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7. Abstract

This is the 1994 annual report for technical task plan (TTP) number RL4-4-20-02. The objective of the TTP is to develop and demonstrate a scaleable process to reclaim sodium nitrate ($NaNO_3$) from Hanford waste tanks as a clean nonradioactive salt. During the reporting period of October 1, 1993, through May 31, 1994, progress was made on four fronts -- laboratory studies, surrogate waste compositions, contracting for university research, and flowsheet development and modeling. Laboratory studies include sodium nitrate crystal growth parameters and occlusion rates. Surrogate wastes include a categorization of single shell tanks according to the weight percent sodium nitrate in each tank. A contract with the University of Arizona to perform continuous crytallizer studies went into effect on May 1, 1994. Detailed flowsheets were developed using the ASPENPlus stead state process simulator.

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TABLE OF CONTENTS

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1.0 SUMMARY

The objective of this technology task plan is to develop and demonstrate a scaleable process to reclaim sodium nitrate ($NaNO_3$) from Hanford waste tanks as a clean nonradioactive salt. The purpose of the so-called "clean salt process" is to reduce the volume of low level waste glass by as much as 70%.

During the reporting period of October 1, 1993, through May 31, 1994, progress was made on four fronts -- laboratory studies, surrogate waste compositions, contracting for university research, and flowsheet development and modeling.

In the laboratory, experiments with simulated waste were done to explore the effects of crystallization parameters on the size and crystal habit of product $NaNO_3$ crystals. Data were obtained to allow prediction of decontamination factor as a function of solid/liquid separation parameters. Experiments with actual waste from tank 101-SY were done to determine the extent of contaminant occlusions in $NaNO_3$ crystals. The occlusion rate determines the theoretical maximum decontamination factor for a single stage crystallization, and therefore defines the size (number of required stages) of an operating plant.

In preparation for defining surrogate waste compositions, single shell tanks were categorized according to the weight percent $NaNO_3$ in each tank. An internal memo report was issued. A copy of the memo is attached to this report.

A contract with the University of Arizona went into effect on May 1, 1994, to build a bench-scale continuous crystallizer using simulated Hanford waste. The principal investigator there is Dr. Alan Randolph. He is a world-class crystallization expert, and has expertise in Hanford waste chemistry through past consulting contracts here. He was instrumental in the selection of the design of Hanford's 242-A and 242-S evaporator/crystallizers that have been used here since the mid-1970's to reduce the volume of tank waste.

A detailed process flowsheet and computer model were created using the ASPENPlus steady state process simulator. This is the same program being used by the Tank Waste Remediation System (TWRS) program for their waste pretreatment and disposal projections. Therefore, evaluations can be made of the effect of the clean salt process on the low level waste volume and composition resulting from the TWRS baseline flowsheet. Our calculations, using the same assumptions as used for the TWRS baseline where applicable, indicate that the number of low level glass vaults would be reduced from 44 to 16 if the clean salt process were incorporated into the baseline flowsheet.

This work is funded by the Office of Technology Development, within the Department of Energy's Office of Environmental Management, under the Efficient Separations and Processing Integrated Program.

2.0 LABORATORY STUDIES

2.1 Crystallization Parameters

The design of a crystallization plant is highly dependent on the ability to separate crystalline product from the mother liquor. In the clean salt process, nearly all of the radioactivity in the crystal slurry is in the liquid phase (see Section 2.2). Therefore, the decontamination factor that can be achieved with each solid/liquid separation is defined by the separation efficiency.

Using cold (nonradioactive) $NaNO_3$, a series of experiments was performed to test the effect of crystallization parameters on the size and habit of $NaNO_3$ crystals formed, and on the separation efficiency. The parameters that were varied were (a) evaporation temperature, (b) crystallization temperature, (c) volume percent solids in slurry before filtering or centrifuging, and (d) separation technique (filtration or centrifugation). The effects that were measured were (a) particle size, (b) weight percent filtered (or centrifuged) solids, and (c) weight percent water in the filter cake (or centrifuge cake). Results of the measurements were used to calculate the solid/liquid separation efficiency.

2.1.1 Experimental

The detailed procedure and data for these tests are recorded in controlled laboratory notebook WHC-N-624, pages 128-152.

The $NaNO_3$ used for these tests was the product of an earlier single-stage crystallization of a simulated tank 101-SY waste. A stock solution was prepared by dissolving 125.5 g of the impure $NaNO_3$ in 224.9 g water. The solution was filtered, then divided into nine 50 mL beakers, each containing a stirbar. The nine fractions were treated as shown in Table 1.

Table 1. Parameters for Crystallization Tests.

Fraction	Evaporation Temperature, °C	Crystallization Temperature, °C	Target Volume Percent Solids
1[a]	25	25	20
2, 7	25	25	20
3	25	25	50
4, 8	80	5	50
5	60	60	20
6, 9	60	60	50

[a] Fraction 1 undisturbed during evaporation; all other fractions stirred.

The evaporation temperature is the temperature at which the solution was held during the evaporation process. The crystallization temperature is the temperature the slurry was brought to before filtering.

When the target volume percent settled solids and crystallization temperature were reached, the slurry was filtered through a 0.45 micron filter. Weights of filter cake, filtrate, and total slurry were recorded. A sample of the filter cake was analyzed for percent water. Another sample of the filter cake was analyzed for particle size by polarized light microscopy.

The entire experiment was repeated using a laboratory-scale clinical centrifuge to perform the solid/liquid separation, rather than filtration.

2.1.2 Data

Measurements taken during the crystallization experiments are shown in Tables 2 and 3.

Table 2. Data from Crystallization Experiments; Separation by Filtration.

Fraction	Slurry Weight, g	Filter cake, g	% H_2O in filter cake	Average size, μm
1	24.2	3.0	4.4	370
2 7	22.0 24.8	5.1 3.2	8.6 10.0	190 120
3	19.7	7.6	9.2	90
4 8	20.5 20.9	6.2 7.7	7.6 10.9	70 90
5	21.1	3.9	5.4	80
6 9	20.2 21.0	4.9 4.9	6.9 7.7	140 150

2.1.3 Results

Crystallization temperature had surprisingly little effect on average crystal size. All of the size averages for the stirred samples fell within the rather narrow range of 50-190 micrometers. The variation between duplicate runs was almost as great as the differences between crystallizing conditions. The only factor that had a significant effect on crystal size was whether or not the solution was stirred during the evaporation. In the unstirred samples, the crystals grew to be quite large. Some individual crystals as large as 7 mm in diameter were measured. In all cases, the crystals that formed were found to be very regular rhombohedra, indicating very low levels of occlusion or crystal defects.

Given that nearly all of the radioactivity in the slurry is in the liquid phase (see Section 2.2), the solid/liquid separation efficiency is a measure of how well the crystals can be decontaminated. The separation efficiency is measured by the amount of liquid phase retained in the filter cake (or centrifuge cake) relative to the total amount of liquid in the slurry. The total liquid in the slurry is equal to the amount retained in filter cake plus the amount of filtrate.

Table 3. Data from Crystallization Experiments; Separation by Centrifugation.

Fraction	Slurry Weight, g	Centrifuge cake, g	% H_2O in c'fuge cake	Average size, µm
1	21.9	5.2	8.6	3500
2	21.8	5.1	16.0	200
7	23.6	3.1	21.0	120
3	22.0	5.1	20.0	50
4	20.1	8.6	23.0	70
8	18.9	11.5	26.0	60
5	20.6	4.7	23.0	100
6	19.4	8.2	24.0	110
9	18.9	8.0	22.0	120

Tables 4 and 5 show the solid/liquid separation efficiency ("Wt % Liquid in Filter Cake") for each test. The weight of liquid in the filter cake was calculated from the measured %H_2O by assuming that the water was saturated in $NaNO_3$. For this purpose, a saturated solution was assumed to contain 0.45 g $NaNO_3$ per gram of solution. The weight of liquid in the filtrate was taken as the difference between the total slurry weight and the weight of filter cake. Then, the weight percent liquid in the filter cake (weight liquid in filter cake divided by total liquid) is a direct measure of the solid/liquid separation efficiency. To a very good approximation, the weight percent liquid in the filter cake is equal to the percentage of radioactivity that would be retained in the filter cake, and thus is directly related to decontamination factor.

The "Wt % Dry Solids in Slurry" in Table 4 is found by taking the weight of filter cake (Table 2), subtracting the weight of liquid in the filter cake (Table 4), and diving by the total weight of the slurry before filtering (Table 2). As shown in Figure 1, there is a strong correlation between the weight percent solids in the slurry and the separation efficiency.

Table 4. Calculation of Solid/Liquid Separation (Filtration) Efficiency.

Fraction	Wt (g) Liquid in Filter Cake	Wt (g) Liquid in Filtrate	Wt % Liquid in Filter Cake	Wt % Dry Solids in Slurry
1	0.2	21.2	1.1	11.4
2	0.8	16.9	4.5	19.7
7	0.6	21.6	2.6	10.6
3	1.3	12.1	9.6	32.2
4	0.9	14.3	5.6	25.9
8	1.5	13.2	10.3	29.4
5	0.4	17.2	2.2	16.7
6	0.6	15.3	3.9	21.3
9	0.7	16.2	4.1	19.9

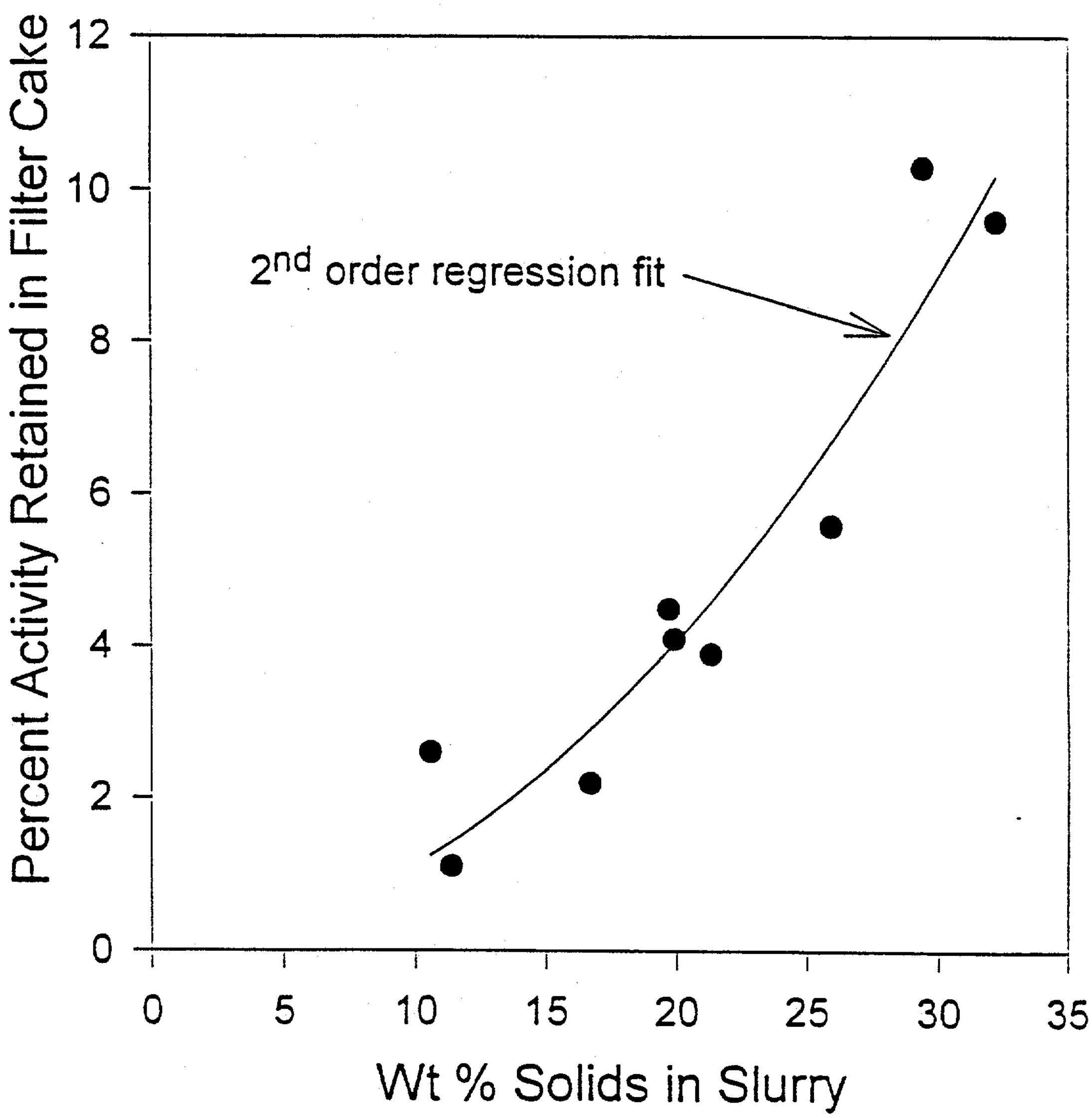
Table 5. Calculation of Solid/Liquid Separation (Centrifugation) Efficiency.

Fraction	Wt (g) Liquid in Centriuge Cake	Wt (g) Liquid in Decantate	Wt % Liquid in Centrifuge Cake	Wt % Dry Solids in Slurry
1	0.8	16.8	4.6	20.2
2	1.5	16.8	8.1	16.5
7	1.2	20.5	5.5	8.1
3	1.8	17.0	9.8	14.7
4	3.6	11.5	23.7	24.8
8	5.4	7.4	42.3	32.0
5	1.9	15.9	10.9	13.2
6	3.6	11.2	24.3	23.9
9	3.2	10.9	22.7	25.4

2.2 Occlusion Testing

Due to the large difference in ionic radii of the Na^+ and Cs^+ ions, it is not possible for the cesium ion to replace sodium ion in the $NaNO_3$ crystal lattice. By their nature, however, crystals do have defects. One type of defect that can lead to crystal impurity is an occlusion, in which the $NaNO_3$ crystal grows "around" a pocket of foreign material. All foreign material present in the interstitial liquid can be removed by washing the crystals, but the material trapped in occlusions within the crystals cannot be removed. In our case, the foreign material contains radioactive contamination. Thus, the level of crystal occlusions sets the limit of decontamination that can be

Figure 1. Filtration Efficiency.



obtained in a single "stage", or crystallization. Of course, the contamination can be removed by recrystallization, or dissolving the contaminated crystals in water and forming new crystals (i.e., by adding "stages" to the process).

