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An Analysis of the New Technical Strategy Flowsheet Applied to the Watch List Tanks

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Abstract

The New Technical Strategy Flowsheet is currently chosen for cleanup of the tanks on the Hanford Reservation. In this study, it is applied to a set of nine single shell tanks on the site. These tanks are considered to have a high potential for uncontrolled releases and have been placed on a *watch list*. Accordingly, it appears that any waste remediation strategy such as the New Technical Strategy Flowsheet might first be applied to these tanks.

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An Analysis of the New Technical Strategy Flowsheet Applied to the Watch List Tanks

Clay P. Booker
LANL TSA-3

I. INTRODUCTION

In a previous report¹, the New Technical Strategy Flowsheet² was analyzed given the contents of Tank SY-101. In terms of contents, this tank is perhaps the best characterized of the tanks on the site. However, the tanks on the Watch List (see section IV.) may be the most likely to be treated first because of their potential to release high level waste. Accordingly, the discrete event model used to analyze the treatment of tank SY-101 is used here to analyze the treatment of the contents of those tanks.

In considering the treatment of the contents of the Watch List Tanks, the New Technical Flowsheet is examined with respect to:

- The total required size of the system
- The amount of material, such as reagents and other added materials that must be supplied
- The final mass of waste that must be stored

II. ProMoS DISCRETE EVENT SIMULATION CODE

In analyzing the tanks for this study, the ProMoS³ code was used. This is a discrete-event simulation tool developed by the Technology Modeling and Assessment group (TSA-7) at Los Alamos National Laboratory. It has been used to examine DOE facilities and has been used by several organizations in designing Complex-21.

The code has several features that are amenable to the analysis of production scale chemical processing systems. Some of these are relevant to this work are:

1. A scenario may be constructed so that the number of days worked per week and the number of shifts can be individually assigned to any single process. Accordingly, a particular process may be constrained to run on a 7 day/week, 3 shift/day work schedule while other process run under different work schedules. More importantly for the present analysis, the work schedule for the entire system may be altered by simply redefining the work-shift structure; this makes variations in a work schedule in a system simple to incorporate globally.
2. Each process in a system may be individually modeled by a combination of a Location and associated Workcenters.
 - A. A Location is analogous to the physical location for a process. The user may associate bulk-containers at a Location where material is to be received. In the simplest incarnation, a Location may just have a bulk-container which receives material but does not process it; such basic Locations are used as storage places to accumulate material.
 - B. Workcenters may be associated with any Location. A Workcenter is analogous to the actual process being modeled at the Location. A Workcenter is specified with:
 - the batch size
 - the batch processing time which *may* be proportional to the available feed

- the work schedule under which to run
- the materials to be added to the batch in proportion to the total batch size or in proportion to particular materials in the feed
- the individual destination of each material in the batch
- the time remaining in the shift which will allow the process to run

Rather than just increasing the batch size to accommodate a larger or smaller through-put, the number of parallel, identical Workcenters associated with a Location may be increased or decreased.

Of course, the ProMoS code has several other features, but those delineated above are most relevant to this discussion. We have examined other commercially available codes, but none have the necessary features for this analysis which ProMoS possesses.

Beyond these attributes, the ProMoS code is installed and up and running on machines to which Los Alamos users have access. Various utilities to ease the burden of creating input files and extracting desired output data are available. Notably, a Macintosh Hypercard database manager allows the user to create a self-consistent input description that is internally checked; thus input errors are virtually eliminated, and the users is confident of having an input file that conforms to what is desired.

The baseline is predicated on the current New Technical Strategy flowsheet⁴ which is depicted in Figure III.1..

At present only the liquid section has been designed; the sludge treatment section to be defined later. Farish⁵ has summarized the current proposals for the baseline processes. It is envisioned that the sludge washing and solid/liquid separation are performed within the tank. For **Cs Removal** ion exchange with CS-100 resin is being considered along with the alternatives, Resorcinol-Formaldehyde resin and Crystalline Silica-Titanates. Calcination is being considered for **Organic Destruction** with Hydrothermal processes as an option. A precipitation process is being considered for **Sr Removal**, and an ion exchange process is the primary alternative. **Tc Removal** is to be accomplished with anion exchange using Rellex-HPQ resin. The resulting Low-Level Waste (LLW) is reduced in volume with the **LLW Evaporator**; a concentrator is also considered for inclusion in this step. Finally the LLW is vitrified with the **LLW Vitrification** process. Note that Cs, Sr, and Tc are returned to the tank for later processing as High-Level Waste (HLW). Of course, the type and number of process steps are to be determined on a tank or farm basis.

