SLUDGE MASS REDUCTION BY ALUMINUM DISSOLUTION AT THE SAVANNAH RIVER SITE - 10428

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ABSTRACT

High Level Waste (HLW) at the Savannah River Site (SRS) is currently stored in aging underground storage tanks. This waste is a complex mixture of insoluble solids, referred to as sludge, and soluble salts. Continued long-term storage of these radioactive wastes poses an environmental risk. The sludge is currently being stabilized in the Defense Waste Processing Facility (DWPF) through a vitrification process that immobilizes the waste in a borosilicate glass matrix for long-term storage in a federal repository. Without performing any additional treatment, the existing volume of sludge waste would produce nearly 8000 canisters of vitrified waste requiring additional storage capacity and extending waste processing operations. Aluminum compounds, along with other non-radioactive components, represent a significant portion of the sludge mass currently planned for vitrification processing in DWPF. Dissolution and removal of aluminum from the HLW waste stream will reduce the volume of sludge requiring vitrification, improve production rates and accelerate waste disposition processing.

Commercial industry has extensively utilized the caustic dissolution process for recovery of aluminum from bauxite ore. In 1982, SRS demonstrated that aluminum could be removed from sludge waste by caustic dissolution at elevated process temperatures (~85°C). Recently, Savannah River Remediation LLC (SRR) has performed aluminum dissolution on two sludge batches at moderate temperatures (60°C – 75°C) and has demonstrated treatment in this manner to be effective for removing aluminum from SRS sludge waste. Performing dissolution at moderate temperatures avoids costly modifications to existing systems and is being incorporated into the overall treatment strategy for processing sludge waste. Minor plant modifications have been identified in order to conduct future dissolution campaigns more efficiently. It is anticipated this process will provide significant sludge mass reduction and avoid production of 900 – 1000 HLW canisters.

This paper discusses results of aluminum dissolution at moderate temperatures recently performed at SRS on Sludge Batch 6. The results of all recent laboratory and full-scale demonstrations of aluminum dissolution at moderate temperatures at SRS are also summarized.

INTRODUCTION

Estimated Sludge Mass

During development and early operations of DWPF, production records and estimates of HLW sludge inventories have projected ~5500 canisters of vitrified waste would be produced to complete the waste disposition mission at SRS. The Waste Characterization System (WCS) is a waste inventory database used to predict the sludge mass (and canisters) of SRS sludge batches. Uncertainty in WCS to accurately predict sludge mass has been a key risk (vulnerability) identified in the SRS High Level Waste System Plans. The risk handling strategy identified for this vulnerability was to determine if WCS is adequate for sludge and salt processing. Studies were performed in 2005 to execute this risk handling strategy. The first study quantified the magnitude of the disparity between WCS predictions and measured batch masses for Sludge Batches 1A through 4. This first study produced a recommendation for adjusting WCS output by the application of “Dial-Up” factors. In a separate effort, a statistical evaluation of the data determined that a strong correlation existed between WCS predicted batch masses and measured batch masses. Since the Dial-Up method and the statistical evaluation predicted similar masses, the masses calculated by the Dial-Up method were selected for use in future system planning [1].

Since 2005, DWPF has completed processing of Sludge Batch 3 and Sludge Batch 4, and is currently processing Sludge Batch 5. Figure 1 provides a comparison of the predicted and measured sludge masses and depicts the discrepancy between these masses.