In order to determine the extent of occlusion-type contamination inherent for $NaNO_3$ crystals, two tests were done using $NaNO_3$ from tank 101-SY. The highly contaminated crystals were recrystallized from water, then washed repeatedly with a saturated $NaNO_3$ solution (to preclude dissolution of the crystals during the washing). Samples of the initial solution before crystallization, of each wash solution, and of the final washed crystals were analyzed to determine what happened to the ^{137}Cs.

2.2.1 Experimental

The detailed procedure and data for these tests are recorded in controlled laboratory notebook WHC-N-384-1, pages 145-148, and WHC-N-384-2, pages 3-7. The $NaNO_3$ crystals used for the tests was obtained from earlier clean salt process development tests on tank 101-SY sample. [See Section 4.2 in WHC-SD-WM-DTR-029, "Clean Salt Process Applied to Double Shell Slurry (Tank 101-SY)", D. L. Herting, August 24, 1993.]

Recrystallization: The highly-contaminated $NaNO_3$ (30.0 g) from tank 101-SY was dissolved in 60.0 g water. The solution was filtered through a 0.45 micron cellulose nitrate filter. (The same type of filter was used throughout these tests.) A small aliquot (5.0 mL) of the filtrate was analyzed for ^{137}Cs by gamma energy analysis (GEA). The solution was evaporated at 80°C until crystals were present, then the slurry was cooled to room temperature. The cooled slurry was allowed to settle to determine the volume percent settled solids, which was measured at 80%. The slurry was filtered, and the filtrate solution was analyzed by GEA.

Wash #1: The crystals were transferred from the filter to a plastic beaker, where they were weighed (19.7 g). An equal weight (19.6 g) of a saturated $NaNO_3$ solution was added to the crystals in the beaker as a wash solution, to displace interstitial liquid contaminated with ^{137}Cs. The use of saturated $NaNO_3$ solution prevented the crystals from dissolving in the wash solution. The slurry was stirred for 5 minutes, then filtered. The filtrate was analyzed by GEA.

Wash #2: The crystals from the first wash weighed 17.1 g, and 20.0 g of saturated $NaNO_3$ solution was added. The slurry was stirred, filtered, and sampled as above.

Wash #3: The crystals from the second wash weighed 17.2 g, and 15.9 g of saturated $NaNO_3$ solution was added. The slurry was stirred, filtered, and sampled as above.

Crystal analysis: The filter cake (17.0 g) remaining from the third wash was dissolved in 28.2 g of water, and the solution was analyzed by GEA.

The entire experiment was repeated, using four washes instead of three. The following weights were recorded during the repeat experiment:

Initial weight of contaminated $NaNO_3$ crystals: 30.2 g
Initial weight of water added to dissolve crystals: 60.3 g
Weight of recrystallized $NaNO_3$ filter cake: 17.3 g
Weight of crystals after first wash: 16.9 g
Weight of crystals after second wash: 18.0 g
Weight of crystals after third wash: 17.4 g
Weight of crystals after fourth wash: 17.8 g

The small variations in weight from wash to wash most likely reflect changes in the amount of liquid retained in the filter cake, rather than actual changes in the weight of dry crystals.

2.2.2 Data

The distribution of ^{137}Cs among the various streams can be calculated from the recorded weights, analyzed (or calculated) densities, and activities. The appropriate data are shown in Table 6 for the first test and Table 7 for the second test.

Table 6. Data and Analytical Results for Occlusion Test #1.

Stream	Weight of Stream (g)	^{137}Cs Activity (μCi/mL)	Density (g/mL)
Initial filtered solution of contaminated $NaNO_3$ crystals	80.93	2.92	1.253
Filtrate from recrystallization	19.21	10.90	1.38
Filtrate from Wash #1	22.26	2.04	1.38
Filtrate from Wash #2	19.79	0.184	1.38
Filtrate from Wash #3	16.12	0.0201	1.38
Solution of washed $NaNO_3$ (16.96 g filter cake)	45.18	0.00825	1.260

2.2.3 Results

In both of the occlusion tests, the amount of ^{137}Cs that could not be washed away from the $NaNO_3$ crystals represented 0.14% of the total amount of ^{137}Cs in the slurry before filtering. This implies that the maximum decontamination factor for a single crystallization stage would be approximately 700. With this information, combined with the TWRS estimate of the ^{137}Cs activity in the stream that would be the feed for the clean salt process, the size of the processing plant (i.e., number of stages) can be designed to match the required decontamination factor.

Table 7. Data and Analytical Results for Occlusion Test #2.

Stream	Weight of Stream (g)	^{137}Cs Activity ($\mu Ci/mL$)	Density (g/mL)
Initial filtered solution of contaminated $NaNO_3$ crystals	98.69	2.13	1.218
Filtrate from recrystallization	21.93	9.40	1.38
Filtrate from Wash #1	16.81	0.983	1.38
Filtrate from Wash #2	20.93	0.0476	1.38
Filtrate from Wash #3	18.59	0.00516	1.38
Filtrate from Wash #4	20.44	0.00089	1.38
Solution of washed $NaNO_3$ (17.81 g filter cake)	51.19	0.00572	1.243

The amount of ^{137}Cs in each stream is calculated by multiplying the activity of the sample (as analyzed by GEA) by the weight of the stream, and dividing by the density. For example, the number of microcuries of ^{137}Cs in the filtrate from recrystallization in test #1 is calculated as follows:

$$(10.90\ \mu Ci/mL)\times(19.21\ g)/(1.38\ g/mL) = 151.7\ \mu Ci\ ^{137}Cs$$

The results of these calculations for all the streams are shown in Table 8. By setting the amount of ^{137}Cs in the initial solution to 100%, the percentage of ^{137}Cs reporting to each of the exit streams can be calculated.

The stream in Table 8 labeled "^{137}Cs Unaccounted For" represents the difference between the initial $NaNO_3$ solution and the sum of all the other streams. In both tests, the amount of ^{137}Cs "lost" is well within the analytical uncertainty of the analyses for the initial solution and the recrystallization filtrate.

The ^{137}Cs distribution can be viewed graphically (see Figure 2) by converting the percentage values in Table 8 to the percentage of ^{137}Cs remaining in the crystals after each step. Thus, in the initial slurry before filtering, 100% of the ^{137}Cs is associated with the crystals. After filtering, the amount of ^{137}Cs retained in the filter cake is represented by the difference between the initial amount and the amount in the filtrate. The values used for Figure 2 are shown in Table 9. The percentage values have been "normalized" to account for the missing ^{137}Cs, i.e. the sum of the amounts of ^{137}Cs in each stream were forced to add up to 100%.

Table 8. ^{137}Cs Distribution in Occlusion Tests.

Stream	Test #1		Test #2	
	Total μCi	% of total	Total μCi	% of total
Initial $NaNO_3$ solution	188.6	100.0	167.8	100.0
Recrystallization Filtrate	151.7	80.5	149.4	89.0
Wash #1 Filtrate	32.9	17.4	12.0	7.1
Wash #2 Filtrate	2.64	1.4	0.72	0.43
Wash #3 Filtrate	0.23	0.12	0.070	0.04
Wash #4 Filtrate	(0.04)[a]	(0.02)[a]	0.013	0.01
Washed Crystals	0.30 (0.26)[a]	0.16 (0.14)[a]	0.23	0.14
^{137}Cs Unaccounted For	0.79	0.42	5.38	2.62

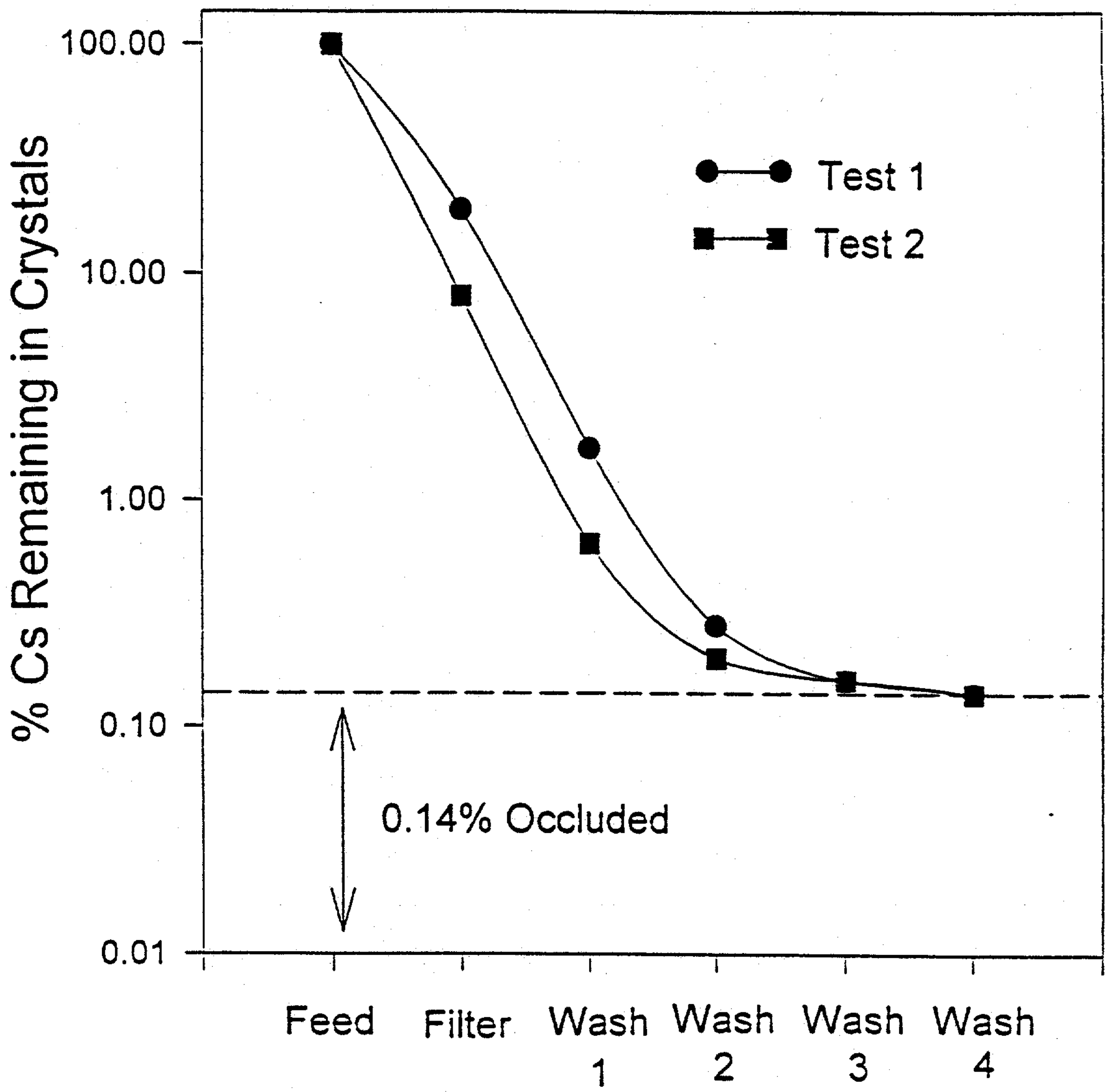
[a] Test #1 included only 3 washes. Values in parentheses are calculated assuming behavior analogous to Test #2 results.

Table 9. Percentage of ^{137}Cs Remaining with Crystals.

Stream	Test #1	Test #2
Initial $NaNO_3$ Solution (Feed)	100.00	100.00
Recrystallization Filtrate	19.16	7.98
Wash #1 Filtrate	1.69	0.64
Wash #2 Filtrate	0.28	0.20
Wash #3 Filtrate	0.16	0.16
Wash #4 Filtrate	0.14	0.14

From the graphic perspective of Figure 2, it is obvious that the effectiveness of the washing falls off rapidly after the second wash, and that the curve reaches a sort of asymptote that represents a level of contamination that can't be removed by washing. That amount is presumed to be held in occlusions within the crystals.

Figure 2. Occlusion Test Results.



3.0 SURROGATE WASTE COMPOSITIONS

Information about waste compositions is needed for a variety of reasons. Simulated wastes are required in order to perform process development experimentation in our laboratory, and to run the bench scale continuous crystallizer at the University of Arizona. Process feed compositions are needed for the computer modeling, both for flowsheet design calculations and for comparing low level waste volume projections with the TWRS baseline flowsheet.

It was recognized early on that some types of waste would be more amenable than others to processing to recover the $NaNO_3$. With this in mind, the inventory of waste in single shell tanks was examined on a tank-by-tank basis. All of the single shell tanks were grouped into categories according to the weight percent $NaNO_3$ in each tank. The results of this examination were reported in an internal memo, which is attached to this report as Appendix A.

4.0 UNIVERSITY OF ARIZONA CONTRACT

On May 1, 1994, Westinghouse Hanford Company (WHC) establish a contract with the University of Arizona to develop a continuous crystallization process and to make scale-up recommendations. Dr. Alan Randolph, a world renowned crystallization expert, will be overseeing the work. The contract was let for $94K and was given a term of one year.

Researchers at the University of Arizona are tasked with building a mixed slurry mixed product removal (MSMPR) crystallizer to investigate various crystallization parameters. Studies performed with the MSMPR crystallizer fall under three tasks:

Task 1. Growth rates and nucleation rates will be determined for sodium nitrate/aluminum nitrate bi-component solutions at a variety of Na/Al ratios.