A. Input Model Description

The liquid section section is treated in detail by the ProMoS code; the block diagram for the code model is shown below in Figure III.A.1.:

Figure III.A.1. Block Diagram of Baseline Overview

The process descriptions for each of the boxes in Figure III.A.1 are drawn from previous work in analyzing the various designs for Complex-21 and from study of the Clean option (See Reference 1.). These process descriptions are given below:

Tank: This process in the ProMoS model is only a bulk container where the specific materials are held and then passed quickly to the next process. At the next process it waits until it can be processed by that process at the specified rate. For each tank this component in the model is changed to reflect the contents of the tank under consideration.

Solid/Liquid Separation: This process is not used in all models since it is not required for simply drawing off the supernate or with the salt-cake solution. It is operated with a batch size of 880 kg with 1 hour per batch. Here the materials of interest are split between the supernate and the sludge sections; specific splits, as appropriate, are mentioned below.

Cs Removal: This process is based on the Resorcinol-Formaldehyde Ion Exchange Resin developed for the Clean Option study because data for the competitors is still not available; this is the same process as in the previous study for Tank SY-101. **Cs Removal** has a 900 kg batch size with 8 hours per batch. Water, 2M NaOH, and 1M Formic Acid are added in this step in proportion to the mass of the bulk input with the ratios: 0.002:1, 0.0016:1, and 0.005:1 by mass respectively. It generates 1 resin as waste for 180,000 of throughput; the waste resin which is assumed to be 100 kg is directed to the process **Resin Oxidation** (not shown). 0.01% of the Cs, Sr, and Tc in the stream are also directed to **Resin Oxidation**; this assumes that traces of these are trapped in the resin. The rest of the Cs and the Formic Acid are directed to **Tank Storage**. The remainder passes on to **Organic Destruction**.

Organic Destruction: This is a calcination step, and no material is added here. It is operated with a 750 kg batch size and 4 hours per batch based on previous experience with Complex-21 analysis.

Sr Removal: The chelating cation exchange process created for the Clean Option study is used here again because data is available for it; this is the same as in the study for tank SY-101. It is operated with a 900 kg batch size and 8 hours for each batch. Water, 2M NaOH, and 1M Nitric Acid are added in proportion to the mass of the bulk input; these proportions are 0.002:1, 0.0016:1, and 0.005:1 by

mass respectively. As with **Cs Removal** it generates waste resin with 0.01% of the Sr and Tc which is then fed to **Resin Oxidation**. The remainder of the Sr goes with the Nitric Acid 1M to the **Sr Evaporator**. The balance of the batch is directed to **Tc Removal**.

Tc Removal: The Strong Base Anion Exchange process created for the Clean Option is used for the Tc Removal process in absence of data on the Reillex-HPQ resin anion exchange; again, this is the same process as in the study for tank SY-101. It has a 900 kg batch size with 8 hours per batch. NaOH 2M, Nitric Acid 0.25M, and Nitric Acid 6M are added here in proportion to the mass of the feed with the ratios: 0.00159:1, 0.0074:1, and 0.23858:1 respectively. As with **Cs Removal** and **Sr Removal** waste resin with 0.01% of the Tc is generated and directed to **Resin Oxidation**. The rest of the Tc follows the Nitric Acid 6M to **Acid Distillation** while the remainder of the batch goes to **LLW Evaporation**.

LLW Evaporation: This process has a 340 kg batch size with 1 hour per batch based on data supplied by D. Chamberlain⁶. No material is added in this step. Evaporation with 60% to 70% of the feed to **LLW Vitrification** being water is the basic model for this process. The balance of the water is directed to a Location called **Off-gas Treatment**.

LLW Vitrification: This process is operated with a batch size of 566.89 kg for 4 hours based on previous Complex-21 work. All water in the feed is assumed to be driven off and is directed to the Location, **Off-gas Treatment**. Glass formers are added to the batch at 4 kgs of Glass Formers per kg of solid feed.

Sr Evaporator: Here the 1M Nitric Acid bearing the Sr is reduced in volume. The resulting concentrated acid which is around 6.5M with the Sr is fed to the Location, **Tank Storage**. The remaining dilute acid is directed to the Location, **Acid Recovery**. No material is added in this process. The batch size is 75 kg processed in 4 hours.

Acid Distillation: The 6M Nitric Acid bearing the Tc is reduced in volume here. Half of the acid with the Tc is fed to the Location, **Tank Storage**, while the rest

of the acid is fed to **Acid Recovery**. The 750 kg batch is processed in 4 hours.

