrieval method addressed concerns regarding tank leak integrity and limited availability of DST space for receipt of retrieved waste. The cost for the 2003 retrieval campaign was roughly $22.4 million or $622 per gallon. Figure 2 depicts the Tank C-106 modified sluicing retrieval system.

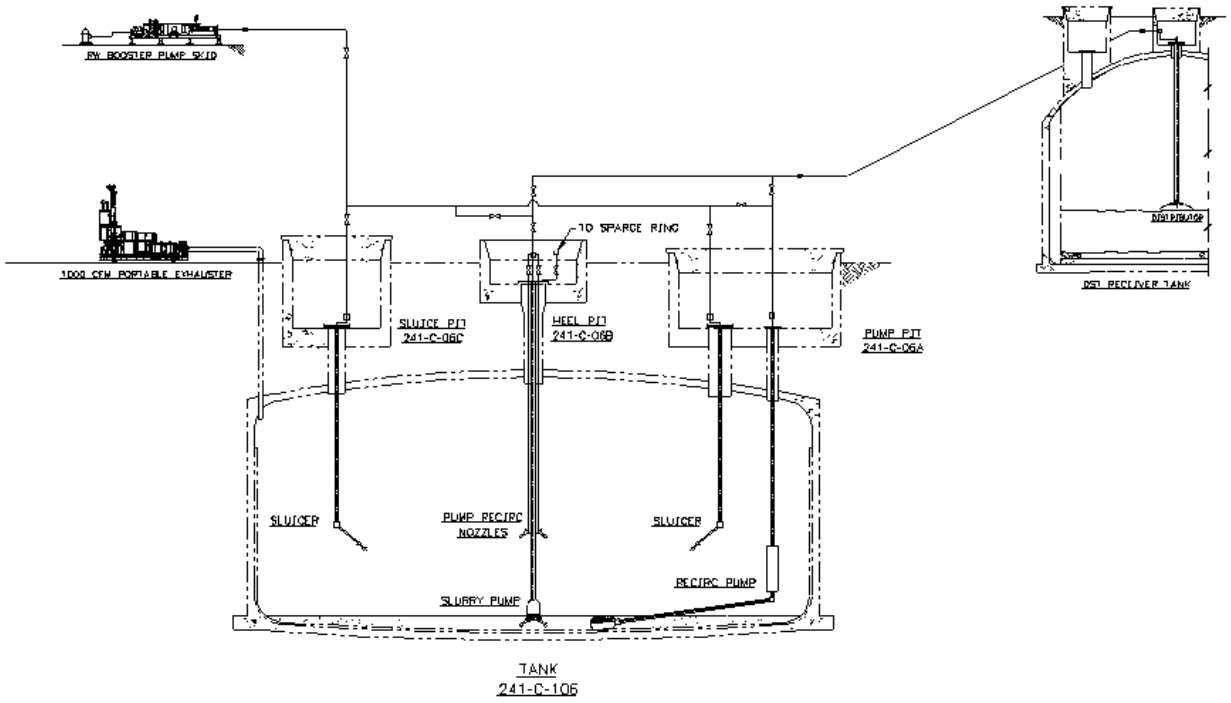

Fig. 2. Tank C-106 modified sluicing retrieval system

Oxalic acid dissolution was used in conjunction with modified sluicing to dissolve and entrain solids to facilitate residual waste removal. Hanford SST waste is highly alkaline and most metals precipitate as solid oxides or hydroxides to form sludge. Oxalic acid is effective because oxalate forms complexes with iron, aluminum, chromium, and manganese present in residual waste sludge following sluicing operations. Very little sodium is present in the residual waste at the time oxalic acid is added. However, the DST waste receiver tank contains sodium resulting in the precipitation of relatively insoluble sodium oxalate following waste transfer operations.

Laboratory testing of oxalic acid solutions demonstrated that roughly 70 percent of the residual waste solids could be dissolved (Bechtold, 2003). The testing also revealed that long contact times, in addition to higher solution-to-sludge volume ratios, did not result in significant gains in waste dissolution. This indicated that those constituents that would dissolve did so in a finite amount of time despite the presence of additional acid to dissolve the waste. Mixtures of oxalic acid and nitric acid were also tested with only slight increases in sludge dissolution results. However, since nitric acid would result in measurable oxidation of tank surfaces, it was not considered suitable for SST waste retrieval due to concerns regarding degradation of tank walls and increased potential for tank waste leakage. The combination of modified sluicing and oxalic acid dissolution methods was designed to maximize removal of the residual waste by chemically and mechanically breaking the insoluble waste particles into smaller sizes that could be more readily entrained in the waste slurry and pumped out of the tank. The oxalic acid had an added benefit of leaching constituents from the waste resulting in a remaining waste form with reduced concentrations of radioactivity.