Task 2. Studies will be performed on more complex aqueous mixtures representing Hanford tank waste. These studies will focus on possible effects of minor chemical constituents on the crystallization process.

Task 3. The researchers will investigate different fines recovery and crystallization techniques.

More details of the contract and the specific tasks can be found in the Statement of Work, which is attached as Appendix B.

5.0 FLOWSHEET DEVELOPMENT

An optimized flowsheet is needed to identify the impacts of the clean salt process on the Tank Waste Remediation Systems (TWRS) baseline tank waste treatment plan. In addition, salt generation and process chemical additions can be estimated. The flowsheet approach, assumptions, description, and results will be discussed in the following sections.

5.1 Flowsheet Approach

The flowsheet was generated with a two-fold purpose. First, a rigorously detailed clean salt process flowsheet was created. The flowsheet needed to be accurate and detailed enough so that variability studies could be performed. Second, the flowsheet generated had to have the ability to be integrated into the TWRS baseline tank waste treatment flowsheet. This allowed comparisons to be drawn between the baseline flowsheet and a flowsheet including a clean salt process.

Since the TWRS flowsheet is being created with the ASPENPlus steady state process simulator, the clean salt flowsheet also was created using that program. The ASPENPlus program allows flowsheets to be developed and steady state conditions calculated based on assumptions inputted into the program. The assumptions used in the development of the clean salt flowsheet are listed in the next section. The result from an ASPENPlus run is a detailed component-by-component listing of each of the process streams, from which the material balance can be calculated.

5.2 Flowsheet Assumptions

To be consistent with the work being done in the development of the TWRS process flowsheet, TWRS flowsheet assumptions are used for the clean salt flowsheet where they apply. Other flowsheet assumptions are derived from experimental data and knowledge of crystallization processes. The following is a list of assumptions used in creating the clean salt flowsheet.

1) Feed stream pH adjusted to 0.01 M H^+
2) Solubility of "cool" $NaNO_3$ is 92.1 g per 100 g H_2O
3) Solubility of "hot" $NaNO_3$ is 180.1 g per 100 g H_2O
4) $3NO_2^- + 2H^+ \rightarrow 2NO(g) + NO_3^- + H_2O$
5) $CO_3^= + 2H^+ \rightarrow CO_2(g) + H_2O$
6) Readjust aqueous effluent to 0.01 M OH^-
7) Solids entrainment in evaporator condensate is 0.01 wt% for most components
8) Solids entrainment is 0.1 wt% for C^{14}, TOC, I^-, TcO_4^-, Cs^+, and Ru^{3+}
9) Occlusion percentage is 0.05 wt%
10) Crystallization takes place in two stages
11) Crystallize to 50 wt% solids exiting 2nd crystallization stage
12) Purge stream (stream 14) based on solubility of $Al(NO_3)_3$
13) Solubility of cool $Al(NO_3)_3$ is 63.7 g per 100 g H_2O
14) Centrifuges leave 19.7 wt% liquid entrained

15) Solids carry-over in aqueous stream is 0.1 wt%
16) Rinse solution is a saturated $NaNO_3$ solution
17) Rinse solution to solids solution is approximately 1.

This list of assumptions dictated the final form of the clean salt flowsheet. The feed stream to the clean salt flowsheet was taken directly from the TWRS baseline flowsheet to ensure the clean salt flowsheet could be integrated. The TWRS baseline flowsheet uses a conglomeration of the total Hanford high-level tank waste inventory as the feed to the process. Table 10 shows a component-by-component breakdown of the feed stream to the TWRS flowsheet.

5.3 Flowsheet Description

The initial clean salt flowsheet was designed with the intent to remove sodium nitrate from a low-level waste stream after it exits the cesium ion exchange process. Figure 3 shows the baseline TWRS flowsheet and Figure 4 shows the location for the clean salt process in the TWRS baseline flowsheet. The stream exiting the cesium ion exchange process is estimated to still be contaminated with 140,000 picocuries/gram (pCi/g) ^{137}Cs, and is estimated to be approximately 30 percent sodium by weight (excluding water). The initial flowsheet was designed so that the decontaminated sodium nitrate was contaminated with no more that 25 pCi/g ^{137}Cs.

These initial conditions led to the three stage clean salt process shown in Figure 5. The occlusion rates dictate the need for three stages. Assuming perfect washing, two stages would leave the salt contaminated with 100 pCi/g ^{137}Cs.

Figure 6 shows the detail for one of the three stages. The dissolved salt solution is introduced into the process by mixing it with the recycle stream. The mixture is fed to the evaporator/crystallizer where enough water is driven off to crystallize the sodium nitrate. The hot slurry is sent to a secondary crystallizer where the mix is cooled to ambient temperatures, crystallizing out additional crystals. The liquid and solid phase are separated, with the liquid phase being recycled after a portion is bled off as the wash for the previous stage. The solid phase is rinsed with a saturated sodium nitrate solution. The rinse solution flows counter-current to the flow of the crystals. After the final wash step the crystals are redissolved and sent to the next stage.

Table 10. Tank Waste Remediation Systems Baseline Feed Composition.

Component	Feed Make-Up (in wt %)	Component	Feed Make-Up (in wt %)
Ag^{+}	5.87e-05	Mo^{+6}	1.12e-03
$Al(OH)_4^{-}$	1.48e+00	Na^{+}	9.03e+00
Al^{+3}	5.39e-06	Ni^{+3}	7.66e-05
Am^{+3}	8.70e-05	NO_2^{-}	1.40e+00
As^{+5}	3.53e-04	NO_3^{-}	1.46e+01
B^{+3}	1.32e-05	Np^{+4}	8.68e-03
Ba^{+2}	3.13e-04	OH^{-}	1.37e+00
Be^{+2}	1.32e-06	Pb^{+4}	4.94e-01
Be^{+3}	3.48e-02	PO_4^{-3}	4.91e-01
Ca^{+2}	2.19e-02	Pu^{+4}	2.79e-01
Cd^{+2}	3.60e-01	Rb^{+}	8.28e-06
Ce^{+3}	3.14e-04	Re^{+7}	3.36e-05
Cl^{-}	6.56e-02	Rh^{+3}	1.96e-06
Cm^{+3}	3.12e-02	Ru^{+3}	8.67e-06
Co^{+3}	3.44e-04	S	5.71e-05
CO_3^{-2}	3.40e-01	Sb^{+5}	7.75e-05
$Cr(OH)_4^{-}$	1.29e-02	Se^{+6}	3.14e-04
Cr^{+3}	2.33e-02	Si^{+4}	2.03e-03
Cs^{+}	1.65e-02	Sm^{+3}	6.20e-03
Cu^{+2}	4.72e-05	Sn^{+4}	6.58e-07
^{14}C	1.48e-07	SO_4^{-2}	2.66e-01
F^{-}	1.55e-01	Sr^{+2}	5.15e-05
Fe^{+3}	9.75e-02	TcO_4^{-}	5.63e-03
$Fe(CN)_6^{-4}$	4.69e-04	Te^{+6}	4.90e-03
H^{+}	1.17e-06	Th^{+4}	1.39e-04
H_2O	6.87e+01	Ti^{+4}	3.35e-05
Hg^{+2}	2.39e-03	Tl^{+3}	1.84e-03
I^{-}	5.15e-03	TOC	1.04e-01
K^{+}	1.89e-01	UO_2^{+2}	1.27e-02
La^{+3}	4.33e-05	V^{+5}	4.42e-03
Li^{+}	6.51e-04	W^{+6}	1.94e-01
Mg^{+2}	7.13e-05	Zn^{+2}	1.22e-04
MnO_2	2.83e-02	$ZrO_2:2H_2O$	3.30e-03

Figure 3. Tank Waste Remediation Systems Baseline Flowsheet.

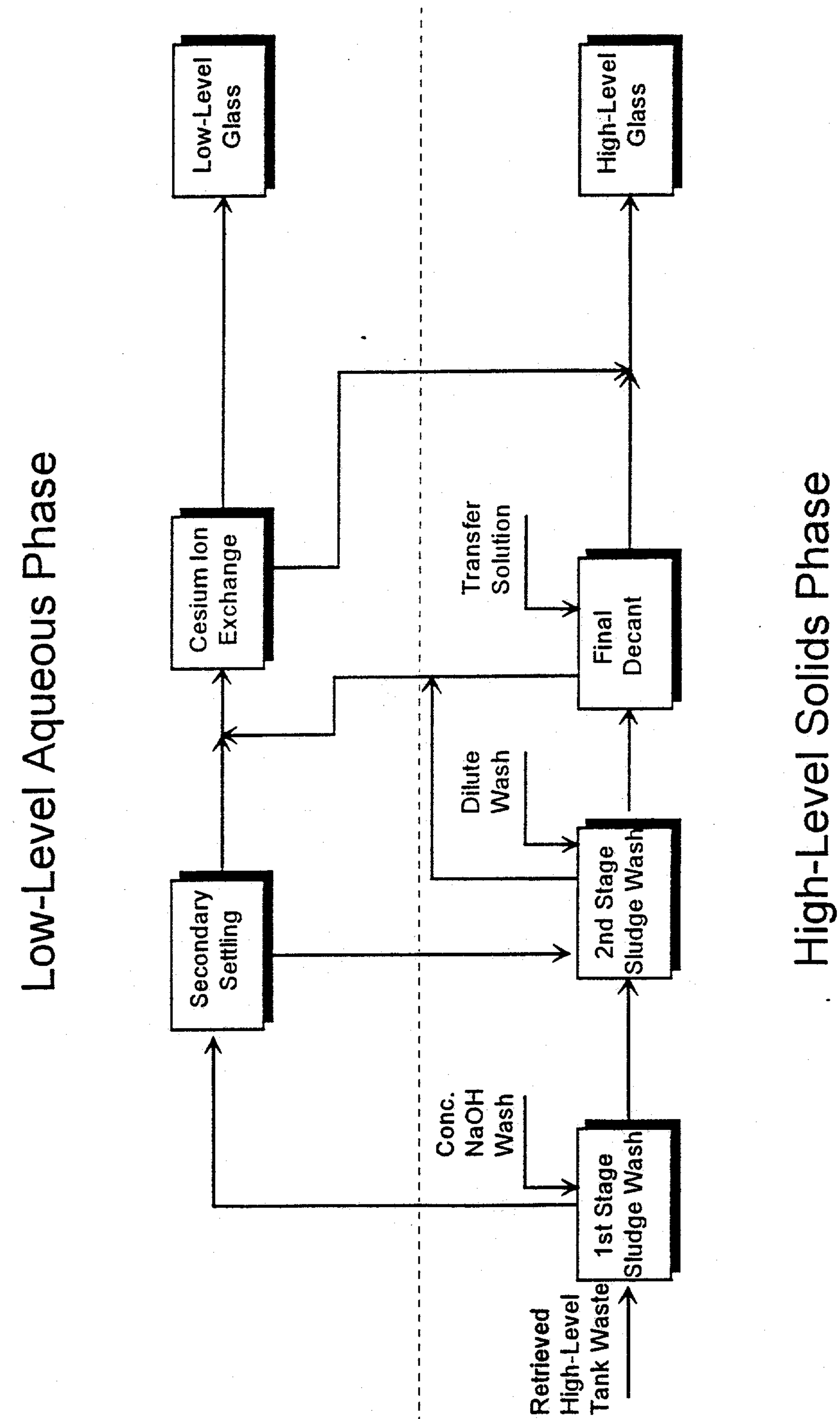


Figure 4. Tank Waste Remediation Systems Baseline Flowsheet Wiith Clean Salt.

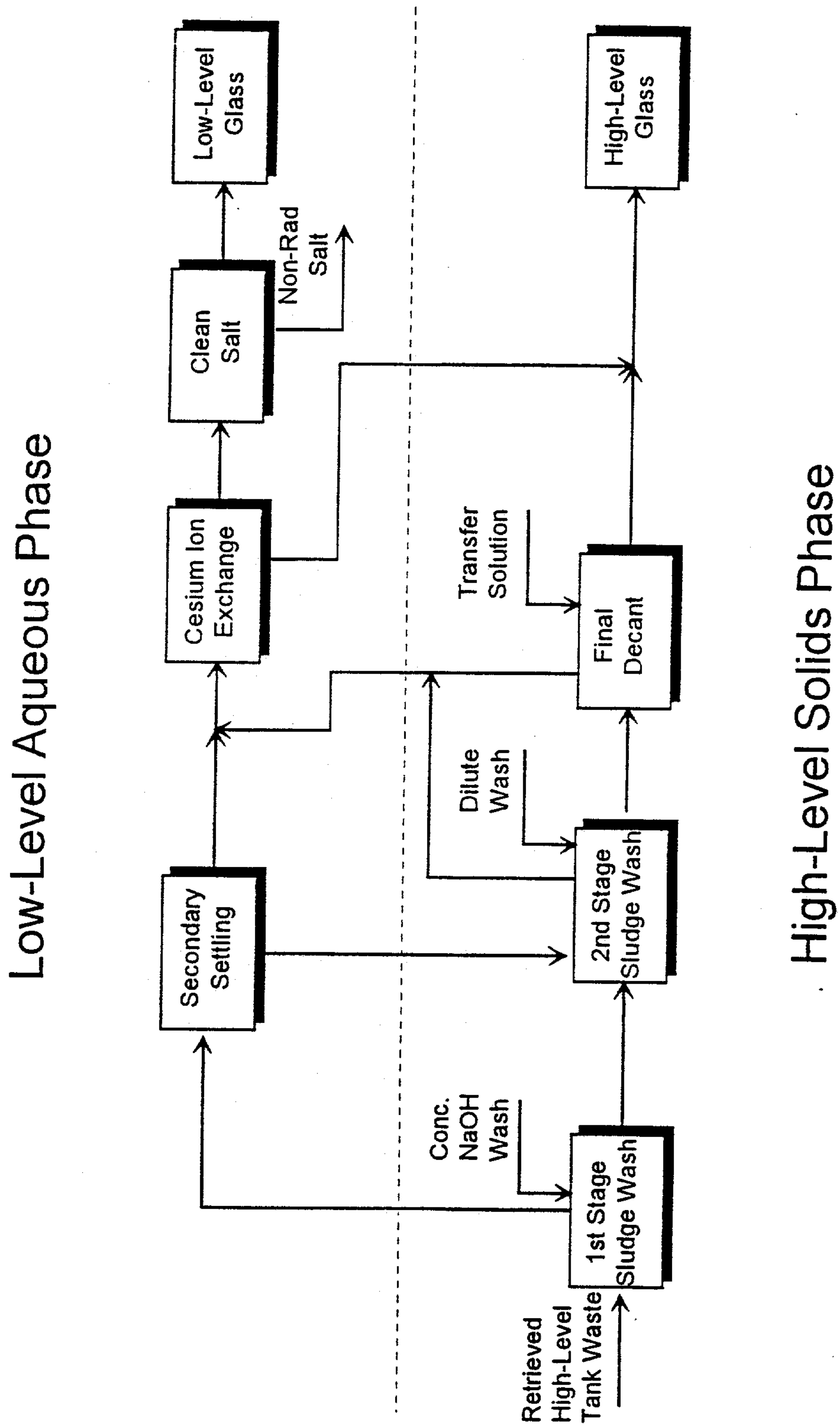


Figure 5. Three Stage Clean Salt Flowsheet.

