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DISCLAIMER

Defense Waste Processing Facility Recycle Stream Evaporation

Michael Stone
Savannah River National Laboratory, Aiken, SC 29808

The Defense Waste Processing Facility (DWPF) at the Savannah River Site (SRS) stabilizes high level radioactive waste (HLW) by vitrification of the waste slurries. DWPF currently produces approximately five gallons of dilute recycle for each gallon of waste vitrified. This recycle stream is currently sent to the HLW tank farm at SRS where it is processed through the HLW evaporators with the concentrate eventually sent back to the DWPF for stabilization. Limitations of the HLW evaporators and storage space constraints in the tank farm have the potential to impact the operation of the DWPF and could limit the rate that HLW is stabilized. After an evaluation of various alternatives, installation of a dedicated evaporator for the DWPF recycle stream was selected for further evaluation.

The recycle stream consists primarily of process condensates from the pretreatment and vitrification processes. Other recycle streams consist of process samples, sample line flushes, sump flushes, and cleaning solutions from the decontamination and filter dissolution processes. The condensate from the vitrification process contains some species, such as sulfate, that are not appreciably volatile at low temperature and could accumulate in the system if 100% of the evaporator concentrate was returned to DWPF. These species are currently removed as required by solids washing in the tank farm. The cleaning solutions are much higher in solids content than the other streams and are generated 5-6 times per year.

The proposed evaporator would be required to concentrate the recycle stream by a factor of 30 to allow the concentrate to be recycled directly to the DWPF process, with a purge stream sent to the tank farm as required to prevent buildup of sulfate and similar species in the process. The overheads are required to meet stringent constraints to allow the condensate to be sent directly to an effluent treatment plant. The proposed evaporator would nearly de-couple the DWPF process from the tank farm by eliminating all recycle transfers to the tank farm except a small purge stream.

The test program performed by the Savannah River National Laboratory (SRNL) consisted of four phases: Radioactive characterization of the recycle streams[1], OLI modeling[2], simulant testing[3], and radioactive testing[4]. The evaluation determined that the operation of a dedicated recycle evaporator is feasible, but some technical and operational issues must be resolved. These issues are incorporation of the higher solids from the cleaning solution, foaming during the evaporation process, and higher than acceptable levels of mercury, nitrate, I-129, and organic carbon in the condensate for some of the potential recycle streams. This paper will focus on the simulant testing.

Characterization included chemical, physical, and radiological characterization of samples of the actual DWPF recycle streams. These samples should be considered a “snapshot” of the process at the time the sample was taken since the compositions of the cleaning solutions can vary considerably as different items are decontaminated and the compositions of the melter offgas and pretreatment condensate will vary as different sludge batches are processed. The characterization data was used in conjunction with engineering judgment to determine the compositions for the simulants used during non-radioactive testing.

Simulant testing was performed to demonstrate the feasibility of the proposed recycle evaporator, determine the processing characteristics of the recycle streams, and determine the processing parameters for the radioactive test. Non-radioactive simulants were developed for each of the major recycle streams, as shown in Table 1. Sump flushes were simulated using DI water. Six different tests were conducted with varying amounts of each recycle in the evaporator feed, as shown in Table 2. Each test concentrated the evaporator feed by a factor of 30X and included a period of steady-state operation.

Table 1. Simulant Compositions and Physical Properties

Simulant	Ag	Al	B	Ba	Ca	Cr	Cu	Fe	Gd	Hg	K	Li
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/kg	mg/L	mg/L
Pretreat Cond.	Ltd	0.439	0.215	ltd	0.069	ltd	ltd	ltd	ltd	173	0.234	ltd
Melter Offgas Condensate	2.26	555	7.27	10.8	307.5	2.72	17.6	2115	8.785	119	26.65	18.15
Decon Solution	Ltd	0.43	1.97	ltd	24.1	ltd	ltd	1465	ltd	187	2.08	ltd
HEME Dissolutions	Ltd	147	293	0.256	250.5	1.415	ltd	2.825	ltd	ltd	115	ltd
Sample Flush	16.9	15050	30.0	71.5	2115	27.95	151	59200	64.5	nm	217.5	46.85
Simulant	Mg	Mn	Na	Ni	P	Pb	S	Si	Sr	Ti	Zn	Zr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Pretreat Cond.	Ltd	ltd	0.494	ltd	ltd	ltd	ltd	1705	ltd	ltd	Ltd	ltd
Melter Offgas Condensate	383.5	631	2315	93.7	6.1	9.865	41.6	40.1	1.135	1.515	29.7	4.64
Decon Solution	57.05	127	197.5	42.45	ltd	ltd	20.2	4.005	ltd	ltd	Ltd	ltd
HEME Dissolutions	72.3	ltd	30200	0.0235	0.3995	0.203	1.83	3550	ltd	1.02	0.073	2.43
Sample Flush	5015	9595	15100	2100	78.7	78.05	487	115.5	4.235	21.75	313	39.1
Simulant	NO_2	NO_3	SO_4	HCO_2	Density		Solids			pH	Acid Equal.	Viscosity @ 25C
					Slurry	Supernate	Total	Soluble	Insoluble			

