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Waste Pretreatment and Interfacing Systems Dynamic Simulation Model (The ITHINK© Model) FY 1996 Year End Report

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Abstract: This report describes the updates to WHC-SD-WM-DR-013, Waste Pretreatment and Interfacing System Dynamic Simulation Model, which enhances the speed and utility of the model, introduces three demonstration glass (vitrification) plants, and provides multiple SST retrieval sequences. Also, the activities performed to verify and validate the modifications are described. The updated model demonstrates that the TPA milestones are met with the appropriate SST retrieval sequence and demonstration glass plant operating scenarios. During peak periods of full scale glass plant operation, all available feed staging tanks must be dedicated to the full scale plants.

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Waste Pretreatment and Interfacing Systems Dynamic Simulation Model (The ithink© Model)

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EXECUTIVE SUMMARY

The Waste Pretreatment and Interfacing Systems Dynamic Simulation model ("the ithink© model") was originally created to estimate the high level waste and low-level waste pretreatment facility processing rates needed to support tank waste remediation activities per the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement). The model subsequently was used to provide additional design and operation information for the entire tank waste retrieval and processing system, since it was built to represent the entire processing train from retrieval of the tank waste through waste vitrification.

In fiscal year 1996, various updates and improvements were made to the model. These include:

1. Improvements in tank usage accounting algorithms,
2. Changes in control logic to improve model execution speed,
3. Additions to the model for Phase 1 and Phase 2 privatization, and
4. Porting of the model to the latest version of the ithink software.

Following completion of these model changes, selected verification activities were conducted by comparing numerical results of the updated model with results from the model prior to updating.

Due to manpower considerations, only a limited selection of simulation cases were run this fiscal year. Three cases, representing three retrieval sequences, were analyzed. For the first two cases, (both similar to the Tri-Party Agreement retrieval schedule), the overall Tri-Party Agreement completion milestones could be met. For the third retrieval case, where much of the retrieval is deferred until late in the program, overall Tri-Party Agreement milestones could not be met. These results are based on the assumptions currently incorporated in the model. One of these assumptions is that available double-shell tanks can be efficiently reassigned for certain purposes as they are needed. For example, double-shell tanks that are normally used for lag storage can be made available for sludge washing.

A limited investigation of demonstration glass plant operating strategies during Phase 2 was also completed. It was found that the demonstration glass plants should be shutdown during times of peak lag storage tank demand by the full size plants, in order to avoid excessive demand for double-shell tanks by the processing facilities.

Several potential future work activities for the ithink© model have been identified. These are enumerated in the following full report. Of particular importance is the need to continue verifying and validating the model against the evolving Phase 1 and Phase 2 process engineering assumptions. If the model is kept current, it can continue to be used for a wide variety of system-level process dynamics and trade study investigations.

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DST	double-shell tank
FIFO	first-in, first-out
FY	fiscal year
HLW	high-level waste
LLW	low-level waste
MM	model month
SST	single-shell tank
TOE	total operating efficiency
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TWRS	Tank Waste Remediation System

1.0 INTRODUCTION

Programming of the Waste Pretreatment and Interfacing Systems Dynamic Simulation model ("the ithink©[1] model") began in fiscal year (FY) 1994, using the ithink© simulation software. The model was originally created to investigate the pretreatment facility processing rates for high-level waste (HLW) and low-level waste (LLW) that are required to meet Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) commitment dates. The model was also used to provide design and operation information concerning other aspects of the Tank Waste Remediation System (TWRS) processing system, because it includes all TWRS activities from retrieval through vitrification. The results of this work were reported in *Description of the Tank Waste Pretreatment Dynamic Simulation* (Chiao and Zimmerman 1994).

In FY 1995, updates were made to the model in accordance with the TWRS Process flowsheet (Orme 1994), and a verification of the model against the flowsheet was completed. Numerous simulation runs were then made, focusing on whether new double-shell tanks (DSTs) would be required by TWRS, and on identifying bottlenecks and needed facility processing rates for the TWRS system. Based on simulation results, facility processing rates were recommended that would allow completion of the TWRS program within Tri-Party Agreement required dates and without requiring new DSTs. The results of this work were reported in *Description of the Waste Pretreatment and Interfacing Systems Dynamic Simulation Model* (Garbrick and Zimmerman 1995).