A total of six batches of oxalic acid were introduced into Tank C-106 in discrete, accurately measured amounts through a mixer-eductor or the pump drop leg. The oxalic acid was

recirculated using the mixer-eductor followed by waste removal with the retrieval pumping system. Raw water was added continuously through one of two sluice nozzles at a rate of 85 to 350 gallons per minute to mobilize and redistribute solids for removal by the retrieval pumping system. The oxalic acid dissolution process leached additional waste constituents directly from residual solids and reacted with carbonates in the waste to increase solid waste porosity. The loss of carbonates and associated increase in porosity, combined with the agitation of waste by the mixer-eductor, increased the overall efficiency of retrieval operations by improving waste dissolution and entrainment.

The oxalic acid was introduced at a concentration of 0.9 molar. The mixer-eductor agitated the waste during the first four batches of oxalic acid processing. Each oxalic acid batch reacted completely with the residual waste and reached steady state after an average of 7 days based on pH readings. Following complete reaction of oxalic acid with the residual waste, the dissolved residual waste was pumped to DST AN-106. Following the fourth oxalic acid dissolution cycle and the second modified sluicing retrieval operation, the mixer-eductor was removed from the tank and replaced with a second sluicing nozzle to enhance retrieval system performance. The single sluicing nozzle was no longer effective in moving solids from the far side of the tank to the pump intake in the middle of the tank. Additionally, sluicing created piles of solids against the tank walls in locations farthest from the single sluicing nozzle. The motive force of the single sluicing nozzle was not able to move the remaining waste to the pump intake. However, the second sluicing nozzle was effective in breaking up remaining waste piles and moving the waste to the pump intake. Also, the second sluicing nozzle caused leveling of waste across the tank bottom allowing the waste to be submerged in oxalic acid thereby enhancing contact and the overall effectiveness of the waste dissolution process.

The pH of the oxalic acid was monitored during the last batch. The pH gradually increased in the first six days and then showed no increase during the remainder of the contact period suggesting the acid reaction had reached steady state. The increase in pH was an indication that acid had reacted with the residual waste heel. The average pH over the last 4 days was approximately 0.79 and never reached the expected acid depletion endpoint of 1.5 suggesting that the exposed waste was fully reacted and that additional unreacted oxalic acid remained. Waste recoveries of less than 3 percent per acid batch and the presence of unreacted oxalic acid in the last batch, combined with a declining trend of waste removed, indicated that the limits of the modified sluicing and oxalic acid dissolution retrieval method had been reached.

The results of the oxalic acid and modified sluicing retrieval operation are shown in Table I and Table II. The material balance was recorded to determine the approximate volume of waste transferred with each batch. Waste retrieval efficiency, based on percent solids in the slurry, was calculated to document the performance of the retrieval method. An observed declining trend of waste removed for each sluicing operation ranged from 8 percent for the first operation to 0.3 percent for the final operation.

Three measures were used to determine that oxalic acid dissolution and modified sluicing had reached the limit of technology performance (Reddick, 2004). These included oxalic acid dissolution, waste entrainment, and sluicing nozzle efficiency. The oxalic acid dissolution process reached its limit based on pH measurements, full reaction of exposed wastes, and the acid depletion endpoint. Remaining solids were resistant to further breakdown by either chemical or mechanical means and could not be entrained in the waste slurry for removal.

During the last sluicing operation, the two nozzles were unable to appreciably move additional waste to the pump intake as indicated by the diminishing amount of entrained waste recorded.