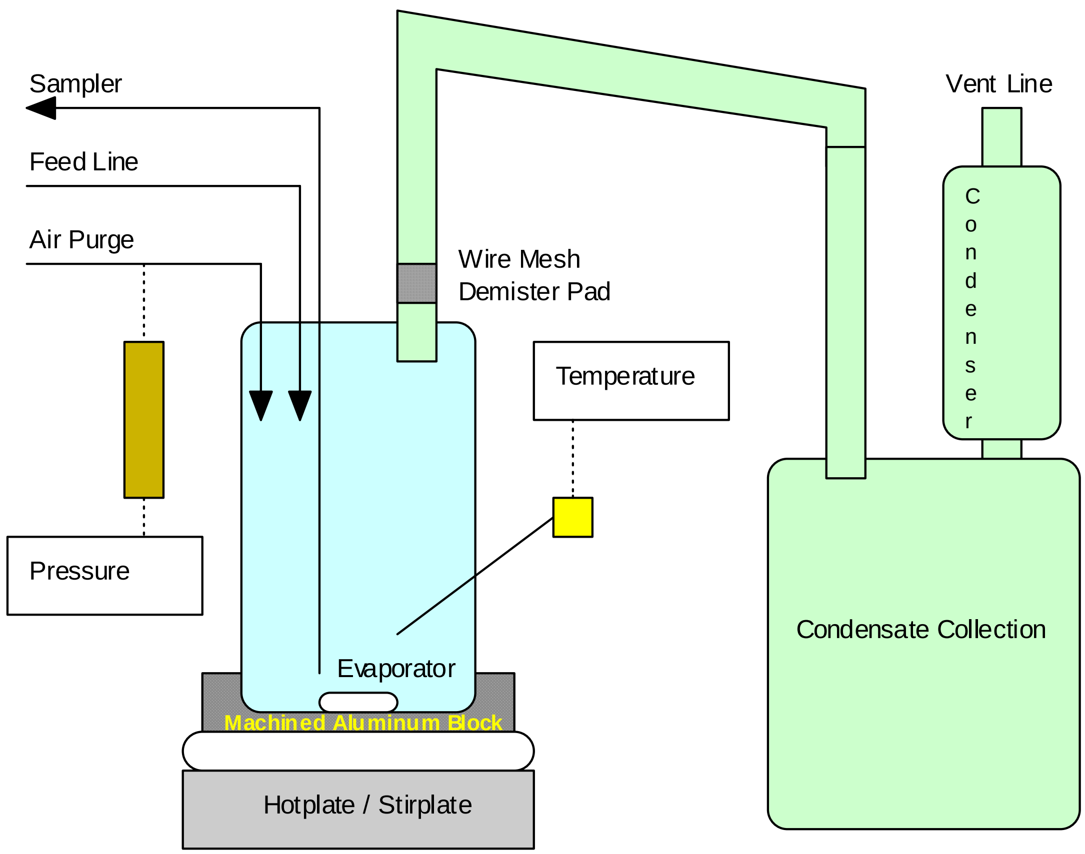
	mg/L	mg/L	mg/L	mg/L	g/ml	g/ml	wt%	wt%	wt%		Molar	cP
Pretreat Cond.	ltd	5930	ltd	442.5	nm	1.0009	ltd	ltd	ltd	0.98	nm	nm
Melter Offgas Condensate	ltd	1595	1018.5	ltd	1.0010	0.9995	0.37	0.09	0.28	2.15	0.01	0.892
Decon Solution	ltd	13650	789	8385	1.0140	1.0108	2.46	1.57	0.89	1.68	0.14	0.921
HEME Dissolutions	201.5	ltd	ltd	ltd	1.0631	1.0613	6.35	6.35	0	13.73	1.39	1.23
Sample Flush	ltd	39550	7575	82100	1.2886	nm	38.22	nm	nm	5	nm	nm

ltd: Less than detectable
nm: Not measured

Table 2. Recycle Blending Scenarios Tested

Scenario	Pretreat. Condensate	Melter Offgas Condensate	Decon Solution	HEME Dissolutions	Sample Flush	Sump Flushes	Total Volume
1	2016	1721	0	0	5	258	4000
2	3539	0	0	0	8	453	4000
3	0	4000	0	0	0	0	4000
4	1452	1240	0	1305	3	0	4000
5	0	2000	2000	0	0	0	4000
6	2016	1721	0	0	5	4258	8000

