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Parametric Study to Characterize Low-Activity Waste Tank Heat Removal Alternatives for Phase 1 Specification Development

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Alternative for removing heat from Phase 1, low-activity waste feed double-shell tanks using the ventilation systems have been analyzed for Phase 1 waste feed delivery. The analysis was a parametric study using a model that predicted the waste temperatures for a range of primary and annulus ventilation system flow rates. The analysis was performed to determine the ventilation flow required to prevent the waste temperature from exceeding the Limiting Conditions for Operation limits during normal operation and the Safety Limits during off-normal events.

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Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

CH2MHILL

Hanford Group, Inc.

Richland, Washington

Contractor for the U.S. Department of Energy
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August 2000

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TERMS

JMI	John Marvin, Inc.
LCO	Limiting Conditions for Operation
LCS	Limiting Control Setting
LAW	Low-Activity Waste
TSR	Technical Safety Requirement

1.0 INTRODUCTION

Alternatives for removing heat from Phase 1, low-activity waste (LAW) feed double-shell tanks using the ventilation systems have been analyzed for Phase 1 waste feed delivery. The analysis was a parametric study using a model that predicted the waste temperatures for a range of primary and annulus ventilation system flow rates. The analysis was performed to determine the ventilation flows required to prevent the waste temperature from exceeding the Limiting Conditions for Operation limits during normal operation and the Safety Limits during off-normal events. The limits are specified in HNF-SD-WM-TSR-006, *Tank Waste Remediation System Technical Safety Requirement* (TSR). The results may change if the temperature limits in the TSR are changed in the future.

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2.0 METHODOLOGY

An analytical model was built using the GOTH SNF thermal model. The analysis was based on the following analytical sequence, the bounding retrieval strategies that were analyzed, and the input parameters. Details of the model are discussed in Section 3.0.

2.1 PARAMETRIC ANALYSES DESCRIPTION

The analytical sequence and input parameters are discussed in the following sections.

2.1.1 Parametric Study Cases

Two system modifications — primary and annulus ventilation system enhancements — were considered for the LAW heat removal parametric analyses. A base case was run using the existing primary and annulus system flow rates. If one or more of the temperature limits were violated, either the primary or annulus ventilation flow rate was increased to determine what flow was required to maintain an acceptable waste temperature. The maximum annulus flow rate was limited to a $0.47 \text{ m}^3/\text{s}$ [$1,000 \text{ ft}^3/\text{min}$ (standard)]. This is the maximum reasonably achievable flow considering the design of the cooling slots at the bottom of the tank.

2.1.2 Parametric Study Analysis Sequence

The LAW parametric analysis was divided into four distinct activities. These activities are (1) preretrieval (i.e., normal storage), (2) retrieval (mixer pump operating), (3) post-retrieval (mixer pump operation stopped), and (4) loss of ventilation system. The expected temperature response of the solids during each activity is shown on Figure 2-1. Each activity is discussed in more detail below:

1. **Preretrieval (normal operation).** First, a thermal analysis was performed to characterize the supernatant and peak solids temperatures during normal tank storage. This analysis initialized the thermal model of the tank waste and surrounding soil before retrieval operations began. Before continuing with the analysis, the predicted waste temperatures must be consistent with actual temperatures. The applicable temperature limit during this portion of the analyses is the Limiting Control Setting (LCS)/Limiting Conditions for Operation (LCO) 3.3.2.b temperature criteria.
2. **Retrieval (mixer pump operating).** Second, the mixer pumps mix and mobilize the settled sludge during retrieval operations (Region 1). The sludge and supernatant are assumed to be in a fully mixed-waste condition. The instantaneous mixed-waste temperature (i.e., the mixed-waste temperature without any pump heat) is the minimum mixed-waste temperature (T_3) at the start of retrieval operations. As mixer pumps continue to operate, the mixed-waste temperature approaches steady state, the maximum mixed-waste temperature during retrieval operations. The applicable temperature limit during mixer pump operations is $\leq 90.6 \text{ }^\circ\text{C}$ ($195 \text{ }^\circ\text{F}$) (LSC/LCO 3.3.2.a).

3. **Post-Retrieval (mixer pump operation stopped).** When mixer pumps operation stops, undissolved waste will begin to resettle, resulting in a fluffed waste layer (i.e., a layer with a smaller particle volume fraction relative to the pre-mixed settled waste). Elevated supernatant temperatures in conjunction with waste resettling could result in elevated settled waste temperatures. The most limiting condition occurs after the mixed-waste temperature reaches steady state. Figure 2-1 shows qualitatively the expected supernatant (T_1') and settled-waste (T_2') profiles. The applicable temperature limit for the post-mixed settled waste is LCS/LCO 3.3.2.b.

Figure 2-1. Overview of Analyses Sequence.

Key:

T_1 = Supernatant waste*

T_2 = Settled waste*

T_3 = Instantaneous mixed-waste (mixed-waste temperature without any pump heat)**

T_4 = Mixed waste (with pump heat)**

T_1' = Expected supernatant temperature (after pumping)**

T_2' = Expected settled waste temperature (after pumping)**

*LCS/LCO 3.3.2.b $T \leq 90.6^\circ\text{C}$ (195°F) (in the top 4.57 m [15 ft] of waste)
 $T \leq 101.7^\circ\text{C}$ (215°F) (in the waste below 4.57 m [15 ft])

**LCS/LCO 3.3.2.a $T \leq 90.6^\circ\text{C}$ (195°F) (in all levels of the waste)

Note: Because double-shell tanks typically operate with a waste level of 9.14 m (30 ft), both temperature limits for LCS/LCO 3.3.2b apply to the LAW parametric analyses.

4. **Loss of Ventilation Flow.** A loss of ventilation when the mixed-waste temperature reaches a maximum could result in higher temperatures if the heat load in the settled solids is significant. However, the LAW tanks have very low heat loads resulting in a low heat-up rate (temperature increase as a function of time), which will provide plenty of time to restore lost ventilation before a temperature limit would be reached. Therefore, thermal analyses were not performed for the loss of ventilation analyses.

2.2 TANK SELECTION

One tank, 241-AN-103, was selected as a bounding case for this analysis based on the combination of radioactive decay heat rate and sludge depth in all the LAW feed source tanks to be retrieved during Phase 1 waste feed delivery. The basis for selecting this tank is provided in Appendix A.

2.3 PARAMETRIC STUDY INPUT PARAMETERS

This section discusses summarizes the input parameters used for the study.

2.3.1 Allocation of Primary and Annulus Flow Rates

The following sections provide the bases for the range of ventilation flow rates used in this analysis.

2.3.1.1 Primary Ventilation System Flow Rates. The seven tanks in the AN-Tank Farm are served by a common primary ventilation system. The maximum flow capability of this system is on the order of $0.47 \text{ m}^3/\text{s}$ ($1,000 \text{ ft}^3/\text{min}$) with a normal flow of $0.04 \text{ m}^3/\text{s}$ ($85.7 \text{ ft}^3/\text{min}$) allocated to tank 241-AN-103. A flow rate of up to $0.094 \text{ m}^3/\text{s}$ ($200 \text{ ft}^3/\text{min}$) to tank 241-AN-103 is achievable with the current system. This will be considered the minimum achievable flow rate for this analysis. A flow rate in excess of $0.47 \text{ m}^3/\text{s}$ ($1,000 \text{ ft}^3/\text{min}$) is not considered reasonable. Once-through flow rates of $0.094 \text{ m}^3/\text{s}$ [$200 \text{ ft}^3/\text{min}$], $0.24 \text{ m}^3/\text{s}$ ($500 \text{ ft}^3/\text{min}$), and $0.47 \text{ m}^3/\text{s}$ ($1,000 \text{ ft}^3/\text{min}$) will be used for these analyses. Chilling of the inlet air will not be considered in this analysis.

2.3.1.2 Annulus Ventilation System Flow Rate. The seven tanks in the AN-Tank Farm are served by a common annulus ventilation system. The current maximum annulus flow rate to tank 241-AN-103 is $0.38 \text{ m}^3/\text{s}$ ($800 \text{ ft}^3/\text{min}$). Operational experience with this system, however, indicates that a flow rate of up to $0.47 \text{ m}^3/\text{s}$ ($1,000 \text{ ft}^3/\text{min}$) for Tank 241-AY-102 may be possible with some configuration changes. It is not certain if annulus flow is required to maintain acceptable temperatures. Therefore, once-through flow rates of $0 \text{ m}^3/\text{s}$ [$0 \text{ ft}^3/\text{min}$] and $0.094 \text{ m}^3/\text{s}$ [$200 \text{ ft}^3/\text{min}$] will be used for the initial analyses. Flow may be increased up to $0.47 \text{ m}^3/\text{s}$ ($1,000 \text{ ft}^3/\text{min}$), if necessary.

2.3.2 Retrieval Strategies

The model will be run to analyze two bounding retrieval strategies. For both, the total radioactive decay heat load will be conservatively assumed to remain in the solids.

2.3.2.1 Decanting. The “decanting” retrieval strategy removes the supernatant liquid without disturbing the underlying waste. Decanting is followed by backfilling the tank with water to the 9.14 m (30 ft) level and operating the mixer pumps to dissolve the solids (see the guidance letter in Appendix B). The remaining insoluble solids depth will be much less than the initial depth.

This case results in the lowest vapor suppression (see Section 2.3.4.2) and minimizes the required ventilation flow rates. This case is consistent with the current retrieval plans.

2.3.2.2 Nondecanting. The “nondecanting” retrieval strategy mixes all the waste currently in the tank and allows the solids to settle. This case maximizes the amount of waste dissolved in the supernatant, which leads to highest vapor suppression (see Section 2.3.4.2), and maximizes the depth of the settled solids after termination of mixer pump operation. This case maximizes the ventilation flow rates. This case is consistent with the retrieval strategy at the beginning of this fiscal year.

2.3.3 Thermal Parameter of the Decanting and Nondecanting Strategies

The thermal input parameters are shown in Tables 2-1 and 2-2. Table 2-1 shows parameters that are common to both the decanting and the nondecanting strategies. Table 2-2 lists the parameters that are not the same for both strategies. The bases for these numbers are provided in Appendix C.

Table 2-1. Thermal Parameters Common to Both Decanting and the Nondecanting Cases.

Thermal Parameter	Tank 241-AN-103 Parameter Value
Solids Density	3000 kg/m ³ (187.2 lbm/ft ³)
Liquid Heat Capacity	3200 J/kg-°C (0.7643 Btu/lbm-°R)
Solids Heat Capacity	837 J/kg-°C (0.20 Btu/lbm-°R)
Thermal Conductivity of Aqueous Solution	90% of the value of water
Thermal Conductivity of Solids	8.65 W/m-°C (5.0 Btu/h-ft-°R)
Radiolytic Heat	10.6 kW (36,300 Btu/h)

Table 2-2. Thermal Parameters that Differ Between Decanting and Nondecanting Cases

Thermal Parameter	Decanted Parameter Value	Nondecanted Parameter Value
Fluffed Sludge Height	0.445 m (1.46 ft)	7.19 m (23.6 ft)
Supernatant Liquid Vapor Pressure	60% of the value of water	31% of the value of water

3.0 PARAMETRIC ANALYSES MODEL

This section describes the GOTH_SNF thermal model used for this parametric study. Development of the model is documented in JMI-9911-01. The GOTH_SNF model was benchmarked with measured data for tank 241-AY-102 (RPP-5637).

3.1 GOTH_SNF MODEL DEVELOPMENT

GOTH_SNF is a general-purpose, thermal-hydraulics computer program developed by John Marvin, Inc. (JMI). The current version and the predecessor program GOTH have been used extensively at the Hanford Site and other U.S. Department of Energy sites and in the commercial nuclear industry for design, safety, and operations analyses (JMI-980306-2 and JMI-980306-3). GOTH_SNF has been verified and validated and is controlled through the JMI Quality Assurance Program (JMI-980306-1).

3.2 GOTH_SNF MODEL GENERAL DESCRIPTION

The GOTH_SNF model incorporates distributed- and lumped-parameter volumes, heat conductors, and flow and pressure boundary conditions to provide a one-dimensional model of tank 241-AN-103 as shown in Figure 3-1.

1. **Distributed- and Lumped-Parameter Volumes.** The volume inside the tank inner liner is modeled as GOTH_SNF Volume 1s. (Volume 1s is a distributed-parameter volume with a one-dimensional model of the waste, supernatant, and dome space. The noding scheme for this volume is shown in Figure 3-2.) GOTH_SNF control volume 2 (Figure 3-1) corresponds to the flow volume of the annulus system on the floor of the tank. The flow volume in the annulus ventilation system, between the steel inner liner and outer liner, is modeled with control volume 3. Control volume 5 models the inlet annulus piping. This includes the drop-legs in the wall annulus region and the horizontal runs of piping leading to the center of the tank. Control volume 4 and valve 1V provide make-up water to maintain the supernatant pool level at a near constant value. These modeling devices provide water to maintain a constant pool level and do not represent actual physical components.
2. **Heat Conductors.** The GOTH_SNF model treats the tank waste and supernatant as fluid volumes with conduction heat transfer within the waste, when the mixer pumps are not operating. Heat transfer from the supernatant surface includes evaporation and convection. Other thermal masses associated with the waste tanks are modeled with one-dimensional heat conductors. The soil directly above the tank is modeled with a one-dimensional wall conductor (Figure 3-1, heat conductor 6. The thickness of this conductor corresponds to the average soil depth above the tank. This conductor uses the ambient temperatures for the top surface and calculated dome temperatures for the bottom surface.

The soil below the tank is modeled with a one-dimensional wall conductor (heat conductor 4). The thickness of this conductor corresponds to the approximate distance to the water table below the tanks. A constant 12 °C (54 °F) temperature is used for the surface of the heat conductor. This is the average annual ambient temperature and, therefore, the soil temperature at a distance removed from the tanks.

The soil surrounding the tank side is modeled with tube heat conductor 5. The inside of the tube is connected to the wall annulus (volume 3). The thickness of the tube conductor corresponds to the mid-point between the modeled tank and the surrounding tanks. The heat conductor boundary is assumed adiabatic for the outside surface of the tube conductor.

The steel plates of the inner liner are modeled with three conductors: heat conductor 1 corresponds with the bottom plate; heat conductors 2 and 3 model the side wall liner.

Figure 3-1. GOTH_SNF Model Schematic.

Figure 3-2. GOTH_SNF One-Dimensional Noding Scheme.

3. **Flow and Pressure Boundary Conditions.** The primary and annulus flow conditions are modeled with flow boundary conditions 4F and 5F (Figure 3-1). The ventilation flow rates are specified by these boundary conditions.

Flow boundary condition 9F (Figure 3-1) is used to model the mixer pump flow. Pumps draw liquid from the supernatant pool and inject the liquid into the bottom level of waste, mixing the settled waste. The heat associated with the operation of the pumps is modeled with a GOTH_SNF heater component, which inputs a specified amount of heat to the supernatant. The heater component is located near the middle of the supernatant pool.

The GOTH_SNF model uses a boundary condition component to establish the temperature, humidity, and ventilation flow rates for the primary and annulus ventilation systems. Boundary conditions 3P and 6P (Figure 3-1) define the monthly average ambient temperature and monthly maximum humidity conditions. Derivation of the monthly average temperature and humidity values used for this analyses are described in Appendix D.

4.0 PARAMETRIC ANALYSES RESULTS

Retrieval operations for LAW tanks (the double-shell tanks except the aging waste tanks 241-AY-101, 241-AY-102, 241-AZ-101, and 241-AZ-102) were analyzed using the GOTH_SNF code and tank 241-AN-103 as the bounding case. Predicted supernatant and slurry temperatures were compared with temperature criteria to evaluate the need for primary or annulus ventilation system upgrades. If temperature limits were exceeded for the nominal ventilation configurations, parametric analyses were performed to determine the required ventilation system performance. The results of the parametric evaluations for tank 241-AN-103 are provided in the following sections.

4.1 MIXER PUMP OPERATION WITH SUPERNATANT DECANTING

The primary and annulus ventilation systems were evaluated for the planned LAW retrieval decanting strategy. The decanting of the supernatant and subsequent mixing of the waste, leads to the maximum dilution of waste. This minimizes the settled solids level after pump operation and reduces the vapor suppression of the supernatant. Parametric analyses were performed for both the primary and annulus ventilation systems. The results of 19 thermal analyses are summarized in Table 4-1. The parametric analyses included mixer pump power (50 percent and 100 percent of full, continuous power), primary ventilation flow, and annulus ventilation flow [0.094, 0.24, 0.38, 0.47 m³/s (0, 200, 500, 800, 1,000 ft³/min)]. The primary ventilation evaluation with supernatant decanting is presented in Section 4.1.1, and the annulus ventilation system evaluation with supernatant decanting is presented in Section 4.1.2.

Table 4-1 summarizes the predicted maximum, mixed-waste temperature and the time required to reach the temperature limit during mixer pump operation for decanted cases. The applicable temperature limit during this period of retrieval operations is 91 °C (195 °F). Operating at 100 percent power with continuous pump operation and primary ventilation flow below 0.47 m³/s (1,000 ft³/min) (Cases D1 through D7), the predicted mixed-waste temperatures exceed the temperature limit. For low primary ventilation flow rates, mixer pump operation must be terminated when the mixed-waste temperature reaches the temperature limit. The table shows that the predicted mixed-waste temperatures do not exceed the temperature limit for a primary ventilation flow of 0.47 m³/s (1,000 ft³/min) or for reduced mixer pump power (50 percent of full power). The table also shows that the moisture carryover of the primary ventilation system (mass of moisture carried with the primary ventilation flow) can exceed 0.126 kg/s (1,000 lb/h) for a primary ventilation flow of 0.47 m³/s (1,000 ft³/min). The moisture carryover is a strong function of primary ventilation flow.

The results of the predicted settled waste temperatures also are shown in Table 4-1. This is the maximum settled waste temperature after the termination of the mixer pump operation. The resettled waste temperatures are below the temperature limit of 102 °C (215 °F) for the parametric cases. A large fraction of the initial settled waste is dissolved during the decanting strategy, which minimizes the resettled waste depth.

Table 4-1. Summary of Results for Decanted Cases.

Pump Power	Primary Ventilation Flow m ³ /s (ft ³ /min)	Annulus Ventilation Flow m ³ /s (ft ³ /min)	Parametric Case Identification Number	Mixer Pump Operation			Post Mixer Pump Operation
				Mixed-Waste Temperature °C (°F)	Time to Reach Temperature Limit (Days)	Moisture Carryover kg/s (lbm/h)	Settled Waste Temperature °C (°F)
100%	0.04 (85.7)	0.38 (800)	D1	116 (240)	27	0.02 (162)	54 (130)
	0.094 (200)	0.38 (800)	D2	106 (222)	30	.0436 (346)	47 (116)
	0.24 (500)	0	D3	97 (206)	34	0.0989 (785)	44 (112)
		0.094 (200)	D4	96 (204)	35	0.0984 (781)	42 (108)
		0.24 (500)	D5	95 (202)	36	0.0975 (774)	40 (104)
		0.38 (800)	D6	94 (202)	37	0.961 (763)	39 (102)
		0.47 (1,000)	D7	93 (200)	37	0.948 (752)	38 (100)
	0.47 (1,000)	0	D8	88 (190)	NA	0.142 (1130)	38 (100)
		0.094 (200)	D9	87 (188)	NA	0.137 (1090)	36 (97)
		0.24 (500)	D10	87 (188)	NA	0.136 (1080)	35 (95)
		0.38 (800)	D11	86 (187)	NA	0.132 (1050)	34 (94)
50%	0.04 (85.7)	0.38 (800)	D12	81 (177)	NA	0.0113 (90)	52 (125)
	0.094 (200)	0.38 (800)	D13	77 (170)	NA	0.019 (151)	44 (112)
	0.24 (500)	0	D14	73 (163)	NA	0.0354 (281)	44 (111)
		0.094 (200)	D15	72 (162)	NA	0.0335 (266)	42 (107)
		0.24 (500)	D16	71 (159)	NA	0.0312 (248)	39 (102)
		0.38 (800)	D17	69 (157)	NA	0.03 (238)	38 (100)
		0.47 (1,000)	D18	69 (156)	NA	0.029 (230)	37 (98)
	0.47 (1,000)	0.38 (800)	D19	63 (146)	NA	0.0386 (306)	34 (93)

4.1.1 Primary Ventilation Evaluation with Supernatant Decanting

The primary ventilation system was evaluated by performing thermal analyses for the expected retrieval operations. This evaluation included primary ventilation flows of 85.7, 200, 500, and 0.47 m³/s (0.04, 0.094, 0.24, and 1,000 ft³/min). A flow of 0.94 m³/s (200 ft³/min) is identified as the nominal ventilation flow for the bounding tank 241-AN-103.

Figure 4-1 is a schematic of a double-shell tank that shows the non-convective slurry layer, the convective liquid (supernatant), and selected GOTH_SNF code parameters. The GOTH_SNF

parameters are identified on the GOTH_SNF graphics shown in the following sections and in Figure 4-1 for clarification. A typical parameter is TLs3. The "T" denotes a temperature parameter, "L" denotes the liquid phase, and "s16" refers to the third cell in tank volume, which is in the settled solid layer. This is the waste temperature at this axial location, when the liquid and waste particles are in thermal equilibrium. The figure also shows the location of parameter TVs16. The "V" denotes vapor. This parameter is the vapor temperature in the dome space. Some labeling will also be provided on the GOTH_SNF graphs for additional clarity.

Figure 4-1. Description of GOTH_SNF Plot Parameters.

The primary ventilation system parametric analyses were performed with an annulus ventilation flow of $0.38 \text{ m}^3/\text{s}$ ($800 \text{ ft}^3/\text{min}$), which is identified as the nominal ventilation flow for tank 241-AN-102 (Appendix A). Four parametric analyses for 100 percent mixer pump power are shown in Table 4-1 as cases D1, D2, D6 and D11. More than a year of preretrieval normal tank operation was simulated to initialize the model to annual ambient meteorological conditions (Figure 4-2). The ambient conditions used for this analysis are described in Appendix D.

Figure 4-2. GOTH_SNF Model Initialization Analyses.*

To convert °F to °C, $t_{\text{C}} = (t_{\text{F}} - 32)/1.8$.

*Monthly average ambient temperature.

In the model, mixer pump operation was initiated approximately 30 days before peak summer temperatures to maximize the mixed-waste temperature near the peak summer temperature. The predicted mixed-waste temperatures for case D2 [0.94 m³/s (200 ft³/min) primary and 0.38 m³/s (800 ft³/min) annulus] are shown in Figure 4-3. The dome and supernatant temperatures are labeled on the figure. The remaining three curves show representative settled waste temperatures after the mixer pump operation is stopped and the waste is allowed to settle. The time axis of Figure 4-3 indicates the days from the beginning of the simulation. The mixer pump operation was initiated at 595 days (from the beginning of the simulation). The mixed-waste temperature increases nearly linearly. The mixed-waste temperature limit of 91 °C (195 °F) is exceeded at 625 days which is 30 days after the initiation of the mixer pumps. This simulation assumes the mixer pumps operate continuously at full power.

Figure 4-3. Typical Mixed-Waste Temperatures with Decanting (Case D2).

To convert °F to °C, $t_{°C} = (t_{°F} - 32)/1.8$.

The predicted maximum mixed-waste temperature for primary ventilation flow rates ranging from 0.04 m³/s (85.7 ft³/min) to 0.47 m³/s (1,000 ft³/min) are shown in Figure 4-4. The annulus system flow rate was constant at the nominal value of 0.38 m³/s (800 ft³/min). These simulations were performed for continuous, full-power mixer pump operation. These parametric analyses for primary ventilation flow rate show that the mixed-waste temperature limit is exceeded for primary system flow rate of 0.24 m³/s (500 ft³/min) or less. The maximum mixed-waste temperature is below the temperature limit for a primary flow rate of 0.47 m³/s (1,000 ft³/min). The mixed-waste temperature is just at the temperature limit for a primary ventilation flow rate between 0.33 m³/s (700 ft³/min) and 0.38 m³/s (800 ft³/min).

Figure 4-4. Maximum Mixed-Waste Temperature with Decanting and 100 Percent Pump Power.

To convert °F to °C, $t_{°C} = (t_{°F} - 32)/1.8$.

The GOTH_SNF simulation for 0.47 m³/s (1,000 ft³/min) primary flow [0.38 m³/s (800 ft³/min) annulus and full-power mixer pump operation] is shown in Figure 4-5. The mixed-waste temperatures are approaching a steady-state temperature below the 91 °C (195 °F) limit. A linear interpolation suggests that a primary flow rate of between 0.33 m³/s (700 ft³/min) and 0.38 m³/s (800 ft³/min) would result in a mixed-waste temperature equal to the temperature limit. Thus, a primary ventilation system flow rate larger than approximately 0.38 m³/s (800 ft³/min) is needed to maintain the mixed-waste temperature below the temperature limit for continuous full-power pump operation.

