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Revision 0

SLUDGE BATCH 5 SIMULANT FLOWSHEET STUDIES

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October 2008

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EXECUTIVE SUMMARY

The Defense Waste Processing Facility (DWPF) will transition from Sludge Batch 4 (SB4) processing to Sludge Batch 5 (SB5) processing in early fiscal year 2009. Tests were conducted using non-radioactive simulants of the expected SB5 composition to determine the impact of varying the acid stoichiometry during the Sludge Receipt and Adjustment Tank (SRAT) and Slurry Mix Evaporator (SME) processes. The work was conducted to meet the Technical Task Request (TTR) HLW/DWPF/TTR-2007-0007, Rev. 1[1] and followed the guidelines of a Task Technical and Quality Assurance Plan (TT&QAP)[2].

The flowsheet studies are performed to evaluate the potential chemical processing issues, hydrogen generation rates, and process slurry rheological properties as a function of acid stoichiometry. Initial SB5 flowsheet studies were conducted to guide decisions during the sludge batch preparation process. These studies were conducted with the estimated SB5 composition at the time of the study. The composition has changed slightly since these studies were completed due to changes in the washing plan to prepare SB5 and the estimated SB4 heel mass.

Nine DWPF process simulations were completed in 4-L laboratory-scale equipment using both a batch simulant (Tank 51 simulant after washing is complete) and a blend simulant (Tank 40 simulant after Tank 51 transfer is complete). Each simulant had a set of four SRAT and SME simulations at varying acid stoichiometry levels (115%, 130%, 145% and 160%). One additional run was made using blend simulant at 130% acid that included additions of the Actinide Removal Process (ARP) waste prior to acid addition and the Modular Caustic Side Solvent Extraction (CSSX) Unit (MCU) waste following SRAT dewatering.

There are several parameters that are noteworthy concerning SB5 sludge:

- This is the first batch DWPF will be processing that contains sludge that has had a significant fraction of aluminum removed through aluminum dissolution.
- The sludge is high in mercury.
- The sludge is high in noble metals
- The sludge is high in U and Pu – components that are not added in sludge simulants.

Two SB5 processing issues were noted during testing. First, high hydrogen generation rates were measured during experiments with both the blend and batch simulant at high acid stoichiometry. Also, the reflux time was extended due to the high mercury concentration in both the batch and blend simulant.

Adding ARP will extend processing times in DWPF. The ARP caustic boil took approximately six hours. The boiling time during the experiment with added MCU was 14 hours at the maximum DWPF steam flux rate. This is comparable to the DWPF processing time for dewatering plus reflux without MCU at a 5000 lbs/hr boil-up rate, but would require significantly more time at boiling at 2000-2500 lbs/hr boil-up rate. The addition of ARP and MCU did not cause any other processing issues, since foaming, rheology and hydrogen generation were less of an issue while processing with ARP/MCU.

- Hydrogen and nitrous oxide generation rates as a function of acid stoichiometry

Hydrogen generation was significantly impacted by the changes in acid stoichiometry from 115% to 160% (1.96 to 2.73 moles acid per liter of batch sludge or 1.28 to 1.79 moles acid per liter of blend sludge). For the batch sludge, the hydrogen generation rate was within DWPF limits in the

SRAT cycle, but exceeded the process limit during the SME cycle at the highest acid stoichiometry (160%). All of the blend experiments were within the process limits throughout the SRAT and SME cycles. As DWPF will be processing blend sludge, hydrogen likely won't be an issue in DWPF processing but lower acid stoichiometries will minimize hydrogen generation. The nitrous oxide generation peak was relatively insensitive to acid stoichiometry and was relatively low due to the low starting nitrite concentration.

- Acid quantities and processing times required for mercury removal

Mercury was added to the sludge simulant at the start of the SRAT cycle as mercuric oxide at approximately 2.5 wt% (solids basis) based on the expected composition of the SB5 batch and blend. Mercury was not added to the ARP simulant. Because of the high mercury concentration, the time at boiling was increased from 12 hours to 18 hours to allow sufficient time to strip mercury from the SRAT. Boiling flux was maintained at a scaled rate of 5,000 lb/hr so a total of 90,000 lb of steam flow in DWPF will be needed to remove 120 lb of mercury. Acid quantities from 115% to 160% resulted in satisfactory mercury removal with 18 hours of boiling time (including dewater and reflux time), with the exception of the two lowest acid stoichiometry runs with the blend simulant. ARP/MCU processing did not impact mercury reduction and removal. If DWPF experiences problems stripping mercury, increasing the acid stoichiometry is likely to improve mercury removal. Simulant testing does not simulate the DWPF heel so starting mercury concentrations will be lower in DWPF and shorter steam stripping times should be achievable.

- Acid quantities and processing times required for nitrite destruction

Acid quantities from 115% to 160% resulted in satisfactory nitrite destruction with 18 hours of boiling. In all runs, the amount of nitrite present in the SRAT product was less than 100 mg/kg, well below the 1,000 mg/kg target. The longer boiling time and low starting nitrite concentration both helped to reduce the nitrite by the end of the SRAT cycle.

- Impact of SB5 composition (in particular, manganese, nickel, mercury, and aluminum) on DWPF processing (i.e. acid addition strategy, foaming, hydrogen generation, REDOX control, rheology, etc.)

Acid quantities from 130% to 160% resulted in satisfactory process performance with no significant issues noted. Foaming was noted during formic acid addition, but the addition of antifoam equal to the amount added at DWPF was sufficient to control foaming.

Except for the 115% run, all SRAT products were outside the design bases for yield stress and consistency with the 130%, 145% and 160% runs being below the process limit. The process limits for SME product yield stress were met for the 130% acid run at 45% solids, but the 115% acid run was above process limits and the 145% and 160% runs were slightly below process limits. It should be noted that the yield stress and consistency trends seen in rheological properties of the simulants are expected to be similar for the DWPF process slurries, but the absolute values for the simulants are not expected to be prototypical in yield stress or consistency. Adjustment in the solids concentration targets and/or acid stoichiometry should be made if processing problems due to viscous process slurries are noted in DWPF.

The pH of the condensate generated for all nine SRAT cycles was acidic, but the 115% acid runs resulted in condensate that was basic by the end of the SRAT cycle and throughout the SME cycle with a pH of approximately 9. All condensates from all other runs had a pH of less than 5.

The following preliminary recommendations apply for DWPF SB5 processing:

- An acid stoichiometry of 130% is recommended for initial SB5 processing with a corresponding acid window of 115% to 160%. The SB5 blend simulant used during the testing had a stoichiometric acid requirement of 1.12 mol/L, giving an acid addition of 1.45 mol/L at 130% acid.

- No changes to the antifoam addition strategy, acid addition rate, or SME solids targets are recommended based on simulant testing.

- The SRAT time at boiling (dewater plus reflux) of 18 hours is recommended based on simulant testing

The recommendation for acid addition during the Shielded Cells processing studies was documented in an internal memorandum. Final recommendations to DWPF on SB5 processing will be made after the SC-7 Shielded Cells testing and will be based on the results of this study and the Shielded Cells tests.

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ACTL	Aiken County Technologies Laboratory
AD	Analytical Development
ARP	Actinide Removal Process
ASP	Analytical Study Plan
CPC	Chemical Process Cell
CS	Calcine Solids
CSSX	Caustic Side Solvent Extraction
DWPF	Defense Waste Processing Facility
FAVC	Formic Acid Vent Condenser
GC	Gas Chromatograph
HLW	High Level Waste
IC	Ion Chromatography
ICP-AES	Inductively Coupled Plasma – Atomic Emission Spectroscopy
IS	Insoluble Solids
MCU	Modular CSSX Unit
MST	Mono Sodium Titanate
MWWT	Mercury Water Wash Tank
PSAL	Process Science Analytical Laboratory
QA	Quality Assurance
REDOX	REDuction / OXidation potential
SB3	Sludge Batch 3
SB4	Sludge Batch 4
SB5	Sludge Batch 5
SME	Slurry Mix Evaporator
SMECT	Slurry Mix Evaporator Condensate Tank
SRAT	Sludge Receipt and Adjustment Tank
SS	Soluble Solids
SVOA	Semi Volatile Organic Analysis
TIC	Total Inorganic Carbon
TS	Total Solids
TT&QAP	Task Technical and Quality Assurance Plan
TTR	Technical Task Request

1.0 Introduction and Background

The Defense Waste Processing Facility (DWPF) will transition from Sludge Batch 4 (SB4) processing to Sludge Batch 5 (SB5) processing in early fiscal year 2009. Tests were conducted using non-radioactive simulants of the expected SB5 composition to determine the impact of varying the acid stoichiometry during the Sludge Receipt and Adjustment Tank (SRAT) and Slurry Mix Evaporator (SME) processes. The work was conducted to meet the Technical Task Request (TTR) HLW/DWPF/TTR-2007-0008[1] and followed the guidelines of a Task Technical and Quality Assurance Plan (TT&QAP)[2].

The flowsheet studies are performed to evaluate the potential chemical processing issues, hydrogen generation rates, and process slurry rheological properties as a function of acid stoichiometry. Initial SB5 flowsheet studies were conducted to guide decisions during the sludge batch preparation process[3,4]. These studies were conducted with the estimated SB5 composition at the time of the study. The composition has changed slightly since these studies were completed due to changes in the washing strategy to prepare SB5 and the estimated SB4 heel mass.

The following TTR requirements were addressed in this testing to validate the existing sludge-only flowsheet and establish a coupled operations (sludge, Actinide Removal Process (ARP) sludge/Monosodium Titanate and/or Modular Caustic Side Solvent Extraction (CSSX) Unit (MCU) strip effluent) flowsheet for use with SB5. Simulated sludge, ARP sludge/MST, and/or MCU strip effluent will be used to conduct these studies. The TTR requested that the evaluation include calculations, paper studies and/or scoping tests in order to determine the following:

1. "The Hydrogen (H_2) and Nitrous Oxide (N_2O) generation rates for SB5 simulant with varying quantities of acid and noble metals."

3. "The acid quantities and processing times required for mercury removal, nitrite destruction, REDOX control and possible rheology adjustments in the Sludge Receipt and Adjustment Tank (SRAT) for sludge only and coupled operations processing."

5. "The impact of SB5 levels of constituents such as oxalate, titanium, manganese, nickel, mercury, aluminum, cerium and uranium on DWPF processing (i.e. sampling, acid addition strategy, hydrogen generation, REDOX, rheology, etc.)."

6. "High and nominal acid level and bounding noble metal concentration SRAT/SME cycles will be required to complete a parametric study of this flowsheet. The flowsheet will be validated by the completion of a nominal SRAT/SME cycle in SRNL's Shielded Cells (separate TTR) with radioactive sludge slurry samples to be obtained from H- and F- Tank Farms." "In the simulant flowsheet runs, any observations of foaming, air entrainment, and/or loss of heat transfer capabilities in the SRAT/SME or any indication of excessive offgas deposits leading to pluggage will be noted and evaluated as appropriate. Flow curves (shear stress vs. shear rate) and Bingham plastic rheology data (yield stress and plastic viscosity) for the SRAT and SME material will also be provided. If warranted, the effects of temperature and weight percent solids on rheological properties of process slurries will also be determined."

2.0 Approach

Nine SRAT/SME runs were completed during this study using acid stoichiometries of 115%, 130%, 145%, and 160% with both the Tank 51 batch simulant (SB5-7,8,9 and 10) and the Tank 40 blend simulant (SB5-11,12, 13, and 14). A ninth run was made at 130% acid stoichiometry with blend simulant that included ARP and MCU additions (SB5-15). These runs were completed and samples analyzed using the practices and procedures typical for Chemical Process Cell (CPC) simulations at the Aiken County Technology Laboratory (ACTL), as described below.

2.1 Simulant Preparation

Two simulant batches were prepared, one simulating the Tank 51 composition of batch simulant (SB5-D) and the other simulating Tank 40 or blend simulant (SB5-C). The SB5 batch simulant used targets specified by David Larsen's e-mail[5]. Since the cations in both the batch and blend simulants were very similar, the same cation basis was used to prepare both simulants. The blend simulant target anion composition was specified by Alex Choi[6]. Compositions of the simulants are shown in Table 1.

Table 1. SB5-C and SB5-D Final Slurry Analyses

Analysis	SB5-C Target	SB5-C Actual	SB5-D Target	SB5-D Actual
Total Solids, wt %	12.47	12.5	14.03	14.58
Insoluble Solids, wt %	8.79	7.85	8.09	8.04
Nitrate, mg/kg	4,533	3,940	6,881	7,114
Nitrite, mg/kg	7,189	6,175	9,961	10,450
TIC, mg/kg	1,633	1,338	2,000	2,485
Fe, wt % of total dried solids	21.09	21.45	20.92	20.90
Al, wt % of total dried solids	11.76	12.55	10.98	11.90
Mn, wt % of total dried solids	4.88	5.05	4.90	4.73
Na, wt % of total dried solids	16.58	17.45	18.21	22.5

The preparation of a simulant for Sludge Batch 5 involved six steps: precipitation of manganese (IV) oxide, caustic precipitation of a metal nitrate solution, addition of sodium carbonate, washing of the precipitated solids, addition of minor insoluble species, and addition of soluble species. The precipitation of metal nitrates to form insoluble oxides and hydroxides was conducted in a Continuous Stirred Tank Reactor (CSTR) and involved generation of a metal nitrate solution followed by precipitation of the metal through the addition of sodium hydroxide. Following the addition of sodium carbonate, the material was washed then soluble/insoluble species were added. Procedure L29 ITS-00124, "SRS HLW Sludge Simulant Preparation (U)" was utilized to perform the tests.

Simulant Preparation

The simulants were prepared intermittently over a two month-long period using facilities at both ACTL and in 735-11A. The MnO_2 precipitation, the precipitation in the CSTR and the precipitation of the insoluble carbonate species were each completed in one day. The washing and concentration of the precipitate took approximately three weeks, while the final insoluble and soluble species were added in one day.

The simulant preparation was completed in six steps as described below.

- Phase I: **Manganese Dioxide (MnO_2) Preparation:** Six batches of manganese dioxide were prepared at ACTL by feeding potassium permanganate at 35 °C at 17.5 mL/min to a Manganese nitrate solution at 35 °C.
- Phase II: **Metal Nitrate Solution Precipitation in CSTR:** The metal oxides were coprecipitated in the CSTR setup in 735-11A Lab 123. The 50 wt % NaOH solution was fed at 11.5 mL/min and the combined MnO_2 and Metal Nitrate Solutions were fed to the CSTR at 89.0 mL/min to produce a precipitate at a pH of ~9.5.
- Phase III: **Precipitation of Insoluble Carbonate Species:** Sodium Carbonate was added to precipitate insoluble carbonate species.
- Phase IV: **Washing and Concentration of Slurry:** The slurry was batch washed in drums. After washing was completed, the slurry was concentrated to the final insoluble solids target in ACTL using paddle filters.
- Phase V: **Add the final insoluble compounds to the concentrated washed slurry:** The remaining insoluble species that might have been removed during washing were added to the washed and concentrated slurry.
- Phase VI: **Add the final soluble compounds to the concentrated washed slurry:** The remaining soluble species that would have been removed during washing were added to the washed and concentrated slurry.

The final slurry was sampled and analyzed at ACTL, the Process Science Analytical Laboratory (PSAL), and by Analytical Development (AD). The results of these analysesare summarized in Table 2. As can be seen, the results agreed well with the planned targets.

The SB5 simulants were very thin rheologically, especially because of the low insoluble solids targets. No measurement of the slurry rheology was completed.

Table 2. Simulant Composition for SB5 Flowsheet Testing

Analyses	SB5-C Blend	SB5-D Batch	Analyses	SB5-C Blend	SB5-D Batch
Elemental	**Wt% calcined solids**		**Solids Data**	**Wt %**	
Al	12.5	11.9	Total	12.47	14.58
Ba	0.013	0.011	Insoluble	7.85	8.04
Ca	2.11	2.31	Soluble	4.62	6.54
Cr	.017	0.026	Calcined	9.51	11.09
Cu	0.020	0.013	**Anions**	**mg/kg**	
Fe	21.5	20.9	Chloride	<100	<100
K	0.157	0.074	Nitrite	6,175	10,450
Mg	0.890	0.841	Nitrate	3,940	7,114
Mn	5.05	4.73	Formate	<100	<100
Na	17.5	22.5	Sulfate	405	526
Ni	2.63	2.44	Oxalate	NM	NM
P	0.111	<0.01	Phosphate	<100	<100
Pb	<0.01	<0.01	Carbonate	1,338	2,485
S	0.158	0.138	**Other Results**		
Si	<0.10	0.022	Base Equivalents (molar)	0.632	0.909
Ti	<0.01	<0.01	Slurry Density (g/ml)	1.09	1.11
Zn	<0.01	<0.01	pH	13.4	13.5
Zr	<0.01	<0.01			

Noble metals, mercury, and rinse water were added to the sludge simulant prior to performing the SRAT cycle; however mercury was not added to SB5-15 until after the ARP addition and concentration were completed to avoid potential issues with dimethyl mercury formation.

Samples were not taken after the additions as the amount of these additions is small compared to the sludge, except in the case of the ARP addition. The noble metal concentrations were based on 110% of the estimated amount in the sludge batch[7]. The concentrations of each trim chemical added are shown in Table 3.

Table 3. Trim Chemical Additions, wt % on Total Solids Basis

Trim Chemical	SB5-C Without ARP/MCU	SB5-C* With ARP/MCU	SB5-D
Trimmed Sludge Target Ag metal content	0.01375	0.01375	0.01328
Trimmed Sludge Target Hg metal content	2.3752	1.6880	2.7149
Trimmed Sludge Target Pd metal content	0.00362	0.00362	0.00448
Trimmed Sludge Target Rh metal content	0.02266	0.02266	0.02325
Trimmed Sludge Target Ru metal content	0.09801	0.09801	0.10800

* The sludge was added at the same concentration of noble metals for runs with and without ARP. However, no mercury was added with the ARP waste, which effectively decreased the mercury concentration in the SRAT receipt sample by 29%.

2.2 Experimental Apparatus

The testing was performed at the ACTL using the four-liter kettle setup. The SRAT rigs were assembled following the guidelines of SRNL-PSE-2006-00074[8]. The intent of the equipment is to functionally replicate the DWPF processing vessels. The 4-liter glass kettle is used to replicate both the SRAT and the SME, and it is connected to the SRAT Condenser, the Mercury Water Wash Tank (MWWT), and the Formic Acid Vent Condenser (FAVC). The Slurry Mix Evaporator Condensate Tank (SMECT) is represented by a sampling bottle that is used to remove condensate through the MWWT. For the purposes of this paper, the condensers and wash tank are referred to as the offgas components. A sketch of the experimental setup is given as Figure 1.

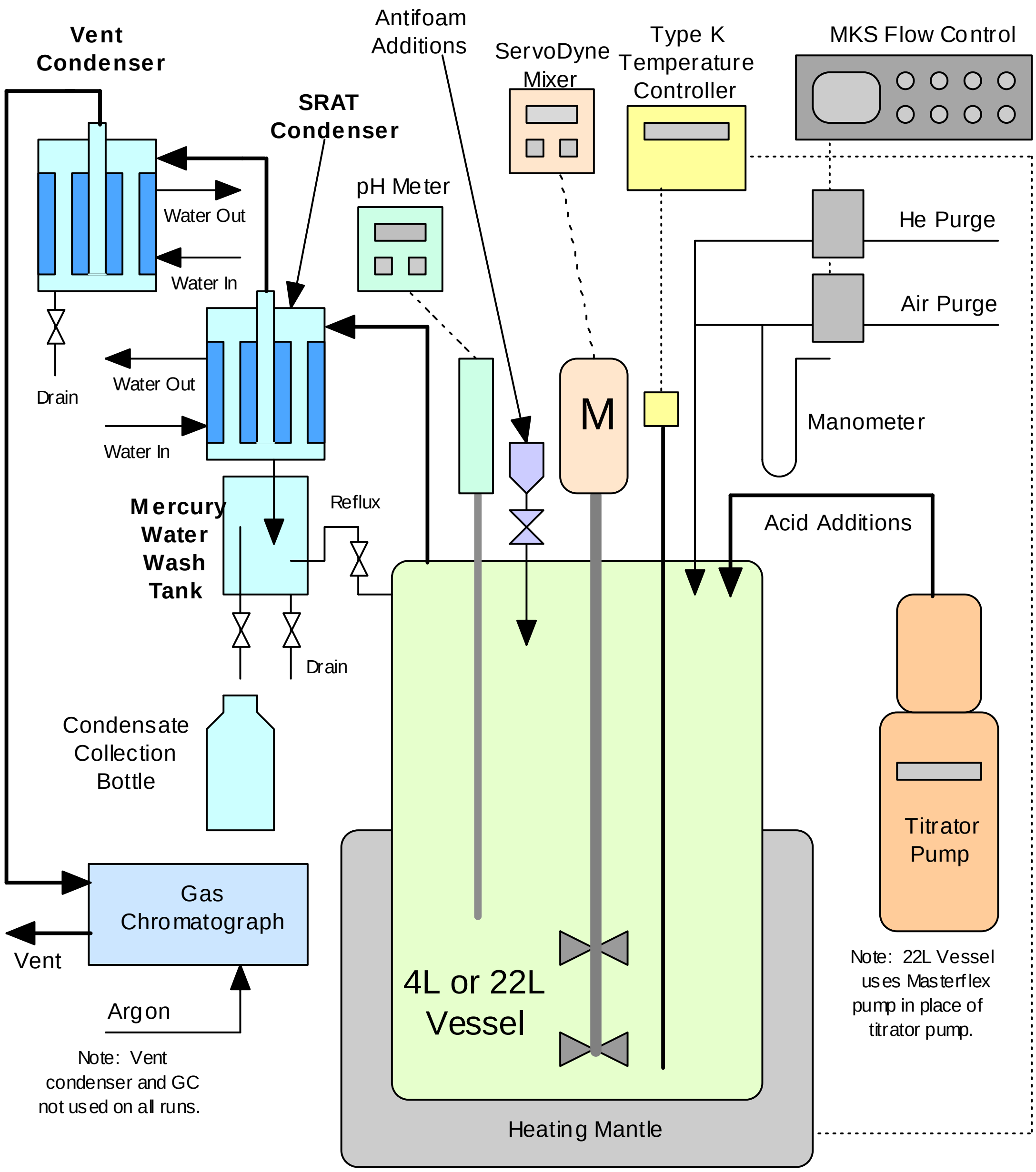

Figure 1. Schematic of SRAT Equipment Set-Up

SRAT and SME processing parameters are summarized in Appendix A. The flowsheet runs were performed using the guidance of Procedure ITS-0094 ("Laboratory Scale Chemical Process Cell Simulations") of Manual L29[9]. Offgas hydrogen, oxygen, nitrogen, nitrous oxide, and carbon dioxide concentrations were measured during the experiments using in-line instrumentation. Helium was introduced at a concentration of 0.5% of the total air purge as an inert tracer gas so that total amounts of generated gas and peak generation rates could be calculated. During the runs, the kettle was monitored to observe reactions that were occurring to include foaming, air entrainment, rheology changes, loss of heat transfer capabilities, and offgas carryover.

Observations were recorded in laboratory notebook WSRC-NB-2008-00015[10] and are discussed in Section 3.0.

An ARP and MCU simulant were added to the SB5-15 run. The ARP simulant was added to the sludge before the ARP simulant is concentrated so the SRAT receipt sample is approximately the same total solids content as the sludge. ARP was added to the SB5-C sludge at boiling. The MCU simulant was added during the boiling phase of the SRAT cycle at a scaled rate approximately equal to the maximum steam flow of 5000 lb/hr.

Concentrated nitric acid (50-wt%) and formic acid (90-wt%) were used to acidify the sludge and perform neutralization and reduction reactions during processing. The amounts of acid to add for each run were determined using the existing DWPF acid addition equation[11]. The split of the acid was determined using the redox equation currently being used in DWPF processing[12]. The redox target ($Fe^{2+}/\Sigma Fe$) was 0.2. To account for the reactions and anion destructions that occur during processing, assumptions about nitrite destruction, nitrite to nitrate conversion, and formate destruction were made for each run. The values used for each run are provided in Section 3.0.

To prevent foaming during the ARP concentration (caustic boiling phase), 200 ppm of IIT antifoam was added before processing. To prevent foaming during SRAT processing, 200 ppm IIT 747 antifoam was added before acid addition, 100 ppm was added after nitric acid addition was complete and 500 ppm was added at the completion of formic acid addition. SRAT processing included 18-hours at boiling (dewater time plus reflux time). In SB5-15, SRAT processing included dewatering time plus MCU addition/dewatering time (about 14 hours). In five of the runs, SME processing did not include the addition of canister dewaters. In the other four, SME processing included the addition of five canister dewaters. The frit addition was split into two equal portions. The frit was added with water and formic acid at DWPF prototypical conditions. Concentration was performed after each frit addition and then heat was removed to allow for the next frit addition A final concentration was performed at the end of the run to meet the target total solids. The SRAT condenser was maintained at 25° C during the run while the vent condenser was maintained at 4° C.

2.3 Analytical Methods

Sample request forms were used for samples to be analyzed, and analyses followed the guidelines for the task. A unique lab identification number was assigned to each sample for tracking purposes. Analyses were performed using approved analytical and Quality Assurance (QA) procedures.

The sludge simulant was analyzed as part of the sludge fabrication process; therefore, those results were used to support this testing and no discussion of the methods will be presented here. The ARP simulant analysis paralleled that of the two sludge simulants. The samples were analyzed at the PSAL and AD. The PSAL performed analyses on the in-process and product samples to determine the chemical composition, total and dissolved solids, density, and pH. The chemical composition was determined in duplicate by calcining the samples at 1100° C and then digesting the product using Na_2O_2/NaOH fusion, a lithium metaborate fusion, and mixed acid method. The preparations were then analyzed using Inductively Coupled Plasma – Atomic Emission Spectroscopy (ICP-AES) to measure the cations present.

Sludge samples for anion analyses were prepped using weighted dilutions (diluting the slurry with water) and were analyzed using Ion Chromatography (IC). The in-process supernates were also analyzed on the IC to determine the soluble anions. The total and dissolved solids were measured on two aliquots and the insoluble and soluble solids fractions were calculated from the results. Density and pH measurements of the samples were also performed on the in-process samples. Rheological properties of the SRAT and SME products (yield stress and plastic viscosity) were measured and evaluated as a function of the test conditions.

The Total Inorganic Carbon (TIC) and mercury analysis were performed by Analytical Development. TIC was analyzed with an OI 1010 High Temperature Total Carbon Analyzer. Mercury was analyzed using Atomic Adsorption Spectroscopy following an aqua regia preparation. The mercury slurry samples were pulled directly into the digestion bottle to minimize the risk of sampling issues effecting results.

Gases were monitored during the runs using high-speed Agilent model 3000 micro Gas Chromatographs (GC) to provide insight into the reactions occurring during processing and to determine whether a flammable mixture was formed. As mentioned above, helium was used as a purge gas tracer. One calibration standard was used to calibrate the GCs before each run to attempt to bound the quantities of the expected gases. The concentration of this calibration standard was 0.5 mol% helium, 1 mol% hydrogen, 20% oxygen, 2.5 mol% nitrous oxide, 0.5 mol% carbon monoxide, and 20 mol% carbon dioxide with the balance nitrogen. A second calibration point for nitrogen used room air. Calibration checks were performed before and after each run.

The GC is self-contained and is designed specifically for fast and accurate analysis. The GCs have five main components. The first is the carrier gas (argon for this testing) to transport the sample through the MolSieve 5A PLOT (Channel A) and PLOT Q (Channel B) columns. The second is the injector, which introduces a measured amount of sample into the inlet of the analytical columns where it is separated. The third component is the column, which is the capillary tubing coated or packed with a chemical substance known as the stationary phase that preferentially attracts the sample components. As a result, components separate as they pass through the column based on their solubility. Since solubility is affected by temperature, column temperature is controlled during the run. Channel A separates helium, hydrogen, nitrogen, oxygen, nitric oxide and carbon monoxide and Channel B separates carbon dioxide and nitrous oxide. The fourth component is a micro-machine thermo conductivity detector. The solid state detector monitors the carrier and senses a change in its composition when a component in the sample elutes from the column. The fifth component is the computer data acquisition system, Cerity software. Its main purpose is to generate both qualitative and quantitative data. It provides a visual recording of the detector output and an area count of the detector response. The detector response is used to identify the sample composition and measure the amount of each component by comparing the area counts of the sample to the analysis of known calibration standards. A sample was taken approximately once every 4.5 minutes.

3.0 Results

Four SRAT/SME cycles with SB-5 batch simulant and five SRAT/SME cycles with SB-5 blend simulant were conducted during this study, as shown in Table 4c and Table 4d. Table numbering started at 4c to correspond to runs using the SB5-C blend simulant and 4d to refer to runs with the SB5-D batch simulant. Numbering of tables throughout this report is consistent with this methodology. A unique run number was assigned to each run[13,14]. All runs targeted a predicted glass REDOX ($Fe^{2+}/\Sigma Fe$) of 0.2 by adjusting the ratio of formic to nitric acid during the SRAT cycle and assumed the current REDOX equation. Frit 418 was utilized during the SME cycle and a waste loading of 35% was targeted.

Table 4c. SB5 Blend (SB5-C) SRAT/SME Tests

RUN NUMBER	ACID STOICHIOMETRY	REDOX TARGET	PROCESS FRIT	WASTE LOADING
SB5-11	115%	0.2	418	35
SB5-12	130%	0.2	418	35
SB5-13	145%	0.2	418	35
SB5-14	160%	0.2	418	35
SB5-15	130%	0.2	418	35

Table 4d. SB5 Batch (SB5-D) SRAT/SME Tests

RUN NUMBER	ACID STOICHIOMETRY	REDOX TARGET	PROCESS FRIT	WASTE LOADING
SB5-7	115%	0.2	418	35
SB5-8	130%	0.2	418	35
SB5-9	145%	0.2	418	35
SB5-10	160%	0.2	418	35

3.1 SRAT Cycle Results

3.1.1 Acid Addition Calculation

3.1.1.1 Calculation Inputs

The SRAT cycle acid calculation utilizes the amount of nitrite, mercury, manganese, carbonate, and base equivalents to calculate the stoichiometric amount of acid to be added. Nitric acid and formic acid amounts are calculated based on the applied stoichiometric factor and the ratio needed to achieve the predicted glass redox target of 0.2 $Fe^{+2}/\Sigma Fe$. The equation for prediction of glass redox utilizes estimates of the amount of formate, oxalate, nitrate, nitrite, manganese, and total solids in the SME product. The estimation of the final concentration for the anions requires assumptions to be made concerning how these species will react during the SRAT and SME cycles. Formate and oxalate are destroyed by reactions with oxidizing species and by catalytic reactions with noble metals. Nitrite is typically consumed during acid additions, but can react to form different species including nitrate. The acid calculation inputs and assumptions are shown in Table 5, Table 6, and Table 7 for SB5-7 and SB5-11. The same assumptions and inputs were used for all four runs, with the exception of the acid stoichiometry.

Table 5. Acid Calculation Inputs

Description	Units	SB5-11[a]	SB5-7[b]
Sludge		SB5-C Blend	SB5-D Batch
Fresh Sludge Mass without trim chemicals	g slurry	3,500.0	3,017.9
Fresh Sludge Weight % Total Solids	wt%	12.47	15.09
Fresh Sludge Weight % Calcined Solids	wt%	9.51	11.25
Fresh Sludge Weight % Insoluble Solids	wt%	7.85	7.95
Fresh Sludge Density	kg / L slurry	1.090	1.117
Fresh Sludge Nitrite	mg/kg slurry	6,175	10,388
Fresh Sludge Nitrate	mg/kg slurry	3,940	7,114
Fresh Sludge Oxalate	mg/kg slurry	287.5	0
Fresh Sludge Formate	mg/kg slurry	0	0
Fresh Sludge Manganese (% of Calcined Solids)	wt % calcined basis	5.050	4.639
Fresh Sludge Slurry TIC (treated as Carbonate)	mg/kg slurry	1,338	2,470
Fresh Sludge Hydroxide (Base Equivalents) pH = 7	Equiv Moles Base/L slurry	0.632	0.909
Fresh Sludge Mercury (% of Total Solids in untrimmed sludge)	wt% dry basis	0.0000	0.0000
Fresh Sludge Supernate manganese	mg/L supernate	0	0
Fresh Sludge Supernate density	kg / L supernate	1.024	1.06

SB5-15 was similar to SB5-11, 3499.6 g slurry, after the ARP addition and boil-down were completed. It had similar wt% total solids, but different concentrations of base, TIC, nitrite, and Mn. The non-aqueous fraction of SB5-15 was about 72% SB5-C Blend simulant solids and 28% ARP simulant solids.

[a] The same parameters were used for runs SB5-11, SB5-12, SB5-13, and SB-14, with the exception of acid stoichiometry.
[b] The same parameters were used for runs SB5-7, SB5-8, SB5-9, and SB-10, with the exception of acid stoichiometry.

Table 6. SRAT Cycle Processing Parameters and Assumptions

Description	Units	SB5-11	SB5-7
Sludge		SB5-C Blend	SB5-D Batch
Conversion of Nitrite to Nitrate in SRAT Cycle	gmol NO_3^-/100 gmol NO_2^-	15.00	25.00
Destruction of Nitrite in SRAT and SME cycle	% of starting nitrite	100.00	100.00
Destruction of Formic acid charged in SRAT	%	30.00	15.00
Destruction of oxalate charged	%	50.00	50.00
Percent Acid in Excess Stoichiometric Ratio	%	115.00	115.00
SRAT Product Target Solids	%	25.00	25.00
Nitric Acid Molarity	Molar	10.534	10.534
Formic Acid Molarity	Molar	23.600	23.600
Scaled Nitric Acid addition Rate	gallons per minute	2.0	2.0
Scaled Formic Acid addition Rate	gallons per minute	2.0	2.0
REDOX Target	Fe^{+2} / ΣFe	0.200	0.200
Trimmed Sludge Target Ag metal content	total wt% dry basis	0.01375	0.01328
Trimmed Sludge Target wt% Hg dry basis	total wt% dry basis	2.37520	2.71490
Trimmed Sludge Target Pd metal content	total wt% dry basis	0.00362	0.00448
Trimmed Sludge Target Rh metal content	total wt% dry basis	0.02266	0.02325
Trimmed Sludge Target Ru metal content	total wt% dry basis	0.09801	0.10800
Water to dilute fresh sludge and/or rinse trim chemicals	g	50.000	50.000
Mass of SRAT cycle samples	g	200.000	200.000
Wt% Active Agent In Antifoam Solution	%	10	10
Basis Antifoam Addition for SRAT (generally 100 mg antifoam/kg slurry)	mg/kg slurry	100.00	100.00
Number of basis antifoam additions added during SRAT cycle			8

Table 7. SME Processing Parameters and Assumptions

Description	Units	SB5-11	SB5-7
Sludge		SB5-C Blend	SB5-D Batch
Frit type		418.00	418.00
Destruction of Formic acid in SME	%	7.00	7.00
Destruction of Nitrate in SME	%	0.00	0.00
Assumed SME density	kg / L	1.45	1.45
Basis Antifoam Addition for SME cycle	mg/kg slurry	100.00	100.00
Number of basis antifoam additions added during SME cycle		4	4
Sludge Oxide Contribution in SME (Waste Loading)	%	35.000	35.000
Frit Slurry Formic Acid Ratio	g 90 wt% FA/100 g Frit	1.5	1.5
Target SME Solids total Wt%	wt%	45.0	45.0
Number of frit additions in SME Cycle		2.000	2.000

3.1.1.2 Acid Calculation Results

The acid calculation determines the values for a large number of processing parameters as well as the amount of formic and nitric acid to be used. Selected values are shown in Table 8c and Table 8d. The stoichiometric acid addition for the sludge simulant was calculated to be 1.12 moles per liter for SB5-C and 1.71 moles per liter for SB5-D. As acid stoichiometry increased, the ratio of formic acid to the total amount of acid decreased. This decrease is due to the presence of nitrate and nitrite in the initial sludge simulant lowering the amount of nitrate or oxidizers needed to balance the formic acid at lower acid stoichiometries. The frit addition increased slightly due to the process samples being more dilute in terms of the original feed as acid stoichiometry increased.