Flowsheet testing was conducted in a laboratory scale evaporator fabricated as shown in Figure 1. The evaporator consists of an evaporation vessel with stirring bar, a stirring hotplate, an aluminum heat transfer plate, a wire mesh demister, a condenser with recirculating water bath, and a condensate collection vessel. A feed tank and pump was utilized to feed the simulated recycle to the evaporator during the run. This apparatus was used for simulant work as well as the radioactive test. The evaporator was operated with a constant volume of 100 ml. After 3000 ml of feed had been fed and concentrated to 100 ml, 1000 ml of feed was fed during steady-state operation with condensate and concentrate being removed from the evaporator. During Scenario 6, these volumes were doubled. Process samples were taken from the end of the steady-state run for compositional analysis.



Evaporator Volume: 300 ml
Evaporator Diameter: 6 cm
Top Ports: 4 #7 Ace Threads
1 24/40 ground glass

Not Shown:
Feed tank and pump
Concentrate tank and pump
Offgas composition instruments
Water bath and lines

Figure 1. Flowsheet Evaporator Apparatus

Antifoam tests were conducted in a larger evaporator designed to achieve a higher flux rate, as shown in Figure 2. The tests were conducted by charging 700 ml of feed to the vessel and evaporating until 400 ml of condensate had been collected. Antifoam (1000 ppm) was added prior to heating the vessel to boiling.

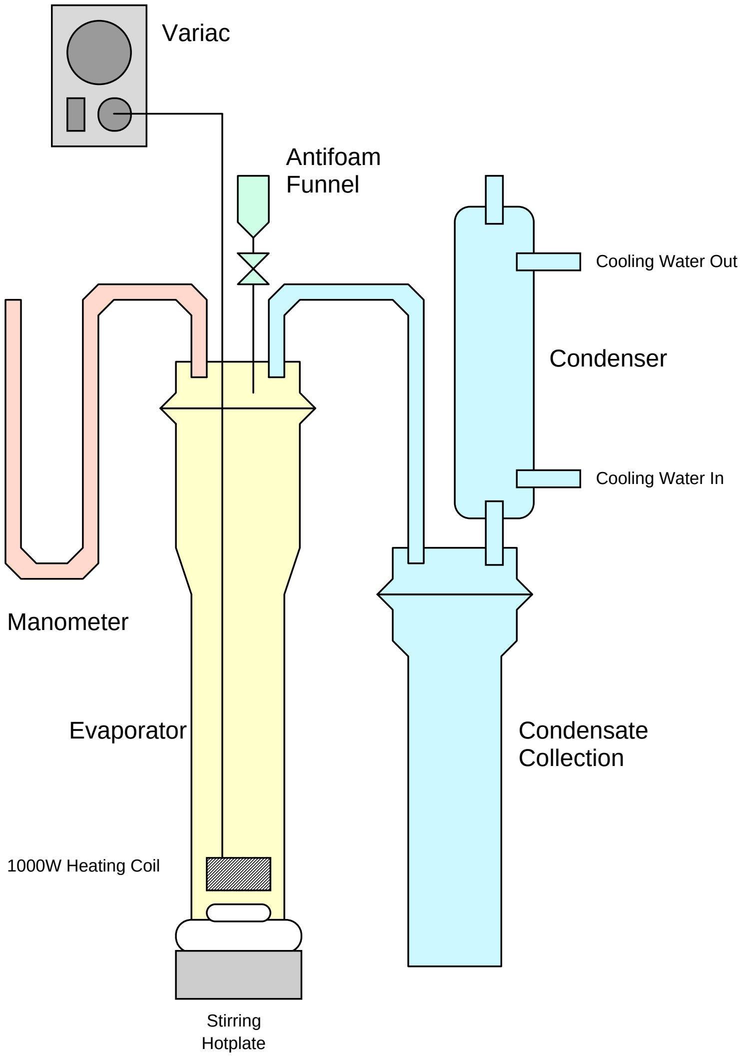


Figure 2. Antifoam Test Apparatus

Scaling parameters for the experimental vessels are shown in Table 3. Note that the boil-up rate of the full-scale process could not be matched by the laboratory scale vessels.

