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FOAMING/ANTIFOAMING IN WTP TANKS EQUIPPED WITH PULSE JET MIXERS AND AIR SPARGERS – INTERIM REPORT

JUNE 2004

SAVANNAH RIVER NATIONAL LABORATORY

Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808

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EXECUTIVE SUMMARY

Actual Hanford waste [pretreated AN-104 blended with Submerged Bed Scrubber (SBS) recycle (from simulant tests) and evaporated to 5 M Na 1.22 specific gravity] and simulants (AP-101, AN-104, and AY-102/C016 sludge/permeate) were tested in a foam column. The simulants and actual Hanford waste have shown a tendency to foam when solid particles are present and the solutions are subjected to air sparging. For example, the amount of foaminess[1] for pretreated AN-104/SBS recycle solution (as received) subjected to air sparging at a flux rate of 4.4ft3/min/ft2 was 138% at solid concentration of 1 wt.% as compared to 156% foaminess at solid concentration of 12 wt.%. Therefore, a test to demonstrate the effectiveness of Q2-3183A antifoam (Dow Corning) to mitigate the foaming tendency in the WTP tanks was completed. Additional testing of the Q2-3183A antifoam with actual Hanford waste (pretreated AN-104 sample from ion exchange column test) is in progress. Our preliminary results and analysis of past experimental efforts indicate that an initial charge of 1400 ppm of Q2-3138A antifoam to each slurry tank will reduce the foaminess in the WTP to an acceptable level. **Therefore, a batch addition of 1400 ppm antifoam (DOW Q2-3183A) added each day is recommended for use in WTP tanks equipped with air spargers and pulse jets.** The recommended dose of the Q2-3183A antifoam is conservative. Further investigation into refining the kinetic behavior of Q2 antifoam under radiation dose is recommended.

Table 1 provides the antifoam addition strategy to reduce the foaminess of the waste. The Ultrafiltration Feed tanks (UFP-VSL-00002A&B) undergo several modes of operation: 1) Concentration, 2) Washing, 3) Leaching, 4) Cleaning, 5) Transfer Pump and Steam Jet Operations. The HLW Lag Storage Tank and Blend Tanks are batch storage vessels that receive treated HLW sludge. In the case of the HLW blend vessel, Cs eluate and washed Sr/TRU precipitate are blended with HLW sludge and then transferred to the HLW vitrification building. The addition strategy is outlined in Table 1 along with relevant comments concerning each specific operation. All antifoam additions to the WTP slurry tanks should be using the recommended initial charge concentration of 1400 ppm in the receiving tank.

Previous investigations into the stability of DOW Q2-3183A antifoam have demonstrated very good chemical stability with little or no degradation observed at 50°C in 3 molar caustic for periods as long as a week.[1] Chemical stability of Q2-3183A at temperatures above 50°C has not been investigated. Discussion with DOW technical personnel indicate that Q2-3183A will likely breakdown at temperatures above 80°C. Therefore, it should be assumed that during leaching operations the antifoam may have to be added continuously to the UFP tanks. Since this study did not address leaching, it is recommended that future R&T studies investigate the foaminess of leached HLW sludge and antifoam performance and degradation during chemical leaching of HLW sludge. The

[1] % Foaminess is defined as the [(total height of liquid + foam – liquid height)/liquid height] * 100

stability and the performance of Q2-3183A in acidic conditions are also unknown. Surfactants of this type are usually tailored for specific pH ranges. These previous radiation and chemical stability tests indicate that a batch addition of Q2-3183A DOW antifoam added to the WTP slurry tanks every 24 hours is more than sufficient to maintain the antifoam concentration at an acceptable level that will reduce the foaminess of the Hanford waste.

Table 1 – Recommended Antifoam Addition Strategy to the UFP Feed, HLW Lag Storage and HLW Blend Tanks

UFP Operations-Addition Point	Frequency of Addition	Comments
Concentration-UFP Feed Tanks	1400 ppm batch addition every 24 hours	
Washing-UFP Feed Tanks & Wash Water Stream to UFP tank	1400 ppm batch addition to both addition points before the start of washing	Added to the UFP tank in a single dose at the start of washing and added to the wash water make-up/addition tank or wash water transfer line into the UFP tank. Thus, antifoam will be added to maintain the UFP tank at 1400 ppm.
Leaching – UFP Feed Tanks	Continuous addition to maintain 1400 ppm in UFP tank	This study did not address the chemical stability of the antifoam above 50°C. Conversations with DOW technical personnel indicate the antifoam may degrade at temperatures above 80°C. Continuous antifoam addition to maintain concentration at 1400 ppm is recommended at this time.
Cleaning – UFP Feed Tanks	Unknown	DOW consultants will be contacted prior to issuing the final report to determine the expected performance of Q2-3183A in acidic conditions. Foaminess of acidic slurries should be addressed by future R&T programs.
Transfer Pump and Steam Jet Operations – UFP Feed Tanks	1400 ppm batch addition before each transfer	This study did not address the foaminess of Hanford waste or simulants when subjected to pumping or steam jet operations. It is expected that some sparger air may be entrained in the waste and become atomized during transfer operations. The atomized air is likely to cause foaming in the waste.[2] Steam jets may also cause foaming in the waste.