Resin Oxidation: This process is omitted from Figure III.A.1. It simply collects all the waste resin and converts it to an equal mass of ash that is then given to the *as yet* undefined sludge treatment section. It has a batch size of 100 kg, about 1 resin, and processes that in 1 hour.

Glass Storage: This is just a Location where the glass from **LLW Vittrification** is collected.

Acid Recovery: This is a Location where clean acid from **Sr Evaporator** and **Acid Distillation** are collected.

Off-gas Treatment: This is a Location where clean water from **LLW Evaporation** and **LLW Vittrification** is collected.

Tank Storage: In Figure III.1., Cs, Sr, Tc are routed back to the tank for later HLW processing. In the code model, the "Tank" actively feeds the liquid stream. Accordingly, reality is approximated by the Location, **Tank Storage**, where the extracted HLW can reside.

The *primary path*, the path of the bulk of the feed, is shown in Figure III.A.2.

B. Modeling Considerations

There are some concessions made for the ProMoS code used in this study. They were evaluated early on and appraised as being of little consequence.

- One difficulty with ProMoS is that at the end of the run, it is typically not practical to force the majority of the Bulk Containers to empty their contents *which is less than a specified batch size* into the appropriate Workcenter. As a result, there is some hold-up in most of the process at the end of the simulation. This does not seriously impact the system design or behavior.

Figure III.A.2. Primary Path.

- While it is capable of handling Workcenters with smaller batch sizes than those noted in section III.A. above, cutting them by a factor of 10 *and increasing the number of parallel units by 10* dramatically increases the code run time and memory usage. Accordingly, the batch sizes are, for the most part, a factor of 10 higher than desired to yield an acceptable use of computer resources. For example, a more realistic batch size for Cs Removal is 90 kg while on the other hand, a batch size of 75 kg for Sr Evaporation is reasonable. This compromise with respect to batch size does not significantly effect the analysis; multiplying the batch size by 10 is tantamount to having 10 times the number of properly sized units. The only adverse consequence is that it increases the hold-up in the process at the end of the simulation.

In the previous paper (Reference 1), the consequence of continuous operation versus operation at 5 days per week and 1 shift per day was examined. There it was clear that the number of units can be reduced by 4 to achieve the same throughput in the same period of time. Because this result does not depend on the tank contents, that variation is not considered here; the system is operated at 5 days per week and 1 shift per day for one year.

Only particular *interesting* materials are tracked through the model. Sr, Tc, and Cs are interesting because they are specifically removed from the waste stream for disposal later. Al, Na, and K can adversely affect ion exchange processes if their concentration is too high; accordingly, these are specifically tracked. All other materials are lumped into general categories. Special handling for certain tank contents are:

- When a tank contains supernate, it is assumed that the supernate is simply drawn off; the supernate is not blended with any sludge or salt-cake. Only a bit of Cs is the interesting constituent of the supernate. As in the previous study, it is assumed that 17.59% of the Cs resides in any supernate.
- If supernate *and* salt-cake are present in a tank, then it is assumed that the supernate is saturated. When the supernate is drawn off, all of the salt cake remains in the tank for treatment later.
- All supernate is assumed to contain 20% solids when evaporated. The results are not sensitive to this assumption since as shown in the next section, the Watch List

tanks contain little supernate compared to sludge and salt-cake.

- The sludge and salt-cake residue is washed with 4 times its mass of water, and the enriched water is drawn off and run through the system.
- It is assumed that the bulk of the sludge is not dissolved in the water; the sludge wash contains 100% of the Tc, 90% of the Cs, 70% of the Al, 99% of the Na, and 99% of the K originally resident in the sludge. The undissolved sludge is deposited in the, as yet undefined, Sludge Treatment section.
- Salt-cake is completely dissolved in the 4 to 1 wash with water and thus goes completely through the liquid treatment section. Accordingly, no solid/liquid separation process is used when no sludge is present.
- When salt-cake and sludge are present, the *interesting* materials are split in proportion to the mass of salt-cake and sludge present between them. This serves to provide the amount of lumped mass that remains in the salt-cake and sludge. In the solid/liquid separation step, the *interesting* materials are divided between the liquid and sludge treatment sections as described above.

IV. THE WATCH LIST TANKS

The Watch List Tanks consist of at least nine single-shell tanks that because of possible uncontrolled increases of temperature or pressure have a potential for the release of high level waste⁷. They contain organics which are potentially flammable or which can deflagrate. The interesting contents of those tanks on the list as of 1993 are itemized in Table IV.1..