Table 8c. Selected Process Values for Testing with Blend Sludge SB5-C

ACID STOICHIOMETRY	TOTAL ACID REQUIRED (MOL/L)	FORMIC ACID RATIO (% OF TOTAL ACID)	FRIT ADDITION AMOUNT (GRAMS)
115%	1.28	88%	560.59
130%	1.45	84%	563.11
130% with ARP/MCU	1.22	86%	531.25
145%	1.62	84%	566.41
160%	1.79	83%	568.41

Less acid and frit were required in the test with ARP/MCU than in the 130% test without ARP/MCU because the concentrated ARP slurry had a lower acid demand per unit volume than an equivalent mass of SB5 simulant, and because the calcined solids fraction of the ARP total solids was lower than that of the SB5 simulant solids.

Table 8d. Selected Process Values for Testing with Batch Sludge SB5-D

ACID STOICHIOMETRY	TOTAL ACID REQUIRED (MOL/L)	FORMIC ACID RATIO (% OF TOTAL ACID)	FRIT ADDITION AMOUNT (GRAMS)
115%	1.96	85%	579.14
130%	2.22	84%	581.87
145%	2.48	83%	584.33
160%	2.73	82%	586.58

3.1.2 Processing Observations

Overall processing during the testing went smoothly with no interruptions or upsets occurring during process runs. The sludge became less viscous during acid additions and no problems were noted with mixing during the runs. Agitator speeds of 250 RPM[c] were needed to mix the sludge simulants.

[c] The mixing geometry of the lab-scale apparatus is not prototypic and mixing was adjusted as required during testing to ensure that the process chemistry is captured. Agitator speed is reported only to give an indication of changes in rheological properties during the testing.

3.1.2.1 Foaming

No additional antifoam was required during any of the nine experiments. No foaming problems were noted during SRAT or SME processing.

3.1.2.2 pH Profiles

The pH profiles of six of the eight runs in general matched profiles noted during previous CPC simulations. As shown in Figure 2, the pH of the runs was lower for runs with higher acid additions. Also, acid addition took longer for the runs with the batch simulant (SB5-7 to 10) due to the higher acid demand. The blend simulant had significantly lower acid demand due to the dilution by pump leakage in Tank 40. Formic acid decomposition during high acid runs can result in lower pH at higher acid stoichiometries, but the decomposition noted during the flowsheet testing was not high enough to raise the pH of the higher acid runs above the lower acid runs in the SRAT cycle. All three runs with acid stoichiometries above 115% had a minimum pH near 4.0 at the end of acid addition. No data is included for runs SB5-11 and SB5-14 because pH probe breakage occurred very early in the runs and the recorded data was not meaningful.

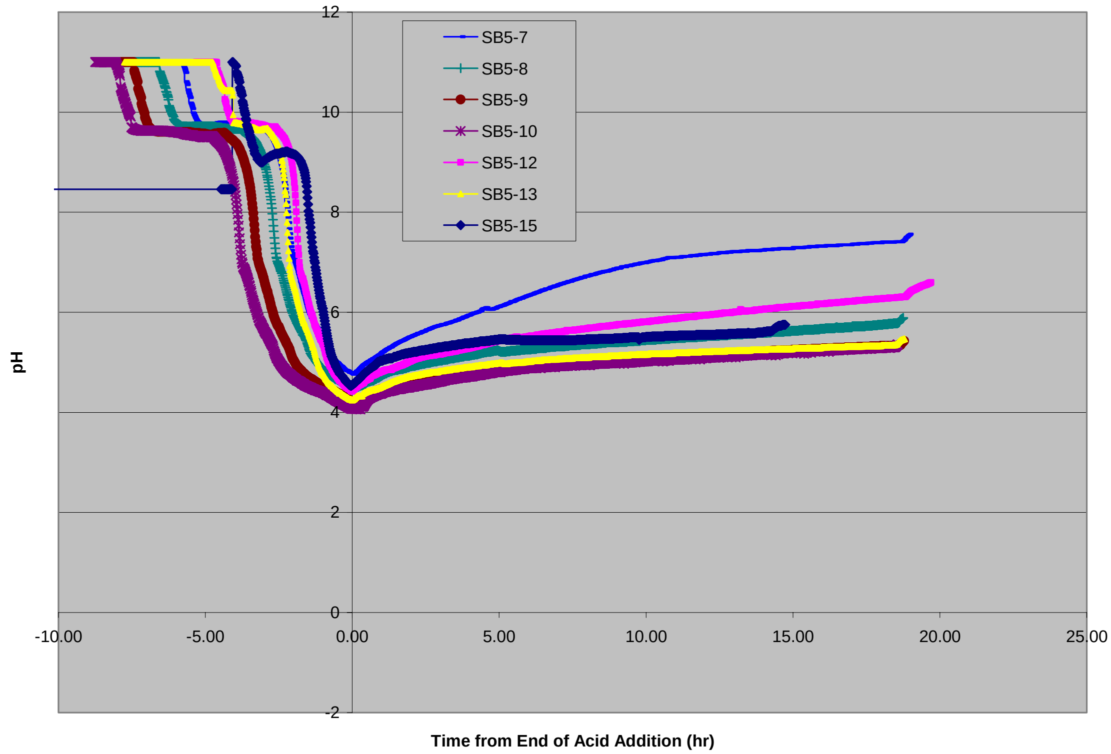

Figure 2. SB5 Flowsheet Testing pH Profiles

3.1.3 SRAT Cycle Sample Results

Samples were pulled at the conclusion of the SRAT cycle. The total solids, mercury, anions, and soluble elemental species were analyzed for all samples. Samples were taken of the SRAT dewater and the MWWT contents at the completion of the SRAT cycle. All sample results are tabulated in Appendix A-2.

3.1.3.1 Nitrite, Nitrate, Formate

Nitrite destruction met the process requirement of <1000 mg/kg at the end of the SRAT cycle for all runs and was 100% complete for all runs. Note that the total time at boiling was 18 hours for each of these experiments due to the high mercury concentration. The longer boiling time may have led to the complete nitrite destruction, even for the lowest acid stoichiometry runs. Anion results are summarized in Table 9c and d.

Table 9c. SRAT Product Anion Concentration from Tests with Blend Sludge SB5-C, mg/kg

Acid Stoichiometry	Sample #08-	F	CL	NO_2	NO_3	SO_4	PO_4	HCO_2
115%	SB5-11-2534	<100	356	<100	20,600	<100	<100	62,250
130%	SB5-12-2545	<100	329	<100	23,600	<100	<100	58,200
145%	SB5-13-2557	<100	332	<100	26,150	108	<100	61,700
160%	SB5-14-2568	<100	342	<100	28,600	185	<100	74,400
130% ARP/MCU	SB5-15-2584	<100	350	<100	27,950	2100	<100	57,200

Table 9d. SRAT Product Anion Concentration from Tests with Batch Sludge SB5-D, mg/kg

Acid Stoichiometry	Sample #08-	F	Cl	NO_2	NO_3	SO_4	PO_4	HCO_2
115%	SB5-7-2505	<100	316	<100	29,550	<100	<100	62,200
130%	SB5-8-2487	<100	338	<100	31,250	153	<100	67,400
145%	SB5-9-2516	<100	325	<100	34,850	194	<100	71,700
160%	SB5-10-2496	<100	312	<100	38,100	282	<100	77,700

In a typical run, approximately one-third of the nitrite is converted to nitrate and the other two-thirds are converted to NO_x and N_2O. In the majority of these runs (Table 10), no additional nitrate was present in the SRAT product due to the destruction of nitrate. A negative nitrite to nitrate conversion number is the result of not only complete nitrite destruction but also nitrate destruction. Numbers between -10% and +10% may be due to analytical error but larger numbers are due to significant nitrate destruction. The presence of sulfate from the concentrated ARP stream was clearly evident in the anion data.

Formate is destroyed by reduction of Mn, Hg and catalytic destruction of formic acid to produce NO, N_2O, and hydrogen. An overall trend of higher formate loss with higher acid stoichiometry is indicated which matches previous results and the amount of formate loss is consistent with previous testing[4,15].

Table 10c. SRAT Anion Conversions from Tests with Blend Sludge SB5-C, mg/kg

Acid Stoichiometry	SRAT Cycle		
	Formate Destruction	Nitrite Destruction	Nitrite to Nitrate Conversion
115%	24%	>99.5%	-16%
130%	29%	>99.5%	-27%
145%	30%	>99.5%	-31%
160%	16%	>99.5%	-14%
130% ARP/MCU	15%	>99.5%	15%

Table 10d. SRAT Product Anion Conversions from Tests with Batch Sludge SB5-D, mg/kg

Acid Stoichiometry	SRAT Cycle		
	Formate Destruction	Nitrite Destruction	Nitrite to Nitrate Conversion
115%	134	>99.5	30
130%	29	>99.5	-17
145%	24	>99.5	2
160%	26	>99.5	-4

3.1.3.2 Mercury

The SRAT product samples were analyzed for mercury content to evaluate the stripping of mercury during the SRAT cycle. The SRAT product must be below 0.45 wt% (solids basis) mercury to meet process specifications. Previous sludge batches except SB1B and SB4 met this requirement without mercury removal, but SB5 is estimated to contain approximately 2.5 wt% mercury in the incoming blended feed. As shown in Table 11c and d, the mercury was reduced to acceptable levels by the end of the SRAT cycle for all but two runs.

Table 11c. SRAT Product Mercury Results from Tests with Blend Sludge SB5-C

Acid Stoichiometry	SRAT Product Mercury, wt % total solids basis
115%	0.984
130%	0.927
145%	0.146
160%	0.052
130% ARP/MCU	0.042

Table 11d. SRAT Product Mercury Results from Tests with Batch Sludge SB5-D

Acid Stoichiometry	SRAT Product Mercury, wt % total solids basis
115%	0.213
130%	0.163
145%	0.041
160%	0.063

The mercury stripping is controlled by the boilup rate and the time at boiling. The simulant testing was completed at a scaled-down maximum boilup rate equivalent to 5000 lb/hr steam. Time at boiling was calculated assuming it takes 750 lb of steam to strip each lb of mercury to reduce the SRAT product to 0.45 wt % Hg. As a result, all eight non-ARP/MCU runs had 18 hours at boiling during the SRAT cycle. The total boilup was 13,500 lb of steam. If DWPF uses a lower boilup rate, they may need to extend the boiling time to meet the mercury limit. SB5-15 with ARP/MCU had 28% less initial mercury than the other four runs with SB5-C simulant, since only the SB5-C simulant portion was trimmed to 2.2375 wt% Hg. The ARP was assumed to be free of Hg in order to better test the hydrogen limit with SB5-15. Only 13 hours of boiling at the maximum boil-up rate were predicted to successfully strip Hg in SB5-15, but 14 hours were required for dewatering and MCU addition. Therefore, dewatering and MCU addition controlled the duration of SB5-15 rather than mercury removal.

The two runs that exceeded the DWPF mercury limit were both low acid runs with the blend simulant. The blend simulant is low in anions due to dilution in Tank 40, which contributed to a low acid demand. If DWPF has problems achieving the mercury limit, a higher acid stoichiometry may improve mercury removal. However, it may also lead to higher hydrogen generation. Note also that the simulant testing was completed without a heel so the starting mercury concentration will be lower in DWPF as the heel will dilute the raw sludge.

3.1.3.3 Condensates

The sample results for all condensate samples are tabulated in Appendix A. Higher acid stoichiometry lowers the pH of the SRAT slurry.

Condensate pH was higher as acid stoichiometry was increased, as shown in Figure 3. The condensate pH of the 130% run was basic at the end of the SRAT cycle as indicated by the pH of the MWWT results. The MWWT was drained at the end of the SRAT cycle and (generally) represents the last condensate generated during that cycle.

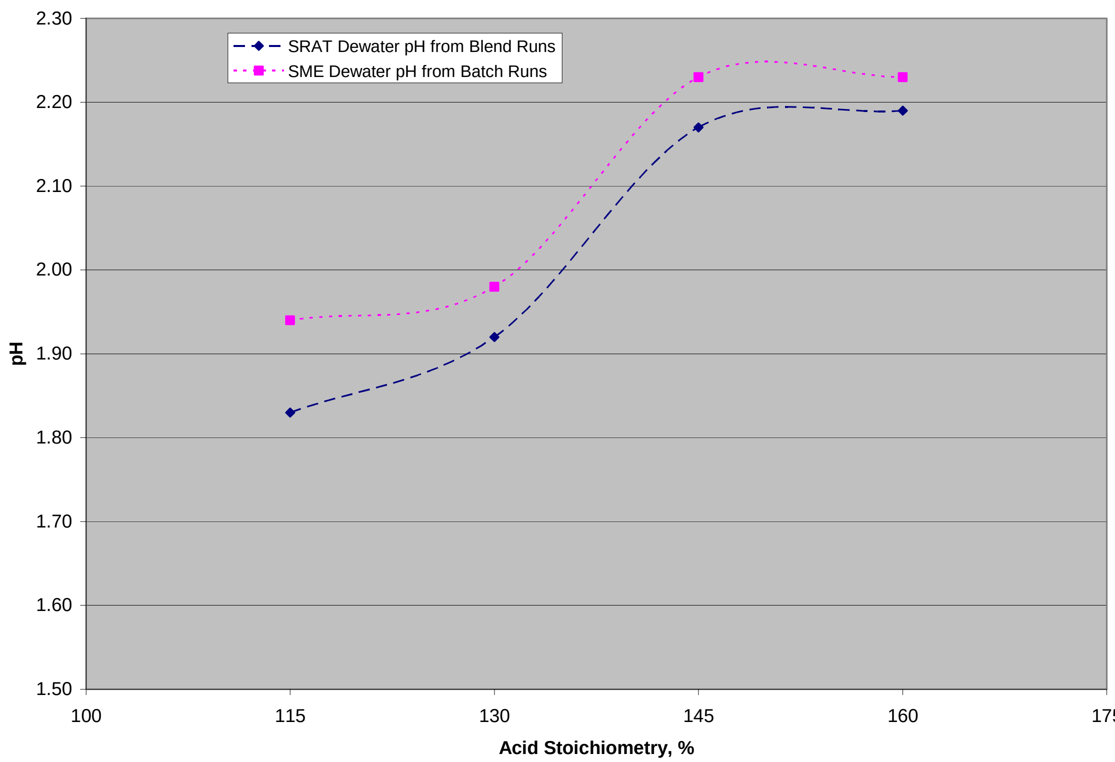

Figure 3. SRAT Dewater pH

3.1.4 SRAT Cycle Offgas Composition Results

A typical offgas concentration profile is shown in Figure 4 while charts from all runs are shown in Appendix C. Helium and nitrogen show reduced concentrations during periods with large quantities of offgas generation due to dilution, while oxygen showed reduced concentrations during these periods due to dilution and from consumption. In general, hydrogen generation began after nitrous oxide emissions had ceased and carbon dioxide emission was noted in conjunction with the hydrogen. The patterns of offgas emissions noted during the runs were typical of offgas generation during the SRAT cycle.

3.1.4.1 Hydrogen Evolution

The peak hydrogen generation for each run is shown in Figure 5, along with the peak carbon dioxide and nitrous oxide rates. In general, the peak hydrogen generation rate increased with increased acid addition. None of the rates exceeded the SRAT processing limits of 0.65 lb/hr, as shown in Table 12 which shows the peak hydrogen generation after scaling to the DWPF process.

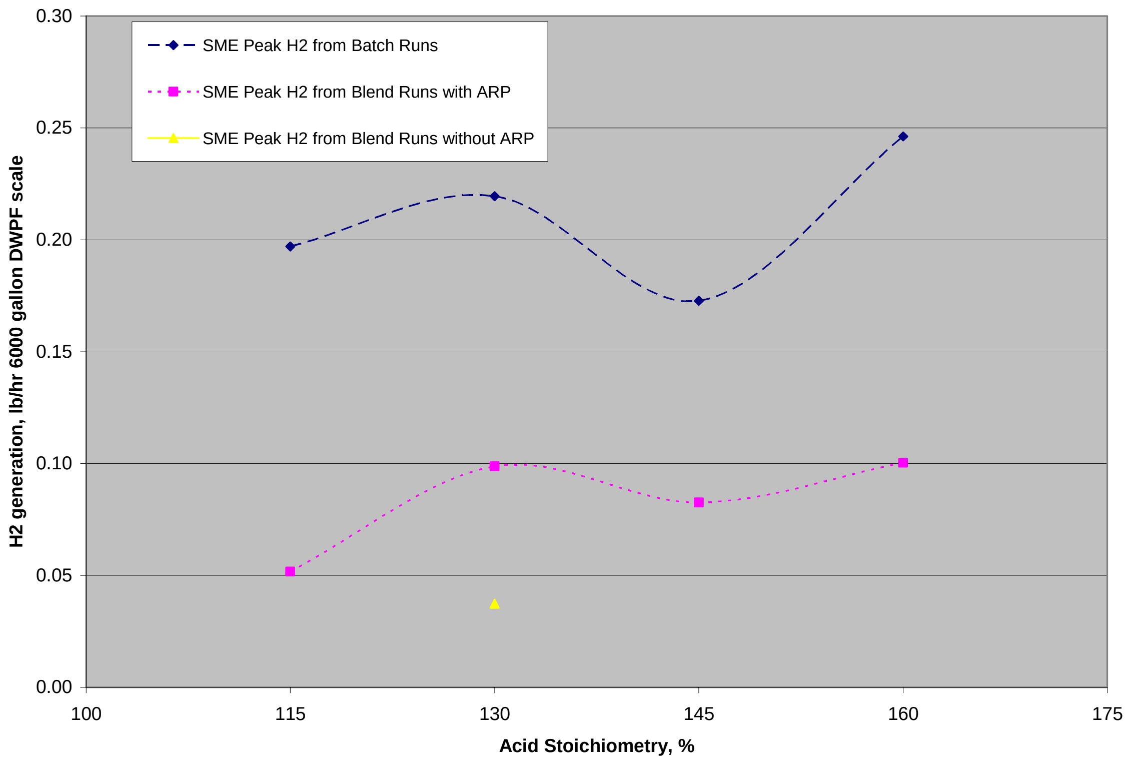

Figure 4. SRAT Cycle Hydrogen Peaks

Table 12. SRAT Cycle Hydrogen Peak Generation Rate

SRAT Hydrogen Peak		Acid Stoichiometry				
		115%	130%	130% ARP/MCU	145%	160%
SB5-C Simulant	lb/hr	0.0476	0.126	-	0.140	0.170
SB5-D Simulant	lb/hr	0.301	0.261	0.0655	0.366	0.569

The hydrogen evolution as a function of time is shown in Figure 5.

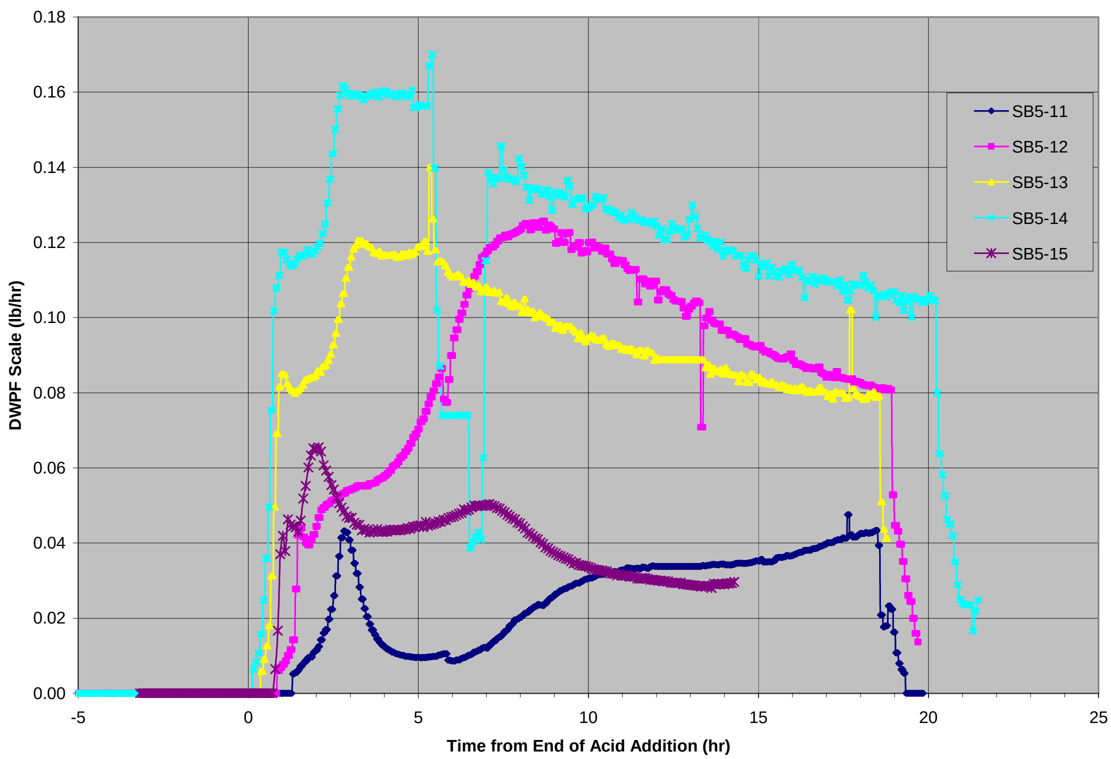

Figure 5c. SRAT Cycle Hydrogen Evolution from Tests with Blend Sludge SB5-C

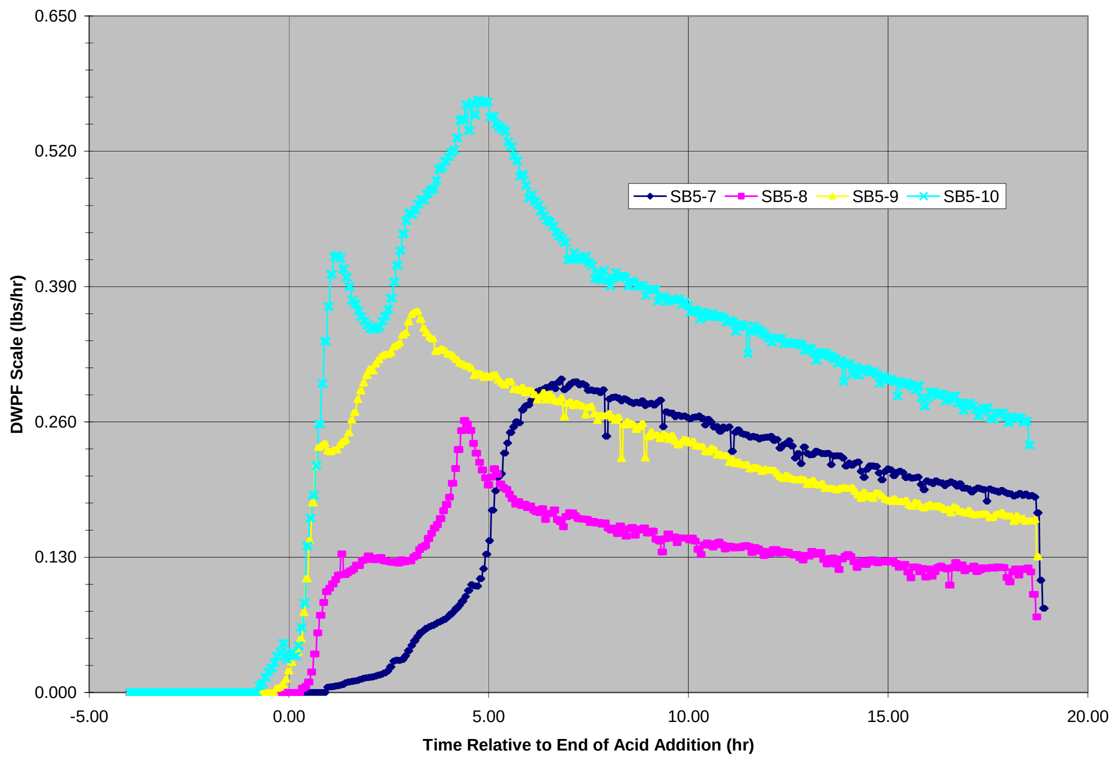

Figure 5d. SRAT Cycle Hydrogen Evolution from Tests with Batch Sludge SB5-D

3.1.4.2 Other Species

The nitrous oxide peak concentrations may have slightly increased as acid addition was increased. The carbon dioxide peak was very similar for all runs. The peak generation of these species is less dependent on acid concentration than hydrogen since more acid is added than needed to destroy carbonate and nitrite, the compounds that are responsible for the highest emissions. The peak generation rates are shown in Table 13c and d after scaling to the DWPF process scale.

Table 13c. SRAT Cycle Nitrous Oxide and Carbon Dioxide Peak Generation Rates from Tests with Blend Sludge SB5-C

		Acid Stoichiometry				
		115%	**130%**	**130% ARP**	**145%**	**160%**
SRAT Nitrous Oxide Peak	lb/hr	21.3	42.1	42.1	43.0	45.0
SRAT Carbon Dioxide Peak	lb/hr	486	489	508	483	471

SB5-15 contained more TIC (from the ARP component). TIC destruction was the source of the maximum SRAT carbon dioxide peak in these runs.

Table 13d. SRAT Cycle Nitrous Oxide and Carbon Dioxide Peak Generation Rates from Tests with Batch Sludge SB5-D

		Acid Stoichiometry			
		115%	130%	145%	160%
SRAT Nitrous Oxide Peak	lb/hr	45.7	45.2	54.9	51.6
SRAT Carbon Dioxide Peak	lb/hr	560	605	604	578

3.1.5 SRAT Product Rheological Properties

The rheological properties of SRAT products were measured for the four runs produced with the batch simulant (SB5-D) along with the product from SB5-15 (blend simulant plus ARP/MCU). The rheological properties were outside the processing limits for yield stress and consistency for SRAT products (yield stress 1.5 to 5 Pa and Consistency 5 to 12 cP)[d] except for the 115% acid run. The yield stress and consistency of the SRAT products are shown in Table 14. The flow curves generated during the testing are shown in Appendix D.

Table 14. SRAT Product Rheological Properties

Run	Acid %	Yield Stress, Pa	Consistency, cP	Insoluble Solids, wt %	Total Solids, wt %
SB5-7	115	3.6	8.3	13.84	25.64
SB5-8	130	0.5	4.2	12.28	24.01
SB5-9	145	0.3	3.6	13.47	23.96
SB5-10	160	0.1	2.2	14.84	24.17
SB5-15	130	1.1	8.2	11.53	24.46

3.1.6 Impact of ARP/MCU on SRAT Processing

The addition of ARP and MCU did not cause any other processing issues, since foaming, rheology and hydrogen generation were less of an issue while processing ARP/MCU. Hydrogen was significantly lower in Run SB5-15 (with added ARP/MCU) compared to Run SB5-12 (no added ARP/MCU), a similar run with the same 130% acid stoichiometry.

Adding ARP or MCU will extend processing times in DWPF. The ARP caustic boil took approximately six hours. The boiling time during the experiment with added MCU was 14 hours at the maximum DWPF steam flux rate. This is slightly longer than typical DWPF processing and will take even longer if boilup rates are lower than the maximum steam flux.

[d] "Technical Data Summary for the Defense Waste Processing Facility: Sludge Plant", DPSTD-80-38-2

3.2 SME Cycle Results

The SME cycle was performed immediately following the SRAT cycle and utilized the estimated amount of frit based on the initial sludge additions and the expected amount of SRAT samples. The SME cycles for Runs SB5-7, 8,9 and 10 included the addition of water simulating five decon water additions along with two frit slurry additions, whereas the SME cycles for Runs SB5-11, 12, 13 and 14 included only the two frit water slurry additions. These latter runs were approximately 12 hours shorter. This decision was conservative from hydrogen generation but also shortens the time for the SME cycles. As stated earlier, the SME cycle targeted a final solids concentration of 45 wt % total solids based on earlier testing with SB4 that resulted in extremely viscous slurries at the end of the SME cycle[16].

3.2.1 Processing Observations

Only hydrogen generation was noted as a potential processing issue during the SME cycle. The hydrogen for the batch simulant was significantly higher than for the blend simulant. Mixing was not an issue during processing. Mixer speed was maintained at 250 RPM throughout each run.

As shown in Figure 6c and d, the pH profile of each SME cycle followed a similar profile with a dip in pH as the frit is added due to the formic acid content of the frit slurry followed by a gradual rise in pH as the slurry mix is evaporated.

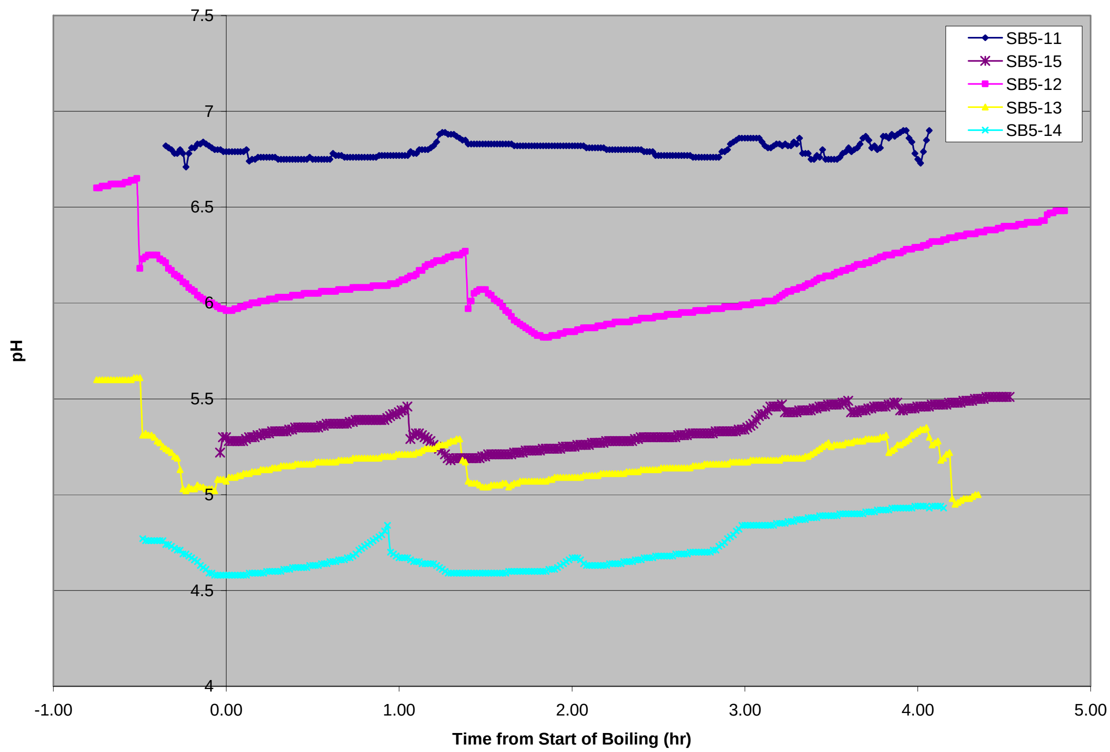

Figure 6c. SME pH Profile from Tests with Blend Sludge SB5-C

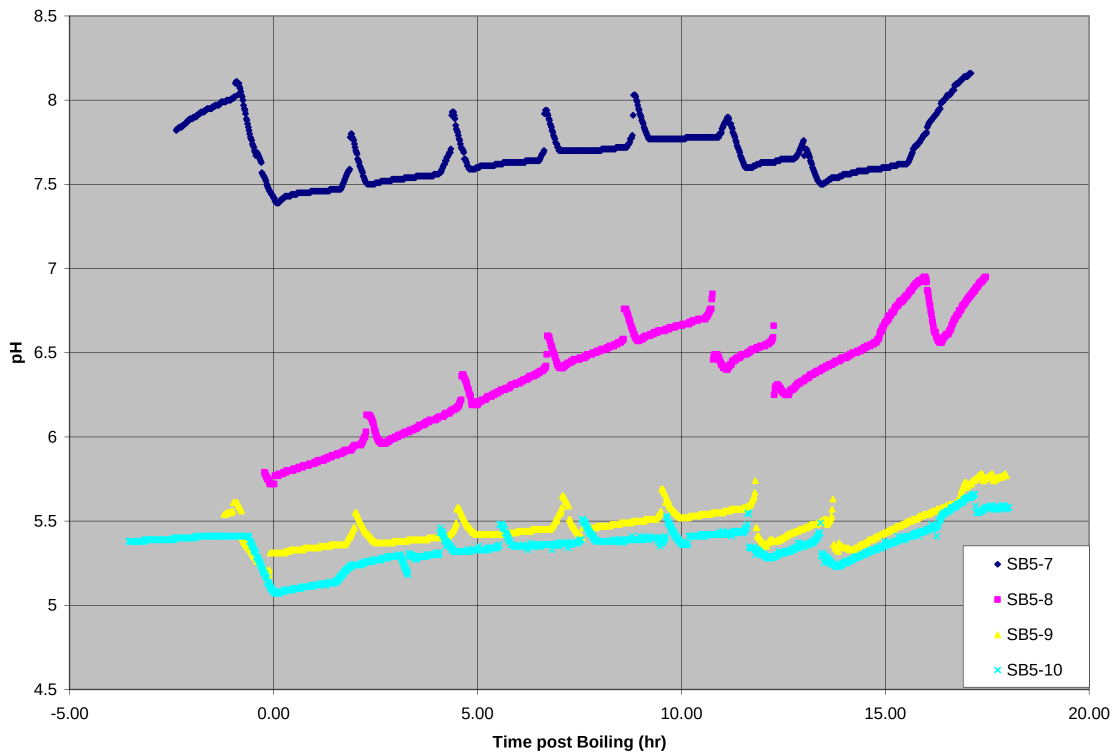

Figure 6d. SME pH Profile from Tests with Batch Sludge SB5-D

3.2.2 SME Cycle Sample Results

Samples were pulled at the conclusion of the SME cycle and analyzed for total solids, anions, soluble elemental species, mercury, and REDOX. Samples were taken of the SME dewater and the FAVC contents at the completion of the SME cycle.

3.2.2.1 SME Product Results

The solids content of the SME products are shown in Table 15c and Table 15d along with the calculated waste loading and pH. The solids content generally were higher than targeted, but the waste loading targets were all >40%, significantly higher than the 35% target. Waste loadings were calculated from the lithium content of the SME product (the frit 418 was 7.42% Li).

Table 15c. SME Product Results from Tests with Blend Sludge SB5-C

Acid %	pH	TOTAL SOLIDS	LITHIUM OXIDE CONTENT	WASTE LOADING[e]
		wt%	wt % Calcined solids	Wt %
115%	6.80	47.7	4.64	37.4
130%	6.33	45.7	4.80	35.2
130% ARP/MCU	4.82	46.2	4.52	39.1
145%	4.71	43.7	4.67	37.1
160%	4.41	47.2	4.72	36.3

[e] % Waste Loading = (1-Lithium in SME product/8)*100%

Table 15d. SME Product Results from Tests with Batch Sludge SB5-D

Acid %	pH	TOTAL SOLIDS Wt%	LITHIUM OXIDE CONTENT, Wt % Calcined Solids	WASTE LOADING, Wt %
115%	8.26	46.6	4.77	35.7
130%	7.22	45.0	4.80	35.3
145%	5.71	44.5	4.80	35.3
160%	5.46	44.6	4.68	36.9

Loss of formate varied considerably during the SME cycles, as shown in Table 16c and Table 16d. The range of values noted during the testing are similar to results from previous runs4. The amount of nitrate loss was high for most runs, with the lowest acid stoichiometry indicating a loss of 27%. The high losses at 115% acid and the negative value for the 130% acid likely resulted from the expected analytical error and cumulative errors in the mass balance as various samples are pulled.