Table I. Material Balance Calculations for Oxalic Acid and Modified Sluicing Operations

Date	Oxalic Acid Added (Gallons)[a]	Water Added (Gallons)[b]	Estimated Waste Removed (Gallons)[c]	Waste Remaining (Gallons)	Waste Remaining (Cubic Feet)
Start	---	---	---	18,000	2,406
8/7/03	15,803	579	1,441	16,559	2,214
8/27/03	25,957	1,343	2,131[d]	14,428	1,929
9/16/03	31,686	1,021	4,727[d]	9,701	1,297
10/14/03	---	56,160	4,873	4,828	645
10/20/03	31,772	1,960	-2,597[d]	7,425	993
10/28/03	---	46,472	1,607	5,818	778
10/30/03	15,632	908	80	5,738	767
12/4/03	---	59,228	857	4,881	653
12/14/03	21,169	315	547	4,334	579
12/28/03	---	83,501	217	4,117	550
Total	142,019	251,487	13,883	---	---

Notes:
[a] Oxalic acid was added in measured batches.
[b] Water additions are based on metered inputs.
[c] Waste removed is calculated by subtracting inputs (acid or water added) from the volume change in DST AN-106 as measured by liquid level instruments.
[d] Estimate of waste removed is dependent on liquid heel remaining from previous batch. Liquid heel volumes varied significantly for some of the September and October batches. Two different pumps were used.

Table II. Material Balance Estimates for Sluice Water Additions and Removal Efficiencies

Sluice Operation	Volume of Water Added (Gallons)	Volume Transferred to DST AN-106 (Gallons)	Volume Increase (Gallons)	Approximate Efficiency; Estimated Volume Percent Waste
1	56,160	61,033	4,873	8
2	46,472	48,079	1,607	3.3
3	59,228	60,085	857	1.4
4	83,501	83,718	217	0.3

At the limit of waste retrieval technology performance for modified sluicing and oxalic acid dissolution, roughly 467 cubic feet of residual waste remained in the tank based on the 95 percent upper confidence level. This upper confidence level reflects uncertainties in the residual waste measurement technique. The actual (or nominal) residual waste volume was calculated to be roughly 370 cubic feet. The residual waste volume at the 95 percent lower confidence level was calculated to be 275 cubic feet.

The volume of residual waste was determined using three methods; material balance, waste immersion technique, and video camera/computer-aided design (CAD) modeling. Material balance calculations were performed by monitoring flow totalizer readings during transfers of waste out of Tank C-106 and into Tank AN-106; measuring liquid levels in both tanks; and

adjusting volumes for oxalic acid, dilution water, and caustic rinse additions. The waste immersion technique required filling Tank C-106 with a known volume of liquid to a tank level that covered the waste. The volume of liquid placed into the tank was compared to the calculated volume based on the liquid level in the tank and the tank geometry. The difference provided an estimate of the volume of insoluble solids remaining in the tank. The video camera/CAD modeling method determines residual waste volume using a topographic model and information obtained from in-tank videos and photographs. The video camera/CAD modeling method also has the capability to estimate residual waste remaining on tank walls, stiffener rings, and equipment abandoned in the tank. Table III provides a summary of the residual waste volume based on the video camera/CAD modeling method. These volumes are in close agreement with those estimated using the waste immersion and material balance methods.

Table III. Residual Waste Volume for Tank C-106 at the 95% Confidence Level

Waste Location	Waste Volume (Cubic Feet)	Estimated Uncertainty (%)		Estimated Uncertainty (Cubic Feet)	
		+	-	+	-
Tank Bottom	336.89	27%	27%	90.96	90.96
Tank Equipment	4.84	0%	25%	0.00	1.21
Stiffener Rings	17.30	18%	0%	3.11	0.00
Liquid Waste	11.30	27%	27%	3.05	3.05
Total	370.33 (nominal)	26%	26%	97.12	95.22
Total Waste Uncertainty	370.33 $\pm$ Uncertainty			467.45	275.11

Although there were no indications of leakage during Tank C-106 waste retrieval operations based on material balance calculations and no history of past tank leaks, it was necessary to establish whether or not a leak had occurred to provide input to post-retrieval risk analyses and performance assessments. Therefore, the waste immersion technique was used both to provide a final estimate of residual waste volume and provide measurable evidence that a leak did not occur.

Conclusions from Retrieval Operations

Using the available tank riser configuration, the limits of technology for retrieval of waste from Tank C-106 were reached for the initial past-practice sluicing method and more recent modified sluicing and oxalic acid dissolution method. Figure 3 depicts in-tank retrieval operations during the removal of waste from Tank C-106 using modified sluicing and oxalic acid dissolution.