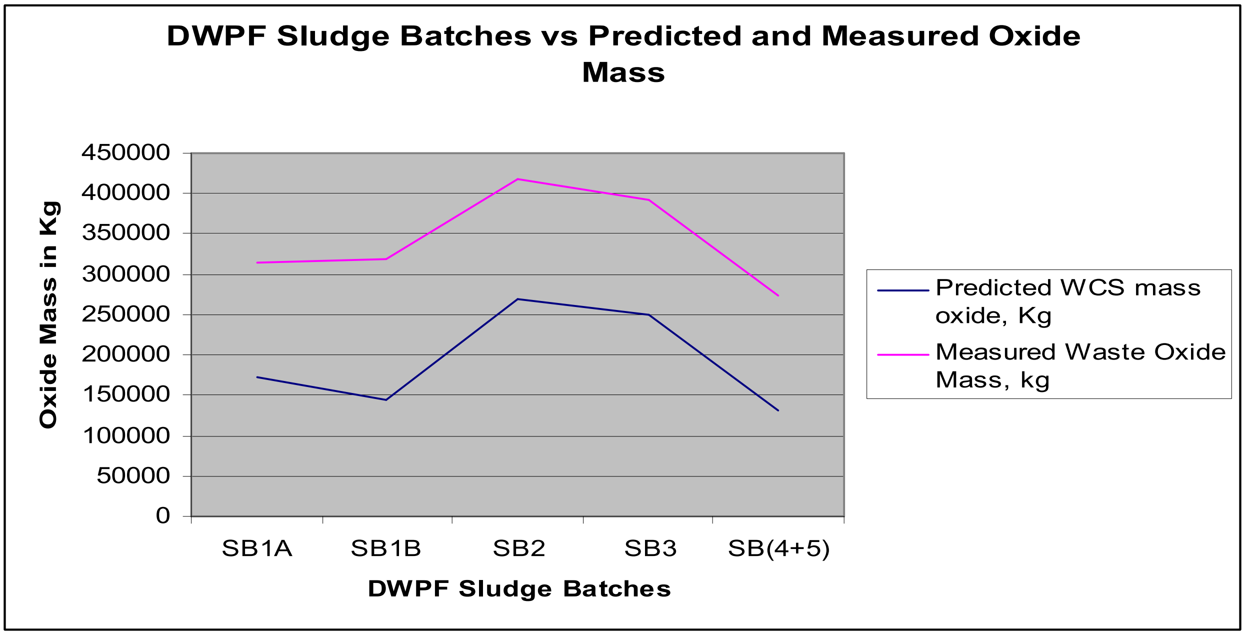

Figure 1. Comparison of the predicted and measured sludge masses for DWPF processing of Sludge Batch 1A through initial operation of Sludge Batch 5.

Approaches to Resolve

In response to the increase in predicted sludge mass, a multi-pronged approach was put forward to define mitigation strategies and schedule needs. The multi-prong approach included:

1. Decrease Inert Mass Vitrified
   - Aluminum Dissolution
   - Other Separation Technologies
2. Mitigate Aluminum Processing Limitations
   - Batch Sequence Optimization and Feed Blending
   - Frit Development
   - Revise RW Criteria / SR Glass
3. Increase DWPF Throughput
   - Facility and Equipment Modifications
   - Canister Modifications
4. Reduce Estimate Uncertainty
   - Improved Characterization
   - Thermodynamic Modeling

A group was chartered to evaluate techniques to mitigate the life cycle impacts. The team focused on three areas: reducing the sludge mass, new melter technology, and DWPF vitrification flowsheet improvements. One promising mitigation option was aluminum dissolution, which offers the potential for significantly reducing the quantity of sludge solids sent to the DWPF, thus reducing the number of canisters produced, and was the most technologically mature. Based on the recommended planning compositions, Tanks 12, 13, 15, 32, 35, and 39 contain over one million kg of aluminum represented in the form of $Al(OH)_3$ (gibbsite) or about 61% of the total aluminum in sludge. Pre-conceptual project planning was initiated to develop and deploy an aluminum dissolution process.

DISSOLUTION PROCESS OVERVIEW

Aluminum is dissolved from sludge waste into the supernate by treatment with caustic at moderate to high temperatures, where decantation and water washing subsequently remove the aluminum. Aluminum solids in the sludge are believed to be present primarily in three compounds – aluminum trihydrate or gibbsite, aluminum monohydrate or boehmite, and aluminosilicate. With caustic treatment, the gibbsite form dissolves readily at the relatively low dissolving temperatures possible in the waste tanks. The boehmite form dissolves much more slowly and is somewhat less soluble than gibbsite. The aluminosilicate has such low solubility in waste slurries that it is generally considered insoluble.

Early Aluminum Dissolution

Aluminum dissolution was performed in a full-scale demonstration in 1982 by adding 50 wt% NaOH to the process tank, Tank 42. Steam heating was used to hold the slurry temperature at 85°C for three to five days while continuously mixing the sludge. The caustic was added in sufficient quantity to provide a minimum initial ratio of 3 moles of free hydroxide per mole of acid soluble aluminum (gibbsite) and to provide a final liquid phase free hydroxide molarity of 3. The actual conditions during dissolution varied from these initial conditions due to a variety of operational issues, but roughly approximated these conditions.

During the full-scale demonstration in 1982, a total of 394,000 liters (104,000 gallons) of 50 wt% sodium hydroxide and 447,000 liters (118,000 gallons) of dissolved salt solution were added to 473,000 liters (125,000 gallons) of high aluminum sludge. The tank was heated from 63°C to 83°C in 38 hours with steam spargers at 2700 kg/hr (6000 lb/hr) and was continuously agitated. Thereafter, a steam flow of 450 kg/hr (1000 lb/hr) was used to maintain tank temperatures between 83 and 85°C. After five days of digestion, sample analyses indicated that approximately 80% of the total aluminum in the sludge had dissolved.