Table 16c. SME Product Anion Conversions from Tests with Blend Sludge SB5-C

Acid Stoichiometry	SME CYCLE	
	Formate Destruction	Nitrate Destruction
115%	5%	4%
130%	6%	-3%
130-ARP/MCU	11%	11%
160%	3%	4%
160%	28%	21%

Table 16d. SME Product Anion Conversions from Tests with Batch Sludge SB5-D

Acid Stoichiometry	SME CYCLE	
	Formate Destruction	Nitrate Destruction
115%	27%	27%
130%	7%	6%
145%	11%	13%
160%	15%	11%

3.2.2.2 Condensates

The condensate pH from SME dewater decreased as acid stoichiometry increased. pH was generally higher than the SRAT dewater and the SRAT MWWT. The pH was higher during runs with the lowest acid addition, as shown in Figure 7.

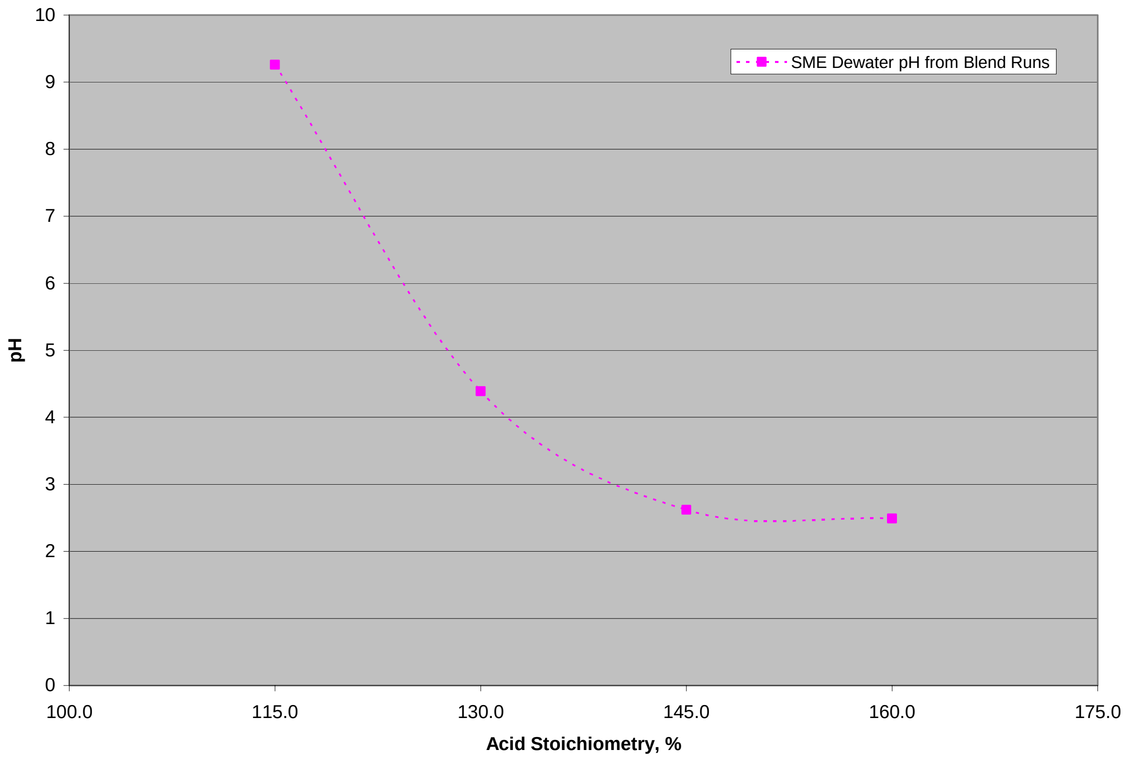

Figure 7. SME Dewater pH

3.2.3 SME Cycle Offgas Composition Results

The amount of offgas generated during the runs generally increased as acid stoichiometry increased, as indicated by the helium concentration in the offgas since helium is added at a constant 0.5 wt% of the incoming air purge. A typical offgas concentration profile is shown in Figure 8 while charts from all runs are shown in Appendix C. The patterns of offgas emissions noted during the runs were typical of offgas generation during the SME cycle with hydrogen and carbon dioxide emissions occurring during dewatering after each frit addition.

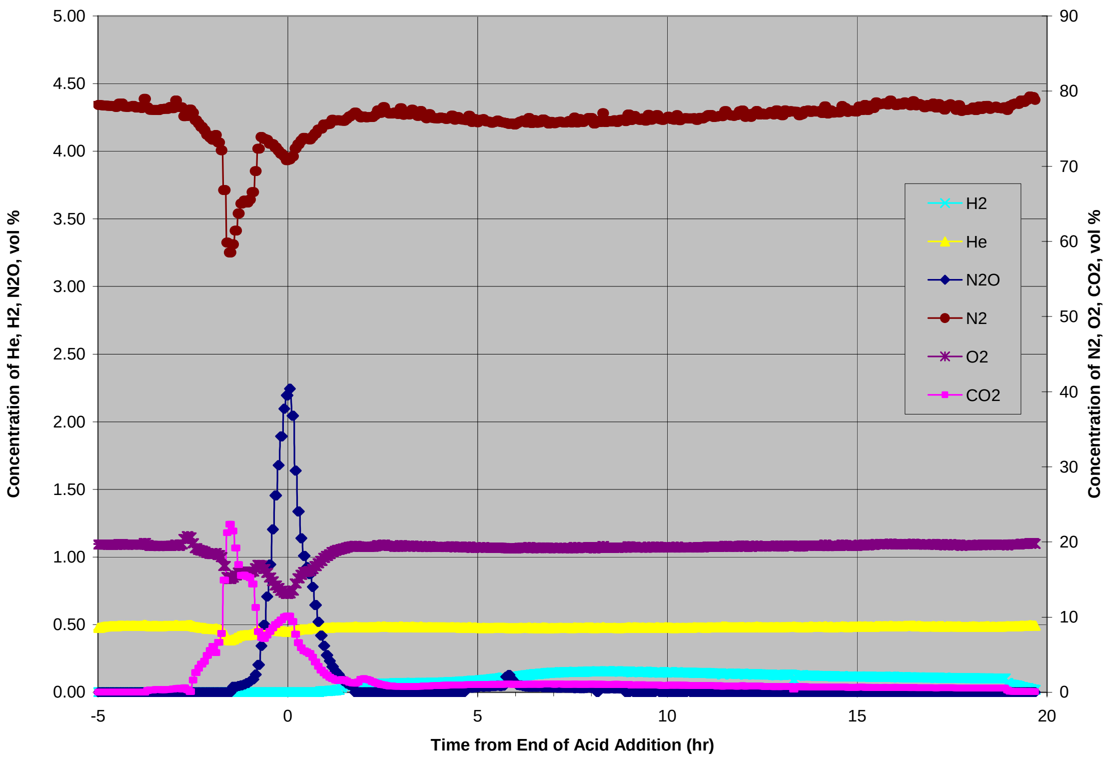

Figure 8. Typical Offgas Profile 130% Acid Stoichiometry, Blend Simulant

3.2.3.1 Hydrogen Evolution

The peak hydrogen generation rates were generally noted as sharp spikes in the data immediately following the start of dewater, as shown in Figure 8 above. Hydrogen reached concentrations higher than noted in the SRAT cycle due to the decreased purge during the SME cycle. Peak hydrogen concentrations reached close to 0.5 volume %, as shown in Figure 9 and were a function of acid stoichiometry. Peak generation rates scaled to the DWPF process are shown in Table 17 and were all below the SME process limit of 0.223 lb/hr, except for the 160% stoichiometry.

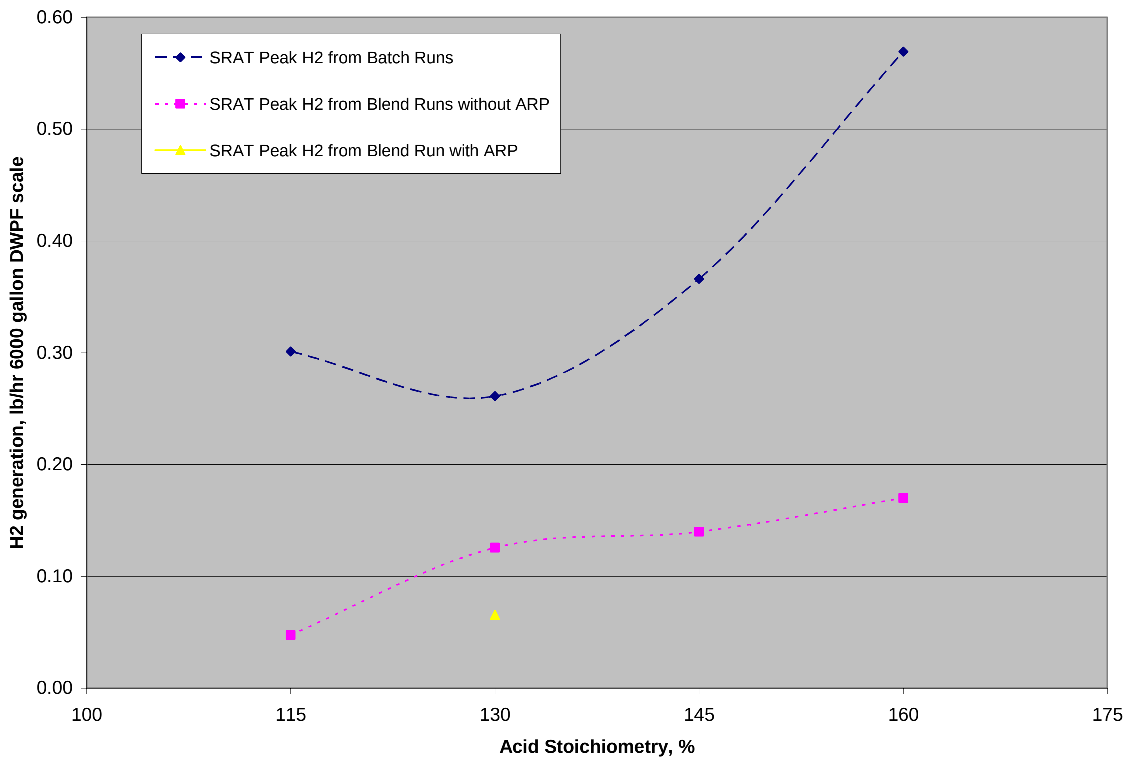

Figure 9. Peak Hydrogen Generation during SME Cycle

Table 17. SME Cycle Hydrogen Peak Generation Rate

SME Hydrogen Peak		Acid Stoichiometry				
		115%	130%	130% ARP/MCU	145%	160%
SB5-C Simulant	lb/hr	0.0517	0.0987	0.116	0.0826	0.100
SB5-D Simulant	lb/hr	0.197	0.220	-	0.173	0.246

3.2.3.2 Other Species

Carbon dioxide was generally the only other gas of any significance emitted during the SME cycle (the higher acid runs contained a small amount of nitrous oxide emissions).

Table 18c. SME Cycle Nitrous Oxide and Carbon Dioxide Peak Generation Rates from Tests with Blend Sludge SB5-C

		Acid Stoichiometry				
		115%	**130%**	**130% ARP**	**145%**	**160%**
SRAT Nitrous Oxide Peak	lb/hr	0.00	0.00	0.00	0.000	0.00
SRAT Carbon Dioxide Peak	lb/hr	23.5	28.8	30.8	20.6	15.7

Table 18d. SME Cycle Nitrous Oxide and Carbon Dioxide Peak Generation Rates from Tests with Batch Sludge SB5-D

		Acid Stoichiometry			
		115%	130%	145%	160%
SME Nitrous Oxide Peak	lb/hr	0.00	1.70	1.59	1.35
SME Carbon Dioxide Peak	lb/hr	38.9	47.8	29.8	31.0

3.2.4 SME Product Rheological Properties

The rheological properties of each SME product with batch simulant were measured along with those of the blend simulant run with ARP/MCU. Higher acid stoichiometry lowered the yield stress and consistency of the SME products. The 115% acid run exceeded the upper process limit for yield stress (15 Pa)[f] and consistency (10 to 40 cP). The two highest acid runs exceeded the process limits for yield stress (2.5 Pa), as shown in Table 19.

Table 19. SME Product Rheological Properties from Tests with Batch Sludge SB5-D

Run	Acid %	Yield Stress, Pa	Consistency, cP	Total Solids, wt %
SB5-7	115	23.8	49.8	46.6
SB5-8	130	3.1	16.0	44.95
SB5-15	130	2.1	24.8	46.2
SB5-9	145	1.8	11.5	44.5
SB5-10	160	1.6	10.9	44.6

3.2.5 REDOX Results

The predicted REDOX values shown in Table 20 are based on the sample results of the SME product. Measured values are the average of duplicate samples generated by the guidelines of L29 ITS-0052 "Vitrification of Melter Slurries for Glass Redox ($Fe^{2+}/\Sigma Fe$) & Chemical Composition Measurement"[17].

Table 20. SME Product REDOX from Blend Runs (SB5-11 to SB5-14)

Run	REDOX Result, $Fe^{+2}/\Sigma Fe$	REDOX Prediction, $Fe^{+2}/\Sigma Fe$	Acid Stoichiometry %
SB5-11	0.23	0.244	115
SB5-12	0.25	0.21	130
SB5-13	0.22	0.22	145
SB5-14	0.26	0.229	160

[f] "Technical Data Summary for the Defense Waste Processing Facility: Sludge Plant", DPSTD-80-38-2

As shown in Figure 10, the measured REDOX increased with increased acid stoichiometry. Although most of the REDOX measurements were greater than predicted, there was a fairly close correlation between the prediction and result. More information on the SB5 REDOX results is summarized in a separate SRNL memo[18].

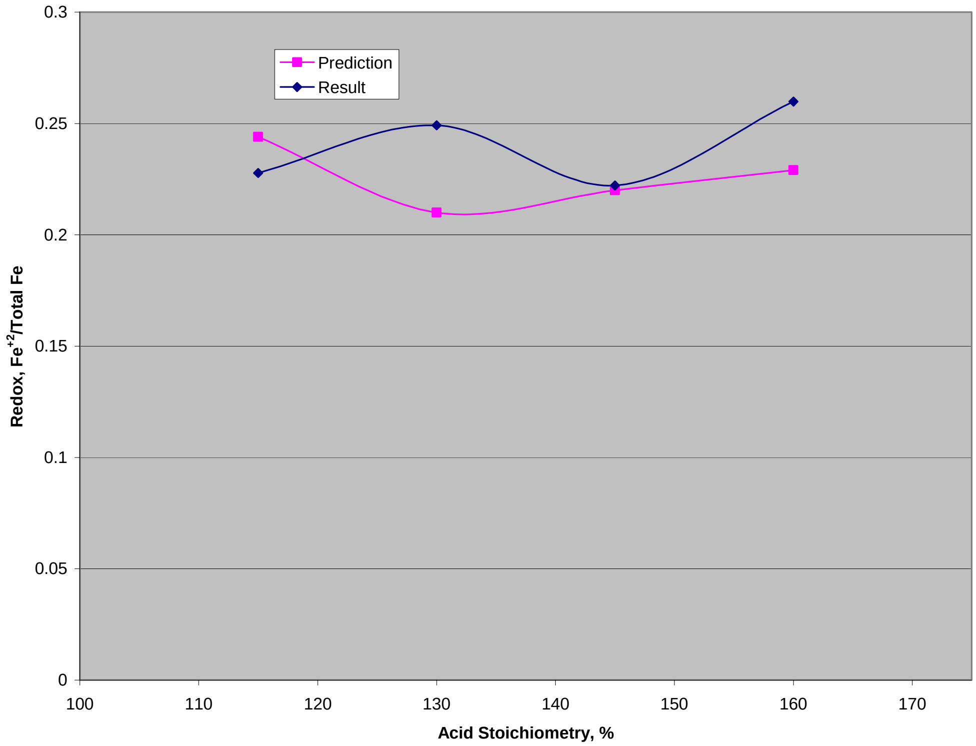

Figure 10. SB5 Flowsheet Testing REDOX Results

4.0 Conclusions

Two SB5 processing issues were noted during testing. First, high hydrogen generation rates were measured during experiments with both the blend and batch simulant at high acid stoichiometry. Also, the reflux time was extended due to the high mercury concentration in both the batch and blend simulant.

Adding ARP will extend processing times in DWPF. The ARP caustic boil took approximately six hours. The boiling time during the experiment with added MCU was 14 hours at the maximum DWPF steam flux rate. This is comparable to the combined dewatering and reflux time for a nominal SRAT batch using 5000 lbs/hr boil-up rates during boiling, but would require considerably more time at 2000-2500 lbs/hr boil-up rates. The addition of ARP and MCU did not cause any other processing issues, as foaming, rheology and hydrogen generation were less of an issue while processing ARP/MCU.

- Hydrogen and nitrous oxide generation rates as a function of acid stoichiometry

Hydrogen generation was significantly impacted by the changes in acid stoichiometry from 115% to 160% (1.96 to 2.73 moles acid per liter of batch sludge or 1.28 to 1.79 moles acid per liter of blend sludge). For the batch sludge, the hydrogen generation rate exceeded the process limit during the SME cycle at the highest acid stoichiometry (160%). All of the blend experiments were within the process limits throughout the SRAT and SME cycles. As DWPF will be processing blend sludge, hydrogen likely won't be an issue in DWPF processing but lower acid stoichiometries will minimize hydrogen generation. The reduction in Hg concentration of the SRAT receipt slurry after combining ARP with sludge and concentrating it to the same wt% total solids led to increased hydrogen generation rates at 130% stoichiometry compared to the run without ARP. The nitrous oxide generation peak was relatively insensitive to acid stoichiometry and was relatively low due to the low starting nitrite concentration. Hydrogen generation and nitrous oxide generation scaled to DWPF are shown in Table 21c and Table 21d.

Table 21c. Offgas Peak Summary Blend

		Acid Stoichiometry			
		115%	130%	145%	160%
SRAT Hydrogen Peak	lb/hr	0.0476	0.126	0.140	0.170
SME Hydrogen Peak	lb/hr	0.0517	0.0987	0.0826	0.100
SRAT Nitrous Oxide Peak	lb/hr	21.3	42.1	43.0	45.0
SME Nitrous Oxide Peak	lb/hr	0.0000	0.0000	0.173	0.0000
SRAT Carbon Dioxide Peak	lb/hr	486	489	483	471
SME Carbon Dioxide Peak	lb/hr	23.5	28.8	20.6	15.7

Table 21d. Offgas Peak Summary Batch

		Acid Stoichiometry			
		115%	130%	145%	160%
SRAT Hydrogen Peak	lb/hr	0.301	0.261	0.366	0.569
SME Hydrogen Peak	lb/hr	0.197	0.220	0.173	0.246
SRAT Nitrous Oxide Peak	lb/hr	45.7	45.2	54.9	51.6
SME Nitrous Oxide Peak	lb/hr	0.00	1.70	1.59	1.35
SRAT Carbon Dioxide Peak	lb/hr	560	605	604	578
SME Carbon Dioxide Peak	lb/hr	38.9	47.8	29.8	31.0

- Acid quantities and processing times required for mercury removal

Mercury was added to the sludge simulant at the start of the SRAT cycle as mercuric oxide at approximately 2.5 wt% (solids basis) based on the expected composition of the SB5 batch and blend. Because of the high mercury concentration, the time at boiling was increased from 12 hours to 18 hours to allow sufficient time to strip mercury from the SRAT. Boiling flux was maintained at a scaled rate of 5,000 lb/hr so a total of 90,000 lb of steam flow in DWPF will be needed to remove 120 lb of mercury. Acid quantities from 115% to 160% resulted in satisfactory mercury removal with 18 hours of boiling time, with the exception of the two lowest acid stoichiometry runs with the blend simulant. If DWPF experiences problems stripping mercury, increasing the acid stoichiometry is likely to improve mercury removal but also will increase hydrogen generation. Simulant testing does not simulate the DWPF heel so starting mercury concentrations will be lower in DWPF and shorter steam stripping times should be achievable.

- Acid quantities and processing times required for nitrite destruction

Acid quantities from 115% to 160% resulted in satisfactory nitrite destruction with 18 hours of boiling. In all runs, the amount of nitrite present in the SRAT product was less than 100 mg/kg, well below the 1,000 mg/kg target. The longer boiling time and low starting nitrite concentration both helped to reduce the nitrite by the end of the SRAT cycle.

- Impact of SB5 composition (in particular, manganese, nickel, mercury, and aluminum) on DWPF processing (i.e. acid addition strategy, foaming, hydrogen generation, REDOX control, rheology, etc.)

Acid quantities from 130% to 160% resulted in satisfactory process performance with no significant issues noted. Foaming was noted during formic acid addition, but the addition of antifoam equal to the amount added at DWPF was sufficient to control foaming.

Except for the 115% run, all SRAT products were outside the process limits for yield stress and consistency with the 130%, 145% and 160% runs being below the process limit. The process limits for SME product yield stress were met for the 130% acid run at 45% solids, but the 115% acid run was above process limits and the 145% and 160% runs were slightly below process limits. It should be noted that the trend seen in rheological properties of the simulants are expected to be similar for the DWPF process slurries, but the absolute values for the simulants are not expected to be prototypical in yield stress or consistency. Adjustment in the solids concentration targets and/or acid stoichiometry should be made if processing problems due to viscous process slurries are noted in DWPF.

The pH of the condensate generated for all eight SRAT cycles was acidic, but the 115% acid runs resulted in condensate that was basic by the end of the SRAT cycle and throughout the SME cycle with a pH of approximately 9. All condensates from all other runs had a pH of less than 5.

Measured REDOX values for most runs were slightly higher than the predicted values for the batch simulant. REDOX values increased slightly as acid stoichiometry was increased.
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5.0 Recommendations

Based on these two sets of runs, an acid stoichiometry of 130% is recommended for initial SB5 processing with an acid window of 115% to 160%. The SB5 batch simulant used during the testing had a stoichiometric acid requirement of 2.22 mol/L at 130% acid, and the SB5 blend simulant had a stoichiometric acid requirement of 1.45 mol/L at 130% acid. The actual DWPF recommendation will be finalized once SB5 shielded cells processing studies are completed.

Due to an expected high mercury concentration in the SB5 sludge (approximately 2.5 wt %), the total mass of steam required for effective steam stripping should be set at 90,000 lb (18 hours times 5,000 lb/hr). The boiling time can be shortened if better mercury stripping efficiency is experienced in DWPF. Increasing acid stoichiometry may lead to better mercury stripping based on simulant testing.

6.0 References

1 Culbertson, B. H., *Sludge Batch 5 Flowsheet Studies*. HLW/DWPF/TTR-2007-0008 Revision 1, Savannah River Site, Aiken, SC 29808 (2006).

2 Lambert, D. P., *Task Technical & QA Plan: Sludge Batch 5 Simulant Flowsheet Studies, WSRC-RP-2006-01208 Revision 0*, Savannah River Site, Aiken, SC 29808 (2007).

3 Baich, M.A., C.C. Herman, D.R. Best, M.F. Williams, and E.K. Hansen, *Sludge Batch 4 Initial Simulant Flowsheet Studies: Phase I SRAT Results,* WSRC-TR-2005-00194, Savannah River Site, Aiken, SC 29808 (2005).

4 Herman, C. C, D. R. Best, D. P. Lambert, M. E. Stone, and M. F. Williams, *Sludge Batch 4 without Tank 4 Simulant Flowsheet Studies: Phase I SRAT Results,* WSRC-TR-2005-00493, Savannah River Site, Aiken, SC 29808 (2005).

5 Larsen, D. D. SB-5 Projected Compositions, e-mail dated 5/5/2008 4:38 pm.

6 Choi, A. S. SB5 Projections 2, e-mail dated 6/12/2008 10:15 am.

7 Reboul, S. H., *Noble Metals in As-Received Tank 51 SB5 Qualification Sample*, SRNL-PSE--001222008-00115, Revision 0, Savannah River Site, Aiken, SC 29808 (2006).

8 Stone, M. E., *Lab-Scale CPC Equipment Set-up,* SRNL-ITS-2006-00074, Savannah River Site, Aiken, SC 29808 (2008).

9 Manual L29, Procedure ITS-0094, Rev. 1, *Laboratory Scale Chemical Process Cell Simulations*, Savannah River Site, Aiken, SC 29808 (2005).

10 *SB5 Flowsheet CPC Experiments*, WSRC-NB-2008-00015.

11 Lambert, D. P., *Acid Calculation Spreadsheet for DWPF Simulations, Revision 1 (Dated 8/14/06),* SRNL-PSE-2006-00173, Savannah River Site, Aiken, SC 29808 (2006).

12 Jantzen, C.M., J.R. Zamecnik, D.C. Koopman, C.C. Herman, and J.B. Pickett, *Electron Equivalents Model for Controlling Reduction-Oxidation (Redox) Equilibrium during High Level Waste (HLW) Vitrification*, WSRC-TR-2003-00126, Savannah River Site, Aiken, SC 29808 (2003).

13 Lambert, D. P.., *4L SRAT R&D Directions for SB5 Qualification Flowsheet Development*, SRNL-PSE-2008-00118, Rev. 1, Savannah River Site, Aiken, SC 29808 (2008).

14 Lambert, D. P.., *4L SRAT R&D Directions for SB5 Blend Flowsheet Development*, SRNL-PSE-2008-00145, Savannah River Site, Aiken, SC 29808 (2008).

15 Stone, M. E., *Sludge Batch 4 Simulant Flowsheet Studies: Phase II Results*, WSRC-STI-2006-00109, Savannah River Site, Aiken, SC 29808 (2006).

16 Stone, M. E., *FY06 Feed Preparation for Melt Rate Testing*, WSRC-STI-2006-0007, Savannah River Site, Aiken, SC 29808 (2006).

17 Manual L29, Procedure ITS-0052, Rev. 1, "Vitrification of Melter Slurries for Glass Redox ($Fe^{2+}/\Sigma Fe$) & Chemical Composition Measurement", (2003).

18 Jantzen, C. M. and J. D. Newell, Defense Waste Processing Facility (DWPF) Sludge Batch 5 (SB5) REDOX Validation, SRNL-PSE-2008-00184, Savannah River Site, Aiken, SC 29808 (2008).

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- M. F. Williams and J. M. Pareizs for assistance with calibration and running the gas chromatographs during the runs.

Appendix A-1: SRAT Receipt Sample Results

Process Science Analytical Laboratory
Customer: Dan Lambert
Date: 5/23/08
Sample ID: 08-SB5D-2480
Lab ID: 08-1250

Sample ID	Lab ID									
elemental wt%-calcined 1100C		Al	B	Ba	Ca	Cd	Ce	Cr	Cu	Fe
08-SB5D-2480 (A)	08-1250	11.9	<0.100	0.011	2.16	<0.010	0.013	0.026	0.011	20.6
08-SB5D-2480 (B)	08-1250	11.9	<0.100	0.011	2.45	<0.010	0.014	0.025	0.015	21.2
oxide wt% - calcined 1100C		Al2O3	B2O3	BaO	CaO	CdO	CeO2	Cr2O3	CuO	Fe2O3
08-SB5D-2480 (A)	08-1250	22.5	0.00	0.012	3.02	0.00	0.016	0.038	0.014	29.5
08-SB5D-2480 (B)	08-1250	22.5	0.00	0.012	3.43	0.00	0.017	0.037	0.019	30.3

elemental wt%-calcined 1100C										
08-SB5D-2480 (A)	08-1250	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb
08-SB5D-2480 (B)	08-1250	0.074	<0.100	0.841	4.73	<0.010	22.8	2.44	<0.010	<0.010
		0.074	<0.100	0.840	4.73	<0.010	22.2	2.44	<0.010	<0.010
oxide wt% - calcined 1100C										
08-SB5D-2480 (A)	08-1250	K2O	Li2O	MgO	MnO2	MoO3	Na2O	NiO	P2O5	PbO
08-SB5D-2480 (B)	08-1250	0.089	0.000	1.40	7.47	0.00	30.8	3.10	0.000	0.000
		0.089	0.000	1.39	7.47	0.00	30.0	3.10	0.000	0.000

elemental wt%-calcined 1100C		S	Si	Sn	Sr	Ti	Zn	Zr	
08-SB5D-2480 (A)	08-1250	0.140	0.026	<0.100	<0.010	<0.010	<0.010	<0.010	
08-SB5D-2480 (B)	08-1250	0.136	0.018	<0.100	<0.010	<0.010	<0.010	<0.010	
oxide wt% - calcined 1100C		SO4	SiO2	SnO2	SrO	TiO2	ZnO	ZrO2	Totals
08-SB5D-2480 (A)	08-1250	0.420	0.056	0.000	0.00	0.00	0.00	0.00	98.4
08-SB5D-2480 (B)	08-1250	0.408	0.039	0.000	0.00	0.00	0.00	0.00	98.8

Units: mg/Kg

Sample ID	Lab ID	F	Cl	NO2	NO3	PO4	HCO2	SO4
08-SB5D-2480 (A)	08-1250	<100	<100	10400	2820	<100	<100	526
08-SB5D-2480 (B)	08-1250	<100	<100	10500	2790	<100	<100	526

Weight % Solids Calculations

Sample	Lab ID	Empty Crucible wt	Crucible Wt + Wet Sample	Crucible Wt + Dry wt	Total Solids	Wet Wt	Dry Wt	Insoluble Solids	Cruc Wt+ Calcined	Wt % Calcined
08-SB5D-2480 (A)	08-1250	44.0110	49.3832	44.7924	14.55%	5.3722	0.781	8.12%	44.6081	11.11%
08-SB5D-2480 (B)	08-1250	43.8754	49.3121	44.6686	14.59%	5.4367	0.793	7.94%	44.4773	11.07%
08-SB5D-2480 (C)	08-1250	42.9247	48.3642	43.7192	14.61%	5.4395	0.794	8.07%	43.5279	11.09%
					14.58%			8.0%		11.09%

Sample	Lab ID	Empty Crucible wt	Crucible Wt + Wet Sample	Crucible Wt + Dry wt	Uncorr	Soluble Solids		Slurry pH	Density
08-SB5D-2480 (A)	08-1250	42.9303	46.5676	43.1845	6.99%	6.42%		13.5	1.11
08-SB5D-2480 (B)	08-1250	43.0181	46.2042	43.2484	7.23%	6.65%			
08-SB5D-2480 (C)	08-1250	44.3207	48.0284	44.5842	7.11%	6.53%			
						6.54%			

supernate (mg/L)		Al	B	Ba	Ca	Cd	Ce	Cr	Cu	Fe
08-SB5D-2480 (A)	08-1250	4200	<0.100	<0.100	6.10	<0.100	<0.100	1.29	<1.00	<0.100
08-SB5D-2480 (B)	08-1250	4100	<0.100	<0.100	7.40	<0.100	<0.100	1.29	<1.00	<0.100
supernate (mg/L)		K	Li	Mg	Mn	Mo	Na	Ni	P	Pb
08-SB5D-2480 (A)	08-1250	264	<10.0	<0.100	<0.100	<1.00	30300	<0.100	<10.0	<0.100
08-SB5D-2480 (B)	08-1250	251	<10.0	<0.100	<0.100	<1.00	30200	<0.100	<10.0	<0.100
supernate (mg/L)		S	Si	Sn	Sr	Ti	Zn	Zr		
08-SB5D-2480 (A)	08-1250	102	1.1	<10.0	<10.0	<0.100	<0.100	<0.100		
08-SB5D-2480 (B)	08-1250	106	0.96	<10.0	<10.0	<0.100	<0.100	<0.100		

ACTL Results

Titration, Total Base

Sample ID	pH 7 Result, m-mole/g	pH 5.5 Result, m-mole/g
SB5Da	0.8203	0.9371
SB5Db	0.8192	0.9363
SB5Dc	0.8170	0.9353
Average	**0.8188**	**0.9362**

AD Results

Sample ID	Mass Empty 60 mL sample bottle, g	Mass sample bottle with sludge, g	Sample Mass, g	Mass sample bottle with sludge and water, g	Total Mass, sample + water, g	Total Volume, mL	TIC, mg/L	Corrected TIC, mg/kg
08_SB5D_2481A	12.687	14.711	2.024	52.78	40.093	39.82	112	2,446
08_SB5D_2481A	12.756	14.77	2.014	52.899	40.143	39.87	115	2,527
08_SB5D_2481A	12.649	14.678	2.029	52.726	40.077	39.81	114	2,483
Average								**2,485**
Sludge Density	1.10995							

Appendix A-1: SRAT Receipt Sample Results

Process Science Analytical Laboratory
Customer: Dan Lambert
Date: 7/02/08
Sample ID: 08-SB5C-2477 (SB5-C6-12-2008)
Lab ID: 08-1514

Sample ID	Lab ID									
elemental wt%-calcined 1100C		Al	B	Ba	Ca	Cd	Ce	Cr	Cu	Fe
08-SB5C-2477 (A)	08-1514	12.7	<0.100	0.013	2.09	<0.010	0.023	0.017	0.021	21.2
08-SB5C-2477 (B)	08-1514	12.4	<0.100	0.013	2.13	<0.010	0.023	0.016	0.019	21.7
oxide wt% - calcined 1100C		Al2O3	B2O3	BaO	CaO	CdO	CeO2	Cr2O3	CuO	Fe2O3
08-SB5C-2477 (A)	08-1514	24.0	0.00	0.015	2.93	0.00	0.028	0.025	0.026	30.3
08-SB5C-2477 (B)	08-1514	23.4	0.00	0.015	2.98	0.00	0.028	0.023	0.024	31.0
elemental wt%-calcined 1100C		K	Li	Mg	Mn	Mo	Na	Ni	P	Pb
08-SB5C-2477 (A)	08-1514	0.158	<0.100	0.890	5.05	<0.010	17.3	2.63	0.111	<0.010
08-SB5C-2477 (B)	08-1514	0.156	<0.100	0.890	5.05	<0.010	17.6	2.62	0.111	<0.010
oxide wt% - calcined 1100C		K2O	Li2O	MgO	MnO2	MoO3	Na2O	NiO	P2O5	PbO
08-SB5C-2477 (A)	08-1514	0.190	0.000	1.48	7.98	0.00	23.4	3.34	0.254	0.000
08-SB5C-2477 (B)	08-1514	0.187	0.000	1.48	7.98	0.00	23.8	3.33	0.254	0.000
elemental wt%-calcined 1100C		S	Si	Sn	Sr	Ti	Zn	Zr		
08-SB5C-2477 (A)	08-1514	0.159	1.26	<0.100	<0.010	<0.010	<0.010	<0.010		
08-SB5C-2477 (B)	08-1514	0.157	1.27	<0.100	<0.010	<0.010	<0.010	<0.010		
oxide wt% - calcined 1100C		SO4	SiO2	SnO2	SrO	TiO2	ZnO	ZrO2	Totals	
08-SB5C-2477 (A)	08-1514	0.477	2.70	0.000	0.00	0.00	0.00	0.00	97.1	
08-SB5C-2477 (B)	08-1514	0.471	2.72	0.000	0.00	0.00	0.00	0.00	97.7	

Units: mg/Kg

Sample ID	Lab ID	F	Cl	NO2	NO3	PO4	HCO2	SO4	C2O4
08-SB5C-2477 (A)	08-1514	<100	<100	6210	3940	<100	<100	405	288
08-SB5C-2477 (B)	08-1514	<100	<100	6140	3940	<100	<100	405	287

Weight % Solids Calculations

Sample	Lab ID	Empty Crucible wt	Crucible Wt + Wet Sample	Crucible Wt + Dry wt	Total Solids	Wet Wt	Dry Wt	Insoluble Solids	Cruc Wt+ Calcined	Wt % Calcined
08-SB5C-2477 (A)	08-1514	44.6504	49.9708	45.3133	12.5%	5.3204	0.663	7.82%	45.1558	9.50%
08-SB5C-2477 (B)	08-1514	45.3284	50.7093	45.9999	12.5%	5.3809	0.671	7.88%	45.8411	9.53%
					12.47			7.85		9.51

Sample	Lab ID	Empty Crucible wt	Crucible Wt + Wet Sample	Crucible Wt + Dry wt	Uncorr	Soluble Solids	Slurry pH	Density
08-SB5C-2477 (A)	08-1514	45.4630	47.5642	45.5688	5.04%	4.64%	13.4	1.09
08-SB5C-2477 (B)	08-1514	44.7255	46.8160	44.8298	4.99%	4.60%		
						4.62		

