OFFICE OF RIVER PROTECTION
P.O. Box 450, MSIN H6-60
Richland, Washington 99352

MAR 21 2013

13-TF-0018

Ms. Jane A. Hedges, Program Manager
Nuclear Waste Program
Washington State
Department of Ecology
3100 Port of Benton Blvd.
Richland, Washington 99354

Ms. Hedges:

THE U.S. DEPARTMENT OF ENERGY, OFFICE OF RIVER PROTECTION (ORP) SUBMITS THE RETRIEVAL COMPLETION CERTIFICATION AND REPORT FOR TANK 241-C-104

ORP is transmitting RPP-53823 "Retrieval Completion Certification for Tank 241-C-104" to the Washington State Department of Ecology (Ecology) in accordance with Section IV-B-5 of the Consent Decree No. 08-5085-FVS, filed October 25, 2010, which states "When DOE completes retrieval of waste from a tank covered by this Decree, DOE will submit to Ecology a written certification that DOE has completed retrieval of that tank."

This letter certifies that ORP has completed retrieval of Tank C-104 in accordance with Part 1 of Appendix C of the Consent Decree (*Washington v. DOE*, Case No. 08 5085-FVS [E. D. Wa. October 25, 2010]) and with the retrieval technology/systems that were established by approval of Ecology on May 3, 2012, in Tank Waste Retrieval Work Plan RPP-22393, Revision 6a.

If you have any questions, please contact me, or your staff may contact Joanne F. Grindstaff, Federal Project Director, Retrieval and Closure, (509) 376-6202.

Thomas W. Fletcher, Assistant Manager
For Tank Farms Project

TF:CJK

Attachment

Distribution see page 2

DISTRIBUTION:

cc w/attach:
S. Harris, CTUIR
D. A. Faulk, EPA
S. E. Hudson, HAB
R. A. Kaldor, MSA
T. W. Noland, MSA
R. E. Piippo, MSA
G. Bohnee, NPT
K. Niles, ODOE
R. Buck, Wanapum
R. E. Fox, WRPS
D. Rowland, YN
R. Jim, YN
Administrative Record
Environmental Portal, LMSI
TPA Administrative Record

cc w/o attach:
J. M. Alzheimer, Ecology
M. W. Barnes, Ecology
J. J. Lyon, Ecology
N. H. Uziemblo, Ecology
C. L. Whalen, Ecology
S. J. Eberlein, WRPS
S. E. Killoy, WRPS
E. M. LaRock, WRPS
J. J. Luke, WRPS
T. G. Miskho, WRPS
K. M. Smith, WRPS
M. G. Peloquin, WRPS
WRPS Correspondence Control

ATTACHMENT

13-TF-0018

RETRIEVAL COMPLETION CERTIFICATION REPORT FOR TANK 241-C-104

RPP-53823
Revision 2A

Retrieval Completion Certification Report for Tank 241-C-104

S. J. Eberlein
M. P. Bergeron
Washington River Protection Solutions, LLC

Date Published
March 2013

Prepared for the U.S. Department of Energy
Office of River Protection

Contract No. DE-AC27-08RV14800

This page intentionally left blank.

RETRIEVAL COMPLETION CERTIFICATION REPORT FOR TANK 241-C-104

Pursuant to Consent Decree in Case No. CV-08-5085-FVS
(*State of Washington v. Department of Energy* [E.D.Wa. October 25, 2010])

1.0 INTRODUCTION

The U.S. Department of Energy (DOE), Office of River Protection (ORP) is hereby submitting this Certificate of Retrieval Completion Report (hereinafter "Retrieval Completion Certification") in accordance with Section IV-B-5 of the Consent Decree in *Washington v. DOE*, Case No. 08-5085-FVS (E.D. Wa. October 25, 2010) (hereinafter the "Decree" or "Consent Decree"), which provides as follows: "When DOE completes retrieval of waste from a tank covered by this Decree, DOE will submit to Ecology a written certification that DOE has completed retrieval of that tank."

This Retrieval Completion Certification provides a summary of completion of retrieval operations on the single-shell tank (SST) 241-C-104 (C-104) on August 17, 2012. Tank C-104 was retrieved using modified sluicing and chemical dissolution (caustic cleaning) technologies as described in the Tank Waste Retrieval Work Plan (RPP-22393, *241-C-102, 241-C-104, 241-C-107, 241-C-108 and 241-C-112 Tanks Waste Retrieval Work Plan*, Revision 6A) approved by the State of Washington Department of Ecology (Ecology) on May 3, 2012. This Retrieval Completion Certification provides a summary of technical information on which the decisions to cease retrieval operations in tank C-104 were based for each of these technologies. The format and content of this Retrieval Completion Certification resulted from numerous discussions between Ecology and DOE-ORP and its Tank Operations Contractor, Washington River Protection Solutions, LLC. and an agreed-upon outline that DOE-ORP followed in preparing this document. The DOE-ORP is hereby declaring that it has completed the retrieval of tank C-104 in full compliance with the requirements of Part 1 of Appendix C of the Consent Decree, and with the retrieval technologies/systems that were established by Part 1 of the Tank Waste Retrieval Work Plan, and is submitting this Retrieval Completion Certification accordingly.