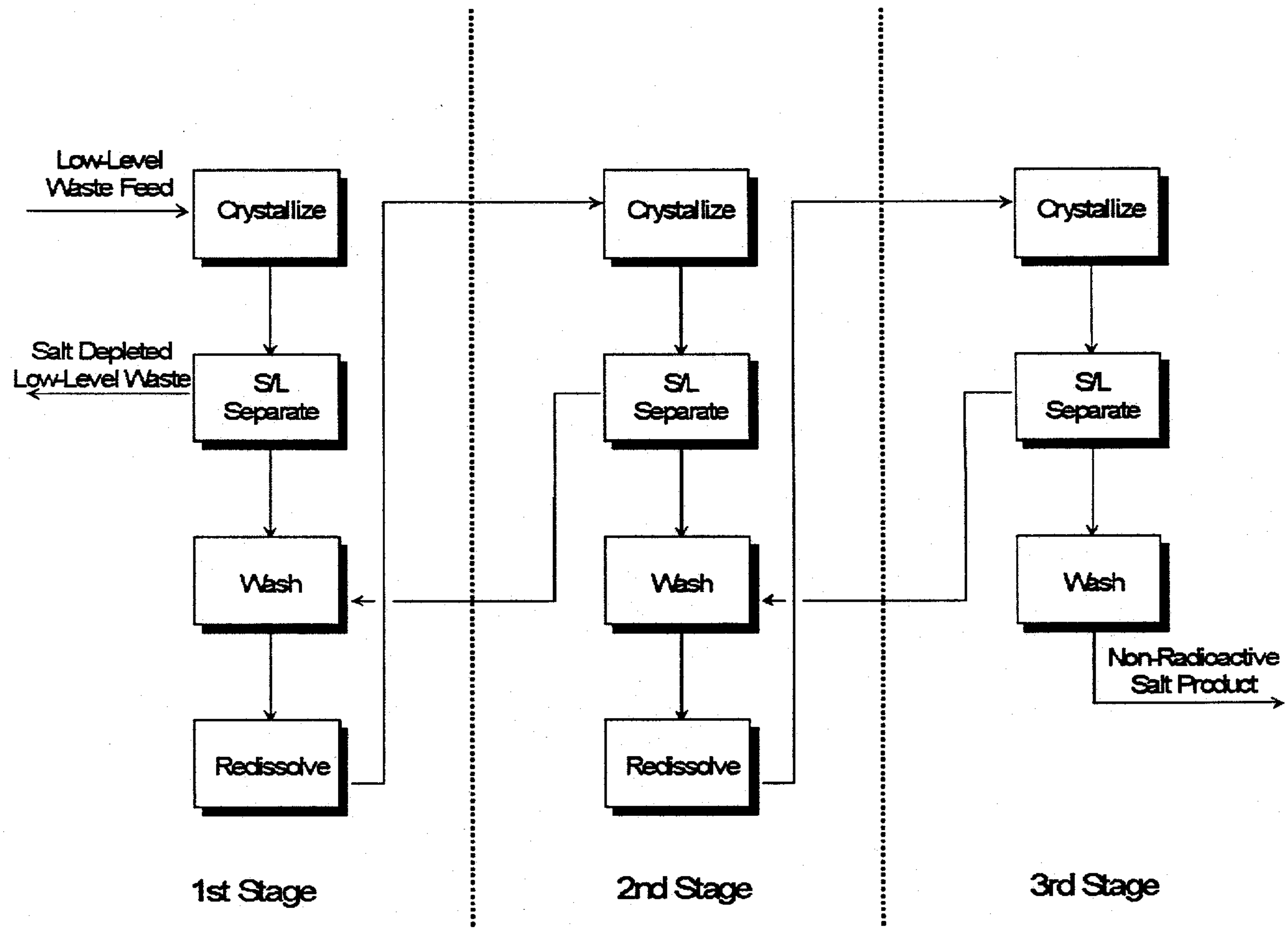


Figure 6. Single Clean Salt Stage Detail.

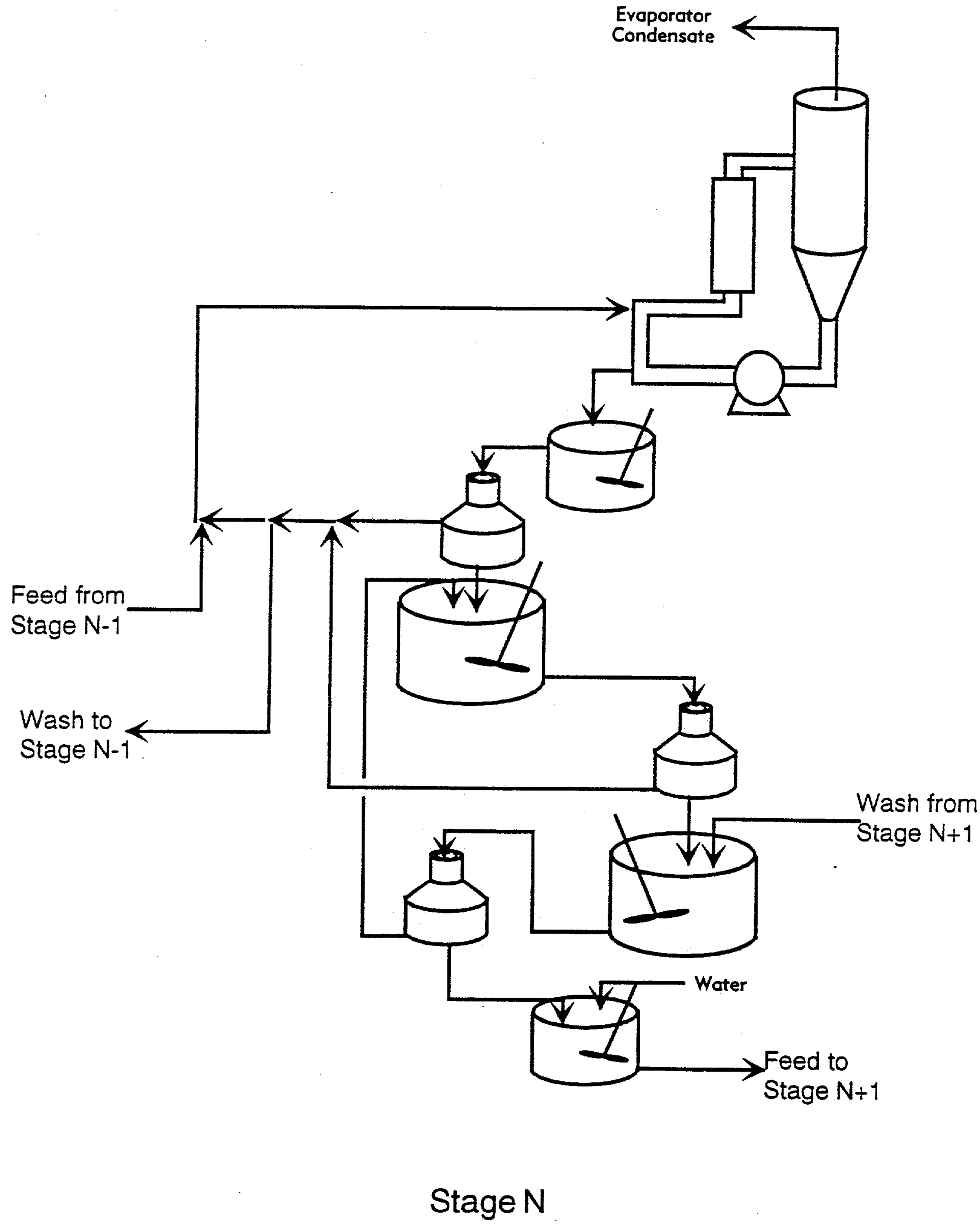


Figure 7 shows the complete clean salt flowsheet. The bleed stream from the first stage is the salt-depleted low-level waste stream. The final salt product from the third stage is split equally by weight. The first half of the salt is the decontaminated salt product from the clean salt process. The second half is redissolved to become the concentrated sodium nitrate wash solution. In each case the evaporator condensate is assumed to be treated at the liquid treatment facility or recycled as process water. The salt is redissolved in process water.

This flowsheet is designed for the recovery of sodium nitrate. The recovered quantity is determined by the concentration of aluminum in the process stream.

As the low-level waste stream becomes depleted of sodium nitrate and water, the solubility of aluminum nitrate is approached. It is at that solubility limit that the maximum amount of sodium nitrate has been recovered.

5.4 Flowsheet Results

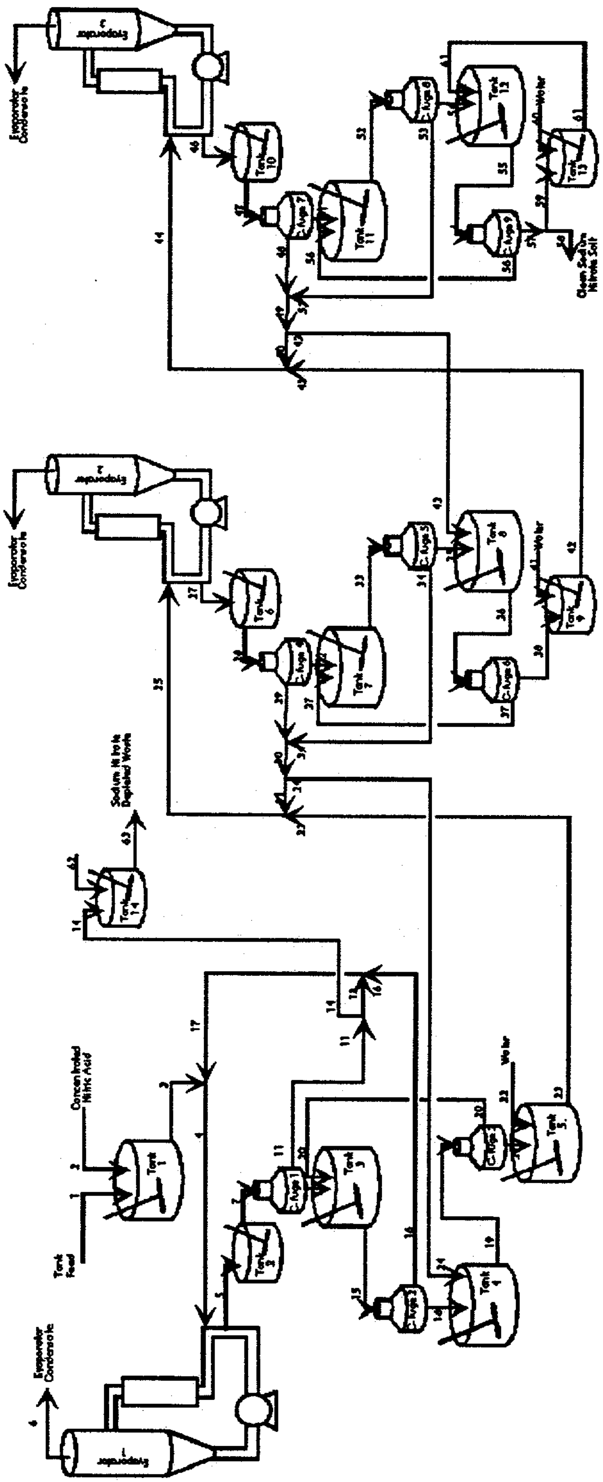
As mentioned previously, the salt recovery in the clean salt flowsheet is controlled by the concentration of aluminum in the feed stream. Since aluminum accounts for approximately 3 wt% of the total waste, the sodium recovery was limited to 70 wt%. Of the 78,000 metric tonnes (MT) of sodium fed, 52,000 MT were recovered. The feed to the clean salt flowsheet was contaminated with 690,000 pCi/g ^{137}Cs and the final decontaminated salt was contaminated with only 4.8 pCi/g ^{137}Cs, for a decontamination factor of 150,000.

Table 11 shows a comparison between the waste volumes generated by the TWRS baseline flowsheet and those generated when the clean salt flowsheet is incorporated into the baseline flowsheet. By recovering 70 wt% of the total sodium in the tank inventory, a low-level waste reduction of approximately 60 wt% can be realized. These numbers are preliminary and are presented for comparison purposes only.

Table 11. Total Waste Generation Comparison.

	Baseline (in MT)	with Clean Salt (in MT)
Tank Waste Fed	752,000	752,000
High-Level Waste Glass	31,300	31,300
Low-Level Waste Glass	570,000	209,000
Decontaminated Sodium Nitrate	0	201,000

Figure 7. Three Stage Flowsheet Detail.