Figure 4-5. Mixed-Waste Temperatures for 0.47 m³/s (1,000 ft³/min) Primary Flow Rate.

To convert °F to °C, $t_{°C} = (t_{°F} - 32)/1.8$.

The time for the mixed-waste temperature to reach the 91 °C (195 °F) temperature limit are shown in Table 4-1, for the parametric cases where the predicted mixed-waste temperature exceeded the temperature limit (Cases D1 through D7). These data are shown graphically in Figure 4-6 for a range of primary ventilation flows. If the mixer pump run-time is limited to these values, the mixed-waste temperature will not exceed the temperature limit. Extrapolation of the curve in Figure 4-6 to zero primary ventilation flow [annulus system is still operating at 0.38 m³/s (800 ft³/min)] shows that the mixer pumps can operate for approximately 20 days with no primary ventilation flow. This is a result of the heat capacity of 9.14 m (30 ft) of waste.

Figure 4-6. Time to Temperature Limit with Decanting and 100 Percent Pump Power.

To convert ft³/min to m³/s, multiply by 4.719 474 E-04.

Parametric analyses also were performed for reduced mixer pump power. These simulations are summarized in Table 4-1 (cases D12 through D19). The mixer pump power was reduced by 50 percent. This corresponds to a single mixer pump operating continuously at full power or two mixer pumps operating continuously at 50 percent power. The results shown in Table 4-1 demonstrate that the maximum mixed-waste temperatures are less than the temperature limit for range of primary and annulus ventilation flow rates. The analyses did not reach full steady-state before termination of the mixer pump operation. The actual steady temperatures may be 2.8 to 5.6°C (5 to 10 °F) higher than shown in Table 4-1. These are still well below the temperature limit. These data are shown graphically in Figure 4-7. The Figure shows parametric analyses for the primary ventilation system flow for an annulus system flow rate of 0.38 m³/s (800 ft³/min). The mixed-waste temperatures are below the temperature limit for primary ventilation flows less than 0.047m³/s (100 ft³/min). The reduced pump power results are compared with the full power pump operation in Figure 4-7. It can be seen that a reduction in mixer pump power dramatically reduces the mixed-waste temperature.

Figure 4-7. Maximum Mixed-Waste Temperature for Reduced Mixer Pump Power.

To convert ft³/min to m³/s, multiply by 4.719 474 E-04.

4.1.2 Annulus Ventilation Evaluation with Supernatant Decanting

Parametric analyses also were performed to evaluate the annulus ventilation system for the bounding LAW tank. The annulus flow rates are summarized in Table 4-1. Parametric analyses were performed for a constant primary flow rate of $0.24 \text{ m}^3/\text{s}$ ($500 \text{ ft}^3/\text{min}$) (Cases D3 through D7) and $0.47 \text{ m}^3/\text{s}$ ($1,000 \text{ ft}^3/\text{min}$) (Cases D8 through D11). The results of the $0.24 \text{ m}^3/\text{s}$ ($500 \text{ ft}^3/\text{min}$) primary flow cases are shown in Figure 4-8. The figure shows there is a 2.8°C (5°F) temperature decrease in mixed-waste temperature as the annulus ventilation flow increases from $0 \text{ m}^3/\text{s}$ to $0.47 \text{ m}^3/\text{s}$ ($1,000 \text{ ft}^3/\text{min}$). Clearly, the annulus ventilation system only has a second-order effect on the mixed-waste temperatures. During this portion of the retrieval operation, the primary ventilation system removes most the mixer pump heat through supernatant evaporation. The annulus ventilation system at summer conditions removes approximately 7 percent of the mixer pump heat [at $0.38 \text{ m}^3/\text{s}$ ($800 \text{ ft}^3/\text{min}$)]. Thus, the effect of the annulus ventilation system on the mixed-waste temperature is small.

Figure 4-8. Annulus Flow Parametric for Maximum Mixed-Waste Temperature with Decanting and 100 Percent Pump Power.

To convert ft^3/min to m^3/s , multiply by $4.719\ 474\ \text{E-}04$.

The effect of the annulus ventilation system during mixer pump operation is further demonstrated in Figure 4-9. This figure shows the predicted time to reach the mixed-waste temperature limit for a range of annulus ventilation flows [with a constant $0.24 \text{ m}^3/\text{s}$ ($500 \text{ ft}^3/\text{min}$) primary ventilation flow rate]. The time to reach the temperature limit is increased by only 3 days as the annulus ventilation flow is increased from $0 \text{ m}^3/\text{s}$ to $0.47 \text{ m}^3/\text{s}$ ($1,000 \text{ ft}^3/\text{min}$). This again illustrates that during mixer pump operation the primary ventilation system is the most effective system for heat removal and the annulus system provides only limited heat removal.

Figure 4-9. Annulus Flow Parametric for Time to Temperature Limit with Decanting and 100 Percent Pump Power.

To convert ft^3/min to m^3/s , multiply by $4.719\,474\text{ E-}04$.

4.1.3 Waste Resettling with Supernatant Decanting

After the supernatant has been decanted and dilution water added to the tank, the mixer pump will mix the waste, resulting in dilution of the waste and a suspension of the undissolved waste into the supernatant. If mixer pump operation is suspended for any reason, the suspended waste will settle resulting in a settled solids layer. This waste is initially expected to settle to a fluffed state with the particle volume fraction less than the pre-mixed settled waste. A fluffing factor of 2.0 is assumed for these analyses. Subsequent compaction of the settled waste eventually will reduce the fluffing factor to unity. Waste compaction is not considered in the parametric analyses. With supernatant decanting strategy, a large fraction of the waste is expected to go into solution. Thus, even with a fluffing factor of 2.0, the settled solids layer after mixer pump

operation [0.45 m (1.46 ft)] is significantly less than the pre-decanted settled waste layer [3.66 m (12 ft)].

The predicted resettled waste temperatures following the termination of mixer pump operation are shown in Figure 4-10. This analysis was performed for a primary ventilation flow rate of $0.94 \text{ m}^3/\text{s}$ (200 ft^3/min) and annulus system flow rate of $0.38 \text{ m}^3/\text{s}$ (800 ft^3/min). These are the nominal flows for both systems. The figure shows that the waste and supernatant temperatures decrease immediately after the mixer pump operation is stopped. The temperatures decrease to a new settled waste temperature in about 30 days. The temperature after waste resettling is higher than the pre-mixed temperatures. However, settled waste temperatures are well below the settled waste temperature limit of 102°C (215°F). The low temperature is a result of the small heat load for the LAW tanks and the dilution of the waste resulting from the supernatant decanting and subsequent mixing. This significantly reduces the settled solids depth.

Figure 4-10. Resettled Waste Temperatures with Decanting.

To convert $^{\circ}\text{F}$ to $^{\circ}\text{C}$, $t_{\text{C}} = (t_{\text{F}} - 32)/1.8$.

The settled waste temperatures are summarized in Table 4-1. These temperatures are well below the settled waste temperature limit for the parametric analyses. The nominal primary and annulus system flow rates of $0.094 \text{ m}^3/\text{s}$ (200 ft^3/min) and $0.38 \text{ m}^3/\text{s}$ (800 ft^3/min) flow provide significantly more cooling than required during waste resettling. Parametric cases D6 and D2 show the effect of primary ventilation flow on the resettled waste temperature. A reduction of $0.14 \text{ m}^3/\text{s}$ (300 ft^3/min) flow results in a 7.8°C (14°F) temperature increase in the waste

temperature. Parametric case D3 shows that with 0.24 m³/s (500 ft³/min) primary flow rate and 0 annulus flow, the resettled waste temperature is only 44.4 °C (112 °F). Thus, a primary flow of 0.094 m³/s (200 ft³/min) with no annulus ventilation flow should result in a settled waste temperature of approximately 52 °C (126 °F). This is well below the settled waste temperature limit of 90.6 °C (195 °F). The resettled waste temperatures with supernatant decanting will be below the temperature limit with only minimal primary ventilation flow.

The results of the parametric analyses can be used to evaluate the impact of a loss of ventilation cooling after waste resettling. The parametric analyses shown in Table 4-1 show that the resettled waste temperatures for the decanted cases are approximately 57 °C (100 °F) below the temperature limit of 102 °C (215 °F) and 57 °C (135 °F) below the 121 °C (250 °F) TSR limit. Figure 4-6 shows that with no primary ventilation flow, it takes nearly 25 days to heat the mixed-waste temperature more than 56 °C (100 °F) to the mixed-waste temperature limit. This heat rate is accomplished with 440 kW (1,500,000 BTU/h) of pump heat. The heat load for tank 241-AN-103 is less than 11.7 kW (40,000 BTU/h) (Table 2-4). It would clearly take many months to heat the settled waste to temperatures approaching the TSR limit, providing sufficient time to restore lost ventilation cooling. The risk of exceeding the TSR limit for a loss of ventilation flow, following mixing with decanting, is negligible.

4.2 MIXER PUMP OPERATION WITHOUT SUPERNATANT DECANTING

As described in Section 2.3.3, mixer pump operation without supernatant decanting assumes that the pumps are placed in the tank, then the waste is mixed and allowed to resettle. Mixer pump operation without supernatant decanting results in more dissolved waste in the supernatant, higher vapor suppression (30 percent of water compared with 60 percent of water for the decanted supernatant after waste mixing) and less settled waste dissolved into the supernatant. Therefore, the resettled solid layer is thicker after pump operation. Although this is not the expected retrieval scenario, it provides a conservative assessment of requirements for the primary and annulus ventilation systems. This scenario also provides a parametric study for the effects of waste dilution.

Parametric analyses were performed for both the primary and annulus ventilation systems. The results of 14 parametric analyses are summarized in Table 4-2. The primary ventilation evaluation is presented in Section 4.2.1, and the annulus ventilation system evaluation is presented in Section 4.2.2.

Table 4-2 summarizes the predicted maximum, mixed-waste temperature during mixer pump operation. The predicted mixed-waste temperatures shown in Table 4-2 exceed the temperature limit for primary ventilation flows up to 0.47 m³/s (1,000 ft³/min). The mixed-waste temperatures are below the mixed-waste temperature limit for a primary ventilation flow of 1.42 m³/s (3,000 ft³/min). The requirement for higher primary ventilation flow (compared with the decanted case) is a direct result of the larger supernatant vapor suppression, which reduces the effectiveness of evaporation cooling. The time to reach the temperature limit is shown in the last column of the table.

The results of the predicted settled waste temperatures are not shown in Table 4-2 but are presented in Section 4.3.3.

Table 4-2. Summary of Results for Nondecanted Cases.

Pump Power	Primary Flow m ³ /s (ft ³ /min)	Annulus Flow m ³ /s (ft ³ /min)	Run No.	Pump Operation		
				Mixed-Waste Temperature °C (°F) [91 °C (195 °F) Temp Limit]	Time to Reach Temperature Limit (Days)	Moisture Carryover kg/s (lbm/h)
100%	0.04 (85.7)	0.38 (800)	UD1	>91 (195)	23	0.0073 (58)
	0.094 (200)	0.38 (800)	UD2	>91 (195)	25	0.0168 (133)
	0.24 (500)	0.38 (800)	UD3	>91 (195)	27	0.318 (252)
	0.47 (1,000)	0.38 (800)	UD4	>91 (195)	30	0.09 (713)
		0.47 (1,000)	UD5	>91 (195)	31	0.69 (551)
	1.42 (3000)	0	UD6	87 (189)	NA	0.136 (1080)
		0.24 (500)	UD7	87 (188)	NA	0.13 (1030)
		0.38 (800)	UD8	86 (187)	NA	0.127 (1010)
50%	0.04 (85.7)	0.38 (800)	UD9	>91 (195)	49	0.0066 (52)
	0.24 (500)	0.38 (800)	UD10	>91 (195)	57	0.0218 (173)
	0.47 (1,000)	0	UD11	>91 (195)	65	0.0386 (306)
		0.094 (200)	UD12	>91 (195)	66	0.0354 (281)
		0.24 (500)	UD13	>91 (195)	69	0.0326 (259)
		0.38 (800)	UD14	>91 (195)	72	245

4.2.1 Primary Ventilation Evaluation without Supernatant Decanting

The GOTH_{SNF} analyses of the bounding LAW tank for 0.094 m³/s (200 ft³/min) primary flow and 0.38 m³/s (800 ft³/min) annulus flow and full-power mixer pump operation, is shown in Figure 4-11. The mixer pump operation begins 595 days from the beginning of the simulation. The first portion of the analyses was used to initialize the waste and soil. The full-power pump heat results in a rapid increase in mixed-waste temperature. The large vapor suppression (30 percent of water) significantly reduces heat removal by evaporation, which decreases the effectiveness of the primary ventilation system. The mixed-waste temperatures exceed the 91 °C (195 °F) temperature limit in 25 days.

Figure 4-11. Typical Mixed-Waste Temperatures without Supernatant Decanting.

To convert °F to °C, $t_{°C} = (t_{°F} - 32)/1.8$.

The results of the parametric analyses for full-power pump operation are shown in Table 4-2 (parametric analyses UD1 through UD8). The predicted mixed-waste temperatures exceed the temperature limit for the parametric analyses. The time to reach the temperature limit is also summarized in Table 4-2. Figure 4-12 shows the result of parametric analyses for the primary ventilation system, with a constant 0.38 m³/s (800 ft³/min) annulus flow rate. Increasing the primary ventilation from 0.47 m³/s (1,000 ft³/min) to 1.42 m³/s (3,000 ft³/min) decreases the maximum mixed-waste temperature to below the temperature limit. Figure 4-12 compares the decanted and nondecanted cases. The effect of the increased supernatant vapor suppression is significant. Although the nondecanted case is conservative, and not consistent with the expected retrieval scenario, it provides parametric analyses for the supernatant vapor suppression.

Parametric analyses were performed for reduced mixer pump power (50 percent of full power). The results of these analyses are shown in Table 4-2 (case UD9 through UD14). The mixed-waste temperatures exceed the temperature limit for annulus ventilation flows up to 0.47 m³/s (1,000 ft³/min). The times to reach the temperature limit are doubled because of the 50 percent reduction in mixer pump power. The time to reach the temperature limit for the 50 percent pump power is shown in Figure 4-12.

Figure 4-12. Time to Temperature Limit Without Decanting.

To convert ft³/min to m³/s, multiply by 0.0283.

4.2.2 Annulus Ventilation Evaluation without Supernatant Decanting

Parametric analyses were performed for the annulus ventilation system for full pump power operation. The results are summarized in Table 4-2 (cases UD11 through UD14) and shown in Figure 4-13. The primary ventilation system flow rate was constant at $0.47 \text{ m}^3/\text{s}$ ($1,000 \text{ ft}^3/\text{min}$). These analyses were performed for 50 percent mixer pump power. The results are similar to the decanted cases. Annulus ventilation flow rates up to $0.47 \text{ m}^3/\text{s}$ ($1,000 \text{ ft}^3/\text{min}$) make only a small change in the time to reach the temperature limit. Comparisons with Table 4-1 (cases D3 through D7) show that the effect is larger for the nondecanted cases than the decanted cases. This is a result of the diminished heat removal of the primary system because of the increased vapor suppression. The primary ventilation, however, still dominates the heat removal during the mixer pump operation.

Figure 4-13. Annulus Ventilation Parametric for Time to Temperature with Decanting and 50 Percent Pump Power.

To convert ft^3/min to m^3/s , multiply by 0.0283.

4.2.3 Waste Resettling without Supernatant Decanting

The post mixer pump operation and subsequent waste resettling were evaluated for the nondecanted waste (no supernatant decanting). The GOTH_SNF analyses for $0.094 \text{ m}^3/\text{s}$ ($200 \text{ ft}^3/\text{min}$) primary flow rate and $0.38 \text{ m}^3/\text{s}$ ($800 \text{ ft}^3/\text{min}$) annulus flow rate are shown in Figure 4-11. The resettled waste depth without supernatant decanting is 7.19 m (23.6 ft) (Table 2-5). The waste resettled waste depth for decanted cases is less than 0.61 m (2 ft).

The effect of the larger waste depth can be seen by comparing Figures 4-10 and 4-11. The waste and supernatant temperature decrease immediately after the mixer pump operation is ended for the decanted cases. For the nondecanted cases, the temperature increases initially and then decreases more slowly. The initial increase for the nondecanted parametric analyses is less than 5.6 °C (10 °F). If the mixer pumps are stopped before the mixed-waste temperatures reach the 91 °C (195 °F) limit, the resettled waste for the bottom 4.57 m (15 ft) will not exceed the 102°C (215 °F) settled waste temperature limit. However, it should be noted that mixer pump operation should be ended at least 5.6 °C (10 °F) below the mixed-waste temperature limit. This will prevent the settled waste temperatures for the top 4.57 m (15 ft) of the waste from exceeding the 91 °C (195 °F).

The analyses were not run to complete steady state conditions. Figure 4-11 shows that the waste has not reached thermal equilibrium after 400 days. These analyses assume a fluffing factor of 2.0 with no waste compaction. The assumption of no compaction is not valid after such long periods.

4.3 PRIMARY VENTILATION MOISTURE CARRYOVER

This evaluation was performed through comparison of predicted waste temperatures with applicable temperature limits. The moisture carryover (mass of steam carried from the tank dome space by the primary ventilation system) is not a consideration for safety limits; however, moisture carryover is an important parameter for the design and operation of the primary ventilation system. This section provides an overview of this important parameter for the parametric analyses performed for tank 241-AN-103.

The results of the predicted moisture carryover are summarized in Tables 4-1 and 4-2. The values shown in the tables are the moisture carryover at the steady-state supernatant temperature during mixer pump operation. If the supernatant temperature exceeded the temperature limit, the value reported in the tables is the moisture carryover at the mixed-waste temperature limit of 90.6 °C (195 °F). The moisture carryover for 0.47 m³/s (1,000 ft³/min) primary and 0.38 m³/s (800 ft³/min) annulus flow rate with full-power pump operation is shown in Figure 4-14. Moisture carryover only becomes important during the mixer pump operation. Figure 4-14 shows that the moisture carryover reaches a maximum near 0.136 kg/s (0.3 lbm/s). This is approximately 0.000131 m³/s (125 gal/h).

Figure 4-14. Predicted Moisture Carryover for Nominal Ventilation Flow.

To convert lbm/s to kg/s, multiply by 0.454.

The moisture carry over is a strong function of the primary flow rate. Figure 4-15 shows the predicted moisture carryover as a function of primary ventilation flow for 50 percent and 100 percent mixer pump power. The annulus system flow was a constant $0.38 \text{ m}^3/\text{s}$ ($800 \text{ ft}^3/\text{min}$). The figure shows that the moisture carryover increases significantly with primary ventilation flow, as expected, and decreases significantly with reduced mixer pump power.

Figure 4-15 shows the predicted moisture carryover for $0.38 \text{ m}^3/\text{s}$ ($800 \text{ ft}^3/\text{min}$) annulus flow rate with full-power pump operation without supernatant decanting. The vapor suppression for the nondecanted case is 50 percent of the suppression for the decanted case (Table 2-3). The lower evaporation rate is comparable to the 50 percent pump power with supernatant decanting.

Figure 4-15. Moisture Carryover for Primary Ventilation Flows.

To convert lbm/s to kg/s, multiply by 0.454.

To convert ft³/min to m³/s, multiply by 0.0283.

5.0 CONCLUSIONS

5.1 RETRIEVAL WITH SUPERNATANT DECANTING

The following conclusions are derived from the parametric analyses with decanting the supernatant and back filling the tank with water before mixer pump operation.

1. The minimum primary ventilation system flow is between $0.33 \text{ m}^3/\text{s}$ ($700 \text{ ft}^3/\text{min}$) and $0.38 \text{ m}^3/\text{s}$ ($800 \text{ ft}^3/\text{min}$) to keep the waste below the LCS/LCO temperature limit when operating two mixer pumps at full power indefinitely.
2. The number of days of full-power mixer pump operation possible before reaching the LCS/LCO temperature limit is very sensitive to primary ventilation system flow.
 - The mixer pumps may operate up to 20 days with no primary ventilation system flow.
 - The mixer pumps may operate up to 34 days with a primary ventilation system flow of $0.094 \text{ m}^3/\text{s}$ ($200 \text{ ft}^3/\text{min}$).
 - Mixer pump operating time is not limited with a primary ventilation system flow of $0.47 \text{ m}^3/\text{s}$ ($1,000 \text{ ft}^3/\text{min}$).
3. Mixer pump operating time is not limited when operating at 50 percent power as long as the primary ventilation system flow is greater than $0.04 \text{ m}^3/\text{s}$ ($90 \text{ ft}^3/\text{min}$).
4. The maximum waste temperature reached during full-power mixer pump operation is insensitive to annulus ventilation system flow.

5.2 RETRIEVAL WITHOUT SUPERNATANT DECANTING

The following conclusions are derived from the parametric analyses if the supernatant is not decanted before mixer pump operation.

1. The decreased vapor pressure resulting from not decanting decreases the allowable full-power mixer pump time of operation significantly.
2. The maximum waste temperature reached during full-power mixer pump operation is insensitive to annulus ventilation system flow.
3. A primary ventilation system flow near $1.42 \text{ m}^3/\text{s}$ ($3,000 \text{ ft}^3/\text{min}$) is required for unlimited full-power mixer pump operation
4. Mixer pump operating time is limited even when operating at 50 percent power for primary ventilation flow rates less than or equal to $0.47 \text{ m}^3/\text{s}$ ($1,000 \text{ ft}^3/\text{min}$).

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6.0 RECOMMENDATIONS

The following recommendations are based on the results of this parametric analysis for LAW feed retrieval.

1. It is recommended that the primary ventilation system be designed to provide a minimum of $0.094 \text{ m}^3/\text{s}$ ($200 \text{ ft}^3/\text{min}$) for heat removal when the mixer pumps are operating.

Basis: The mixer pumps can be operated at full power approximately 32 days for decanted case and 27 days for the nondecanted case with a primary ventilation system flow of $0.094 \text{ m}^3/\text{s}$ ($200 \text{ ft}^3/\text{min}$). This flow rate is within the existing system capability and provides a design factor of 3 over the estimated 10 days for dissolution of soluble waste. Increasing the flow rate for heat removal to $0.24 \text{ m}^3/\text{s}$ ($500 \text{ ft}^3/\text{min}$) increases the pump operating time insignificantly (approximately 3 days and is not a sufficient basis for increasing the capability of the installed systems). It should be noted that other drivers (e.g., maintaining vacuum with risers open) might require increased capacity. Evaluation of these other drivers, however, is outside the scope of this analysis.

2. It is recommended that the annulus ventilation system be designed to be capable of providing a minimum of $0.094 \text{ m}^3/\text{s}$ ($200 \text{ ft}^3/\text{min}$) flow.

Basis: Although the analyses show that no annulus flow is required during mixer pump operation, the analysis is insufficient to determine that no flow will ever be required. For instance, this analysis did not address off-normal events that may require annulus flow to mitigate them (e.g., loss of primary cooling). In addition, the recommended flow rate will be sufficient to continue using the CAMs for leak detection. Lastly, this flow is sufficient to maintain the flexibility to retrieve a tank of waste without decanting first. Additional analysis might show that the temperature in the solids could be controlled adequately without annulus flow.

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7.0 REFERENCES

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APPENDIX A

**TANK SELECTION FOR A PARAMETRIC STUDY TO CHARACTERIZE
LOW-LEVEL WASTE TANK HEAT REMOVAL ALTERNATIVES FOR
PHASE 1 SPECIFICATION DEVELOPMENT**

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LIST OF TERMS

DST	double-shell tank
HMS	Hanford Meteorological Station
LLW	low-level waste
LAW	low activity waste
TSR	Technical Safety Requirements

APPENDIX A

TANK SELECTION FOR A PARAMETRIC STUDY TO CHARACTERIZE LOW-LEVEL WASTE TANK HEAT REMOVAL ALTERNATIVES FOR PHASE 1 SPECIFICATION DEVELOPMENT

A1.0 INTRODUCTION

This Appendix provides the basis for selecting the tank analyzed by the parametric thermal analyses to quantify heat removal requirements for the low-activity waste (LAW) tanks associated with Phase 1 waste feed delivery. The parametric analysis will determine the maximum ventilation flow required to control waste temperature. This flow will then be included as a performance requirement in the DST Ventilation Subsystem specification. The bounding waste tank will be selected as the worst case Phase 1, waste feed delivery LAW tank. The potential maximum temperature of a tank is a function of both the radioactive decay heat and sludge depth in a tank.

Tables A2-1 list the waste types and volumes in the tanks that are scheduled for retrieval during Phase 1 as documented by the Waste Tank Summary Report (HNF-EP-0182-137) and the Tank Characterization Reports. The Waste Tank Summary Report differentiates between double-shell slurry (DSS) and saltcake; whereas, the Tank Characterization Reports combine them as "double-shell slurry." As used in the Waste Tank Summary Report, DSS is considered to be insoluble and is conducive to the formation of a fluffed (fluffing) solids layer.