ACTL Results

Titration, Total Base

Sample ID	pH 7 Result, m-mole/g	pH 5.5 Result, m-mole/g
2.1731	0.5822	0.6662
2.1956	0.579	0.6648
2.169	0.5774	0.663
Average	**0.5795**	**0.6647**

AD Results

Sample ID	Mass Empty 60 mL sample bottle, g	Mass sample bottle with sludge, g	Sample Mass, g	Mass sample bottle with sludge and water, g	Total Mass, sample + water, g	Total Volume, mL	TIC, mg/L	Corrected TIC, mg/kg
08_SB5C_2478A	12.556	14.57	2.014	52.576	40.02	39.79	72.6	1,434
08_SB5C_2478B	12.587	14.627	2.04	52.659	40.072	39.84	66.5	1,299
08_SB5C_2478C	12.574	14.614	2.04	52.906	40.332	40.09	65.2	1,281
Average								**1,338**
Slurry Density, g/mL	1.09							

Appendix A-2: SRAT Product Sample Results

SRNL Process Science Analytical Laboratory
Customer: Dan Lambert
Date: 8/1/08
Sample ID: SRAT Prod - 08-SB5-7-2505, 9-2516, 8-2487, 10-2496
Lab ID: 08-1372-1379
Units: wt%, mg/Kg, mg/L

Sample ID	Lab ID									
elemental wt%-calcined 1100C		**Al**	**B**	**Ba**	**Ca**	**Cr**	**Cu**	**Fe**	**K**	**Li**
08-SB5-7-2505 (A)	**08-1372**	**11.4**	**<0.100**	**0.013**	**2.04**	**0.027**	**0.012**	**18.8**	**0.084**	**<0.100**
08-SB5-7-2505 (B)	**08-1372**	**11.4**	**<0.100**	**0.013**	**2.17**	**0.027**	**0.024**	**18.4**	**0.085**	**<0.100**
08-SB5-9-2516 (A)	**08-1373**	**11.4**	**<0.100**	**0.014**	**2.18**	**0.029**	**0.011**	**18.4**	**0.117**	**<0.100**
08-SB5-9-2516 (B)	**08-1373**	**11.4**	**<0.100**	**0.013**	**2.28**	**0.028**	**0.009**	**18.4**	**0.111**	**<0.100**
08-SB5-8-2487 (A)	**08-1374**	**11.4**	**<0.100**	**0.013**	**2.11**	**0.028**	**0.013**	**18.3**	**0.100**	**<0.100**
08-SB5-8-2487 (B)	**08-1374**	**11.3**	**<0.100**	**0.013**	**2.05**	**0.028**	**0.015**	**18.5**	**0.099**	**<0.100**
08-SB5-10-2496 (A)	**08-1375**	**11.8**	**<0.100**	**0.014**	**2.00**	**0.029**	**0.016**	**18.6**	**0.088**	**<0.100**
08-SB5-10-2496 (B)	**08-1375**	**11.7**	**<0.100**	**0.013**	**1.92**	**0.028**	**0.014**	**18.8**	**0.089**	**<0.100**
oxide wt% - calcined 1100C		Al2O3	B2O3	BaO	CaO	Cr2O3	CuO	Fe2O3	K2O	Li2O
08-SB5-7-2505 (A)	**08-1372**	21.6	0.0	0.015	2.86	0.040	0.015	26.9	0.101	0.000
08-SB5-7-2505 (B)	**08-1372**	21.5	0.0	0.015	3.04	0.040	0.030	26.3	0.102	0.000
08-SB5-9-2516 (A)	**08-1373**	21.6	0.0	0.015	3.06	0.042	0.014	26.3	0.141	0.000
08-SB5-9-2516 (B)	**08-1373**	21.5	0.0	0.015	3.19	0.041	0.012	26.3	0.133	0.000
08-SB5-8-2487 (A)	**08-1374**	21.6	0.0	0.015	2.96	0.041	0.016	26.1	0.119	0.000
08-SB5-8-2487 (B)	**08-1374**	21.4	0.0	0.015	2.86	0.041	0.018	26.4	0.119	0.000
08-SB5-10-2496 (A)	**08-1375**	22.3	0.0	0.015	2.79	0.042	0.020	26.6	0.106	0.000
08-SB5-10-2496 (B)	**08-1375**	22.2	0.0	0.015	2.69	0.042	0.018	26.8	0.106	0.000
elemental wt%-calcined 1100C		**Mg**	**Mn**	**Na**	**Ni**	**P**	**Pb**	**Pd**	**Rh**	**Ru**
08-SB5-7-2505 (A)	**08-1372**	**0.845**	**4.51**	**22.4**	**2.33**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**0.014**
08-SB5-7-2505 (B)	**08-1372**	**0.841**	**4.44**	**22.4**	**2.28**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**0.023**
08-SB5-9-2516 (A)	**08-1373**	**0.852**	**4.31**	**22.5**	**2.27**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**0.014**
08-SB5-9-2516 (B)	**08-1373**	**0.852**	**4.33**	**22.4**	**2.28**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**0.014**
08-SB5-8-2487 (A)	**08-1374**	**0.847**	**4.49**	**22.4**	**2.29**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**0.014**
08-SB5-8-2487 (B)	**08-1374**	**0.853**	**4.53**	**22.1**	**2.31**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**0.016**
08-SB5-10-2496 (A)	**08-1375**	**0.857**	**4.27**	**21.9**	**2.24**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**0.014**
08-SB5-10-2496 (B)	**08-1375**	**0.863**	**4.35**	**21.8**	**2.27**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**0.013**
oxide wt% - calcined 1100C		MgO	MnO2	Na2O	NiO	P2O5	PbO	PdO	RhO2	RuO2
08-SB5-7-2505 (A)	**08-1372**	1.40	7.13	30.2	2.96	0.000	0.000	0.000	0.000	0.018
08-SB5-7-2505 (B)	**08-1372**	1.40	7.01	30.3	2.89	0.000	0.000	0.000	0.000	0.030
08-SB5-9-2516 (A)	**08-1373**	1.41	6.81	30.4	2.88	0.000	0.000	0.000	0.000	0.019
08-SB5-9-2516 (B)	**08-1373**	1.41	6.85	30.2	2.90	0.000	0.000	0.000	0.000	0.018
08-SB5-8-2487 (A)	**08-1374**	1.41	7.10	30.2	2.90	0.000	0.000	0.000	0.000	0.019
08-SB5-8-2487 (B)	**08-1374**	1.42	7.16	29.8	2.94	0.000	0.000	0.000	0.000	0.021
08-SB5-10-2496 (A)	**08-1375**	1.42	6.74	29.6	2.84	0.000	0.000	0.000	0.000	0.018
08-SB5-10-2496 (B)	**08-1375**	1.43	6.87	29.5	2.88	0.000	0.000	0.000	0.000	0.017
elemental wt%-calcined 1100C		**S**	**Si**	**Sn**	**Sr**	**Ti**	**Zn**	**Zr**		
08-SB5-7-2505 (A)	**08-1372**	**0.161**	**0.051**	**0.020**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-7-2505 (B)	**08-1372**	**0.165**	**0.045**	**0.023**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-9-2516 (A)	**08-1373**	**0.168**	**0.051**	**0.023**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-9-2516 (B)	**08-1373**	**0.168**	**0.048**	**0.022**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-8-2487 (A)	**08-1374**	**0.168**	**0.048**	**0.022**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-8-2487 (B)	**08-1374**	**0.171**	**0.045**	**0.023**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-10-2496 (A)	**08-1375**	**0.167**	**0.039**	**0.023**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-10-2496 (B)	**08-1375**	**0.164**	**0.040**	**0.021**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
oxide wt% - calcined 1100C		SO4	SiO2	SnO2	SrO	TiO2	ZnO	ZrO2	Totals	
08-SB5-7-2505 (A)	**08-1372**	0.483	0.108	0.026	0.00	0.00	0.00	0.00	93.8	
08-SB5-7-2505 (B)	**08-1372**	0.494	0.097	0.030	0.00	0.00	0.00	0.00	93.3	
08-SB5-9-2516 (A)	**08-1373**	0.505	0.108	0.029	0.00	0.00	0.00	0.00	93.3	
08-SB5-9-2516 (B)	**08-1373**	0.503	0.102	0.028	0.00	0.00	0.00	0.00	93.2	
08-SB5-8-2487 (A)	**08-1374**	0.505	0.102	0.028	0.00	0.00	0.00	0.00	93.1	
08-SB5-8-2487 (B)	**08-1374**	0.514	0.096	0.029	0.00	0.00	0.00	0.00	92.9	
08-SB5-10-2496 (A)	**08-1375**	0.501	0.084	0.029	0.00	0.00	0.00	0.00	93.1	
08-SB5-10-2496 (B)	**08-1375**	0.492	0.085	0.027	0.00	0.00	0.00	0.00	93.2	

anions (mg/Kg)		**F**	**Cl**	**NO2**	**NO3**	**SO4**	**PO4**	**HCO2**		
08-SB5-7-2505 (A)	**08-1372**	**<100**	**314**	**<100**	**29300**	**<100**	**<100**	**62000**		
08-SB5-7-2505 (B)	**08-1372**	**<100**	**318**	**<100**	**29800**	**<100**	**<100**	**62400**		
08-SB5-9-2516 (A)	**08-1373**	**<100**	**323**	**<100**	**34400**	**235**	**<100**	**70900**		
08-SB5-9-2516 (B)	**08-1373**	**<100**	**327**	**<100**	**35300**	**237**	**<100**	**72500**		
08-SB5-8-2487 (A)	**08-1374**	**<100**	**337**	**<100**	**31200**	**150**	**<100**	**67500**		
08-SB5-8-2487 (B)	**08-1374**	**<100**	**339**	**<100**	**31300**	**155**	**<100**	**67300**		
08-SB5-10-2496 (A)	**08-1375**	**<100**	**311**	**<100**	**38200**	**283**	**<100**	**77600**		
08-SB5-10-2496 (B)	**08-1375**	**<100**	**313**	**<100**	**38000**	**281**	**<100**	**77800**		
08-SB5-7-2505	**08-1372**	**<100**	**316**	**<100**	**29,550**	**<100**	**<100**	**62,200**		
08-SB5-9-2516	**08-1373**	**<100**	**325**	**<100**	**34,850**	**194**	**<100**	**71,700**		
08-SB5-8-2487	**08-1374**	**<100**	**338**	**<100**	**31,250**	**153**	**<100**	**67,400**		
08-SB5-10-2496	**08-1375**	**<100**	**312**	**<100**	**38,100**	**282**	**<100**	**77,700**		
		Weight % Solids Calculations								
		Empty	Crucible Wt +	Crucible Wt +				**Insoluble**	Cruc Wt+	Wt %
Sample		Crucible wt	Wet Sample	Dry wt	**Total Solids**	Wet Wt	Dry Wt	**Solids**	Calcined	Calcined
08-SB5-7-2505 (A)	**08-1372**	43.7363	49.5856	45.2355	**25.6%**	5.8493	1.499	**10.8%**	44.6329	**15.3%**
08-SB5-7-2505 (B)	**08-1372**	43.0288	48.9617	44.5508	**25.7%**	5.9329	1.522	**11.1%**	43.9384	**15.3%**
					25.642%			**10.922%**		**15.330%**
08-SB5-9-2516 (A)	**08-1373**	42.3517	48.2841	43.7763	**24.0%**	5.9324	1.425	**10.9%**	43.1637	**13.7%**
08-SB5-9-2516 (B)	**08-1373**	43.8465	49.7728	45.2689	**24.0%**	5.9263	1.422	**10.2%**	44.6554	**13.6%**
					24.008%			**10.579%**		**13.668%**
08-SB5-8-2487 (A)	**08-1374**	43.9078	49.6660	45.2862	**23.9%**	5.7582	1.378	**10.0%**	44.7059	**13.9%**
08-SB5-8-2487 (B)	**08-1374**	43.9281	49.8130	45.3393	**24.0%**	5.8849	1.411	**9.68%**	44.7433	**13.9%**
					23.959%			**9.865%**		**13.856%**
08-SB5-10-2496 (A)	**08-1375**	43.2751	49.2118	44.7019	**24.0%**	5.9367	1.427	**10.8%**	44.0550	**13.1%**
08-SB5-10-2496 (B)	**08-1375**	42.1893	48.1201	43.6308	**24.3%**	5.9308	1.442	**11.1%**	42.9754	**13.3%**
					24.169%			**10.912%**		**13.196%**
		Empty	Crucible Wt +	Crucible Wt +		**Soluble**				
Sample		Crucible wt	Wet Sample	Dry wt	Uncorr	**Solids**		**pH**	**Density**	
08-SB5-7-2505 (A)	**08-1372**	42.3872	43.4910	42.5712	16.67%	**14.9%**		**8.12**	**1.181**	
08-SB5-7-2505 (B)	**08-1372**	44.1676	45.2861	44.3508	16.38%	**14.6%**				
08-SB5-9-2516 (A)	**08-1373**	42.0052	43.1176	42.1686	14.69%	**13.1%**		**5.06**	**1.179**	
08-SB5-9-2516 (B)	**08-1373**	44.0245	45.1468	44.1967	15.34%	**13.8%**				
08-SB5-8-2487 (A)	**08-1374**	43.6629	44.7864	43.8364	15.44%	**13.9%**		**5.57**	**1.176**	
08-SB5-8-2487 (B)	**08-1374**	43.2445	44.3747	43.4234	15.83%	**14.3%**				
08-SB5-10-2496 (A)	**08-1375**	44.9318	46.0514	45.0984	14.88%	**13.3%**		**4.87**	**1.181**	
08-SB5-10-2496 (B)	**08-1375**	45.1006	46.2214	45.2674	14.88%	**13.2%**				

Appendix A-2: SRAT Product Sample Results

SRNL Process Science Analytical Laboratory
Customer: Dan Lambert
Date: 8/1/08
Sample ID: SRAT Prod - 08-SB5-11-2534, 12-2545, 13-2557, 14-2568
Lab ID: 08-1526-1529
Units: wt%, mg/Kg, mg/L

Sample ID	Lab ID									
elemental wt%-calcined 1100C		**Al**	**B**	**Ba**	**Ca**	**Cr**	**Cu**	**Fe**	**K**	**Li**
08-SB5-11-2534 (A)	08-1526	12.2	<0.100	0.016	2.28	0.019	0.011	20.4	0.180	<0.100
08-SB5-11-2534 (B)	08-1526	12.2	<0.100	0.015	2.09	0.019	0.010	20.9	0.182	<0.100
08-SB5-12-2545 (A)	08-1527	12.4	<0.100	0.016	2.05	0.020	0.012	21.1	0.159	<0.100
08-SB5-12-2545 (B)	08-1527	12.3	<0.100	0.015	2.07	0.020	0.012	21.1	0.163	<0.100
08-SB5-13-2557 (A)	08-1528	12.2	<0.100	0.016	2.14	0.020	0.007	20.0	0.151	<0.100
08-SB5-13-2557 (B)	08-1528	12.4	<0.100	0.015	2.12	0.019	0.008	20.3	0.162	<0.100
08-SB5-14-2568 (A)	08-1529	12.1	<0.100	0.016	2.02	0.019	0.010	20.1	0.239	<0.100
08-SB5-14-2568 (B)	08-1529	12.0	<0.100	0.015	2.00	0.018	0.014	20.4	0.242	<0.100
08-SB5-15-2584 (A)	08-1671	10.9	<0.100	0.037	2.14	0.032	0.013	17.5	0.154	<0.100
08-SB5-15-2584 (B)	08-1671	11.0	<0.100	0.037	2.21	0.032	0.013	17.5	0.159	<0.100
oxide wt% - calcined 1100C		Al2O3	B2O3	BaO	CaO	Cr2O3	CuO	Fe2O3	K2O	Li2O
08-SB5-11-2534 (A)	08-1526	23.0	0.0	0.017	3.19	0.028	0.014	29.2	0.216	0.000
08-SB5-11-2534 (B)	08-1526	23.0	0.0	0.017	2.93	0.027	0.013	29.8	0.219	0.000
08-SB5-12-2545 (A)	08-1527	23.5	0.0	0.018	2.87	0.029	0.015	30.1	0.191	0.000
08-SB5-12-2545 (B)	08-1527	23.3	0.0	0.017	2.89	0.029	0.014	30.2	0.195	0.000
08-SB5-13-2557 (A)	08-1528	23.1	0.0	0.018	3.00	0.029	0.009	28.6	0.182	0.000
08-SB5-13-2557 (B)	08-1528	23.4	0.0	0.017	2.97	0.028	0.010	29.0	0.194	0.000
08-SB5-14-2568 (A)	08-1529	22.9	0.0	0.017	2.82	0.028	0.012	28.8	0.287	0.000
08-SB5-14-2568 (B)	08-1529	22.7	0.0	0.016	2.80	0.027	0.017	29.2	0.290	0.000
08-SB5-15-2584 (A)	08-1671	20.6	0.00	0.041	3.00	0.047	0.016	25.0	0.185	0.000
08-SB5-15-2584 (B)	08-1671	20.8	0.00	0.041	3.10	0.047	0.016	25.0	0.191	0.000
elemental wt%-calcined 1100C		**Mg**	**Mn**	**Na**	**Ni**	**P**				
08-SB5-11-2534 (A)	08-1526	0.948	4.80	18.2	2.24	0.111				
08-SB5-11-2534 (B)	08-1526	0.936	4.87	18.2	2.49	0.118				
08-SB5-12-2545 (A)	08-1527	0.978	4.87	18.4	2.52	0.121				
08-SB5-12-2545 (B)	08-1527	0.950	4.92	18.1	2.29	0.119				
08-SB5-13-2557 (A)	08-1528	0.973	4.82	17.7	2.45	0.118				
08-SB5-13-2557 (B)	08-1528	0.949	4.92	18.0	2.55	0.116				
08-SB5-14-2568 (A)	08-1529	0.941	5.37	17.2	2.65	0.114				
08-SB5-14-2568 (B)	08-1529	0.922	5.56	17.2	2.65	0.115				
08-SB5-15-2584 (A)	08-1671	0.833	3.95	20.5	1.97	<0.010				
08-SB5-15-2584 (B)	08-1671	0.817	3.99	20.4	1.97	<0.010				
oxide wt% - calcined 1100C		MgO	MnO2	Na2O	NiO	P2O5				
08-SB5-11-2534 (A)	08-1526	1.57	7.59	24.5	2.84	0.255				
08-SB5-11-2534 (B)	08-1526	1.55	7.69	24.5	3.16	0.269				
08-SB5-12-2545 (A)	08-1527	1.62	7.69	24.8	3.20	0.276				
08-SB5-12-2545 (B)	08-1527	1.58	7.77	24.5	2.91	0.273				
08-SB5-13-2557 (A)	08-1528	1.62	7.62	23.9	3.11	0.270				
08-SB5-13-2557 (B)	08-1528	1.58	7.77	24.3	3.24	0.266				
08-SB5-14-2568 (A)	08-1529	1.56	8.48	23.3	3.37	0.261				
08-SB5-14-2568 (B)	08-1529	1.53	8.79	23.2	3.37	0.263				
08-SB5-15-2584 (A)	08-1671	1.39	6.24	27.7	2.51	0.000				
08-SB5-15-2584 (B)	08-1671	1.41	6.30	27.5	2.50	0.000				

elemental wt%-calcined 1100C		**S**	**Si**	**Sn**	**Sr**	**Ti**	**Zn**	**Zr**		
08-SB5-11-2534 (A)	**08-1526**	**0.176**	**1.33**	**0.017**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-11-2534 (B)	**08-1526**	**0.180**	**1.24**	**0.015**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-12-2545 (A)	**08-1527**	**0.178**	**1.25**	**0.016**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-12-2545 (B)	**08-1527**	**0.179**	**1.25**	**0.017**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-13-2557 (A)	**08-1528**	**0.178**	**1.24**	**0.018**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-13-2557 (B)	**08-1528**	**0.177**	**1.23**	**0.016**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-14-2568 (A)	**08-1529**	**0.179**	**1.35**	**0.023**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-14-2568 (B)	**08-1529**	**0.178**	**1.30**	**0.020**	**<0.010**	**<0.010**	**<0.010**	**<0.010**		
08-SB5-15-2584 (A)	**08-1671**	**0.337**	**1.16**			**3.64**	**0.043**	**0.062**		
08-SB5-15-2584 (B)	**08-1671**	**0.342**	**1.15**			**3.73**	**0.033**	**0.066**		

oxide wt% - calcined 1100C		SO4	SiO2	SnO2	SrO	TiO2	ZnO	ZrO2	um of Oxides	
08-SB5-11-2534 (A)	**08-1526**	0.528	2.84	0.021	0.00	0.00	0.00	0.00	95.9	
08-SB5-11-2534 (B)	**08-1526**	0.539	2.66	0.019	0.00	0.00	0.00	0.00	96.5	
08-SB5-12-2545 (A)	**08-1527**	0.533	2.68	0.020	0.00	0.00	0.00	0.00	97.6	
08-SB5-12-2545 (B)	**08-1527**	0.536	2.67	0.021	0.00	0.00	0.00	0.00	96.9	
08-SB5-13-2557 (A)	**08-1528**	0.535	2.66	0.022	0.00	0.00	0.00	0.00	94.7	
08-SB5-13-2557 (B)	**08-1528**	0.530	2.64	0.020	0.00	0.00	0.00	0.00	96.0	
08-SB5-14-2568 (A)	**08-1529**	0.537	2.89	0.029	0.00	0.00	0.00	0.00	95.2	
08-SB5-14-2568 (B)	**08-1529**	0.535	2.78	0.026	0.00	0.00	0.00	0.00	95.6	
08-SB5-15-2584 (A)	**08-1671**	1.01	2.47			6.09	0.053	0.084	96.4	
08-SB5-15-2584 (B)	**08-1671**	1.02	2.46			6.23	0.041	0.089	96.7	

anions (mg/Kg)		**F**	**Cl**	**NO2**	**NO3**	**SO4**	**PO4**	**HCO2**	**C2O4**	
08-SB5-11-2534 (A)	**08-1526**	**<100**	**357**	**<100**	**20900**	**<100**	**<100**	**62900**		
08-SB5-11-2534 (B)	**08-1526**	**<100**	**355**	**<100**	**20300**	**<100**	**<100**	**61600**		
08-SB5-12-2545 (A)	**08-1527**	**<100**	**327**	**<100**	**23600**	**<100**	**<100**	**58400**		
08-SB5-12-2545 (B)	**08-1527**	**<100**	**330**	**<100**	**23600**	**<100**	**<100**	**58000**		
08-SB5-13-2557 (A)	**08-1528**	**<100**	**331**	**<100**	**26700**	**<100**	**<100**	**62800**		
08-SB5-13-2557 (B)	**08-1528**	**<100**	**333**	**<100**	**25600**	**108**	**<100**	**60600**		
08-SB5-14-2568 (A)	**08-1529**	**<100**	**342**	**<100**	**28400**	**186**	**<100**	**73900**		
08-SB5-14-2568 (B)	**08-1529**	**<100**	**341**	**<100**	**28800**	**184**	**<100**	**74900**		
08-SB5-15-2584 (A)	**08-1671**		**352**	**<100**	**27900**	**2040**		**57200**	**1930**	
08-SB5-15-2584 (B)	**08-1671**		**348**	**<100**	**28000**	**2150**		**57200**	**1850**	

Weight % Solids Calculations

Sample		Empty Crucible wt	Crucible Wt + Wet Sample	Crucible Wt + Dry wt	**Total Solids**	Wet Wt	Dry Wt	**Insoluble Solids**	Cruc Wt+ Calcined	Wt % Calcined
08-SB5-11-2534 (A)	**08-1526**	43.6795	49.2695	45.1832	**26.90%**	5.5900	1.504	**13.6%**	44.6093	**16.6%**
08-SB5-11-2534 (B)	**08-1526**	43.7421	49.2371	45.2256	**27.00%**	5.4950	1.484	**14.1%**	44.6605	**16.7%**
08-SB5-12-2545 (A)	**08-1527**	44.8901	50.497	46.3169	**25.45%**	5.6069	1.427	**12.2%**	45.7587	**15.5%**
08-SB5-12-2545 (B)	**08-1527**	43.0164	48.6843	44.4676	**25.60%**	5.6679	1.451	**12.4%**	43.902	**15.6%**
08-SB5-13-2557 (A)	**08-1528**	42.3529	48.1796	43.8481	**25.66%**	5.8267	1.495	**13.4%**	43.2379	**15.2%**
08-SB5-13-2557 (B)	**08-1528**	43.2346	48.9672	44.7072	**25.69%**	5.7326	1.473	**13.5%**	44.1066	**15.2%**
08-SB5-14-2568 (A)	**08-1529**	42.1907	48.0666	43.7541	**26.61%**	5.8759	1.563	**14.6%**	43.0870	**15.3%**
08-SB5-14-2568 (B)	**08-1529**	43.0300	48.995	44.6408	**27.00%**	5.9650	1.611	**15.1%**	43.9514	**15.4%**
08-SB5-15-2584 (A)	**08-1671**	43.2270	48.7308	44.5758	**24.51%**	5.5038	1.349	**11.4%**	44.0509	**15.0%**
08-SB5-15-2584 (B)	**08-1671**	44.0044	49.3758	45.3148	**24.40%**	5.3714	1.310	**11.7%**	44.8008	**14.8%**
Sample		Empty Crucible wt	Crucible Wt + Wet Sample	Crucible Wt + Dry wt	Uncorr	**Soluble Solids**		**pH**	**Density**	
08-SB5-11-2534 (A)	**08-1526**	42.5148	44.7414	42.8579	15.41%	**13.3%**		**4.22**	**1.204**	
08-SB5-11-2534 (B)	**08-1526**	44.0144	46.2463	44.3494	15.01%	**12.9%**				
08-SB5-12-2545 (A)	**08-1527**	42.5167	44.7437	42.8536	15.13%	**13.3%**		**4.12**	**1.195**	
08-SB5-12-2545 (B)	**08-1527**	45.1075	47.3019	45.4381	15.07%	**13.2%**				
08-SB5-13-2557 (A)	**08-1528**	44.5483	46.7650	44.8615	14.13%	**12.2%**		**4.04**	**1.193**	
08-SB5-13-2557 (B)	**08-1528**	43.2708	45.5011	43.5849	14.08%	**12.2%**				
08-SB5-14-2568 (A)	**08-1529**	42.3673	44.5880	42.6804	14.10%	**12.0%**		**4.11**	**1.192**	
08-SB5-14-2568 (B)	**08-1529**	40.4674	42.6912	40.7788	14.00%	**11.9%**				
08-SB5-15-2584 (A)	**08-1671**	42.5073	43.6253	42.6729	14.81%	**13.13%**		**5.38**	**1.173**	
08-SB5-15-2584 (B)	**08-1671**	40.4369	41.5548	40.5980	14.41%	**12.73%**				

Appendix A-3: SME Product Sample Results

SRNL Process Science Analytical Laboratory
Customer: Dan Lambert
Date: 8/1/08
Sample ID: SME Prod - 08-SB5-7-2514, 9-2525, 8-2529, 10-2530
Lab ID: 08-1376-1379
Units: wt%, mg/Kg, mg/L

Sample ID	Lab ID									
elemental wt%-calcined 1100C		**Al**	**B**	**Ba**	**Ca**	**Cr**	**Cu**	**Fe**	**K**	**Li**
08-SB5-7-2514 (A)	**08-1376**	**4.39**	**1.25**	**0.011**	**0.580**	**0.020**	**0.025**	**6.94**	**0.077**	**2.20**
08-SB5-7-2514 (B)	**08-1376**	**4.33**	**1.27**	**0.011**	**0.592**	**0.020**	**0.025**	**6.77**	**0.078**	**2.24**
08-SB5-9-2525 (A)	**08-1377**	**4.29**	**1.42**	**0.011**	**0.556**	**0.020**	**<0.010**	**6.78**	**0.098**	**2.23**
08-SB5-9-2525 (B)	**08-1377**	**4.26**	**1.40**	**0.011**	**0.561**	**0.019**	**<0.010**	**6.85**	**0.096**	**2.24**
08-SB5-8-2529 (A)	**08-1378**	**4.30**	**1.33**	**0.011**	**0.592**	**0.020**	**0.017**	**6.96**	**0.100**	**2.21**
08-SB5-8-2529 (B)	**08-1378**	**4.23**	**1.33**	**0.011**	**0.586**	**0.019**	**0.017**	**6.89**	**0.099**	**2.25**
08-SB5-10-2530 (A)	**08-1379**	**4.22**	**1.30**	**0.011**	**0.605**	**0.020**	**0.020**	**6.67**	**0.098**	**2.16**
08-SB5-10-2530 (B)	**08-1379**	**4.31**	**1.29**	**0.011**	**0.609**	**0.020**	**0.022**	**6.69**	**0.094**	**2.20**
oxide wt% - calcined 1100C		Al2O3	B2O3	BaO	CaO	Cr2O3	CuO	Fe2O3	K2O	Li2O
08-SB5-7-2514 (A)	**08-1376**	8.30	4.03	0.012	0.812	0.029	0.032	9.93	0.093	4.73
08-SB5-7-2514 (B)	**08-1376**	8.18	4.09	0.013	0.829	0.029	0.031	9.67	0.094	4.81
08-SB5-9-2525 (A)	**08-1377**	8.10	4.57	0.012	0.778	0.029	0.000	9.70	0.117	4.79
08-SB5-9-2525 (B)	**08-1377**	8.05	4.52	0.012	0.785	0.028	0.000	9.79	0.115	4.81
08-SB5-8-2529 (A)	**08-1378**	8.12	4.28	0.012	0.829	0.029	0.021	9.96	0.120	4.75
08-SB5-8-2529 (B)	**08-1378**	8.00	4.29	0.012	0.820	0.028	0.021	9.86	0.119	4.84
08-SB5-10-2530 (A)	**08-1379**	7.98	4.18	0.013	0.847	0.029	0.025	9.54	0.117	4.65
08-SB5-10-2530 (B)	**08-1379**	8.14	4.16	0.012	0.853	0.029	0.027	9.57	0.113	4.72
elemental wt%-calcined 1100C		**Mg**	**Mn**	**Na**	**Ni**	**P**	**Pb**	**Pd**	**Rh**	**Ru**
08-SB5-7-2514 (A)	**08-1376**	**0.350**	**1.63**	**12.1**	**0.801**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**0.010**
08-SB5-7-2514 (B)	**08-1376**	**0.346**	**1.60**	**12.0**	**0.794**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**0.013**
08-SB5-9-2525 (A)	**08-1377**	**0.334**	**1.60**	**11.8**	**0.775**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**<0.010**
08-SB5-9-2525 (B)	**08-1377**	**0.335**	**1.62**	**11.8**	**0.772**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**<0.010**
08-SB5-8-2529 (A)	**08-1378**	**0.350**	**1.62**	**11.8**	**0.792**	**<0.100**	**0.015**	**<0.100**	**<0.100**	**<0.010**
08-SB5-8-2529 (B)	**08-1378**	**0.346**	**1.60**	**11.6**	**0.784**	**<0.100**	**0.014**	**<0.100**	**<0.100**	**<0.010**
08-SB5-10-2530 (A)	**08-1379**	**0.342**	**1.55**	**11.8**	**0.784**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**0.013**
08-SB5-10-2530 (B)	**08-1379**	**0.337**	**1.55**	**12.0**	**0.773**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	**0.015**
oxide wt% - calcined 1100C		MgO	MnO2	Na2O	NiO	P2O5	PbO	PdO	RhO2	RuO2
08-SB5-7-2514 (A)	**08-1376**	0.581	2.57	16.4	1.02	0.000	0.000	0.000	0.000	0.014
08-SB5-7-2514 (B)	**08-1376**	0.574	2.52	16.3	1.01	0.000	0.000	0.000	0.000	0.017
08-SB5-9-2525 (A)	**08-1377**	0.554	2.52	15.9	0.984	0.000	0.000	0.000	0.000	0.000
08-SB5-9-2525 (B)	**08-1377**	0.555	2.55	15.9	0.980	0.000	0.000	0.000	0.000	0.000
08-SB5-8-2529 (A)	**08-1378**	0.581	2.57	15.9	1.01	0.000	0.016	0.000	0.000	0.000
08-SB5-8-2529 (B)	**08-1378**	0.574	2.53	15.7	1.00	0.000	0.016	0.000	0.000	0.000
08-SB5-10-2530 (A)	**08-1379**	0.568	2.45	16.0	1.00	0.000	0.000	0.000	0.000	0.017
08-SB5-10-2530 (B)	**08-1379**	0.560	2.45	16.2	0.982	0.000	0.000	0.000	0.000	0.020
elemental wt%-calcined 1100C		**S**	**Si**	**Sn**	**Sr**	**Ti**	**Zn**	**Zr**		
08-SB5-7-2514 (A)	**08-1376**	**0.063**	**24.1**	**<0.010**	**<0.010**	**0.039**	**0.010**	**0.091**		
08-SB5-7-2514 (B)	**08-1376**	**0.063**	**24.2**	**<0.010**	**<0.010**	**0.039**	**0.010**	**0.091**		
08-SB5-9-2525 (A)	**08-1377**	**0.053**	**24.7**	**<0.010**	**<0.010**	**0.041**	**0.020**	**0.093**		
08-SB5-9-2525 (B)	**08-1377**	**0.055**	**25.0**	**<0.010**	**<0.010**	**0.041**	**0.026**	**0.095**		
08-SB5-8-2529 (A)	**08-1378**	**0.056**	**24.4**	**<0.010**	**<0.010**	**0.039**	**0.009**	**0.093**		
08-SB5-8-2529 (B)	**08-1378**	**0.059**	**24.8**	**<0.010**	**<0.010**	**0.038**	**0.012**	**0.091**		
08-SB5-10-2530 (A)	**08-1379**	**0.061**	**23.9**	**<0.010**	**<0.010**	**0.041**	**0.012**	**0.111**		
08-SB5-10-2530 (B)	**08-1379**	**0.059**	**24.1**	**<0.010**	**<0.010**	**0.040**	**0.015**	**0.117**		
oxide wt% - calcined 1100C		SO4	SiO2	SnO2	SrO	TiO2	ZnO	ZrO2	Totals	
08-SB5-7-2514 (A)	**08-1376**	0.190	51.5	0.00	0.00	0.066	0.013	0.123	100	
08-SB5-7-2514 (B)	**08-1376**	0.188	51.7	0.00	0.00	0.066	0.012	0.123	100	
08-SB5-9-2525 (A)	**08-1377**	0.158	52.9	0.00	0.00	0.068	0.025	0.125	101	
08-SB5-9-2525 (B)	**08-1377**	0.165	53.4	0.00	0.00	0.068	0.032	0.128	102	
08-SB5-8-2529 (A)	**08-1378**	0.167	52.1	0.00	0.00	0.064	0.011	0.126	101	
08-SB5-8-2529 (B)	**08-1378**	0.176	53.2	0.00	0.00	0.064	0.015	0.123	101	
08-SB5-10-2530 (A)	**08-1379**	0.184	51.2	0.00	0.00	0.068	0.015	0.150	99	
08-SB5-10-2530 (B)	**08-1379**	0.177	51.5	0.00	0.00	0.067	0.019	0.157	100	

anions (mg/Kg)		**F**	**Cl**	**NO2**	**NO3**	**SO4**	**PO4**	**HCO2**		
08-SB5-7-2514 (A)	**08-1376**	**<100**	**297**	**<100**	**17100**	**<100**	**<100**	**51100**		
08-SB5-7-2514 (B)	**08-1376**	**<100**	**296**	**<100**	**17800**	**<100**	**<100**	**51500**		
08-SB5-9-2525 (A)	**08-1377**	**<100**	**279**	**<100**	**18900**	**<100**	**<100**	**49300**		
08-SB5-9-2525 (B)	**08-1377**	**<100**	**283**	**<100**	**19300**	**<100**	**<100**	**50300**		
08-SB5-8-2529 (A)	**08-1378**	**<100**	**280**	**<100**	**21700**	**150**	**<100**	**54600**		
08-SB5-8-2529 (B)	**08-1378**	**<100**	**279**	**<100**	**21800**	**143**	**<100**	**55100**		
08-SB5-10-2530 (A)	**08-1379**	**<100**	**310**	**<100**	**25400**	**214**	**<100**	**62900**		
08-SB5-10-2530 (B)	**08-1379**	**<100**	**308**	**<100**	**24600**	**213**	**<100**	**62000**		
		Weight % Solids Calculations								
		Empty	Crucible Wt +	Crucible Wt +				**Insoluble**	Cruc Wt+	Wt %
Sample		Crucible wt	Wet Sample	Dry wt	**Total Solids**	Wet Wt	Dry Wt	**Solids**	Calcined	Calcined
08-SB5-7-2514 (A)	**08-1376**	44.6011	49.9916	47.1140	**46.6%**	5.3905	2.513	**33.2%**	46.6451	**37.9%**
08-SB5-7-2514 (B)	**08-1376**	43.6724	47.979	45.6808	**46.6%**	4.3066	2.008	**32.6%**	45.3038	**37.9%**
08-SB5-9-2525 (A)	**08-1377**	43.8488	50.4433	46.8182	**45.0%**	6.5945	2.969	**32.5%**	46.1950	**35.6%**
08-SB5-9-2525 (B)	**08-1377**	43.3192	50.0942	46.3600	**44.9%**	6.7750	3.041	**32.7%**	45.7197	**35.4%**
08-SB5-8-2529 (A)	**08-1378**	44.4342	50.7762	47.2625	**44.6%**	6.3420	2.828	**32.0%**	46.6985	**35.7%**
08-SB5-8-2529 (B)	**08-1378**	42.9239	49.2524	45.7335	**44.4%**	6.3285	2.810	**32.4%**	45.1674	**35.5%**
08-SB5-10-2530 (A)	**08-1379**	42.8934	49.4247	45.8113	**44.7%**	6.5313	2.918	**31.9%**	45.1812	**35.0%**
08-SB5-10-2530 (B)	**08-1379**	42.2957	48.9031	45.2367	**44.5%**	6.6074	2.941	**32.4%**	44.5975	**34.8%**
		Empty	Crucible Wt +	Crucible Wt +		**Soluble**				
Sample		Crucible wt	Wet Sample	Dry wt	Uncorr	**Solids**		**pH**	**Density**	**Waste Loadi**
08-SB5-7-2514 (A)	**08-1376**	43.2649	44.4064	43.4945	20.11%	**13.4%**		**8.26**	**1.344**	**35.7%**
08-SB5-7-2514 (B)	**08-1376**	44.0107	45.1540	44.2488	20.83%	**14.0%**				
08-SB5-9-2525 (A)	**08-1377**	44.5394	45.6843	44.7524	18.60%	**12.6%**		**5.71**	**1.341**	**35.3%**
08-SB5-9-2525 (B)	**08-1377**	44.5039	45.6820	44.7175	18.13%	**12.2%**				
08-SB5-8-2529 (A)	**08-1378**	44.3061	45.4411	44.5165	18.54%	**12.6%**		**7.22**	**1.340**	**35.3%**
08-SB5-8-2529 (B)	**08-1378**	42.9303	44.0851	43.1358	17.80%	**12.0%**				
08-SB5-10-2530 (A)	**08-1379**	40.4607	41.5974	40.6740	18.76%	**12.8%**		**5.46**	**1.351**	**36.9%**
08-SB5-10-2530 (B)	**08-1379**	42.9057	44.0469	43.1106	17.95%	**12.1%**				