2.0 RETRIEVAL PROCESS DESCRIPTION AND CHRONOLOGY

2.1 PRE-RETRIEVAL CONDITION

Tank C-104 is a 530,000-gal (70,850-ft^3) SST that was used to store radioactive waste beginning in 1946. Prior to retrieval, the initial waste volume in tank C-104 was estimated in the Best-Basis Inventory (BBI) (see Tank Waste Information Network System [TWINS], Queried 06/10/2011, [Characterization Reports, Tank 241-C-104, C-104 BBI Derivation FY10 Q4.pdf], https://twins.pnl.gov/twinsdata/Forms/About.aspx?subject=TWINS) to contain ~259,000 gal (34,600 ft^3) of waste that was deposited in this tank primarily during the 1940s, 1950s, and 1960s. The liquid portion of waste (supernate) in the tank was removed in 1983 and the tank was declared interim stabilized on September 26, 1989. Tank C-104 is currently classified as

"sound" (i.e., surveillance data indicates no loss of liquid attributed to a breach of integrity) in HNF-EP-0182, *Waste Tank Summary Report for Month Ending December 31, 2012*, Revision 297.

The chemical and radionuclide composition and waste inventory used in the BBI was based on the analytical laboratory results of core samples obtained in 1996 and 1998 and process knowledge of the types of waste that were deposited into tank C-104 (TWINS, 06/10/2011). The BBI identifies the waste as consisting primarily of plutonium-uranium extraction (PUREX) plant cladding wastes, PUREX organic wash waste, and thoria processing high level waste. The BBI sludge volume was based on a January 1, 2001 Enraf®[1] waste level measurement with an adjustment for a depression observed to be located under the Enraf plummet. Prior to the start of retrieval, ~6,000 gal of water were added to the tank as a result of construction support and testing. Roughly 259,000 gal (~34,600 ft^3) of waste existed in tank C-104 prior to beginning retrieval operations on January 8, 2010.

2.2 PROCESS DESCRIPTION

Candidate waste retrieval technologies that were available for initial deployment at tank C-104 were (1) modified sluicing, (2) the mobile retrieval system (MRS), (3) modified sluicing with an in-tank vehicle, and (4) the Mobile Arm Retrieval System (MARS) (see Revision 4B of RPP-22393). After considering each candidate waste retrieval technology and designation of the tank as "sound," modified sluicing using recycled double-shell tank (DST) supernate was selected as the initial preferred technology for deployment in tank C-104. This plan was approved by Ecology on August 27, 2009.

In the modified sluicing deployment, supernate from tank 241-AN-101 (AN-101) was used as the sluicing media to mobilize the waste in tank C-104 and the resulting slurry was pumped to tank AN-101. The slurry from tank C-104 also contained insoluble solid material. The solids settled in tank AN-101 and the supernate was reused in the sluicing operations.

The modified sluicing operation was suspended when DOE determined that the bulk of the remaining waste consisted of solids (hard heel) that were not mobilized by sluicing. In accordance with the general approach provided in Revision 6A of RPP-22393 and Appendix C, Part 1, of the Consent Decree, DOE-ORP considered two second technology alternatives for removing the residual waste after modified sluicing operations: an in-tank vehicle or a chemical retrieval process. A chemical retrieval process was selected as the second technology for tank C-104 because it could be deployed in less time than an in-tank vehicle and it was believed that the process could reduce the resulting residual waste volume to less than 360 ft^3 without

[1] Honeywell Enraf is a product of Honeywell Process Solutions, Strahlenbergerstr. 110-112, 63067 Offenbach, Germany.

significantly impacting available DST space or the Waste Treatment Plant operations. Options for chemical retrieval processes for removal of the hard heel in tank C-104 evaluated the following:

- Water to remove insoluble compounds in the saturated caustic liquids found in the tanks,
- High molarity caustic solution to break down aluminum hydroxide compounds, or
- Other chemicals to aid the retrieval of sludge.

Although the tank C-104 post-sluicing hard heel was not sampled, a BBI estimate of waste remaining was prepared by assuming retrieval of tank waste materials by waste layers in a top-down retrieval of the waste types. In this approach, a chemical and radiological composition is formulated based on sampling data from tanks that contain a similar waste type to tank C-104, supplemented with Hanford Defined Waste model data (see RPP-RPT-46616, *Derivation of Best-Basis Inventory for Tank 241-C-104 as of May 8, 2011*).