Process Development

As a result of the increased estimate of sludge mass to be vitrified, the aluminum dissolution process was pursued as a means to reduce the amount of sludge mass thereby reducing the projected number of canisters and DWPF lifecycle. To assist in identification of operating parameters and equipment selection, a kinetics model was developed utilizing the 1982 full-scale demonstration, along with several laboratory tests and literature data, as the basis [2]. The kinetics model is shown below.

$$t = \frac{\alpha\, F(wf,\alpha)}{(2\times 10^{15})\sqrt{C^0_{OH}}}\, e^{\frac{14800}{T}} \qquad \text{(Eq. 1)}$$

where:

t = Dissolution time, hr

$$F(wf,\alpha) = \frac{1}{\sqrt{\alpha(\alpha-1)}}\,\mathrm{Ln}\left|\frac{(\sqrt{\alpha}-\sqrt{\alpha-1})(\sqrt{\alpha-1+wf}+\sqrt{\alpha-1})}{(\sqrt{\alpha}+\sqrt{\alpha-1})(\sqrt{\alpha-1+wf}-\sqrt{\alpha-1})}\right|$$

α = Mole ratio at initial conditions of free OH ion in the liquid phase relative to Al in the solid phase, dimensionless

C^0_{OH} = Initial liquid phase concentration of free OH ion in molal units, gmol/kg water

T = Dissolution operating temperature, K

wf = Weight fraction of initial Al remaining in solids at the conclusion of the dissolution process, dimensionless

Low Temperature Aluminum Dissolution

In 2007, it was proposed that a significant portion of aluminum in sludge could be dissolved at moderate processing temperatures over a slightly longer time period (weeks vs. days). A 3L sludge slurry sample from Tank 51 was sent to the Savannah River National Laboratory (SRNL) for demonstration of a low temperature aluminum dissolution process. The characterization of the as-received sample of sludge slurry shows a typical high aluminum HM sludge. The XRD analysis of the dried solids indicated the boehmite form of aluminum predominates. Over a twenty-one day test, 42% of the aluminum was dissolved out of the sludge solids [3,4]. The process appeared to be selective for aluminum with no other metals dissolving to any appreciable extent. At the termination of 21 day test, the aluminum concentration in the supernate was still increasing indicating more aluminum could be dissolved from the sludge with longer contact times or higher temperatures. The aluminum dissolution process appeared to have minimal impact on the settling rate of the post aluminum dissolution sludge. The sludge settling was complete after approximately twelve days. The supernate decanted from the settled sludge after aluminum dissolution appeared stable and did not precipitate aluminum over the course of several weeks.

The results from the SRNL demonstration were promising. It was decided to perform dissolution in Tank 51 H for SB5. The dissolution process consisted of the following steps in Tank 51 H for SB5:

- Forty-three 11,400 liter (3000 gallon) tankers of 50% sodium hydroxide solution were unloaded to Tank 51 via HPT 7 and HPT 8.
- Two to four slurry pumps were used to increase slurry temperature in Tank 51 and maintain the temperature as warm as practical. The temperature ranged from about 55 to 64°C during the entire treatment time.
- Tank 51 was mixed for the number of days available, which resulted in 46 day dissolution period, including a 12-day mixing break due to slurry pump and ventilation system maintenance.
- Slurry pumps were turned off and the sludge slurry was allowed to settle for 29 days.
- Approximately 1,160,000 liters (307,000 gallons) of aluminum-laden supernate was decanted to the storage tank, Tank 11.

Dissolution was successfully completed in Tank 51 with existing tank equipment and minimal impact on waste tank operation. Dissolution at about 60°C for 46 days dissolved 26,800-30,400 kg of aluminum, 56-64% of the aluminum originally in Tank 51 sludge slurry, exceeding the original planned estimate of 50%. It reduced the sludge solids mass from 188,000 kg to about 110,000 kg for a total solids reduction of 78000-88,000 kg of sludge solids as Al(OH)3. Uranium and plutonium leached into solution without corresponding leaching of iron or metal other than aluminum, but the total mass leached was a small fraction of the total uranium and plutonium in the sludge. A small amount of mercury leached into solution from the sludge causing the liquid phase concentration to increase 6 to 10 fold, which is consistent with the 4 to 14 fold increase observed during the 1982 aluminum dissolution demonstration. The aluminum leachate solution is currently stored for feed to the Salt Waste Processing Facility (SWPF) or another salt waste process installed in the future.

The results of the 3L sample demonstration and full-scale dissolution in Tank 51 show good agreement with the kinetics model. The higher amount of aluminum dissolved in the full-scale demonstration, after accounting for periods of no tank mixing (poor contact time) and water dilution from pump leakage, shows process temperature to be the predominant factor for determining dissolution rate.

Dissolution of Tank 12 Sludge Sample

Tank 12 sludge showed a substantially larger fraction of aluminum than Tank 11 which was the major component in Sludge Batch 5. Early indications from process modeling indicated the sludge would impact canister waste loading and could be difficult to process through DWPF due to slurry rheology. With the previously successful dissolution of aluminum from Sludge Batch 5, SRR identified an opportunity to perform aluminum dissolution on Tank 12 sludge which was planned to be a primary component of Sludge Batches 6 and 7. A 3L Tank 12 sample was obtained in September 2008 and submitted to SRNL for a laboratory scale demonstration. The overall goals of the demonstration were:

- Characterization of the Tank 12 sludge to provide data for waste transfer needs, aluminum dissolution flowsheet support, and sludge batch planning,
- Validation of the aluminum dissolution effectiveness as a function of time and temperature,
- Monitor changes in physical behavior that could effect DWPF processing.