Although deployment of alternative waste retrieval technologies (those currently available and those requiring research and development) was considered to further reduce the volume of the residual waste heel, the impacts included a minimum of $5.7 million in additional cost; 12 months in additional retrieval time; exposing workers to additional radiological, chemical, and industrial risk; and placing additional demands on limited DST space at the expense of initiating additional SST retrievals. These impacts are not offset by commensurate reductions in long-term risks to human health and the environment. The results of residual waste risk assessments following completion of modified sluicing and oxalic acid dissolution retrieval operations in Tank C-106 indicate that the Incremental Lifetime Cancer Risk (ILCR) does not exceed the

Environmental Protection Agency (EPA) ILCR threshold values of 1.0E-4 to 1.0E-6 or the Ecology threshold of 1.0E-5 for the industrial receptor at the Waste Management Area (WMA) C fence line. The cumulative risk for WMA C, including the Tank C-106 residual waste inventory, is 9.57E-7 for the industrial receptor scenario. No groundwater quality standards are exceeded based on assumptions consistent with the planned tank farm closure approach.

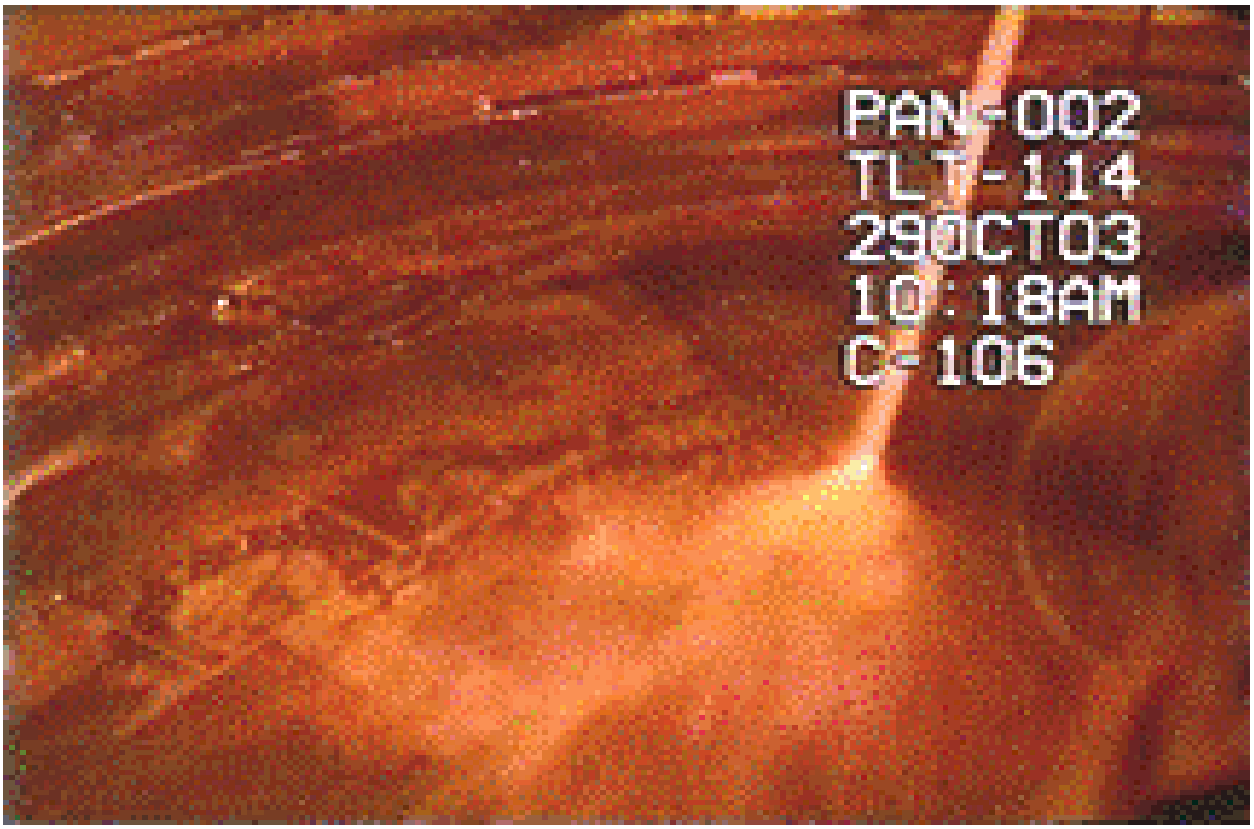

Fig. 3. Modified sluicing and oxalic acid dissolution in tank C-106

Tank C-106 contained roughly 10 million curies of radioactivity prior to the 1998/1999 retrieval campaign. The 1998/1999 retrieval campaign removed approximately 8 million curies, leaving 2 million curies in the residual waste. The 2003 retrieval campaign removed the bulk of the remaining radioactivity resulting in a total current residual waste inventory of roughly 135,000 curies or about 1% of the 1998 inventory. Furthermore, the residual waste exists in an insoluble, low leach rate form.