The ithink© model activities continued during FY 1996, though at a reduced level. These activities included upgrading the model to improve performance and to incorporate current TWRS Phase 1 and Phase 2 privatization plans, completing selected verification and validation activities related to the upgrades, and completing selected simulation studies to demonstrate current capabilities of the model and to present sample results. Because of manpower considerations, not all activities originally scheduled for FY 1996 could be accomplished. However, based on the FY 1996 work, the model is available for simulation studies involving the TWRS system including the Phase 1 and Phase 2 privatization program architecture.

The ithink© model activities completed during FY 1996 are detailed in the following sections of this report. Also included are suggestions for future work.

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1 ithink© is a registered trademark of High Performance Systems, Inc. of Hanover, New Hampshire.

2.0 MODEL UPGRADES

Model upgrades included tank utilization accounting modifications, code simplifications to reduce execution time, addition of three demonstration glass plants, and upgrade to ithink© Version 3.0.6.

2.1 TANK UTILIZATION ACCOUNTING

Tank accounting algorithms were improved to more accurately represent DST utilization during two conditions: low feed flow to the glass plant feed staging tanks and temporary allocation of HLW glass plant feed staging tanks for use as LLW glass plant feed staging tanks. In the low feed flow condition, a staging tank is "closed" if there is no feed flow for three months. This closure results in a partially filled tank. The previous accounting algorithm added the contents of all the tanks within a category (e.g., LLW glass plant lag storage) and rounded up to the nearest million gallons to determine tank count. This count could be low by one or two tanks during low flow conditions. This inaccuracy was eliminated by counting the number of fill and drain sequences associated with LLW and HLW lag storage (i.e., tanks in use equals fills initiated less drains completed).

The second tank accounting improvement was made for the situation when capacity is added to a LLW glass plant feed staging tank to represent capacity borrowed from HLW glass plant feed staging. When the capacity was again needed for HLW glass plant feed staging, it was immediately taken from LLW. Thus a tank with a million gallon capacity could be left holding 1.8 million gallons. This resulted in LLW glass plant feed staging using one more tank than allocated for this purpose. This problem was corrected by counting the actual number of tanks used for LLW and HLW feed staging and holding one tank in reserve for HLW. This way the total 12 tank allocations for LLW and HLW was fully used but not exceeded; and HLW retained first priority access to its tank allotment.

2.2 IMPROVEMENTS IN EXECUTION SPEED

Efficiency improvements were focused in two areas: (1) simplification of the complex HLW and LLW glass plant feed staging control logic, and (2) providing a "Quick Start" feature which starts the simulation seven years after time zero (January 1994). Control code simplifications and consolidations reduced the (graphical) code from 88 to 47 pages even though the privatization logic was added.

2.2.1 Feed Staging Control Logic

To control material movement through each group of glass plant feed staging tanks, the model used a six path fill token ring, a six path drain token ring, six fill timers, and six sample delay timers. In addition, six integrator stocks were used to represent the six physical tanks in each group. Besides its complexity, this structure presented problems allocating tanks between groups (see Section 2.1). This logic structure was originally chosen because of its versatility. During FY 1996, the logic was simplified by introducing the conveyor element for sampling interval timing and implementing a first-in, first-out (FIFO) queue (or buffer) to represent tanks with contents awaiting transfer to the glass plants.

One conveyor, one three-month fill timer, and one FIFO queue are used for each glass plant feed staging group. A filled tank immediately begins its sampling delay by entering a conveyor. With the transit time set to the sample delay time, a conveyor replaces at least six timers. Tanks having completed their sampling interval enter a FIFO queue awaiting drain to a glass plant. The LLW FIFO queue is sufficiently deep to handle borrowed capacity from HLW. Ten lag tank fill timers, 4 token rings, and 12 sample delay timers are eliminated while all control requirements are met.