UFP Operations-Addition Point	**Frequency of Addition**	**Comments**
HLW Lag Storage Tank Operations – Lag Storage Tank	1400 ppm batch addition every 24 hours and prior to each transfer of waste from the tank	
HLW Blend Tank Operations – Blend Storage Tank	1400 ppm batch addition every 24 hours and prior to each transfer of waste from the tank	
Transfer of Sr/TRU	None, as long as a batch addition is made every 24 hrs	The foaminess of HLW sludges with eluate was not tested by this study. Future R&T programs should assess this operating scenario.
Transfer of Eluate	None, as long as a batch addition is made every 24 hrs	The foaminess of HLW sludges with eluate was not tested by this study. Future R&T programs should assess this operating scenario.

INTRODUCTION

The River Protection Project-Waste Treatment Plant (RPP-WTP) requested Savannah River National Laboratory (SRNL) to conduct small-scale foaming and antifoam testing using actual Hanford waste and simulants subjected to air sparging. The foaminess of Hanford tank waste solutions was previously demonstrated in SRNL during WTP evaporator foaming and ultrafiltration studies and commercial antifoam DOW Q2-3183A was recommended to mitigate the foam in the evaporators.[3, 6] Currently, WTP is planning to use air spargers in the HLW Lag Storage Vessels (HLP-VSL-00027A/B), HLW Concentrate Receipt Vessel (HCP-VSL-00001/00002), and the Ultrafiltration Vessels (UFP-VSL-00002A&B) to assist the performance of the Jet Pulse Mixers (JPM). Sparging of air into WTP tanks will induce a foam layer within the process vessels. The air dispersion in the waste slurries and generated foams could present problems during plant operation. Foam in the tanks could also adversely impact hydrogen removal and mitigation. Antifoam (DOW Q2-3183A) will be used to control foaming in Hanford sparged waste processing tanks. These tanks will be mixed by a combination of pulse-jet mixers and air spargers. The percent allowable foaminess or freeboard in WTP tanks are shown below. Table 2 values were calculated from the data in the spreadsheet provided by WTP. The original spreadsheet is included in the CD-ROM.

Table 2 - % Allowable Foaminess in WTP Tanks before Reaching Overflow Level

WTP Tank	WTP Tank	% Allowable Foaminess (or freeboard) before reaching Overflow Level
Ultrafiltration Feed Process Vessels	UFP-VSL-0002 A/B	29-32%
HLW Lag Storage Vessels	HLP-VSL-00028	19-21%
HLW Blend Vessel	HLP-VSL-00027 A/B	18-21%
HLW Concentrate Receipt Vessel (CRV)	HCP-VSL-0000 1/2	40-45%

Table 2 provides a basis for an acceptance criteria for the antifoam used in these studies. Given the scale of the tests involved for this study and the estimated measurement error involved, a preliminary acceptance criterion of 10 - 40% foaminess after antifoam addition will be used to evaluate the antifoam. The basis for this success criterion is engineering judgment and analysis of available design and relevant development data. This criterion is expected to change, as more data becomes available. Future R&T studies using a pilot test rig could be employed to optimize this criterion and the antifoam addition strategy. After this study was initiated, the CRV was deleted from the design. Therefore, this criterion will be reevaluated before the final report is issued for this task.

The suitability and period of effectiveness of the Dow Corning anti-foam agent Q2-3183A and/or alternative antifoams will be evaluated.

FOAM TESTING OBJECTIVES

Small-scale foam and antifoam testing was initiated at SRNL in April 2004. The test objectives and status are listed below.