The two factors relevant to selecting a tank for this study are the decay heat load and depth of solids after fluffing. The maximum temperature in the solids is directly related to the decay heat load in the solids. For this analysis, it is assumed that all of the decay heat is in the insoluble fraction. The maximum waste temperature also is related directly to the depth of solids. Fluffing increases the heat conduction path length, resulting in higher settled solids temperatures.

For tank selection and this analysis, it was assumed that fluffing will increase the solids depth of DSS by a factor of two, but that saltcake will not fluff. The criterion used to select a bounding tank was the product of the solids depth after fluffing and the heat load. By inspection of the data in Table A2-1, tank 241-AN-103 will have the highest temperatures in the solids. As a result, this tank was selected as the bounding tank for this analysis.

Table A2-1. Phase 1 LAW Feed Tank Contents and Heat Load. (2 sheets)

Tank	Per HNF-EP-0182-137				Per Tank Characterization Reports (TCR)				
	Supernatant Volume (gal)	Double-Shell Slurry Volume (gal)	Salt Cake Volume (gal)	Total Waste Volume (gal)	Total Waste Volume (gal)	Supernatant Volume (gal)	Double-Shell Slurry Volume (gal)	Heat Load Btu/h	Applicable TCR (additional reports)
241-AP-101	1,114,000	0	0	1,114,000	1,116,000	1,116,000	0	10,800	HNF-SD-WM-ER-357
241-AP-102	1,092,000	0	0	1,092,000	1,097,000	1,097,000	0	15,400	HNF-SD-WM-ER-358
241-AP-104	24,000	0	0	24,000	27,000	27,000	0	309	HNF-SD-WM-ER-596
241-AP-105	676,000	0	89,000	765,000	771,000	682,000	89,000	10,310	HNF-SD-WM-ER-360
241-AN-101	127,000	0	33,000	160,000	117,000	84,000	33,000	2,380	HNF-SD-WM-ER-578
241-AN-102	971,000	0	89,000	1,060,000	1,064,000	975,000	89,000	32,400 41,000	HNF-SD-WM-ER-545 (WHC-SD-WM-SARR-010)
241-AN-103	501,000	457,000	0	958,000	955,000	545,000	410,000	36,300 45,000	HNF-SD-WM-ER-702 (WHC-SD-WM-SARR-010)
241-AN-104	603,000	0	449,000	1,052,000	1,055,000	600,500	454,500	39,600	HNF-SD-WM-ER-690
241-AN-105	636,000	0	489,000	1,125,000	1,129,000	1,129,000	0	33,600	HNF-SD-WM-ER-678,
241-AN-106	22,000	0	17,000	39,000	282,000	265,000	17,000	450	HNF-SD-WM-ER-569
241-AN-107	797,000	0	247,000	1,044,000	1,058,000	924,000	134,000	27,500	HNF-SD-WM-ER-600
241-AW-101	819,000	0	306,000	1,125,000	1,124,000	818,000	306,000	31,900	HNF-SD-WM-ER-470
241-AW-104	888,000	0	231,000	1,119,000	1,119,000	888,000	231,000	232 37,000	HNF-SD-WM-ER-453 (WHC-SD-WM-SARR-010)
241-SY-101	604,000	0	585,000	1,189,000	1,113,000	1,072,000	41,000	40,300	HNF-SD-WM-ER-490

To convert gallons to liters, multiply by 3.785.

^aDouble-Shell Slurry: Waste that exceeds the sodium aluminate saturation boundary in the evaporator without exceeding receiver tank composition limits. For reporting purposes, double-shell slurry is considered a solid.

^bSalt Cake: Results from crystallization and precipitation after concentration of liquid waste, usually in an evaporator. If salt cake is layered over sludge, it is only possible to measure total solids volume.

^cSludge: Solids formed during sodium hydroxide additions to waste. Sludge usually was in the form of suspended solids when the waste was originally received in the tank from the waste generator.

Table A2-1. Phase 1 LAW Feed Tank Contents and Heat Load. (2 sheets)

HNF-EP-0182-137, 1999, <i>Waste Tank Summary Report for Month Ending August 31, 1999</i> , Fluor Daniel Hanford, Inc., Richland, Washington.
HNF-SD-WM-ER-357, 1998, <i>Tank Characterization Report for Double-Shell Tank 241-AP-101</i> , Rev. 0, COGEMA Engineering Corporation, Richland, Washington.
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HNF-SD-WM-ER-453, 1998, <i>Tank Characterization Report for Double-Shell Tank 241-AW-104</i> , Rev. 0-A, Lockheed Martin Hanford Corporation, Richland, Washington.
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WHC-SD-WM-SARR-010, 1995, <i>Heat Removal Characteristics of Waste Storage Tanks</i> , Rev. 1, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX B

**MEMORANDUM – “INTERIM GUIDANCE ON LAW
RETRIEVAL STRATEGY”**

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INTEROFFICE MEMO

LOCKHEED MARTIN

From: Waste Feed Delivery System Definition 73600-99-006
Phone: 373-3824 R2-75
Date: June 22, 1999
Subject: INTERIM GUIDANCE ON LAW RETRIEVAL STRATEGY

To: A. F. Choho R3-73

cc: P. J. Certa R3-73
T. W. Conrads R3-73
WFD File/LB R3-73

References: (1) HNF-4669, Rev. 0, Decision Document for the Low Activity Waste Retrieval Strategy Decision, dated June 1999.

(2) HNF-4347, Rev. 0A, Draft, Alternative Generation Analysis, dated April 29, 1999.

The decision on the LAW retrieval strategy is being developed and is awaiting the results of modeling the likelihood and consequences of degassing the tank waste under several retrieval scenarios. The modeling is due to be completed by the end of July, and a final decision on the strategy is due by the end of August.

Until you receive further instructions from me, please use the attached information as interim guidance for the development of specifications. This guidance results from the decision support board's recommendations on May 7, 1999.

If you have any questions or require additional information, please contact me at 373-3824.

R. L. Treat
Manager

slv

Attachment

Interim Guidance on the LAW Retrieval Strategy

1.0 Guidance

1.1 Preferred Phase 1 Retrieval Strategy for Low Activity Waste

Change the current baseline case for the retrieval of low activity waste from tanks AN-103, AN-104, AN-105 and AW-101, and adopt the following sequence:

- (1) Install a transfer pump in the supernatant only and remove the existing clarified supernatant without disturbing the underlying settled solids.
- (2) Using additional water and tank space created by the removal of the supernatant, install mixer pumps in the tanks and mix the contents, dissolving the soluble salts.
- (3) Allow the undissolved solids to settle and then remove the clarified supernatant from the tank.

A schematic of the recommended approach is shown in the attached figure.

1.2 Accelerate the Schedule for the Initial Retrieval of Supernatant

Accelerate the schedule for the retrieval of supernatant from tanks AN-104 and/or AN-105 in order to confirm equipment designs early so adjustments can be made if necessary.

1.3 Additional Guidance

In implementing the retrieval approach outlined in 1.0 above, include the following guidance:

- (1) Flexibility in Dilution During the Removal of the Supernatant

The in-line dilution system should have the capacity to increase the dilution flow rate sufficiently to dissolve entrained solids should a waste rollover occur during the removal of the initial volume of supernatant.

- (2) Evaluation of Blending to Bring Out-of-Specification Feed into Specification

Evaluate the potential flexibility provided by blending waste in order to achieve compliance with sulfate specifications for tank AN-104.

2.0 Considerations

The guidance above is based primarily on the considerations discussed below.

2.1 Preferred Phase I Retrieval Strategy for Low Activity Waste

- (1) It was assumed that removing the supernatant provides no greater risk of generating a rollover than installation and controlled operation of mixer pumps.
- (2) The baseline process strategy is perceived to have a high risk to the construction personnel, if a large waste rollover were to occur during installation of the mixer pumps. The recommended strategy reduces this risk by first installing a small decanting pump and removing the bulk of the supernatant. It is thought that a waste rollover could occur during the removal of the supernatant, if it occurs at all. After the supernatant is removed, then the mixer pumps would be installed.
- (3) The baseline process strategy has a high risk of late feed delivery due to slow settling solids after the initial mixing of the tank contents. The recommended strategy reduces this risk by removing the supernatant without mixing and subsequently mixing and dissolving in water added to the tank.
- (4) The baseline strategy calls for installation of mixer pumps in the full tanks, some of which have only 10,000 gallons of headspace for additional water addition. The recommended strategy avoids this problem by delaying mixer pump installation until the tank(s) is about half empty. This provides the opportunity to add a considerable quantity of water as needed to install the mixer pumps.
- (5) Like the baseline, the recommended strategy leaves most of the undissolved solids in the source tank. This was deemed to be preferable to transferring solids to the staging tank(s), which would then require more frequent cleaning to remove settled solids.
- (6) It is possible, perhaps likely, that the initial removal of supernatant will initiate a waste rollover. It is speculated that control of the rate at which the initial volume of supernatant is removed from the tank might reduce the possibility of a rollover and allow progressive gaseous releases.
- (7) The recommended strategy includes the flexibility to sample and qualify the dissolved solids feed batch in the source tank. This would reduce the staging tank requirements.
- (8) The baseline and the recommended strategy both deliver the initial supernatant waste separately from the dissolved solids. The chemical

composition of the supernatant and the solids might be sufficiently different that one could be out of specification when a mixture of both would be in specification. This appears to be the case for the dissolved solids batch from tank AN-104.

2.2 Accelerate the Schedule for the Initial Retrieval of Supernatant

- (1) Accelerating the schedule for retrieval of the initial supernatant provides an early opportunity to observe the waste behavior during the removal of the supernatant and allows for the early installation and operation of mixer pumps to be used to dissolve soluble solids. This early test of the process and equipment will allow time for changes if they are needed before continuous production starts.
- (2) Accelerating the schedule for retrieval of the initial supernatant allows the removal of a tank from flammable gas watch list, if it can be shown that the gas is released during the removal of the supernatant.
- (3) Accelerating the schedule for the retrieval of the initial supernatant allows the RPP to demonstrate that successful retrieval has occurred at an early date.

DSB RECOMMENDED LAW RETRIEVAL STRATEGY:
DECANT WITH STAGGERED PUMP INSTALLATION

*This Strategy recommended by the
Decision Support Board during the
meeting on 6-7 May, 1999*

Draft 6/1/99

APPENDIX C

**PHYSICAL PROPERTIES OF TANK 241-AN-103 WASTE FOR
USE IN HEAT REMOVAL ALTERNATIVES STUDY**

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CORRESPONDENCE DISTRIBUTION COVERSHEET

Author
K. Sathyanarayana, 376-2527

Addressee
C. E. Grenard, NHC

Correspondence No.
FH-0003661

Subject: PHYSICAL PROPERTIES OF TANK 241-AN-103 WASTE FOR USE IN HEAT REMOVAL
ALTERNATIVES STUDY

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Fluor Hanford
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FLUOR GLOBAL SERVICES

July 14, 2000

FH-0003661

Mr. Charles E. Grenard MSIN R3-73
Numatec Hanford Corporation
Post Office Box 1300
Richland, Washington 99352-1300

Dear Mr. Grenard:

PHYSICAL PROPERTIES OF TANK 241-AN-103 WASTE FOR USE IN HEAT REMOVAL ALTERNATIVES STUDY

This memo is in response to the request for the documentation of the physical parameters used in the thermal analysis for Tank 241-AN-103 Heat Removal Alternatives Study. The physical parameters used are given in Table 1 and 2.

Table 1. Tank 241-AN-103 Waste Properties

Waste Property	Parameter Value
Solids Density	187.2 lbm/ft ³ (3gm/cc)
Liquid Heat Capacity	0.7643 Btu/lbm-°R (3.2 kJ/kg-°K)
Solids Heat Capacity	0.20 Btu/lbm-°R (0.84 kJ/kg-°K)
Thermal Conductivity of Aqueous Solution	90% of the value of water
Thermal Conductivity of Solids	5.0 Btu/hr-ft-°R (8.65 W/m-°K)
Total Heat Generation Rate in the Waste	36,300 Btu/hr (10.64 kW)

Table 2. Undiluted and Diluted Waste Parameters

Waste Property	Undiluted Waste	Diluted Waste
Fluffed Sludge Height	24.8 ft (7.56 m)	1.46 ft (0.445 m)
Volume Fraction of Solids	0.163	0.10
Liquid Vapor Pressure	31% of the value of water	60% of the value of water

Mr. C. E. Grenard
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1. Solids Density

The density of waste solids was estimated from various ESP simulations. Additional ESP simulations were performed and the density values derived are tabulated below corresponding to the average waste temperature. (See Attachment 1)

Waste Temperature, °F	Solids Density, gm/cc	Liquid Density, gm/cc
104	2.82	1.38
140	3.48	1.35
176	3.5	1.33
212	3.45	1.32
248	3.2	1.39

The solids density of 3 gm/cc was selected at the time based on earlier calculations performed at 104 and 195 °F. Based on the results of those two calculations, it was assumed that solids density of 3 gm/cc is more reasonable. However, the recent ESP calculations show that a solids density of 3.5 gm/cc is more appropriate. Since for thermal analysis calculations, the total waste heat load and the nonconvective waste (sludge) volume were defined independently and are not based on solids density, the results and therefore, the conclusions will not be affected by this value. The solids density parameter in GOTH calculations will become important for calculating the settling time. The settling time, however, is defined independently for these analyses and so the value has no effect on the thermal analysis results.

2. Liquid Specific Heat

Specific Heats of Solutions in the System NaNO₃-H₂O

Temperature F	NaNO ₃ Solution Concentration (wt%)		
	20.12	30.19	40.19
	C _p Btu/lmb-F	C _p Btu/lmb-F	C _p Btu/lmb-F
77	0.837	0.777	0.714
122	0.839	0.775	0.712
167	0.840	0.774	0.711
212	0.840	0.774	0.710

The liquid specific heat for 30 wt. % sodium nitrate is 0.77 (Btu/lbm-° F) (3.22 KJ/Kg-K).

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Reference: Puchkov, Matveeva, and Baranova, "Specific Heats of Aqueous Solutions of Sodium and Potassium Nitrates at Temperatures in the Range 25-340 °C," Zhurnal Prikladnoi Khimii, Vol. 46, No.2, pp.443-445.(Translated Feb 1973)

3. Solids Specific Heat

A value of 0.2 Btu/lbm-°F was used for the solids in the waste. For solids representing minerals and impervious rocks, the heat capacity is given by the formula:

$$C_p = 0.55 / \text{Specific Gravity} = 0.18 \approx 0.2$$

Using a solids specific gravity of 3 gm/cc, it is approximately equal to 0.2 Btu/lbm-°F.

Reference: Touloukian, Y. S., W. R. Judd and R. F. Roy, "CINDAS Data Series on Material Properties," Vol. 11-2, 1981, page 413, McGraw-Hill Co.

4. Thermal Conductivity of Aqueous Solution

The mixture thermal conductivity for dilute solutions usually decreases with an increase in the concentration of the dissolved salts. The mixture conductivity has been estimated using the formula given Perry's Chemical Engineer's Handbook. For details of the calculation see Attachment 2. The thermal conductivity of the aqueous phase in AN-103 is 90% of that of water.

Reference: Perry, R. H., D. W. Green and J. O. Maloney, Perry's Chemical Engineers Handbook, 6th Edition, 1984, Page 3-285.

5. Thermal Conductivity of solids

The solids in the tank were treated as containing only a single component whose thermal conductivity has been assumed as 5 Btu/hr-ft-R. This is supported by the values of thermal conductivity for minerals and ceramics. The thermal conductivity of some solid salts (CRC Handbook P. E-4) such as Sodium Chloride and Potassium Chloride are about 5.3 Btu/hr-ft-R. Also for series thermal conductivity model used in GOTH calculations, the effect of solids thermal conductivity on the mixture thermal conductivity is negligible (For explanation see Reference 1, Section 4.2.5 and Figure 4.1) because the volume fraction of solids in the sludge (slurry) is less than 20%.

Reference: 1. Sathyanarayana, K., 2000, "Thermal Analysis of High Level Waste Tanks for Phase 1 Waste Feed Delivery," HNF-5386, Fluor Hanford Inc., Richland, Washington.

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2. CRC, 1975, CRC Handbook of Chemistry and Physics, 56th Edition, CRC Press, Inc., Cleveland, Ohio

6. Heat Generation Rate

The total heat generation rate in the tank waste is 36,300 Btu/hr as per the Tank Waste Characterization Report.

Reference: Kupfer, M.J., 1998, "Tank Characterization Report for Double -Shell Tank 241-AN-103," HNF-SD-WM-ER-702, Rev. 0-B, COGEMA Engineering Corp., Richland, Washington.

7. Fluffed Sludge Height

a) Undiluted Waste

The double shell sludge volume as per the characterization report and shown in Table A2-2 of RPP-5643 is 410,000 gallons. Based on this volume and assuming the fluffing factor of 2, the fluffed sludge height is estimated to be 24.8 ft. (See Attachment 3, Page 3 of 3, Eqn. 6.21.)

b) Diluted Waste

The following parameters are used to calculate the fluffed sludge height for diluted waste.

Solids density = 3 gm/cc

Liquid density = 1.33 gm/cc

Insoluble solids in the mixed waste = 0.5 volume% or ~1 % by weight

Total Waste Volume = 958,000 gallons as per Hanlon's report (see Table A2-1 of RPP-5643)

Assuming that final compacted non-convective waste (sludge) will have 40 wt% solids and the fluffed waste will have 20wt% solids. Using these waste parameters the height of the initial non-convective waste is estimated to be 1.46 ft. (See Attachment 3 for details)

8. Volume Fraction of Solids

a) Undiluted Waste

The following parameters (TCR Report of Kupfer) were used to estimate the volume fraction of solids in the undiluted waste. (See Attachment 4)

Mr. C. E. Grenard
July 14, 2000
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FH-0003661

Sludge bulk density = 1.62 gm/cc
Weight % of water in slurry = 31.8
Supernatant density = 1.46 gm/cc
Weight % of water in Supernatant = 51.1

Using these waste parameters, the density of solids and the volume fraction of solids in the undisturbed current sludge were estimated to be 1.95 gm/cc and 0.326. For the fluffed sludge, the volume fraction of solids is assumed to be 0.163.

b) Diluted Sludge

As explained for sludge height calculation, the solids volume fraction of the fluffed sludge is estimated to be about 0.1.

9. Supernatant Liquid Vapor Pressure

a) Undiluted Waste

The vapor pressure of liquid is calculated using the value of water activity from ESP simulation. For undiluted AN-103 waste, the liquid vapor pressure is 31% of that for water at the corresponding temperature. The vapor pressure of liquid is estimated using the ESP calculated vapor composition. (See Attachment 5)

b) Diluted Waste

The water activity from ESP simulation for diluted AN-103 waste is 0.6. The vapor pressure of the liquid is therefore 60% of that for water. (See Attachment 1 for ESP results)

Sincerely,

7/14/2000

K. Sathyanarayana
Process Engineering and Modeling
Fluor Hanford Inc.

KS: sj

Attachments (5)

ATTACHMENT 1

ESP RESULTS
FOR DILUTED TANK 241-AN-103 WASTE STREAM

- a) WASTE STREAM TEMPERATURE 40 °C (104 °F)
- b) WASTE STREAM TEMPERATURE 60 °C (140 °F)
- c) WASTE STREAM TEMPERATURE 80 °C (176 °F)
- d) WASTE STREAM TEMPERATURE 100 °C (212 °F)
- e) WASTE STREAM TEMPERATURE 120C (248°F)
- f) Undiluted AN-103 Waste Stream at 41 °C (106 °F)

Fluor Federal Services
1200 Jadwin, PO Box 1050
Richland, WA 99352-1050

509 372-2000 phone
509 372-3000 fax

FLUOR GLOBAL SERVICES

July 3, 2000

Dr. K. Sathyanarayana
Fluor Hanford
P.O. Box 1000, MSIN L6-35
Richland, Washington 99352-1000

Dear Dr. Sathyanarayana:

PHYSICAL PROPERTIES OF TANK AN-103 WASTE FOR USE IN COMPUTATIONAL
FLUID DYNAMICS SIMULATIONS

The physical property values supplied for use in Computational Fluid Dynamics simulations of mixing diluted Tank AN-103 waste were obtained as follows:

Solid Phase Density = $3 \frac{kg}{L}$, the average density of tank waste sludge solids estimated from various ESP simulations and hand calculations.

Solid Phase Heat Capacity = $\frac{.55}{S.G.} \cong .2 \frac{BTU}{lb^{\circ}F}$

Reference: formula for heat capacity of minerals and impervious rocks in "CINDAS Data Series on Material Properties," Y.S. Touloukian, W.R. Judd, R.F. Roy, Vol. 11-2, 1981, p.413, McGraw-Hill.

Solid Phase Thermal Conductivity = $5 \frac{BTU}{hr \cdot ft \cdot ^{\circ}F}$

Reference: gross average of values for minerals and ceramics in various handbooks. Experimental data is very limited, so the value is only approximate.

Solution Density = $1.33 \frac{kg}{L}$, average of ESP survey values for diluted AN-103 sludge from 60-80°C (see attached).

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Dr. K. Sathyanarayana
 Fluor Hanford
 Richland, WA 99352

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$$\text{Solution Heat Capacity} = .77 \frac{\text{BTU}}{\text{lb}^\circ\text{F}}$$

Reference: average value for 30 wt.% sodium nitrate in "Specific Heats of Aqueous Solutions of Sodium and Potassium Nitrates at Temperatures in the Range 25-340°C," Puchkov, Matveeva, and Baranova, Zhurnal Prikladnoi Khimii, Vol. 46, No.2, pp. 443-445, translated to English Feb. 1973

$$\text{Solution Thermal Conductivity} = .35 \frac{\text{BTU}}{\text{hr} \cdot \text{ft} \cdot ^\circ\text{F}}$$

Reference: average of values for 20-30 wt.% sodium nitrate and nitrite in "Handbook of Physical Properties of Liquids and Gases," N.B. Vargaftik, 2nd ed., 1975, Hemisphere Publishing Corporation, p. 685.

Insoluble Solids Mass Concentration = 1.0 wt.%, approximate value from ESP survey for diluted AN-103 sludge from 60-100°C (see attached).

$$\text{Insoluble Solids Volume Concentration} = \frac{C_m}{C_m + r(100 - C_m)} = .5 \text{ vol.}\%, \text{ in which } C_m = \text{wt.}\% \text{ insoluble solids, } r = \text{ratio of solids density to solution density.}$$

Water vapor partial pressure = 60% of pure water vapor pressure at the same temperature, since the water activity calculated with ESP (see attached survey) is about .6 from 40-100°C.