Prior to performing the laboratory demonstration, Tank 12 sample was characterized, indicating a very high aluminum fraction of the total solids. Speciation of the aluminum was determined by XRD to be >95% boehmite. Aluminum dissolution was performed over a 26 day period at a temperature of 65°C. Approximately 60% of the insoluble aluminum dissolved during the demonstration, with the rate of dissolution slowing significantly at the end of the demonstration period [6]. Quantification of iron dissolution was less clear, but appeared to be on the order of 1% based on the majority of data (a minor portion of the data suggested iron dissolution could be as high as 10%). Figure 2 depicts the extent of aluminum dissolution for this demonstration. Again, there is good correlation between the measured results and the kinetic model projection for dissolution rate. The slight increase in process temperature above the previous laboratory demonstration increased the amount of aluminum dissolved from ~40% to ~60% over a similar 21 day period.

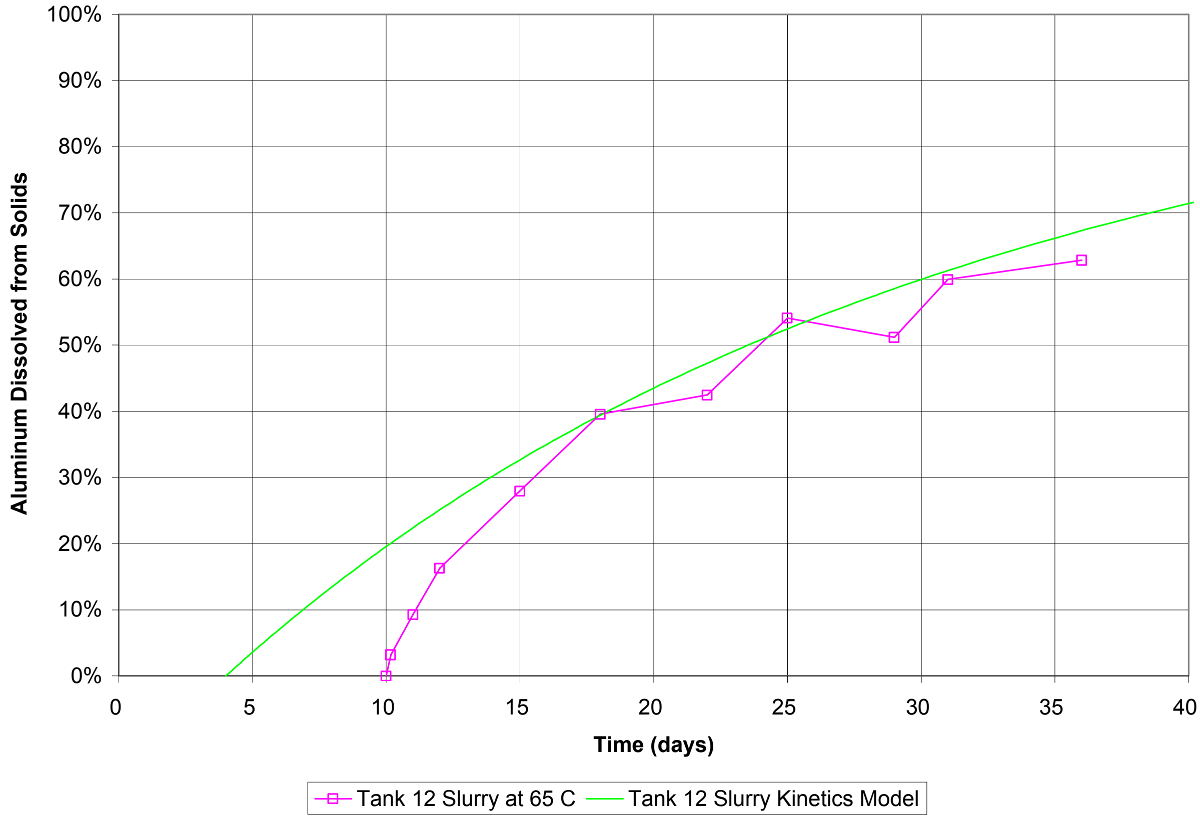

Figure 2. Extent of aluminum dissolution on a 3-L sample of Tank 12 sludge at 65°C.

Another consequence of the dissolution was a somewhat increased sludge settling rate (by a factor of about two). However, the settling rate slowed significantly after about two weeks, yielding barely discernible additional settling over the third week. Rheology measurements were performed on the as received sludge and the post-dissolution material. A decrease in slurry yield stress by a factor of 3 from the as received to the post-dissolution material was measured for similar weight percent insoluble and total solids, and only a slight increase in slurry plastic viscosity (~30%) was measured. The improvements in the slurry physical properties are attributed to the removal of aluminum oxide solids.

Process Data Summary

Table I provides a summary of the primary process conditions and the dissolution results for the main evolutions performed at SRS. Comparing the recent laboratory and full-scale dissolution conditions and results to the 1982 in-tank demonstration shows that process temperature is the dominant attribute in determining dissolution rate and that comparable results can be achieved by performing dissolution at moderate temperatures for a nominal increase in process time for the evolution. When factored into an overall schedule duration of 50 to 75 weeks to prepare and qualify sludge feed for vitrification, this represents only a 4-6% increase in overall duration.