Test Objective	Status	Discussion
1. Determine the foaminess of actual Hanford Waste when subjected to air sparging	In progress	Simulant work and one radioactive waste test has been completed.
2. Determine if the baseline WTP evaporator antifoam agent (or alternative antifoam agents) will effectively mitigate foaming in the WTP tanks containing non-Newtonian slurries that are equipped with pulse jet mixers and air spargers	In progress	Test to demonstrate the effectiveness of the commercial antifoam Q2-3183A to mitigate the foaming tendency of actual Hanford waste (pretreated AN-104/SBS recycle) has been completed.
3. Determine if incorporation of CO_2 from air sparging changes the pH (chemical composition) of the simulant as a function of air sparge time, volume, etc	In progress	The work began in May
4. Determine if the rheology of simulant changes as a function of air sparge time, volume, etc.	In progress	The work began in May

SUMMARY EXPERIMENTAL FINDINGS

1. Actual Hanford waste sample (pretreated AN-104 blended with SBS recycle) and simulants have been demonstrated to foam when subjected to air sparging. The amount of foaminess was quantified by measuring the total height of air entrained liquid and foam as well as the liquid height prior to air sparging.

2. The amount of foaminess of the pretreated AN-104 blended with SBS recycle increased with the initial increase in the concentration of solid particles. Figure 11 shows a side view of foam bubbles generated from the Hanford waste. The picture to the left shows that the foam height of air sparged AN-104/SBS recycle sample (as received) at 1 $ft^3/min/ft^2$ before the addition of the Q2 antifoam. To the left, the picture shows after addition of 1100 ppm Q2 antifoam.

For example, the amount foaminess of the as received pretreated AN-104/SBS recycle sample, which contained 1 wt.% solids was 138% as compared to 156% foaminess for the samples at 12 wt.% solids at the flux rate.

3. The amount of foaminess of AN-104 and AP-101 simulants without insoluble solids was negligible. The maximum foaminess for these simulants reached 200-300 % at solid concentrations of 12-15 wt. % for the range of air flux rates studied.

4. The rate at which air was sparged into the liquid has direct (but not linear) bearing on the amount of foaminess.

5. A concentration of 1400 ppm Q2-3183A antifoam has demonstrated effectiveness in reducing the amount of foaminess of the pretreated Hanford waste AN-104 /SBS recycle at or below the allowable 20% foaminess.

6. The performance of DOW Q2-3183A as both an antifoam and defoamer has been demonstrated with simulant waste testing of AY-102/C106 at 10 wt.% solids concentration. For example, the addition of 100- 400 ppm of the antifoam Q2-3183A completely destroyed existing foams in the foam column.

7. The foam generated in the actual Hanford waste and simulants was unstable. The foam collapsed within seconds after the air sparging was stopped.

FOAM TEST APPARATUS AND METHODOLOGY

The apparatus used to perform the foaming and antifoam experiments consisted of a glass foam column (3.1cm diameter x 60cm height) with graduations along the column wall, an air flow metering device with three-way valve, a Disto Pro4 laser measuring device interfaced to a computer data collection system, and a Mini-DV video recording camera. The foam column had a coarse fritted disk (75-100 micron) fitted into its base. To provide the air sparging, air was introduced into the column through a 0.6cm (1/4-inch) i.d. tube directly below the fritted disk. The flow of air was controlled by a mass flow meter. A three-way valve below the column air-supply tube was utilized to divert air away from the column during intermittent air flux rate changes between tests.

The non-radioactive experiments were conducted within a ventilation hood at the SRNL facilities within the Aiken County Technology Laboratory (ACTL). The experiments with radioactive waste (actual Hanford sample) were conducted in a rad-hood at the SRNL 773-A, C-Wing laboratory. A photograph of the apparatus in the rad-hood is shown in Figure 1 (below).

Figure1. Photograph of Foam Test Apparatus in Rad-hood in SRNL 773-A, C-Wing laboratory Module

Foaming experiments were carried out in the apparatus described above. Air was introduced via the fritted disk through the sample at air flux rates of 1.1, 2.2, 3.3, 4.4, 6.6, 8.8, 11.0, 13.2, 15.4 and 17.6 $ft^3/min/ft^2$. These flux rates correspond to air flow rates of 0.25, 0.5, 0.75, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, and 4.0 L/min, controlled by a mass flow meter (MKS Instruments, Inc.). The experiments were first conducted with simulants (supernatant liquids) free of solid particles. This was followed with simulants containing different initial concentrations of insoluble solids. The solutions with insoluble solids were prepared from the simulants or actual Hanford waste and a simulant of AY-102/C106 sludge at 20-24 wt.% insoluble solids. Known amounts of the solutions (typically, 48 mL for simulants and 32 mL for actual Hanford waste) were added to the foam column to a level of about 4 cm above the fritted disk. Air-flow was started, and foam height was measured as a function of time using a Disto Pro4 laser measuring device; the foam height at steady state was also recorded by visual observation. The air-flow was then switched off, and the foam collapse was followed as function of time. All experiments were performed in an open system at atmospheric pressure and ambient temperature (25 ± 2 ^oC).