Sincerely,

Graham T. MacLean
 Principal Process Engineer

GTM:mb

Attachment

ENVIRONMENTAL SIMULATION PROGRAM

SURVEY: DILUTED SLUDGE

THIS FILE NAME: DILUTEDS.LIS

65	64	63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
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STREAM SECTION

C-10

STREAM: DILUTED SLUDGE

POINT : 1

Phases----->	Aqueous	Solid	Vapor	Organic
Temperature, C	40.	40.	40.	40.
Pressure, mmHg	754.999	754.999	754.999	754.999
pH	14.7647			
Total mol/hr	5403.14	30.5498	0.0	0.0
-----	molefrac-----	molefrac-----	molefrac-----	molefrac-----
H2O	0.690905	0.0	0.0	0.0
ACETACID	7.1007E-15	0.0	0.0	0.0
CO2	1.0009E-18	0.0	0.0	0.0
HCL	1.3701E-24	0.0	0.0	0.0
HF	5.5216E-17	0.0	0.0	0.0
HNO2	6.9713E-15	0.0	0.0	0.0
HNO3	7.4068E-20	0.0	0.0	0.0
N2	4.2014E-08	0.0	0.0	0.0
O2	1.6818E-08	0.0	0.0	0.0
CSNO3	3.4990E-07	0.0	0.0	0.0
FEIIIIOH3	1.6722E-15	0.0	0.0	0.0
ALF3	1.0955E-28	0.0	0.0	0.0
H2SIO3	0.0	0.0	0.0	0.0
CAACET2	9.4597E-13	0.0	0.0	0.0
H3PO4	1.1924E-30	0.0	0.0	0.0
CAC2O4	1.4249E-12	0.0	0.0	0.0
CACO3	1.7987E-10	0.0	0.0	0.0
CAH2SIO4	3.1033E-28	0.0	0.0	0.0
KACET	4.3744E-06	0.0	0.0	0.0
KCL	6.7900E-07	0.0	0.0	0.0
KHSO4	2.0545E-22	0.0	0.0	0.0
MNACET2	7.5961E-21	0.0	0.0	0.0
MNC2O4	9.1356E-18	0.0	0.0	0.0
MNNO32	8.6459E-19	0.0	0.0	0.0
MNOH2	4.6919E-12	0.0	0.0	0.0
MNSO4	3.0843E-21	0.0	0.0	0.0
CASO4	1.5987E-13	0.0	0.0	0.0
NAACET	4.8666E-04	0.0	0.0	0.0
NAF	4.0576E-04	0.0	0.0	0.0
NAHCO3	2.5353E-09	0.0	0.0	0.0
NAHSIO3	2.4084E-23	0.0	0.0	0.0
NANO3	4.9860E-04	0.0	0.0	0.0
NIACET2	2.8632E-23	0.0	0.0	0.0
NIC2O4	3.7766E-19	0.0	0.0	0.0
NIOH2	1.3283E-11	0.00104474	0.0	0.0
NISO4	8.6372E-24	0.0	0.0	0.0
ALOH3	1.4410E-11	0.700731	0.0	0.0
OXALAC	0.0	0.0	0.0	0.0
PUIVOH4	1.1500E-12	6.0592E-07	0.0	0.0
CROH3	1.9467E-16	0.0	0.0	0.0
CSACET	6.3463E-09	0.0	0.0	0.0
SIO2	0.0	0.0	0.0	0.0
CSCL	2.1354E-08	0.0	0.0	0.0
UO2CO3	4.3712E-30	0.0	0.0	0.0
UO2F2	0.0	0.0	0.0	0.0
UO2OH2	3.5152E-20	0.0	0.0	0.0
OHION	0.0386392	0.0	0.0	0.0

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ALF2ION	2.5200E-30	0.0	0.0	0.0
ALF4ION	1.0521E-26	0.0	0.0	0.0
ALF5ION	1.0512E-25	0.0	0.0	0.0
ALF6ION	8.9562E-25	0.0	0.0	0.0
ALOH2ION	1.5632E-20	0.0	0.0	0.0
ALOH4ION	0.0234582	0.0	0.0	0.0
ALOHION	1.1138E-30	0.0	0.0	0.0
CAACETION	2.2643E-11	0.0	0.0	0.0
CAFION	4.4105E-13	0.0	0.0	0.0
CAH2PO4ION	6.7846E-24	0.0	0.0	0.0
CAHC2O4ION	9.2582E-24	0.0	0.0	0.0
CAHCO3ION	2.1585E-16	0.0	0.0	0.0
CAION	8.6756E-10	0.0	0.0	0.0
CANO3ION	6.0375E-18	0.0	0.0	0.0
CAOHION	8.0308E-09	0.0	0.0	0.0
CAPO4ION	1.7419E-08	0.0	0.0	0.0
CLION	0.00178763	0.0	0.0	0.0
CO3ION	0.00428797	0.0	0.0	0.0
CR2O7ION	1.7037E-24	0.0	0.0	0.0
CRO4ION	1.0267E-05	0.0	0.0	0.0
CROH2ION	7.9310E-25	0.0	0.0	0.0
CROH4ION	2.2821E-11	0.0	0.0	0.0
CROHION	0.0	0.0	0.0	0.0
CSION	7.0489E-11	0.0	0.0	0.0
CSSO4ION	1.3943E-09	0.0	0.0	0.0
FEIIIOH2ION	1.9227E-24	0.0	0.0	0.0
FEIIIOH4ION	7.5807E-09	0.0	0.0	0.0
FION	4.3636E-04	0.0	0.0	0.0
H2PO4ION	1.3171E-16	0.0	0.0	0.0
H2SIO4ION	4.9610E-30	0.0	0.0	0.0
H3SIO4ION	9.7753E-26	0.0	0.0	0.0
HCO3ION	4.9398E-09	0.0	0.0	0.0
HCRO4ION	2.1335E-15	0.0	0.0	0.0
HF2ION	4.5055E-18	0.0	0.0	0.0
HION	1.0288E-17	0.0	0.0	0.0
HOXALATION	1.3177E-17	0.0	0.0	0.0
HP2O7ION	1.7606E-24	0.0	0.0	0.0
HPO4ION	1.3238E-07	0.0	0.0	0.0
HSIO3ION	0.0	0.0	0.0	0.0
HSO4ION	2.5246E-19	0.0	0.0	0.0
KION	0.00246038	0.0	0.0	0.0
KSO4ION	3.9997E-06	0.0	0.0	0.0
MNACET3ION	5.7500E-21	0.0	0.0	0.0
MNACETION	4.1652E-19	0.0	0.0	0.0
MNC2O42ION	3.4456E-20	0.0	0.0	0.0
MNC2O43ION	7.5754E-19	0.0	0.0	0.0
MNCLION	9.4049E-19	0.0	0.0	0.0
MNION	7.2369E-17	0.0	0.0	0.0
MNNO3ION	1.4215E-18	0.0	0.0	0.0
MNOH3ION	1.4369E-08	0.0	0.0	0.0
MNOH4ION	5.1608E-06	0.0	0.0	0.0
MNOHION	3.4602E-14	0.0	0.0	0.0
NA2FION	9.9681E-12	0.0	0.0	0.0
NACO3ION	0.00134883	0.0	0.0	0.0
NAION	0.153958	0.0	0.0	0.0

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NASO4ION	2.2690E-05	0.0	0.0	0.0
NIACET3ION	3.1816E-23	0.0	0.0	0.0
NIACETION	1.6186E-21	0.0	0.0	0.0
NIC2O42ION	6.1876E-21	0.0	0.0	0.0
NICLION	6.4934E-23	0.0	0.0	0.0
NIFION	2.9087E-22	0.0	0.0	0.0
NIION	1.1806E-19	0.0	0.0	0.0
NINO3ION	4.9986E-21	0.0	0.0	0.0
NIOH3ION	1.1501E-06	0.0	0.0	0.0
NIOHION	1.8894E-16	0.0	0.0	0.0
NO2ION	0.0332751	0.0	0.0	0.0
NO3ION	0.0470385	0.0	0.0	0.0
ACETATEION	2.6600E-04	0.0	0.0	0.0
OXALATION	2.8456E-05	0.0	0.0	0.0
P2O7ION	1.2284E-21	0.0	0.0	0.0
PO4ION	1.3483E-04	0.0	0.0	0.0
PUIVOH3ION	4.0811E-22	0.0	0.0	0.0
SIO3ION	1.5811E-28	0.0	0.0	0.0
SO4ION	5.3596E-04	0.0	0.0	0.0
UO2C2O43ION	0.0	0.0	0.0	0.0
UO2CO32ION	2.2983E-22	0.0	0.0	0.0
UO2CO33ION	2.1070E-15	0.0	0.0	0.0
UO2F3ION	2.0206E-30	0.0	0.0	0.0
UO2F4ION	5.3112E-30	0.0	0.0	0.0
UO2OHION	3.1278E-27	0.0	0.0	0.0
NA2C2O4	0.0	0.19945	0.0	0.0
NA2U2O7	0.0	1.6978E-04	0.0	0.0
CASOHPO43	0.0	0.00357773	0.0	0.0
CAFE2O4	0.0	0.0020312	0.0	0.0
CR2O3	0.0	0.0199674	0.0	0.0
NA3FSO4	0.0	0.00460687	0.0	0.0
NA4SIO4	0.0	0.0684213	0.0	0.0
=====				
Total kg/hr	129.92	3.06417	0.0	0.0
Volume, L/hr	94.1597	1.08862	0.0	0.0
Enthalpy, kJ/hr	-1.6052E+06	-42300.2	0.0	0.0
Density, kg/L	1.3797	2.8147		
Osmotic Pres, mmHg	5.7625E+05			
Redox Pot, volts	0.0			
E-Con, 1/ohm-cm	0.306868			
E-Con, cm2/ohm-mol	37.0951			
Abs Visc, cP	4.54763			
Rel Visc	6.95772			
Ionic Strength	12.9905			

STREAM: DILUTED SLUDGE

POINT : 2

Phases----->	Aqueous	Solid	Vapor	Organic
Temperature, C	60.	60.	60.	60.
Pressure, mmHg	754.999	754.999	754.999	754.999
pH	14.0733			
Total mol/hr	5406.38	8.90589	0.0	0.0
-----	molefrac-----	molefrac-----	molefrac-----	molefrac-----
H2O	0.69049	0.0	0.0	0.0
ACETACID	3.8420E-14	0.0	0.0	0.0
CO2	2.0680E-17	0.0	0.0	0.0
H2F2	0.0	0.0	0.0	0.0
ACET2	0.0	0.0	0.0	0.0
HCL	2.1344E-23	0.0	0.0	0.0
HF	3.8169E-16	0.0	0.0	0.0
HNO2	2.5970E-14	0.0	0.0	0.0
HNO3	9.6111E-19	0.0	0.0	0.0
N2	4.1989E-08	0.0	0.0	0.0
O2	1.6808E-08	0.0	0.0	0.0
CSNO3	3.4879E-07	0.0	0.0	0.0
FEIIIIOH3	9.6229E-15	0.0	0.0	0.0
ALF3	2.5655E-27	0.0	0.0	0.0
H2SIO3	9.6591E-30	0.0	0.0	0.0
CAACET2	5.8849E-13	0.0	0.0	0.0
H3PO4	1.7988E-28	0.0	0.0	0.0
CAC2O4	3.7570E-12	0.0	0.0	0.0
CACO3	1.7462E-10	0.0	0.0	0.0
CAH2SIO4	1.0457E-27	0.0	0.0	0.0
KACET	5.4565E-06	0.0	0.0	0.0
KCL	1.0178E-06	0.0	0.0	0.0
KHSO4	1.8482E-21	0.0	0.0	0.0
MNACET2	5.9861E-20	0.0	0.0	0.0
MNC2O4	1.3661E-16	0.0	0.0	0.0
MNNO32	8.1333E-18	0.0	0.0	0.0
MNOH2	1.6722E-11	0.0	0.0	0.0
MNSO4	2.0984E-20	0.0	0.0	0.0
CASO4	7.2154E-14	0.0	0.0	0.0
NAACET	4.7805E-04	0.0	0.0	0.0
NAF	3.8880E-04	0.0	0.0	0.0
NAHCO3	1.6189E-08	0.0	0.0	0.0
NAHSIO3	2.2324E-22	0.0	0.0	0.0
NANO3	4.4098E-04	0.0	0.0	0.0
NIACET2	7.5379E-23	0.0	0.0	0.0
NIC2O4	2.5967E-18	0.0	0.0	0.0
NIOH2	1.2646E-11	0.00407073	0.0	0.0
NISO4	3.2267E-23	0.0	0.0	0.0
ALOH3	3.7636E-11	0.0	0.0	0.0
OXALAC	1.1722E-29	0.0	0.0	0.0
PUIVOH4	3.0070E-12	2.0774E-06	0.0	0.0
CROH3	3.3532E-16	0.0	0.0	0.0
CSACET	6.4845E-09	0.0	0.0	0.0
SIO2	2.7641E-29	0.0	0.0	0.0
CSCL	2.2576E-08	0.0	0.0	0.0
UO2CO3	1.6681E-28	0.0	0.0	0.0
UO2F2	0.0	0.0	0.0	0.0

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UO2OH2	4.0694E-19	0.0	0.0	0.0
OHION	0.0346576	0.0	0.0	0.0
ALF2ION	4.6869E-29	0.0	0.0	0.0
ALF4ION	2.2508E-25	0.0	0.0	0.0
ALF5ION	2.3160E-24	0.0	0.0	0.0
ALF6ION	1.8106E-23	0.0	0.0	0.0
ALOH2ION	6.9823E-20	0.0	0.0	0.0
ALOH4ION	0.0274037	0.0	0.0	0.0
ALOHION	9.0304E-30	0.0	0.0	0.0
CAACETION	1.4878E-11	0.0	0.0	0.0
CAFION	8.7819E-13	0.0	0.0	0.0
CAH2PO4ION	1.1906E-22	0.0	0.0	0.0
CAHC2O4ION	5.9936E-23	0.0	0.0	0.0
CAHCO3ION	6.5303E-16	0.0	0.0	0.0
CAION	4.4213E-10	0.0	0.0	0.0
CANO3ION	1.3117E-18	0.0	0.0	0.0
CAOHION	4.5802E-09	0.0	0.0	0.0
CAPO4ION	1.8443E-08	0.0	0.0	0.0
CLION	0.00178622	0.0	0.0	0.0
CO3ION	0.00461026	0.0	0.0	0.0
CR2O7ION	3.7397E-23	0.0	0.0	0.0
CRFION	0.0	0.0	0.0	0.0
CRO4ION	1.0261E-05	0.0	0.0	0.0
CROH2ION	4.9672E-24	0.0	0.0	0.0
CROH4ION	1.2443E-11	0.0	0.0	0.0
CROHION	5.5207E-30	0.0	0.0	0.0
CSION	1.7278E-16	0.0	0.0	0.0
CSSO4ION	9.8643E-10	0.0	0.0	0.0
FEIIIOH2ION	1.5297E-23	0.0	0.0	0.0
FEIIIOH4ION	2.8103E-08	0.0	0.0	0.0
FION	4.7885E-04	0.0	0.0	0.0
H2PO4ION	2.7987E-15	0.0	0.0	0.0
H2SIO4ION	1.2315E-29	0.0	0.0	0.0
H3SIO4ION	2.7172E-24	0.0	0.0	0.0
HCO3ION	2.2634E-08	0.0	0.0	0.0
HCRO4ION	1.4645E-14	0.0	0.0	0.0
HF2ION	4.3842E-17	0.0	0.0	0.0
HION	5.3481E-17	0.0	0.0	0.0
HOXALATION	1.6055E-16	0.0	0.0	0.0
HP2O7ION	3.3334E-22	0.0	0.0	0.0
HPO4ION	5.4786E-07	0.0	0.0	0.0
HSIO3ION	0.0	0.0	0.0	0.0
HSO4ION	1.6627E-18	0.0	0.0	0.0
KION	0.00245819	0.0	0.0	0.0
KSO4ION	3.2829E-06	0.0	0.0	0.0
MNACET3ION	3.6112E-20	0.0	0.0	0.0
MNACETION	3.4385E-18	0.0	0.0	0.0
MNC2O42ION	5.6519E-19	0.0	0.0	0.0
MNC2O43ION	5.0831E-17	0.0	0.0	0.0
MNCLION	8.4299E-18	0.0	0.0	0.0
MNION	4.5266E-16	0.0	0.0	0.0
MNNO3ION	1.2715E-17	0.0	0.0	0.0
MNOH3ION	2.7852E-08	0.0	0.0	0.0
MNOH4ION	5.1442E-06	0.0	0.0	0.0
MNOHION	2.3856E-13	0.0	0.0	0.0

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NA2FION	3.6864E-12	0.0	0.0	0.0
NACO3ION	0.00102313	0.0	0.0	0.0
NAION	0.154395	0.0	0.0	0.0
NASO4ION	1.5614E-05	0.0	0.0	0.0
NIACET3ION	5.1598E-23	0.0	0.0	0.0
NIACETION	5.4472E-21	0.0	0.0	0.0
NIC2O42ION	4.6491E-20	0.0	0.0	0.0
NICLION	2.8976E-22	0.0	0.0	0.0
NIFION	1.9016E-21	0.0	0.0	0.0
NIION	3.7652E-19	0.0	0.0	0.0
NINO3ION	1.6738E-20	0.0	0.0	0.0
NIOH3ION	3.4726E-07	0.0	0.0	0.0
NIOHION	4.8222E-16	0.0	0.0	0.0
NO2ION	0.0332552	0.0	0.0	0.0
NO3ION	0.0470677	0.0	0.0	0.0
ACETATEION	2.7308E-04	0.0	0.0	0.0
OXALATION	4.6989E-05	0.0	0.0	0.0
P2O7ION	2.8068E-20	0.0	0.0	0.0
PO4ION	1.3432E-04	0.0	0.0	0.0
PUIVOH2ION	0.0	0.0	0.0	0.0
PUIVOH3ION	3.5363E-21	0.0	0.0	0.0
SIO3ION	1.6359E-28	0.0	0.0	0.0
SO4ION	5.6944E-04	0.0	0.0	0.0
UO2C2O43ION	9.2699E-29	0.0	0.0	0.0
UO2CO32ION	1.8556E-20	0.0	0.0	0.0
UO2CO33ION	7.4987E-14	0.0	0.0	0.0
UO2F3ION	6.9628E-29	0.0	0.0	0.0
UO2F4ION	2.0931E-28	0.0	0.0	0.0
UO2FION	0.0	0.0	0.0	0.0
UO2OHION	4.1692E-26	0.0	0.0	0.0
NA2C2O4	0.0	0.67291	0.0	0.0
NA2U2O7	0.0	5.8240E-04	0.0	0.0
CA5OHPO43	0.0	0.0122742	0.0	0.0
CAFE2O4	0.0	0.00696138	0.0	0.0
CR2O3	0.0	0.068494	0.0	0.0
NA4SIO4	0.0	0.234705	0.0	0.0
=====				
Total kg/hr	131.63	1.3554	0.0	0.0
Volume, L/hr	97.3742	0.38877	0.0	0.0
Enthalpy, kJ/hr	-1.6264E+06	-14205.9	0.0	0.0
Density, kg/L	1.3517	3.4864		
Osmotic Pres, mmHg	5.6340E+05			
Redox Pot, volts	0.0			
E-Con, 1/ohm-cm	0.345059			
E-Con, cm2/ohm-mol	43.1356			
Abs Visc, cP	3.01137			
Rel Visc	6.45514			
Ionic Strength	13.0633			

STREAM: DILUTED SLUDGE

POINT : 3

Phases----->	Aqueous	Solid	Vapor	Organic
Temperature, C	80.	80.	80.	80.
Pressure, mmHg	754.999	754.999	754.999	754.999

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pH	13.5278			
Total mol/hr	5407.82	8.81247	0.0	0.0
-----	molefrac-----	molefrac-----	molefrac-----	molefrac-----
H2O	0.690306	0.0	0.0	0.0
ACETACID	1.3829E-13	0.0	0.0	0.0
CO2	2.7601E-16	0.0	0.0	0.0
H2F2	3.3053E-30	0.0	0.0	0.0
ACET2	0.0	0.0	0.0	0.0
HCL	2.0165E-22	0.0	0.0	0.0
HF	1.6362E-15	0.0	0.0	0.0
HNO2	6.8801E-14	0.0	0.0	0.0
HNO3	1.0986E-17	0.0	0.0	0.0
N2	4.1978E-08	0.0	0.0	0.0
O2	1.6804E-08	0.0	0.0	0.0
CSNO3	3.4755E-07	0.0	0.0	0.0
FEIII OH3	4.3007E-14	0.0	0.0	0.0
ALF3	2.0013E-26	0.0	0.0	0.0
H2SIO3	1.2865E-28	0.0	0.0	0.0
CAACET2	3.4762E-13	0.0	0.0	0.0
H3PO4	1.1588E-26	0.0	0.0	0.0
CAC2O4	6.1181E-12	0.0	0.0	0.0
CACO3	1.3926E-10	0.0	0.0	0.0
CAH2SIO4	1.5023E-27	0.0	0.0	0.0
KACET	6.5783E-06	0.0	0.0	0.0
KCL	1.4367E-06	0.0	0.0	0.0
KHSO4	1.0465E-20	0.0	0.0	0.0
MNACET2	2.2622E-19	0.0	0.0	0.0
MNC2O4	6.7017E-16	0.0	0.0	0.0
MNNO32	3.6729E-17	0.0	0.0	0.0
MNOH2	3.5296E-11	0.0	0.0	0.0
MNSO4	5.3856E-20	0.0	0.0	0.0
CASO4	2.5073E-14	0.0	0.0	0.0
NAACET	4.7942E-04	0.0	0.0	0.0
NAF	3.7071E-04	0.0	0.0	0.0
NAHCO3	7.9720E-08	0.0	0.0	0.0
NAHSIO3	9.1849E-22	0.0	0.0	0.0
NANO3	3.9144E-04	0.0	0.0	0.0
NIACET2	1.4503E-22	0.0	0.0	0.0
NIC2O4	8.9083E-18	0.0	0.0	0.0
NIOH2	1.0628E-11	0.00425751	0.0	0.0
NISO4	6.7486E-23	0.0	0.0	0.0
ALOH3	5.8129E-11	0.0	0.0	0.0
OXALAC	3.6136E-28	0.0	0.0	0.0
PUIVOH4	5.7161E-12	2.0977E-06	0.0	0.0
CROH3	7.5069E-16	0.0	0.0	0.0
CSACET	6.4533E-09	0.0	0.0	0.0
SIO2	5.2164E-28	0.0	0.0	0.0
CSCL	2.4052E-08	0.0	0.0	0.0
UO2C2O4	0.0	0.0	0.0	0.0
UO2CO3	2.9913E-27	0.0	0.0	0.0
UO2F2	7.4356E-30	0.0	0.0	0.0
UO2OH2	2.8992E-18	0.0	0.0	0.0
OHION	0.03465	0.0	0.0	0.0
ALF2ION	3.2813E-28	0.0	0.0	0.0
ALF4ION	1.5618E-24	0.0	0.0	0.0

ALF5ION	1.4620E-23	0.0	0.0	0.0
ALF6ION	9.0618E-23	0.0	0.0	0.0
ALFION	0.0	0.0	0.0	0.0
ALOH2ION	1.6695E-19	0.0	0.0	0.0
ALOH4ION	0.0273964	0.0	0.0	0.0
ALOHION	3.3537E-29	0.0	0.0	0.0
CAACETION	8.6582E-12	0.0	0.0	0.0
CAFION	1.2793E-12	0.0	0.0	0.0
CAH2PO4ION	1.1884E-21	0.0	0.0	0.0
CAHC2O4ION	2.0826E-22	0.0	0.0	0.0
CAHCO3ION	1.3990E-15	0.0	0.0	0.0
CAION	1.9400E-10	0.0	0.0	0.0
CANO3ION	1.7651E-19	0.0	0.0	0.0
CAOHION	2.5649E-09	0.0	0.0	0.0
CAPO4ION	1.7503E-08	0.0	0.0	0.0
CLION	0.00178533	0.0	0.0	0.0
CO3ION	0.00475031	0.0	0.0	0.0
CR2O7ION	5.1175E-22	0.0	0.0	0.0
CRFION	5.6243E-30	0.0	0.0	0.0
CRIIIHPO4ION	4.5974E-30	0.0	0.0	0.0
CRO4ION	1.0258E-05	0.0	0.0	0.0
CROH2ION	3.2982E-23	0.0	0.0	0.0
CROH4ION	9.3886E-12	0.0	0.0	0.0
CROHION	7.3439E-29	0.0	0.0	0.0
CSION	5.3788E-24	0.0	0.0	0.0
CSSO4ION	6.7714E-10	0.0	0.0	0.0
FEIIIC2O43ION	0.0	0.0	0.0	0.0
FEIIIOH2ION	6.1352E-23	0.0	0.0	0.0
FEIIIOH4ION	7.9873E-08	0.0	0.0	0.0
FEIIIOHION	0.0	0.0	0.0	0.0
FION	4.9671E-04	0.0	0.0	0.0
H2PO4ION	3.7639E-14	0.0	0.0	0.0
H2SIO4ION	1.0652E-29	0.0	0.0	0.0
H3SIO4ION	2.8411E-23	0.0	0.0	0.0
HCO3ION	8.0469E-08	0.0	0.0	0.0
HCRO4ION	7.9267E-14	0.0	0.0	0.0
HF2ION	3.3141E-16	0.0	0.0	0.0
HION	2.0621E-16	0.0	0.0	0.0
HOXALATION	1.2532E-15	0.0	0.0	0.0
HP2O7ION	3.1707E-20	0.0	0.0	0.0
HPO4ION	1.8418E-06	0.0	0.0	0.0
HSIO3ION	0.0	0.0	0.0	0.0
HSO4ION	7.1345E-18	0.0	0.0	0.0
KION	0.0024567	0.0	0.0	0.0
KSO4ION	2.5725E-06	0.0	0.0	0.0
MNACET3ION	1.3238E-19	0.0	0.0	0.0
MNACETION	1.2595E-17	0.0	0.0	0.0
MNC2O42ION	3.0354E-18	0.0	0.0	0.0
MNC2O43ION	9.6377E-16	0.0	0.0	0.0
MNCLION	3.3287E-17	0.0	0.0	0.0
MNION	1.3505E-15	0.0	0.0	0.0
MNNO3ION	5.1048E-17	0.0	0.0	0.0
MNOH3ION	4.1665E-08	0.0	0.0	0.0
MNOH4ION	5.1290E-06	0.0	0.0	0.0
MNOHION	7.9750E-13	0.0	0.0	0.0