2.2.2 Quick Start

The Quick Start feature was added to allow the model to begin execution at month 83 (December 2000), skipping seven years of model run time. This alternate start date was chosen because of fixed activities prior to this point such as single-shell tank (SST) interim stabilization pumping, dilute non-complex tank draining, DST sludge addition, DST liquid addition, and water recycling. For eight integrators (see Sector Quick Start on ithink© diagram), two initial condition values are provided, one for starting simulation at time zero and one for time 83 months. Using the Quick Start feature saves 20 percent execution time for each run. Starting the simulation at any other time gives invalid results.

2.3 PRIVATIZATION—DEMONSTRATION GLASS PLANTS AND DELAYED FULL SCALE PLANTS

Privatization occurs in two phases: Phase 1 provides "early" demonstration glass plants and Phase 2 provides full-scale glass plants delayed from the previous (Tri-Party Agreement) schedule. All Phase 1 and Phase 2 plants have 60 percent total operating efficiency (TOE). Outages due to lack of feed are included in this TOE factor (i.e., some failures occur and maintenance and repairs are performed during these intervals).

One demonstration HLW glass plant and two demonstration LLW glass plants are added to the model to reflect Phase 1 privatization. Also, the full-scale glass plant parameters are changed to reflect Phase 2 privatization. The parameters are shown in Table 1 (from Paul Certa, March 1996) all rates represent maximum instantaneous processing capacity. The LLW glass waste loading is adjustable, in the model but 25 percent is taken as nominal for the demonstration and full-scale plants. The HLW glass waste loading is adjustable but 45 percent is taken as nominal for the demonstration and full-scale plants. Off-gas condensate from the demonstration plants is recycled the same as for the full-scale plants.

Table 1. Privatization Parameters.

Glass Plant	Start of Operations	End of Operations	Maximum Instantaneous Processing Rate
LLW Demonstration	6/1/2002	May run to 5/31/2017	2.5 MT Na per day per plant[1]
HLW Demonstration	6/1/2003	Will run to at least 5/31/2007	0.25 MT waste oxide per day[2]
Phase 2 LLW	2011		170 MT glass per day
Phase 2 HLW	2013		7.2 MT glass per day (45 wt % waste oxide loading); 13 MT glass per day (25 wt % waste oxide loading)

Notes:

MT = million tons

[1]MT is metric tons. 2.5 MT sodium is equivalent to 3.37 MT sodium oxide. Using 25 % Na_2O in glass gives 13.5 MT per day glass production rate.

[2]This represents a 0.56 MT per day glass production rate at 45 wt % waste oxide loading. An average rate of 0.5 MT per day while feed is present is used to approximate the 60 % TOE.

Tank allocation to the demonstration plants is as follows. Eighteen months before HLW demonstration plant startup, one million gallons of feed is staged for its sampling delay. When complete, the waste fills the dedicated plant feed tank making a batch for processing. When the plant is within 18 months of completing this batch, the next batch enters the staging tank for its sampling interval *providing that a HLW lag storage tank is available*. The Phase 2 HLW glass plant has priority for lag storage capacity. Both Phase 1 and 2 HLW staging operations receive waste from a common "HLW Pretreatment" (evaporator/concentrator) source.

Feed for the LLW glass plants is taken from the LLW pretreatment feed tanks. This is waste for which pretreatment (cesium extraction) is not required. One month before LLW demonstration plant startups, one million gallons of feed is staged for its sampling delay for each plant. When complete, the waste fills the dedicated plant feed tanks providing two batches for processing. Additional batches are provided as LLW lag storage tanks are available. The Phase 2 LLW glass plant has priority over the LLW demonstration glass plants for lag storage capacity.

2.4 UPGRADE TO ITHINK© VERSION 3.0.6

The ithink© application software was upgraded to the newest version (Version 3.0.6). This version has a multi-level, hierarchical environment for constructing and interacting with models as well as the ability to execute selected modules independently. An improved operator interface is also provided and graphical editing efficiency is significantly improved. The model loaded into ithink© Version 3.0.6 with two difficulties: (1) the control of the settle-decant process no longer functioned properly, and (2) fresh water addition was computed incorrectly. These two difficulties are described in Section 2.4.1 and 2.4.2.