Antifoam tests were performed by two methods. A solution of antifoam DOW Q2 was prepared using 1 part of Q2-3183A in 100 parts de-ionized water. In the first method, an incremental dose of the antifoam was added drop wise to existing foam in the foam column under constant air-flow, and the collapse of the foam was followed. In the second method, the Q2 antifoam was mixed into the test solution at rest prior to introduction into the foam column, and then the foaming test was carried out as previously described.

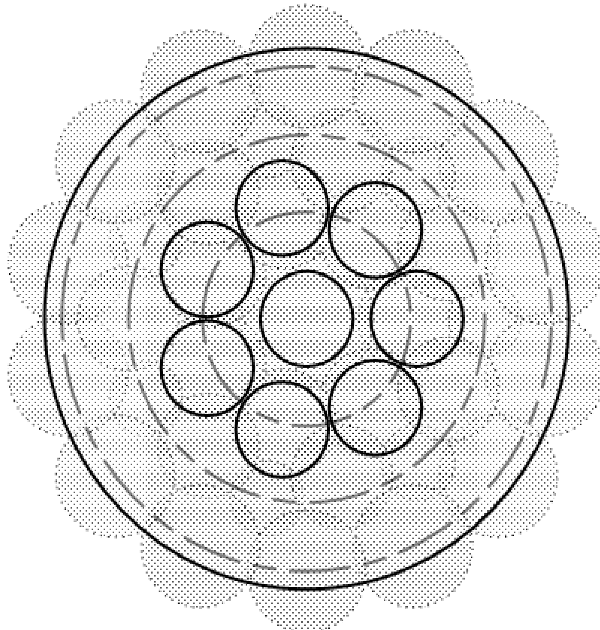
AIR FLUX RATE DETERMINATION

The air sparge rates used in the foam experiments was derived from information provided by WTP personnel. The size of the SRNL small-scale foam column was based on the dimensions of the HLW LAG Storage Vessel (HLP-VSL-00027A/B). This vessel has an inside diameter of 25 feet and contains 36 sparge tubes with a total air sparge requirement of 1249 scfm (2.037 liter/min). The nominal air flux rate for this vessel is 2.575 $ft^3/min/ft^2$ during normal air sparging. This air flux rate was considered to be the nominal for the small-scale foam test being investigated. Rates above and below this nominal flux rate were selected for the sparging tests with the simulant and actual Hanford waste.

The air flux rates used in the experiments were in the range of 1.1 to 17.6 $ft^3/min/ft^2$. The flow rates were calculated based on the dimensions and the total air flow for the full-scale tank (HLW Lag Storage Vessels -HLP-VSL-00027A/B) with 36 sparge tubes as illustrated in Figure 2. The full-scale tank vs. small foam column scale factor was 1/49. The size of the fritted disk (75-100 micron) was selected to provide the same air flow as that from 36 air nozzles in the full-scale tank.

The calculated air flux rate for the HLW Blend vessel and Ultrafiltration Feed vessels are encompassed by this test range.

36 Sparge Tube Cluster Design	# OF TUBES	2/3 ZOI (in.)	flow/tube (acfm)	subtotal (acfm)
	14	68	27.3	382
	7	42	6.9	48
	7	58	17.3	121
	7	60	19.1	133
	1	76	37.5	37
			Total Sparge Tubes:	36
			Total Air Flow (acfm):	722
			Total Air Flow (scfm):	1264



HLP-VSL-00027A/B
Cluster Design
36 Sparge Tubes
PLAN VIEW

Figure 2. Plan view of HLW Lag Storage tank air sparge tubes

COLUMN WALL EFFECTS

The effect of column diameter (wall effects) was determined to allow selection of the most appropriate (e.g. sample volume, L/D) size column for the simulant and radioactive tests.

To determine the wall effect of air sparged liquids, three foam columns of different internal diameters were tested. It has already been reported that the wall effect is negligible if the inner diameter of the foam column is larger than 3 cm. Therefore, the columns we selected had inside diameters 1.45, 3.1, and 5 cm and a height of 60 cm. The experiments in the three foam columns were conducted identically at open atmospheric pressure and a temperature of 25 ± ^{o}C. The air sparge rates used varied from 1.1 to 6.6 $ft^3/min/ft^2$. A sample of AY-102/C106 simulant at 10 wt. % solids was added into each column to the same height of liquid (4.0 cm at rest). Air was introduced into each column through the 75 – 100 micron fritted disk located in the base of the column at flux rates between 1.1 and 6.6 $ft^3/min/ft^2$. The steady state foam height (air entrained) was recorded for each flux rate.