Table IV.1. Watch List Tanks Contents⁸.

Tank	Material and Amount (kg)						
	Cs	Sr	Al	Na	Supernate	Sludge Solids	Salt-Cake
B-103	0.1144	0.0669	5,443.1	73,482.0	0.0	299,824.4	0.0
C-103	0.0	2.7785	38,555.4	231,785.7	804,219.3	127,910.3	0.0
S-102	0.0	0.3719	13,607.8	732,098.1	0.0	19,226.8	2,143,954.9
SX-106	2.6810	1.1367	27,669.1	706,243.3	368,770.6	54,803.2	1,748,223.1
TX-105	0.2343	0.0224	14,968.5	812,383.9	0.0	0.0	2,394,060.3
TX-118	0.0118	0.0054	8,618.3	463,117.8	0.0	0.0	1,363,952.2
U-106	0.0	0.0	10,432.6	296,649.4	90,718.5	122,167.1	716,071.3
U-107	0.9645	0.5375	17,690.1	534,785.4	187,333.6	69,602.6	1,378,262.9
U-111	0.2561	0.2807	9,525.4	436,809.5	0.0	124,827.8	1,198,754.2

Note that there is no indication that Tc resides in these tanks. Nevertheless, the **Tc-Removal** step remains in the model for the analysis below. If it were certain that no Tc is present, then it is conceivable that this step could be bypassed in the system and thus avoid the addition of considerable added material such as Nitric Acid and NaOH. Further, the waste resin generated in this process could be avoided. Tanks C-103, S-102, and U-106 appear to contain no Cs; thus for these tanks it may be possible to bypass the **Cs-Removal** stage avoiding the added material and waste resin for this process.

Only four tanks, C-103, SX-106, U-106, and U-107 contain supernate. Tanks TX-105 and TX-118 contain just salt-cake. Tank TX-105 contains the most material by mass, over 3,200 tonnes.

Characterization of the origin of the wastes noted in the text below is taken from reference 7.

A. Tank B-103

Tank B-103 contains waste from the first and second cycle from B plant along with in-tank solidification evaporator bottoms. It is known to be leaking and contains only sludge; the calculated composition of the sludge wash is given in Table IV.B.1.:

Table IV.A.1. Tank B-103 Sludge Wash Composition.

Material	Amount (kg)
Al	3,810.2
Cs	0.1030
Na	72,747.2
Sr	0.0669
Water <i>added</i>	1,515,000.0

The results from a ProMoS run are shown below in table IV.B.2.:

Table IV.A.2. Tank B-103 Process Descriptions — Sludge Wash.

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	2		
Cs Removal	900	8	Water	3,517
			Formic Acid 1M	7,988
			NaOH 2M	2,578
LLW Evaporation	340	15		
LLW Vitrify	566.89	1	Glass-Formers	306,121
Organic Destruction	750	8		
Resin Oxidation	100	1		
Sr Evaporator	75	1		
Sr Removal	900	8	Water	3,481
			Nitric Acid 1M	8,047
			NaOH 2M	2,539
Tc Removal	900	8	Water	2,357
			NaOH 2M	2,547
			Nitric Acid 0.25M	1,185
			Nitric Acid 6M	382,203

B. Tank C-103

Tank C-103 contains both supernate and sludge. Its contents come from the PUREX process and from insoluble strontium sluicing solids from the operation of 244-CR Vault and it is assumed to be sound. The assumed composition of the supernate is given in Table IV.B.1.:

Table IV.B.1. Tank C-103 Supernate Composition.

Material	Amount (kg)
Cs	0.0
Supernate <i>remainder</i>	804,219.3

The consequence of feeding the supernate through the ProMoS model yields the results shown in Table IV.B.2.:

Table IV.B.2. Tank C-103 Process Descriptions — Supernate Treatment.

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	1		
Cs Removal	900	2	Water	1,776
			Formic Acid 1M	4,035
			NaOH 2M	1,302
LLW Evaporation	340	5		
LLW Vitrify	566.89	1	Glass-Formers	641,719
Organic Destruction	750	3		
Resin Oxidation	100	1		
Sr Evaporator	75	1		
Sr Removal	900	3	Water	1,756
			Nitric Acid 1M	4,060
			NaOH 2M	1,281
Tc Removal	900	3	Water	1,188
			NaOH 2M	1,285
			Nitric Acid 0.25M	598
			Nitric Acid 6M	192,820

The composition of the sludge is shown in Table IV.B.3:

Table IV.B.3. Tank C-103 Sludge Wash Composition.