2.4.1 Settle-Decant Timing

The settle-decant timing problem was traced to a change in fundamental integration element. The internal accounting within a time step was changed. Previously, an equal flow in and out left an integrator contents of flow x dt. The new integrator element adds flow in and subtracts flow out at the beginning of each integration step; equal flow in and out leaves an integrator content of zero. The settle-decant timing logic was corrected by re-establishing the one dt outflow delay in the token ring logic.

2.4.2 Fresh Water Addition

The new integration element also resulted in incorrect calculation of fresh water addition. A material balance error occurred because fresh water was added when not needed and not used by the system. The problem was traced to the "Recycle H2O Retention" integrator. The problem was corrected by changing the "Add Water" flow from the "Fresh Water Tank" to equal system demand flow minus flow available from recycle.

3.0 MODEL RESULTS

Besides addition of the demonstration plants, revised SST retrieval sequences were identified and evaluated using the ithink© model. The sequences were developed by the TWRS Process Engineering function to support Tri-Party Agreement Milestone M45-02A, "Submit Annual Report of SST Retrieval Sequences." The Tri-Party Agreement results of three retrieval sequences are discussed below. The first is a modified Tri-Party Agreement sequence in which retrieval from TX Tank Farm (saltcake) is still retrieved early, but much of the remaining tank waste retrieval is deferred until after 2012. The second retrieval sequence has increased sludge retrieval at the beginning while the start of TX Tank Farm (saltcake) retrieval is deferred until 2011. The final retrieval sequence begins with very low initial sludge retrieval rate, has a burst of sludge retrieval in 2012 when TX Tank Farm retrieval is also initiated, and completes with an aggressive retrieval rate for the last three and one-half years.

The settings for the dominant parameters used for these simulations are provided in Table 2.

Table 2. Simulation Fixed Parameter Settings.

Parameter		Units
Desired Retrieval Na Molarity	4.9	Mols/liter
Main LLW Evaporator Capacity	50	Gallons per Minute
Desired Main LLW Evaporator Na Morarity	9.996	Mols/liter
LLW Pretreat Capacity	27	Gallons per Minute
HLW Pretreat Capacity (including Evaporator)	15	Gallons per Minute
LLW Glass Plant Capacity	110	Metric Tons per Day
LLW Demo. Glass Plant Capacity (Each Plant)	10.1	Metric Tons per Day
HLW Glass Plant Capacity	5.0	Metric Tons per Day
HLW Demo. Glass Plant Capacity	0.5	Metric Tons per Day
Sludge Wash Settle Time	1	Month
Wash Add Decant Offset Time	0.375	Month
Glass Plant Feed Storage (Dynamically Allocated Among Five Plants)	12 (max.)	Million Gallon Tanks
LLW Pretreatment Feed	Variable Limit (Note)	Million Gallon Tanks
Washed HLW Solids Storage	Variable Limit (Note)	Million Gallon Tanks

Note:

Tanks are allocated as required. The model assumes that the empty tanks are available to perform these storage functions.

3.1 MODIFIED TRI-PARTY AGREEMENT SINGLE-SHELL TANK RETRIEVAL SEQUENCE

The modified Tri-Party Agreement SST retrieval sequence (developed by C. Grenard for use in the SIMAN/ARENA model) was similar to that used in the original ithink© report (Case 3, from Chiao and Zimmerman 1994) with salt cake tanks retrieved first as specified in the Tri-Party Agreement. Retrieval sequence volume data from the SIMAN/ARENA model (provided by R. Wittman, March 1996) was curve fit using three-segment, linear regression to obtain an accurate (1.9 percent root-mean-square error) approximation to the predicted SST retrieval profile. The chart in the upper left of Figure 1 shows the SIMAN/ARENA retrieval profile, the three-segment approximation, and the revised ithink© model profile. The original ithink© retrieval rate was essentially constant. The three-segment approximation shown was used as the retrieval sequence for the TWRS technical baseline Dynamic Verification Facility of Requirements Driven Design (RDD-100). An equivalent sequence for the ithink© model was more difficult to define as separate profiles are needed for tank farm "TX 16" and all remaining SSTs ("SST SC SL").