5.5 On-going Flowsheet Development

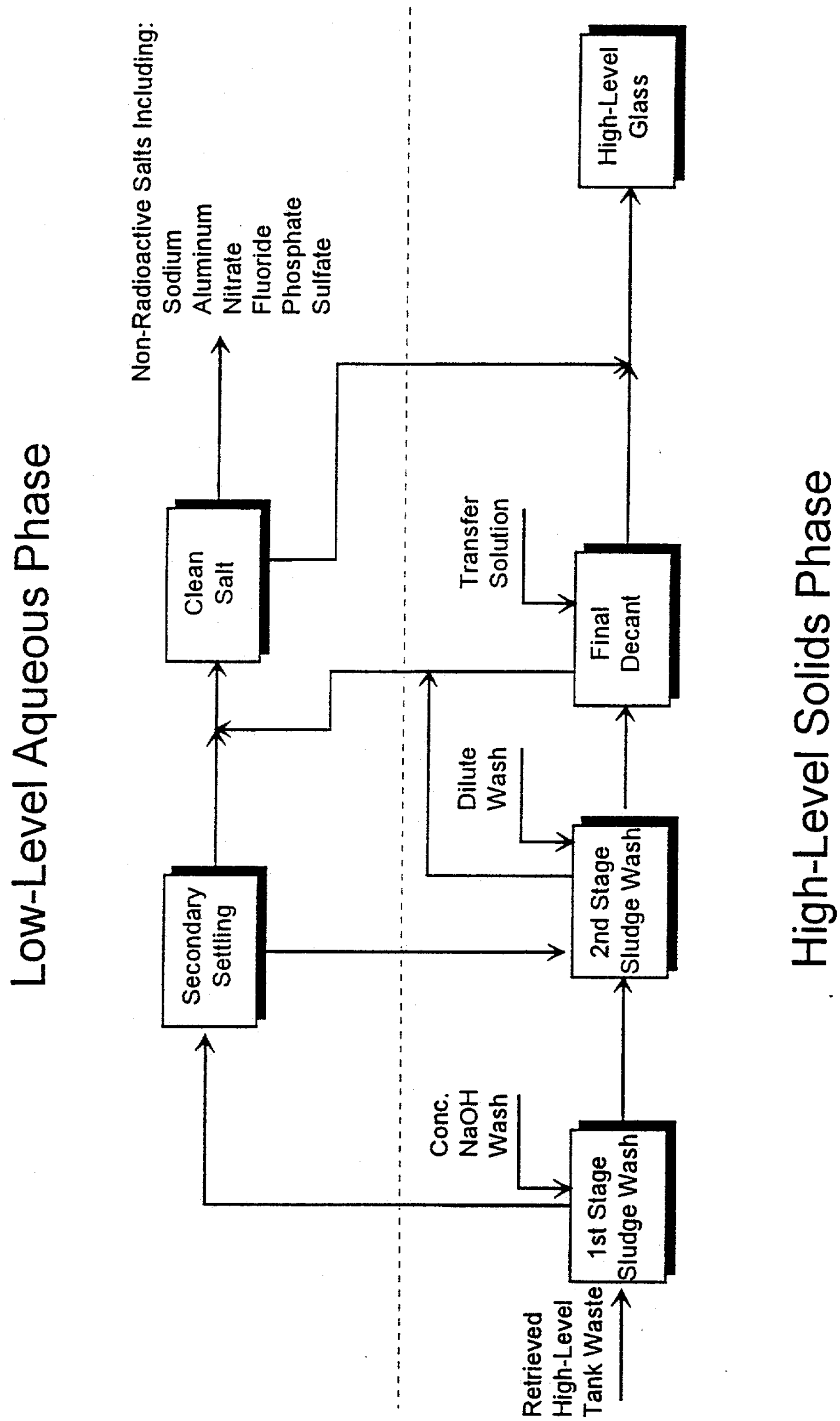
Additional clean salt flowsheet options are being considered. These options involve placing the clean salt operation before the cesium ion exchange operation instead of after it, and a one glass option. Each of these flowsheet options under development is more complex than the baseline clean salt flowsheet because the cesium contamination in the feed is two orders of magnitude greater before the cesium ion exchange. In order to get a salt with the same low cesium contamination level, additional process steps need to be included.

The first alternative being considered places the clean salt process before the cesium ion exchange. Doing this would increase the cesium to sodium ratio in the feed to the ion exchange process, making that process more efficient. In addition, the size of the ion exchange process stream would be greatly reduced, decreasing the size of the process facility. To keep the same low cesium contamination in the clean salt product, the number of wash steps would need to be increased by an estimated 40 to 50%.

The second alternative being considered is the single glass process. The proposed flowsheet shown in Figure 8 would eliminate the cesium ion exchange process and the low-level waste disposal from the TWRS baseline flowsheet. For this process to be viable, components that negatively impact the high-level glass would need to be removed. These components include sodium, aluminum, phosphate, sulfate, fluoride, and nitrate. Although the process chemistry needs some additional study, it is proposed that phosphate and fluoride would be removed as a sodium fluoride phosphate salt, sulfate would be removed as sodium sulfate, the aluminum would be removed as aluminum nitrate, and the remaining sodium would be removed as sodium nitrate. The final products generated by this flowsheet would be decontaminated salts and a high-level glass. The high-level glass quantity would increase an estimated 30 to 50% compared to the baseline flowsheet. A large quantity of decontaminated salt would be generated, and the need for low-level waste disposal would be eliminated.

These two flowsheets will be included in the final milestone report.

Figure 8. The One Glass Concept.



6.0 BUDGET

The Efficient Separations and Processing Integrated Program has provided $300K for fiscal year 1994 activities. As of May 11, 1994, $107K has been spent on development activities. A one year contract for $94K was let on May 1, 1994 to the University of Arizona for process development activities. The entire cost of the contract will be committed from fiscal year 1994 and intended to carry over any necessary dollars to fiscal year 1995 to cover the cost of the contract over its life. The remaining funds will pay for just over one full time equivalent of exempt staff time for the remainder of this fiscal year to finish the remaining milestones.

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APPENDIX A

Internal Memo 12110-PCL93-105

Single Shell Tanks Appropriate for Clean Salt Processing

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Westinghouse Hanford Company | **Internal Memo**

From: Process Chemistry Laboratories 12110-PCL93-105
Phone: 373-2532 MO-346/200W T6-09
Date: December 9, 1993
Subject: SINGLE SHELL TANKS APPROPRIATE FOR CLEAN SALT PROCESSING

To: J. P. Sloughter T6-09

cc: C. H. Delegard T6-09
K. M. Hodgson S4-25
J. R. Jewett T6-09
T. R. Lunsford S4-25
DLH File/LB

References:

(1) WHC-EP-0616, "Tank Waste Technical Options Report", Rev. 0, Appendix D, K. D. Boomer et al., March 31, 1993.

(2) WHC-EP-0182-63, "Tank Farm Surveillance and Waste Status Summary Report for June 1993", B. M. Hanlon, October 1993.

(3) WHC-SD-WM-TI-565, Rev. 1, "Radionuclide and Chemical Inventories for the Single Shell Tanks", R. J. Van Vleet, August 10, 1993.

(4) Unpublished document ARH-CD-623, "Projected Properties and Volumes of Hanford High Level Wastes", C. H. Delegard and N. C. Rodewald, December 1976.

(5) Tables 3-4 and 3-5 (pages 3-10 and 3-11) from WHC-EP-0405 Draft A.

The purpose of this memo is to document recent efforts to determine which selected single shell tanks (SST's) contain waste most appropriate for pretreatment by the Clean Salt Process (CSP). A number of references (1-5 above) were reviewed for the evaluation. In the end, a decision was made to use the data in Reference 1, since it appears to be the most defensible in at least some respects (see Evaluation of Reference Data section).

Analysis of the data indicates that approximately 80% (by weight) of the waste in SST's is amenable to pretreatment by the CSP. The other 20% of the waste contains too little $NaNO_3$ to warrant processing, or contains enough soluble sodium aluminate to make processing difficult.

Appendix A shows a listing of the database used for this study, and shows which tanks are most suited to pretreatment by the CSP.

J. P. Slughter T6-07 12110-93PCL-105
Page 2
December 9, 1993

Method and Results of Analysis

A database was constructed, using the data from Reference 1, containing the weight of Al, Na, NO_2^-, NO_3^-, OH^-, and "other" in each of the 149 SST's. ("Other" includes all other chemical components except water.) Appendix A shows a complete listing of the database. Table 1 shows the total inventory, in grams and weight percent, of each of the components in the SST's.

Table 1. Overall Inventory of Hanford Single Shell Tanks

Component	Weight, g	Weight %
Al	2.4×10^{9}	1.3
Na	5.2×10^{10}	27.9
NO_2^-	4.8×10^{9}	2.6
NO_3^-	9.6×10^{10}	52.2[b]
OH^-	9.1×10^{9}	4.9
other[a]	2.0×10^{10}	11.0
Total	1.8×10^{11}	100.0

[a] "Other" includes all other chemical components except water.
[b] Multiplying by 85/62 converts 52.5% NO_3^- to 71.6% $NaNO_3$

The values in the database were used to calculate the weight percent $NaNO_3$ in each tank. Then the database was sorted according to weight percent $NaNO_3$, and divided arbitrarily into five groups, each containing approximately 20% by volume of all the waste in the tanks. (Tank waste volumes were taken from Reference 2.) The results are shown in Table 2.

Table 2. Division of Single Shell Tanks into Groups by $NaNO_3$ Content[1]

Group	Average Wt% $NaNO_3$	# of Tanks in Group	Wt % of all $NaNO_3$ in SST's	Total Weight, g
1	89	26	33	4.9×10^{10}
2	79	23	42	6.9×10^{10}
3	66	29	17	3.5×10^{10}
4	48	27	6	1.7×10^{10}
5	14	44	2	1.5×10^{10}
Total	--	149	100	1.8×10^{11}

[1] Each group contains 20% by volume of all the waste in SST's.

The tanks in groups 1-3 in Table 2 are best suited to pretreatment by the Clean Salt Process. The 78 tanks in these three groups account for 92% of all the $NaNO_3$ in the SST inventory, and contain 83% by weight of the total waste. Only four of the 78 tanks contain a significant amount (4% by weight) of soluble aluminum that would complicate the clean salt processing.

It's pretty clear that the tanks in group 5 are not amenable to pretreatment by the CSP. These tanks average only 14% by weight $NaNO_3$, and contain less than 2% of SST inventory of $NaNO_3$. In addition, ten of the 44 tanks in this group contain large amounts of soluble sodium aluminate, in concentrations up to 13% Al by weight (equivalent to 39% $NaAlO_2$). It is doubtful whether any volume reduction of waste could be achieved at all on this group by use of the CSP.

Group 4 falls somewhere between clearly amenable and clearly not amenable to pretreatment. This group contains an average 48% $NaNO_3$, so even a CSP operating at 100% efficiency could not achieve a 50% volume reduction for this group. In addition, five out of the 27 tanks in the group contain high concentrations (4-7%) of soluble aluminum.

It is interesting to note that the total group weights of groups 4 and 5 are significantly less than groups 1-3, despite the fact that every group contains approximately the same volume of waste. This is a reflection of the fact that water is not included in the total weights, and sludge tanks contain more water than salt cake tanks. Typical sludges contain 50-80% water by weight; typical salt cakes contain 3-24% water (see Table XIV in Reference 4).

Evaluation of Reference Data

The data in Figure 1 were derived from Reference 5. One conclusion that can be inferred from the figure is that SST salt cake waste is ideally suited to treatment by CSP, and that treatement of SST sludge waste is not so attractive.

Reference 5 contained only general information on the inventory of the tank farms as a whole, divided into sludge and salt cake categories. The purpose of the effort described in this memo was to take a closer look at the composition of the waste in individual tanks, and evaluate the treatability of the waste on a tank-by-tank basis.

Three sources of information were available (References 1-3). Reference 2 contains information on the current waste volume in each tank, and the waste designation (salt cake, sludge, supernate). It does not include any chemical component data. When compared to chemical data from other sources (References 1 and 3), it is difficult to understand how the waste designations were assigned for Reference 2. Some tanks that are believed to contain nearly all $NaNO_3$ are described as sludges, and conversely, some tanks described as salt cakes are believed to contain virtually no $NaNO_3$ at all. The waste volumes from Reference 2 were used to divide the tank inventory into the five equal-volume groups previously discussed. The waste designations were not used.

Reference 3 contains two sources of chemical component information on a tank-by-tank basis. One is an estimated tank inventory based on the TRAC computer code, which in turn is based on the known amounts of chemicals used in chemical processing on the Hanford site. Distribution (by TRAC) of those chemicals into the individual tanks is based on what is known about the processing histories of the operating plants and the fill histories of the tanks.

The second source of data in Reference 3 is a fairly complete copilation of all waste tank samples that have been taken from the SST's. This data source is less than ideal for the current purpose for two reasons. First, a limited number of tanks have been analyzed. Second, in the majority of cases, the sample taken from the tank represents only a fraction of waste in the tank. For example, there are many instances of analysis of a supernate sample from a tank that contains 99% sludge and 1% supernate.

An attempt was made to construct a database containing the best of the available information by combining the two data sources in Reference 3 with the known current volumes of waste from Reference 2. For every tank, the analytical data (if available) were evaluated to determine whether the sample taken was representative of the bulk of the waste. The TRAC data were evaluated to see if the total amount of waste in the tank was consistent with the known current volume. Then, a "best estimate" of the inventory in the tank was entered into the database. This approach was abandoned for two reasons. First, it was recognized that the database would be unique to this internal memo (i.e., not comparable to similar studies done for other pretreatment processes), and the number of assumptions made in constructing the database would be a monumental task to document and defend. Second, the total tank farm inventory derived from the database did not match very well the data from Reference 5 that has been used in previous presentations on the CSP (see Table 3).