Overview of Single-Shell Tank System Closure

Hanford Federal Facility Agreement and Consent Order

In 1989, Ecology, EPA, and DOE entered into a legally enforceable agreement known as the Hanford Federal Facility Agreement and Consent Order (HFFACO). The HFFACO was developed under the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA) to cleanup the Hanford Site. The HFFACO and subsequent modifications establish regulatory requirements under which wastes within the SST WMAs will be retrieved, and the WMAs subsequently closed pursuant to applicable state and federal laws.

The HFFACO requires retrieval of as much waste as technically possible, with waste residuals not exceeding 360 cubic feet in 530,000 gallons or larger tanks; 30 cubic feet in 55,000 gallons or smaller tanks; or the limit of waste retrieval technology, whichever is less. If these specific criteria for residual waste volumes are not achieved using the selected retrieval method, then provisions under Appendix H of the HFFACO may be invoked to request Ecology approval of an exception to the waste retrieval criteria (as was done in the case of Tank C-106 with a nominal residual waste volume of 370 cubic feet).

Under Appendix I of the HFFACO, a SST waste retrieval and closure process has been developed to address all aspects of SST system waste retrieval and closure including the SSTs, ancillary equipment (e.g., waste transfer piping, valve pits, diversion boxes, vaults, active and inactive miscellaneous underground storage tanks, etc.), contaminated soils, and contaminated groundwater. The major phases of the closure process include tank waste retrieval; SST system, WMA, and component closure including WMA corrective actions; and groundwater actions. The SST system has been grouped into seven WMAs based on waste management history, proximity, and similarity of planned actions.

The SST System Closure Plan describes the process for closing the entire SST system and consists of three tiers arranged in a hierarchical manner. Tier 1, the highest level plan, documents requirements that apply to the overall SST system and is referred to as the Framework Plan. Tier 2 plans document requirements pertaining to each of the seven SST WMAs and are termed WMA Closure Action Plans. Tier 3, the lowest level plan, documents requirements germane to closure of individual SSTs and associated ancillary equipment and are referred to as Component Closure Activity Plans. The SST System Closure Plan will be incorporated into the Hanford Site-Wide Permit issued under the Resource Conservation and Recovery Act (RCRA). The Hanford Site-Wide RCRA Permit will be modified through time as closure actions and corrective actions are developed for the WMAs and associated components.

Closure decisions for SST contaminated soils will be made through the RCRA corrective action process based on implementation of RCRA Facility Investigation/Corrective Measure Study (RFI/CMS) work plans to determine the nature and extent of soil contamination. It is anticipated that Phase I of the RCRA corrective action process will result in sufficient characterization to support final closure decisions. However, Ecology reserves the right to require additional characterization either through a Phase II corrective action process or through the development of a Component Closure Activity Plan if additional characterization is required.

The EPA and DOE are electing to investigate and remediate groundwater under the CERCLA past-practice authority. Information generated through the CERCLA groundwater Remedial Investigation/Feasibility Study (RI/FS) or RCRA RFI/CMS processes will be utilized in the development of the SST System Closure Plan and associated performance assessment. Integration of CERCLA past-practice authority with RCRA closure and corrective action requirements will allow Ecology and EPA to address all regulatory and environmental obligations associated with contaminated soil and groundwater regardless of the types of contaminants present.

Ecology, EPA, and DOE have elected to develop and maintain one performance assessment, as part of the SST System Closure Plan, for the purposes of evaluating impacts of SST system

closure conditions and actions on human health and the environment for all contaminants of concern (radiological and non-radiological). A performance assessment will also be developed for each WMA and will incorporate the latest information available. As individual components are retrieved or characterized, and other component closure activities are completed, the resulting information will be incorporated into the WMA performance assessments to determine the components relative risk compared to the entire WMA performance. This approach will support interim closure decision making for individual components. Final WMA closure decisions will be made after all components are retrieved or characterized, and all other component closure activities have been completed including preparation of final WMA performance assessments.