Evaluation of the BBI estimate for tank C-104 post-modified sluicing determined that the waste residual was similar to estimated waste residual composition found in tank C-108 at the same stage of retrieval. The BBI for tank C-104, prior to modified sluicing, was attributed to contain primarily PUREX cladding waste, PUREX organic wash wastes, and thoria wastes. Although the process history of tank C-104 differs from that of tank 241-C-108 (C-108) (bismuth phosphate, tributyl phosphate, and scavenged ferrocyanide waste), the prevalence of sluicing residuals as gibbsite [$Al(OH)_3$] and natrophosphate [$Na_7(PO_4)_2F \cdot 19(H_2O)$] would be anticipated as materials not readily solubilized by the supernatant liquor employed during its bulk retrieval operations. Analysis of samples taken in tank C-108 reveal that roughly 40 wt% of the residual heel existed in the form of gibbsite and 60 wt% of the heel was in the form of natrophosphate. Based on the retrieval experience at tank C-108 and other tanks, natrophosphate was anticipated to be removed during the hot water washing used in tank C-104 after bulk retrieval, leaving gibbsite as the primary solid in the remaining residuals. Based on this information, DOE-ORP selected the caustic cleaning process as the best available technology to remove the remaining hard heel (RPP-PLAN-51574, *Single-Shell Tank 241-C-104 Hard Heel Retrieval Technology Selection*). This chemical retrieval process (caustic cleaning) was identified as a second retrieval technology as described in Revision 6A of RPP-22393, which was approved by Ecology on May 3, 2012.

The first step in the caustic cleaning process, referred to as the metathesis reaction step, involved the addition of 50 wt% sodium hydroxide (caustic) solution to convert gibbsite to sodium aluminate [$NaAl(OH)_4$]. Metathesis is a process which exchanges the bonds between chemical species so that the products are comparable to the reactants. In the tank C-104 heel retrieval process, this means using caustic to convert aluminum-rich wastes (i.e., gibbsite) to sodium aluminate, which is soluble in water.

The second of the caustic cleaning process steps, called aluminate dissolution, involved adding water to the caustic solution to allow the sodium aluminate to dissolve. The solution is then transferred to the receiver tank (AN-101). In steps involving solid dissolution, the liquids added to tank C-104 were circulated in the tank to increase contact between the liquids and solids and facilitate reaction and dissolution.

During the chemical cleaning process in tank C-108, DOE-ORP decided to add an additional water sluicing step at the end (RPP-RPT-52449, *Single-Shell Tank 241-C-108 Hard Heel Retrieval Completion Report*; RPP-52290, *Practicability Evaluation Request to Forego a Third Retrieval Technology for Tank 241-C-108*). In tank C-108, DOE-ORP estimated that ~520 gal (~70 ft^3) of additional solids were removed by adding this water sluicing step (RPP-CALC-52225, *Waste Volume of Single-Shell Tank 241-C-108 Remaining after Hard Heel Retrieval*). Because of the success of this step, DOE-ORP revised the process control plan for tank C-104 heel retrieval to allow sluicing with water to remove additional fine solids at the end of the caustic cleaning process (RPP-PLAN-51575, *Process Control Plan For Tank 241-C-104 Hard Heel Retrieval*).

2.3 RETRIEVAL CAMPAIGN CHRONOLOGY

2.3.1 Modified Sluicing

The general chronology for modified sluicing at tank C-104 is described in SVF-1848, *C-104 volume balance (2011-06-09).xlsx, Version 3*. Modified sluicing was performed during 66 operating days (147 shifts) starting on January 8, 2010 and ending on May 9, 2011. The retrieval progressed until March 22, 2010 when retrieval was halted because an obstruction beneath the slurry pump was preventing the pump from being lowered into the waste to continue retrieval. The Articulating Mast System (AMS) was installed to move the obstruction in order to allow the slurry pump to be lowered to continue retrieval operations. The AMS was able to successfully move the obstruction; retrieval operations using the modified sluicing system resumed on January 6, 2011 and continued through May 9, 2011.