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NA2FION	9.8667E-13	0.0	0.0	0.0
NAC03ION	8.8145E-04	0.0	0.0	0.0
NAION	0.154602	0.0	0.0	0.0
NASO4ION	9.4968E-06	0.0	0.0	0.0
NIACET3ION	7.4198E-23	0.0	0.0	0.0
NIACETION	1.2368E-20	0.0	0.0	0.0
NIC2O42ION	1.7391E-19	0.0	0.0	0.0
NICLION	8.4838E-22	0.0	0.0	0.0
NIFION	7.4021E-21	0.0	0.0	0.0
NIION	8.5027E-19	0.0	0.0	0.0
MINO3ION	3.8613E-20	0.0	0.0	0.0
NIOH3ION	1.1311E-07	0.0	0.0	0.0
NIOHION	9.1052E-16	0.0	0.0	0.0
NO2ION	0.0332463	0.0	0.0	0.0
NO3ION	0.0471046	0.0	0.0	0.0
ACETATEION	2.7038E-04	0.0	0.0	0.0
OXALATION	6.4465E-05	0.0	0.0	0.0
P2O7ION	2.9537E-19	0.0	0.0	0.0
PO4ION	1.3297E-04	0.0	0.0	0.0
PUIVOH2ION	0.0	0.0	0.0	0.0
PUIVOH3ION	1.7559E-20	0.0	0.0	0.0
SIO3ION	5.8087E-29	0.0	0.0	0.0
SO4ION	5.7612E-04	0.0	0.0	0.0
UO2AC3ION	0.0	0.0	0.0	0.0
UO2C2O42ION	0.0	0.0	0.0	0.0
UO2C2O43ION	5.0235E-27	0.0	0.0	0.0
UO2CO32ION	8.0024E-19	0.0	0.0	0.0
UO2CO33ION	1.6120E-12	0.0	0.0	0.0
UO2F3ION	1.0478E-27	0.0	0.0	0.0
UO2F4ION	3.5107E-27	0.0	0.0	0.0
UO2FION	1.0585E-30	0.0	0.0	0.0
UO2OHION	3.0462E-25	0.0	0.0	0.0
NA2C2O4	0.0	0.669311	0.0	0.0
NA2U2O7	0.0	5.8858E-04	0.0	0.0
CASOHPO43	0.0	0.012408	0.0	0.0
CAFE2O4	0.0	0.00701929	0.0	0.0
CR2O3	0.0	0.0692201	0.0	0.0
NA4SIO4	0.0	0.237194	0.0	0.0
=====				
Total kg/hr	131.64	1.34283	0.0	0.0
Volume, L/hr	98.7774	0.38329	0.0	0.0
Enthalpy, kJ/hr	-1.6200E+06	-14055.3	0.0	0.0
Density, kg/L	1.3327	3.5035		
Osmotic Pres, mmHg	5.7178E+05			
Redox Pot, volts	0.0			
E-Con, 1/ohm-cm	0.926772			
E-Con, cm2/ohm-mol	117.525			
Abs Visc, cP	2.22318			
Rel Visc	6.27694			
Ionic Strength	13.0963			

STREAM: DILUTED SLUDGE

POINT : 4

Phases----->	Aqueous	Solid	Vapor	Organic
Temperature, C	100.	100.	100.	100.
Pressure, mmHg	754.999	754.999	754.999	754.999
pH	13.0614			
Total mol/hr	5408.04	9.21576	0.0	0.0
-----	molefrac-----	molefrac-----	molefrac-----	molefrac-----
H2O	0.690147	0.0	0.0	0.0
ACETACID	4.1438E-13	0.0	0.0	0.0
CO2	3.2035E-15	0.0	0.0	0.0
H2F2	1.8958E-28	0.0	0.0	0.0
ACET2	8.2634E-30	0.0	0.0	0.0
HCL	1.4083E-21	0.0	0.0	0.0
HF	5.2858E-15	0.0	0.0	0.0
HNO2	1.5748E-13	0.0	0.0	0.0
HNO3	1.3546E-16	0.0	0.0	0.0
N2	4.1976E-08	0.0	0.0	0.0
O2	1.6803E-08	0.0	0.0	0.0
CSNO3	3.4619E-07	0.0	0.0	0.0
FEIIIIOH3	2.1850E-13	0.0	0.0	0.0
ALF3	1.1396E-25	0.0	0.0	0.0
H2SIO3	1.1467E-27	0.0	0.0	0.0
CAACET2	6.7079E-14	0.0	0.0	0.0
H3PO4	7.5608E-25	0.0	0.0	0.0
CAC2O4	2.5145E-12	0.0	0.0	0.0
CACO3	3.2816E-11	0.0	0.0	0.0
CAH2SIO4	5.2928E-28	0.0	0.0	0.0
KACET	7.9174E-06	0.0	0.0	0.0
KCL	1.9969E-06	0.0	0.0	0.0
KHSO4	4.6384E-20	0.0	0.0	0.0
MNACET2	6.8456E-19	0.0	0.0	0.0
MNC2O4	2.1432E-15	0.0	0.0	0.0
MNNO32	1.3370E-16	0.0	0.0	0.0
MNOH2	6.0809E-11	0.0	0.0	0.0
MNSO4	9.4965E-20	0.0	0.0	0.0
CASO4	2.4991E-15	0.0	0.0	0.0
NAACET	4.8836E-04	0.0	0.0	0.0
NAF	3.6318E-04	0.0	0.0	0.0
NAHCO3	3.4000E-07	0.0	0.0	0.0
NAHSIO3	3.0133E-21	0.0	0.0	0.0
NANO3	3.5032E-04	0.0	0.0	0.0
NIACET2	2.6406E-22	0.0	0.0	0.0
NIC2O4	2.3398E-17	0.0	0.0	0.0
NIOH2	8.5131E-12	0.0041161	0.0	0.0
NISO4	1.1145E-22	0.0	0.0	0.0
ALOH3	7.6347E-11	0.0	0.0	0.0
OXALAC	7.9960E-27	0.0	0.0	0.0
PUIVOH4	8.2885E-12	2.0044E-06	0.0	0.0
CROH3	2.1731E-15	0.0	0.0	0.0
CSACET	6.2737E-09	0.0	0.0	0.0
SIO2	6.7240E-27	0.0	0.0	0.0
CSCL	2.5817E-08	0.0	0.0	0.0
UO2C2O4	0.0	0.0	0.0	0.0
UO2CO3	3.7984E-26	0.0	0.0	0.0

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UO2F2	5.2221E-29	0.0	0.0	0.0
UO2OH2	1.5632E-17	0.0	0.0	0.0
OHION	0.0346985	0.0	0.0	0.0
ALF2ION	1.7331E-27	0.0	0.0	0.0
ALF4ION	7.6099E-24	0.0	0.0	0.0
ALF5ION	6.0641E-23	0.0	0.0	0.0
ALF6ION	2.7577E-22	0.0	0.0	0.0
ALFION	0.0	0.0	0.0	0.0
ALOH2ION	3.2469E-19	0.0	0.0	0.0
ALOH4ION	0.0273953	0.0	0.0	0.0
ALOHION	9.6422E-29	0.0	0.0	0.0
CAACETION	1.5593E-12	0.0	0.0	0.0
CAFION	5.0159E-13	0.0	0.0	0.0
CAH2PO4ION	4.3504E-21	0.0	0.0	0.0
CAHC2O4ION	1.7717E-22	0.0	0.0	0.0
CAHCO3ION	8.3976E-16	0.0	0.0	0.0
CAION	2.5084E-11	0.0	0.0	0.0
CANO3ION	5.4251E-21	0.0	0.0	0.0
CAOHION	4.3223E-10	0.0	0.0	0.0
CAPO4ION	7.2190E-09	0.0	0.0	0.0
CLION	0.00178469	0.0	0.0	0.0
CO3ION	0.00471557	0.0	0.0	0.0
CR2O7ION	5.6337E-21	0.0	0.0	0.0
CRFION	5.2503E-28	0.0	0.0	0.0
CRIIIHPO4ION	5.4230E-27	0.0	0.0	0.0
CRO4ION	1.0258E-05	0.0	0.0	0.0
CROH2ION	2.6461E-22	0.0	0.0	0.0
CROH4ION	9.4344E-12	0.0	0.0	0.0
CROHION	1.0958E-27	0.0	0.0	0.0
CSION	0.0	0.0	0.0	0.0
CSSO4ION	4.4238E-10	0.0	0.0	0.0
FEIIIC2O43ION	2.4686E-29	0.0	0.0	0.0
FEIIIOH2ION	2.4938E-22	0.0	0.0	0.0
FEIIIOH4ION	2.4541E-07	0.0	0.0	0.0
FEIIIOHION	0.0	0.0	0.0	0.0
FION	5.0420E-04	0.0	0.0	0.0
H2PO4ION	5.9567E-13	0.0	0.0	0.0
H2SIO4ION	5.6729E-30	0.0	0.0	0.0
H3SIO4ION	2.0726E-22	0.0	0.0	0.0
HCO3ION	2.5313E-07	0.0	0.0	0.0
HCRO4ION	3.8394E-13	0.0	0.0	0.0
HF2ION	2.2929E-15	0.0	0.0	0.0
HION	6.6253E-16	0.0	0.0	0.0
HOXALATION	8.0540E-15	0.0	0.0	0.0
HP2O7ION	4.5039E-18	0.0	0.0	0.0
HPO4ION	8.1810E-06	0.0	0.0	0.0
HSIO3ION	0.0	0.0	0.0	0.0
HSO4ION	2.3943E-17	0.0	0.0	0.0
KION	0.00245533	0.0	0.0	0.0
KSO4ION	1.9499E-06	0.0	0.0	0.0
MNACET3ION	4.2905E-19	0.0	0.0	0.0
MNACETION	3.4685E-17	0.0	0.0	0.0
MNC2O42ION	1.0989E-17	0.0	0.0	0.0
MNC2O43ION	1.2110E-14	0.0	0.0	0.0
MNCLION	9.8900E-17	0.0	0.0	0.0

RPP 5643 REV 0

MNION	2.8845E-15	0.0	0.0	0.0
MNNO3ION	1.5581E-16	0.0	0.0	0.0
MNOH3ION	5.5082E-08	0.0	0.0	0.0
MNOH4ION	5.1153E-06	0.0	0.0	0.0
MNOHION	1.9498E-12	0.0	0.0	0.0
NA2FION	1.9685E-13	0.0	0.0	0.0
NACO3ION	8.0298E-04	0.0	0.0	0.0
NAION	0.154754	0.0	0.0	0.0
NASO4ION	5.0965E-06	0.0	0.0	0.0
NIACET3ION	1.1154E-22	0.0	0.0	0.0
NIACETION	2.4823E-20	0.0	0.0	0.0
NIC2O42ION	5.1497E-19	0.0	0.0	0.0
NICLION	2.1589E-21	0.0	0.0	0.0
NIFION	2.3686E-20	0.0	0.0	0.0
NIION	1.6071E-18	0.0	0.0	0.0
NINO3ION	8.0255E-20	0.0	0.0	0.0
NIOH3ION	3.6600E-08	0.0	0.0	0.0
NIOHION	1.5116E-15	0.0	0.0	0.0
NO2ION	0.033245	0.0	0.0	0.0
NO3ION	0.0471437	0.0	0.0	0.0
ACETATEION	2.6008E-04	0.0	0.0	0.0
OXALATION	8.2210E-05	0.0	0.0	0.0
P2O7ION	4.2205E-18	0.0	0.0	0.0
PO4ION	1.8730E-04	0.0	0.0	0.0
PUIVOH2ION	1.7308E-30	0.0	0.0	0.0
PUIVOH3ION	6.0845E-20	0.0	0.0	0.0
SIO3ION	1.2551E-29	0.0	0.0	0.0
SO4ION	5.8111E-04	0.0	0.0	0.0
UO2AC3ION	0.0	0.0	0.0	0.0
UO2ACION	0.0	0.0	0.0	0.0
UO2C2O42ION	0.0	0.0	0.0	0.0
UO2C2O43ION	1.7945E-25	0.0	0.0	0.0
UO2CO32ION	2.5073E-17	0.0	0.0	0.0
UO2CO33ION	2.9405E-11	0.0	0.0	0.0
UO2F3ION	1.1143E-26	0.0	0.0	0.0
UO2F4ION	4.1817E-26	0.0	0.0	0.0
UO2FION	9.6244E-30	0.0	0.0	0.0
UO2OHION	1.6933E-24	0.0	0.0	0.0
NA2C2O4	0.0	0.629606	0.0	0.0
NA2U2O7	0.0	5.6281E-04	0.0	0.0
CR2O3	0.0	0.066191	0.0	0.0
FEIII2O3	0.0	0.00666354	0.0	0.0
NA4SIO4	0.0	0.226814	0.0	0.0
CACO3.H2O	0.0	0.0660445	0.0	0.0
=====				
Total kg/hr	131.64	1.34342	0.0	0.0
Volume, L/hr	99.5813	0.38897	0.0	0.0
Enthalpy, kJ/hr	-1.6134E+06	-14039.	0.0	0.0
Density, kg/L	1.3219	3.4538		
Osmotic Pres, mmHg	5.8323E+05			
E-Con, 1/ohm-cm	1.01124			
E-Con, cm2/ohm-mol	129.279			
Abs Visc, cP	1.83791			
Rel Visc	6.52719			
Ionic Strength	13.1241			

STREAM: DILUTED SLUDGE

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POINT : 5

Phases----->	Aqueous	Solid	Vapor	Organic
Temperature, C	120.	120.	120.	120.
Pressure, mmHg	754.999	754.999	754.999	754.999
pH	13.0629			
Total mol/hr	4230.91	12.2403	1169.95	0.0
-----	molefrac-----	molefrac-----	molefrac-----	molefrac-----
H2O	0.605619	0.0	1.	0.0
ACETACID	3.4933E-13	0.0	6.3150E-12	0.0
CO2	2.1336E-15	0.0	8.0243E-10	0.0
H2F2	1.8333E-27	0.0	1.1561E-26	0.0
ACET2	1.9933E-29	0.0	1.1611E-22	0.0
HCL	2.3715E-21	0.0	4.2379E-17	0.0
HF	1.1464E-15	0.0	5.5560E-13	0.0
HNO2	7.6448E-14	0.0	7.3024E-10	0.0
HNO3	8.9200E-16	0.0	6.8479E-16	0.0
N2	8.5170E-14	0.0	1.9403E-07	0.0
O2	5.5647E-14	0.0	7.7670E-08	0.0
CSNO3	4.2371E-07	0.0	0.0	0.0
FEIIIIOH3	1.2272E-13	0.0	0.0	0.0
ALF3	8.1600E-26	0.0	0.0	0.0
H2SIO3	1.8599E-29	0.0	0.0	0.0
CAACET2	1.6387E-14	0.0	0.0	0.0
H3PO4	1.3297E-24	0.0	0.0	0.0
CAC2O4	1.1960E-13	0.0	0.0	0.0
CACO3	2.6520E-12	0.0	0.0	0.0
CAH2SIO4	1.5020E-30	0.0	0.0	0.0
KACET	1.2631E-05	0.0	0.0	0.0
KCL	3.6111E-06	0.0	0.0	0.0
KHSO4	2.0731E-20	0.0	0.0	0.0
MNACET2	2.0337E-19	0.0	0.0	0.0
MNC2O4	6.4905E-17	0.0	0.0	0.0
MNNO32	2.2642E-17	0.0	0.0	0.0
MNOH2	1.0857E-11	0.0	0.0	0.0
MNSO4	1.7393E-21	0.0	0.0	0.0
CASO4	3.3941E-17	0.0	0.0	0.0
NAACET	6.0889E-04	0.0	0.0	0.0
NAF	3.9048E-04	0.0	0.0	0.0
NAHCO3	3.5044E-07	0.0	0.0	0.0
NAHSIO3	7.7923E-23	0.0	0.0	0.0
NANO3	2.6278E-04	0.0	0.0	0.0
NIACET2	1.8004E-22	0.0	0.0	0.0
NIC2O4	2.1986E-18	0.0	0.0	0.0
NIOH2	2.6846E-12	0.00310748	0.0	0.0
NISO4	7.0818E-24	0.0	0.0	0.0
ALOH3	2.1855E-11	0.0	0.0	0.0
OKALAC	3.8174E-27	0.0	0.0	0.0
PUIVOH4	3.7019E-12	1.5115E-06	0.0	0.0
CROH3	2.2480E-15	0.0	0.0	0.0
CSACET	1.0723E-08	0.0	0.0	0.0
SIO2	1.9876E-28	0.0	0.0	0.0
CSCL	4.9396E-08	0.0	0.0	0.0
UO2C2O4	0.0	0.0	0.0	0.0
UO2CO3	9.2028E-27	0.0	0.0	0.0

UO2F2	1.8464E-29	0.0	0.0	0.0
UO2OH2	6.1029E-18	0.0	0.0	0.0
OHION	0.0443675	0.0	0.0	0.0
ALF2ION	1.3045E-27	0.0	0.0	0.0
ALF4ION	1.8144E-23	0.0	0.0	0.0
ALF5ION	2.3728E-22	0.0	0.0	0.0
ALF6ION	1.6580E-21	0.0	0.0	0.0
ALFION	0.0	0.0	0.0	0.0
ALOH2ION	1.1292E-19	0.0	0.0	0.0
ALOH4ION	0.0350173	0.0	0.0	0.0
ALOHION	7.4749E-30	0.0	0.0	0.0
CAACETION	3.5527E-13	0.0	0.0	0.0
CAFION	1.9500E-13	0.0	0.0	0.0
CAH2PO4ION	1.8641E-21	0.0	0.0	0.0
CAHC2O4ION	1.4099E-23	0.0	0.0	0.0
CAHCO3ION	1.3466E-16	0.0	0.0	0.0
CAION	2.0228E-12	0.0	0.0	0.0
CANO3ION	8.0673E-25	0.0	0.0	0.0
CAOHION	7.3996E-11	0.0	0.0	0.0
CAPO4ION	2.7978E-09	0.0	0.0	0.0
CLION	0.00228015	0.0	0.0	0.0
CO3ION	0.00554273	0.0	0.0	0.0
CR2O7ION	2.0940E-20	0.0	0.0	0.0
CRFION	5.3744E-27	0.0	0.0	0.0
CRIIIHPO4ION	2.1793E-25	0.0	0.0	0.0
CRO4ION	1.3112E-05	0.0	0.0	0.0
CROH2ION	6.7602E-22	0.0	0.0	0.0
CROH4ION	1.7712E-11	0.0	0.0	0.0
CROHION	1.0726E-27	0.0	0.0	0.0
CSSO4ION	2.6550E-10	0.0	0.0	0.0
FEIIIC2O43ION	4.2403E-30	0.0	0.0	0.0
FEIIIOH2ION	1.0993E-22	0.0	0.0	0.0
FEIIIOH4ION	4.0108E-07	0.0	0.0	0.0
FEIIIOHION	0.0	0.0	0.0	0.0
FION	7.1822E-04	0.0	0.0	0.0
H2PO4ION	1.8347E-12	0.0	0.0	0.0
H3SIO4ION	9.1765E-24	0.0	0.0	0.0
HCO3ION	2.7966E-07	0.0	0.0	0.0
HCRO4ION	6.1305E-13	0.0	0.0	0.0
HF2ION	1.1511E-14	0.0	0.0	0.0
HION	4.3430E-16	0.0	0.0	0.0
HOKALATION	5.0448E-15	0.0	0.0	0.0
HP2O7ION	1.8048E-17	0.0	0.0	0.0
HPO4ION	2.5852E-05	0.0	0.0	0.0
HSO4ION	7.8574E-18	0.0	0.0	0.0
KION	0.00313637	0.0	0.0	0.0
KSO4ION	1.0144E-06	0.0	0.0	0.0
MNACET3ION	6.6182E-19	0.0	0.0	0.0
MNACETION	9.3395E-18	0.0	0.0	0.0
MNC2O42ION	4.4868E-19	0.0	0.0	0.0
MNC2O43ION	1.3040E-15	0.0	0.0	0.0
MNCLION	2.8428E-17	0.0	0.0	0.0
MNION	4.4641E-16	0.0	0.0	0.0
MNNO3ION	2.8822E-17	0.0	0.0	0.0
MNOH3ION	3.6747E-08	0.0	0.0	0.0

MNOH4ION	6.5722E-06	0.0	0.0	0.0
MNOHION	4.0618E-13	0.0	0.0	0.0
NA2FION	7.3393E-16	0.0	0.0	0.0
NACO3ION	8.5440E-04	0.0	0.0	0.0
NAION	0.196831	0.0	0.0	0.0
NASO4ION	1.3894E-06	0.0	0.0	0.0
NIACET3ION	3.0538E-22	0.0	0.0	0.0
NIACETION	1.8437E-20	0.0	0.0	0.0
NIC2O42ION	6.4938E-20	0.0	0.0	0.0
NICLION	1.9812E-21	0.0	0.0	0.0
NIFION	2.3382E-20	0.0	0.0	0.0
NIION	7.6348E-19	0.0	0.0	0.0
NINO3ION	3.8514E-20	0.0	0.0	0.0
NIOH3ION	2.2310E-08	0.0	0.0	0.0
NIOHION	8.3997E-16	0.0	0.0	0.0
NO2ION	0.0424944	0.0	0.0	0.0
NO3ION	0.0604452	0.0	0.0	0.0
ACETATEION	3.4526E-04	0.0	0.0	0.0
OXALATION	4.7122E-05	0.0	0.0	0.0
P2O7ION	1.8868E-19	0.0	0.0	0.0
PO4ION	2.2402E-04	0.0	0.0	0.0
PUIVOH2ION	0.0	0.0	0.0	0.0
PUIVOH3ION	6.3927E-20	0.0	0.0	0.0
SO4ION	7.4940E-04	0.0	0.0	0.0
UO2AC3ION	0.0	0.0	0.0	0.0
UO2ACION	0.0	0.0	0.0	0.0
UO2C2O43ION	4.3005E-26	0.0	0.0	0.0
UO2CO32ION	4.4469E-17	0.0	0.0	0.0
UO2CO33ION	7.1064E-11	0.0	0.0	0.0
UO2F3ION	2.4970E-26	0.0	0.0	0.0
UO2F4ION	2.1272E-25	0.0	0.0	0.0
UO2FION	5.8982E-30	0.0	0.0	0.0
UO2OHION	6.4522E-25	0.0	0.0	0.0
NA2C2O4	0.0	0.494065	0.0	0.0
NA2U2O7	0.0	4.2373E-04	0.0	0.0
CR2O3	0.0	0.0498352	0.0	0.0
FEIII2O3	0.0	0.00500188	0.0	0.0
NA2CO3	0.0	0.22707	0.0	0.0
NA4SIO4	0.0	0.170768	0.0	0.0
CACO3.H2O	0.0	0.0497273	0.0	0.0
=====				
Total kg/hr	110.23	1.67085	21.077	0.0
Volume, L/hr	79.3315	0.51955	37720.1	0.0
Enthalpy, kJ/hr	-1.2758E+06	-17438.5	-2.7924E+05	0.0
Density, kg/L	1.3895	3.216	5.5877E-04	
Osmotic Pres, mmHg	8.7175E+05			
Redox Pot, volts	0.0			
E-Con, 1/ohm-cm	0.602702			
E-Con, cm2/ohm-mol	61.3828			
Abs Visc, cP	10.4198			
Rel Visc	44.9141			
Ionic Strength	18.975			

CASE	CELL	TEMPERATURE I		H2OVAP	ACETACIDVAP
		C		molefrac	molefrac
1.000	1.000	40.00	12.99	0.0000	0.0000
2.000	1.000	60.00	13.06	0.0000	0.0000
3.000	1.000	80.00	13.10	0.0000	0.0000
4.000	1.000	100.0	13.12	0.0000	0.0000
5.000	1.000	120.0	18.98	1.000	0.6315E-11
SOLFLOW (MOL)				LIQFLOW	
mol/hr				mol/hr	
30.55				5403.	
8.906				5406.	
8.812				5408.	
9.216				5408.	
12.24				4231.	
LIQFLOW	ENTHAL	ENTHAV	ENTHAS	ENTHALPY	PRESSURE
mol/hr	kJ/hr	kJ/hr	kJ/hr	kJ/hr	mmHg
5403.	-0.1605E+07	0.0000	-0.4230E+05	-0.1648E+07	755.0
5406.	-0.1626E+07	0.0000	-0.1421E+05	-0.1641E+07	755.0
5408.	-0.1620E+07	0.0000	-0.1406E+05	-0.1634E+07	755.0
5408.	-0.1613E+07	0.0000	-0.1404E+05	-0.1627E+07	755.0
4231.	-0.1276E+07	-0.2792E+06	-0.1744E+05	-0.1573E+07	755.0
KH2OVAP	AYH2O	AH2O	KACETACIDVAP	AYACETACID	AACETACIDAQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
2.617	0.0000	-0.5142	7.144	0.0000	1.776
1.626	0.0000	-0.4884	6.176	0.0000	1.728
0.7649	0.0000	-0.4742	5.361	0.0000	1.732
0.1089E-01	0.0000	-0.4615	4.691	0.0000	1.736
-0.6528	-0.7207E-02	-0.6667	4.158	-0.1798E-01	2.510
KCO2VAP	AYCO2	ACO2AQ	KH2F2VAP	AYH2F2	AH2F2AQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-3.751	0.0000	2.730	8.957	0.0000	1.776
-4.112	0.0000	2.740	7.866	0.0000	1.728
-4.365	0.0000	2.738	6.886	0.0000	1.732
-4.537	0.0000	2.670	6.002	0.0000	1.736
-4.647	-0.4899E-03	3.666	5.202	-0.8814E-02	2.510
KACET2VAP	AYACET2	AACET2AQ	KH2SO4VAP	AYH2SO4	AH2SO4AQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-6.305	0.0000	1.776	11.21	0.0000	1.776
-6.960	0.0000	1.728	9.086	0.0000	1.728
-7.541	0.0000	1.732	7.025	0.0000	1.732
-8.059	0.0000	1.736	5.015	0.0000	1.736
-8.525	-0.1798E-01	2.510	3.044	-0.5555E-01	2.510
KHCLVAP	AYHCL	AHCLAQ	KHFVAP	AYHF	AHFAQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-0.5504	0.0000	1.776	9.012	0.0000	3.018
-1.145	0.0000	1.728	7.894	0.0000	3.087
-1.706	0.0000	1.732	6.777	0.0000	3.345
-2.240	0.0000	1.736	5.661	0.0000	3.736
-2.755	-0.1083E-02	2.510	4.544	-0.8874E-02	6.194