Table 3. Scaling Parameters

	Full-Scale	Antifoam Test Apparatus	Boil-Down Test Apparatus
Diameter (inches)	60	3.25	2.4
Boil-Up Rate (g/min)	28000	14	2.5
Flux Rate (g/min-in^2)	9.20	1.7	0.6
Flux Rate (% of full scale)	100	17	7
Heating Source	Steam	Hotplate and heating coil	Hotplate w/ aluminum block

Sample Analysis Methods

Samples were taken of each simulant and blended feed stream prior to each run. Samples of the concentrate and condensate were taken at the conclusion of each flowsheet run. Each analysis was performed as outlined below.

pH

An IQ Scientific model IQ150 pH probe was utilized to measure the pH of the samples. This instrument is an ion-selective pH meter with automatic temperature measurement and compensation. The instrument was checked with pH 4, 7, and 10 buffers before and after use.

Density

An Anton Paar DMA-4500 density meter was utilized to determine the density of samples. This instrument utilizes the dampening of a vibrating u-tube to measure density. The instrument was checked with DI water prior to each use.

Solids Content

The solids content was measured with a Mettler-Toledo HR83 halogen moisture meter. The solids content of the slurry and the solids content of supernate were measured. Supernate was prepared by filtration of the slurry through a syringe filter. The insoluble and soluble solids content were calculated from the results. The instrument was checked with standards before and after use.

Viscosity

Viscosity was measured with a Haake RS-600 rheometer using the 0.5 degree, 60 mm cone and plate geometry at a single shear rate (2000 seconds^{-1}). The instrument was checked with viscosity standards before each use.

Composition Measurements

Metals and anion analysis were performed by the Process Science and Analytical Laboratory at SRNL. Standards and blank analyses were performed before and after each set of analytical runs.

Titrations

The initial samples from this study were titrated using a Mettler-Toledo DL40GP autotitrator. The standard titration method utilized two milliliters of sample diluted into approximately 60 ml of DI water. 0.1M hydrochloric acid or sodium hydroxide solution was added while the sample was mechanically agitated. pH is continuously monitored during the acid addition. Duplicate analysis was performed on each sample and the results were averaged. Results were rejected if the difference between the duplicate samples was greater than 10%.

The autotitrator failed during the test program, therefore direct titration using manual additions of sodium hydroxide to the sample was utilized. The pH probe utilized during the direct titration tests was the same as for the pH measurements. The direct titration method utilized approximately 5 ml of sample diluted to 20 ml with DI water. The sample was continuously mixed while 0.1 ml additions of sodium hydroxide solution were added. The pH was allowed to stabilize between each addition and was recorded prior to the next addition. A plot of pH versus amount of acid added per ml of sample was generated. The intercept of the pH curve with pH = 7 was then determined. Two measurements were taken for each sample and the results checked for consistency.

Mercury Analysis

Mercury was analyzed using atomic adsorption cold vapor methods after digestion with aqua regia. Standards were analyzed before and after each set of analytical runs.

XRD Analysis

X-Ray Diffraction (XRD) analysis was performed on solids filtered onto filter paper. The supernate from the solids filtration was filtered through a second filter and submitted with the solids to provide a “blank” to determine if solids in the XRD analysis are from the supernate or solids content of the sample.

Results

All six of the scenarios outlined above were tested and Scenario 1 was tested in triplicate. Decontamination Factors (DF’s) were calculated for each species based on the sample results. Foaming was noted in all runs, with severe foaming occurring in some of the runs. Foaming was controlled by reducing the boil-up rate. No evidence of solids precipitation was noted during any of the runs. Scaling below the liquid surface was not noted, but splattering of particulate onto the vessel led to some solids deposition on the vessel walls above the foam layer.

Foaming

Foaming during the evaporation process was noted to some extent during all runs. Foam was controlled during the tests by reducing the boil-up rate. The reduced boil-up rate lowered the vapor flux rate at the liquid surface and significantly reduced the amount of foam in the evaporation vessel. The flux rate for the boil-down tests was less than 10% of the flux rate in the conceptual design, as shown above in Table 3. Higher flux rates would have led to increased foaming; therefore the foaming that occurred during the boil-down tests was noted as a concern for operation of the recycle evaporator. The maxima in foam height were observed for the runs at the onset of boiling with a gradual decrease in foam height noted as the runs progressed, as shown in Figure 3. Foaming was least in the run during evaporation of Scenario 3 (OGCT only) recycle.

Figure 3. Foaming during Initial and Final Stages of Scenario 1, Run 1 Evaporation

Scaling of foaming phenomena is difficult from tests conducted in small-scale apparatus due to the effects of the vessel walls in stabilizing foam lamellas. The “wall effect” is appreciable in the small-scale tests but disappears on scale-up. The wall effect is especially pronounced if the diameter of the bubbles in the foam lamella are greater than 1/3 the diameter of the vessel. As shown in the above figures, bubbles during the boil-down tests were much smaller than the vessel and the amount of foam noted was not attributed to wall effects.