To approximate the modified Tri-Party Agreement SST retrieval sequence, a three-segment TX 16 retrieval rate (beginning in 2004) was combined with a constant SST SC SL retrieval rate (beginning April 2011 and completing in June 2017). The sequence is shown as the solid line in the upper left chart in Figure 1. Three primary factors account for the offset in the ithink© curve. First is the retrieval water addition factor. The SIMAN/ARENA model data are based on a fixed water multiplier of 2.378 (retrieval water is 2.378 times the stored solids). The ithink© model computes a 4.492 multiplier for TX 16 salt cake and 1.992 for SST SC SL to achieve a sodium molarity of 4.9 (as specified by Orme 1994). As a result, the SIMAN/ARENA model adds 7.2 x 106 gal more retrieval water than ithink©. The second factor is that the SIMAN/ARENA model has an initial inventory of an additional 4 million gal of SST solids, mostly in the TX Tank Farm. Finally, the SIMAN/ARENA model concentrates TX Tank Farm retrieval toward the end of the SST retrieval interval while ithink© has this retrieval first as specified in the Tri-Party Agreement.

The system is able to complete its mission with existing DST capacity as seen in the curve in the upper right of Figure 1. The LLW lag tank usage peaks at nine in 2008 or model month (MM) 168 as seen in the left center chart while washed HLW solids lag storage (HLW evaporator feed) peaks at 17 in 2018 (MM 294) as seen at the lower left. The LLW glass plant utilization is near 100% over its life cycle with a brief period at 60% beginning in 2010 (MM 200) as seen on the right center chart. The tank waste retrieval rate is insufficient to fully utilize the plant capacity during this three-year period. No fresh water needs to be added to the system for this sequence; the cumulative recycled water is shown in the lower right chart. A twenty million gallon retention basin is needed to handle the four hundred eighty-nine million gallons which are recycled.

3.2 SINGLE-SHELL TANK RETRIEVAL SEQUENCE 2 (DEFERRED TX TANK FARM)

Retrieval sequence 2 had increased sludge retrieval at the beginning and TX Tank Farm (salt cake) retrieval was deferred until 2011 (MM 204). The SST waste retrieval profile is seen in the upper left corner of Figure 2. The tank waste cleanup mission is completed within the Tri-Party Agreement time constraints using the existing 28 DSTs (see upper right corner of Figure 2). The left center chart shows that the LLW lag storage peaks at nine million gallons in 2007 (MM 168). The LLW glass plant is starved for feed in 2011 as seen on the right center chart. Solids storage ahead of the HLW evaporator peaks at thirteen million gallons in 2018 (MM 296, see lower left chart). Cumulative recycled water is 464 million gallons as seen on the lower right chart; and no fresh water addition is needed.

Figure 1. System Response to Single-Shell Tank Retrieval Sequence 1 (Modified Tri-Party Agreement)