KHNO2VAP Ln()	AYHNO2 Ln()	AHNO2AQ Ln()	KHNO3VAP Ln()	AYHNO3 Ln()	AHNO3AQ Ln()
1.448	0.0000	1.776	9.168	0.0000	3.360
0.4592	0.0000	1.728	8.111	0.0000	2.870
-0.4553	0.0000	1.732	7.035	0.0000	2.175
-1.310	0.0000	1.736	5.933	0.0000	1.220
-2.115	-0.1431E-01	2.510	4.801	-0.1270E-01	-0.3269E-03
KO2VAP Ln()	AYO2 Ln()	AO2AQ Ln()	KO2VAP Ln()	AYO2 Ln()	AO2AQ Ln()
-7.508	0.0000	1.776	-6.879	0.0000	1.776
-7.639	0.0000	1.728	-7.051	0.0000	1.728
-7.687	0.0000	1.732	-7.135	0.0000	1.732
-7.672	0.0000	1.736	-7.152	0.0000	1.736
-7.609	0.5036E-02	2.510	-7.118	0.4108E-02	2.510
KSICL4VAP Ln()	AYSICL4 Ln()	ASICL4AQ Ln()	KSIF4VAP Ln()	AYSIF4 Ln()	ASIF4AQ Ln()
-10.86	0.0000	1.776	5.033	0.0000	1.776
-12.86	0.0000	1.728	4.806	0.0000	1.728
-14.67	0.0000	1.732	4.579	0.0000	1.732
-16.32	0.0000	1.736	4.352	0.0000	1.736
-17.82	-0.1659E-01	2.510	4.125	-0.5191E-04	2.510
KSO3VAP Ln()	AYSO3 Ln()	ASO3AQ Ln()	KALBITELWPAPAHION Ln()	ANAION Ln()	
18.79	0.0000	1.776	3.929	0.7322	-0.2797
15.82	0.0000	1.728	2.905	0.6754	-0.4303
13.12	0.0000	1.732	2.009	0.5816	-0.5270
10.65	0.0000	1.736	1.225	0.4881	-0.6192
8.351	-0.2296E-01	2.510	0.5421	0.7764	-0.6797
KXONOTLITEPPKZOISITEPPT PH Ln()	Ln()		DENSITY mol/L	ZCOMP	VOLVAP L/hr
-16.34	8.581	14.76	57.38	0.9680	0.0000
-19.42	7.569	14.07	55.52	0.9732	0.0000
-22.56	6.664	13.53	54.75	0.9773	0.0000
-25.73	5.848	13.06	54.31	0.9807	0.0000
-28.90	5.108	13.06	53.33	0.9928	0.3772E+05
VAPFLOW(MOL) VOLSOL mol/hr	L/hr	VOLLIQ L/hr	DENSITY mol/L	OSPRES mmHg	ECOND 1/ohm/cm
0.0000	1.089	94.16	57.38	0.5763E+06	0.3069
0.0000	0.3888	97.37	55.52	0.5634E+06	0.3451
0.0000	0.3833	98.78	54.75	0.5718E+06	0.9268
0.0000	0.3890	99.58	54.31	0.5832E+06	1.011
1170.	0.5195	79.33	53.33	0.8718E+06	0.6027
ECONDM cm2/ohm/	VISABS	VISREL	VOL L/hr	VOL L/hr	
37.10	4.548	6.958	95.25	95.25	
43.14	3.011	6.455	97.76	97.76	
117.5	2.223	6.277	99.16	99.16	
129.3	1.838	6.527	99.97	99.97	
61.38	10.42	44.91	0.3780E+05	0.3780E+05	

ESP V-6.3

PROCESS:AN103DIL

01/10/2000 PAGE = 4

STREAM: AN-103
 TO : AN-103 Decantation
 FROM :

Phases----->	Aqueous	Solid	Vapor	Organic
Temperature, C	41.1111	41.1111	41.1111	41.1111
Pressure, mmHg	755.	755.	755.	755.
pH	15.7513			
Total mol/hr	128.533	12.4906	0.00984014	0.0
----->	mol/hr-----	mol/hr-----	mol/hr-----	mol/hr-----
H2O	77.1856	0.0	2.6930E-04	0.0
CO2	5.5843E-20	0.0	2.5726E-18	0.0
N2	1.6089E-05	0.0	0.00788393	0.0
O2	6.4386E-06	0.0	0.00168691	0.0
CAACET2	9.3647E-11	0.0	0.0	0.0
CAC2O4	3.4867E-13	0.0	0.0	0.0
CASO4	5.9106E-14	0.0	0.0	0.0
ACETACID	7.1743E-14	0.0	0.0	0.0
CSCL	4.7982E-05	0.0	0.0	0.0
CSNO3	9.6948E-05	0.0	0.0	0.0
FEIII OH3	1.2057E-13	0.0	0.0	0.0
H3PO4	0.0	0.0	0.0	0.0
HNO2	1.5739E-14	0.0	0.0	0.0
KCL	5.2439E-04	0.0	0.0	0.0
MNC2O4	0.0	0.0	0.0	0.0
MNNO32	0.0	0.0	0.0	0.0
MNOH2	2.3525E-23	0.0	0.0	0.0
NAACET	0.179945	0.0	0.0	0.0
NAF	0.00793632	0.128409	0.0	0.0
NAHCO3	4.7368E-09	0.0	0.0	0.0
NANO3	0.015449	6.38446	0.0	0.0
NIC2O4	1.3445E-20	0.0	0.0	0.0
NIOH2	2.3373E-10	7.9474E-04	0.0	0.0
PUIVOH4	2.1500E-11	5.3859E-07	0.0	0.0
SIO2	1.4102E-14	0.0	0.0	0.0
ALOH3	5.2546E-11	0.0	0.0	0.0
OHION	13.8449	0.0	0.0	0.0
ALOH2ION	3.6072E-20	0.0	0.0	0.0
ALOH4ION	3.60997	0.0	0.0	0.0
ALOHION	0.0	0.0	0.0	0.0
CAFION	1.4511E-12	0.0	0.0	0.0
CAHCO3ION	6.0595E-17	0.0	0.0	0.0
CAION	2.0349E-08	0.0	0.0	0.0
CANO3ION	1.7252E-13	0.0	0.0	0.0
CAOHION	6.1807E-07	0.0	0.0	0.0
CAPO4ION	3.3650E-06	0.0	0.0	0.0
CLION	0.478705	0.0	0.0	0.0
CO3ION	0.138114	0.0	0.0	0.0
CR2O7ION	5.4323E-23	0.0	0.0	0.0
CRO4ION	0.00394225	0.0	0.0	0.0
CROH4ION	1.1428E-10	0.0	0.0	0.0
CSION	2.7128E-20	0.0	0.0	0.0
CSSO4ION	6.1985E-07	0.0	0.0	0.0

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FEIIIOH2ION	9.1566E-23	0.0	0.0	0.0
FEIIIOH4ION	2.1955E-05	0.0	0.0	0.0
FION	0.0116704	0.0	0.0	0.0
H2PO4ION	1.7196E-15	0.0	0.0	0.0
H2SIO4ION	1.0868E-07	0.0	0.0	0.0
H3SIO4ION	4.2414E-08	0.0	0.0	0.0
HCO3ION	1.4250E-08	0.0	0.0	0.0
HCRO4ION	6.4096E-14	0.0	0.0	0.0
HION	1.5967E-16	0.0	0.0	0.0
HOXALATION	6.8501E-18	0.0	0.0	0.0
HP2O7ION	5.8412E-24	0.0	0.0	0.0
HPO4ION	2.0542E-05	0.0	0.0	0.0
HSO4ION	2.1260E-19	0.0	0.0	0.0
KION	0.798564	0.0	0.0	0.0
KSO4ION	5.8036E-04	0.0	0.0	0.0
MNCLION	1.5399E-30	0.0	0.0	0.0
MNION	3.9401E-28	0.0	0.0	0.0
MNNO3ION	0.0	0.0	0.0	0.0
MNOH3ION	2.8301E-18	0.0	0.0	0.0
MNOH4ION	6.7288E-15	0.0	0.0	0.0
MNOHION	1.1510E-25	0.0	0.0	0.0
NA2FION	1.4109E-05	0.0	0.0	0.0
NACO3ION	0.0971993	0.0	0.0	0.0
NAION	24.9246	0.0	0.0	0.0
NASO4ION	8.9698E-04	0.0	0.0	0.0
NIC2O42ION	1.1189E-22	0.0	0.0	0.0
NIION	1.9913E-18	0.0	0.0	0.0
NIOH3ION	7.7322E-04	0.0	0.0	0.0
NIOHION	2.2450E-15	0.0	0.0	0.0
NO2ION	4.40835	0.0	0.0	0.0
NO3ION	2.62892	0.0	0.0	0.0
ACETATEION	0.110739	0.0	0.0	0.0
OXALATION	2.6131E-04	0.0	0.0	0.0
P2O7ION	1.0321E-15	0.0	0.0	0.0
PO4ION	0.0746228	0.0	0.0	0.0
PUIVOH3ION	1.0759E-20	0.0	0.0	0.0
SO4ION	0.0109723	0.0	0.0	0.0
UO2CO32ION	1.3301E-24	0.0	0.0	0.0
UO2CO33ION	4.7783E-18	0.0	0.0	0.0
CASOHP043	0.0	1.1763E-04	0.0	0.0
CAOH2	0.0	0.0171147	0.0	0.0
CROH3	0.0	0.035486	0.0	0.0
FEOOH	0.0	0.00360197	0.0	0.0
KALSIO4	0.0	0.0607984	0.0	0.0
NA2C2O4	0.0	0.181594	0.0	0.0
NA2CO3.1H2O	0.0	0.745869	0.0	0.0
NA2U2O7	0.0	1.5087E-04	0.0	0.0
NA6SO42CO3	0.0	0.0437092	0.0	0.0
NANO2	0.0	3.41862	0.0	0.0
MNO2	0.0	8.1331E-04	0.0	0.0
NAALO22.2.5H2O	0.0	1.38416	0.0	0.0
NACL	0.0	0.0849064	0.0	0.0
=====				
Total kg/hr	3.00449	1.22717	2.7969E-04	0.0
Volume, L/hr	2.07585	0.56373	0.2554	0.0
Enthalpy, kJ/hr	-38052.6	-10118.6	-0.0605471	0.0
Density, kg/L	1.4474	2.1769	0.00109509	

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ATTACHMENT 2

Thermal Conductivity of Aqueous Solutions

Thermal Conductivity of the aqueous phase of the waste in AN-103

Graham MacLean's analyses consider the diluted waste after the supernatant liquid has been decanted and the tank has been refilled with water. Note that it is reasonable to expect that the resulting solution has characteristics similar to the liquid that was decanted. The dominant species dissolved in the aqueous phase are expected to be sodium nitrate and sodium nitrite. The supernatant liquid is estimated to have a specific gravity of 1.33.

Based on data of Tables 3-91 and 3-92 in Perry's Chemical Handbook, NaNO_3 and NaNO_2 have about the same density versus weight percent dissolved characteristics. Though the data for NaNO_2 is incomplete but the data that is presented is very similar to that of NaNO_3 .

Using the supernatant liquid density of 1.33 that is consistent with 45 wt% and the equation 3-131 of Perry's Chemical Handbook for estimating the dilute solution thermal conductivity and associated constants in Table 3-341 (Perry's Chemical Handbook)

$$\text{KH2020} := 0.353 \frac{\text{Btu}}{\text{hr-ft-R}} = \boxed{0.001458 \frac{\text{cal}}{\text{sec-cm-K}}}$$

Assuming that the only species is NaNO_3 and further assume that since the initial undiluted case has almost twice the vapor pressure suppression of this case that there is twice the concentration and hence that the effect is twice as strong.

$$K\Delta := \left(\frac{\frac{450}{1.33}}{85} \cdot \left(-6.978 \times 10^{-5} \right) \right) \cdot 1 \frac{\text{cal}}{\text{sec-cm-K}}$$

$$= \boxed{-6.636 \times 10^{-05} \frac{\text{cal}}{\text{sec-cm-K}}}$$

$$K_{\text{soln}} := K_{\text{H2O20}} + 2 \cdot K\Delta = \boxed{0.001325 \frac{\text{cal}}{\text{sec-cm-K}}}$$

$$K_{\text{ratio}} := \frac{K_{\text{soln}}}{K_{\text{H2O20}}} = \boxed{0.909}$$

So it is assumed that the thermal conductivity of the aqueous phase in AN-103 is about 90% of that of water for all cases.

RPP 5643 REV 0

ATTACHMENT 3

Estimation of Non-Convective Slurry Volume
For Diluted Waste

Fluffed Sludge Height and Volume Fraction of Solids for Diluted Case

$$p_{\text{solids}} := 3 \frac{\text{gm}}{\text{cm}^3} = 187.3 \frac{\text{lbm}}{\text{ft}^3}$$

$$p_{\text{liquid}} := 1.33 \frac{\text{gm}}{\text{cm}^3} = 83.03 \frac{\text{lbm}}{\text{ft}^3}$$

$$V_{\text{an3waste}} := 958000 \text{ gal} = 1.281 \times 10^{+05} \text{ ft}^3$$

Insoluble solids in the mixed waste is 0.5% by volume.

$$V_{\text{fsolids}} := 0.005$$

$$V_{\text{solids}} := V_{\text{an3waste}} \cdot V_{\text{fsolids}} = 640.3 \text{ ft}^3$$

$$W_{\text{solids}} := V_{\text{solids}} \cdot p_{\text{solids}} = 1.199 \times 10^{+05} \text{ lbm}$$

$$V_{\text{liquidinwaste}} := V_{\text{an3waste}} - V_{\text{solids}} = 1.274 \times 10^{+05} \text{ ft}^3$$

$$W_{\text{liquidinwaste}} := V_{\text{liquidinwaste}} \cdot p_{\text{liquid}}$$

$$= 1.058 \times 10^{+07} \text{ lbm}$$

Assuming that the final compacted sludge will have 40wt% solids and the initial non-convective fluffed sludge will have 20wt% solids,

$$W_{\text{percentsolids}} := 0.2$$

$$W_{\text{liquidinsldg}} := W_{\text{solids}} \cdot \frac{1 - W_{\text{percentsolids}}}{W_{\text{percentsolids}}} = 4.797 \times 10^{+05} \text{ lbm}$$

$$V_{\text{liquidinsldg}} := \frac{W_{\text{liquidinsldg}}}{\rho_{\text{liquid}}} = 5777 \text{ ft}^3$$

$$V_{\text{solidsinsldg}} := V_{\text{solids}} = 640.3 \text{ ft}^3$$

$$V_{\text{sldginitial}} := V_{\text{liquidinsldg}} + V_{\text{solidsinsldg}} = 6418 \text{ ft}^3$$

$$A_{\text{tank}} = 4418 \text{ ft}^2$$

$$H_{\text{sldginitial}} := \frac{V_{\text{sldginitial}}}{A_{\text{tank}}} = 1.453 \text{ ft}$$

So it is assumed that the fluffed sludge height will be about 1.46 ft.

$$V_{\text{solidsinsldg}} := \frac{V_{\text{solidsinsldg}}}{V_{\text{sldginitial}}} = 0.09977$$

The fluffed sludge of the diluted waste will contain 10 volume percent of solids.

$$\text{undilutedsludgeheightff2} := \frac{410000 \text{ gal}}{A_{\text{tank}}} \cdot 2 = 24.81 \text{ ft}$$

The undiluted Tank 241-AN-103 waste will have a fluffed sludge height of 24.8 ft.

RPP 5643 REV 0

ATTACHMENT 4

**Estimation of Undiluted Waste
Solids Volume**

Estimation of Undiluted Waste Solids Volume

$$\text{sludgedensity} := 1.62 \frac{\text{gm}}{\text{cm}^3} = \boxed{101.1 \frac{\text{lbm}}{\text{ft}^3}}$$

$$\text{massofwater} := 0.31 \cdot \text{sludgedensity} = \boxed{31.35 \frac{\text{lbm}}{\text{ft}^3}}$$

$$\text{massofsalts} := 0.49 \cdot \frac{\text{massofwater}}{0.51} = \boxed{30.12 \frac{\text{lbm}}{\text{ft}^3}}$$

Slurry has 31% of water. Supernatant has 51% of water and 49% of salts.

$$\text{massofsolids} := \text{sludgedensity} - \text{massofwater} - \text{massofsalts}$$

$$= \boxed{39.66 \frac{\text{lbm}}{\text{ft}^3}}$$

$$\text{massofliquid} := \text{massofwater} + \text{massofsalts} = \boxed{61.47 \frac{\text{lbm}}{\text{ft}^3}}$$

$$\text{densityofliquid} := 1.46 \frac{\text{gm}}{\text{cm}^3}$$

$$\text{volumefractionofliquid} := \frac{\text{massofliquid}}{\text{densityofliquid}} = \boxed{0.6745}$$

$$\text{densityofsolids} := \frac{\text{massofsolids}}{1 - \text{volumefractionofliquid}} = \boxed{121.8 \frac{\text{lbm}}{\text{ft}^3}}$$

$$\text{densityofsolids} = 1.951 \frac{\text{gm}}{\text{cm}^3}$$

$$\text{volumefractionofsolids} := 1 - \text{volumefractionofliquid}$$

$$= 0.3255$$

For a fluff factor of 2, the solids volume fraction will be half of this value.

$$\text{volumefractionofsolidsff2} := \frac{\text{volumefractionofsolids}}{2}$$

$$= 0.1628$$

The undiluted Tank 241-AN-103 waste will have a fluffed sludge containing 0.163 volume fraction of solids.

RPP 5643 REV 0

ATTACHMENT 5

**Liquid Vapor Pressure
Undiluted Waste**

Sathyanarayana, K

From: MacLean, Graham T
Sent: Tuesday, July 11, 2000 8:45 AM
To: Sathyanarayana, K
Subject: AN-103 Partial Pressure

Sathya,

Since the water partial pressure is equal to the water activity times the water vapor pressure at the same temperature, ESP predictions of water activity are used to estimate the water partial pressure above tank wastes. The value of the water activity calculated by ESP for the expected future composition of Tank AN-103 waste is .318. In the attached ESP survey, the value of AH₂O found near the end of the file is the natural log of the water activity, or $\ln(-1.145)$, which = .318. You indicated that I gave you a value of .31, so I obviously truncated the calculated value to two significant digits.

an103baw.xls

Graham MacLean
Fluor Federal Services
Process Engineering
509-372-0405

ENVIRONMENTAL SIMULATION PROGRAM

SURVEY: AN-103

CHEMISTRY MODEL: GENTANK

THIS FILE NAME: AN103BSu.LIS

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ESP V-6.4

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STREAM: AN-103

POINT : 1

Phases----->	Aqueous	Solid	Vapor	Organic
Temperature, F	104.	104.	104.	104.
Pressure, mmHg	754.999	754.999	754.999	754.999
pH	15.8825			
Total mol/hr	4311.01	349.714	0.257702	0.0
	mol/hr-----	mol/hr-----	mol/hr-----	mol/hr-----
H2O	2736.78	0.0	0.00606323	0.0
CO2	3.0197E-17	0.0	1.8702E-17	0.0
ACETACID	1.8713E-12	0.0	8.6661E-18	0.0
H2	2.2390E-28	0.0	1.7516E-27	0.0
HF	2.6034E-14	0.0	2.1999E-20	0.0
HNO2	8.5260E-12	0.0	1.1742E-14	0.0
HNO3	2.7915E-17	0.0	8.1126E-23	0.0
N2	0.0237816	0.0	0.251639	0.0
NO2	1.1133E-15	0.0	1.1165E-17	0.0
NO	7.3379E-14	0.0	6.6891E-10	0.0
O2	4.9785E-29	0.0	2.8097E-28	0.0
CASO4	2.2876E-11	0.0	0.0	0.0
CROH3	2.4003E-19	0.0	0.0	0.0
CSACET	3.5293E-05	0.0	0.0	0.0
CSCL	0.00196186	0.0	0.0	0.0
CSNO3	0.00271699	0.0	0.0	0.0
FEIIIIOH3	1.2104E-10	0.0	0.0	0.0
H2SIO3	4.8654E-12	0.0	0.0	0.0
ALOH3	3.2313E-08	0.0	0.0	0.0
CAACET2	7.5814E-11	0.0	0.0	0.0
CAC2O4	1.2711E-10	0.0	0.0	0.0
KACET	0.189461	0.0	0.0	0.0
KCL	0.485842	0.0	0.0	0.0
MNC2O4	3.2955E-16	0.0	0.0	0.0
MNNO32	5.4630E-17	0.0	0.0	0.0
MNSO4	1.7847E-19	0.0	0.0	0.0
CACO3	6.7828E-08	0.0	0.0	0.0
NAACET	9.77742	0.0	0.0	0.0
NAF	4.99469	0.0	0.0	0.0
NAHCO3	2.9796E-06	0.0	0.0	0.0
NAHSIO3	0.0405713	0.0	0.0	0.0
NANO2	191.097	65.5806	0.0	0.0
NANO3	120.548	166.882	0.0	0.0
NIC2O4	4.8624E-18	0.0	0.0	0.0
NIOH2	2.8155E-07	0.0228702	0.0	0.0
CAH2SIO4	8.9307E-08	0.0	0.0	0.0
PUIVOH4	2.4375E-08	1.8754E-05	0.0	0.0
SIO2	1.9169E-11	0.0	0.0	0.0
OHION	480.114	0.0	0.0	0.0
ALOH2ION	6.5318E-19	0.0	0.0	0.0
ALOH4ION	65.9452	0.0	0.0	0.0
ALOHION	1.6635E-30	0.0	0.0	0.0
CAACETION	9.4226E-10	0.0	0.0	0.0
CAFION	1.1264E-11	0.0	0.0	0.0
CAION	7.9922E-07	0.0	0.0	0.0