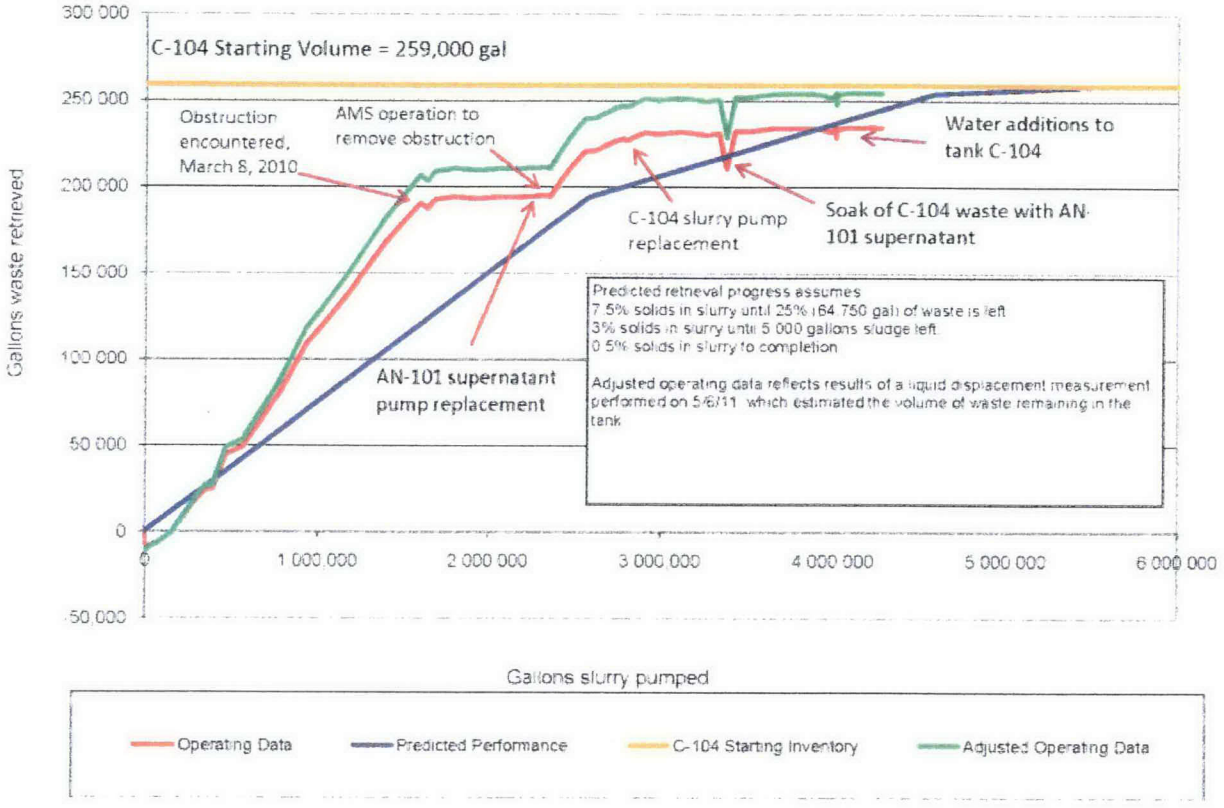
Overall, the modified sluicing process effectively removed most of the sludge from tank C-104. Most of the waste consisted of moist, soft, brown sludge that was easily retrieved. As retrieval proceeded, gray- and brown-colored coarse solids were revealed on the bottom of the tank. The solids were generally difficult to mobilize with the sluicers, and most were too large to be entrained and pumped to tank AN-101. Near the end of retrieval, some water additions were performed to attempt to dissolve or soften the waste material in order to increase sluicing effectiveness. The water additions were unsuccessful at increasing the effectiveness enough to meet the retrieval objective of less than 360 ft^3.

Figure 1 shows retrieval system performance as a function of the volume of slurry (solids plus recycled tank AN-101 supernate) transferred from tank C-104 to tank AN-101. The occasional decreases in the volume retrieved in Figure 1 reflect fluctuations in the tank C-104 liquid pool volume near the end of the retrieval process. It was not always possible to pump the tank C-104 liquid pool to the same minimum heel at the end of each operating period. Figure 1 is annotated to highlight key events during the retrieval process.

Retrieval system performance was tracked by trending the net waste volume increase in receiver tank AN-101 after accounting for water additions. This running volume balance tends to underestimate the amount of waste removed because it does not distinguish between liquids and solids and does not account for solids dissolution or liquid evaporation. There are also

uncertainties associated with the estimates of initial waste volume because of pore space in the waste. Near the end of retrieval, the operating data was adjusted to account for evaporation and pore space, as shown in the "Adjusted Operating Data" line in Figure 1.

Figure 1. Tank 241-C-104 Modified Sluicing System Performance.



Volume of the waste remaining in tank C-104 at the end of modified sluicing was initially estimated using volume displacement measurements (RPP-CALC-49703, *Estimate of Waste Volume and Percent Retrieved for Single-Shell Tank 241-C-104*). Approximately 25,000 gal of supernate were added to tank C-104 from tank AN-101, and subsequently pumped out in roughly equivalent 5,000-gal batches. Tank AN-101 and tank C-104 liquid level measurements were taken after the 25,000 gal were pumped in and after each 5,000-gal pump-out.