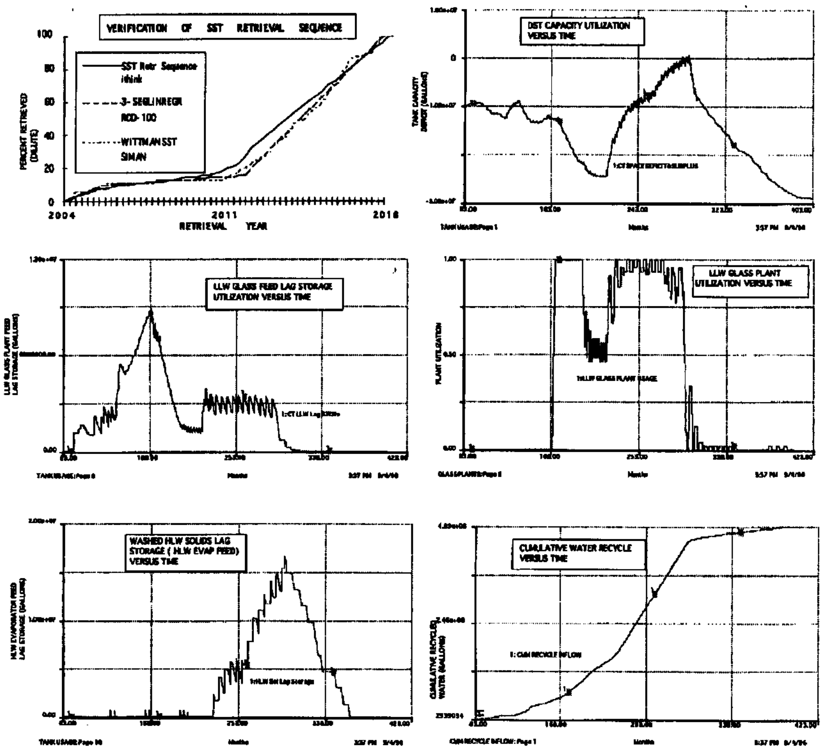

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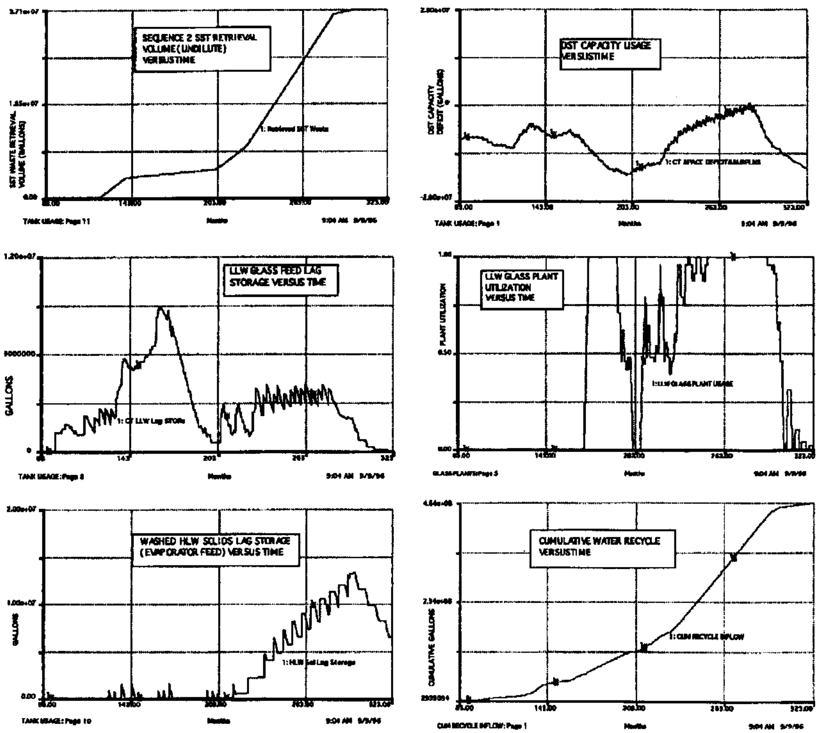
Figure 2. System Response to Single-Shell Tank Retrieval Sequence 2 (Delayed TX Farm).



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3.3 SINGLE-SHELL TANK RETRIEVAL SEQUENCE 3 (DEFERRED SLUDGE)

Retrieval sequence 3 was characterized by very slow initial retrieval, a burst of retrieval in 2012 (MM 220) and an aggressive, steady retrieval rate from 2014 (MM 250) to completion. This sequence is shown in the top left corner of Figure 3 as curve 1 (ARENA Case 241). Curve 2, shifted to the right, represents a 20% reduction in the final retrieval rate; this reduced rate allowed completion of the mission with the available DSTs (see curve 2 in upper right corner). The chart at the lower left corner shows recycle water overflow; the aggressive retrieval rate results in significantly higher recycle overflow (curve 1) requiring liquid effluent treatment. Also, as seen at the lower right, the aggressive final retrieval rate results in the need for seven million gallons of fresh water addition.