SST System Closure and Integration with other Central Plateau Activities

DOE is responsible for closure of all SST WMAs, including post-closure activities. These closure and post-closure activities must be conducted in coordination with other cleanup and closure activities on the Central Plateau. These cleanup and closure actions involve facilities and operable units regulated under both RCRA and CERCLA. Ecology is the lead regulatory agency responsible for closure of the SST system under the auspices of RCRA as implemented through the Hazardous Waste Management Act (HWMA) and associated regulations. The EPA is the support regulatory agency providing oversight of Ecology's authorized program.

The Central Plateau of the Hanford Site has been placed on the National Priorities List by the EPA. The completion of remediation of the Central Plateau will eventually be finalized by CERCLA decisions made by the EPA and permitting decisions made by Ecology. The DOE, EPA, and Ecology recognize the need for SST system closure in a manner that integrates RCRA Treatment, Storage, and Disposal (TSD) facility closure requirements (including RCRA corrective action requirements), the closure requirements of the Atomic Energy Act (AEA), and Central Plateau CERCLA remedial action requirements in order to achieve a comprehensive, cohesive, and effective approach to SST system closure ensuring that applicable regulatory requirements are met. It is expected that regulatory processes established by the HFFACO will provide a mechanism for avoiding duplication of regulation by Ecology and the EPA through the lead regulatory agency concept.

Closure of SST system components, such as ancillary equipment and contaminated soil outside of established WMAs, will require close integration with decision making at adjacent sites. A consistent groundwater monitoring, protection, and risk/performance assessment methodology will also be realized through close coordination and integration of activities. Finally, Central Plateau cleanup integration will provide efficiencies through the coordination of operational interfaces on the Hanford Site and avoid duplicative or inconsistent efforts.

Single-Shell Tank Farm Closure

Final closure of Hanford's 149 SSTs will be conducted in accordance with applicable laws and regulations, and include the tanks, ancillary equipment, contaminated soil, and contaminated groundwater. The timing of certain actions proposed in the SST System Closure Plan, such as mixing cementitious material with waste residuals during the closure process to stabilize and isolate the waste, may require decisions that must be made under the AEA and/or in accordance with other applicable regulatory requirements and judicial decisions. Such actions must also be consistent with the future Record of Decision (ROD) for the Tank Closure Environmental Impact

Statement (TCEIS). No irreversible closure actions will be taken unless and until they are shown to be consistent with applicable radioactive waste management requirements that must be addressed under the AEA, DOE Orders, applicable tank closure regulations, judicial decisions, and the ROD for the TCEIS.

Planned closure activities will include, but may not be limited to, removing wastes from tanks and ancillary equipment to the limits of retrieval technology capabilities and treating that waste for disposal; minimizing the potential for spills and leaks during waste retrieval and providing leak detection, monitoring, and mitigation; characterizing residual wastes, contaminated soil, and groundwater; isolating and stabilizing residual wastes in tanks and ancillary equipment; evaluating, selecting, and implementing closure options for contaminated soil and groundwater; constructing engineered barriers to control water infiltration, wind and water erosion, and plant, animal, and human intrusion; and instituting post-closure monitoring and long-term stewardship.

Final closure actions will be conducted on a Tank Farm or WMA basis. Individual component closures will not be deemed final until closure of the associated WMA. Interim closure actions will be conducted to ensure that residual wastes are immobilized and tank void spaces are stabilized pending final tank and tank farm closure actions. Interim corrective measures have also been implemented in some Hanford tank farms to control water infiltration into the vadose zone and potential for subsequent contaminant migration (e.g., cutting and capping of excess water lines, building run-on and run-off control berms, etc.). Furthermore, RCRA RFI/CMS's are being completed for the tank farms to ascertain the nature and extent of contamination and evaluate alternatives for remediating contaminated soils.

The actual closure mode is yet to be determined. Major closure activities have been developed based upon an assumption that the WMAs will be closed as landfills, if it is demonstrated that clean closure cannot be practicably achieved. A TCEIS is being prepared in accordance with National Environmental Policy Act (NEPA) requirements. Following completion of the TCEIS and issuance of the ROD, the Tank C-106 Closure Plan will be reviewed by the regulators and approved closure actions will be implemented in accordance with the ROD. The draft TCEIS is scheduled for issuance by June 2005 and the ROD is currently planned by January 2006.