Material	Amount (kg)
Al	26,988.7
Cs	0.0
Na	229,467.8
Sr	2.7785
Water <i>added</i>	1,593,020.0

Running the sludge wash through the ProMoS model yields the data in Table IV.B.4.:

Table IV.B.4. Tank C-103 Process Descriptions — Sludge Wash.

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	2		
Cs Removal	900	9	Water	4,085
			Formic Acid 1M	9,280
			NaOH 2M	2,995
LLW Evaporation	340	16		
LLW Vitrify	566.89	2	Glass-Formers	1,024,940
Organic Destruction	750	9		
Resin Oxidation	100	1		
Sr Evaporator	75	1		
Sr Removal	900	9	Water	4,046
			Nitric Acid 1M	9353
			NaOH 2M	2,951
Tc Removal	900	9	Water	2,738
			NaOH 2M	2,962
			Nitric Acid 0.25M	1,379
			Nitric Acid 6M	444,476

Note that Cs is assumed not to reside in this tank so that it is conceivable that *both* the Cs-

Removal and Tc-Removal step could be bypassed saving considerable added material.

C. Tank S-102

Tank S-102 contains waste from the REDOX process. The contents consists only of sludge and salt cake. This tank does not appear to leak. The sludge wash composition is summarized in Table IV.C.1. while Table IV.C.2. summarizes the sludge wash treatment:

Table IV.C.1. Tank S-102 Sludge Wash Composition.

Material	Amount (kg)
Al	9,525.4
Cs	0.0
Na	724,777.1
Sr	0.3719
Salt Cake Solids	2,143,954.9
Water <i>added</i>	1,163,560.0

Table IV.C.2. Tank S-102 Process Descriptions — Sludge Wash.
Material Added

Process	Size (kg)	Units	Name	Amount (kg)
Acid Distillation	750	19		
Cs Removal	900	83	Water	32,075
			Formic Acid 1M	72,857
			NaOH 2M	23,512
LLW Evaporation	340	110		
LLW Vitrify	566.89	4	Glass-Formers	11,530,500
Organic Destruction	750	52		
Resin Oxidation	100	2		
Sr Evaporator	75	5		
Sr Removal	900	83	Water	31,785
			Nitric Acid 1M	73,483
			NaOH 2M	23,182
Tc Removal	900	83	Water	21,529
			NaOH 2M	23,288
			Nitric Acid 0.25M	10,839
			Ntric Acid 6M	3,494,386

Note that no Cs resides in this tank so that it may be possible to bypass **Cs-Removal**.

D. Tank SX-106

The contents of Tank SX-106 consists of supernate and salt cake. The tank is assumed to be sound and its contents derive from REDOX and Evaporator bottoms. The assumed supernate composition is shown in Table IV.D.1.:

Table IV.D.1. Tank SX-106 Supernate Composition.

Material	Amount (kg)
Cs	0.4715
Supernate remainder	368,770.1

The data from the ProMoS analysis is shown in Table IV.D.2.:

Table IV.D.2. Tank SX-106 Process Descriptions — Supernate Treatment.

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	1		
Cs Removal	900	1	Water	814
			Formic Acid 1M	1,848
			NaOH 2M	596
LLW Evaporation	340	2		
LLW Vitrify	566.89	1	Glass-Formers	292,515
Organic Destruction	750	1		
Resin Oxidation	100	1		
Sr Evaporator	75	1		
Sr Removal	900	1	Water	418
			Nitric Acid 1M	1,855
			NaOH 2M	585
Tc Removal	900	1	Water	542
			NaOH 2M	587
			Nitric Acid 0.25M	273
			Nitric Acid 6M	88,036

The assumed salt cake solution composition is shown in Table IV.D.3:

Table IV.D.3. Tank SX-106 Salt Cake Solution Composition.

Material	Amount (kg)
Al	19,368.4
Cs	1.9886
Na	699,180.9
Sr	1.1367
Salt Cake Solids	1,748,223.1
Water <i>added</i>	10,147,800.0

The ProMoS analysis results are shown in Table IV.D.4.:

Table IV.D.4. Tank SX-106 Process Descriptions — Salt Cake Solution.