4.0 PARAMETRIC RUNS

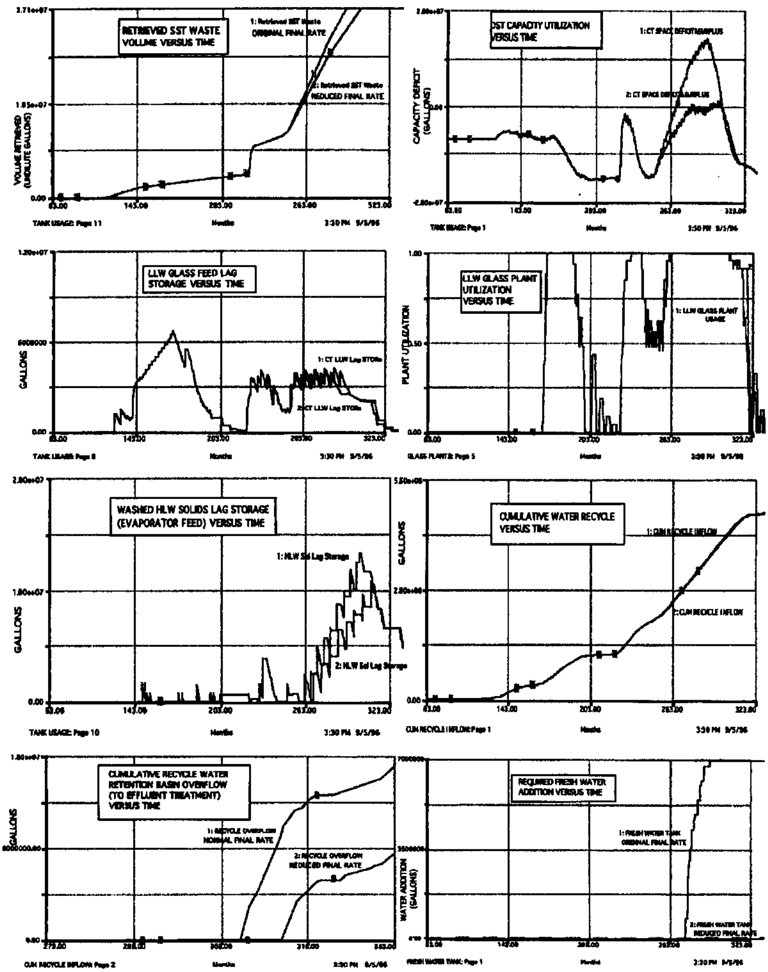
Operational strategies for the demonstration glass plants were explored through the use of parametric or sensitivity runs. Three strategies were considered: (1) one one-million gallon batch per plant, (2) continuous batches to each plant, and (3) shutdown during high peak lag tank demand by full scale plants. Strategies 1 and 3 were viable while strategy 2 resulted in large DST capacity deficits. Strategy 3 was selected for use with the various SST retrieval sequences discussed in Section 3.0 because it allowed the demonstration plants to process multiple tank batches while placing reasonable demands on the limited DST waste storage resource.

5.0 VERIFICATION AND VALIDATION

Model verification is performed at the module level to determine that elementary level mathematical algorithms, logic, and timing are as described by domain experts and as typically specified in the model's controlling documents. Verification of changes which improve the model's performance and ease of use is typically performed by comparing results with the verified reference model (Garbrick and Zimmerman 1995). Key cumulative flows of the reference model had previously been verified to agree with the TWRS Process Flowsheet (Orme 1994). Accurate reproduction of liquid, solid, and sodium constituent quantities had also been demonstrated.

With the same inputs and settings, verification of the revised model requires that the revised model's results be identical to the reference model.

Figure 3. System Response to Sequence 3 (Deferred Retrieval)



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In general, model validation requires positive responses to the following three questions:

1. Does model adequately represent the real-world system?
2. Are the model-generated behavioral data characteristic of the real system's behavioral data?
3. Does the simulation model user have confidence in the model's results?

The present version on the model was verified and informally validated primarily by comparison with the reference version, as described above. However, it is possible that recent changes to the TWRS reference flowsheet are not full reflected in the model. It is desirable that a detailed comparison of the current reference flowsheet with the model be made in order to increase confidence in the model's results.