Additional tests were conducted to study the potential for foam formation and to evaluate the performance of antifoams recommended by Dow Corning and the antifoams identified for use in the Hanford RPP project (Dow Corning Q2-3183A). These tests were conducted in a larger diameter vessel with increased flux rates to better simulate the full-scale process. The tests were conducted by charging 700 ml of feed to the vessel and evaporating until 400 ml of condensate had been collected. Antifoam (1000 ppm) was added prior to heating the vessel to boiling.

A water run was conducted to determine the maximum boil-up rate and the height of vapor disengagement in the vessel with a non-foaming liquid. During this run, full power (1000 watts) on the coil and a temperature setting of 500° C on the hotplate yielded a boil-up rate of 25 grams per minute. Vapor disengagement amounted to approximately 100 ml during the run. A baseline run without antifoam was then conducted. The foam quickly rose in the vessel to a height greater than 2000 ml (height of last graduation line) and would likely have foamed over in the condensate collection vessel if the coil power had not been reduced to 600 watts. The foam level remained above 2000 ml until the conclusion of the run. All subsequent tests were conducted at 600 watts to allow direct comparison to this test and prevent foam-over if the antifoam tested was ineffective.

The next test was conducted with Dow Corning Q2-3183A. The foam height at the onset of boiling was significantly reduced, but the foam level was judged to be excessive and an additional 1000 ppm of the antifoam was added. Foam control during this run was not deemed adequate, and additional tests were performed with antifoams recommended by Dow Corning (1430, 2210, and DSP). As shown in Figure 4, foam control with these antifoams was much improved over the Q2 3183A antifoam and all three antifoams performed similarly.

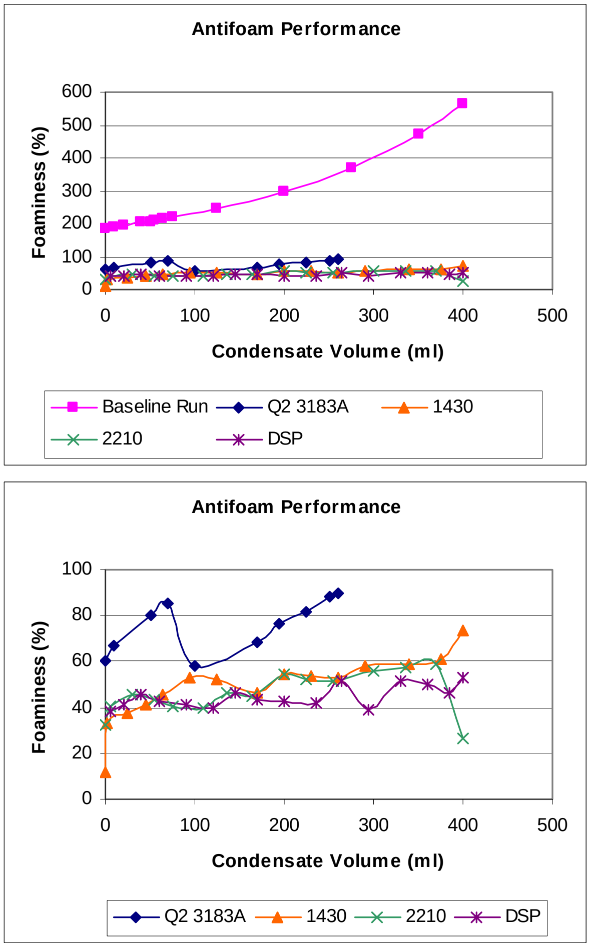


Figure 4. Performance of Antifoams

Flocculation of the feed material was noted in both the 2210 and DSP antifoam tests, as shown in Figure 5. The flocculation occurred just prior to the onset of boiling and resulted in the solution appearance changing from a red, opaque slurry to a clear liquor containing large red chunks. A significant portion of the solids were trapped in a surface film. This film was agitated and mixed into the body of the solution at the onset of boiling. Antifoams often contain flocculating agents to aid in foam control; therefore the flocculation noted could have been the result of the addition of more antifoam than required. As the run progressed, the solids began to break apart and the appearance of the slurry at the conclusion of the tests was similar to the baseline run.

Figure 5. Flocculation during Addition of DSP Antifoam

A test run was performed with DSP antifoam to determine the concentration of the antifoam required to control the foam and to determine how often additional antifoam would be required during evaporator operation. The antifoam test apparatus was modified to allow continuous operation and the test was performed. An initial charge of 700 ml was added to the evaporation vessel and the run was started. Feed material was added to match the boil off amounts to maintain the level in the evaporator at 700 ml and the feed was concentrated 30X.