Appendix A-3: SME Product Sample Results

SRNL Process Science Analytical Laboratory
Customer: Dan Lambert
Date: 8/1/08
Sample ID: SME Prod - 08-SB5-11-2542, 12-2553, 13-2565, 14-2576
Lab ID: 08-1530-1533
Units: wt%, mg/Kg, mg/L

Sample ID	Lab ID									
elemental wt%-calcined 1100C		**Al**	**B**	**Ba**	**Ca**	**Cr**	**Cu**	**Fe**	**K**	**Li**
08-SB5-11-2542 (A)	**08-1530**	**4.59**	**1.23**	**0.011**	**0.626**	**0.016**	**<0.010**	**7.24**	**0.122**	**2.13**
08-SB5-11-2542 (B)	**08-1530**	**4.59**	**1.28**	**0.011**	**0.656**	**0.016**	**<0.010**	**7.32**	**0.117**	**2.19**
08-SB5-12-2553 (A)	**08-1531**	**4.61**	**1.29**	**0.011**	**0.624**	**0.016**	**<0.010**	**7.35**	**0.106**	**2.25**
08-SB5-12-2553 (B)	**08-1531**	**4.57**	**1.32**	**0.010**	**0.621**	**0.015**	**<0.010**	**7.32**	**0.105**	**2.22**
08-SB5-13-2565 (A)	**08-1532**	**4.70**	**1.28**	**0.011**	**0.614**	**0.017**	**<0.010**	**7.52**	**0.116**	**2.21**
08-SB5-13-2565 (B)	**08-1532**	**4.66**	**1.25**	**0.011**	**0.621**	**0.017**	**<0.010**	**7.49**	**0.118**	**2.13**
08-SB5-14-2576 (A)	**08-1533**	**4.48**	**1.28**	**0.011**	**0.637**	**0.016**	**<0.010**	**7.23**	**0.144**	**2.22**
08-SB5-14-2576 (B)	**08-1533**	**4.53**	**1.28**	**0.010**	**0.630**	**0.016**	**<0.010**	**7.17**	**0.155**	**2.18**
08-SB5-15-2590 (A)	**08-1672**	**3.82**	**1.39**	**0.012**	**0.560**	**0.019**	**0.017**	**5.64**	**0.088**	**2.10**
08-SB5-15-2590 (B)	**08-1672**	**3.87**	**1.40**	**0.013**	**0.587**	**0.020**	**0.020**	**5.96**	**0.092**	**2.10**
oxide wt% - calcined 1100C		Al2O3	B2O3	BaO	CaO	Cr2O3	CuO	Fe2O3	K2O	Li2O
08-SB5-11-2542 (A)	**08-1530**	8.67	3.95	0.012	0.877	0.023	0.00	10.4	0.146	4.58
08-SB5-11-2542 (B)	**08-1530**	8.68	4.11	0.013	0.918	0.024	0.00	10.5	0.140	4.71
08-SB5-12-2553 (A)	**08-1531**	8.71	4.16	0.012	0.874	0.024	0.00	10.5	0.127	4.83
08-SB5-12-2553 (B)	**08-1531**	8.64	4.26	0.012	0.870	0.023	0.00	10.5	0.126	4.77
08-SB5-13-2565 (A)	**08-1532**	8.89	4.14	0.013	0.859	0.025	0.00	10.8	0.139	4.76
08-SB5-13-2565 (B)	**08-1532**	8.81	4.02	0.012	0.869	0.025	0.00	10.7	0.141	4.57
08-SB5-14-2576 (A)	**08-1533**	8.47	4.11	0.012	0.891	0.024	0.00	10.3	0.172	4.76
08-SB5-14-2576 (B)	**08-1533**	8.57	4.12	0.012	0.882	0.023	0.00	10.2	0.186	4.69
08-SB5-15-2590 (A)	**08-1672**	7.21	4.47	0.014	0.785	0.027	0.021	8.07	0.106	4.51
08-SB5-15-2590 (B)	**08-1672**	7.32	4.50	0.015	0.821	0.029	0.025	8.52	0.111	4.52
elemental wt%-calcined 1100C		**Mg**	**Mn**	**Na**	**Ni**	**P**	**Pb**	**Pd**	**Rh**	
08-SB5-11-2542 (A)	**08-1530**	**0.359**	**1.68**	**10.2**	**0.821**	**<0.100**	**0.013**	**<0.100**	**<0.100**	
08-SB5-11-2542 (B)	**08-1530**	**0.377**	**1.70**	**10.1**	**0.878**	**<0.100**	**0.013**	**<0.100**	**<0.100**	
08-SB5-12-2553 (A)	**08-1531**	**0.371**	**1.66**	**10.2**	**0.885**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	
08-SB5-12-2553 (B)	**08-1531**	**0.365**	**1.66**	**10.1**	**0.868**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	
08-SB5-13-2565 (A)	**08-1532**	**0.370**	**1.77**	**10.3**	**0.892**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	
08-SB5-13-2565 (B)	**08-1532**	**0.369**	**1.75**	**10.0**	**0.894**	**<0.100**	**<0.010**	**<0.100**	**<0.100**	
08-SB5-14-2576 (A)	**08-1533**	**0.364**	**1.65**	**10.0**	**0.846**	**<0.100**	**0.054**	**<0.100**	**<0.100**	
08-SB5-14-2576 (B)	**08-1533**	**0.350**	**1.64**	**10.1**	**0.808**	**<0.100**	**0.050**	**<0.100**	**<0.100**	
08-SB5-15-2590 (A)	**08-1672**	**0.964**	**1.18**	**9.84**	**0.557**	**<0.010**	**<0.010**	**<0.100**	**<0.100**	
08-SB5-15-2590 (B)	**08-1672**	**1.02**	**1.25**	**9.85**	**0.594**	**<0.010**	**<0.010**	**<0.100**	**<0.100**	
oxide wt% - calcined 1100C		MgO	MnO2	Na2O	NiO	P2O5	PbO	PdO	RhO2	
08-SB5-11-2542 (A)	**08-1530**	0.596	2.65	13.7	1.04	0.000	0.014	0.000	0.000	
08-SB5-11-2542 (B)	**08-1530**	0.626	2.68	13.6	1.11	0.000	0.014	0.000	0.000	
08-SB5-12-2553 (A)	**08-1531**	0.616	2.62	13.7	1.12	0.000	0.000	0.000	0.000	
08-SB5-12-2553 (B)	**08-1531**	0.606	2.62	13.6	1.10	0.000	0.000	0.000	0.000	
08-SB5-13-2565 (A)	**08-1532**	0.614	2.79	13.9	1.13	0.000	0.000	0.000	0.000	
08-SB5-13-2565 (B)	**08-1532**	0.613	2.76	13.5	1.13	0.000	0.000	0.000	0.000	
08-SB5-14-2576 (A)	**08-1533**	0.604	2.61	13.4	1.07	0.000	0.059	0.000	0.000	
08-SB5-14-2576 (B)	**08-1533**	0.581	2.59	13.6	1.03	0.000	0.055	0.000	0.000	
08-SB5-15-2590 (A)	**08-1672**	1.60	1.86	13.3	0.708	0.000	0.000	0.000	0.000	
08-SB5-15-2590 (B)	**08-1672**	1.69	1.98	13.3	0.754	0.000	0.000	0.000	0.000	

elemental wt%-calcined 1100C		Ru	S	Si	Sn	Sr	Ti	Zn	Zr	
08-SB5-11-2542 (A)	08-1530	<0.010	0.073	23.6	<0.010	<0.010	0.017	<0.010	0.012	
08-SB5-11-2542 (B)	08-1530	<0.010	0.070	24.1	<0.010	<0.010	0.018	<0.010	0.013	
08-SB5-12-2553 (A)	08-1531	<0.010	0.070	24.6	<0.010	<0.010	0.018	<0.010	0.015	
08-SB5-12-2553 (B)	08-1531	<0.010	0.065	24.5	<0.010	<0.010	0.018	<0.010	0.014	
08-SB5-13-2565 (A)	08-1532	<0.010	0.062	24.2	<0.010	<0.010	0.018	<0.010	0.018	
08-SB5-13-2565 (B)	08-1532	<0.010	0.061	23.1	<0.010	<0.010	0.023	<0.010	0.019	
08-SB5-14-2576 (A)	08-1533	<0.010	0.066	24.1	<0.010	<0.010	0.018	<0.010	0.016	
08-SB5-14-2576 (B)	08-1533	<0.010	0.065	23.9	<0.010	<0.010	0.018	<0.010	0.017	
08-SB5-15-2590 (A)	08-1672	0.011	0.082	24.8			1.11	0.013	0.032	
08-SB5-15-2590 (B)	08-1672	0.011	0.089	25.1			1.12	0.018	0.031	

oxide wt% - calcined 1100C		RuO2	SO4	SiO2	SnO2	SrO	TiO2	ZnO	ZrO2	Sum ofOxides
08-SB5-11-2542 (A)	08-1530	0.000	0.219	50.6	0.000	0.00	0.028	0.000	0.016	92.9
08-SB5-11-2542 (B)	08-1530	0.000	0.209	51.6	0.000	0.00	0.029	0.000	0.017	94.2
08-SB5-12-2553 (A)	08-1531	0.000	0.209	52.7	0.000	0.00	0.030	0.000	0.021	95.5
08-SB5-12-2553 (B)	08-1531	0.000	0.195	52.3	0.000	0.00	0.029	0.000	0.018	94.9
08-SB5-13-2565 (A)	08-1532	0.000	0.185	51.9	0.000	0.00	0.029	0.000	0.024	95.3
08-SB5-13-2565 (B)	08-1532	0.000	0.184	49.5	0.000	0.00	0.038	0.000	0.025	92.4
08-SB5-14-2576 (A)	08-1533	0.000	0.197	51.6	0.000	0.00	0.030	0.000	0.022	93.6
08-SB5-14-2576 (B)	08-1533	0.000	0.194	51.1	0.000	0.00	0.030	0.000	0.023	93.3
08-SB5-15-2590 (A)	08-1672	0.014	0.246	53.2			1.86	0.016	0.044	98.0
08-SB5-15-2590 (B)	08-1672	0.014	0.267	53.7			1.87	0.022	0.041	99.5

anions (mg/Kg)		F	Cl	NO2	NO3	SO4	PO4	HCO2	C2O4	
08-SB5-11-2542 (A)	08-1530	<100	297	<100	17100	<100	<100	51100		
08-SB5-11-2542 (B)	08-1530	<100	296	<100	17800	<100	<100	51500		
08-SB5-12-2553 (A)	08-1531	<100	279	<100	18900	<100	<100	49300		
08-SB5-12-2553 (B)	08-1531	<100	283	<100	19300	<100	<100	50300		
08-SB5-13-2565 (A)	08-1532	<100	280	<100	21700	150	<100	54600		
08-SB5-13-2565 (B)	08-1532	<100	279	<100	21800	143	<100	55100		
08-SB5-14-2576 (A)	08-1533	<100	310	<100	25400	214	<100	62900		
08-SB5-14-2576 (B)	08-1533	<100	308	<100	24600	213	<100	62000		
08-SB5-15-2590 (A)	08-1672		293	<100	23200	2600		50300	3610	
08-SB5-15-2590 (B)	08-1672		290	<100	23100	2830		50200	3340	

Weight % Solids Calculations

Sample		Empty Crucible wt	Crucible Wt + Wet Sample	Crucible Wt + Dry wt	Total Solids	Wet Wt	Dry Wt	Insoluble Solids	Cruc Wt+ Calcined	Wt % Calcined
08-SB5-11-2542 (A)	08-1530	43.9275	49.5838	46.6204	47.6%	5.6563	2.693	36.9%	46.1519	39.3%
08-SB5-11-2542 (B)	08-1530	43.9071	49.5504	46.5987	47.7%	5.6433	2.692	37.1%	46.1337	39.5%
08-SB5-12-2553 (A)	08-1531	44.0028	50.0713	46.7724	45.6%	6.0685	2.770	34.8%	46.2697	37.4%
08-SB5-12-2553 (B)	08-1531	43.1834	49.368	46.0175	45.8%	6.1846	2.834	35.3%	45.4995	37.4%
08-SB5-13-2565 (A)	08-1532	43.4687	49.9884	46.3119	43.6%	6.5197	2.843	33.6%	45.7496	35.0%
08-SB5-13-2565 (B)	08-1532	43.7324	50.2239	46.576	43.8%	6.4915	2.844	33.8%	46.0146	35.2%
08-SB5-14-2576 (A)	08-1533	43.9942	50.7963	47.2027	47.2%	6.8021	3.209	37.0%	46.5792	38.0%
08-SB5-14-2576 (B)	08-1533	44.5008	51.2906	47.7125	47.3%	6.7898	3.212	37.1%	47.0916	38.2%
08-SB5-15-2590 (A)	08-1672	43.9943	50.5615	47.0377	46.34%	6.5672	3.043	35.47%	46.4940	38.06%
08-SB5-15-2590 (B)	08-1672	43.4679	50.1523	46.5500	46.11%	6.6844	3.082	35.28%	45.9944	37.80%

Sample		Empty Crucible wt	Crucible Wt + Wet Sample	Crucible Wt + Dry wt	Uncorr	Soluble Solids		pH	Density	Waste Loading
08-SB5-11-2542 (A)	08-1530	42.9349	45.1831	43.3155	16.93%	10.7%		6.80	1.391	37.4%
08-SB5-11-2542 (B)	08-1530	44.5089	46.7703	44.8899	16.85%	10.6%				
08-SB5-12-2553 (A)	08-1531	40.4459	42.7024	40.8218	16.66%	10.9%		6.33	1.332	35.2%
08-SB5-12-2553 (B)	08-1531	43.1671	45.4340	43.5369	16.31%	10.6%				
08-SB5-13-2565 (A)	08-1532	42.9079	45.1610	43.2486	15.12%	10.0%		4.71	1.328	37.1%
08-SB5-13-2565 (B)	08-1532	44.1714	46.4307	44.5115	15.05%	10.0%				
08-SB5-14-2576 (A)	08-1533	42.0030	44.2573	42.3669	16.14%	10.2%		4.41	1.369	36.3%
08-SB5-14-2576 (B)	08-1533	44.9357	47.1949	45.3029	16.25%	10.2%				
08-SB5-15-2590 (A)	08-1672	42.5096	43.6486	42.7015	16.85%	10.87%		4.82	1.347	39.1%
08-SB5-15-2590 (B)	08-1672	42.3659	43.5074	42.5569	16.73%	10.83%				

Appendix A-4: Condensate Sample Results

Process Science Analytical Laboratory
Customer: Dan Lambert
Date: 7/22/08
Sample ID: MWWT 08-SB5-7-2508, 9-2519, 8-2490, 10-2499
Sample ID: FAVC 08-SB5-7-2509, 9-2520, 8-2491, 10-2500
Lab ID: 08-1364-1371

MWWT anions (mg/L)

Sample Number	PSAL#	F	NO2	NO3	HCO2	SO4	PO4	Cl	pH	Density
08-SB5-7-2508 (A)	08-1364	<100	<100	181	<100	<100	<100	<100	10.1	1.02
08-SB5-7-2508 (B)	08-1364	<100	<100	183	<100	<100	<100	<100		
08-SB5-8-2490 (A)	08-1366	<100	<100	<100	440	<100	<100	<100	3.07	1.02
08-SB5-8-2490 (B)	08-1366	<100	<100	<100	445	<100	<100	<100		
08-SB5-9-2519 (A)	08-1365	<100	<100	<100	1120	<100	<100	<100	2.80	1.01
08-SB5-9-2519 (B)	08-1365	<100	<100	<100	1170	<100	<100	<100		
08-SB5-10-2499 (A)	08-1367	<100	<100	114	15900	<100	<100	<100	2.68	1.02
08-SB5-10-2499 (B)	08-1367	<100	<100	116	16200	<100	<100	<100		

FAVC anions (mg/L)

Sample Number	PSAL#	F	NO2	NO3	HCO2	SO4	PO4	Cl	pH	Density
08-SB5-7-2509 (A)	08-1368	<100	<100	152000	527	<100	<100	<100	<1.00	1.09
08-SB5-7-2509 (B)	08-1368	<100	<100	153000	518	<100	<100	<100		
08-SB5-8-2491 (A)	08-1370	<100	<100	284000	844	<100	<100	<100	2.37	1.12
08-SB5-8-2491 (B)	08-1370	<100	<100	277000	841	<100	<100	<100		
08-SB5-9-2520 (A)	08-1369	<100	<100	227000	1210	<100	<100	<100	2.41	1.11
08-SB5-9-2520 (B)	08-1369	<100	<100	231000	1220	<100	<100	<100		
08-SB5-10-2500 (A)	08-1371	<100	209	223000	1010	<100	<100	<100	2.62	1.13
08-SB5-10-2500 (B)	08-1371	<100	208	220000	1020	<100	<100	<100		

Process Science Analytical Laboratory
Customer: Dan Lambert
Date: 7/23/08
Sample ID: Dewater 08-SB5-7-2510, 9-2521, 8-2494, 10-2503
Lab ID: 08-1360-1363

Dewater anions (mg/L)

Sample Number	PSAL#	F	NO2	NO3	HCO2	SO4	PO4	Cl	pH	Density
08-SB5-7-2510 (A)	08-1360	<100	<100	1580	985	<100	<100	<100	1.94	1.01
08-SB5-7-2510 (B)	08-1360	<100	<100	1620	1040	<100	<100	<100		
08-SB5-8-2494 (A)	08-1362	<100	<100	1290	3520	<100	<100	<100	1.98	1.02
08-SB5-8-2494 (B)	08-1362	<100	<100	1310	3440	<100	<100	<100		
08-SB5-9-2521 (A)	08-1361	<100	<100	485	7020	<100	<100	<100	2.23	1.01
08-SB5-9-2521 (B)	08-1361	<100	<100	491	7090	<100	<100	<100		
08-SB5-10-2503 (A)	08-1363	<100	<100	330	9780	<100	<100	<100	2.23	1.02
08-SB5-10-2503 (B)	08-1363	<100	<100	330	9900	<100	<100	<100		

Appendix A-4: Condensate Sample Results

Process Science Analytical Laboratory										
Customer: David Koopman, Dan Lambert										
Date: 7/30/08										
Sample ID: 08-SB5-15-2587, 2588, 2589										
Lab ID: 08-1668-1670										
MWWT anions (mg/L)										
Sample Number	**PSAL#**	**F**	**NO2**	**NO3**	**HCO2**	**SO4**	**PO4**	**Cl**	**pH**	**Density**
08-SB5-11-2537	08-2040	<100	<100	9160	<100	<100	<100	<100	9.38	1.02
08-SB5-11-2537	08-2040	<100	<100	9250	<100	<100	<100	<100		
08-SB5-12-2548	08-2041	<100	<100	<100	<100	<100	<100	<100	9.16	1.02
08-SB5-12-2548	08-2041	<100	<100	<100	<100	<100	<100	<100		
08-SB5-13-2560	08-2042	<100	<100	<100	948	<100	<100	<100	2.42	1.02
08-SB5-13-2560	08-2042	<100	<100	<100	1020	<100	<100	<100		
08-SB5-14-2571	08-2043	<100	<100	<100	1450	<100	<100	<100	2.30	1.02
08-SB5-14-2571	08-2043	<100	<100	<100	1520	<100	<100	<100		
08-SB5-15-2588 (A)	08-1669	<100	<100	<100	1680	<100	775	<100	1.25	
08-SB5-15-2588 (B)	08-1669	<100	<100	<100	1660	<100	766	<100		
FAVC anions (mg/L)										
Sample Number	**PSAL#**	**F**	**NO2**	**NO3**	**HCO2**	**SO4**	**PO4**	**Cl**	**pH**	**Density**
08-SB5-11-2544	08-2044	<100	119	209000	<100	<100	<100	<100	<1.00	1.10
08-SB5-11-2544	08-2044	<100	117	210000	<100	<100	<100	<100		
08-SB5-12-2555	08-2045	<100	<100	169000	1100	<100	<100	<100	<1.00	1.09
08-SB5-12-2555	08-2045	<100	<100	169000	1060	<100	<100	<100		
08-SB5-13-2567	08-2046	<100	<100	175000	1600	<100	<100	<100	<1.00	1.10
08-SB5-13-2567	08-2046	<100	<100	176000	1610	<100	<100	<100		
08-SB5-14-2578	08-2047	<100	175	150000	179	<100	<100	<100	<1.00	1.07
08-SB5-14-2578	08-2047	<100	166	154000	176	<100	<100	<100		
08-SB5-15-2589 (A)	08-1670	<100	<100	<100	163000	<100	677	<100	2.46	
08-SB5-15-2589 (B)	08-1670	<100	<100	<100	165000	<100	636	<100		
Process Science Analytical Laboratory										
Customer: Dan Lambert										
Date: 7/23/08										
Sample ID: SRAT Dewater 08-SB5-11-2538, 12-2549, 13-2561, 14-2572										
Sample ID: SME Dewater 08-SB5-11-2540, 12-2551, 13-2563, 14-2574										
Lab ID: 08-1555-1562										
SRAT Dewater anions (mg/L)										
Sample Number	**PSAL#**	**F**	**NO2**	**NO3**	**HCO2**	**SO4**	**PO4**	**Cl**	**pH**	**Density**
08-SB5-11-2538 (A)	08-1555	<100	<100	1640	170	<100	<100	<100	1.83	1.02
08-SB5-11-2538 (B)	08-1555	<100	<100	1720	171	<100	<100	<100		
08-SB5-12-2549 (A)	08-1556	<100	<100	1400	1740	<100	<100	<100	1.92	1.03
08-SB5-12-2549 (B)	08-1556	<100	<100	1420	1770	<100	<100	<100		
08-SB5-13-2561(A)	08-1557	<100	<100	626	4510	<100	<100	<100	2.17	1.02
08-SB5-13-2561 (B)	08-1557	<100	<100	626	4600	<100	<100	<100		
08-SB5-13-2561	08-2070	<100	<100	604	3460	<100	<100	<100	1.87	1.02
08-SB5-13-2561	08-2070	<100	<100	603	3560	<100	<100	<100		
08-SB5-14-2572 (A)	08-1558	<100	<100	491	7490	<100	<100	<100	2.19	1.02
08-SB5-14-2572 (B)	08-1558	<100	<100	495	7440	<100	<100	<100		
08-SB5-15-2587 (A)	08-1668	<100	<100	<100	100	<100	783	<100		2.36
08-SB5-15-2587 (B)	08-1668	<100	<100	<100	101	<100	834	<100		
SME Dewater anions (mg/L)										
08-SB5-11-2540 (A)	08-1559	<100	<100	<100	<100	<100	<100	<100	9.26	1.01
08-SB5-11-2540 (B)	08-1559	<100	<100	<100	<100	<100	<100	<100		
08-SB5-12-2551 (A)	08-1560	<100	<100	<100	108	<100	<100	<100	4.39	1.01
08-SB5-12-2551(B)	08-1560	<100	<100	<100	102	<100	<100	<100		
08-SB5-13-2563 (A)	08-1561	<100	<100	<100	2090	<100	<100	<100	2.62	1.01
08-SB5-13-2563 (B)	08-1561	<100	<100	<100	2130	<100	<100	<100		
08-SB5-14-2574 (A)	08-1562	<100	<100	<100	3310	<100	<100	<100	2.49	1.01
08-SB5-14-2574 (B)	08-1562	<100	<100	<100	3330	<100	<100	<100		

Appendix A-5: Formate and Nitrate Balance				
Run Number	SB5-7	SB5-8	SB5-9	SB5-10
Sludge Simulant	SB5-D	SB5-D	SB5-D	SB5-D
Acid Stoichiometry	115	130	145	160
Fresh Sludge Mass, g	3,017.89	3,017.89	3,017.89	3,017.89
ARP Slurry Added, g	0.00	0.00	0.00	0.00
Fresh Sludge Nitrite, mg/kg	10388	10388	10388	10388
Fresh Sludge Nitrate, mg/kg	7114	7114	7114	7114
Nitric Added, mL	33.08	36.78	32.26	37.37
Nitric Acid Molarity	10.53	10.53	10.53	10.53
Formic Added, mL	32.87	41.51	39.76	43.14
Formic Acid Molarity	23.60	23.60	23.60	23.60
SRAT Product, g	2,377.52	2,688.70	2,645.42	2,771.29
SRAT Product Nitrite, mg/kg	62,200	64,750	71,700	72,450
SRAT Product Nitrate, mg/kg	0	0	0	0
SRAT Product Formate, mg/kg	29,550	29,750	34,850	36,200
Calculations				
SRAT Data				
Formate Added, g	197.61	226.37	249.21	272.50
Nitrate Added, g	48.55	59.29	69.44	80.08
Nitrite in Feed, g	31.35	31.35	31.35	31.35
Nitrate in Feed, g	21.73	21.73	21.73	21.73
Nitrite in SRAT product (grams)	0.00	0.00	0.00	0.00
Nitrate in SRAT product (grams)	70.26	73.99	92.19	100.32
Formate in SRAT product (grams)	147.88	161.04	189.68	200.78
SRAT Formate Destruction, g	49.73	65.32	59.54	71.72
SRAT Nitrite Destruction (grams)	31.35	31.35	31.35	31.35
Nitrite to Nitrate Conversion, g	-0.02	-7.03	1.03	-1.49
Nitrate from nitrite in SRAT product, mol	0.00	-0.11	0.02	-0.02
Moles of nitrite reacted	0.68	0.68	0.68	0.68
% nitrite conversion to nitrate	**-0.05**	**-16.63**	**2.43**	**-3.53**
SRAT Nitrite Destruction (%)	**100.00**	**100.00**	**100.00**	**100.00**
SRAT Formate Destruction (%)	**25.16**	**28.86**	**23.89**	**26.32**
SME Data				
Total SME Product, g	2,313.94	2,540.80	2,533.12	2,543.20
SME Feed formate (grams)	135.44	147.99	175.34	186.29
SME Feed nitrate (grams)	64.35	68.00	85.22	93.08
SME Formate Added, g	7.64	7.68	7.71	7.75
Nitrate in SME product (grams)	55.53	64.28	74.60	82.65
Formate in SME product (grams)	119.28	145.08	162.50	165.05
SME Formate Destruction (grams)	23.80	10.59	20.55	28.99
SME Nitrate Destruction (grams)	8.81	3.71	10.62	10.43
SME Nitrate Destruction (%)	**13.69**	**5.46**	**12.46**	**11.20**
SME Formate Destruction (%)	**16.63**	**6.80**	**11.23**	**14.94**

Appendix A-5: Formate and Nitrate Balance					
Run Number	SB5-11	SB5-12	SB5-13	SB5-14	SB5-15
Sludge Simulant	SB5-C	SB5-C	SB5-C	SB5-C	SB5-C
Acid Stoichiometry	115	130	145	160	130
Fresh Sludge Mass, g	3,500.00	3,500.00	3,500.00	3,500.00	2,450.00
ARP Slurry Added, g	0.00	0.00	0.00	0.00	971.00
Fresh Sludge Nitrite, mg/kg	6,175	6,175	6,175	6,175	6,175
Fresh Sludge Nitrate, mg/kg	3,940	3,940	3,940	3,940	3,940
Nitric Added, mL	31.02	38.84	30.49	37.70	0.00
Nitric Acid Molarity	10.53	10.53	10.53	10.53	10.53
Formic Added, mL	34.73	45.08	35.05	40.93	0.00
Formic Acid Molarity	23.60	23.60	23.60	23.60	23.60
SRAT Product, g	1,960.00	2,150.00	2,180.00	2,424.90	2,200.00
SRAT Product Nitrite, mg/kg	62,250	58,200	61,700	74,400	57,200
SRAT Product Nitrate, mg/kg	0	0	0	0	0
SRAT Product Formate, mg/kg	20,600	23,600	26,150	28,600	27,950
Calculations					
SRAT Data					
Formate Added, g	161.26	176.44	193.28	213.49	148.82
Nitrate Added, g	31.09	44.67	52.13	59.34	31.38
Nitrite in Feed, g	21.62	21.62	21.62	21.62	16.71
Nitrate in Feed, g	14.03	14.03	14.03	14.03	26.80
Nitrite in SRAT product (grams)	0.00	0.00	0.00	0.00	0.00
Nitrate in SRAT product (grams)	40.38	50.74	57.01	69.35	61.49
Formate in SRAT product (grams)	122.01	125.13	134.51	180.41	125.84
SRAT Formate Destruction, g	39.25	51.31	58.78	33.07	22.98
SRAT Nitrite Destruction (grams)	21.62	21.62	21.62	21.62	16.71
Nitrite to Nitrate Conversion, g	-4.74	-7.96	-9.16	-4.03	3.31
Nitrate from nitrite in SRAT product, mol	-0.08	-0.13	-0.15	-0.06	0.05
Moles of nitrite reacted	0.47	0.47	0.47	0.47	0.36
% nitrite conversion to nitrate	**-16.28**	**-27.32**	**-31.42**	**-13.81**	**14.69**
SRAT Nitrite Destruction (%)	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
SRAT Formate Destruction (%)	**24.34**	**29.08**	**30.41**	**15.49**	**15.44**
SME Data					
Total SME Product, g	2,146.70	2,303.80	2,319.00	2,001.00	2,088.00
SME Feed formate (grams)	109.48	113.47	123.33	165.47	111.01
SME Feed nitrate (grams)	36.23	46.01	52.27	63.61	54.25
SME Formate Added, g	7.40	7.45	7.48	7.50	7.01
Nitrate in SME product (grams)	37.46	44.00	50.44	50.03	48.34
Formate in SME product (grams)	110.13	114.73	127.20	124.96	104.92
SME Formate Destruction (grams)	6.75	6.19	3.62	48.01	13.10
SME Nitrate Destruction (grams)	-1.23	2.01	1.83	13.58	5.91
SME Nitrate Destruction (%)	**-3.40**	**4.37**	**3.51**	**21.36**	**10.89**
SME Formate Destruction (%)	**5.78**	**5.12**	**2.77**	**27.76**	**11.10**

Appendix A-6: SRAT & SME Cycle Run Data

Run Number	SB5-7	SB5-8	SB5-9	SB5-10
Sludge Simulant	SB5-D	SB5-D	SB5-D	SB5-D
Acid Stoichiometry	115	130	145	160
GC Calibration Gas	K027610H	0	KP02454H	0
Pre-Run Leak Check In	90	90	90	90
Pre-Run Leak Check Out	90.8	89.6	89.7	90
Post-Run Leak Check In	90	90	0	90
Post-Run Leak Check Out	90.2	0	0	90.8
pH Pre-Run Cal: Buffer 4	4.01	4.01	4.01	4
pH Pre-Run Cal: Buffer 10	10.02	10	10	10
pH Pre-Run Cal: Buffer 7	7.04	7.1	7.06	6.97
pH Post-Run Cal: Buffer 4	6.11	NA	0	0
pH Post-Run Cal: Buffer 10	10.23	NA	0	7.2
pH Post-Run Cal: Buffer 7	8.52	NA	0	0
Air Purge, sccm	787.5	787.5	787.5	787.5
He Purge, sccm	3.939	3.939	3.939	3.939
MWWT Water Added, g	41.7	43.433	48.3	42.364
MWWT Final Mass, g	50.01	39.6	50.01	47.9
FAVC Final Mass, g	33.83	33.64	33.83	29.82
Additions, g				
Sludge Added	3017.90	3018.00	3017.90	3017.89
ARP Added				
NaNO3	17.89	17.8906	17.89	17.8908
AgNO3	0.0987	0.0984	0.0983	0.0988
Pd(NO3)2*H2O	0.1389	0.1384	0.1381	0.1393
Rh(NO3)3*2H2O	2.2213	2.2218	2.2211	2.2208
RuCl3	1.2188	1.2190	1.2184	1.2184
Flush Water	50.0000	50.0400	50.0000	50.0500
HgO	13.8032	13.8038	13.8033	13.8037
Antifoam prior to acid	6.17	6.17	6.17	6.17
Water with 1st antifoam addition	6.17	6.17	6.17	6.17
Additional Antifoam	3.09	0	3.09	3.09
Water with addition antifoam	3.09	0	3.09	3.09
Antifoam prior to boiling	15.43	0	15.43	15.43
Water with 2nd antifoam addition	15.43	0	15.43	15.43
Total Antifoam	24.69	6.17	24.69	24.69