Table I. Comparative Data of SRS Aluminum Dissolution Demonstrations Previous to Sludge Batch 6

Dissolution Attribute	Unit	Tank 42 In-tank Dissolution Demo (1982)	Low Temp Lab Demo of Sludge Batch 5 (2007)	Tank 51 In-tank Dissolution of Sludge Batch 5 (2008)	Lab Demo of Sludge Batch 6 (2008)
Sludge Source		Tank 15	Tank 11	Tank 11	Tank 12
Free Hydroxide Concentration	M	3	4.3	4.1	5.0
Dissolution Temperature	°C	83-85	55	55-63	65
Duration of Dissolution	days	7	21	46	26
Aluminum Dissolved	%	80	42	56-64	60

ALUMINUM DISSOLUTION OF SLUDGE BATCH 6

Objectives

The main objectives for performing aluminum dissolution on Sludge Batch 6 were:

- Accomplish dissolution pretreatment of the Tank 12 sludge, as a component of Sludge Batch 6, to effectively prepare and deliver a sludge batch for efficient vitrification processing at DWPF.
- Effectively reduce the sludge mass from Sludge Batch 6 thereby reducing the amount of HLW canisters produced and shortening the overall lifecycle.
- Assess the repeatability of the process parameters employed in the earlier aluminum dissolutions at SRS for long term application.

During initial sampling and characterization, the sludge from Tank 12H was determined to have a much higher than predicted aluminum concentration, exhibited very poor settling characteristics, and additional process modeling predicted ineffective vitrification of the waste. In order to improve the chemical and physical characteristics and enhance vitrification processing in DWPF, performing aluminum dissolution in Tank 51 for Sludge Batch 6 was necessary.

Process Flowsheet

Most of the steps developed for the flowsheet for Sludge Batch 6 aluminum dissolution performance were the same as the Sludge Batch 5 dissolution effort with the exceptions of the caustic volume to be added and the storage tank location for aluminum leachate storage (Tank 8) [7]. The summary of processing steps is given below:

1. Transfer Tank 12 sludge waste into Tank 51.
2. Valve out cooling water to Tank 51.
3. Unload 50% sodium hydroxide solution to Tank 51 via HPT 7 and HPT 8.
4. Use slurry pumps to mix Tank 51 periodically during the batch transfers of caustic from HPT 7 and HPT 8 to Tank 51.
5. Use slurry pumps to increase slurry temperature in Tank 51 and maintain the temperature as necessary. A supplemental heater may be used if installed. If necessary, cooling coils may be used to avoid exceeding the upper operating temperature limits.
6. Periodically mix tank for number of days available.
7. Turn off slurry pumps.
8. Settle for as long as allowable by the Q-Time program for a maximum decant to Tank 8.
9. Decant the maximum amount of aluminum-laden supernate to decant storage tank, Tank 8.

Process sampling plans and field operating plans were developed based on the sequential performance of activities as outlined in the flowsheet. Transfer of the waste from Tank 12 to Tank 51 was planned to be performed in 3 evolutions, with planned supernate decants from Tank 51 back to Tank 12 as the slurry medium to minimize the overall liquid volume and the total amount of caustic necessary. After the waste was transferred to Tank 51, the tank would be sampled to determine the amount of caustic to be added. Periodic sampling would be performed throughout the reaction period, projected to be 46 days at 65°C, to measure rate and extent of dissolution. Once the flowsheet objective of 75% aluminum dissolved was met, the tank contents would be allowed to settle and cool for separation and transfer of the aluminum leachate for storage.

Process Execution

As is typically experienced throughout industry, it is rare when plans are executed as originally developed. Several difficulties were encountered during the waste retrieval operations in Tank 12 and subsequent transfers to Tank 51. Significant deviations were made from the original flowsheet to account for many unforeseen difficulties and outages, and to recover from the schedule delays incurred during waste retrieval operations.

The first attempt to transfer sludge from Tank 12 with the submersible transfer pump was unsuccessful. Tank 12 slurry pump operations and sample analysis for the Inhalation Dose Potential (IDP) evaluation was performed concurrently with development of a path forward for transfer pump operations. Performance of the path forward with subsequent attempts to transfer sludge at two transfer pump elevations were also unsuccessful. Additional samples were then taken to analyze the material physical properties of the slurry. Results of the analysis indicated a yield stress higher than previously measured and utilized as a planning basis for H Modified (HM) waste. Significant dilution of the Tank 12 sludge slurry was necessary to lower the weight percent solids and yield stress in order for the transfer pump to successfully transfer the material to Tank 51. Supernate from Tank 24 was used as the diluent, which also served to augment the amount of caustic called for in the flowsheet and aid in minimizing the increased volume projected from dilution. From the first initial attempt to transfer waste from Tank 12 in early December, 2008, until the first successful transfer out introduced a 3 month schedule delay.