A new database was constructed using the data from Reference 1, which is based on a "normalized" TRAC prediction. (See Reference 1 for a description of the normalization.) Apparently, this database is being used throughout Hanford for evaluation of waste pretreatment options. For this reason, it was chosen as the database for use in this memo. It is not without its problems. For example, tank SX-115 contains 2.8×10^{7} grams (not including water) according to the database; if that weight is divided by the volume from Reference 2, the result is a density of 55 g/mL. (Adding in the weight of the water would drive the density even higher.) Tank SX-115 is just an example, not an isolated incident, of inconsistencies between the chemical composition in the database and the known volume of waste in the tank. Other inconsistencies, such as instances of gross cation/anion imbalance, are known to exist in the database.

Table 3 shows comparisons of the inventory of total waste (excluding water) and $NaNO_3$ for the three references that contain such data (References 1, 3, and 5). As noted before, the "best estimate" data derived from Reference 3 did not agree very well with the values (Reference 5) that have been used in previous CSP presentations. The data from Reference 1 are in much better agreement with Reference 5. For Reference 1, "salt cake" is arbitrarily defined as the waste in the tanks in groups 1-3 of the database, and "sludge" represents the waste in groups 4 and 5. An analogous division was made for the database derived from Reference 3.

Table 3. Comparison of SST Inventory Estimates from Various References. (all values $\times 10^{11}$ grams)

	Reference	Salt Cake	Sludge	Total
total waste	1	1.53	0.32	1.85
	3	0.85	0.50	1.35
	5	1.22	0.53	1.75
$NaNO_3$	1	1.22	0.10	1.32
	3	0.57	0.23	0.80
	5	1.10	0.20	1.30

Conclusions

There is too little known about the chemical composition of the SST's to design CSP flowsheets for specific SST's with any kind of confidence. There seems to be some general agreement about the overall inventory of chemicals in the SST's, but the distribution of the inventory on a tank-by-tank basis is not well known. Many discrepancies exist between the currently used database for chemical composition and the known volumes and chemistries of waste in the tanks.

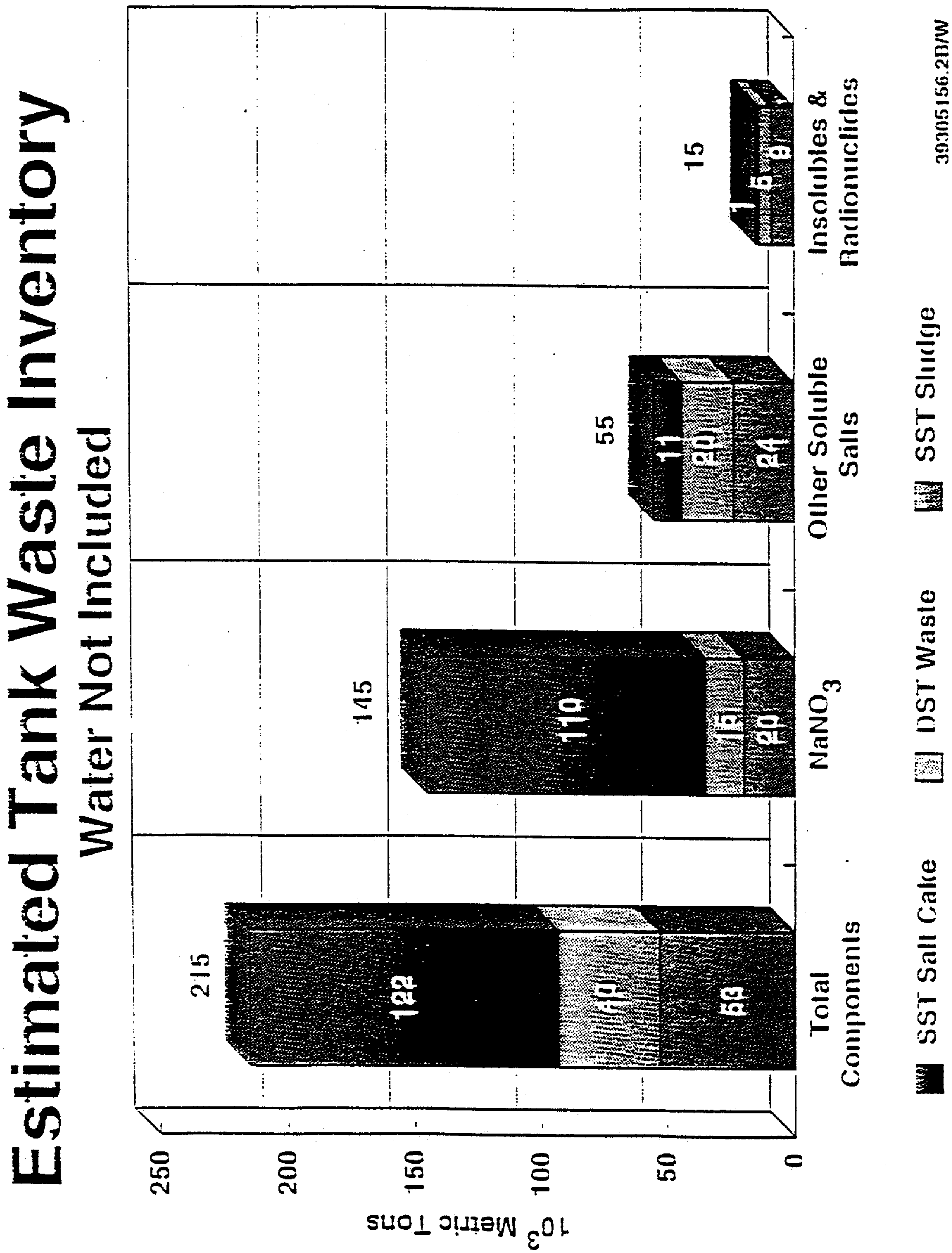
My recommendation is that flowsheets can be designed for each group of tanks as arbitrarily defined in this memo. We know from historical analysis of actual salt cake tanks, like those described in Reference 4, that there are tanks that contain waste with characteristics like those of Group 1. The open question is whether the particular tanks assigned to Group 1 in the Appendix are the correct tanks. The same could be said about any of the other four groups.

Please call if you have any questions or recommendations regarding the data analysis presented here.

D. L. Herting, ~~Senior~~ Principal Scientist
Process Chemistry Laboratories

dls
Attachments

FIGURE 1


Estimated Tank Waste Inventory
Water Not Included
10^3 Metric Tons
250
200
150
100
50
0
215
122
40
53
145
110
15
20
55
11
20
24
15
1
5
9
Total Components
NaNO3
Other Soluble Salts
Insolubles & Radionuclides
SST Salt Cake
DST Waste
SST Sludge
39305156.2B/W

APPENDIX

Chemical Inventory of Single Shell Tanks

Sorted by weight percent $NaNO_3$

Divided into five groups, each containing 20% by volume of the entire waste inventory

Average weight percent $NaNO_3$ in each group is calculated by multiplying the group total weight of nitrate by the factor 85/62, and dividing the result by the total weight of the group. The resulting fraction is multiplied by 100 to convert to percent.

Summary statistics follow Group 5.

SST CHEMICAL INVENTORY DATABASE FROM REFERENCE 1
(Sorted by weight percent NaNO3)

GROUP 1: 84-99% NaNO3 (26 tanks)

Tank	Type	VOL, L	Al	Na	NO2	NO3	OH	OTHER	TOTAL	Wt % NaNO3	Flag
U-102	SC/SUP	1.6E+06	1.3E+07	4.9E+07	1.8E+07	2.5E+08	3.9E+04	1.6E+07	3.4E+08	99	
S-109	SALTCAKE	2.4E+06	7.6E+07	1.4E+09	5.8E+07	3.7E+09	2.7E+06	8.3E+07	5.3E+09	95	
S-106	SC/SUP	2.3E+06	2.0E+07	4.4E+08	2.9E+07	1.1E+09	2.7E+06	1.1E+07	1.6E+09	94	
U-202	SL/SUP	2.1E+04	2.8E+06	2.9E+07	8.4E+06	8.6E+07	3.4E+02	1.8E+06	1.3E+08	92	
U-201	SL/SUP	2.1E+04	2.4E+06	3.3E+07	6.8E+06	9.0E+07	3.6E+02	2.1E+06	1.3E+08	92	
SX-115	SLUDGE	5.0E+04	3.5E+07	7.8E+08	0.0E+00	1.8E+09	9.2E+07	5.7E+06	2.8E+09	92	
U-203	SL/SUP	1.3E+04	2.4E+06	2.7E+07	7.4E+06	7.9E+07	3.0E+02	2.1E+06	1.2E+08	92	
U-109	SC/SUP	1.9E+06	1.8E+06	2.5E+07	6.5E+06	6.7E+07	2.3E+04	6.2E+05	1.0E+08	91	
U-204	SL/SUP	1.3E+04	8.0E+05	7.4E+06	2.9E+06	2.3E+07	8.7E+01	4.3E+05	3.4E+07	91	
S-105	SALTCAKE	1.9E+06	1.2E+07	3.6E+08	1.0E+07	8.2E+08	2.4E+07	6.3E+06	1.2E+09	91	
S-112	SALTCAKE	2.7E+06	1.8E+08	2.7E+09	2.5E+08	7.1E+09	2.2E+07	4.3E+08	1.1E+10	91	
U-103	SC/SUP	2.0E+06	7.5E+03	2.1E+08	3.1E-04	4.1E+08	8.0E+03	-4.6E-04	6.2E+08	90	
S-103	SC/SUP	1.0E+06	3.4E+05	1.3E+09	0.0E+00	2.6E+09	2.7E+06	7.0E+06	3.9E+09	90	
U-112	SLUDGE	2.0E+05	1.0E+07	2.8E+08	1.2E+07	6.3E+08	1.4E+06	3.1E+07	9.6E+08	89	
SX-110	SLUDGE	2.6E+05	1.2E+03	1.3E+09	0.0E+00	2.4E+09	4.4E+07	1.6E+07	3.8E+09	89	
SX-113	SLUDGE	1.1E+05	2.2E+07	5.2E+08	0.0E+00	1.2E+09	5.1E+07	5.5E+07	1.8E+09	89	
TX-102	SALTCAKE	4.7E+05	1.6E+03	2.7E+07	2.9E+05	5.0E+07	1.2E+04	7.0E+05	7.8E+07	88	
U-111	SC/SUP	1.4E+06	5.6E-07	3.3E+08	5.8E+06	6.4E+08	1.2E+07	1.3E+07	1.0E+09	88	
S-108	SALTCAKE	2.5E+06	1.4E+07	1.5E+08	1.5E+07	4.1E+08	2.4E+07	2.8E+07	6.4E+08	88	
U-108	SC/SUP	2.0E+06	2.3E+06	2.3E+08	8.4E+04	4.2E+08	1.4E+07	2.7E+06	6.7E+08	87	
TX-106	SALTCAKE	1.9E+06	2.5E+06	1.2E+07	4.0E-04	3.9E+07	8.4E+06	1.7E+05	6.2E+07	86	1
U-101	SLUDGE	1.0E+05	3.8E+06	1.5E+08	0.0E+00	2.9E+08	1.5E+04	2.1E+07	4.6E+08	86	
SX-114	SLUDGE	7.5E+05	8.8E+06	9.5E+08	0.0E+00	1.8E+09	1.5E+08	1.5E+07	3.0E+09	85	
TX-101	SLUDGE	3.6E+05	1.3E+07	5.2E+08	6.8E-03	1.0E+09	7.9E+07	5.2E+06	1.6E+09	85	
U-105	SC/SUP	1.7E+06	1.2E+04	9.7E+04	4.9E+04	2.9E+05	2.0E+04	3.1E+03	4.7E+05	84	
SX-103	MIX	2.7E+06	6.2E+07	2.5E+09	1.6E+08	5.1E+09	9.2E+07	3.6E+08	8.3E+09	84	
Group 1 total		3.0E+07	4.8E+08	1.4E+10	5.9E+08	3.2E+10	6.2E+08	1.1E+09	4.9E+10		
% of SST total		20.0	19.9	27.9	12.2	33.4	6.8	5.5	26.7		
wt % in group			1.0	29.2	1.2	65.1	1.3	2.3			

Average = 89.3

Flag 1 - Potential for high soluble aluminum (4% Al and 14% OH)

SST CHEMICAL INVENTORY DATABASE FROM REFERENCE 1
(Sorted by weight percent NaNO3)

GROUP 2: 73-84% NaNO3 (23 tanks)