Appendix A-6: SRAT & SME Cycle Run Data

Run Number	SB5-7	SB5-8	SB5-9	SB5-10
Sludge Simulant	SB5-D	SB5-D	SB5-D	SB5-D
Acid Stoichiometry	115	130	145	160
Ratio: Formic to Total Acid	0.85	0.84	0.83	0.82
Run #	SB5-7	SB5-8	SB5-9	SB5-10
Sludge Feed Batch #	SB5-D	SB5-D	SB5-D	SB5-D
SRAT Vessel Volume, L	4.00	4.00	4.00	4.00
Fresh Sludge Weight % Total	15.09	15.09	15.09	15.09
Fresh Sludge Weight % Calci	11.25	11.25	11.25	11.25
Fresh Sludge Weight % Insolu	7.95	7.95	7.95	7.95
Fresh Sludge Density	1.12	1.12	1.12	1.12
Fresh Sludge Manganese (% c	4.64	4.64	4.64	4.64
Fresh Sludge Slurry TIC (trea	2470.34	2470.34	2470.34	2470.34
Fresh Sludge Hydroxide (Bas	0.91	0.91	0.91	0.91
Fresh Sludge Mercury (% of T	0.00	0.00	0.00	0.00
Fresh Sludge Supernate mang	0.00	0.00	0.00	0.00
Fresh Sludge Supernate densit	1.06	1.06	1.06	1.06
Conversion of Nitrite to Nitrat	25.00	25.00	25.00	25.00
Destruction of Nitrite in SRAT	100.00	100.00	100.00	100.00
Destruction of Formic acid ch	15.00	15.00	15.00	15.00
Destruction of oxalate charged	50.00	50.00	50.00	50.00
Percent Acid in Excess Stoich	115.00	130.00	145.00	160.00
SRAT Product Target Solids	25.00	25.00	25.00	25.00

Appendix A-6: SRAT & SME Cycle Run Data

Run Number	SB5-7	SB5-8	SB5-9	SB5-10
Sludge Simulant	SB5-D	SB5-D	SB5-D	SB5-D
Acid Stoichiometry	115	130	145	160
DWPF Nitric Acid addition R	2.00	2.00	2.00	2.00
DWPF Formic Acid addition I	2.00	2.00	2.00	2.00
Mass of pure formic acid (H(	208.06	232.19	256.39	280.45
Mass of pure nitric acid (HN	49.71	60.31	70.81	81.51
REDOX Target	0.20	0.20	0.20	0.20
REDOX Equation (7 for Mn+	7.00	7.00	7.00	7.00
Nitric acid density, 20 °C	1.31	1.31	1.31	1.31
Formic acid density, 20 °C	1.20	1.20	1.20	1.20
Nitric acid, wt %	50.55	50.55	50.55	50.55
Formic acid, wt %	90.16	90.16	90.16	90.16
Formic acid amount	4.52	5.04	5.57	6.09
Nitric acid amount	0.79	0.96	1.12	1.29
Total Stoichiometric Acid req	4.62	4.62	4.62	4.62
Percent Acid in Excess Stoich	115.00	130.00	145.00	160.00
Actual acid to add to SRAT	5.31	6.00	6.69	7.39
Acid required in moles per lite	1.96	2.22	2.48	2.73
Final sludge mass in SRAT af	2342.46	2466.91	2591.21	2715.81
Mass of SRAT cycle samples	200.00	200.00	200.00	200.00
Mass of treated sludge going i	2142.46	2266.91	2391.21	2515.81
SME sample ratio	0.91	0.92	0.92	0.93
Calcined Solids going to SME	311.85	313.31	314.64	315.85

Appendix A-6: SRAT & SME Cycle Run Data

Run Number	SB5-7	SB5-8	SB5-9	SB5-10
Sludge Simulant	SB5-D	SB5-D	SB5-D	SB5-D
Acid Stoichiometry	115	130	145	160
99.5% of scaled air purge	787.46	787.46	787.46	787.46
Helium purge rate at 0.5 vol%	3.94	3.94	3.94	3.94
Scaled boil-up rate	4.59	4.59	4.59	4.59
Required dewatering time at a	225.67	208.18	190.70	173.20
SME Cycle				
Frit type	418.00	418.00	418.00	418.00
Destruction of Formic acid in	7.00	7.00	7.00	7.00
Destruction of Nitrate in SME	0.00	0.00	0.00	0.00
Assumed SME density	1.45	1.45	1.45	1.45
Basis Antifoam Addition for S	100.00	100.00	100.00	100.00
Number of basis antifoam add	4.00	4.00	4.00	4.00
Sludge Oxide Contribution in	35.00	35.00	35.00	35.00
Frit Slurry Formic Acid Ratio	1.50	1.50	1.50	1.50
Target SME Solids total Wt%	45.00	45.00	45.00	45.00
Number of frit additions in SM	2.00	2.00	2.00	2.00
# DWPF Canister decons simu	5.00	5.00	5.00	5.00
Volume of water per deconed	1000.00	1000.00	1000.00	1000.00
SME scale factor (ADJUSTEI	8997.65	8955.48	8917.74	8883.65
99.5% scaled SME air purge	231.72	232.81	233.80	234.70
Helium purge rate at 0.5 vol%	1.16	1.16	1.17	1.17
Frit solids (total)	579.14	581.87	584.33	586.58

Appendix A-6: SRAT & SME Cycle Run Data

Run Number	SB5-7	SB5-8	SB5-9	SB5-10
Sludge Simulant	SB5-D	SB5-D	SB5-D	SB5-D
Acid Stoichiometry	115	130	145	160
90 wt% formic acid (correctio	8.69	8.73	8.76	8.80
Water in frit slurry	570.46	573.14	575.57	577.78
Number of equal SME frit slu	2.00	2.00	2.00	2.00
Scaled SME boil-up rate	4.20	4.22	4.24	4.25
Approximate time to remove	68.93	68.93	68.93	68.93
Final solids content in SME	1122.79	1156.68	1190.26	1223.70
Target SME solids total wt%	45.00	45.00	45.00	45.00
Mass of water to boil off for f	230.80	282.91	335.30	388.09
Approximate time to reach sol	54.94	67.03	79.10	91.21
Predicted Fe+2/Fe total in gla	0.20	0.22	0.20	0.19
Start Heatup	6/10/08 6:10	6/3/08 7:33	6/11/08 8:05	6/3/08 6:50
Start Nitric Acid Addition	6/10/08 8:49	6/3/08 8:38	6/11/08 9:06	6/3/08 7:40
Stop Nitric Acid Addition	6/10/08 10:13	6/3/08 10:23	6/11/08 11:05	6/3/08 10:15
Nitric Acid Feed Time, min	84.00	105.00	119.00	155.00
Start Formic Acid Addition	6/10/08 10:30	6/3/08 10:43	6/11/08 11:35	6/3/08 10:43
Stop Formic Acid Addition	6/10/08 14:01	6/3/08 14:35	6/11/08 15:55	6/3/08 15:16
Formic Acid Feed Time, min	211.00	232.00	260.00	273.00
Boiling Begins	6/10/08 6:10	1/0/00 0:00	6/11/08 16:30	6/3/08 15:40
Dewater Complete	6/10/08 18:32	6/3/08 19:26	6/11/08 15:55	6/3/08 18:53
Dewater Time, min	742.00	57028046.00	1405.00	193.00
Boiling Complete	6/11/08 8:40	6/4/08 9:00	6/12/08 10:30	6/4/08 9:42
Total Boiling Time, min	1590.00	57028860.00	1080.00	1082.00
Nitric Acid Feed Rate, mL/mi	0.89	0.87	0.90	0.79
Formic Acid Feed Rate, mL/n	0.91	0.92	0.91	0.95

Appendix A-6: SRAT & SME Cycle Run Data

Run Number	SB5-11	SB5-12	SB5-13	SB5-14	SB5-15
Sludge Simulant	SB5-C	SB5-C	SB5-C	SB5-C	SB5-C
Acid Stoichiometry	115	130	145	160	130
GC Calibration Gas	0	0	0	0	K027610H
Pre-Run Leak Check In	90	90	90	90	90
Pre-Run Leak Check Out	92.2	91	98.1	88	83.5
Post-Run Leak Check In	90	90	90	90	90
Post-Run Leak Check Out	92	88.1	94.2	86.2	92.2
pH Pre-Run Cal: Buffer 4	4	4	4	4	4
pH Pre-Run Cal: Buffer 10	10	10	10	10	10
pH Pre-Run Cal: Buffer 7	7.07	7.02	7.02	7.02	6.99
pH Post-Run Cal: Buffer 4	7.12	4.49	4.47	4.79	4.49
pH Post-Run Cal: Buffer 10	7.46	10.31	9.94	3.83	10.32
pH Post-Run Cal: Buffer 7	7.14	7.31	7.38	0	7.77
Air Purge, sccm	932.3	932.3	932.3	932.3	922.5
He Purge, sccm	4.66	4.66	4.66	4.66	4.61
MWWT Water Added, g	49.07	40.73	51	40.04	49.5
MWWT Final Mass, g	51.97	41.84	54.31	42.23	49.31
FAVC Final Mass, g	29.49	34.12	34.69	34.9	30.5
Additions, g					
Sludge Added	3500.50	3501.20	3501.20	3501.60	2,450.00
ARP Added					971.00
NaNO3					
AgNO3	0.0973	0.0973	0.0973	0.0973	0.0960
Pd(NO3)2*H2O	0.1066	0.1065	0.1065	0.1064	0.1045
Rh(NO3)3*2H2O	2.0661	2.0661	2.0662	2.0660	2.0264
RuCl3	1.0555	1.0555	1.0556	1.0554	1.0354
Flush Water	50.0200	50.0100	50.0000	50.0000	50.0100
HgO	11.5276	11.5276	11.5276	11.5275	8.1167
Antifoam prior to acid	7.1300	7.1300	7.1300	7.1330	7.0500
Water with 1st antifoam addition	7.1300	7.1300	7.1300	7.1300	7.0500
Additional Antifoam	0.0000	3.5600	0.0000	3.5600	21.1600
Water with addition antifoam	0.0000	3.5600	0.0000	3.5700	21.1400
Antifoam prior to boiling	17.8200	17.8200	17.8200	17.8200	17.6200
Water with 2nd antifoam addition	17.8200	17.8200	17.8200	17.8200	17.6200
Total Antifoam	24.95	28.51	24.95	28.513	45.83

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Appendix A-6: SRAT & SME Cycle Run Data

Run Number	SB5-11	SB5-12	SB5-13	SB5-14	SB5-15
Sludge Simulant	SB5-C	SB5-C	SB5-C	SB5-C	SB5-C
Acid Stoichiometry	115	130	145	160	130
Ratio: Formic to Total Acid	0.88	0.84	0.84	0.83	0.87
Run #	SB5-11	SB5-12	SB5-13	SB5-14	SB5-15
Sludge Feed Batch #	SB5-C	SB5-C	SB5-C	SB5-C	SB5-C
SRAT Vessel Volume, L	4.00	4.00	4.00	4.00	4.00
Fresh Sludge Weight % Total Solids	12.47	12.47	12.47	12.47	12.47
Fresh Sludge Weight % Calcined Solids	9.51	9.51	9.51	9.51	9.51
Fresh Sludge Weight % Insoluble Solids	7.85	7.85	7.85	7.85	7.85
Fresh Sludge Density	1.09	1.09	1.09	1.09	1.09
Fresh Sludge Manganese (% of Calcined Solids)	5.05	5.05	5.05	5.05	5.05
Fresh Sludge Slurry TIC (treated as Carbonate)	1338.06	1338.06	1338.06	1338.06	1338.06
Fresh Sludge Hydroxide (Base Equivalents) pH = 7	0.63	0.63	0.63	0.63	0.63
Fresh Sludge Mercury (% of Total Solids in untrimmed sludge)	0.00	0.00	0.00	0.00	0.00
Fresh Sludge Supernate manganese	0.00	0.00	0.00	0.00	0.00
Fresh Sludge Supernate density	1.02	1.02	1.02	1.02	1.02
Conversion of Nitrite to Nitrate in SRAT Cycle	-16.30	-27.30	-31.40	0.00	14.70
Destruction of Nitrite in SRAT and SME cycle	100.00	100.00	100.00	100.00	100.00
Destruction of Formic acid charged in SRAT	24.30	29.10	30.40	25.00	15.40
Destruction of oxalate charged	50.00	50.00	50.00	50.00	20.00
Percent Acid in Excess Stoichiometric Ratio	115.00	130.00	145.00	160.00	130.00
SRAT Product Target Solids	26.09	25.15	25.06	25.00	25.11

Appendix A-6: SRAT & SME Cycle Run Data

Run Number	SB5-11	SB5-12	SB5-13	SB5-14	SB5-15
Sludge Simulant	SB5-C	SB5-C	SB5-C	SB5-C	SB5-C
Acid Stoichiometry	115	130	145	160	130
DWPF Nitric Acid addition Rate	2.00	2.00	2.00	2.00	2.00
DWPF Formic Acid addition Rate	2.00	2.00	2.00	2.00	2.00
Mass of pure formic acid (HCOOH) added	166.42	180.82	199.97	219.33	152.46
Mass of pure nitric acid (HNO3) added	31.66	45.79	53.42	60.76	32.18
REDOX Target	0.20	0.20	0.20	0.20	0.20
REDOX Equation (7 for Mn+7, otherwise assumes Mn+4)	7.00	7.00	7.00	7.00	7.00
Nitric acid density, 20 °C	1.31	1.31	1.31	1.31	1.31
Formic acid density, 20 °C	1.20	1.20	1.20	1.20	1.20
Nitric acid, wt %	50.55	50.55	50.55	50.55	50.55
Formic acid, wt %	90.16	90.16	90.16	90.16	90.16
Formic acid amount	3.62	3.93	4.34	4.77	3.31
Nitric acid amount	0.50	0.73	0.85	0.96	0.51
Total Stoichiometric Acid required	3.58	3.58	3.58	3.58	2.94
Percent Acid in Excess Stoichiometric Ratio	115.00	130.00	145.00	160.00	130.00
Actual acid to add to SRAT	4.12	4.66	5.19	5.73	3.82
Acid required in moles per liter of starting sludge (less receipt samples)	1.28	1.45	1.62	1.78	1.75
Final sludge mass in SRAT after acid addition and dewater (neglecting samples)	2013.96	2154.25	2236.05	2372.28	2159.80
Mass of SRAT cycle samples (excluding SRAT Receipt)	201.27	200.00	181.10	200.00	259.21
Mass of treated sludge going into SME cycle	1812.69	1954.25	2054.95	2172.28	1900.59
SME sample ratio	0.90	0.91	0.92	0.92	0.88
Calcined Solids going to SME	300.84	303.21	307.18	306.07	277.35

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Appendix A-6: SRAT & SME Cycle Run Data

Run Number	SB5-11	SB5-12	SB5-13	SB5-14	SB5-15
Sludge Simulant	SB5-C	SB5-C	SB5-C	SB5-C	SB5-C
Acid Stoichiometry	115	130	145	160	130
99.5% of scaled air purge	932.29	932.29	932.29	932.29	922.48
Helium purge rate at 0.5 vol%	4.66	4.66	4.66	4.66	4.61
Scaled boil-up rate	5.44	5.44	5.44	5.44	5.38
Required dewatering time at above rate	326.88	306.92	297.06	279.72	582.84
SME Cycle					
Frit type	418.00	418.00	418.00	418.00	418.00
Destruction of Formic acid in SME	5.80	5.10	2.80	7.00	11.10
Destruction of Nitrate in SME	-3.40	4.40	3.50	0.00	10.90
Assumed SME density	1.45	1.45	1.45	1.45	1.45
Basis Antifoam Addition for SME cycle	100.00	100.00	100.00	100.00	100.00
Number of basis antifoam additions added during SME cycle	4.00	4.00	4.00	4.00	4.00
Sludge Oxide Contribution in SME (Waste Loading)	35.00	35.00	35.00	35.00	35.00
Frit Slurry Formic Acid Ratio	1.50	1.50	1.50	1.50	1.50
Target SME Solids total Wt%	45.00	45.00	45.00	45.00	45.00
Number of frit additions in SME Cycle	2.00	2.00	2.00	2.00	2.00
# DWPF Canister decons simulated	0.00	0.00	0.00	0.00	0.00
Volume of water per deconed can	1000.00	1000.00	1000.00	1000.00	1000.00
SME scale factor (ADJUSTED FOR SRAT SAMPLES)	7722.76	7662.34	7563.55	7590.94	7982.94
99.5% scaled SME air purge	269.98	272.11	275.66	274.67	261.18
Helium purge rate at 0.5 vol%	1.35	1.36	1.38	1.37	1.31
Frit solids (total)	558.71	563.11	570.47	568.41	531.25

Appendix A-6: SRAT & SME Cycle Run Data

Run Number	SB5-11	SB5-12	SB5-13	SB5-14	SB5-15
Sludge Simulant	SB5-C	SB5-C	SB5-C	SB5-C	SB5-C
Acid Stoichiometry	115	130	145	160	130
90 wt% formic acid (corrections necessary for other concentrations)	8.38	8.45	8.56	8.53	7.97
Water in frit slurry	550.33	554.67	561.91	559.88	523.28
Number of equal SME frit slurry additions	2.00	2.00	2.00	2.00	2.00
Scaled SME boil-up rate	4.89	4.93	5.00	4.98	4.73
Approximate time to remove water:	57.07	57.07	57.07	57.07	56.10
Final solids content in SME	1039.37	1062.41	1093.40	1119.37	1015.86
Target SME solids total wt%	45.00	45.00	45.00	45.00	45.00
Mass of water to boil off for final SME concentration	65.32	160.35	199.75	257.55	256.10
Approximate time to reach solids target concentration.	13.35	32.51	39.97	51.72	52.30
0					
Predicted Fe+2/Fe total in glass (no SME cycle)	0.29	0.23	0.23	0.28	0.18
Start Heatup	7/10/08 18:15	7/9/08 6:24	7/9/08 18:10	7/8/08 6:37	7/23/08 6:40
Start Nitric Acid Addition	7/10/08 20:03	7/9/08 7:44	7/9/08 19:10	7/8/08 8:00	7/23/08 7:36
Stop Nitric Acid Addition	7/10/08 20:49	7/9/08 8:50	7/9/08 20:27	7/8/08 9:25	7/23/08 8:14
Nitric Acid Feed Time, min	46.00	66.00	77.00	85.00	38.00
Start Formic Acid Addition	7/10/08 21:16	7/9/08 8:57	7/9/08 20:42	7/8/08 9:44	7/23/08 8:25
Stop Formic Acid Addition	7/10/08 23:40	7/9/08 12:20	7/9/08 23:35	7/8/08 12:54	7/23/08 10:38
Formic Acid Feed Time, min	144.00	203.00	173.00	190.00	133.00
Boiling Begins	7/11/08 0:05	7/9/08 12:20	7/9/08 23:57	7/8/08 13:30	7/23/08 11:03
Dewater Complete	7/11/08 5:23	7/9/08 17:11	7/10/08 4:44	7/8/08 18:05	7/23/08 15:32
Dewater Time, min	318.00	291.00	287.00	275.00	269.00
Boiling Complete	7/11/08 18:05	7/10/08 6:23	7/10/08 17:52	7/9/08 9:01	7/24/08 0:57
Total Boiling Time, min	1080.00	1083.00	1075.00	1171.00	834.00
Nitric Acid Feed Rate, mL/min	1.04	1.05	1.05	1.08	1.06
Formic Acid Feed Rate, mL/min	1.06	0.82	1.06	1.06	1.08

Appendix A- 7. Mercury Results: SRAT Products

Sample Id	User SampleID	LIMS Method	Element	Result	Units	Rv	Sample Mass, g	Digested Volume, mL	Slurry Total Solids, wt %	Hg, wt %
300250088	08_SB5_7_2506	CV Hg Digested	Hg	8.1238	mg/L	1	1.49	100	25.642	0.213
300250089	08_SB5_8_2492	CV Hg Digested	Hg	9.6036	mg/L	1	2.46	100	24.008	0.163
300250090	08_SB5_9_2517	CV Hg Digested	Hg	1.2495	mg/L	1	1.26	100	23.959	0.041
300250091	08_SB5_10_2501	CV Hg Digested	Hg	2.9766	mg/L	1	1.958	100	24.169	0.0629
300250861	08_SB5_11_2535	CV Hg Digested	Hg	34.675	mg/L	1	1.31	100	26.8998	0.984
300250862	08_SB5_12_2546	CV Hg Digested	Hg	46.414	mg/L	1	1.961	100	25.5255	0.927
300250863	08_SB5_13_2558	CV Hg Digested	Hg	3.7471	mg/L	1	1	100	25.6747	0.146
300250864	08_SB5_14_2569	CV Hg Digested	Hg	2.1279	mg/L	1	1.5369	100	26.8056	0.0517
300251641	08_SB5_15_2586	CV Hg Digested	Hg	101.52	mg/L	1	47.2146	250	24.451	0.0415