Video recordings were also made before, during, and after the supernate addition. At the end of the sluicing, this information was used to estimate the volume of waste remaining in tank C-104, below the surface level of the supernatant liquid. Evaluation of the videos was used to estimate the volume of waste piles protruding above the liquid surface, and waste remaining on tank walls and stiffener rings. Details of that evaluation are provided in RPP-CALC-49703.

Based on a volume balance using the increase in tank AN-101 liquid level, ~234,400 gal (~31,340 ft^3) of tank C-104 waste were estimated to have been retrieved, leaving ~24,600 gal (~3,290 ft^3) in tank C-104. A visual examination of the waste in tank C-104 indicates the actual volume of waste remaining was considerably less than 24,600 gal (~3,290 ft^3). The volume of

waste remaining in the tank on May 8, 2012 was estimated at ~4,700 gal (~630 ft^3) as reported in RPP-CALC-49703. This estimate is ~20,000 gal (~2,670 ft^3) less than the volume estimated from the running volume balance (Operating Data line in Figure 1). This difference, which represents ~7.7% of the initial waste volume, is attributed to void spaces in the tank C-104 waste, water evaporation and transport through the exhausters, uncertainties in the volume displacement measurements, and uncertainties in the initial volume as established by the BBI. This difference in the BBI waste volume and the actual measured waste removed during retrieval operation reflects the uncertainty in the BBI due to a number of factors that include tank construction tolerances and waste characteristics (layering and retained gas). Waste retrieval performance measures throughout the waste retrieval operation are based on the initial BBI waste volume estimate, and actual waste volumes retrieved from tank C-104 are subsequently addressed and described in the retrieval completion documentation.

The line noted as "Adjusted Operating Data" in Figure 1 is an estimate of the actual volume of waste retrieved from tank C-104, after accounting for void spaces in the wastes, water that evaporated during retrieval, and the other factors mentioned in the previous paragraph (i.e., water transport through the exhausters, uncertainties in the volume displacement measurements, and uncertainties in the initial volume as established by the BBI).

Figure 2 shows the trend in retrieval system volumetric efficiency, as measured by the average solids loading in the slurry, as a function of the volume of slurry pumped from tank C-104. At the beginning of retrieval, the modified sluicing process was effective at removing waste out of the tank. The high solids concentration in the slurry showed that the bulk of the waste in the tank was being removed. Retrieval operations progressed until the end of the modified sluicing campaign when most of the waste had been removed. Note that the decrease in solids loading mid-range in the figure reflects the obstruction that was encountered inhibiting the pump to be lowered further. Once the obstruction was removed, waste removal performance resumed as projected.

The final days of operations show a slurry solids loading of ~0.4 bulk vol. percent with less than 600 gal (~80 ft^3) of waste retrieved over ~133 hours of pumping; this low retrieval rate was also supported by visual observations of the retrieval operations.