Tank	Type	VOL, L	Al	Na	NO2	NO3	OH	OTHER	TOTAL	Wt % NaNO3	Flag
SX-109	SLUDGE	1.0E+06	1.1E+07	7.6E+08	0.0E+00	1.5E+09	1.4E+08	2.0E+07	2.4E+09	84	
BY-109	MIX	1.8E+06	2.5E+07	7.4E+08	7.3E+07	1.5E+09	7.9E+07	4.9E+07	2.4E+09	83	
BY-102	SUPERNATE	1.4E+06	2.3E+07	8.8E+08	6.5E+07	1.7E+09	8.7E+07	5.6E+07	2.8E+09	83	
BX-106	SL/SUP	1.9E+05	1.4E+08	2.6E+09	3.7E+08	5.7E+09	1.4E+08	5.8E+08	9.5E+09	82	
A-104	SLUDGE	1.2E+05	1.3E-05	5.9E+08	0.0E+00	1.0E+09	2.3E+07	7.9E+07	1.7E+09	82	
TX-108	SALTCAKE	5.6E+05	1.1E+07	2.0E+08	3.5E+07	4.2E+08	1.6E+04	4.5E+07	7.1E+08	81	
AX-103	SC/SUP	4.7E+05	1.0E+06	7.0E+06	1.6E+06	2.2E+07	2.2E+04	5.3E+06	3.7E+07	81	
BY-103	SC/SUP	1.7E+06	3.8E+07	2.0E+09	1.2E+07	3.5E+09	2.2E+08	1.8E+08	5.9E+09	81	
SX-111	SLUDGE	5.2E+05	2.3E+07	6.6E+08	0.0E+00	1.3E+09	2.1E+08	7.7E+06	2.2E+09	80	
SX-102	MIX	2.3E+06	5.4E+07	1.5E+09	6.9E+04	2.7E+09	4.2E+08	9.3E+05	4.7E+09	79	
BX-105	SLUDGE	2.1E+05	2.0E+07	1.1E+09	1.1E+07	2.0E+09	8.3E+07	2.6E+08	3.4E+09	79	
BX-103	SLUDGE	2.8E+05	5.1E+06	1.5E+09	5.3E+07	2.4E+09	5.9E+07	1.5E+08	4.2E+09	79	
BX-104	SL/SUP	4.1E+05	5.1E+06	1.5E+09	5.3E+07	2.4E+09	5.9E+07	1.5E+08	4.2E+09	79	
TY-101	SLUDGE	4.9E+05	1.8E+05	1.2E+08	7.8E+05	2.2E+08	1.2E+07	3.1E+07	3.9E+08	78	
A-101	SC/SUP	4.0E+06	1.6E+06	4.4E+08	0.0E+00	8.5E+08	1.1E+08	8.3E+07	1.5E+09	78	
TX-118	SALTCAKE	1.4E+06	7.0E+07	4.3E+09	2.9E+08	7.4E+09	1.6E+06	1.0E+09	1.3E+10	77	
SX-104	MIX	2.6E+06	3.7E+07	7.2E+08	1.9E+07	1.4E+09	2.6E+08	5.0E+07	2.5E+09	77	
A-102	MIX	1.7E+05	1.0E+07	5.6E+08	1.5E+07	1.0E+09	2.6E+07	1.7E+08	1.8E+09	77	
SX-106	SC/SUP	2.2E+06	1.2E+07	3.1E+08	4.1E+07	6.3E+08	2.3E+07	1.0E+08	1.1E+09	77	
SX-105	SC/SUP	2.8E+06	1.2E+07	3.1E+08	4.1E+07	6.3E+08	2.3E+07	1.0E+08	1.1E+09	77	
S-111	MIX	2.5E+06	5.6E+07	9.8E+07	1.8E+07	4.8E+08	2.0E+08	3.6E+07	8.9E+08	74	1
S-104	SLUDGE	1.2E+06	3.5E+07	3.1E+08	8.5E+06	8.0E+08	2.4E+08	9.3E+07	1.5E+09	74	
BY-112	SALTCAKE	1.2E+06	3.1E+07	3.3E+08	4.3E+07	6.6E+08	1.5E+08	3.6E+07	1.2E+09	73	
Group 2 total		3.0E+07	6.2E+08	2.2E+10	1.1E+09	4.0E+10	2.6E+09	3.3E+09	6.9E+10		
% of SST total		19.6	25.6	41.8	23.9	41.7	28.2	16.2	37.6		
wt % in group			0.9	31.1	1.7	57.9	3.7	4.7			

Average = 79.4

Flag 1 - Potential for high soluble aluminum (6% Al and 22% OH)

SST CHEMICAL INVENTORY DATABASE FROM REFERENCE 1
(Sorted by weight percent $NaNO_3$)

GROUP 3: 58-73% $NaNO_3$ (29 tanks)

Tank	Type	VOL, L	Al	Na	NO2	NO3	OH	OTHER	TOTAL	Wt % NaNO3	Flag
C-101	SLUDGE	3.7E+05	9.9E+06	1.0E+08	5.0E+05	2.0E+08	6.1E+07	1.0E+06	3.8E+08	73	
TY-104	SL/SUP	1.9E+05	2.7E+05	4.2E+06	1.2E+06	8.7E+06	4.3E+05	1.8E+06	1.7E+07	72	
U-107	SC/SUP	1.7E+06	5.3E+06	1.1E+07	2.2E+07	7.1E+07	1.1E+05	2.6E+07	1.4E+08	72	
SX-107	SLUDGE	4.3E+05	1.5E+07	2.3E+07	6.0E+07	1.8E+08	3.1E+05	7.4E+07	3.6E+08	71	
T-101	SLUDGE	4.3E+05	2.1E+06	6.6E+07	5.5E+06	1.1E+08	1.0E+06	2.8E+07	2.1E+08	70	
C-104	SLUDGE	1.2E+06	4.5E+07	1.8E+09	2.7E-02	2.5E+09	3.6E+08	3.1E+08	5.0E+09	69	
C-103	SL/SUP	8.1E+05	4.5E+07	1.8E+09	2.7E-02	2.5E+09	3.6E+08	3.1E+08	5.0E+09	69	
B-202	SLUDGE	1.1E+05	2.0E+04	7.5E+06	0.0E+00	1.2E+07	1.7E+06	3.3E+06	2.5E+07	69	
BY-101	SALTCAKE	1.6E+06	4.1E+07	3.9E+08	2.3E+08	8.6E+08	2.5E+07	1.8E+08	1.7E+09	69	
S-110	MIX	1.6E+06	6.5E+07	1.1E+08	1.9E+07	5.1E+08	2.9E+08	3.8E+07	1.0E+09	68	1
S-101	MIX	1.8E+06	3.3E+07	3.1E+08	1.2E+07	6.1E+08	2.3E+08	3.2E+07	1.2E+09	68	
SX-101	MIX	1.9E+06	4.5E+07	4.3E+08	0.0E+00	8.4E+08	3.6E+08	1.8E+07	1.7E+09	68	
C-107	SLUDGE	1.1E+06	6.9E+06	7.1E+07	0.0E+00	1.4E+08	5.0E+07	1.0E+07	2.7E+08	68	
T-102	SL/SUP	1.3E+05	5.0E+04	1.1E+06	9.3E+04	1.8E+06	1.1E+05	5.0E+05	3.7E+06	67	
BY-111	SALTCAKE	1.9E+06	4.3E+07	2.6E+08	2.3E+08	6.8E+08	3.4E+07	1.4E+08	1.4E+09	67	
BX-111	MIX	9.6E+05	2.9E+07	2.2E+08	1.8E+08	5.2E+08	7.7E+05	1.3E+08	1.1E+09	67	
BX-110	SLUDGE	8.3E+05	3.2E+07	2.0E+08	1.7E+08	5.0E+08	2.8E+07	1.2E+08	1.1E+09	66	
BY-110	SC/SL	1.7E+06	3.4E+07	2.3E+08	2.1E+08	6.0E+08	5.4E+06	1.9E+08	1.3E+09	65	
B-111	SLUDGE	9.9E+05	2.2E+06	7.7E+08	4.2E+07	1.2E+09	1.6E+07	4.9E+08	2.5E+09	65	
BY-106	SC/SUP	2.7E+06	4.9E+07	2.8E+08	2.3E+08	7.1E+08	7.2E+07	1.8E+08	1.5E+09	64	
BY-108	SC/SL	9.5E+05	1.9E+07	1.8E+08	1.3E+08	3.9E+08	7.6E+06	1.1E+08	8.4E+08	63	
SX-112	SLUDGE	3.8E+05	2.6E+07	1.9E+08	0.0E+00	3.6E+08	2.1E+08	9.5E+06	8.0E+08	63	
BX-109	SLUDGE	8.0E+05	3.9E+06	3.9E+07	1.0E+07	6.6E+07	1.7E+07	1.3E+07	1.5E+08	61	
SX-108	SLUDGE	4.8E+05	3.1E+07	3.8E+08	0.0E+00	5.8E+08	3.1E+08	7.9E+06	1.3E+09	61	
U-110	SLUDGE	7.8E+05	1.9E+07	1.4E+08	1.4E+06	2.7E+08	1.6E+08	2.0E+07	6.0E+08	60	
BX-102	SLUDGE	4.0E+05	6.0E+07	5.7E+08	1.2E+08	1.0E+09	2.2E+08	3.8E+08	2.4E+09	59	
BY-104	SALTCAKE	1.7E+06	3.8E+07	3.1E+08	2.3E+08	6.8E+08	9.7E+06	3.2E+08	1.6E+09	59	
S-107	SLUDGE	1.5E+06	5.0E+07	2.9E+08	0.0E+00	5.4E+08	3.7E+08	3.6E+07	1.3E+09	58	2
T-202	SLUDGE	8.8E+04	0.0E+00	3.5E+06	0.0E+00	4.3E+06	8.8E+05	1.5E+06	1.0E+07	58	
Group 3 total		3.0E+07	7.5E+08	9.1E+09	1.9E+09	1.7E+10	3.2E+09	3.2E+09	3.5E+10		
% of SST total		19.6	30.6	17.7	39.6	17.3	35.0	15.6	18.9		
wt % in group			2.1	26.2	5.5	47.9	9.2	9.1			

Average = 65.7

Flag 1 - Potential for high soluble aluminum (6% Al and 28% OH)

Flag 2 - Potential for high soluble aluminum (4% Al and 28% OH)

SST CHEMICAL INVENTORY DATABASE FROM REFERENCE 1
(Sorted by weight percent NaNO3)

GROUP 4: 35-58% NaNO3 (27 tanks)

Tank	Type	VOL, L	Al	Na	NO2	NO3	OH	OTHER	TOTAL	Wt % NaNO3	Flag
TX-105	SALTCAKE	2.5E+06	1.8E+07	1.8E+08	1.2E+07	3.0E+08	7.6E+07	1.4E+08	7.2E+08	58	
BY-107	SALTCAKE	1.1E+06	2.0E+07	9.9E+07	8.4E+07	2.5E+08	4.1E-07	9.4E+07	5.8E+08	58	
B-203	SLUDGE	2.1E+05	0.0E+00	7.0E+06	0.0E+00	8.5E+06	1.8E-06	3.0E-06	2.0E+07	57	
B-107	SLUDGE	6.9E+05	2.7E+06	1.2E+08	2.0E+07	1.5E+08	1.1E+07	7.1E+07	3.7E+08	55	
T-203	SLUDGE	1.5E+05	0.0E+00	7.5E+06	0.0E-00	9.1E+06	2.2E+06	4.3E+06	2.3E+07	54	
BY-105	SC/SUP	2.1E+06	5.1E+07	2.3E+08	1.8E+08	5.4E+08	1.4E+08	2.3E+08	1.4E+09	54	1
TX-109	SALTCAKE	1.6E+06	9.8E+07	2.5E+08	4.0E+08	8.7E+08	3.4E+07	5.8E+08	2.2E+09	53	
TX-110	SALTCAKE	1.9E+06	4.2E+07	2.3E+08	1.7E+08	4.8E+08	3.4E-06	3.0E-08	1.2E+09	53	
T-104	SLUDGE	1.9E+06	3.6E+06	1.2E+08	1.6E+07	1.7E+08	2.3E-07	1.1E+08	4.4E+08	53	
TX-115	SALTCAKE	2.7E+06	4.9E+06	1.4E+08	1.1E+07	1.6E+08	2.3E-05	9.5E+07	4.1E+08	53	
C-106	SL/SUP	9.5E-05	1.0E+08	3.9E+08	9.0E+04	7.4E+08	6.4E-08	1.6E+08	2.0E+09	50	2
B-103	SLUDGE	2.5E+05	9.3E+05	1.5E+07	2.5E+06	2.2E+07	4.1E+06	1.6E+07	6.0E-07	49	
B-204	SLUDGE	2.1E+05	0.0E+00	6.9E+06	0.0E+00	8.4E+06	2.6E+06	5.6E+06	2.4E+07	49	
TY-105	SLUDGE	9.6E+05	1.5E+03	6.8E+07	3.9E+03	6.6E+07	3.7E-05	5.1E+07	1.8E+08	49	
B-108	SLUDGE	3.9E+05	2.4E+06	2.0E+08	1.5E+07	2.1E+08	1.1E+06	1.7E+08	6.1E+08	48	
TX-112	SALTCAKE	2.7E+06	7.2E+06	2.8E+08	3.2E+07	2.6E+08	5.3E+04	1.9E+08	7.7E+08	46	
A-105	SLUDGE	7.9E+04	6.8E+05	4.1E+06	1.2E+06	5.2E+06	4.4E+06	4.7E+05	1.6E+07	44	3
TX-116	SALTCAKE	2.6E+06	1.0E+06	7.1E+08	4.6E+06	5.8E+08	9.4E+04	5.7E+08	1.9E+09	42	
TY-102	SALTCAKE	2.7E-05	1.4E+05	9.2E+07	7.1E+06	6.9E+07	4.0E-05	5.6E-07	2.3E+08	42	
BX-112	SLUDGE	6.9E+05	3.4E+06	4.1E+07	6.9E+06	5.5E+07	1.8E+07	5.8E+07	1.8E+08	41	
B-112	SLUDGE	1.4E+05	3.9E+05	1.2E+08	1.1E+08	3.2E+08	4.0E+06	5.1E+08	1.1E+09	41	
C-105	SLUDGE	6.2E+05	5.2E+07	1.1E+08	5.4E-04	2.1E+08	3.2E+08	3.2E+07	7.3E+08	40	4
S-102	SC/SUP	2.3E+06	1.5E+07	3.0E+08	0.0E+00	2.9E+08	9.7E+07	3.1E+08	1.0E+09	39	
AX-104	SLUDGE	2.9E+04	4.2E+05	5.9E+06	4.4E+05	1.3E+07	1.4E+07	1.2E+07	4.6E+07	39	
TX-103	SLUDGE	6.5E+05	1.0E+05	5.7E+06	4.1E+05	4.1E+06	2.1E+04	4.5E+06	1.5E+07	38	
A-103	SLUDGE	1.5E+06	3.5E+06	1.1E+07	5.0E+05	2.3E+07	3.2E+07	1.9E+07	8.7E+07	35	5
BX-107	SLUDGE	1.4E+06	1.0E+06	8.7E+07	4.5E+06	6.2E+07	1.1E+07	7.6E+07	2.4E+08	35	
Group 4 total		3.1E+07	4.3E+08	3.8E+09	1.1E+09	5.8E+09	1.5E-09	3.9E+09	1.7E+10		
% of SST total		20.3	17.6	7.4	22.4	6.1	16.3	19.0	9.0		
wt % in group			2.6	23.2	6.5	35.4	9.0	23.4			