Single-Shell Tank 241-C-106 Interim Closure

In 2002, the ORP established the Accelerated Tank Closure Demonstration (ATCD) Project at the Hanford Site. The ATCD Project is charged with establishing and demonstrating the technical, regulatory, and administrative aspects of retrieval and interim closure, and providing data needed to support future tank and tank farm closure decisions. Tank C-106 was selected as the first tank to be addressed by ATCD Project activities.

Interim closure includes, but may not be limited to, isolation of post-retrieval residual waste from the accessible environment, stabilization of tank void spaces to prevent differential settlement and subsidence, and surface barriers or other treatments to prevent water infiltration and bio-intrusion. Investigations are underway to evaluate cementitious material formulations that incorporate reducing agents and other special additives (e.g., calcium hydroxyapatite) to chemically transform and bind contaminants of concern (e.g., technetium) in residual waste to reduce their mobility.

Interim closure of Tank C-106 will not be initiated until completion of the TCEIS and issuance of the ROD. In the meantime, an interface has been established with the Nuclear Regulatory Commission to review tank closure documentation.

Future Retrieval and Closure of Hanford Single-Shell Tanks

The HFFACO, signed by the DOE, EPA, and Ecology in May 1989, paves the way for Hanford Site cleanup and remediation activities over the next few decades. The HFFACO has changed many times in its 15-year lifespan and it continues to change to ensure cost effective, timely, and regulatory compliant cleanup of the Hanford Site. It provides a roadmap for cleanup with specific tasks, milestones, and due dates for cleanup actions that are under strict configuration management and change control.

The Hanford Site has made significant progress as it endeavors to cleanup legacy wastes from six decades of Hanford Site operations in support of a variety of national defense initiatives. Roughly 3 million gallons of pumpable liquids have been removed from all 149 SSTs thereby reducing the potential for waste leakage while the tanks await initiation and completion of retrieval operations.

Retrieval of the Hanford Sites first SST, Tank C-106, has been completed using an oxalic acid dissolution and modified sluicing retrieval method. Retrieval of the second SST, Tank S-112, is nearing completion. Approximately 600,000 gallons of radioactive waste has been retrieved from Tank S-112 using a salt-cake dissolution and modified sluicing retrieval method. Retrieval of the third SST, Tank C-203, is also nearing completion. Tank C-203 is a smaller 200-Series tank and waste is being removed by a vacuum retrieval method. A mobile retrieval system has also been demonstrated at the Hanford Cold Test Facility for future SST retrieval operations where a remotely operated, crawler-based retrieval method is desired.

The Hanford Site is meeting the challenge head-on to retrieve and close its SST farms in accordance with the terms and conditions of the HFFACO. Lessons learned from retrieval operations are being incorporated into work planning and system designs for future retrieval activities to ensure the safe, cost-effective, timely, and regulatory compliant completion of waste retrieval from all SSTs by September 30, 2018. Closure activities on the first WMA are to be initiated by March 31, 2012 with completion by March 31, 2014. Closure of all SST farms and WMAs is planned by September 30, 2024.

REFERENCES

1. Bailey, J. W., 2000, "Waste Retrieval Sluicing System (WRSS) and Project W-320, Tank 241-C-106 Sluicing, Lessons Learned," RPP-5687, March 2, 2000, CH2M HILL Hanford Group, Inc., Richland, Washington.

2. Bechtold, D. B., et al., 2003, "Laboratory Testing of Oxalic Acid Dissolution of Tank 241-C-106 Sludge," RPP-17158, July 10, 2003, Fluor Hanford, Inc., Richland, Washington.

3. Fitzsimmons, T., 1999, "Completion of Hanford Federal Facility Agreement and Consent Order Interim Milestone M-45-03B," (Letter to K. A. Klein, Manager, U.S. Department of Energy, Richland Operations Office, and R. T. French, Manager, U.S. Department of Energy, Office of River Protection, December 21, 1999), Washington State Department of Ecology, Olympia, Washington.

4. Hanlon, B. M., 2004, "Waste Tank Summary Report for Month Ending August 31, 2004," HNF-EP-0182, Rev. 197, CH2M HILL Hanford Group, Inc., Richland, Washington.

5. May, T. H., 2003, "Process Control Plan for Tank 241-C-106 Closure," RPP-13707, April 30, 2003, CH2M HILL Hanford Group, Inc., Richland, Washington.

6. Reddick, G. W., 2004, "Campaign Report for the Retrieval of Waste Heel from Tank 241-C-106," RPP-19919, February 12, 2004, CH2M HILL Hanford Group, Inc., Richland, Washington.