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CANO3ION	5.2795E-15	0.0	0.0	0.0
CAOHION	2.6606E-05	0.0	0.0	0.0
CAPO4ION	5.4603E-05	0.0	0.0	0.0
CLION	19.1813	0.0	0.0	0.0
CO3ION	1.95835	0.0	0.0	0.0
CRO4ION	1.37464	0.0	0.0	0.0
CROH4ION	3.6699E-14	0.0	0.0	0.0
CSION	3.5993E-04	0.0	0.0	0.0
CSSO4ION	4.2179E-07	0.0	0.0	0.0
FEIIIOH2ION	2.3800E-21	0.0	0.0	0.0
FEIIIOH4ION	7.1562E-04	0.0	0.0	0.0
FION	0.166142	0.0	0.0	0.0
H2PO4ION	1.7446E-14	0.0	0.0	0.0
H2SIO4ION	1.2785E-08	0.0	0.0	0.0
H3SIO4ION	2.8801E-06	0.0	0.0	0.0
HCO3ION	1.9033E-07	0.0	0.0	0.0
HCRO4ION	2.1264E-11	0.0	0.0	0.0
HION	1.0057E-14	0.0	0.0	0.0
HOXALATION	1.1535E-16	0.0	0.0	0.0
HP2O7ION	1.6393E-22	0.0	0.0	0.0
HPO4ION	2.1796E-04	0.0	0.0	0.0
HSIO3ION	4.1082E-12	0.0	0.0	0.0
KION	27.2355	0.0	0.0	0.0
KSO4ION	0.0090316	0.0	0.0	0.0
MNCLION	2.5336E-16	0.0	0.0	0.0
MNION	1.5609E-13	0.0	0.0	0.0
NA2FION	9.0883E-07	0.0	0.0	0.0
NACO3ION	3.9704	0.0	0.0	0.0
NAION	600.632	0.0	0.0	0.0
NASO4ION	0.0250883	0.0	0.0	0.0
NIACETION	9.7209E-21	0.0	0.0	0.0
NIC2O42ION	4.4026E-22	0.0	0.0	0.0
NIION	7.4140E-17	0.0	0.0	0.0
NINO3ION	6.1766E-20	0.0	0.0	0.0
NIOH3ION	0.0317945	0.0	0.0	0.0
NIOHION	6.8633E-14	0.0	0.0	0.0
NO2ION	17.9302	0.0	0.0	0.0
NO3ION	25.6093	0.0	0.0	0.0
ACETATEION	0.167279	0.0	0.0	0.0
OXALATION	0.00333562	0.0	0.0	0.0
P2O7ION	1.1193E-17	0.0	0.0	0.0
PO4ION	2.61443	0.0	0.0	0.0
SIO3ION	7.6563E-07	0.0	0.0	0.0
SO4ION	0.100497	0.0	0.0	0.0
UO2CO32ION	2.7967E-24	0.0	0.0	0.0
UO2CO33ION	3.1996E-18	0.0	0.0	0.0
CAOH2	0.0	0.617227	0.0	0.0
NA6SO42CO3	0.0	1.67359	0.0	0.0
FE0OH	0.0	0.125624	0.0	0.0
KALSIO4	0.0	2.07902	0.0	0.0
MNO2	0.0	0.028355	0.0	0.0
NA2C2O4	0.0	6.33675	0.0	0.0
NA2CO3.1H2O	0.0	28.1287	0.0	0.0
NA2U2O7	0.0	0.00526	0.0	0.0
NAALO22.2.5H2O	0.0	78.2341	0.0	0.0
=====				
Total kg/hr	107.09	40.4419	0.00715848	0.0

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Volume, gal/hr	18.2424	5.0146	1.76089	0.0
Enthalpy, kJ/hr	-1.2861E+06	-3.9654E+05	-1.35492	0.0
Density, kg/gal	5.87041	8.06482	2.1340000406527	
Vapor fraction	0.0	0.0	1.	0.0
Solid fraction	0.0	1.	0.0	0.0
Organic fraction	0.0	0.0	0.0	0.0
Osmotic Pres, mmHg	1.3959E+06			
Redox Pot, volts	-0.163632			
E-Con, 1/ohm-cm	0.333462			
E-Con, cm2/ohm-mol	10.0263			
Abs Visc, cP	7.80388			
Rel Visc	11.9397			
Ionic Strength	12.9635			

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POINT : 1

Solid	Scale Tend.	Temperature Range		
CAFE2O4PPT	1.00386E+03			
NA3PO4.6H2O	1.19783E+01	122.000	249.800	EXCL TR
FE00HPPT	1.00000E+00			
KALSIO4PPT	1.00000E+00			
NA2U2O7PPT	1.00000E+00			
NA6SO42CO3PPT	1.00000E+00	86.000	302.000	
NANO3PPT	1.00000E+00	32.000	356.000	
NIOH2PPT	1.00000E+00			
NAALO22.2.5H2O	1.00000E+00	68.000	248.000	
NA2C2O4PPT	1.00000E+00	32.000	300.000	
NA2CO3.1H2O	1.00000E+00	50.000	228.200	
NANO2PPT	1.00000E+00	32.000	262.400	
PUIVOH4PPT	1.00000E+00			
CAOH2PPT	1.00000E+00			
NACLPPT	9.77363E-01	32.000	662.000	
NA3FSO4PPT	9.31541E-01	50.000	176.000	
CA5OHPO43PPT	7.66495E-01			
NA2CO3PPT	7.32496E-01	228.200	392.000	EXCL TR
NAFPO4.19H2O	6.04012E-01	59.000	167.000	
NAFPPT	5.25930E-01	32.000	212.000	
NA3PO4.8H2O	4.60704E-01	68.000	158.000	
KNO3PPT	4.08052E-01	32.000	230.000	
NA2SO4PPT	3.45128E-01	50.000	465.800	
ALOOHPPT	3.15763E-01	212.180	482.000	EXCL TR
NA2CRO4PPT	2.49114E-01	77.000	500.000	
NA2UO4PPT	2.33706E-01			
KNO2PPT	2.13370E-01	32.000	248.000	
ALOH3PPT	1.05792E-01	32.000	212.000	
KCLPPT	9.81471E-02	32.000	392.000	
NIOPT	8.91352E-02			
NAALSIO4PPT	8.20414E-02			
NAOH.1H2O	6.85655E-02	41.000	131.000	
MNOH2PPT	5.92318E-02			
NAPHOH.12H2O	5.45053E-02	32.000	104.000	
CR2O3PPT	4.31635E-02			
NA3PO4.1H2O	3.68317E-02	249.800	419.000	EXCL TR
NA2CRO4.4H2O	1.37522E-02	50.000	149.018	
NAACETPPT	1.25851E-02	122.000	253.400	EXCL TR
KOH.2H2O	4.89444E-03	32.000	91.400	EXCL TR
K2CRO4PPT	3.18770E-03	32.000	572.000	
NA2CO3.7H2O	2.69450E-03	89.600	95.666	EXCL TR
NAACET.3H2O	2.26246E-03	32.000	122.000	
KOH.1H2O	1.66962E-03	91.400	289.400	
NAOHPPT	1.14480E-03	572.000	572.000	EXCL TR
NA2OPPT	1.04741E-03			
AL2O3PPT	1.04620E-03			
K2SO4PPT	8.06839E-04	49.460	557.600	
NA2CRO4.6H2O	4.13689E-04	50.000	78.620	EXCL TR
K2SO4.1H2O	2.58066E-04	32.000	49.460	EXCL TR

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CACO3PPT	2.13347E-04			
NA2CO3.10H2O	2.10519E-04	32.000	89.600	EXCL TR
CAF2PPT	1.20270E-04			
K3NASO42PPT	7.65226E-05	95.000	302.000	
NA2CRO4.10H2O	5.55547E-05	32.000	67.100	EXCL TR
K3PO4PPT	5.43205E-05			
NAALCO3OH2PPT	4.90591E-05			
NA2HPO4.2H2O	4.26218E-05	122.000	205.160	EXCL TR
K2C2O4PPT	3.76022E-05			
FEIIIOH3PPT	3.39802E-05	32.000	212.000	
K2OPPT	1.22618E-05			
NA2SO4.10H2O	6.28026E-06	32.000	90.320	EXCL TR
K2C2O4.1H2O	2.78494E-06	32.000	302.000	
CA3PO42PPT	1.71973E-06			
KF.2H2O	7.35919E-07	63.860	104.360	
K2CO3.1.5H2O	3.51076E-07	32.000	176.000	
NA2HPO4.7H2O	3.50073E-07	97.700	122.000	
TRONAPPT	3.11953E-07	77.000	374.000	
NAHCO3PPT	2.27406E-07	32.000	392.000	
KFPPT	1.92290E-07	104.360	176.000	EXCL TR
KF.4H2O	1.53332E-07	32.000	63.860	EXCL TR
CAC2O4.1H2O	9.68137E-08	32.000	203.000	
K2CO3PPT	6.24517E-08	932.000	932.000	EXCL TR
CACRO4PPT	9.28856E-09			
NA4P2O7PPT	6.39349E-09	175.118	204.800	EXCL TR
KOHPPPT	6.32425E-09			
K2HPO4PPT	2.94144E-09	118.940	210.920	EXCL TR
K3PO4.3H2O	2.93657E-09	125.600	140.000	EXCL TR
K3PO4.7H2O	1.99763E-09	32.000	125.600	
QUARTZPPT	1.61924E-09			
KHCO3PPT	1.16951E-09	32.000	158.000	
NA2HPO4.12H2O	1.04690E-09	31.154	97.700	EXCL TR
CAOPPT	8.69062E-10			
NA4P2O7.10H2O	8.04002E-10	32.000	175.100	
CAC2O4PPT	8.03092E-10			
K2HPO4.3H2O	5.25820E-10	58.460	118.940	
CAHPO4PPT	1.96867E-10			
CASO4PPT	1.25374E-10	212.000	482.000	EXCL TR
SIO2PPT	9.81724E-11			
K2HPO4.6H2O	6.67530E-11	32.000	58.460	EXCL TR
NA2HPO4PPT	1.41379E-11	205.160	248.000	EXCL TR
CASO4.2H2O	1.37288E-11	32.000	212.000	
CAHPO4.2H2O	9.87144E-12			
UO2OH2PPT	1.74373E-12			
CANO22PPT	1.46665E-12	932.000	932.000	EXCL TR
CANO22.1H2O	6.01936E-13	94.280	239.000	
CANO22.4H2O	1.22239E-13	32.000	94.280	EXCL TR
CAACET2.2H2O	1.15209E-13	32.000	185.000	
CANO32.3H2O	1.11936E-13	108.500	123.980	EXCL TR
CANO32.4H2O	9.01563E-14	32.000	108.500	
CAACET2.1H2O	5.27359E-14	185.000	212.000	EXCL TR
CANO32PPT	4.38446E-14	131.000	303.800	EXCL TR
CROH3PPT	8.83571E-15			
NAH2PO4PPT	7.15153E-16	140.000	212.000	EXCL TR
NAH2PO4.1H2O	2.85452E-16	105.800	140.000	EXCL TR
NIC2O4PPT	2.58545E-16			
NICO3PPT	2.55699E-16			

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KH2PO4PPT	1.43780E-16	32.000	194.000	
NAH2PO4.2H2O	1.17030E-16	32.000	105.800	
NIC2O4.2H2O	4.26919E-18	32.000	77.000	EXCL TR
P4O10PPT	2.00067E-19			
NINO32.2H2O	6.46030E-23	185.720	247.640	EXCL TR
ALPO4PPT	1.21136E-24			
NINO32.4H2O	7.82258E-25	129.200	185.720	EXCL TR
NINO32.6H2O	1.79599E-25	32.000	129.200	
NIF2.4H2O	1.59375E-25	32.000	194.000	
NINO32PPT	1.46937E-25			
FEIIPO4.2H2O	2.27922E-26			
NISO4.6H2O	2.58616E-27	88.160	212.000	
NISO4.7H2O	6.62220E-28	32.000	88.160	EXCL TR
NA5P3O10PPT	4.80566E-29			
NA5P3O10.6H2O	1.80184E-29			
NISO4PPT	2.12565E-30	932.000	932.000	EXCL TR
CRO3PPT	7.56852E-31			
CAACET2PPT	3.76528E-31			
FEIIPO4PPT	2.71056E-31			
ALF3.3H2O	1.11381E-32	32.000	194.000	
OXALACPPT	5.91571E-33			
OXALAC.2H2O	1.00035E-33	32.000	194.360	
UO2NO32.3H2O	1.00000E-35	137.480	235.400	EXCL TR
UO2NO32.6H2O	1.00000E-35	32.000	137.480	
CAH2PO42.1H2O	1.00000E-35			
UO2SO4.3H2O	1.00000E-35	32.000	308.480	
UO2SO4PPT	1.00000E-35			
K1ALSO4.12H2O	1.00000E-35	32.000	167.000	
NI3PO42PPT	1.00000E-35			
K1ALSO4PPT	1.00000E-35	440.330	442.130	EXCL TR
CAH2PO42PPT	1.00000E-35			
ALNO33.6H2O	1.00000E-35	224.600	264.200	EXCL TR
ALNO33.8H2O	1.00000E-35	176.000	224.600	EXCL TR
ALNO33.9H2O	1.00000E-35	32.000	176.000	
CR2SO4.14H2O	1.00000E-35	77.000	77.000	EXCL TR
CR2SO4.16H2O	1.00000E-35	77.000	77.000	EXCL TR
NA3PO4PPT	1.00000E-35	419.000	662.000	EXCL TR
CR2SO4PPT	1.00000E-35			
CRF3PPT	1.00000E-35			
CRIINO33.9H2O	1.00000E-35	32.000	95.000	EXCL TR
AL2SO43.6H2O	1.00000E-35			
UO2NO32PPT	1.00000E-35			
UVIF6PPT	1.00000E-35			
FE2SO43PPT	1.00000E-35			
FEIIIF3PPT	1.00000E-35			
FEIIINO33.9H2O	1.00000E-35	32.000	104.000	
PUIVF4PPT	1.00000E-35			
AL2SO43PPT	1.00000E-35			
AL2SO43.16H2O	1.00000E-35	32.000	190.400	
KAL3SULFATPPT	1.00000E-35			
UO22P2O7PPT	1.00000E-35			
UO23PO42.4H2O	1.00000E-35			
UO23PO42PPT	1.00000E-35			
UO2C2O4.3H2O	1.00000E-35	32.000	212.000	
UO2F2.3H2O	1.00000E-35			
UO2F2PPT	1.00000E-35			
UO2NO32.2H2O	1.00000E-35	235.400	363.200	EXCL TR

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SURVEY-VARIABLES

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CASE	CELL	TEMPERATURE I F	H2OVAP moles	CH4VAP moles
1.000	1.000	104.0	0.6063E-02	0.0000

CO2VAP moles	ACETACIDVAP moles	H2VAP moles	HCOOHVAP moles	HFVAP moles	HNO2VAP moles
0.1870E-16	0.8666E-17	0.1752E-26	0.0000	0.2200E-19	0.1174E-13

HNO3VAP moles	N2VAP moles	NH3VAP moles	NO2VAP moles	NOVAP moles	O2VAP moles
0.8113E-22	0.2516	0.0000	0.1117E-16	0.6689E-09	0.2810E-27

CH4AQ moles	CO2AQ moles	ACETACIDAQ moles	H2AQ moles	HCOOH AQ moles	HFAQ moles
0.0000	0.3020E-16	0.1871E-11	0.2239E-27	0.0000	0.2603E-13

HNO2AQ moles	HNO3AQ moles	N2AQ moles	NH3AQ moles	NO2AQ moles	NOAQ moles
0.8526E-11	0.2791E-16	0.2378E-01	0.0000	0.1113E-14	0.7338E-13

O2AQ moles	CASO4AQ moles	AGNO2AQ moles	AGCLAQ moles	CROH3AQ moles	CSACETAQ moles
0.4979E-28	0.2288E-10	0.0000	0.0000	0.2400E-18	0.3529E-04

CSCLAQ moles	CSGLYCOLAQ moles	CSNO3AQ moles	FEIIIOH3AQ moles	GLYCOLACIDAQ moles	AGOH AQ moles
0.1962E-02	0.0000	0.2717E-02	0.1210E-09	0.0000	0.0000

H2SIO3AQ moles	ALOH3AQ moles	BIOH3AQ moles	HGCL2AQ moles	HGOH2AQ moles	CAACET2AQ moles
0.4865E-11	0.3231E-07	0.0000	0.0000	0.0000	0.7581E-10

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SURVEY-VARIABLES

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CAC2O4AQ	KACETAQ	KCOOHAQ	KCLAQ	KGLYCOLATAQ	MNC2O4AQ
moles	moles	moles	moles	moles	moles
0.1271E-09	0.1895	0.0000	0.4858	0.0000	0.3296E-15

MNNO32AQ	MNSO4AQ	CACO3AQ	NAACETAQ	NACOOHAQ	NAFAQ
moles	moles	moles	moles	moles	moles
0.5463E-16	0.1785E-18	0.6783E-07	9.777	0.0000	4.995

NAGLYCOLATAQ	NAHCO3AQ	NAHSIO3AQ	NANO2AQ	NANO3AQ	CACOOH2AQ
moles	moles	moles	moles	moles	moles
0.0000	0.2980E-05	0.4057E-01	191.1	120.5	0.0000

NH4ACETAQ	NH4NO3AQ	NIC2O4AQ	NIOH2AQ	CAGLYCOL2AQ	CAH2SIO4AQ
moles	moles	moles	moles	moles	moles
0.0000	0.0000	0.4862E-17	0.2816E-06	0.0000	0.8931E-07

CAHC2O42AQ	PBC2O4AQ	PBNO22AQ	PBOAQ	PUIVOH4AQ	SIO2AQ
moles	moles	moles	moles	moles	moles
0.1160E-39	0.0000	0.0000	0.0000	0.2437E-07	0.1917E-10

SRC2O4AQ	SRCOOH2AQ	SRGLYCOL2AQ	SRHPO4AQ	SRNO32AQ	OHION
moles	moles	moles	moles	moles	moles
0.0000	0.0000	0.0000	0.0000	0.0000	480.1

AGC2O4ION	AGCL2ION	AGCL3ION	AGCL4ION	AGION	AGNO22ION
moles	moles	moles	moles	moles	moles
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AGOH2ION	ALION	ALOH2ION	ALOH4ION	ALOHION	BIION
moles	moles	moles	moles	moles	moles
0.0000	0.1244E-40	0.6532E-18	65.95	0.1664E-29	0.0000

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BIOH4ION	CAACETION	CACOOHION	CACTRTION	CAEDTAION	CAFION
moles	moles	moles	moles	moles	moles
0.0000	0.9423E-09	0.0000	0.0000	0.0000	0.1126E-10

CAGLYCOLION	CAION	CANO3ION	CAOHION	CAPO4ION	CITRATION
moles	moles	moles	moles	moles	moles
0.0000	0.7992E-06	0.5280E-14	0.2661E-04	0.5460E-04	0.0000

CLION	CO3ION	COOHION	CRIIHP04ION	CRIIION	CRO4ION
moles	moles	moles	moles	moles	moles
19.18	1.958	0.0000	0.2764E-42	0.0000	1.375

CROH4ION	CSCTRTION	CSGLYCOL2ION	CSION	CSSO4ION	EDTAION
moles	moles	moles	moles	moles	moles
0.3670E-13	0.0000	0.0000	0.3599E-03	0.4218E-06	0.0000

FEIIION	FEIIIOH2ION	FEIIIOH4ION	FEIIIOHION	FION	GLYCOLATION
moles	moles	moles	moles	moles	moles
0.0000	0.2380E-20	0.7156E-03	0.3344E-32	0.1661	0.0000

H2PO4ION	H2SIO4ION	H3SIO4ION	HCITRATION	HCO3ION	HCRO4ION
moles	moles	moles	moles	moles	moles
0.1745E-13	0.1279E-07	0.2880E-05	0.0000	0.1903E-06	0.2126E-10

HEDTAION	HSEO3ION	HION	HGCL3ION	HGCL4ION	HGEDTAION
moles	moles	moles	moles	moles	moles
0.0000	0.0000	0.1006E-13	0.0000	0.0000	0.0000

HGION	HGNH32ION	HGNH33ION	HGNH34ION	HGOH3ION	HOXALATION
moles	moles	moles	moles	moles	moles
0.0000	0.0000	0.0000	0.0000	0.0000	0.1153E-15

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SURVEY-VARIABLES

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HP2O7ION	HPBO2ION	HPO4ION	HSIO3ION	KCTRION	KEDTAION
moles	moles	moles	moles	moles	moles
0.1639E-21	0.0000	0.2180E-03	0.4108E-11	0.0000	0.0000

KGLYCOL2ION	KION	KSO4ION	LAION	MNCLION	MNEDTAION
moles	moles	moles	moles	moles	moles
0.0000	27.24	0.9032E-02	0.0000	0.2534E-15	0.0000

MNION	NA2FION	NACO3ION	NACTRION	NAEDTAION	NAION
moles	moles	moles	moles	moles	moles
0.1561E-12	0.9088E-06	3.970	0.0000	0.0000	600.6

NASO4ION	NH2CO2ION	NH4ION	NH4SO4ION	NIACETION	NIC2O42ION
moles	moles	moles	moles	moles	moles
0.2509E-01	0.0000	0.0000	0.0000	0.9721E-20	0.4403E-21

NICTRION	NIEDTAION	NIION	NINH32ION	NINH33ION	NINH3ION
moles	moles	moles	moles	moles	moles
0.0000	0.0000	0.7414E-16	0.0000	0.0000	0.0000

NINO3ION	NIOH3ION	NIOHEDTAION	NIOHION	NO2ION	NO3ION
moles	moles	moles	moles	moles	moles
0.6177E-19	0.3179E-01	0.0000	0.6863E-13	17.93	25.61

ACETATEION	OXALATION	PBEDTAION	PBION	PBNO23ION	PBNO2ION
moles	moles	moles	moles	moles	moles
0.1673	0.3336E-02	0.0000	0.0000	0.0000	0.0000

PBOHION	PO4ION	PUIVION	SEO3ION	SEO4ION	SIO3ION
moles	moles	moles	moles	moles	moles
0.0000	2.614	0.0000	0.0000	0.0000	0.7656E-06

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SO4ION	SRACETION	SRCOOHION	SRCTRTION	SREDTAION	SRFION
moles	moles	moles	moles	moles	moles
0.1005	0.0000	0.0000	0.0000	0.0000	0.0000

SRGLYCOLION	SRION	SRNO3ION	SROHION	SRPO4ION	TCVII04ION
moles	moles	moles	moles	moles	moles
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

UO2CO32ION	UO2CO33ION	UO2ION	ZRION	H2OIN	CH4IN
moles	moles	moles	moles	moles	moles
0.2797E-23	0.3200E-17	0.4750E-37	0.0000	1935.	0.0000

CO2IN	ACETACIDIN	H2IN	HCOOHIN	HFIN	HNO2IN
moles	moles	moles	moles	moles	moles
0.0000	0.0000	0.0000	0.0000	0.0000	272.9

HNO3IN	N2IN	NH3IN	NO2IN	NOIN	O2IN
moles	moles	moles	moles	moles	moles
314.8	0.2754	0.0000	0.0000	0.0000	0.7321E-01

CAOH2IN	CROH3IN	CSOHIN	FEIII0H3IN	HGOH2IN	KOHIN
moles	moles	moles	moles	moles	moles
0.6173	1.237	0.5075E-02	0.1263	0.0000	0.0000

LAOH3IN	MNOH2IN	NIOH2IN	PBOH2IN	PUIVOH4IN	SROH2IN
moles	moles	moles	moles	moles	moles
0.0000	0.2836E-01	0.5466E-01	0.0000	0.1878E-04	0.0000

UO2OH2IN	ZROH4IN	NH4OHIN	CITRACIN	HCLIN	H2CO3IN
moles	moles	moles	moles	moles	moles
0.0000	0.0000	0.0000	0.0000	19.61	35.73

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BIOH3IN moles 0.0000	H2CRO4IN moles 0.1374	H4EDTAIN moles 0.0000	HTCVIIIO4IN moles 0.0000	GLYCOLACIDINH4SIO4IN moles 0.0000	2.120
AGOHIN moles 0.0000	ALOH3IN moles 219.3	NAOHIN moles 1399.	OXALACIN moles 6.340	H3PO4IN moles 2.615	H2SO4IN moles 0.0000
H2SEO3IN moles 0.0000	H2SEO4IN moles 0.0000	H6F6IN moles 0.8601	UCL6IN moles 0.1052E-01	TRONAIN moles 0.0000	K2OIN moles 14.13
KAL3SULFATINCS2OIN moles 1.741	ETTRINGITEINFORM2IN moles 0.0000	H2ZRF6IN moles 0.0000	NA6SO42CO3IN moles 0.0000		
ACET2IN moles 5.067	AGCLIN moles 0.0000	AGNO2IN moles 0.0000	CAACET2IN moles 0.0000	CAC2O4IN moles 0.0000	CACO3IN moles 0.0000
CACOOH2IN moles 0.0000	CAGLYCOL2IN moles 0.0000	CAH2SIO4IN moles 0.0000	CAHC2O42IN moles 0.0000	CASO4IN moles 0.0000	CSACETIN moles 0.0000
CSCLIN moles 0.0000	CSGLYCOLIN moles 0.0000	CSNO3IN moles 0.0000	H2SIO3IN moles 0.0000	HGCL2IN moles 0.0000	KACETIN moles 0.0000
KCOOHIN moles 0.0000	KCLIN moles 0.0000	KGLYCOLATIN moles 0.0000	MNC2O4IN moles 0.0000	MNNO32IN moles 0.0000	MNSO4IN moles 0.0000