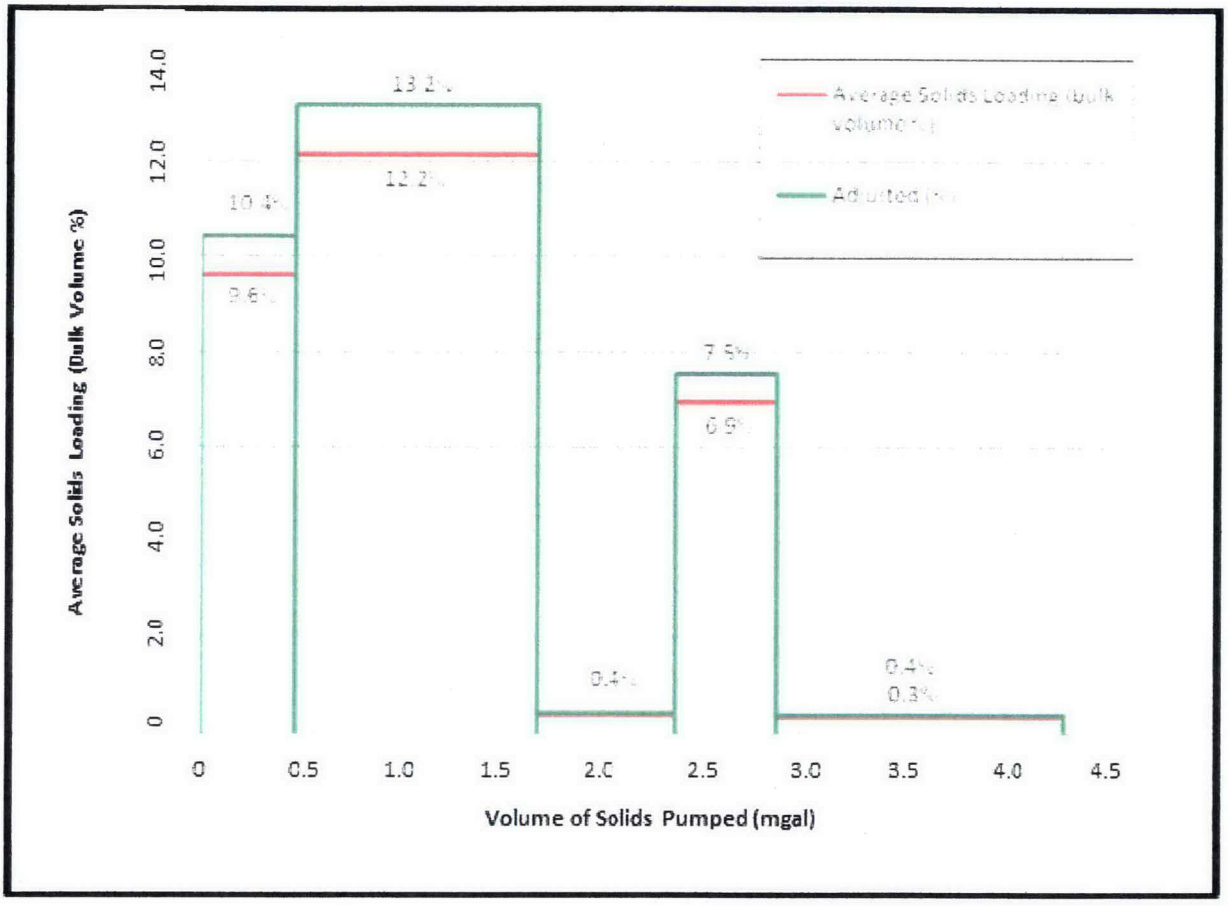
A summary of the amount of waste retrieved and waste remaining in tank C-104 after the modified sluicing is provided below in Sections 3.0 and 4.0.

2.3.2 Caustic Cleaning

Caustic cleaning was performed starting on June 14, 2012 and ending on August 15, 2012, reaching the limit of technology at the end of this retrieval period. In this process, a sodium hydroxide (caustic) solution (50 wt%) was added to tank C-104. The slurry pump and sluicers were used to circulate the sodium hydroxide solution in the tank. As the solids were not completely submerged in the sodium hydroxide solution at onset, the sluicers were used to erode and reduce the solids that were protruding above the surface into the pool. The caustic fluids were further circulated to enable the sodium hydroxide solution to contact the solids. Samples of the liquid were obtained to monitor the metathesis reaction. Sample analyses indicated that the

metathesis reaction, in terms of hydroxide consumption, was over 100% of planned consumption based on inventory estimates. Details of these evaluations and supporting analytical data are provided in RPP-RPT-53367, *Single-Shell Tank 241-C-104 Hard Heel Retrieval Completion Report*.

Figure 2. Solids Loading in Tank 241-C-104 Slurry.



After the metathesis reaction phase, water was added to the tank to dissolve the sodium aluminate formed by the reaction; this water was used to clean the tank wall and provide mixing. The aluminate dissolution liquor was circulated and sampled, then transferred out of tank C-104 using a volumetric displacement procedure to determine the volume of the residual waste. Details of these evaluations are provided in RPP-RPT-53367.

After completion of the caustic cleaning steps, starting on August 16, 2012 and ending on August 17, 2012, ~29,500 gal of water were used to sluice solids from tank C-104. This was done to flush out the waste fines. Two shifts of water sluicing were conducted, with the first removing ~185 ft^3 of the residual waste and the second only ~51 ft^3 of the residual waste. At the completion of the second water sluicing shift, it was clear that subsequent operations would not provide substantially more waste retrieval.

Final waste retrieval activities in the caustic cleaning campaign started with an estimate of ~4,700 gal (630 ft^3) of waste remaining in the tank. Details of this retrieval phase on removal of wastes from the tank bottom, walls, and stiffener rings are documented in RPP-CALC-53365, *Waste Volume of Single-Shell Tank 241-C-104 Remaining After Hard Heel Retrieval* and RPP-RPT-53367.

A summary of the amount of waste retrieved and waste remaining in tank C-104 after the modified sluicing caustic cleaning process is provided below in Sections 3.0 and 4.0.

2.4 LIMIT OF TECHNOLOGY

2.4.1 Modified Sluicing

According to RPP-50910, *Single-Shell Tank Waste Retrieval Limit of Technology Definition for Modified Sluicing*, meeting the following two criteria constitutes reaching the "limit of technology" for retrieval of waste from a Hanford Site SST using modified sluicing with only DST supernate or water as the sluicing medium.