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	17		
Cs Removal	900	68	Water	27,878
			Formic Acid 1M	63,324
			NaOH 2M	20,435
LLW Evaporation	340	91		
LLW Vitrify	566.89	4	Glass-Formers	9,882,030
Organic Destruction	750	43		
Resin Oxidation	100	2		
Sr Evaporator	75	4		
Sr Removal	900	68	Water	27,625
			Nitric Acid 1M	63,867
			NaOH 2M	20,148
Tc Removal	900	68	Water	18,709
			NaOH 2M	20,240
			Nitric Acid 0.25M	9420
			Nitric Acid 6M	3,037,028

E. Tank TX-105

Tank TX-105 contents derive from TBP process waste and 242-T Evaporator bottoms. It leaks, and it contains only salt cake; the assumed salt cake solution composition is shown in Table IV.E.1.:

Table IV.E.1. Tank TX-105 Salt Cake Solution Composition.

Material	Amount (kg)
Al	14,968.5
Cs	0.2343
Na	812,383.9
Sr	0.0224
Salt Cake Solids	2,394,060.3
Water <i>added</i>	12,885,700.0

The system data from the ProMoS model are shown in Table IV.E.1.:

Table IV.E.2. Tank TX-105 Process Descriptions — Salt Cake Solution.

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	22		
Cs Removal	900	93	Water	35,595
			Formic Acid 1M	80,854
			NaOH 2M	26,092
LLW Evaporation	340	123		
LLW Vitrify	566.89	5	Glass-Formers	12,907,000
Organic Destruction	750	58		
Resin Oxidation	100	2		
Sr Evaporator	75	5		
Sr Removal	900	93	Water	35,275
			Nitric Acid 1M	81,553
			NaOH 2M	25,728
Tc Removal	900	93	Water	23,901
			NaOH 2M	25,845
			Nitric Acid 0.25M	12,029
			Nitric Acid 6M	3,878,080

This tanks contains the most material by mass of all the Watch List Tanks.

F. Tank TX-118

Tank TX-118 like TX-105 contains only salt cake and derives from the same source. It is assumed to be sound; the assumed salt cake solution composition is shown in Table IV.F.1.:

Table IV.F.1. Tank TX-118 Salt Cake Solution Composition.

Material	Amount (kg)
Al	6,032.8
Cs	0.0106
Na	458,486.6
Sr	0.0054
Salt Cake Solids	1,363,952.2
Water <i>added</i>	7,342,750.0

The results of the ProMoS run with the salt cake solution is shown in Table IV.F.2.:

Table IV.F.2. Tank TX-118 Process Descriptions — Salt Cake Solution

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	13		
Cs Removal	900	53	Water	20,284
			Formic Acid 1M	46,075
			NaOH 2M	14,869
LLW Evaporation	340	70		
LLW Vitrify	566.89	3	Glass-Formers	7,353,700
Organic Destruction	750	33		
Resin Oxidation	100	1		
Sr Evaporator	75	3		
Sr Removal	900	53	Water	20,101
			Nitric Acid 1M	44,471
			NaOH 2M	14,661
Tc Removal	900	53	Water	13,620
			NaOH 2M	14,728
			Nitric Acid 0.25M	6,954
			Nitric Acid 6M	2,209,918

G. Tank U-106

The contents of Tank U-106 is supernate, sludge, and salt-cake. The origin of the contents is the same as that of Tank TX-105. The assumed supernate composition is given in Table IV.G.1:

Table IV.G.1. Tank U-106 Supernate Composition.

Material	Amount (kg)
Cs	0.0
<i>Supernate remainder</i>	90,718.5

The results of the ProMoS run are shown in Table IV.G.2.:

Table IV.G.2. Tank U-106 Process Descriptions — Supernate Treatment.

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	1		
Cs Removal	900	1	Water	199
			Formic Acid 1M	452
			NaOH 2M	146
LLW Evaporation	340	1		
LLW Vitrify	566.89	1	Glass-Formers	70,294
Organic Destruction	750	1		
Resin Oxidation	100	1		
Sr Evaporator	75	1		
Sr Removal	900	1	Water	194
			Nitric Acid 1M	449
			NaOH 2M	142
Tc Removal	900	1	Water	160
			NaOH 2M	142
			Nitric Acid 0.25M	66
			Nitric Acid 6M	21,217

The assumed sludge wash composition is shown in Table IV.G.3.:

Table IV.G.3. Tank U-106 Sludge Wash Composition.

Material	Amount (kg)
Al	7,302.8
Cs	0.0
Na	293,682.9
Sr	0.3686
Salt Cake Solids	716,071.3
Water <i>added</i>	4,581,280.0

The ProMoS results are shown in Table IV.G.4.:

Table IV.G.4. Tank U-106 Process Descriptions — Sludge Wash.