Antifoam was added in small amounts until the foam height was less than 1200 ml, with approximately ~700 ppm required. Additional 100 ppm antifoam additions were required after approximately 30 minutes to keep the foam height below 1200 ml. As the initial foaming subsided, less antifoam was required. While the foam was stable, an additional charge of DSP antifoam was added to determine if the foam height would be reduced. The foam height increased significantly after addition, and 100 ppm 2210 antifoam was added to control the foam, as shown in Figure 6. No additional antifoam was required, but an additional charge of 2210 antifoam was added to determine if the stable foam height could be reduced. Very little reduction in the foam height was noted, but the foam height did not increase as was noted with the DSP antifoam.

Figure 6: Foaming During Antifoam Tests with DSP and After 2210 Addition

Condensate Characterization

The condensate was sampled at the conclusion of the each flowsheet test run, but this sample did not represent an aggregate sample of all condensate from the run. Condensate was collected continuously during the test run, but was removed batch wise when the condensate collection tank was filled. A small heel was left in the collection vessel during each transfer. The evaporator contents at the start of the run matched the feed composition, therefore the condensate generated during the initial portion of the run would not be representative. The first three liters of feed were required to reach steady-state concentration in the evaporator. An additional liter of feed was fed during steady-state operation; condensate from this stage of operation was contained in the sample at the conclusion of the run. The Scenario 4 condensate sample represents the last sample pulled prior to the foam over.

The sample results obtained for the condensate were compared to the Effluent Treatment Plant (ETP) Waste Acceptance Criteria (WAC). Major species noted in the condensate are shown in Table 4.

Table 4. Major Species in Recycle Evaporator Condensate

	Description	Hg	Si	Nitrate	Formate	TOC*	pH
	ETP WAC Acceptance Limits	40.6	99.2	1180		385	1-12.5
Scenario #		ppm	ppm	ppm	ppm	ppm	
1-1	"Typical" Operation	152	408	429	361	96	2.2
1-2	"Typical" Operation	12	67	284	398	106	2.4
1-3	"Typical" Operation	77	67	420	434	116	2.3
2	Melter Idled	17	1120	703	819	218	1.9
3	CPC Idled	0	0	0	0	0	3.0
4	HEME Dissolution	36	28	840	0	0	2.0
5	Decon Operation	20	0	1080	3015	804	2.0
6	Salt Operations	23	9.5	172	177	47	2.5

* Calculated from formate concentration.

The WAC for mercury, silicon, and organic carbon was exceeded during at least one of the test runs. The mercury results contained a significant amount of scatter and are discussed below. The silicon noted for Scenario 1-1 may be an outlier, but the result from Scenario 2 is well above the limits and is consistent with the larger amounts of silicon-based antifoam that would be present during a run that only contains material from the CPC operations. The run with high TOC contained a large amount of formate in the SME solids dissolved in the decon solution. Limiting the amount of decon solution in the evaporator feed would likely prevent formate from exceeding the limit.

Beads of mercury were noted in the condensate collection vessel for all runs except Scenario 3 (OGCT only). Based on the presence of elemental mercury beads in the condensate, the condensate was saturated with Hg. Typically, the saturation point of a solution is pH dependant. However, the concentration of Hg in the condensate samples varied from run to run at the same pH. These data suggest that the saturation point of mercury in the condensate samples was not merely a function of the pH. A possible explanation for the different concentrations noted for the three runs of Scenario 1, could be due to the reducing and oxidizing agents present in the samples. The presence of oxidizing and reducing agents is known to impact the solubility of mercury.

Concentrate Characterization

The concentrate from each boil-down test was sampled and characterized. A concentration factor was calculated for each species in the concentrate by dividing the concentrate concentration by the feed concentration. The concentration factors vary somewhat from the concentration target due to uncertainties in the sample analysis and the errors in determining the solution height during the run. The foaming in the evaporator led to difficulty in the determination of the liquid height during the run. During steady state operation, errors in the level would have resulted in removal of concentrate that was too dilute or too concentrated. These errors led to some variability in the actual concentration of the final sample.

All runs except Scenario 4 were able to achieve the concentration target, within the uncertainties described above and resulted in concentrate that was free flowing. Solids contents ranged from 3 to 30%, dependent on the solids content of the incoming feed, with a nominal value of 10% for runs without DWTT content. The solids content of the DWTT stream raises the solids content of the feed considerably. The amount of HEME dissolution material in Scenario 4 resulted in a feed that would have exceeded 100% solids if concentrated 30X, resulting in a foam over when the feed became too concentrated for the evaporator apparatus. The run with coil decontamination solution from the DWTT reached 30% solids content.

Precipitation

No precipitation of solids was noted during the runs, based on visual observations during the runs and XRD results. Results from the solids analysis were inconclusive due to the small amount of solids originally present. Figures 7 and 8 are typical XRD results for the feed and concentrate samples and are from Scenario 1. Note that much of the gibbsite noted in the feed is converted to aluminum oxide during the evaporation process.