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NAACETIN moles 0.0000	NACOOHIN moles 0.0000	NAFIN moles 0.0000	NAGLYCOLATIN moles 0.0000	NAHCO3IN moles 0.0000	NAHSIO3IN moles 0.0000
NANO2IN moles 0.0000	NANO3IN moles 0.0000	NH4ACETIN moles 0.0000	NH4NO3IN moles 0.0000	NIC2O4IN moles 0.0000	PBC2O4IN moles 0.0000
PBNO22IN moles 0.0000	PBOIN moles 0.0000	SIO2IN moles 0.0000	SRC2O4IN moles 0.0000	SRCOOH2IN moles 0.0000	SRGLYCOL2IN moles 0.0000
SRHPO4IN moles 0.0000	SRNO32IN moles 0.0000	AG2CO3IN moles 0.0000	BI2O3IN moles 0.0000	CA5OHPO43IN moles 0.0000	CAC2O4.1H2OIN moles 0.0000
CAF2IN moles 0.0000	CASEO3.2H2O moles 0.0000	ICR2O3IN moles 0.0000	FEOOHIN moles 0.0000	HGOIN moles 0.0000	KALSIO4IN moles 0.0000
KNO3IN moles 0.0000	KTCVIIIO4IN moles 0.0000	LAP04.2H2OIN moles 0.0000	MNO2IN moles 0.0000	NA2C2O4IN moles 0.0000	NA2CO3.1H2OIN moles 0.0000
NA2SEO3.5H2O moles 0.0000	NA2SEO3IN moles 0.0000	NA2SEO4.10H2O moles 0.0000	NA2SEO4IN moles 0.0000	NA2U2O7IN moles 0.0000	NA3FSO4IN moles 0.0000
NAALO22.2.5HNA moles 0.0000	ALSIO4IN moles 0.0000	NACLIN moles 0.0000	NAFPO4.19H2ON moles 0.0000	ATCVIIIO4IN moles 0.0000	NAPHOH.12H2OIN moles 0.0000

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NISEO3IN	PB3PO42IN	SR3PO42IN	SRCO3IN	UO2NO32IN	UVIF6IN
moles	moles	moles	moles	moles	moles
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

ZRO2IN	SOLM1	AG2CO3PPT	ALOH3PPT	CA5OHPO43PPT	TCROH3PPT
moles		moles	moles	moles	moles
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

FEOOHPPPT	KALSIO4PPT	MNO2PPT	NA2U2O7PPT	NA6SO42CO3PP	NAALSIO4PPT
moles	moles	moles	moles	moles	moles
0.1256	2.079	0.2836E-01	0.5260E-02	1.674	0.0000

NANO3PPT	NIOH2PPT	NISEO3PPT	PBOH2PPT	ZRO2PPT	SOLM2
moles	moles	moles	moles	moles	
166.9	0.2287E-01	0.0000	0.0000	0.0000	0.0000

NAALO22.2.5HCAC2O4.1H2O	CACO3PPT	CAF2PPT	CASEO3.2H2O	PB3PO42PPT
moles	moles	moles	moles	moles
78.23	0.0000	0.0000	0.0000	0.0000

UO2NO32PPT	UVIF6PPT	BI2O3PPT	HGOPPT	LAOH3PPT	LAP04.2H2O
moles	moles	moles	moles	moles	moles
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

SR3PO42PPT	SRCO3PPT	KCLPPT	SOLM3	KNO3PPT	KTCVIIIO4PPT
moles	moles	moles		moles	moles
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

NA2C2O4PPT	NA2CO3.1H2O	NACLPPPT	NAFPO4.19H2ONAFPPPT	NAHCO3PPT
moles	moles	moles	moles	moles
6.337	28.13	0.0000	0.0000	0.0000

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NANO2PPT	NAPHOH.12H2OPUIVOH4PPT	NA3FSO4PPT	NA2SEO3.5H2ONA2SEO3PPT
moles	moles	moles	moles
65.58	0.0000 0.1875E-04	0.0000	0.0000 0.0000

NA2SEO4.10H2SOLM4	NA2SEO4PPT	NATCVIIIO4PPTCAOH2PPT	CR2O3PPT
moles	moles	moles	moles
0.0000	0.0000 0.0000	0.0000 0.6172	0.0000

SOLFLOW(MOL) LIQFLOW	H2O	LIQFLOW	ENTHAL	ENTHAV
mol/hr	mol/hr	mol/hr	kJ/hr	kJ/hr
349.7	4311.	2737.	4311.	-0.1286E+07 -1.355

ENTHAS	ENTHALPY	PRESSURE	KH2OVAP	AYH2O	AH2O
kJ/hr	kJ/hr	mmHg	Ln()	Ln()	Ln()
-0.3965E+06	-0.1683E+07	755.0	2.617	-0.5865E-02	-1.145

 $\ln(0.1313) = -1.145$

KCH4VAP	AYCH4	ACH4AQ	KCO2VAP	AYCO2	ACO2AQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-6.705	-0.9541E-03	0.9884E-01	-3.751	-0.2593E-02	1.015

KACETACIDVAP	AYACETACID	AACETACIDAQ	KH2VAP	AYH2	AH2AQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
7.144	-0.1024E-01	0.9884E-01	-7.207	0.1464E-02	0.9884E-01

KHCOOHVAP	AYHCOOH	AHCOOHAQ	KHFVAP	AYHF	AHFAQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
7.636	-0.9508E-02	0.9884E-01	9.012	-0.6280E-02	0.2696

KHNO2VAP	AYHNO2	AHNO2AQ	KHNO3VAP	AYHNO3	AHNO3AQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
1.448	-0.9185E-02	0.9884E-01	9.168	-0.8389E-02	1.658

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KN2VAP Ln() -7.508	AYN2 Ln() 0.8505E-04	AN2AQ Ln() 0.9886E-01	KNH3VAP Ln() 3.358	AYNH3 Ln() -0.3824E-02	ANH3AQ Ln() 0.9884E-01
KNO2VAP Ln() -0.5411	AYNO2 Ln() -0.5129E-02	ANO2AQ Ln() 0.9884E-01	KNOVAP Ln() -14.27	AYNO Ln() 0.1216E-03	ANOAAQ Ln() 0.9884E-01
KO2VAP Ln() -6.879	AYO2 Ln() -0.4103E-03	AO2AQ Ln() 0.9884E-01	KALOH4ION Ln() -16.44	AALOH4ION Ln() -0.6511	AALOH3AQ Ln() 0.9884E-01
AOHION Ln() 1.975	KALOHION Ln() -20.69	AALOHION Ln() 3.117	AALION Ln() 3.800	KBIOH3AQ Ln() -74.57	ABIOH3AQ Ln() 0.9884E-01
ABIION Ln() 4.112	KBIOH4ION Ln() -2.945	ABIOH4ION Ln() -0.9454	KCA5OHPO43PPACAION Ln() -12.65	APO4ION Ln() -3.428	APO4ION Ln() -5.940
KCAACET2AQ Ln() -4.890	ACAACET2AQ Ln() 0.9884E-01	AACETATEION Ln() 0.3730	KCAACETION Ln() -2.218	ACAACETION Ln() 0.2198	KCAC2O4AQ Ln() -8.217
ACAC2O4AQ Ln() 0.9884E-01	AOXALATION Ln() -3.835	KCACO3AQ Ln() -7.994	ACACO3AQ Ln() 0.9884E-01	ACO3ION Ln() -3.708	KCACOOH2AQ Ln() -1.924
ACACOOH2AQ Ln() 0.9884E-01	ACACOOHION Ln() 0.2194	ACOOHION Ln() 0.6814	KCACOOHION Ln() -3.268	KCACTRTION Ln() -10.76	ACACTRTION Ln() -0.9454

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ACITRATION	KCAEDTAION	ACAEDTAION	AEDTAION	KCAFION	ACAFION
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-2.935	-28.04	-3.782	-8.534	1.631	0.2198
AFION	KCAGLYCOL2AQ	ACAGLYCOL2AQ	AGLYCOLATION	KCAGLYCOLION	ACAGLYCOLION
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-0.1974	-5.285	0.9884E-01	0.5779	-3.150	0.2194
KCAH2SIO4AQ	ACAH2SIO4AQ	AH2SIO4ION	KCAHC2O42AQ	ACAH2C2O42AQ	AHOXALATION
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-10.93	0.9884E-01	12.47	-5.649	0.9884E-01	0.5779
KCANO3ION	ACANO3ION	ANO3ION	KCAOH2PPT	KCAOHION	ACAOHION
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-1.037	15.31	-0.4793	-12.86	-3.077	0.3953
KCAPO4ION	ACAPO4ION	KCASEO3.2H2OASEO3ION	KCASO4AQ	ACASO4AQ	
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-15.58	-0.9454	-11.32	-3.835	-4.990	0.9884E-01
ASO4ION	KAGCL2ION	AAGCL2ION	AAGION	ACLION	KCO2AQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-5.729	-11.46	-0.9454	0.3954	0.5367	-14.47
AHION	AHCO3ION	KAGC2O4ION	AAGC2O4ION	KCSACETAQ	ACSACETAQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-0.4423	-0.5973	-7.129	-0.9454	-0.1941	0.9884E-01
ACSION	KCSCLAQ	ACSCLAQ	KCSCTRTION	ACSCTRTION	KCSGLYCOL2ION
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
2.896	0.6936	0.9884E-01	-2.199	-3.782	-0.1401

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ACSGLYCOL2IOKCSGLYCOLAQ	ACSGLYCOLAQ	KCSNO3AQ	ACSNO3AQ	KCSSO4ION	
Ln()	Ln()	Ln()	Ln()	Ln()	
-0.9454	0.4039	0.9884E-01	-0.3590	0.9884E-01 -1.334	
ACSSO4ION	KCRIIIHPO4IOACRIIIHPO4IOACRIIIION	AHPO4ION	KCROH3AQ		
Ln()	Ln()	Ln()	Ln()		
-0.9454	-29.01	0.2426	3.677	-4.993 -54.00	
ACROH3AQ	KCROH3PPT	KCROH4ION	ACROH4ION	KFEIIIOH2IONAFEIIIOH2ION	
Ln()	Ln()	Ln()	Ln()	Ln()	
0.9884E-01	-68.31	-60.64	-0.9454	-21.07 0.3517	
AFEIIIOHION	KFEIIIOH3AQ	AFEIIIOH3AQ	KFEIIIOH4IONAFEIIIOH4ION	KFEIIIOHION	
Ln()	Ln()	Ln()	Ln()	Ln()	
2.324	-20.15	0.9884E-01	-10.30	-0.9454 -26.91	
AFEIIIIION	KFEOOHPT	KGLYCOLACIDAAGLYCOLACIDAKH2O	KACETACIDAQ		
Ln()	Ln()	Ln()	Ln()		
3.804	-93.61	-8.835	0.9884E-01 -31.17	-11.08	
KH2PO4ION	AH2PO4ION	KH2SIO3AQ	AH2SIO3AQ	AHSIO3ION	KAGCL3ION
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-16.54	-1.775	-21.53	0.9884E-01	15.31	-13.64
AAGCL3ION	KH3SIO4ION	AH3SIO4ION	KHCITRATION	AHCITRATION	KHCO3ION
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-3.782	-30.03	0.5118	-14.81	-3.835	-23.54
KHCOOHAQ	KAGCL4ION	AAGCL4ION	KHCRO4ION	AHCRO4ION	ACRO4ION
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-8.795	-12.39	-8.509	-15.06	0.5779	-2.800

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KHEDTAION Ln() -26.00	AHEDTAION Ln() -2.935	KHSEO3ION Ln() -16.72	AHSEO3ION Ln() 0.5779	KHFAQ Ln() -7.553	KAGCLAQ Ln() -7.327
AAGCLAQ Ln() 0.9884E-01	KHGCL2AQ Ln() -31.13	AHGCL2AQ Ln() 0.9884E-01	AHGION Ln() 1.988	KHGCL3ION Ln() -33.28	AHGCL3ION Ln() -0.9454
KHGCL4ION Ln() -34.67	AHGCL4ION Ln() -3.782	KHGEDTAION Ln() -54.37	AHGEDTAION Ln() -3.782	KHGNH32ION Ln() -38.44	AHGNH32ION Ln() 1.791
KHGNH33ION Ln() -40.40	AHGNH33ION Ln() 1.791	KHGNH34ION Ln() -42.00	AHGNH34ION Ln() 1.791	KHGOH2AQ Ln() -48.89	AHGOH2AQ Ln() 0.9884E-01
KHGOH3ION Ln() -46.68	AHGOH3ION Ln() -0.9454	KHNO2AQ Ln() -7.142	ANO2ION Ln() 1.153	KAGNO22ION Ln() -8.338	AAGNO22ION Ln() -0.9454
KHNO3AQ Ln() 2.652	KAGNO2AQ Ln() -5.111	AAGNO2AQ Ln() 0.9884E-01	KHOXALATION Ln() -9.988	KHP2O7ION Ln() -21.40	AHP2O7ION Ln() -2.911
AP2O7ION moles 55.66	KHPBO2ION Ln() -6.733	AHPBO2ION Ln() 0.5118	APBOAQ Ln() 0.9884E-01	KHPO4ION Ln() -28.13	KHSIO3ION Ln() -27.27
ASIO3ION Ln() 12.47	KKACETAQ Ln() 0.4791	AKACETAQ Ln() 0.9884E-01	AKION Ln() 0.9229	KKALSIO4PPT Ln() 21.56	ASIO2AQ Ln() 0.9884E-01

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KKCOOHAQ	AKCOOHAQ	KKCLAQ	AKCLAQ	KKCTRITION	AKCTRITION
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-0.1314	0.9884E-01	4.443	0.9884E-01	-2.818	-3.784
KKEDTAION	AKEDTAION	KKGLYCOL2ION	AKGLYCOL2ION	KKGLYCOLATAQ	AKGLYCOLATAQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-3.810	-8.267	1.443	-0.8793	0.4782	0.9884E-01
KKSO4ION	AKSO4ION	KKTCVIO4PPT	ATCVIO4ION	KMNC2O4AQ	AMNC2O4AQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-2.111	-0.8793	-4.206	15.31	-14.65	0.9884E-01
AMNION	KMNCLION	AMNCLION	KMNEDTAION	AMNEDTAION	KMNNO32AQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-7.278	-1.528	0.2659	-35.64	-3.782	-1.688
AMNNO32AQ	KMNSO4AQ	AMNSO4AQ	KAGOH2ION	AAGOH2ION	KNA2FION
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
0.9884E-01	-5.620	0.9884E-01	-9.038	-0.9454	4.304
ANA2FION	ANAION	ANAF AQ	KNA2SEO3.5H2O	KNA2SEO3PPT	KNA2SEO4.10H2O
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
15.31	1.496	0.9884E-01	-0.4193	0.6711	-1.384
ASEO4ION	KNA2SEO4PPT	KNA2U2O7PPT	AUO2ION	KNA6SO42CO3PK	KNAACETAQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
-3.835	0.5175E-01	-44.80	2.212	-6.809	0.2016
ANAACETAQ	KNAALO22.2.5K	KNAALSIO4PPT	KNACO3ION	ANACO3ION	KNACOOHAQ
Ln()	Ln()	Ln()	Ln()	Ln()	Ln()
0.9884E-01	8.988	27.73	-0.9310	0.5118	-0.1055

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ANACOOHAQ Ln() 0.9884E-01	KNACTRTION Ln() -3.106	ANACTRTION Ln() -3.833	KNAEDTAION Ln() -5.859	ANAEDTAION Ln() -3.177	KNAFAQ Ln() 0.2960
KNAGLYCOLATA Ln() 0.5042	AANAGLYCOLATA Ln() 0.9884E-01	AKNAHCO3AQ Ln() 0.5486	ANAHCO3AQ Ln() 0.9884E-01	KNAHSIO3AQ Ln() -3.807	ANAHHSIO3AQ Ln() 0.9884E-01
KNANO2AQ Ln() 1.967	ANANO2AQ Ln() 0.8150	KNANO3AQ Ln() 1.355	ANANO3AQ Ln() 0.6118	KNANO3PPT Ln() 2.861	KNASO4ION Ln() -0.1900
ANASO4ION Ln() -0.1555	KNATCVII04PP Ln() 3.993	KNH2CO2ION Ln() -0.4023	ANH2CO2ION Ln() 0.5367	KNH3AQ Ln() -10.90	ANH4ION Ln() 0.1057
KAGOHAQ Ln() -4.595	AAGOHAQ Ln() 0.9884E-01	KNH4ACETAQ Ln() -0.5909	ANH4ACETAQ Ln() 0.9884E-01	KNH4NO3AQ Ln() -2.167	ANH4NO3AQ Ln() 0.9884E-01
KNH4SO4ION Ln() -2.630	ANH4SO4ION Ln() -0.9454	KNIACETION Ln() -3.145	ANIACETION Ln() 0.2199	ANIION Ln() -6.552	KNIC2O42ION Ln() -17.61
ANIC2O42ION Ln() -3.782	KNIC2O4AQ Ln() -17.36	ANIC2O4AQ Ln() 0.9884E-01	KNICTRTION Ln() -14.71	ANICTRTION Ln() -0.9454	KNIEDTAION Ln() -46.21
ANIEDTAION Ln() -3.782	KNINH32ION Ln() -10.64	ANINH32ION Ln() 1.791	KNINH33ION Ln() -14.12	ANINH33ION Ln() 1.791	KNINH3ION Ln() -5.956

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ANINH3ION Ln() 1.791	KNINO3ION Ln() -0.8771	ANINO3ION Ln() 0.2815	KNIOH2AQ Ln() -10.72	ANIOH2AQ Ln() 0.9884E-01	ANIOHION Ln() 0.3522
KNIOH2PPT Ln() -39.09	KNIOH3ION Ln() -6.339	ANIOH3ION Ln() -0.9454	KNIOHEDTAION Ln() -2.939	ANIOHEDTAION Ln() -8.509	KNIOHION Ln() -9.483
KNISEO3PPT Ln() -28.03	KALOH2ION Ln() -19.82	AALOH2ION Ln() 0.4889	KALOH3AQ Ln() -19.98	KALOH3PPT Ln() -2.365	KP2O7ION moles -2364.
KPBC2O4AQ Ln() -17.88	APBC2O4AQ Ln() 0.9884E-01	APBION Ln() -16.46	KPBEDTAION Ln() -44.35	APBEDTAION Ln() -3.782	KPBNO22AQ Ln() -12.74
APBNO22AQ Ln() 0.9884E-01	KPBNO23ION Ln() -14.76	APBNO23ION Ln() -0.9454	KPBNO2ION Ln() -8.823	APBNO2ION Ln() 0.2629	KPBOAQ Ln() -25.10
KPBOH2PPT Ln() -44.89	KPBOHION Ln() -14.87	APBOHION Ln() 0.3950	KPUIVOH4AQ Ln() -104.9	APUIVOH4AQ Ln() 0.9884E-01	APUIVION Ln() 4.567
KSIO2AQ Ln() -21.95	KSIO3ION Ln() 17.85	KSRACETION Ln() -2.737	ASRACETION Ln() 0.2198	ASRION Ln() -3.656	KSRC2O4AQ Ln() -8.012
ASRC2O4AQ Ln() 0.9884E-01	KSRCOOH2AQ Ln() -5.233	ASRCOOH2AQ Ln() 0.9884E-01	KSRCOOHION Ln() -3.383	ASRCOOHION Ln() 0.2194	KSRCTRITION Ln() -10.05

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ASRCTRTION Ln() -0.9454	KSREDAION Ln() -23.85	ASREDAION Ln() -3.782	KSRFION Ln() -0.5914	ASRFION Ln() 0.2198	KSRGLYCOL2AQ Ln() -4.213
ASRGLYCOL2AQ Ln() 0.9884E-01	KSRGLYCOLION Ln() -2.596	ASRGLYCOLION Ln() 0.2194	KSRHPO4AQ Ln() -3.386	ASRHPO4AQ Ln() 0.9884E-01	KSRNO32AQ Ln() -0.5276
ASRNO32AQ Ln() 0.9884E-01	ASRNO3ION Ln() -0.9454	KSRNO3ION Ln() -1.843	KSROHION Ln() -2.169	ASROHION Ln() 0.2433	KSRPO4ION Ln() -11.34
ASRPO4ION Ln() -0.9454	KUO2CO32ION Ln() -39.58	AUO2CO32ION Ln() -3.782	KUO2CO33ION Ln() -49.12	AUO2CO33ION Ln() -15.13	KZRO2PPT Ln() -130.9
AZRION Ln() 17.29	KAG2CO3PPT Ln() -49.61	KCAC2O4.1H2OKCACO3PPT Ln() -19.80	KCAF2PPT Ln() -19.85	KCAF2PPT Ln() -24.12	KPB3PO42PPT Ln() -102.3
KUO2NO32PPT Ln() 26.42	KUVIF6PPT Ln() 35.24	KBI2O3PPT Ln() 0.1028E-01	KHGOPPT Ln() -57.23	KLAOH3PPT Ln() -62.34	ALAION Ln() 3.420
KLAP04.2H2O Ln() -81.25	KSR3PO42PPT Ln() -65.67	KSRCO3PPT Ln() -22.04	KKCLPPT Ln() 2.243	KKNO3PPT Ln() 0.9145E-01	KNA2C2O4PPT Ln() -5.445
KNA2CO3.1H2OKNACL PPT Ln() -0.8765E-01	KNAFPO4.19H2KNAFPPT Ln() 3.611	KNAFPO4.19H2KNAFPPT Ln() -16.92	KNAHCO3PPT Ln() -1.252	KNAHCO3PPT Ln() -0.6777	KNANO2PPT Ln() 4.137

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KNAPHOH.12H2KPUIVOH4PPT	KNA3FSO4PPT	KCR2O3PPT	KMNO2PPT	KSEO4ION	
Ln()	Ln()	Ln()	Ln()	Ln()	
-5.657	-126.2	-5.757	-16.65	-65.50	-6.103
KCRIIIIION	KH2AQ	KNOAQ	KNO2ION	KNO2AQ	PH
Ln()	Ln()	Ln()	Ln()	Ln()	
-8.488	20.16	15.43	14.87	18.34	15.88
DENSITY	ZCOMP	VOLVAP	VAPFLOW (MOL)	VOLSOL	VOLLIQ
mol/gal		gal/hr	mol/hr	gal/hr	gal/hr
236.3	0.9999	1.761	0.2577	5.015	18.24
DENSITY	OSPRES	ORP	ECOND	ECONDM	VISABS
mol/gal	mmHg	volts	1/ohm/cm	cm2/ohm/	
236.3	0.1396E+07	-0.1636	0.3335	10.03	7.804
VISREL	D_H2O	D_CH4AQ	D_CO2AQ	D_ACETACIDAQ	D_H2AQ
		moles	moles	moles	moles
11.94	0.2512E-15	0.5580E-14	0.7066E-14	0.8604E-14	0.1993E-13
D_ZRION	VOL				
moles	gal/hr				
0.2320E-14	25.02				

APPENDIX D

**BOUNDARY CONDITIONS – VENTILATION INLET NOMINAL
TEMPERATURE AND ABSOLUTE HUMIDITY**

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APPENDIX D

BOUNDARY CONDITIONS – VENTILATION INLET NOMINAL TEMPERATURE AND ABSOLUTE HUMIDITY

Because the thermal time constant for a tank full of waste is on the order of two weeks, it is appropriate to use inlet air temperatures (dry-bulb) averaged over each month as an inlet condition. Monthly average temperatures for the Hanford Site from 1945 through 1999 are provided in Table 3.1 of the *Climatological Data Summary, 1993, with Historical Data* (PNL-9809). The model monthly average temperatures were derived as an average of the temperatures for each month plus two standard deviations (Table D-1). The table also shows the record monthly average temperatures and the year the record occurred. The record temperatures for March, May, June, July, August, September, and October exceed the modeled temperatures. All but one year (1990) contained only one record month. Two record hot months occurred in 1990. The data in PNL-9809 also show that two years (1985 and 1955) contained both record high and record low monthly average temperatures. It was therefore, concluded that the modeled temperatures represent a conservatively hot year.

Table D-1. Monthly Average Temperature for Heat Removal Analysis.

Month	Modeled Monthly Temperature (°F)	Record Monthly Average Temperature (°F)	Year of Record Monthly Average Temperature
January	44.0	42.5	1953
February	46.2	44.5	1958
March	50.4	51.5	1992
April	58.3	58.2	1994
May	68.0	68.7	1947
June	75.2	76.8	1992
July	82.0	82.2	1985
August	80.7	81.5	1967
September	72.2	72.4	1990
October	57.5	59.6	1988
November	48.3	46.5	1990
December	40.7	38.5	1957

To convert °F to °C, $t_{°C} = (t_{°F} - 32)/1.8$.

Table 6.3 in PNL-9809 provides monthly average psychrometric data for 1950 through 1993. Monthly averages for each year were not available in the document. Therefore, the record monthly dew points listed in the table were assumed to be conservatively representative of a high

humidity year. A humidity ratio (pounds moisture per pound of dry air) was calculated using the record dew points for use in the model (Table D-2).

Table D-2. Monthly Average Humidity for Heat Removal Analysis.

Month	Record Dewpoint	Humidity Ratio (lbm H ₂ O/lbm air)
January	34.4	0.0042
February	36.7	0.0045
March	37.2	0.0046
April	37.1	0.0046
May	43.8	0.0060
June	47.5	0.0069
July	50.1	0.0077
August	48.4	0.0072
September	45.4	0.0064
October	43.5	0.0059
November	38.3	0.0049
December	34.3	0.0041

REFERENCES

PNL-9809, 1994, *Climatological Data Summary, 1993, with Historical Data*, Pacific Northwest Laboratory, Richland, Washington.