1) The concentration of SST waste in the retrieved slurry sent to the DST is within or bracketing a 0 to 0.6 vol. percent range for three operating periods. Bracketing refers to two successive data points, one of which is below 0 and the next near or above 0.6, which average less than 0.6 vol. percent. An operating period is a period over which retrieval performance is measured. An operating period is normally one operating day, but as a minimum must be greater than or equal to 8 hours in duration and consist of at least 10,000 gal (1,340 ft^3) of slurry transferred from the SST.

2) The DOE-ORP and the Tank Operations Contractor have provided documentation to Ecology that demonstrates that all reasonable efforts were attempted to enhance the effectiveness of the installed modified sluicing retrieval system in order to increase waste removal from all quadrants of the tank under consideration.

Per the Consent Decree, during evaluation of the limits of technology related to modified sluicing, DOE-ORP also considered an examination of other factors specified in the Decree including risk reduction, facilitating tank closures, worker safety, and the overall impact on mission and costs. A brief discussion of these factors as they relate to use of modified sluicing is as follows.

- As indicated in Figure 2 above, DOE-ORP showed the trend in retrieval system volumetric efficiency as measured by the average solids loading in the slurry as a function of the volume of slurry pumped from tank C-104. Retrieval operations progressed until the end of the modified sluicing campaign when most of the waste had been removed. Modified sluicing was determined to be at the limit of technology based on three successive operating periods of less than 0.4 vol. percent in the slurry from May 3 through May 5, 2011. The final days of operations show a slurry solids loading of ~0.4 bulk vol. percent with less than 600 gal of waste retrieved over ~133 hours of

pumping; this low retrieval rate was also supported by visual observations of the retrieval operations. The modified sluicing method was effective in removing the bulk of the waste from most areas of the tank. At the end of modified sluicing in tank C-104, waste had been mobilized and removed from the areas under the sluicers and the center of the tank. In these areas, the bottom of the tank was exposed or partially covered by loose solids. Most of the solids that still remained were near the tank walls in the areas furthest from the two sluicers. The sluicers were at the north and south ends of the tank and most of the solids were near the tank walls at the east and west sides of the tank. There were small amounts of solids between the two sluicers. These observations, coupled with the measured decrease in recovery with continued operation (see Figure 2), demonstrate that all reasonable efforts were made to remove the waste from all quadrants of the tank; and that the installed modified sluicing retrieval system had been effective in retrieving the sludge. Hard waste also remained on the stiffener rings and on the tank wall. A small pool of liquid remained in the center of the tank. Given the location and form of the residual waste, no further actions using the installed modified sluicing system were considered likely to remove the remaining waste.

- The continued deployment of the modified sluicing system would require continued use of work crews, resources, and equipment that DOE-ORP needs to use to retrieve other tanks within Waste Management Area (WMA) C. The small incremental amount of residual wastes that would be removed by continuing modified sluicing would result in an insignificant reduction in risk from residual wastes left in tank C-104 and would result in little or no benefit to facilitating closure of tank C-104 and other tanks and facilities in WMA C.

- Continued modified sluicing would result in continued exposure to workers that is not justified by the minimal amount of waste that could be removed by continuing with modified sluicing efforts. Although sluicing operations are controlled from a control trailer, multiple field activities (valve line-ups, field measurements and monitoring, etc.) are required to support the sluicing operations, resulting in continued exposure.

- Continued deployment of modified sluicing would delay the completion of retrieval activities at tank C-104 with limited benefits. At this point in time, any delay in completion would have the potential to adversely affect schedules of other retrieval activities and therefore impact the ability of the overall retrieval and treatment mission to meet current Consent Decree milestones and commitments.

- Continued use of work crews, resources, and equipment during modified sluicing would incur additional costs with little or no incremental benefit to decreasing risks from residual wastes in tank C-104. These efforts would divert resources from other more pressing retrieval activities associated with un-retrieved tanks and would likely result in an overall increase in costs associated with the retrieval and closure mission.

Based on the performance metrics evaluated with the implementation of this technology and consideration of the factors specified in the Consent Decree, DOE-ORP has concluded that the modified sluicing retrieval technology has been deployed to the limit of technology at tank C-104.