Three transfers from Tank 24 to Tank 12 of a total estimated 820,000 liters (217,000 gallons) were required to provide the necessary dilution. Although the caustic concentration of the supernate was 4.5M, this represented a significant increase in the planned liquid volume. Additionally, one decant of Tank 51 back to Tank 12 was able to be accomplished as a result of 2 week steam outage (providing the necessary gravity settling period). Four transfers from Tank 12 to Tank 51 were required to provide the mass of sludge solids needed for Sludge Batch 6. The first successful transfer of waste from Tank 12 was performed on March 9, 2009, and the final transfer out was completed on June 21, 2009. The overall duration for waste retrieval and transfer operations amounted to 15 weeks; the original flowsheet had planned for a 6-8 week duration introducing an additional 2 month delay.

As a result of the delays in the waste retrieval efforts, it was decided to initiate early caustic additions to recover some schedule time. Following completion of the second waste transfer into Tank 51, it was evaluated that future waste transfers could be executed successfully and up to two-thirds of the 409,000 liter (108,000 gallon) caustic volume outlined in the flowsheet could be added before sampling to determine the total amount of caustic that would be required. Caustic additions were initiated on May 15, 2009 and within two weeks, 24 tankers totaling 271,000 liters (71,600 gallons) had been added. It was also decided to initiate tank heatup during caustic additions to take benefit from the temperature increase caused by heat of dilution, initiate dissolution of the aluminum solids that had already been transferred into the tank, and reduce the temperature decrease that would occur the remaining future waste transfers. At the completion of these initial caustic additions, tank temperature had risen to 57°C and steadily increasing from mixing pump operation.

Although the completion of waste slurry transfers were planned immediately following the initial caustic addition, delays were again encountered as a result of mixing pump equipment issues. Tank heating continued in Tank 51 through mixing pump operation. Two of the four mixing pumps were run continuously and provided approximately a ~1°C/day temperature increase. The third and fourth pumps were only run intermittently to ensure adequate mixing of the entire tank contents due to high bearing and seal water in leakage. Tank temperature had increased to ~65°C during this period.

The third waste transfer from Tank 12 was performed on June 5, 2009. During waste retrieval operations, cooling to Tank 12 was reduced to maintain the temperature of the waste slurry as high as allowable to minimize the process impacts during transfer to Tank 51. During receipt of the waste transfer, Tank 51 process temperature only dropped to 62°C and was quickly recovered afterward with mixing pump operation. Unfortunately, the amount of sludge received from the transfer did not meet the necessary mass of solids for the flowsheet. A fourth waste retrieval campaign and transfer were scheduled to bring additional waste into Tank 51. As a result, a sample was pulled from the tank to quantify the amount of solids, caustic concentration and extent of dissolution that had occurred to this point. Continued process operations were evaluated and eight additional tankers of caustic totaling 90,640 liters (24,000 gallons) were scheduled and added the following week. Tank process temperature had increased to 69°C following these evolutions.

Sample results confirmed the need for the additional waste transfer. The results also indicated that dissolution was ongoing and that a substantial amount of the initial aluminum solids transferred had dissolved. A second sample was pulled following the second batch of caustic additions to monitor dissolution rate and extent of caustic depletion in preparation for the fourth waste transfer and final caustic additions. Results indicated continued dissolution of aluminum solids and approximate dissolution rate corresponding to a process temperature of ~55-60°C.

The final waste transfer occurred on June 20, 2009. The remaining contract value of 111,260 liters (29,400 gallons) of caustic was added to the tank on June 23-24 and June 30, 2009. Mixing pumps were operated to maintain process temperature between 69-72°C until the dissolution evolution was stopped on July 14, 2009. A sample was obtained on July 6 to monitor dissolution rate, which appeared to be lower than projected and attributed to the little reaction time for the last sludge transfer and caustic additions. A final sample was pulled on July 14 at the completion of dissolution operations. Figure 3 below provides a chronological representation of waste transfers, caustic additions, process tank temperature and sample results. A model projection segmented into three temperature periods is also presented for comparison.