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	9		
Cs Removal	900	33	Water	12,372
			Formic Acid 1M	28,102
			NaOH 2M	9,069
LLW Evaporation	340	43		
LLW Vitrify	566.89	3	Glass-Formers	4,074,810
Organic Destruction	750	21		
Resin Oxidation	100	1		
Sr Evaporator	75	2		
Sr Removal	900	33	Water	12,259
			Nitric Acid 1M	28,341
			NaOH 2M	8,941
Tc Removal	900	33	Water	2,302
			NaOH 2M	8,981
			Nitric Acid 0.25M	4,180
			Nitric Acid 6M	1,347,597

Here Cs is assumed not to reside in this tank so that the treatment scheme could be simplified.

H. Tank U-107

Tank U-107 contains supernate, sludge, and salt-cake. Its origin is the same as that for Tank TX-105 and it is assumed not to be leaking. The assumed supernate composition is shown in Table IV.H.1.:

Table IV.H.1. Tank U-107 Supernate Composition.

Material	Amount (kg)
Cs	0.1696
Supernate remainder	187,333,5

The ProMoS results are shown in Table IV.H.2.:

Table IV.H.2. Tank U-107 Process Descriptions — Supernate Treatment.

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	1		
Cs Removal	900	1	Water	414
			Formic Acid 1M	940
			NaOH 2M	303
LLW Evaporation	340	2		
LLW Vitrify	566.89	1	Glass-Formers	147,391
Organic Destruction	750	1		
Resin Oxidation	100	1		
Sr Evaporator	75	1		
Sr Removal	900	1	Water	408
			Nitric Acid 1M	943
			NaOH 2M	298
Tc Removal	900	1	Water	275
			NaOH 2M	298
			Nitric Acid 0.25M	139
			Nitric Acid 6M	44,662

The assumed sludge wash composition is shown in Table IV.H.3.:

Table IV.H.1. Tank U-107 Sludge Wash Composition.

Material	Amount (kg)
Al	12,383.1
Cs	0.7154
Na	529,437.6
Sr	0.5375
Salt Cake Solids	1,378,262.9
Water added	8,001,370

The results from the ProMoS run are shown in Table IV.H.2.:

Table IV.H.2. Tank U-107 Process Descriptions — Sludge Wash.

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	14		
Cs Removal	900	54	Water	21,925
			Formic Acid 1M	49,802
			NaOH 2M	16,072
LLW Evaporation	340	72		
LLW Vitrify	566.89	4	Glass-Formers	7,691,560
Organic Destruction	750	34		
Resin Oxidation	100	1		
Sr Evaporator	75	3		
Sr Removal	900	54	Water	21,727
			Nitric Acid 1M	50,231
			NaOH 2M	15,847
Tc Removal	900	27	Water	14,721
			NaOH 2M	15,918
			Nitric Acid 0.25M	7,409
			Nitric Acid 6M	2,388,567

L Tank U-111

The contents of Tank U-111 derive from B Plant wastes, and is assumed not to be leaking. It contains both sludge and salt cake. The assumed sludge wash composition is shown in Table IV.I.1.:

Table IV.I.1. Tank U-111 Sludge Wash Composition.

Material	Amount (kg)
Al	6,667.8
Cs	0.2305
Na	432,441.4
Sr	0.2807
Salt Cake Solids	1,198,754.2
Water <i>added</i>	7,079,670.0

The ProMoS results are summarized in Table IV.I.2.:

Table IV.I.2. Tank U-111 Process Descriptions — Sludge Wash.

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	12		
Cs Removal	900	48	Water	19,265
			Formic Acid 1M	43,761
			NaOH 2M	14,122
LLW Evaporation	340	63		
LLW Vitrify	566.89	3	Glass-Formers	6,562,320
Organic Destruction	750	31		
Resin Oxidation	100	1		
Sr Evaporator	75	3		
Sr Removal	900	48	Water	18,932
			Nitric Acid 1M	44,304
			NaOH 2M	13,924
Tc Removal	900	48	Water	12,935
			NaOH 2M	13,987
			Nitric Acid 0.25M	6,510
			Nitric Acid 6M	2,098,692

J. Summary

The vitrified waste generated by the Watch List Tanks is summarized in Table IV.J.1; a total of 65,134 tonnes of glass waste is produced.

Table IV.J.1. Watch List Tank Waste Generated.

<u>Tank</u>	<u>Vitrified Waste (kg)</u>
B-106	382,651
C-103	2,083,319
S-102	1,441,320
SX-106	12,718,144
TX-105	16,133,700
TX-118	9,192,120
U-106	5,181,378
U-107	9,798,689
U-111	8,202,900
Total	65,134,221

This mass is, of course, sensitive to the ratio of the glass added to the waste. In this case, a ratio of 4 to 1 is used; a smaller ratio can *greatly* reduce the amount of vitrified waste. However, the minimum with no glass added is just over 13,000 tonnes.