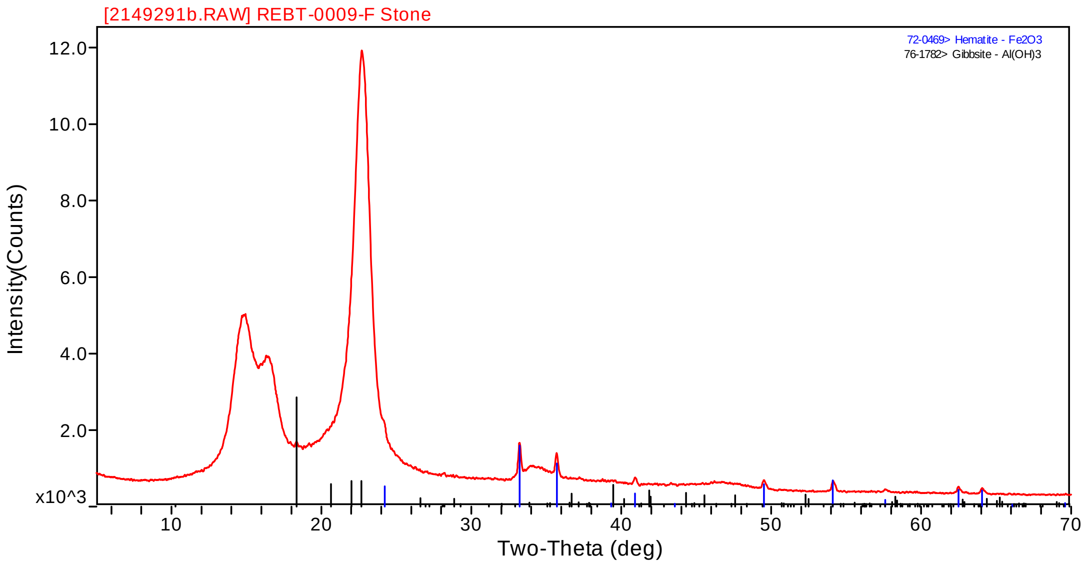


Figure 7. XRD from Scenario 1 Feed Sample

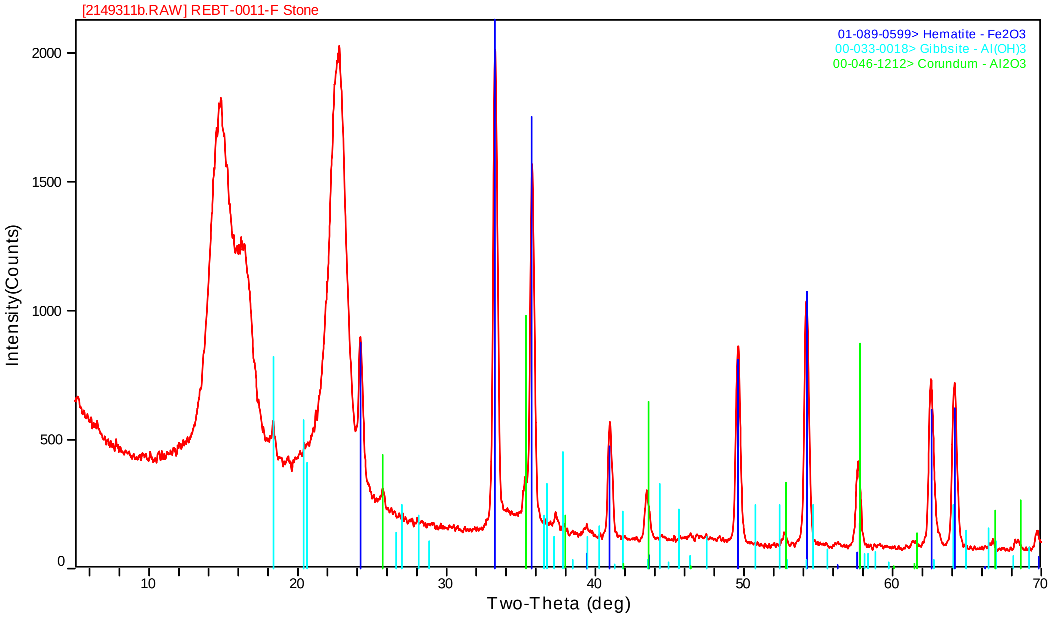


Figure 8. XRD from Scenario 1 Concentrate Sample

Scaling

Visual observations of the evaporation apparatus after each test were conducted to determine if scaling was occurring. During all runs, the boiling surface was vigorous and caused some splatter of solids onto the vessel walls. These solids tended to stick to the walls, as shown in Figure 9 and were not washed off by the limited amount of internal reflux that occurred during the runs. The solids deposited on the walls were not easily removed by 2M nitric acid rinses. Two of the antifoams (Q2-3183A and 1430) led to a film formation above the foam line during antifoam testing. This film was easily cleaned from the vessel with water. The flocculation caused by 2210 and DSP antifoams led to larger particles being deposited on the walls, but these particles were easily removed during cleaning.