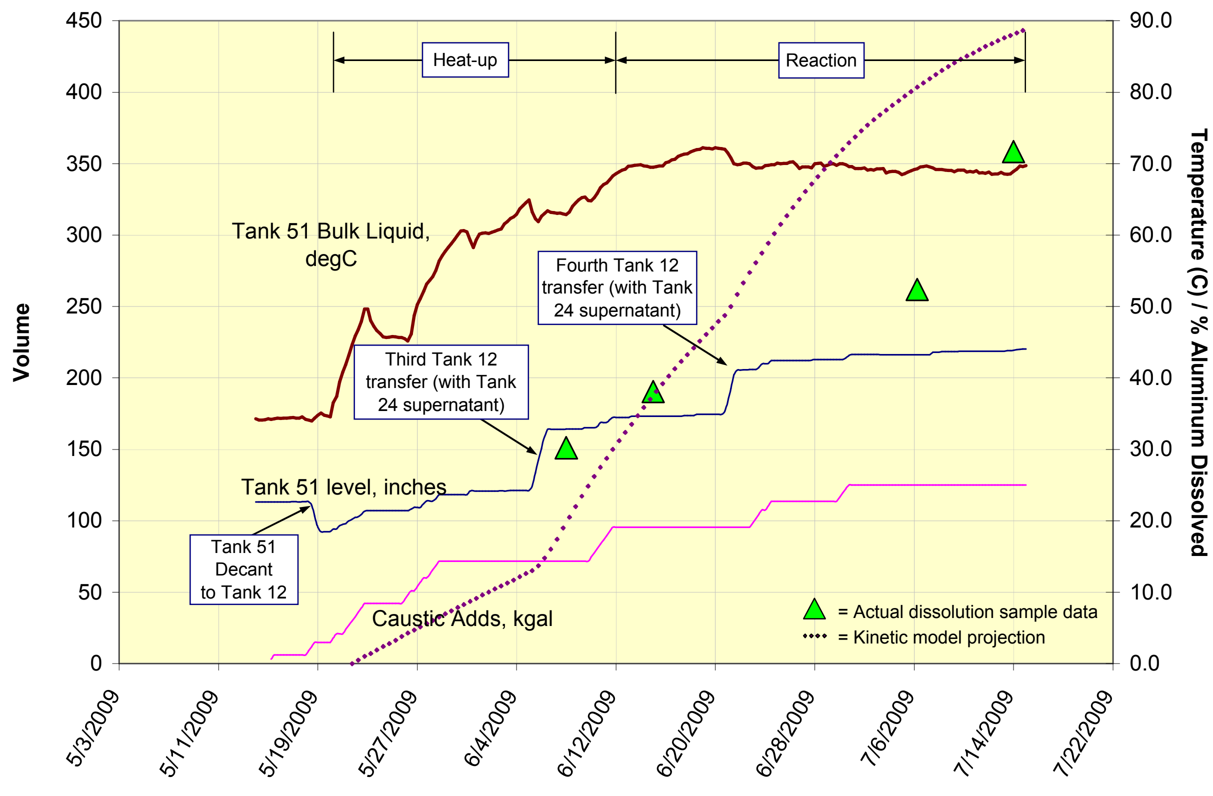

Figure 3. Recorded operating conditions and measured results of Sludge Batch 6 aluminum dissolution.

The contents of Tank 51 were allowed to cool and gravity settle in preparation for transfer to the storage tank. Observed settling rates were much improved over the pre-dissolution settling and laboratory demonstration. The aluminum leachate decants were accomplished in two separate transfers on August 9-11 and September 1-3, 2009. A total decant volume of 1,650,000 liters (436,000 gallons) of leachate were transferred to Tank 8 for storage and eventual disposition through SWPF. Additional sludge from Tank 4 was transferred into Tank 51 and sludge washing initiated to prepare Sludge Batch 6.

Figure 4 below provides a schematic representation of the Sludge Batch 6 Aluminum Balance and material volumes for the Tank 51 evolution. After completion of the aluminum dissolution effort and transfer of waste from Tank 4, additional caustic was added to Tank 51 to inhibit future aluminum precipitation during sludge washing. It is estimated that an additional quantity of 32,000 kg of dissolved aluminum will be removed in the wash water decants.