For the entire set of Watch List Tanks, the total amount of waste resin generated by the ion exchange processes is just over 137.6 tonnes. Just under 0.4 g of the Cs clings to the waste resin while just over 1 g of Sr goes with the waste resin.

Table IV.J.2. summaries the number of units required and the total materials added for the treatment of the Watch List Tanks:

Table IV.J.2. System for Treatment of All Watch List Tanks.

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	22		
Cs Removal	900	93	Water	180,199
			Formic Acid 1M	409,318
			NaOH 2M	132,091
LLW Evaporation	340	123		
LLW Vitrify	566.89	5	Glass-Formers	62,484,900
Organic Destruction	750	58		
Resin Oxidation	100	2		
Sr Evaporator	75	5		
Sr Removal	900	93	Water	178,007
			Nitric Acid 1M	410,957
			NaOH 2M	130,227
Tc Removal	900	93	Water	114,977
			NaOH 2M	130,808
			Nitric Acid 0.25M	60,981
			Nitric Acid 6M	19,627,682

It seems reasonable that processes of the New Technical Strategy could be bypassed. For example, all of the Watch List Tanks considered here have no Tc listed among the contents; If this were certain, then the Tc-Removal Process could be bypassed and save considerably on added materials. Three of the tanks, C-103, S-102, and U-106 list no Cs among their contents so that Cs-Removal could be bypassed for them. The results of this bypass is shown in Table IV.J.3:

Table IV.J.3. Minimal System for Treatment of All Watch List Tanks.

Process	Size (kg)	Units	Material Added	
			Name	Amount (kg)
Acid Distillation	750	22		
Cs Removal	900	93	Water	129,692
			Formic Acid 1M	294,592
			NaOH 2M	95,067
LLW Evaporation	340	123		
LLW Vitrify	566.89	5	Glass-Formers	62,484,900
Organic Destruction	750	58		
Resin Oxidation	100	2		
Sr Evaporator	75	5		
Sr Removal	900	93	Water	178,007
			Nitric Acid 1M	410,957
			NaOH 2M	130,227
Tc Removal	900	0	Water	0
			NaOH 2M	0
			Nitric Acid 0.25M	0
			Nitric Acid 6M	0

This reduces the waste resin generated down to just over 78.7 tonnes.

V. CONCLUDING REMARKS

It is clear that the New Technical Strategy Flowsheet involves a large apparatus and requires considerable added materials. However, based on the lack of Cs in some tanks and the apparent lack of Tc in all of the Watch List Tanks, it is possible to bypass some stages. This provides a reduction in:

- Material added — Notably, NaOH and Nitric Acid.
- Waste Resin generated — almost a factor of 2 reduction.

Further, as mentioned in the previous study (Reference 1), the size of the system can be reduced by about a factor of 4 if the system is run over the same time period, but in a continuous manner. Of course, the amount of material added is unaffected by this option.

It was also pointed out in the previous study that an evaporator placed before Cs-Removal can greatly reduce the size of the system and the materials added. If such a less dilute solution is tractable, then the size of the treatment system for the Watch List Tanks could be greatly reduced and considerable added materials could be saved.

- 1 Clay P. Booker: An Analysis of Alternative New Technical Strategy Flowsheets for Tank Waste Remediation, LAUR-94-1658, Los Alamos National Laboratory, 1994 May 5.
- 2 Hanford Site Tank Remediation System Technical Strategy, Draft 1, Revision 0, WHC, 1/20/94.
- 3 H. W. Egendorf: Lisp and Portability: The Process Modeling System, Lisp User's and Vendors '92 Conference, San Diego, CA, 1992 August 10-13, LAUR-92-2780.
- 4 Private Communication to Thomas J. Farish, 2/2/94.
- 5 Thomas J. Farish, Experimental Infrastructure and Logistics Required to Support TWRS Technology Development, LAUR-94-1140, 1994 March 25, Los Alamos National Laboratory.
- 6 Private Communication to Thomas J. Farish, 2/1/94.
- 7 Tank Farm Surveillance and Waste Status Summary Report for December 1993, WHC-EP-0182-69.
- 8 J. K. Rouse, T.J. McLaughlin, S.P. Airhart, E.J. Jensen, S.L. Lindberg, D.D. Robinson, and J. M. Cruse: Underground Storage Tank — Integrated Demonstration Participant Site Characteristic Summary, WHC-EP-0566.

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