Figure 9: Scale Buildup on Walls during Scenario 1-1

During antifoam testing, a stainless steel heating coil was utilized. No significant deposition was noted on the heating surface during the tests.

Evaporator DF

The evaporator Decontamination Factor (DF) was calculated for each species present in the feed samples based on the sample results from the feed and condensate for each run. When the condensate results indicated less than detectable amounts, the detection limit was utilized to determine the DF. The average results along with the lowest and highest value are shown in Table 5 for selected species. Values shown in bolded italics in Table 5 are based on the sample detection limits.

Table 5. Evaporator DF for Selected Species

	Sample Detection Limit	Low	Average	High
Al	0.1	***5***	355	2255
B	n/a	1.2	10	22
Fe	0.04	***2663***	***22138***	***46750***
K	n/a	4	38	155
Hg	2.5	1.0	13	64
Mo	n/a	2	20	44
Si	n/a	0.05	8	33
NO_3	n/a	7	13	29
HCO_2	n/a	0.80	1.08	1.39

Several issues with the DF's should be noted. The small evaporator size utilized during the boil-down tests could have impacted the results and no attempts were made to make the vent system "prototypical". A crude demister was utilized during the test which consisted of a steel mesh wrapped into a cylinder and forced into the offgas line. This demister was likely less efficient than a commercially designed unit. Deposition of selected species on the walls of the offgas system could have raised the apparent DF for that species.

A review of the results for selected species was performed to determine the magnitude of the impacts of the issues listed above. The relatively high DF values for iron indicate that entrainment of drops into the offgas system was not excessive, therefore, foaming is likely not the cause of the low DF's seen for some species. When the DF for silicon is examined, runs with large amounts of frit had much higher DF's than runs with larger amounts of siloxanes from the antifoam. The presence of elemental mercury beads in the condensate collection indicates that the holdup of mercury on vessel and tubing walls did not affect the amount of mercury seen in the condensate.

Conclusions from Simulant Testing

- Concentration of the “typical” recycle stream in DWPF by 30X was feasible. The addition of DWTT recycle streams to the typical recycle stream raises the solids content of the evaporator feed considerably and lowers the amount of concentration that can be achieved.
- Foaming was noted during all evaporation tests and must be addressed prior to operation of the full-scale evaporator. Tests were conducted that identified Dow Corning 2210 as an antifoam candidate that warrants further evaluation.
- The condensate has the potential to exceed the ETP WAC for mercury, silicon, and TOC. Controlling the amount of equipment decontamination recycle in the evaporator blend would help meet the TOC limits. The evaporator condensate will be saturated with mercury and elemental mercury will collect in the evaporator condensate collection vessel.
- No scaling on heating surfaces was noted during the tests, but splatter onto the walls of the evaporation vessels led to a buildup of solids. These solids were difficult to remove with 2M nitric acid. Precipitation of solids was not noted during the testing.
- Some of the aluminum present in the recycle streams was converted from gibbsite to aluminum oxide during the evaporation process.

Recommendations from Simulant Testing

- Recycle from the DWTT should be metered in slowly to the “typical” recycle streams to avoid spikes in solids content to allow consistent processing and avoid process upsets. Additional studies should be conducted to determine acceptable volume ratios for the HEME dissolution and decontamination solutions in the evaporator feed.
- Dow Corning 2210 antifoam should be evaluated for use to control foaming. Additional tests are required to determine the concentration of antifoam required to prevent foaming during startup, the frequency of antifoam additions required to control foaming during steady state processing, and the ability of the antifoam to control foam over a range of potential feed compositions. This evaluation should also include evaluation of the degradation of the antifoam and impact on the silicon and TOC content of the condensate.
- The caustic HEME dissolution recycle stream should be neutralized to at least pH of 7 prior to blending with the acidic recycle streams.
- Dow Corning 2210 should be used during the evaporation testing using the radioactive recycle samples received from DWPF.
- Evaluation of additional antifoam candidates should be conducted as a backup for Dow Corning 2210.
- A camera and/or foam detection instrument should be included in the evaporator design to allow monitoring of the foaming behavior during operation.

- The potential for foam formation and high solids content should be incorporated into the design of the evaporator vessel.

References

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