Appendix B. Sample/Run Results: Graphical Presentations

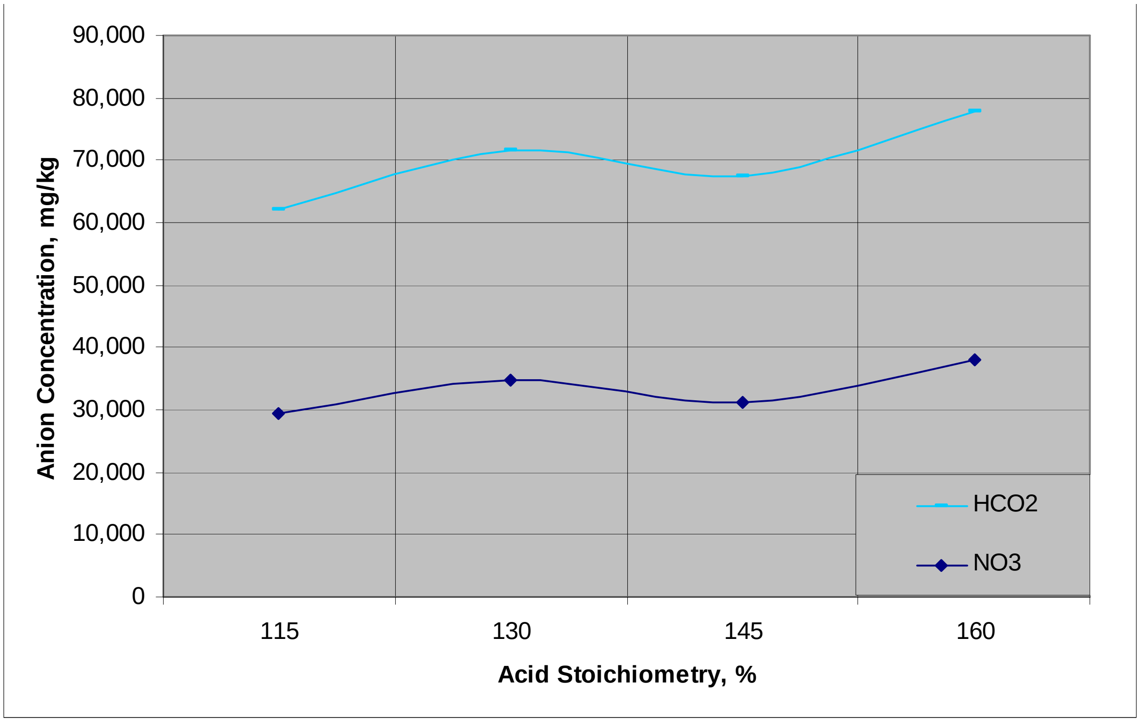


Figure B- 1c. Blend SRAT Product Nitrate and Formate versus Acid Stoichiometry

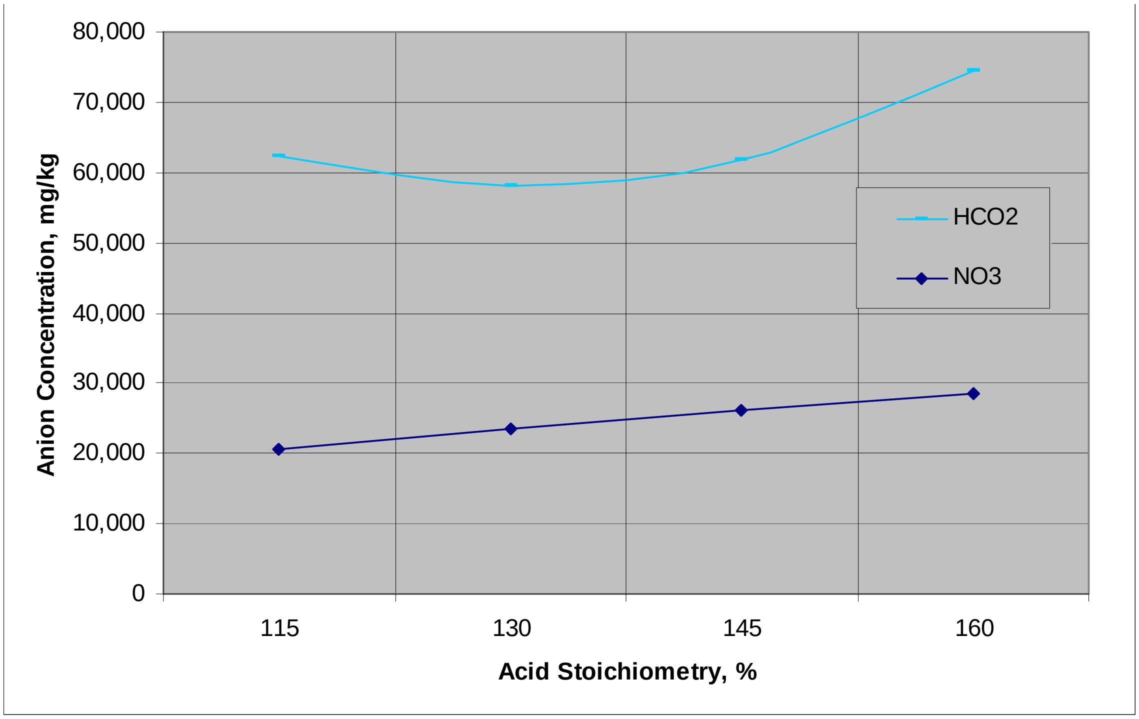


Figure B- 1d. Batch SRAT Product Nitrate and Formate versus Acid Stoichiometry

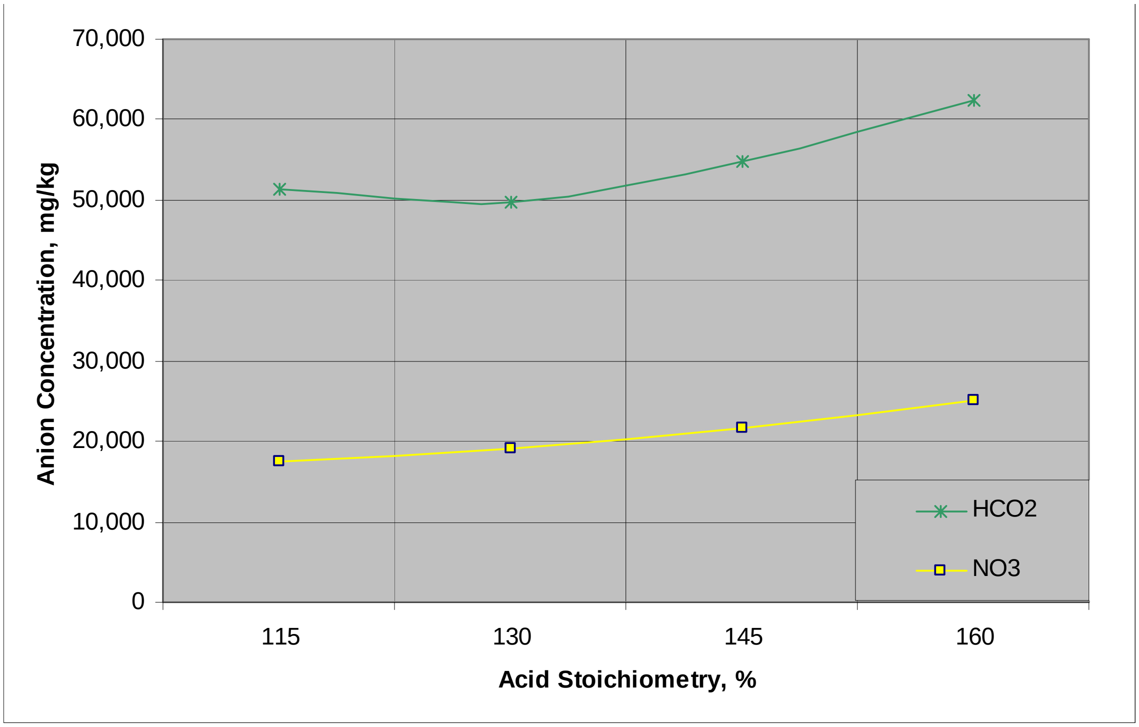


Figure B- 2c. Blend SME Product Nitrate and Formate versus Acid Stoichiometry

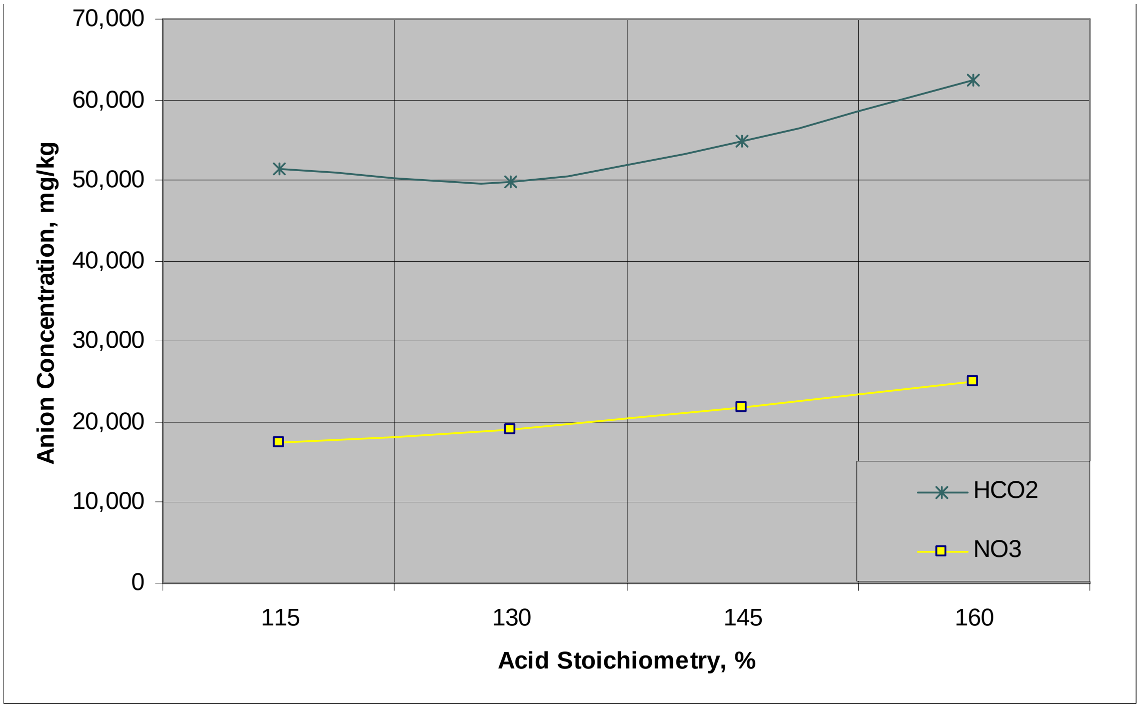


Figure B- 2d. Batch SME Product Nitrate and Formate versus Acid Stoichiometry

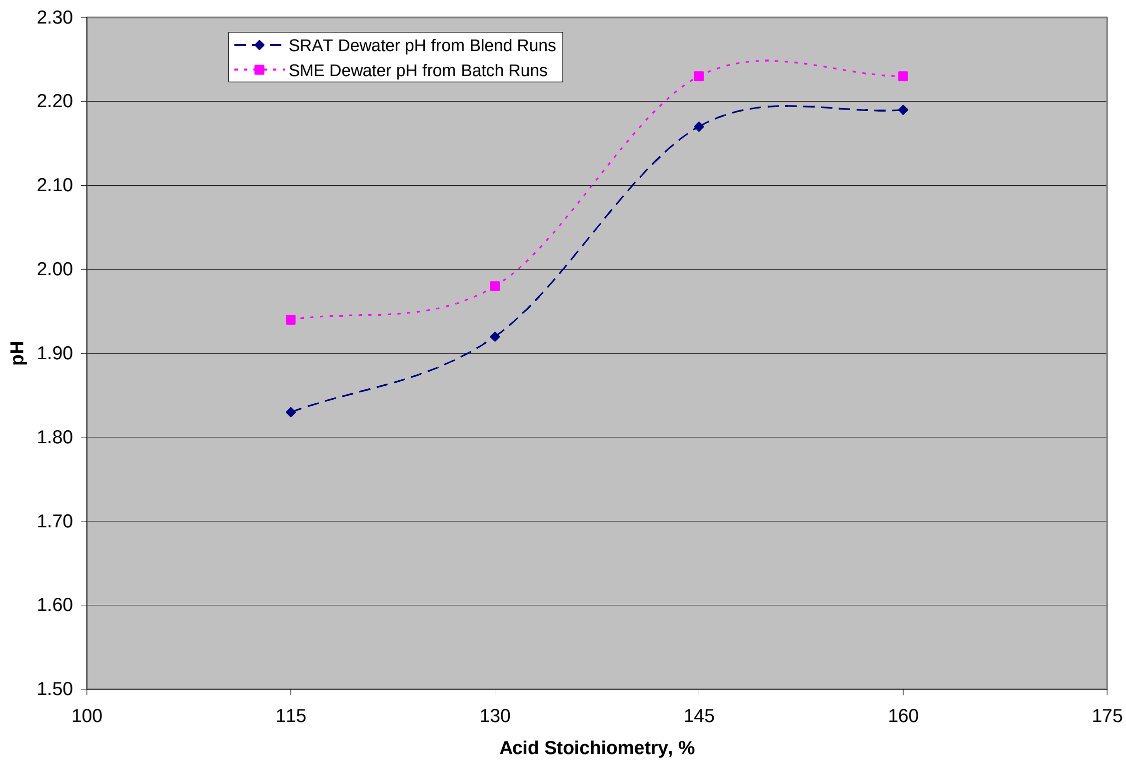


Figure B- 3c. Blend SRAT Dewater Anion Concentrations

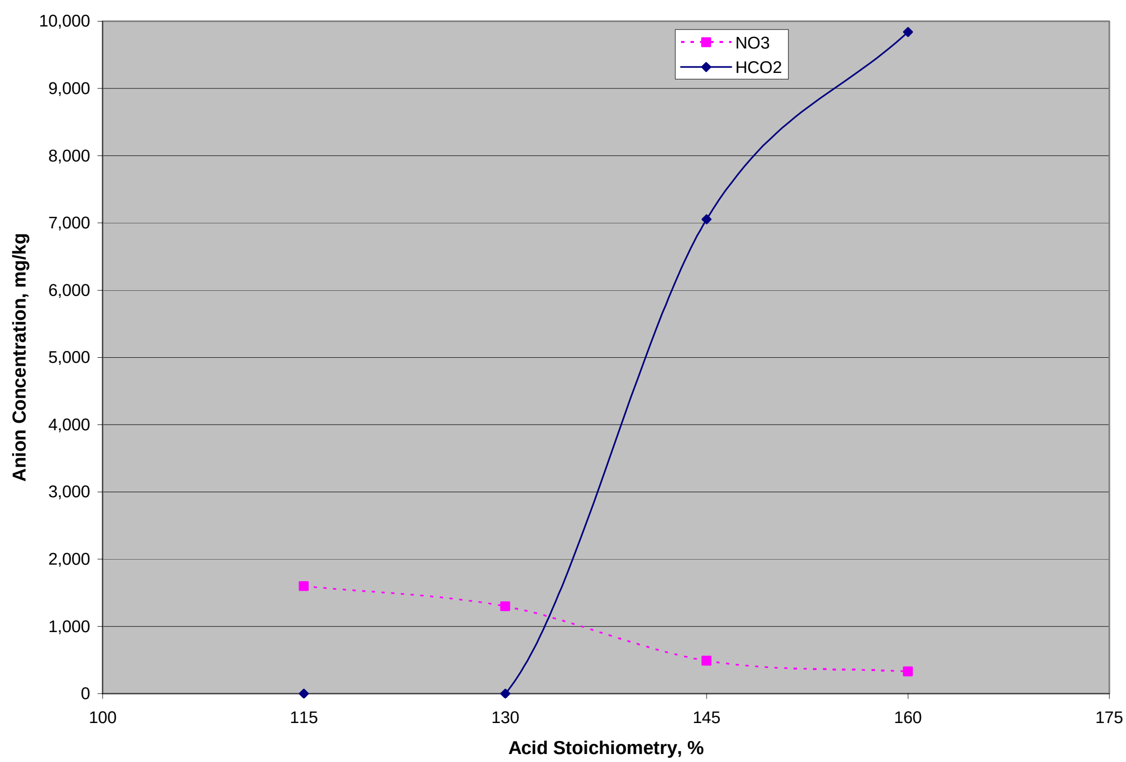


Figure B- 3d. Batch SRAT Dewater Anion Concentrations

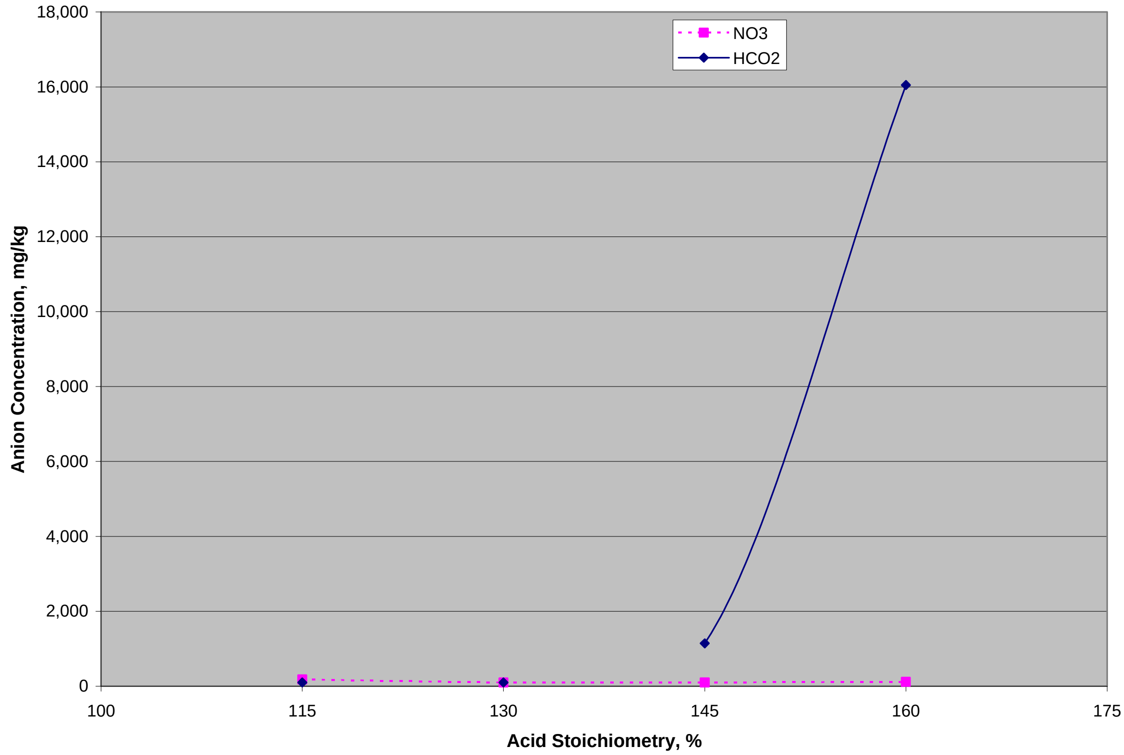


Figure B- 4c. Blend MWWT Formate Concentration

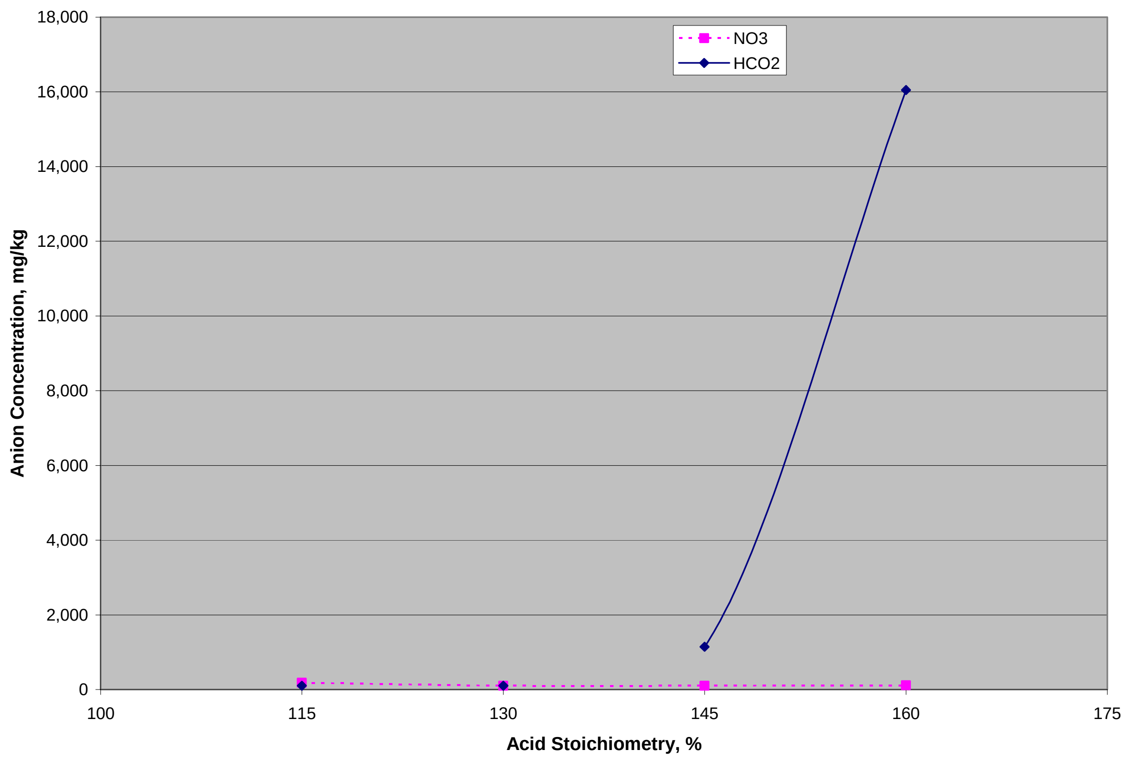


Figure B- 4d. Batch MWWT Formate Concentration

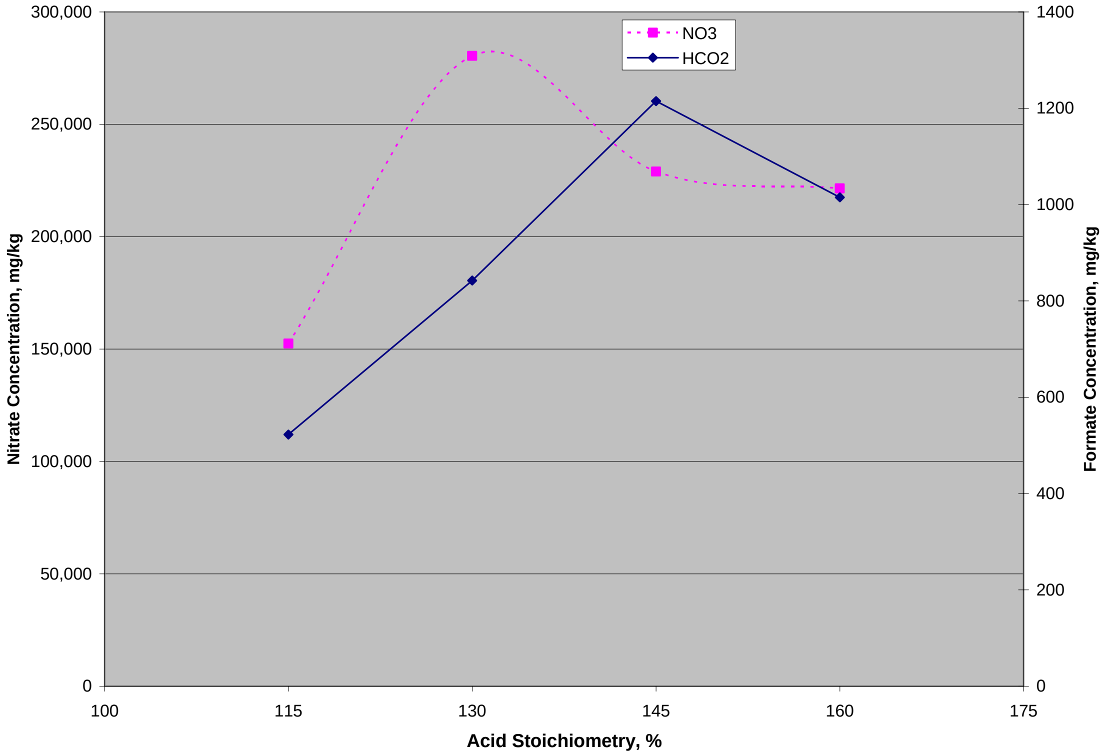


Figure B- 5c. Blend FAVC Nitrate & Formate Concentration

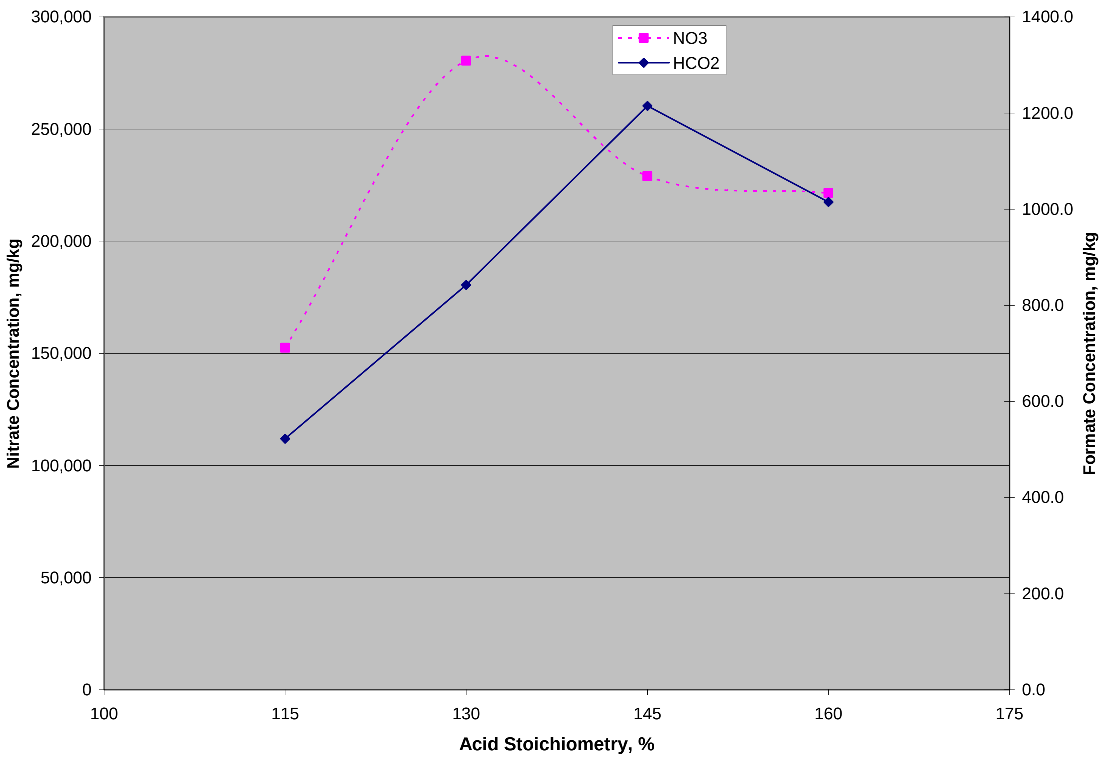


Figure B- 5d. Batch FAVC Nitrate & Formate Concentration

Appendix C. Offgas Composition Data

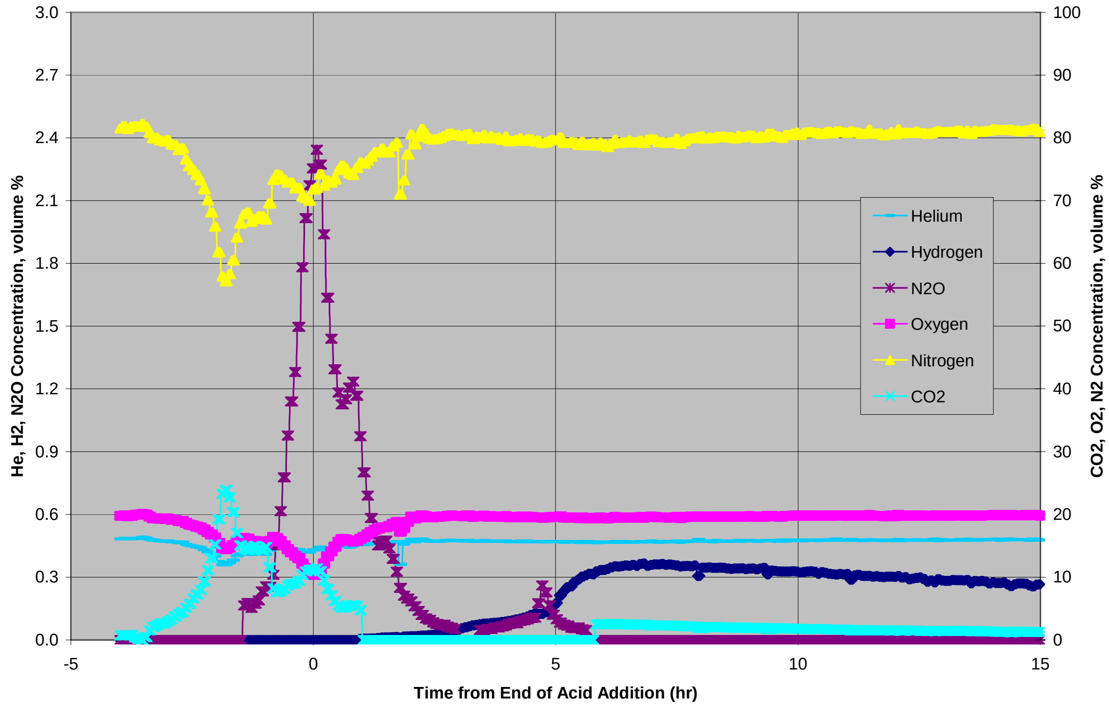


Figure C- 1. SB5-7 (115% Acid) Offgas Data

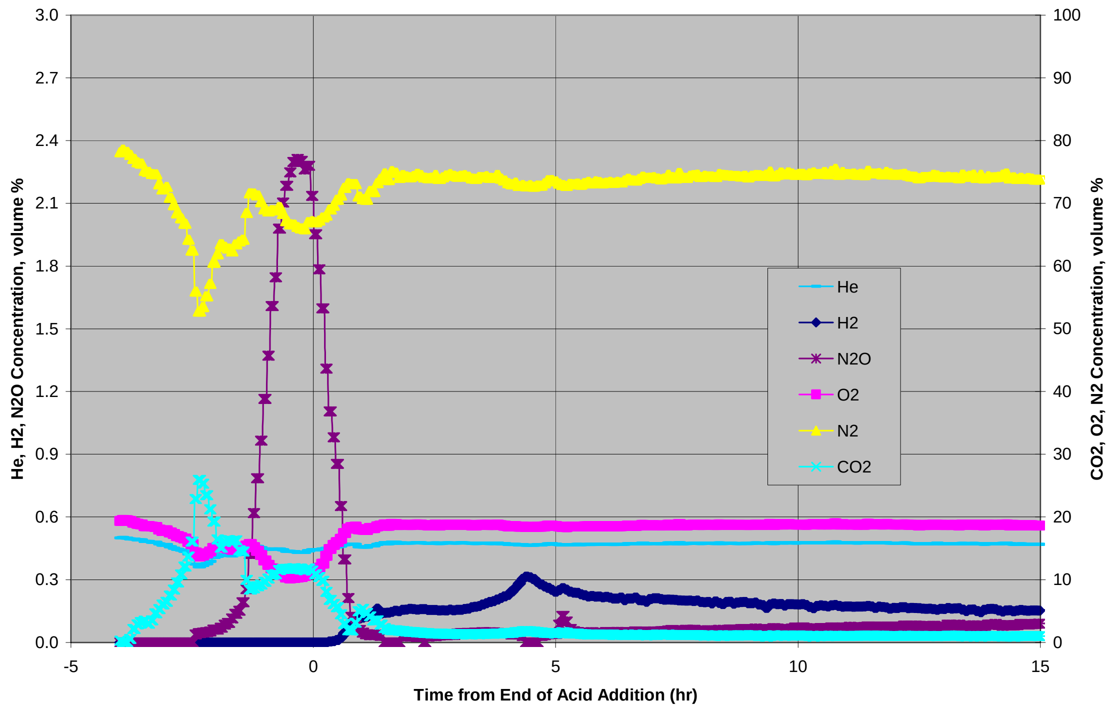


Figure C- 2. SB5-8 (130% Acid) Offgas Data

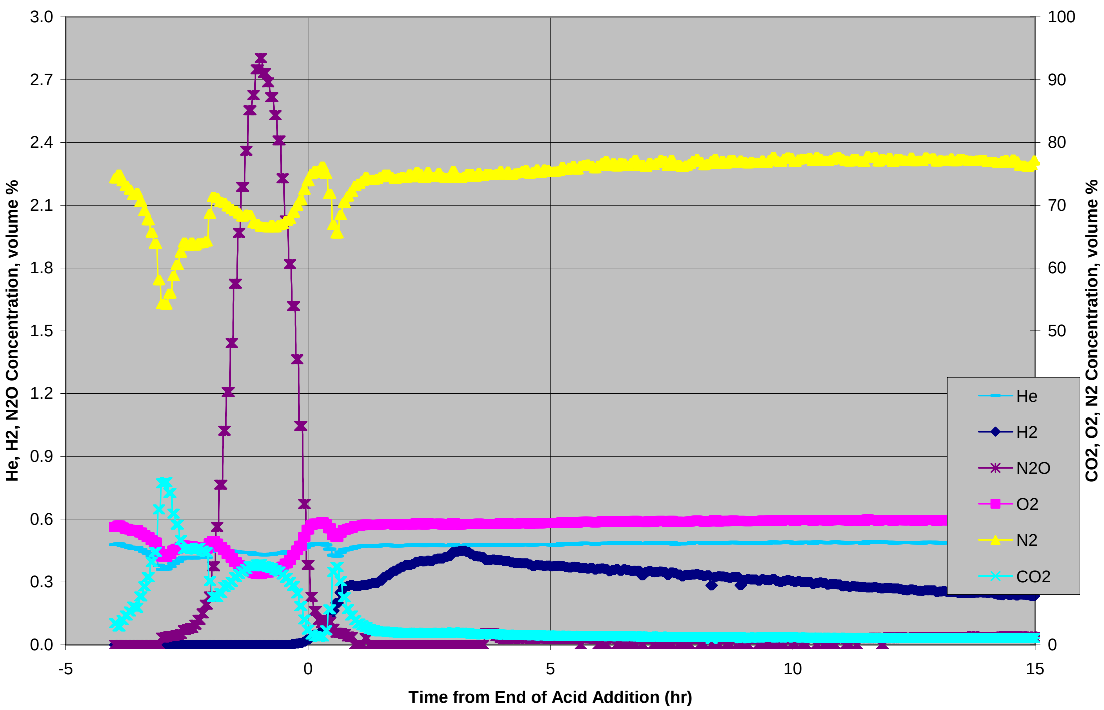


Figure C- 3. SB5-9 (145% Acid) Offgas Data

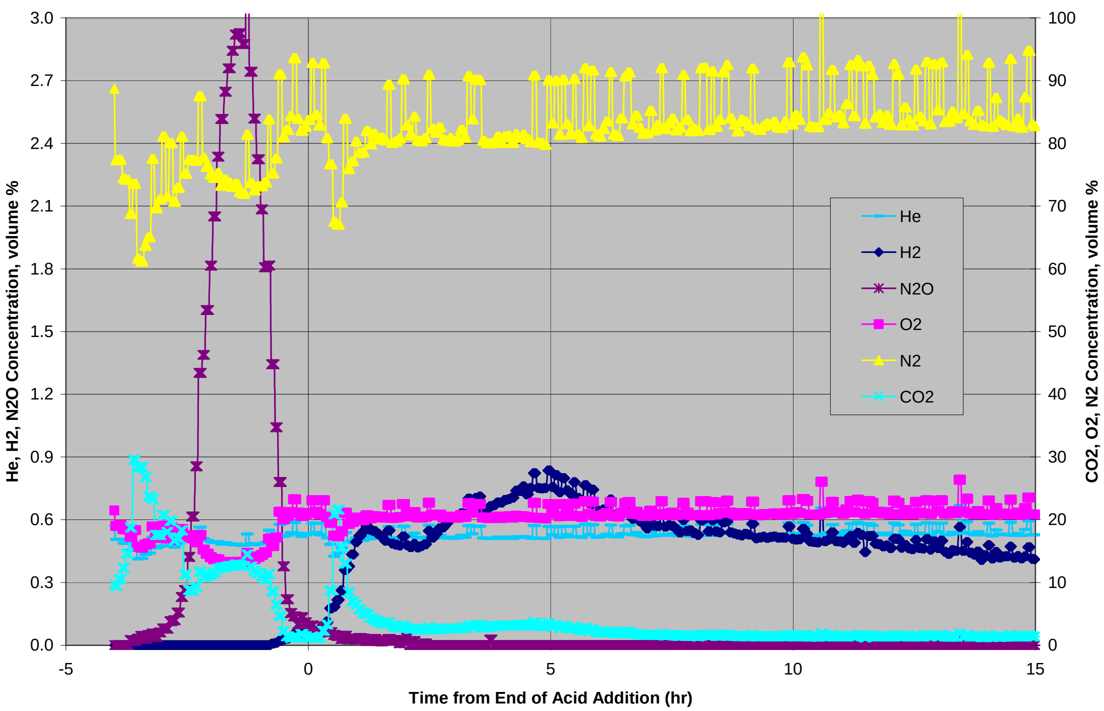


Figure C- 4. SB5-10 (160% Acid) Offgas Data

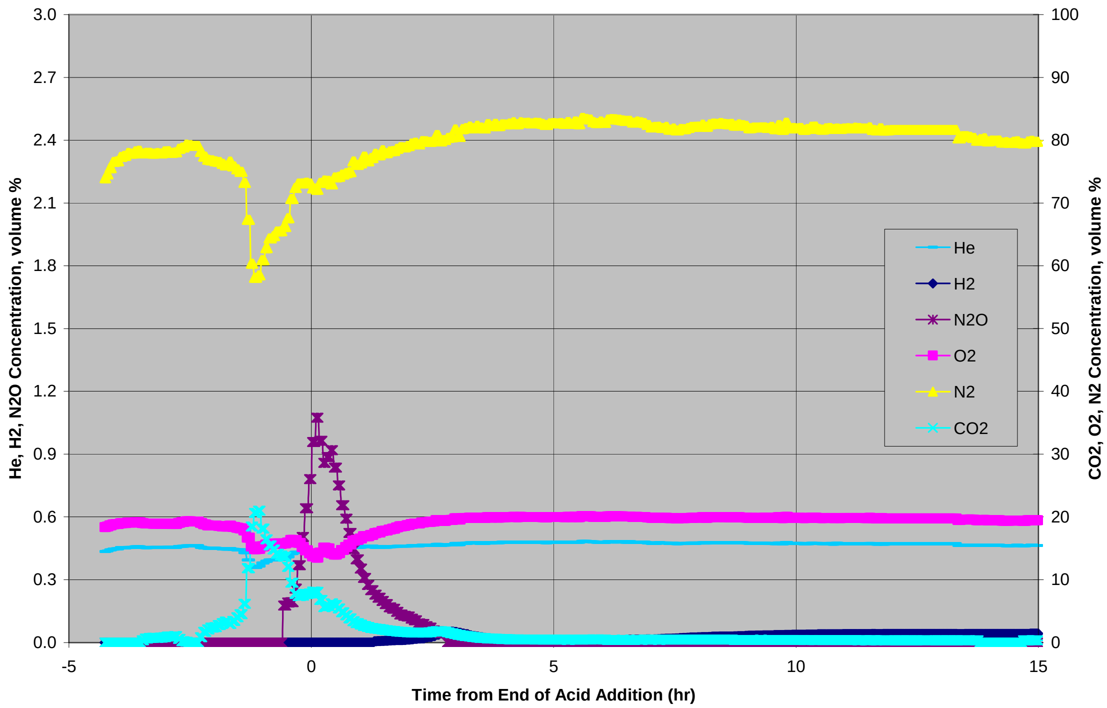


Figure C- 5. SB5-11 (115% Acid) Offgas Data

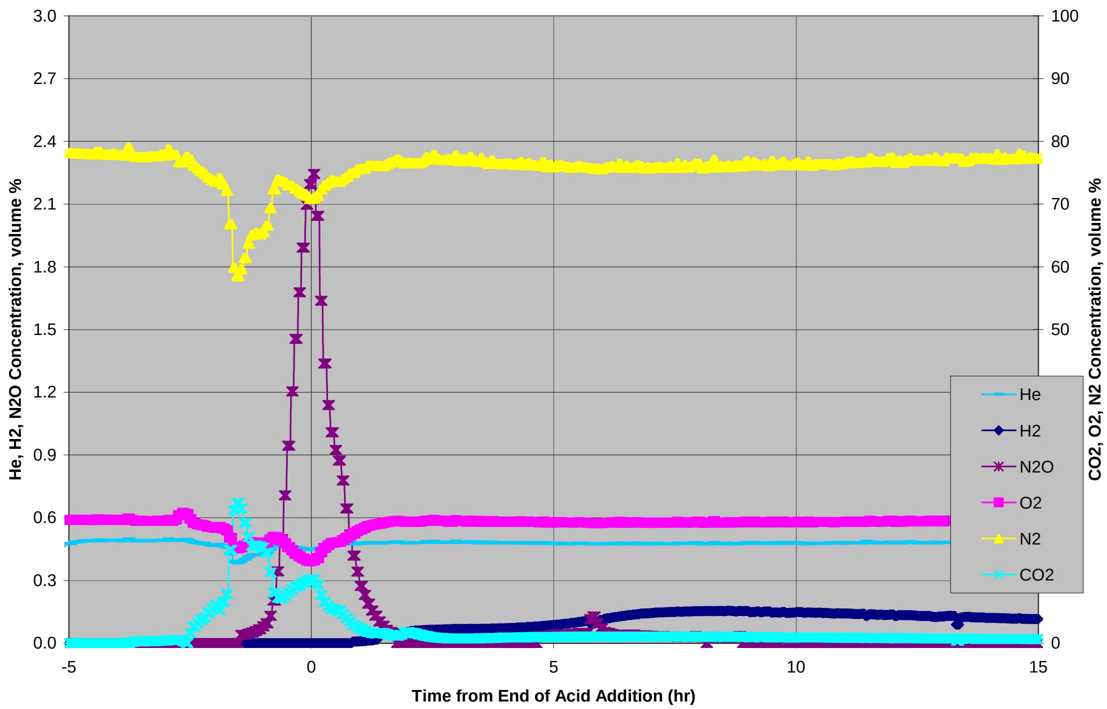


Figure C- 6. SB5-12 (130% Acid) Offgas Data

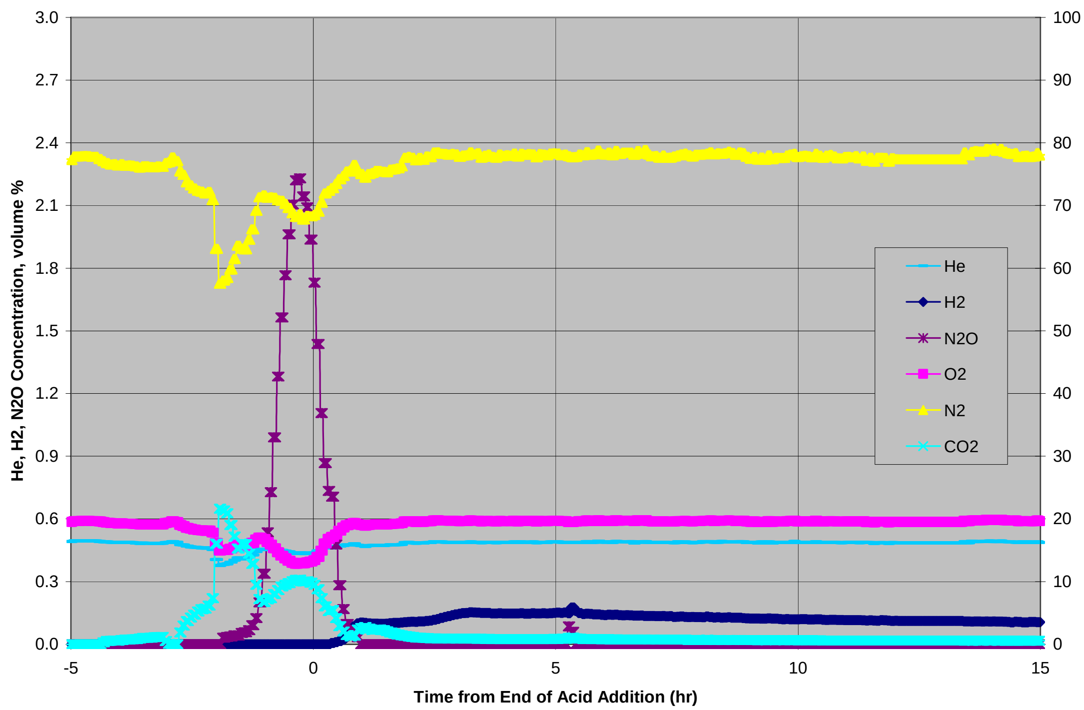


Figure C- 7. SB5-13 (145% Acid) Offgas Data

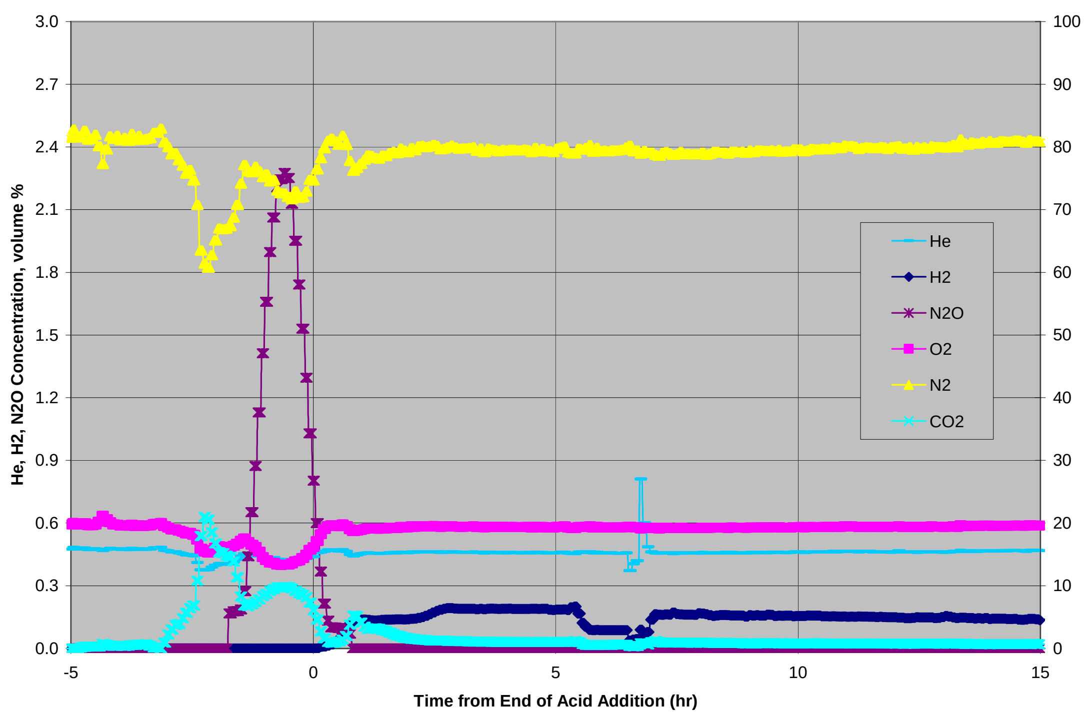


Figure C- 8. SB5-14 (160% Acid) Offgas Data

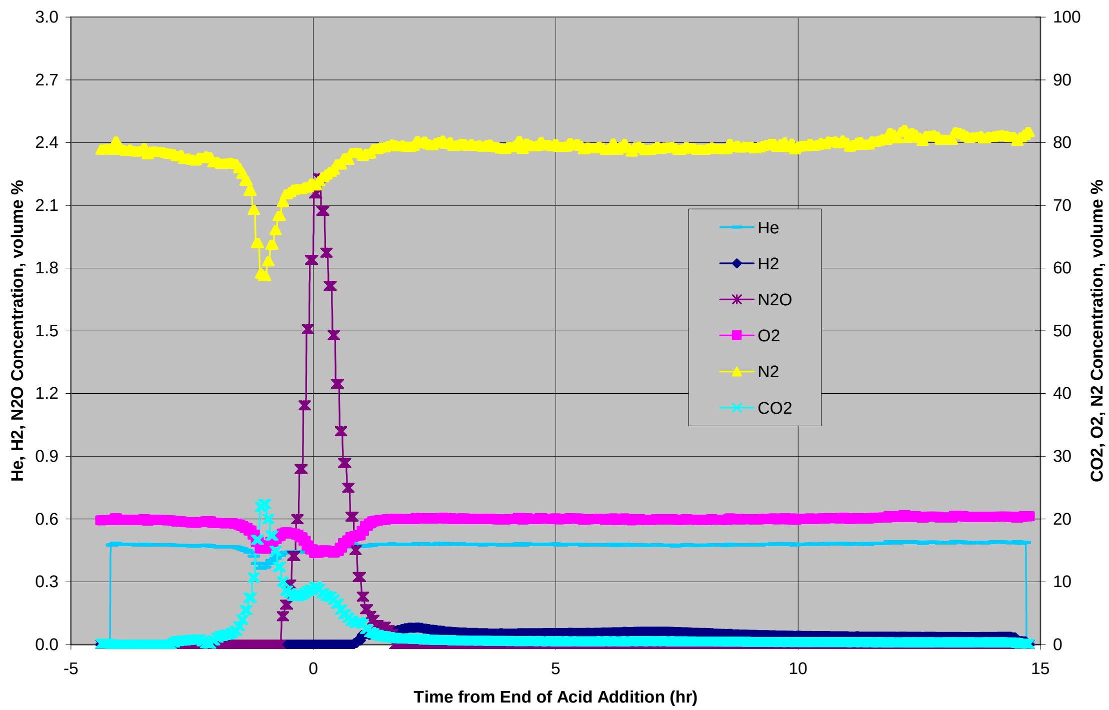


Figure C- 9. SB5-15 (130% Acid) Offgas Data

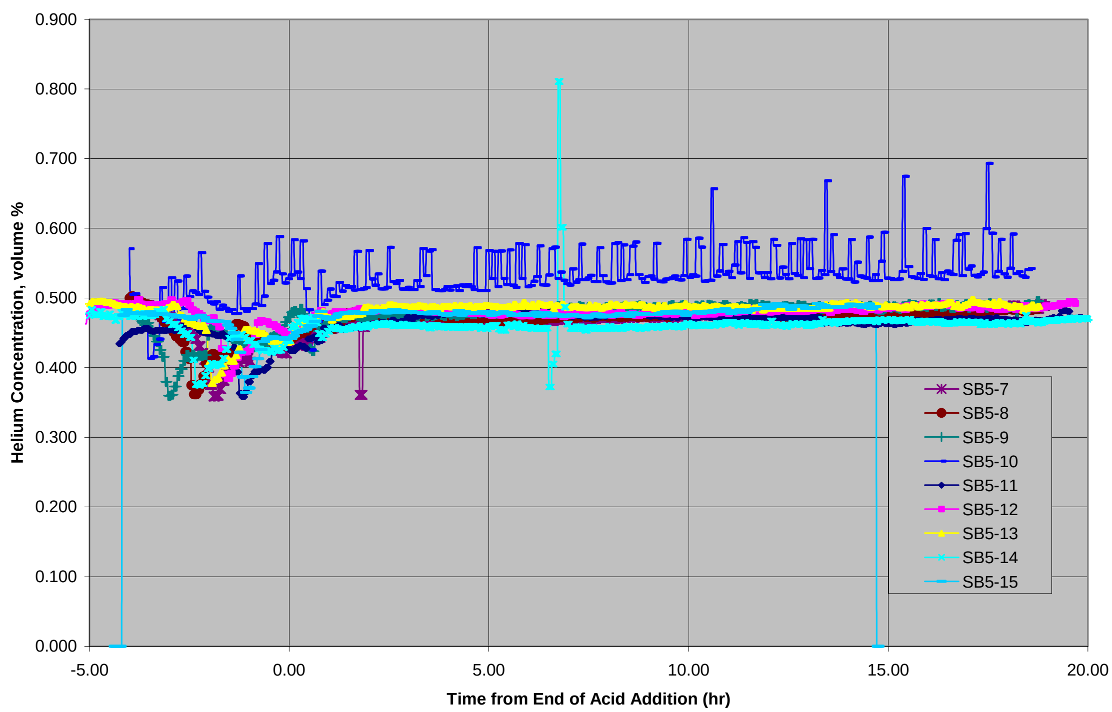


Figure C- 10. Helium Profiles

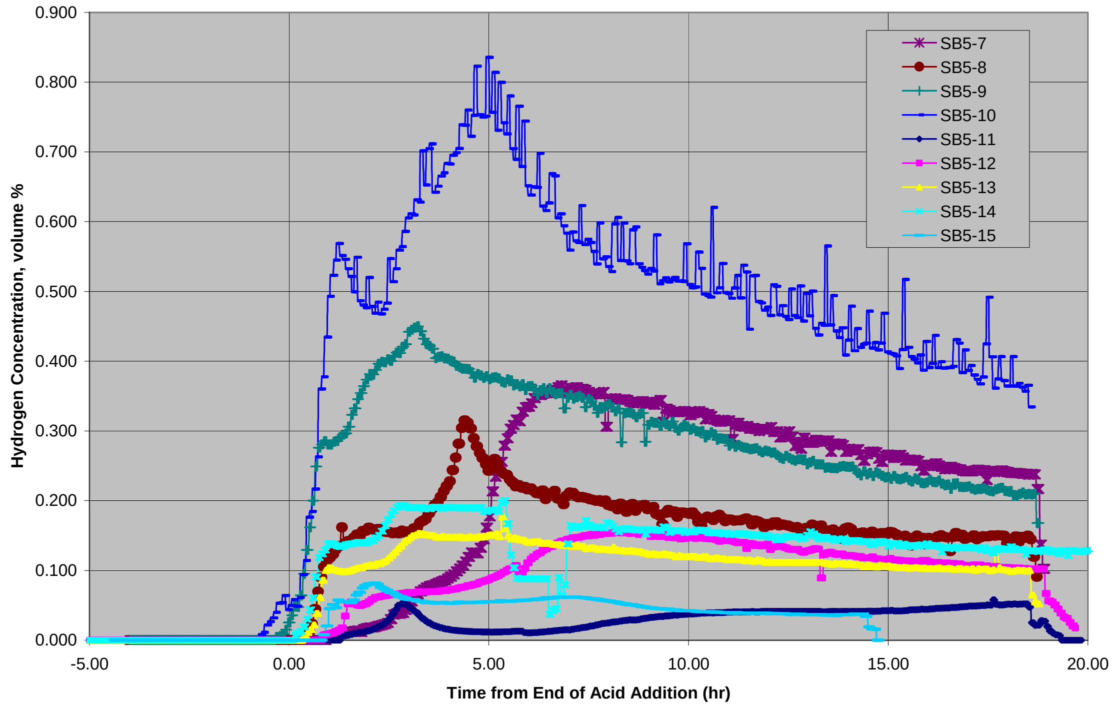


Figure C- 11. Oxygen Profiles

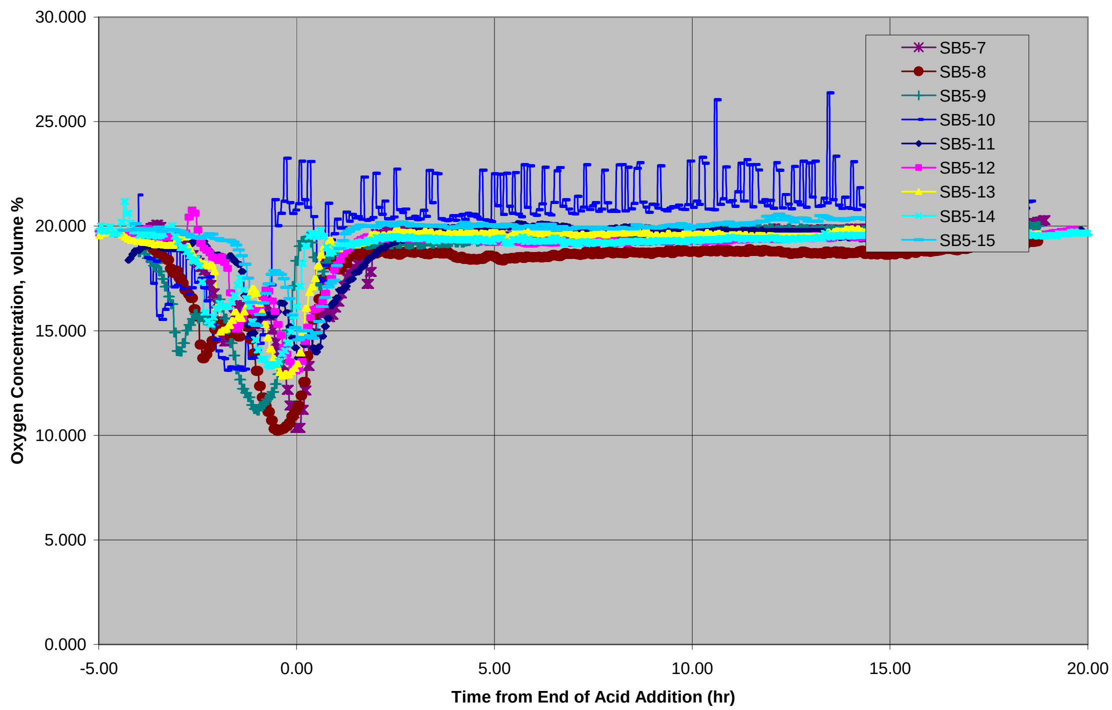


Figure C- 12. Oxygen Profiles

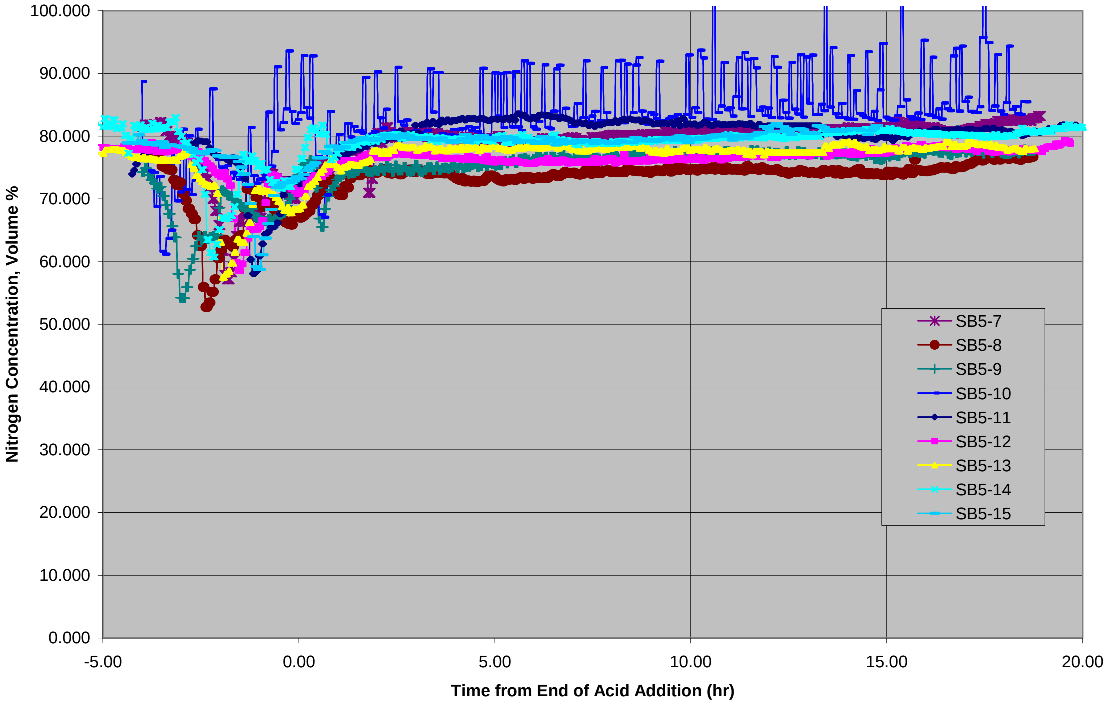


Figure C- 13. Nitrogen Profiles

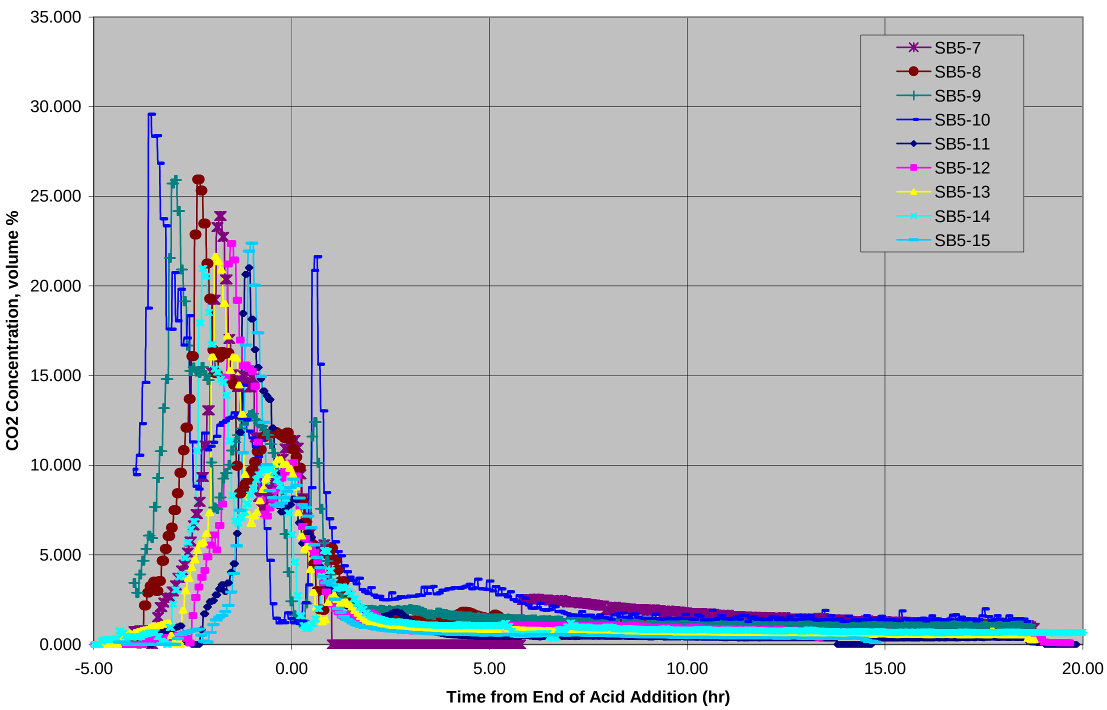


Figure C- 14. Carbon Dioxide Profiles

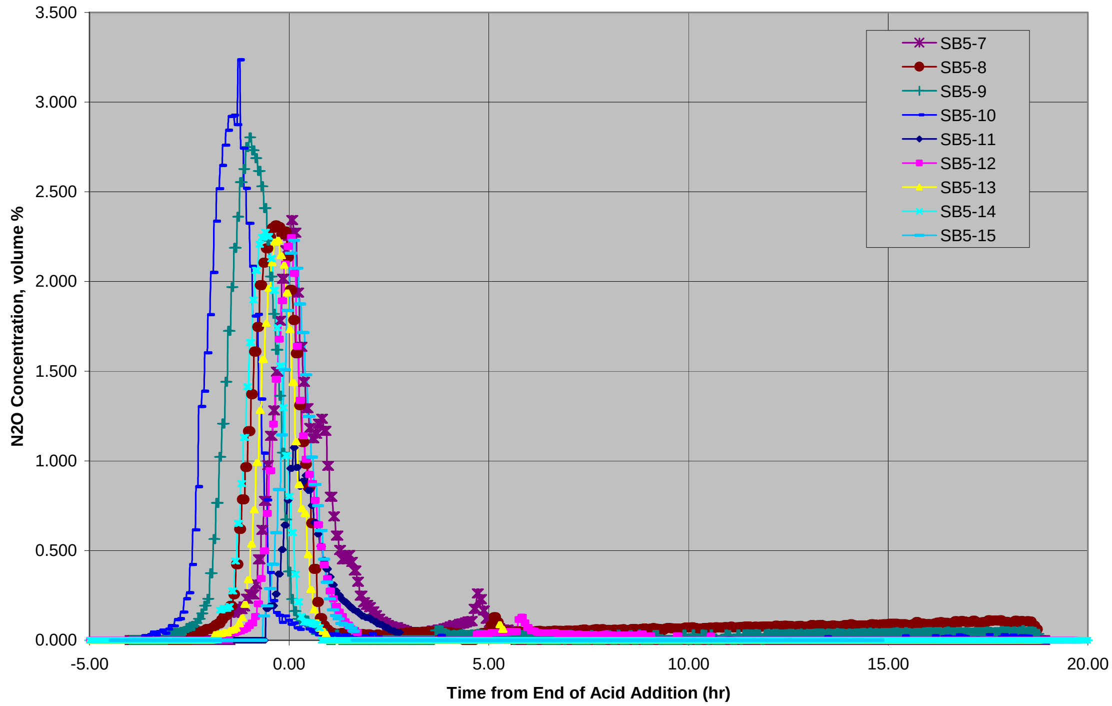
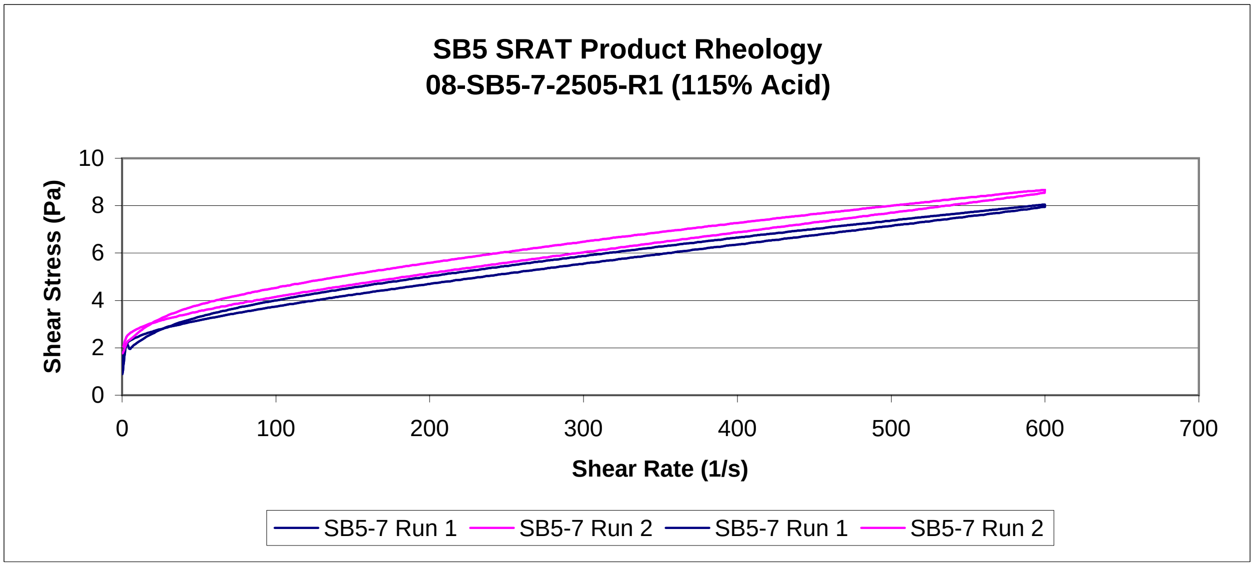


Figure C- 15. Nitrous Oxide Profiles

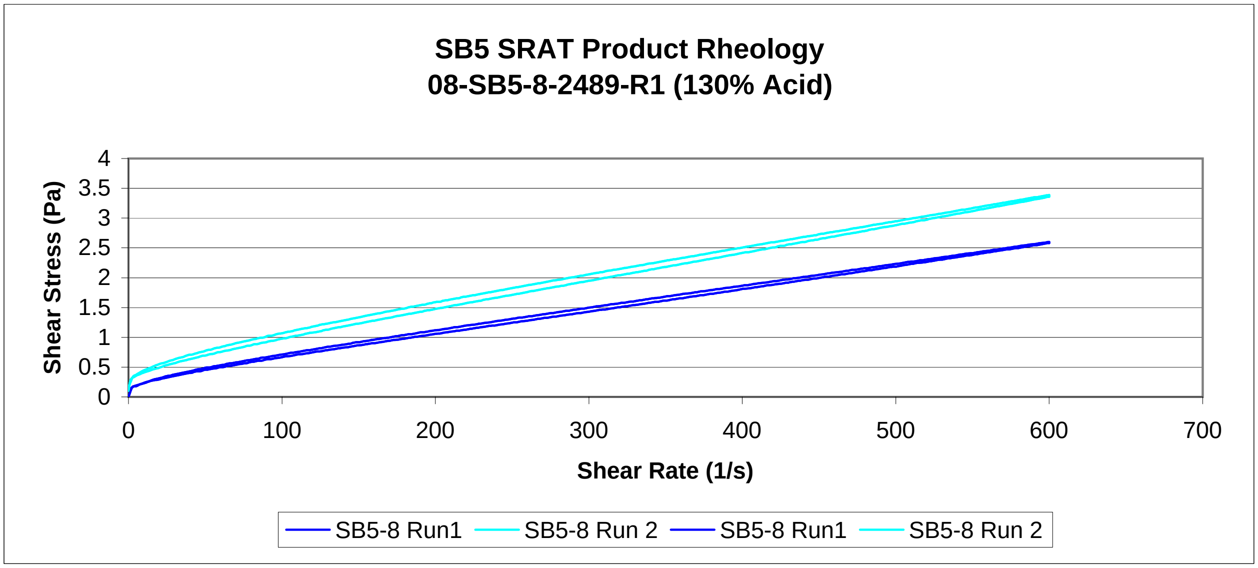