2.4.2 Caustic Cleaning

Specific criteria by which to measure the limit of technology for chemical retrieval processes such as caustic cleaning have not been defined to this point due to the lack of operational experience. The DOE-ORP gained limited previous in-tank experience with caustic dissolution during retrieval of tank 241-S-112 (RPP-RPT-35112, *Retrieval Data Report for Single-Shell Tank 241-S-112*). In that tank, ~4,500 gal (~600 ft^3) of granular waste material remained in the tank at the end of the remote water lance retrieval campaign. Additions of 25 wt% caustic and 50 wt% caustic were performed, followed by sluicing. The caustic treatment resulted in some breakup of the waste particles which allowed them to be retrieved by sluicing. This experience provided confidence that a chemical retrieval process could be effective as a waste retrieval technology, but did not provide sufficient information to define a limit of technology.

From the analytical data on samples of caustic solutions and water used during the caustic cleaning process, and the video evidence that shows waste residuals diminishing in size during the caustic cleaning process, DOE-ORP concluded that the metathesis reaction and dissolution processes associated with caustic cleaning had reached practical limits. The DOE-ORP did not expect significant additional waste removal by repeating these processes in tank C-104.

After completion of the caustic cleaning steps, two additional water sluicing steps were conducted to remove fines remaining in the residuals. At the completion of the second water sluicing shift, it was clear that subsequent operations would not provide substantially more waste retrieval.

The DOE-ORP's evaluation of the limits of technology also considered Consent Decree factors related to risk reduction, facilitating tank closures, worker safety, and the overall impact on mission and costs. A brief discussion of these factors as they relate to use of caustic cleaning is as follows.

- All steps in the chemical cleaning process using caustic solutions for tank C-104 were performed as described in the process control plan (RPP-PLAN-51575). Analytical results from samples obtained during the metathesis step confirm that the reactions had consumed the hydroxide and had gone to completion. Results from the caustic solution sampling indicated that more than enough of the reactant was present (i.e., caustic solutions in the metathesis step and water in aluminate dissolution step) to support the objectives of this deployed chemical retrieval process. Systematic efforts were made to contact all areas of the waste with the caustic solutions and/or water. Observation of the operations, discussion with operators, and observance of the waste itself (e.g., reduction of waste piles) confirm that the efforts to contact the caustic solution and the residual wastes were successful. Continued deployment of this chemical retrieval process would not result in appreciably reducing the amount of waste remaining in tank C-104 and therefore the risk from the residual wastes in tank C-104.

- A redeployment of the caustic cleaning process would not make efficient use of work crews, resources, and equipment being used in other areas of WMA C and would interfere with other retrieval efforts. The incremental decrease in amount of residual

wastes by redeployment would be very small, would not significantly reduce the associated risk from residual wastes left in tank C-104, and would result in little or no benefit to facilitating closure of tank C-104 and other tanks and facilities in WMA C.

- A redeployment of caustic cleaning would result in continued exposure to workers. Although retrieval operations are controlled from a control trailer, multiple field activities (valve line-ups, field measurements and monitoring, etc.) are required to support the sluicing operations, resulting in continued exposure.

- A redeployment of caustic cleaning would delay the completion of retrieval activities at tank C-104 with limited or no benefit. This delay in completion would have the potential to adversely affect schedules of other retrieval activities and therefore impact the ability of the overall retrieval and treatment mission to meet current Consent Decree milestones and commitments.

- Continued use of work crews, resources, and equipment with a redeployment of caustic cleaning would continue to incur costs with little or no incremental benefit to decreasing risks from residual wastes in tank C-104. These efforts would divert resources from other, more pressing retrieval activities associated with unretrieved tanks and would likely result in an overall increase in costs associated with the retrieval and closure mission.

Based on the performance metrics examined with the implementation of this technology and consideration of the factors specified in the Consent Decree, DOE-ORP has concluded that the caustic cleaning retrieval technology has been deployed to the limit of technology at tank C-104.

3.0 POST-RETRIEVAL CONDITIONS

Several methods (i.e., volume displacement, video observations, and engineering judgment) were used to estimate the waste volume removed and the residual waste volume left after each retrieval phase. A complete discussion of these methods and associated calculations of the estimated waste volume removed from tank C-104 during the two retrieval phases (modified sluicing and caustic cleaning) is documented in RPP-CALC-49703 and RPP-CALC-53365.

The initial BBI volume for tank C-104 was estimated at 259,000 gal (34,600 ft^3) at the start of retrieval. The amount of waste remaining in tank C-104 after the first retrieval technology was completed was estimated at 4,700 gal (630 ft^3). The amount of wastes remaining after the caustic cleaning process technology followed by final sluicing is estimated to be ~1,425 gal (~190 ft^3) (see RPP-CALC-53365)[2]. This final volume is below the 2,690 gal (360 ft^3) requirement specified in the Consent Decree.

[2] Recent updates of RPP-CALC-53365 provide an estimate of the 95% upper confidence limit for this volume. Details of this calculation will be provided in the final retrieval data report for tank C-104.