5.1 MODULE VERIFICATION

The model was verified by a DST utilization graphical comparison and a material balance. These verification methods are resolved in sections 5.1.1 and 5.1.2.

5.1.1 Double-Shell Tank Utilization Graphical Comparison

Replacement of the LLW and HLW lag storage token ring logic with conveyors and FIFO queues was verified by comparing tank contents with the reference model over the usage interval. Exactly the same behavior was observed as with the previous token ring implementation.

5.1.2 Material Balance

A material balance calculation is performed for every run. Total waste solids and liquids from initial conditions plus additions during a simulation are checked against total glass produced and recycle water remaining at the end of a simulation. After the demonstration glass plant products were added to the calculation and logic was added for the Quick Start feature, material balance was achieved. Total HLW glass and LLW glass produced was verified to remain unchanged from the earlier model.

The material balance calculation flagged the problem in the fresh water addition logic which was introduced with the new revision of the ithink© program. An ending material balance approximately equal to minus the fresh water addition led to the discovery that indicated water addition was much greater than actually entering the system. The logic was corrected to agree with the new ithink© program revision and material balance was satisfied.

5.2 INTEGRATED MODEL VALIDATION

The only new features which modify the system level behavior and products are the demonstration glass plants. These provide early conversion of tank waste to glass product but consume significant DST capacity while providing little system throughput capability. Several different operating scenarios for the demonstration plants were explored and widely varying, but logical results were achieved. The results indicate that the TWRS can meet the commitments of the Tri-Party Agreement and privatization under the following conditions:

- All 28 DSTs are committed to the TWRS cleanup mission
- The HLW demonstration plant has no more than three one-million gallon campaigns and just-in-time availability for the sampling tank is used.
- The LLW demonstration plants are operated before and after, but not during the peak demand for LLW lag storage.

These results are subject to further assessment by domain experts to ensure model validation.

6.0 SUGGESTED FUTURE WORK

6.1 REFINE SLUDGE WASH PROCESS (IN-TANK/OUT-OF-TANK)

The TWRS Baseline Dynamic Simulation Model (ARENA) increased the sludge wash rate to simulate out-of-tank processing in order to meet the Tri-Party Agreement milestones for retrieval sequence described in section 3.3. Sludge wash rate is a dominant system parameter. The TWRS flowsheet (Orme 1994), on which the ithink© model is based, specifies settling in-tank for 30 days to achieve a settled solids concentration of 20% by weight. Experience at Savannah River and laboratory testing now indicates the settled solids concentration will reach only about 15% percent (Raytheon/BNFL 1994). This significantly increases the water and caustic usage's as well as lowering the effective sludge wash rate. To enhance the ithink© model, the sludge wash process should be re-addressed and updated to reflect best available in-tank and out-of-tank technology.

6.2 ADDITIONAL VERIFICATION AND VALIDATION ACTIVITIES

Additional model verification and validation activities should be provided as described in Section 5.0 to ensure compatibility with the TWRS baseline flowsheet.

6.3 TRAINING IN SYSTEM BEHAVIOR

This model may be used to train engineers and managers in TWRS dynamic behavior over its life cycle. Control panels, graphs, and tables generated and displayed during run time, as well as animation features, make this model an excellent training aid.

6.4 PARAMETRIC RUNS TO MEET SPECIFIC CUSTOMER NEEDS

This model is designed to generate sets of parametric or sensitivity runs automatically. A possible sensitivity run would determine peak tank usage versus glass plant start date for various plant capacities.

6.5 IMPACT OF UNSCHEDULED OUTAGES

The statistical features of ithink© should be used to assess system performance in the presence of random process failures. The present model uses TOE factors which roughly approximate the impact of random failures by assigning reduced but constant plant throughput capacities. During peak tank usage, the impact of an unexpected process or facility outage may be much more significant than at other times. This behavior is not captured through the use of TOE factors.

6.6 ADVERTISE MODEL'S CAPABILITIES

Marketing should be provided as necessary to identify and attract the customers whose needs are met by this model.

7.0 REFERENCES

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