Appendix D. Rheological Results Charts and Flow Curves

Figure D- 1. SB5-7 (115% Acid) SRAT Product Flow Curves



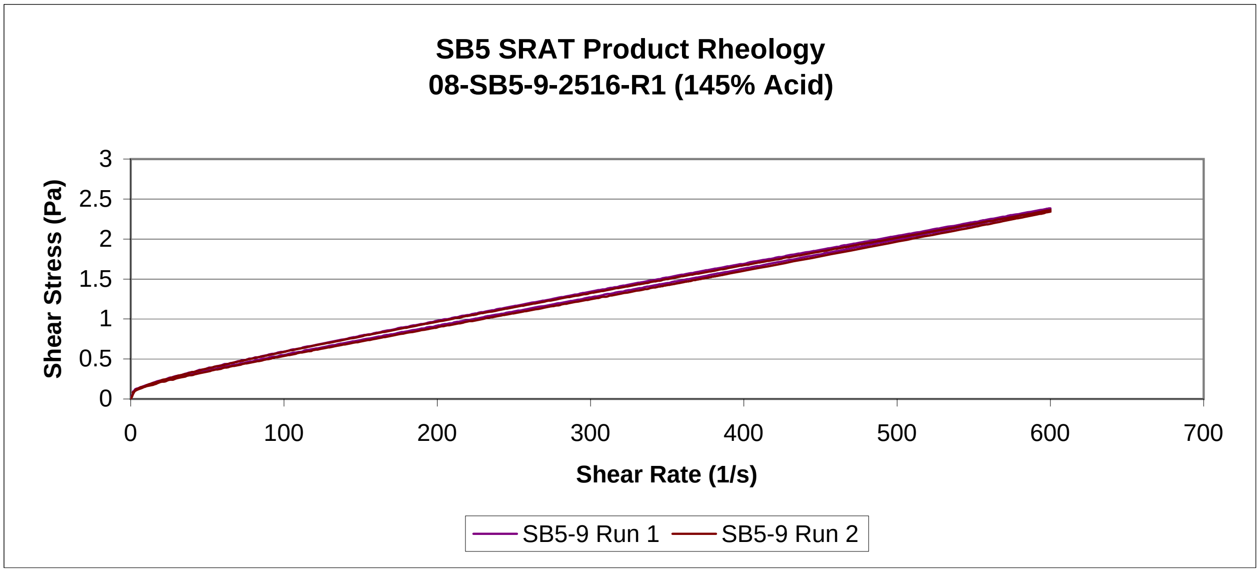
	Run 1		Run 1	
Curve	Yield Stress, Pa	Consistency, cP	Yield Stress, Pa	Consistency, CP
up	3.32	8.17	3.85	8.36
down	2.99	8.35	3.36	8.73

Figure D- 2. SB5-8 (130% Acid) SRAT Product Flow Curves



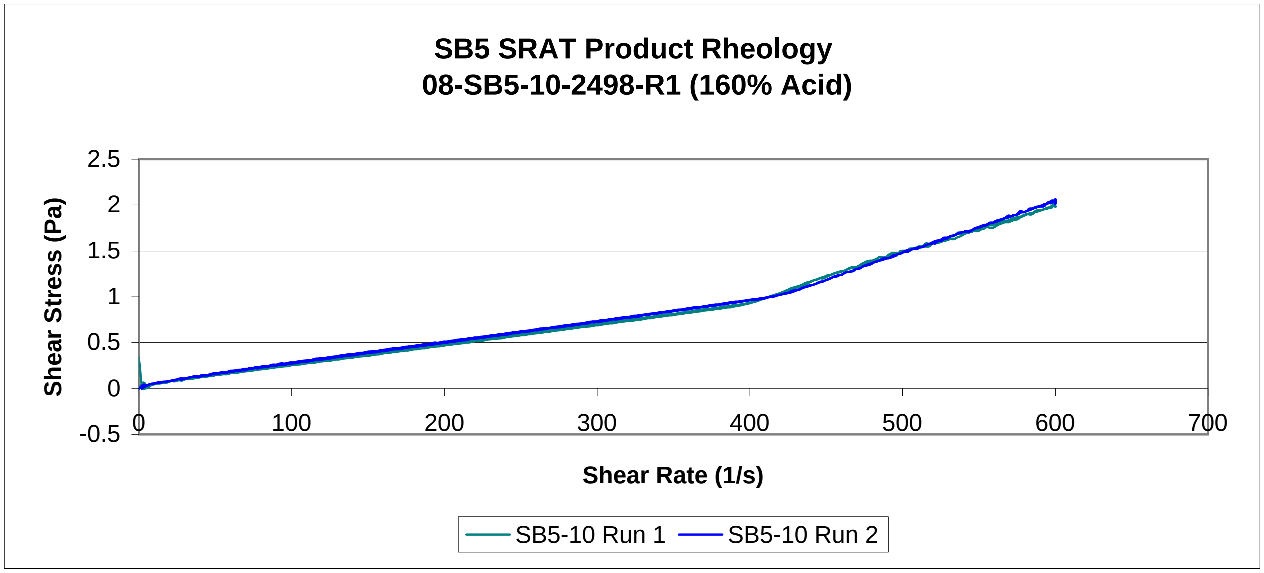
	Run 1		Run 1	
Curve	Yield Stress, Pa	Consistency, cP	Yield Stress, Pa	Consistency, CP
up	0.35	3.77	0.64	4.63
down	0.29	3.81	0.52	4.74

Figure D- 3. SB5-9 (145% Acid) SRAT Product Flow Curves



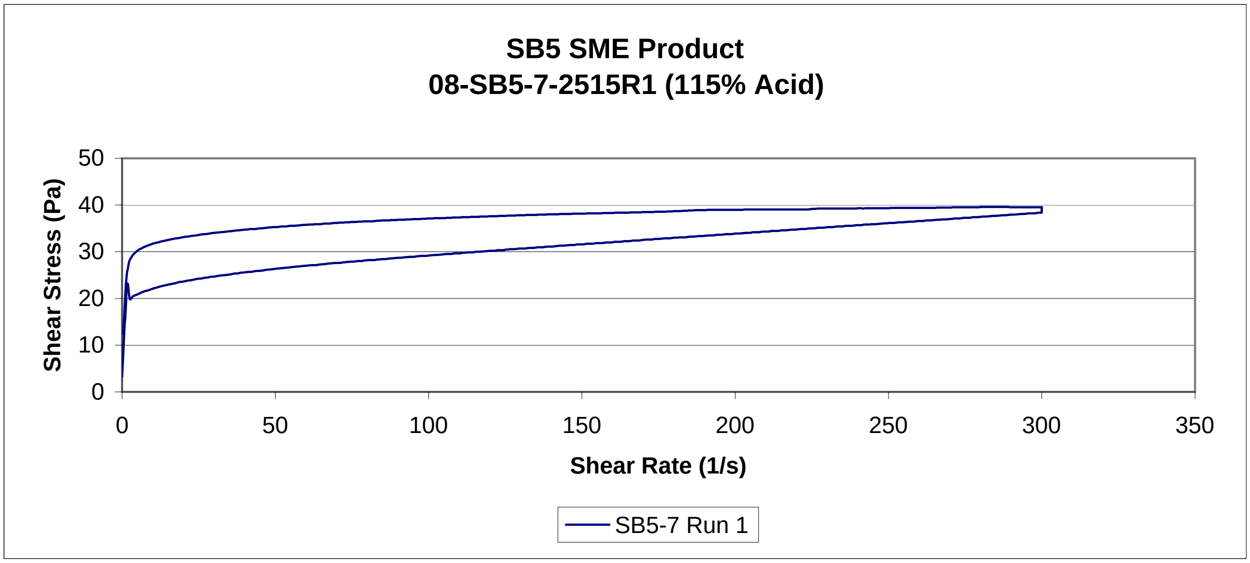
	Run 1		Run 1	
Curve	Yield Stress, Pa	Consistency, cP	Yield Stress, Pa	Consistency, CP
up	0.25	3.58	0.25	3.54
down	0.19	3.61	0.17	3.58

Figure D- 4. SB5-10 (160% Acid) SRAT Product Flow Curves



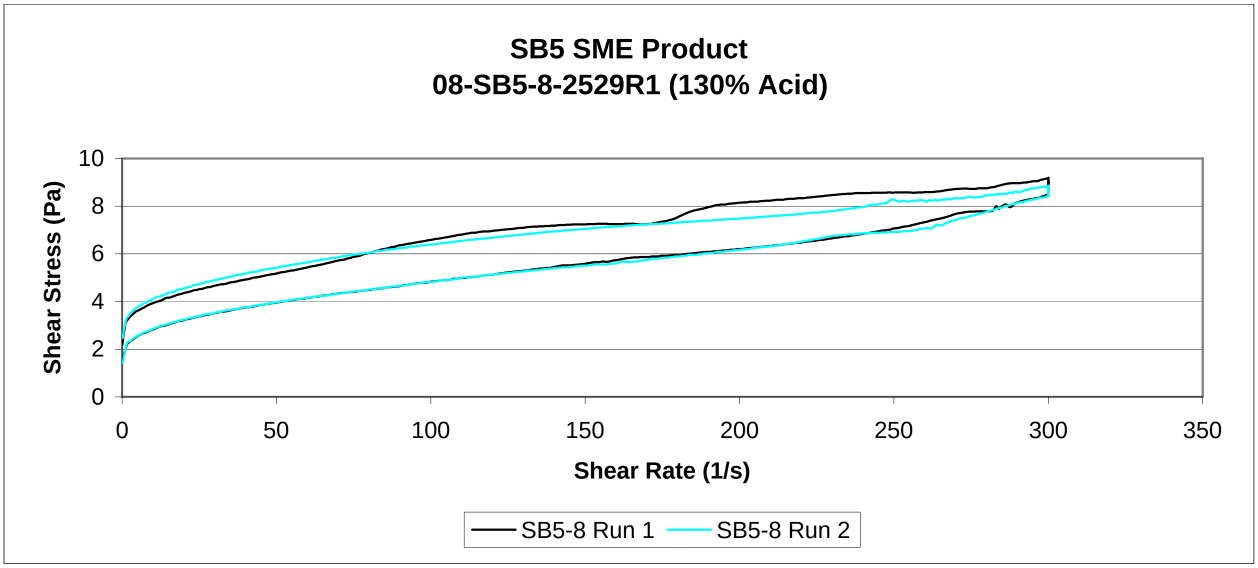
	Run 1		Run 1	
Curve	Yield Stress, Pa	Consistency, cP	Yield Stress, Pa	Consistency, CP
up	0.04	2.21	0.06	2.26
down	0.03	2.22	0.04	2.28

Figure D- 5. SB5-7 (115% Acid) SME Product Flow Curves



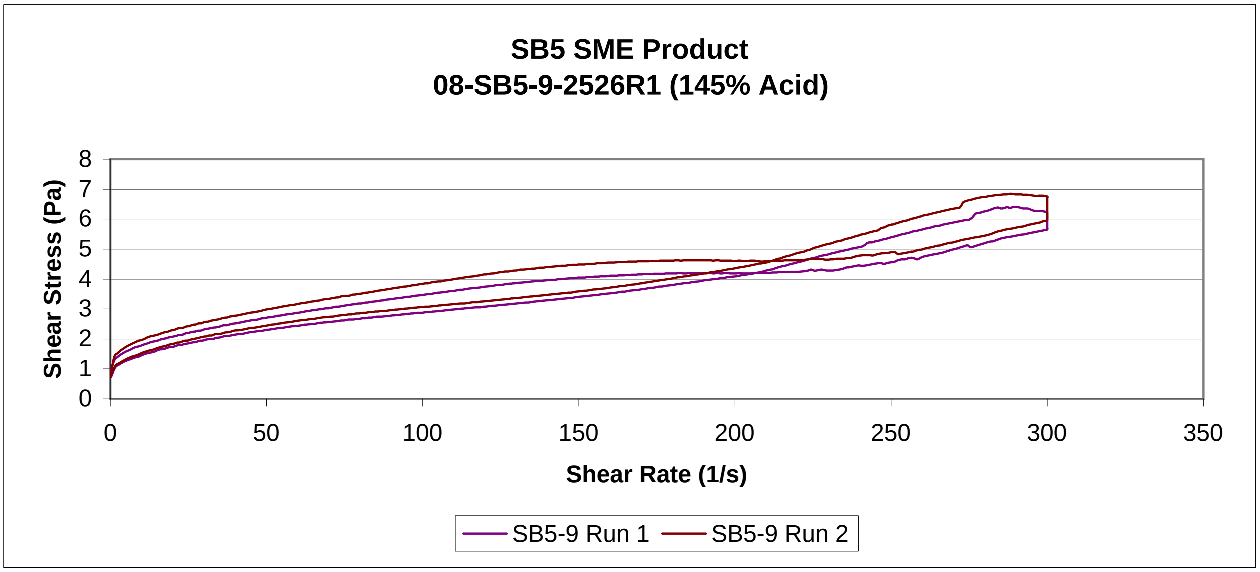
	Run 1		Run 1	
Curve	Yield Stress, Pa	Consistency, cP	Yield Stress, Pa	Consistency, CP
up	24.19	48.02	23.35	51.56
down	35.00	17.95	37.10	17.69

Figure D- 6. SB5-8 (130% Acid) SME Product Flow Curves



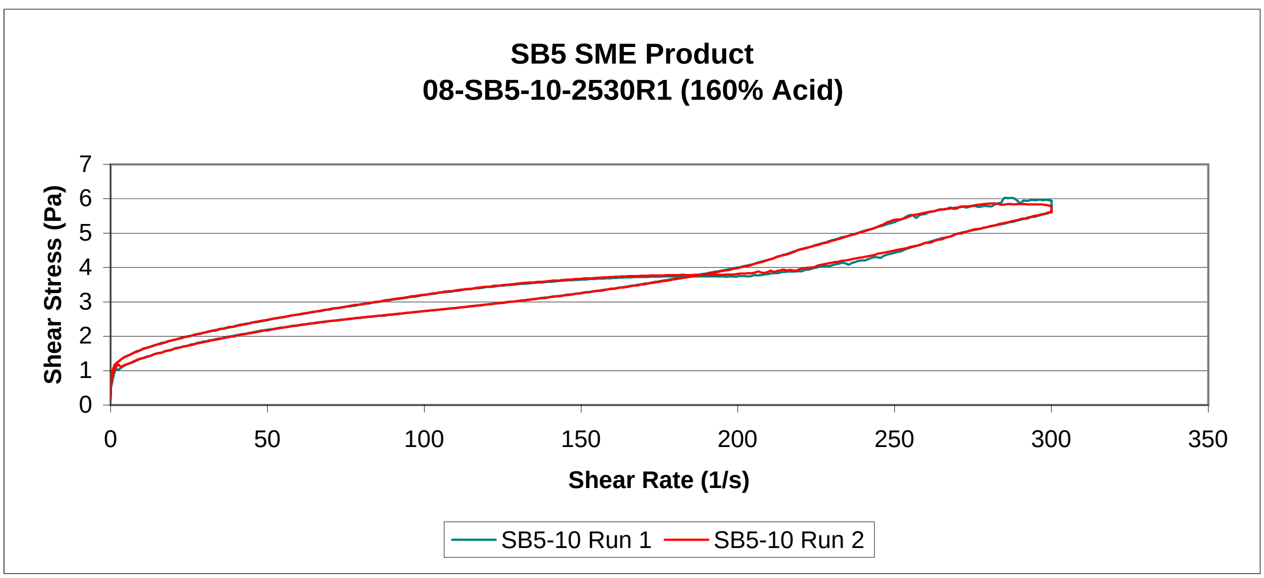
	Run 1		Run 1	
Curve	Yield Stress, Pa	Consistency, cP	Yield Stress, Pa	Consistency, CP
up	3.12	16.26	3.15	15.83
down	4.78	15.45	4.98	12.72

Figure D- 7. SB5-9 (145% Acid) SME Product Flow Curves



	Run 1		Run 1	
Curve	Yield Stress, Pa	Consistency, cP	Yield Stress, Pa	Consistency, CP
up	1.74	11.26	1.86	11.78
down	1.99	14.38	2.18	16.14

Figure D- 8. SB5-10 (160% Acid) SME Product Flow Curves



	Run 1		Run 1	
Curve	Yield Stress, Pa	Consistency, cP	Yield Stress, Pa	Consistency, CP
up	1.64	10.84	1.63	10.91
down	1.84	12.95	1.84	13.12

Distribution:

J.E. Marra, 773-A
J.C. Griffin, 773-A
C.C. Herman, 999-W
A.B. Barnes. 999-W
B. J. Giddings, 786-5A
S.D. Fink, 773-A
C. W. Gardner, 773-A
D. J. McCabe, 773-42A
D.A. Crowley, 773-43A
N.E. Bibler, 773-A
C.M. Jantzen, 773-A
M.E. Stone, 999-W
S.H. Reboul, 773-42A
J.D. Newell, 999-W
C.J. Bannochie, 773-42A
D.C. Koopman, 999-W
D.P Lambert, 999-W
J.M. Pareizs, 773-A
B.R. Pickenheim, 999-W
D.K. Peeler, 999-W
J.E. Occhipinti, 704-S
D.C. Sherburne, 704-S
R.T. McNew, 704-27S
T.L. Fellinger, 704-27S
J.M. Bricker, 704-27S
M.T. Keefer, 766-H
J.F. Iaukea, 704-30S
J.W. Ray, 704-S
B.A. Davis, 704-27S
H.B. Shah, 766-H
J.M. Gillam, 766-H
E.W. Holtzscheiter, 704-15S