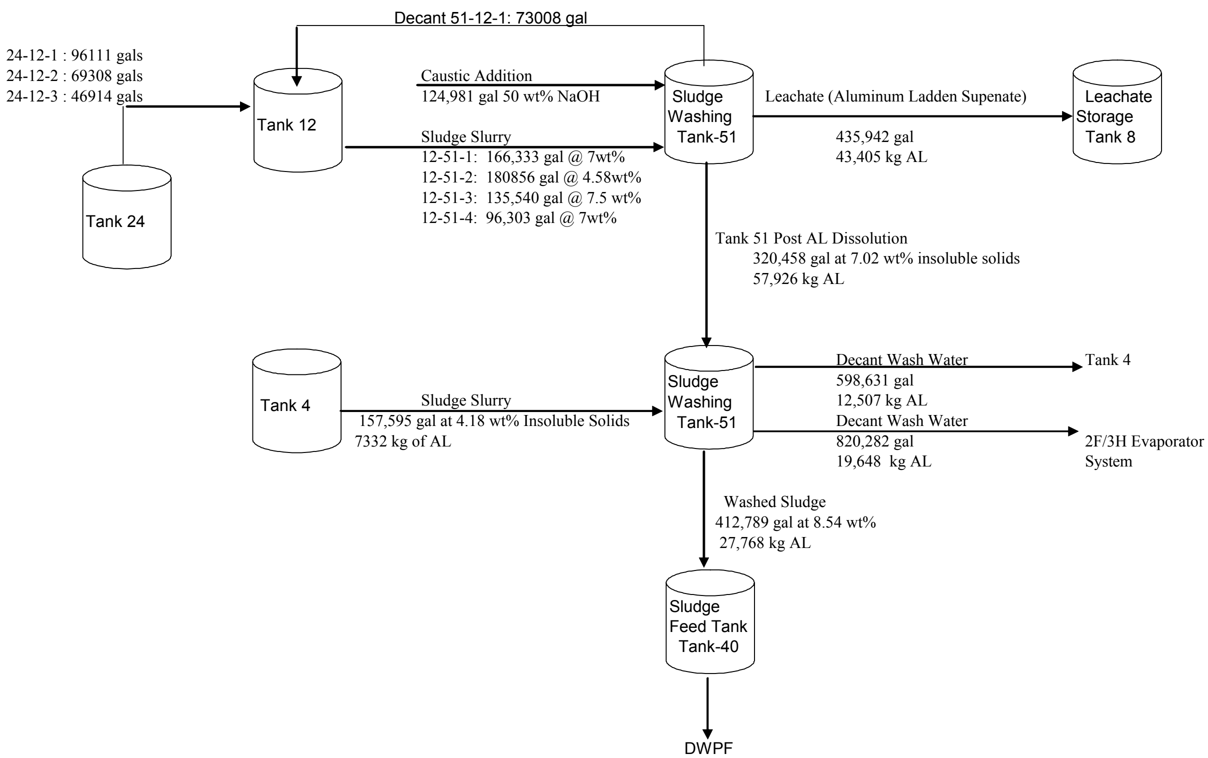

Figure 4. Sludge Batch 6 aluminum and liquid volume balance schematic.

Results

Table II summarizes the process data for this dissolution effort. Despite the delays in waste retrieval operations and numerous process upsets, approximately 72% of the aluminum solids transferred into Tank 51 was dissolved. Deviations from the original flowsheet were necessary to recover schedule caused by the delays. The final stoichiometric volume of caustic could not be determined as waste transfers, caustic additions and tank heating evolutions were performed in parallel and could not be quantified. Tank temperature was elevated as high as practical to achieve the desired results. Tank mixing pump operation was limited as a result of bearing and seal water in leakage. Differences between the measured results for sample data obtained and the model projection are attributable to the delayed waste transfers and shortened durations that the aluminum solids were exposed to the caustic and process temperatures. The final result of approximately 72% of the aluminum solids is attributed to the process temperature attained.

Table II. Tank 51 In-tank Dissolution of Sludge Batch 6.

Evolution Attribute	Unit	Value
Caustic Addition (@50 wt%)	liters	473,053
Free Hydroxide Concentration	M	4.23
Dissolution Temperature	◦C	68-72
Dissolution Duration (at temperature)	days	26-32
Elemental Aluminum (Pre-Dissolution)	Kg	101,330
Aluminum Dissolved	%	71.7
Aluminum Removed in Leachate	Kg	43,405

SUMMARY/CONCLUSIONS

Conclusions drawn from Sludge Batch 6 aluminum dissolution are as follows:

1. Dissolution at >50°C for 54 days (~70°C for 32 days) dissolved approximately 65,217 kg of elemental aluminum, approximately 72% of the aluminum originally in the Tank 51 sludge slurry. It reduced the sludge solids mass from 270,000 kg to approximately 145,000 kg for an insoluble solids reduction of 125,000 kg of aluminum oxide (boehmite).
2. The total amount of aluminum dissolved exceeded the Tank 12 laboratory demonstration of 60% primarily attributable to the higher processing temperature.
3. Tank 8 is currently storing an estimated 43,405 kg of dissolved aluminum. Approximately 25,771 kg of dissolved aluminum remained in Tank 51 after the transfer to Tank 8.
4. It is inferred from the data that intermittent addition of caustic does not adversely impact the rate of dissolution. Caustic was added even before all the needed sludge was received in Tank 51 to recover the schedule. It is apparent from the data that % Al dissolved is dependent upon the temperature rather than parameters such as hydroxide concentration.
5. The total potential reduction in canister production at the Defense Waste Processing Facility (DWPF) is estimated from 180-200 canisters at 38% waste loading.

Table III below provides a summary of the projected canister avoidance from performing the two aluminum dissolution campaigns on Sludge Batches 5 and 6. A nominal canister reduction of 300 canisters corresponds to an 18 month reduction to the overall SRS liquid waste system lifecycle.

Table III. Projected HLW Canisters Avoided at Various Waste Loadings.

Canister Waste Loading	Sludge Batch 5 Canisters Avoided	Sludge Batch 6 Canisters Avoided	Total Projected Canisters Avoided (nominal)
36%	120-133	190-211	326
38%	116-126	180-200	311
40%	108-120	170-190	294

The final conclusion drawn is that project plans were modified to implement the modified aluminum dissolution process in a modular fashion to perform dissolution at these moderate processing temperatures as a permanent treatment process at SRS. The slight schedule increase in sludge batch preparation can be accommodated into the overall system operating lifecycle. Deployment of this moderate temperature process avoids the equipment needs and capital investment to achieve the higher dissolution rates projected at the elevated process temperatures.

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