Average = 48.5

Flag 1 - Potential for high soluble aluminum (4% Al and 10% OH)
Flag 2 - Potential for high soluble aluminum (5% Al and 32% OH)
Flag 3 - Potential for high soluble aluminum (4% Al and 28% OH)
Flag 4 - Potential for high soluble aluminum (7% Al and 45% OH)
Flag 5 - Potential for high soluble aluminum (4% Al and 36% OH)

SST CHEMICAL INVENTORY DATABASE FROM REFERENCE 1
(Sorted by weight percent NaNO3)

GROUP 5: 0-34% NaNO3 (44 tanks)

Tank	Type	VOL, L	Al	Na	NO2	NO3	OH	OTHER	TOTAL	Wt % NaNO3	Flag
TX-111	SALTCAKE	1.5E+06	5.2E+06	1.9E+08	2.1E+07	1.2E+08	4.6E+05	1.5E+08	4.9E+08	34	
T-109	SLUDGE	2.4E+05	2.1E+05	2.4E+07	9.4E+05	1.3E+07	1.6E+05	1.7E+07	5.5E+07	32	
T-106	SLUDGE	8.8E+04	5.0E+05	1.5E+08	2.0E+06	9.2E+07	2.0E+06	1.5E+08	4.0E+08	32	
B-105	SALTCAKE	1.3E+06	4.9E+04	2.7E+08	2.1E+05	1.6E+08	1.8E+06	2.7E+08	7.0E+08	31	
TX-113	SALTCAKE	2.5E+06	4.5E+06	3.6E+08	2.0E+07	2.3E+08	1.5E+07	4.2E+08	1.0E+09	30	
B-102	MIX	1.3E+05	1.5E+05	8.7E+06	3.2E+05	8.6E+06	5.5E+06	1.7E+07	4.0E+07	29	
TX-117	SALTCAKE	2.6E+06	4.3E+05	6.7E+08	1.9E+06	3.4E+08	1.2E+05	6.0E+08	1.6E+09	29	
TX-114	SALTCAKE	2.2E+06	1.3E+06	2.0E+08	5.5E+06	8.8E+07	1.6E+06	1.5E+08	4.4E+08	27	
C-109	SLUDGE	2.8E+05	4.8E+05	9.5E+06	3.6E+06	1.9E+07	2.4E+05	6.7E+07	1.0E+08	26	
TY-103	SLUDGE	6.8E+05	8.9E+06	7.2E+07	1.9E+07	5.1E+07	6.8E+07	6.1E+07	2.8E+08	25	
C-111	SLUDGE	2.4E+05	4.4E+06	6.7E+06	2.8E+06	1.4E+07	2.6E+07	2.7E+07	8.1E+07	24	1
B-110	SLUDGE	1.0E+06	2.8E+06	1.2E+08	0.0E+00	2.1E+08	2.8E+07	1.2E+09	1.6E+09	19	
T-103	SL/SUP	1.1E+05	9.8E+06	4.2E+06	7.7E+05	1.0E+07	5.8E+07	1.0E+06	8.4E+07	17	2
C-112	SL/SUP	4.3E+05	4.5E+06	8.2E+06	2.4E+06	1.3E+07	2.6E+07	8.6E+07	1.4E+08	13	
C-108	SLUDGE	2.8E+05	2.3E+07	1.2E+07	2.5E+06	2.0E+07	1.5E+08	1.8E+07	2.2E+08	12	2
B-106	SLUDGE	4.9E+05	1.2E+05	1.6E+08	1.8E+05	3.1E+07	4.0E+05	1.9E+08	3.7E+08	11	
B-109	SLUDGE	5.3E+05	1.0E+06	1.9E+08	5.3E+06	2.0E+07	5.9E+05	2.2E+08	4.3E+08	6	
B-104	SLUDGE	1.5E+06	6.2E+05	7.6E+07	2.8E+06	3.4E+07	1.7E+07	6.9E+08	8.2E+08	6	
BX-108	SLUDGE	1.1E+05	3.2E+06	9.3E+05	4.3E+05	1.0E+06	2.0E+07	1.9E+06	2.8E+07	5	2
C-201	SLUDGE	8.3E+03	0.0E+00	9.8E+03	0.0E+00	6.0E+02	4.6E+02	7.0E+03	1.8E+04	5	
T-108	SLUDGE	1.8E+05	9.4E+03	9.0E+06	1.7E+04	7.4E+05	1.1E+06	1.2E+07	2.3E+07	4	
C-204	SLUDGE	1.3E+04	0.0E+00	8.4E+02	0.0E+00	2.6E+01	3.5E+02	3.0E+02	1.5E+03	2	
T-110	SLUDGE	1.6E+06	0.0E+00	1.8E+06	0.0E+00	1.3E+06	2.5E+07	1.1E+09	1.1E+09	0	
U-106	SC/SUP	9.4E+05	1.5E+03	2.0E+03	0.0E+00	1.4E+00	1.1E+04	9.3E+02	1.5E+04	0	2
TX-107	SALTCAKE	1.5E+05	0.0E+00	2.2E+03	0.0E+00	1.3E-01	1.8E+03	9.9E+00	4.1E+03	0	
TX-104	SALTCAKE	2.7E+05	8.2E+03	5.9E+02	5.4E-02	3.5E-01	5.1E+04	1.5E+03	6.1E+04	0	2
C-203	SLUDGE	2.1E+04	0.0E+00	2.4E+04	0.0E+00	1.6E-03	9.4E+02	1.6E+04	4.2E+04	0	
A-106	SLUDGE	5.2E+05	5.3E+06	9.3E+02	0.0E+00	1.4E+00	8.2E+07	4.0E+07	1.3E+08	0	1
C-110	SLUDGE	7.8E+05	7.2E+03	1.9E+03	5.9E-04	7.6E-03	1.0E+07	1.5E+07	2.6E+07	0	
C-102	SLUDGE	1.8E+06	6.4E+07	7.0E+07	6.8E-02	2.2E-01	5.2E+08	2.5E+08	9.0E+08	0	1
C-202	SLUDGE	4.2E+03	0.0E+00	2.6E+05	0.0E+00	7.8E-06	1.6E+03	1.7E+05	4.4E+05	0	
T-201	SLUDGE	1.2E+05	0.0E+00	2.9E+02	0.0E+00	0.0E+00	2.4E+02	0.0E+00	5.3E+02	0	
T-204	SLUDGE	1.6E+05	0.0E+00	3.8E+02	0.0E+00	0.0E+00	3.2E+02	0.0E+00	7.0E+02	0	
T-112	SLUDGE	2.8E+05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.6E+07	1.3E+09	1.4E+09	0	
T-111	SLUDGE	1.9E+06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.9E+07	1.4E+09	1.4E+09	0	
B-201	SLUDGE	1.2E+05	0.0E+00	2.5E+02	0.0E+00	0.0E+00	2.1E+02	0.0E+00	4.6E+02	0	
U-104	SLUDGE	5.1E+05	0.0E+00	5.5E+07	0.0E+00	0.0E+00	9.0E+02	1.3E+08	1.8E+08	0	
TY-106	SLUDGE	7.1E+04	2.7E+02	2.3E+07	0.0E+00	0.0E+00	8.0E+04	6.5E+07	9.2E+07	0	
T-107	SLUDGE	7.5E+05	7.6E+03	1.8E+05	0.0E+00	0.0E+00	1.1E+07	1.5E+07	2.6E+07	0	
B-101	SLUDGE	4.7E+05	1.1E+04	8.4E+06	0.0E+00	0.0E+00	5.0E+06	1.5E+07	2.8E+07	0	

Continued on next page

GROUP 5 continued

Tank	Type	VOL, L	Al	Na	NO2	NO3	OH	OTHER	TOTAL	Wt % NaNO3	Flag
AX-102	SALTCAKE	1.6E+05	2.2E+04	4.6E+02	0.0E+00	0.0E+00	3.4E+06	2.4E+06	5.8E+06	0	
T-105	SLUDGE	4.1E+05	1.5E+06	6.5E+00	0.0E+00	0.0E+00	1.8E+07	2.3E+08	2.5E+08	0	
AX-101	SC/SUP	3.1E+06	1.5E+06	6.6E+03	0.0E+00	0.0E+00	1.5E+07	4.5E+06	2.1E+07	0	1
BX-101	SLUDGE	1.8E+05	1.0E+07	3.6E+06	0.0E+00	0.0E+00	6.9E+07	1.3E+07	9.6E+07	0	2
Group 5 total		3.1E+07	1.5E+08	2.7E+09	9.2E+07	1.5E+09	1.3E+09	8.9E+09	1.5E+10		
% of SST total		20.4	6.3	5.2	1.9	1.5	13.8	43.7	7.9		
wt % in group			1.1	18.5	0.6	10.1	8.6	61.0			

Average = 13.9

Flag 1 - Potential for high soluble aluminum (4-7% Al and 32-64% OH)
Flag 2 - Potential for high soluble aluminum (10-13% Al and 67-83% OH)

OVERALL SUM OF CHEMICAL INVENTORY IN SST'S

	VOL, L	Al	Na	NO2	NO3	OH	OTHER	TOTAL
Total Inventory	1.5E+08	2.4E+09	5.2E+10	4.8E+09	9.6E+10	9.1E+09	2.0E+10	1.8E+11
Weight %		1.3	27.9	2.6	52.2	4.9	11.0	100.0

WEIGHT PERCENT BREAKDOWN OF SST INVENTORY BY GROUPS

(VOL, L in volume %)

Wt% NaNO3	VOL, L	Al	Na	NO2	NO3	OH	OTHER	TOTAL
Group 1: 84-99%	20.0	19.9	27.9	12.2	33.4	6.8	5.5	26.7
Group 2: 73-84%	19.6	25.6	41.8	23.9	41.7	28.2	16.2	37.6
Group 3: 58-73%	19.6	30.6	17.7	39.6	17.3	35.0	15.6	18.9
Group 4: 35-58%	20.3	17.6	7.4	22.4	6.1	16.3	19.0	9.0
Group 5: 0-34%	20.4	6.3	5.2	1.9	1.5	13.3	43.7	7.9
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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APPENDIX B

Statement of Work

University of Arizona Contract

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STATEMENT OF WORK PO #352167

STATEMENT OF WORK SUMMARY

Westinghouse Hanford Company (WHC) is investigating removing sodium nitrate and other non-radioactive salts from Hanford tank waste. This effort is currently being funded by the Department of Energy's (DOE) Office of Technology Development under the Efficient Separations Processing Integrated Program (ESPIP). An individual or organization with crystallization expertise is required to perform several engineering studies. These studies are needed to support a DOE-HQ decision at the end of FY 1994 of whether to pursue pilot-scale development of this process. Copies of all existing work to date on sodium nitrate recovery will be provided to the researchers.

INTRODUCTION

The Clean Salt process being developed by WHC involves crystallizing essentially pure sodium nitrate from a complex low-level aqueous waste matrix. Successful development of the Clean Salt process could significantly decrease the volume of radioactive waste, saving millions of dollars in disposal costs.

Crystallization is an art as well as a science and the crystallization process can be affected by any number of seemingly insignificant factors. The successful design of a salt recovery process needs to be developed and tested under carefully controlled conditions that are scaleable to pilot and full scale systems. To accomplish this, the studies conducted by the expert researchers need to demonstrate mixed slurry, mixed product reactor (MSMPR) crystallization, and efficient fines recovery.

OBJECTIVE/PURPOSE

The objective/purpose of this research effort will be to provide WHC with data from which the viability of scaling the process can be evaluated. Key studies to be performed are Mixed Slurry Mixed Product Reactor (MSMPR) crystallization studies, fines recovery, and different crystallization techniques.

The researchers will provide information and reports to support the outlined tasks. All tests will be non-radioactive. Non-radioactive stand-ins will be substituted for radioactive species whenever possible.

TASK OUTLINE

Task 1: Growth Rate Studies for Single Component and Simple Mixture Systems.

The researchers shall perform simple growth rate studies for single component sodium nitrate and aluminum nitrate. The researchers will perform at least four bi-component studies for sodium nitrate and aluminum nitrate at various relative concentrations. Aluminum concentrations will be varied between 0.5 and 17 weight percent on a cation basis and the sodium concentrations will be varied between 83 and 95.5 weight percent on a total cation basis. These studies will establish the MSMPR crystallization growth rates and nucleation rates for these components. Westinghouse Hanford will provide the researchers with the necessary chemical reagents.

Task 2: Crystallization Studies for Complex Mixture Systems.

The researchers will perform crystallization studies for complex aqueous solutions that represent Hanford tank waste. Minor chemical constituents can adversely affect the crystallization process. These studies will provide information on solubility interactions and on the process dynamics for MSMPR crystallization. Westinghouse Hanford will either provide the experimenter with the complex aqueous solutions, or with the recipes and necessary chemical reagents. The researchers will need to allow for trace component analyses to support their conclusion.

Task 3: Fines Recovery and Crystallization Technique

The researcher will investigate different fines recovery and crystallization techniques. The efficient recovery of sodium nitrate and other non-radioactive salts depends on the ability to grow sufficiently large particles. Researchers will study the various techniques and make a recommendation to WHC as to which techniques would be apply to the Clean Salt process. Westinghouse Hanford will provide the researchers with the necessary chemical reagents.

DELIVERABLES

Interim Reports/Technical Briefs

Interim reports are required to document completion of each task. The interim reports will detail findings for each particular task. A technical brief for fiscal year 1994 activities is required. Letters from the experimenters will suffice for the interim reports and technical brief.

Final Report

A final report is due upon completion of all of the tasks. The report will contain a detailed summary of the interim reports.

All reports prepared by the researchers shall be reviewed and approved by WHC prior to acceptance.

REQUIRED SCHEDULE

The completion date for this project is one year from the date the contract is awarded. The schedule for interim reports for each task is flexible. The technical brief needs to be submitted by September 15, 1994 for inclusion in a WHC report due September 30, 1994.