The results of the experiments for three column sizes are shown in Figure 3. The results indicate the smallest column (1.45 cm i.d.) is impacted by wall effects. The comparison of the 3.1 and 5.0 cm inside diameter columns clearly shows negligible wall effects in the same experimental conditions. The foaminess in the 3.1 and 5 cm columns are in agreement. Therefore, the 3.1 cm i.d. column was selected for testing. A rigorous analysis of the effects of fluid dynamics (liquid velocity, gas holdup, bubble velocity and size) in the 3.1 cm i.d. column has not been investigated.

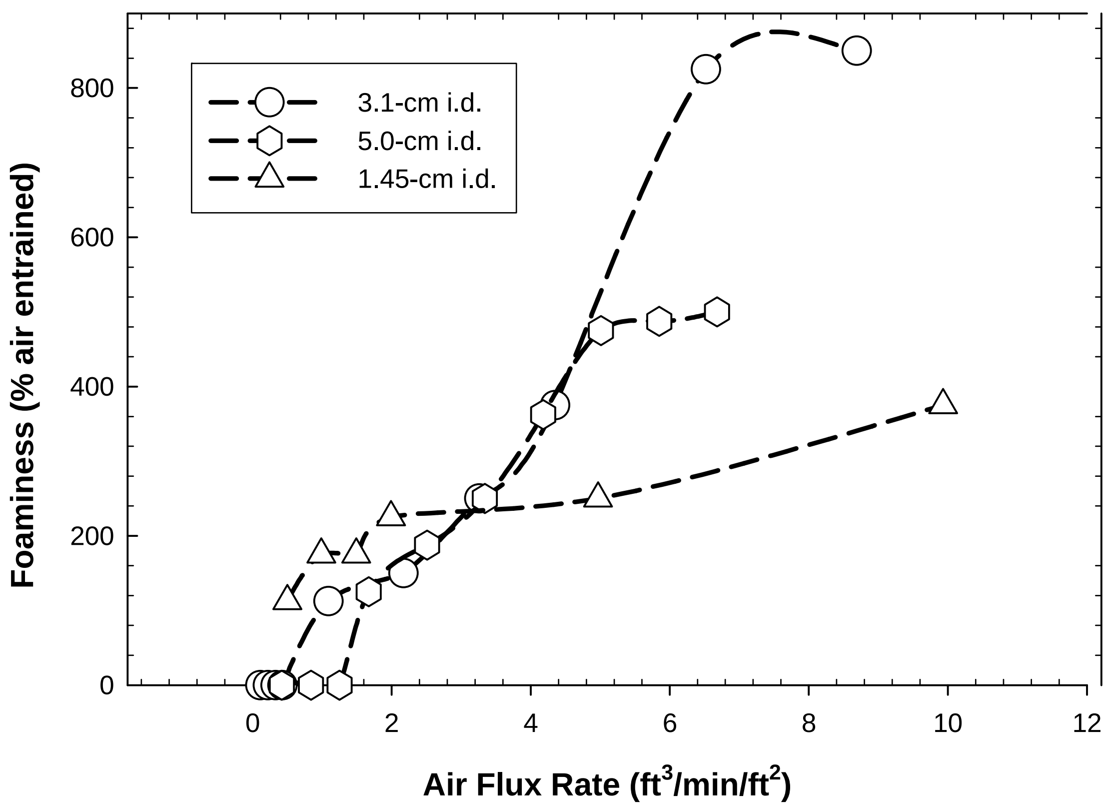


Figure 3. The effect of column diameter on foam behavior (wall effect)

EFFECT OF NOZZLE SIZE

Three separate column tests were conducted to determine if the method (fritted disk) for introducing the sparge gas into the simulant solution was conservative with respect to the WTP sparge nozzle design. Three different nozzles were fabricated to deliver air into the 3.1 cm i.d. graduated column. The nozzles were constructed with bore sizes of 1/16, 1/8 and ¼ inch. Each nozzle was supplied with air that produced incremental sparge rates from 1.1 to 17.6 $ft^3/min/ft^2$ through the 3.1 cm column. As is indicated by the data chart below, all three single nozzles performed similarly to one another. When the % foaminess produced by the single nozzle air sparge tests are compared to the 75-100 micron coarse fritted disk tests at the same air flux rates, it is evident that the % foaminess values produced by the fritted disk are more than double that of the single nozzles. The testing performed at SRNL all incorporated the fritted disk, which provides the more extreme foaming condition and therefore provides a more conservative test of foaming and antifoam properties.

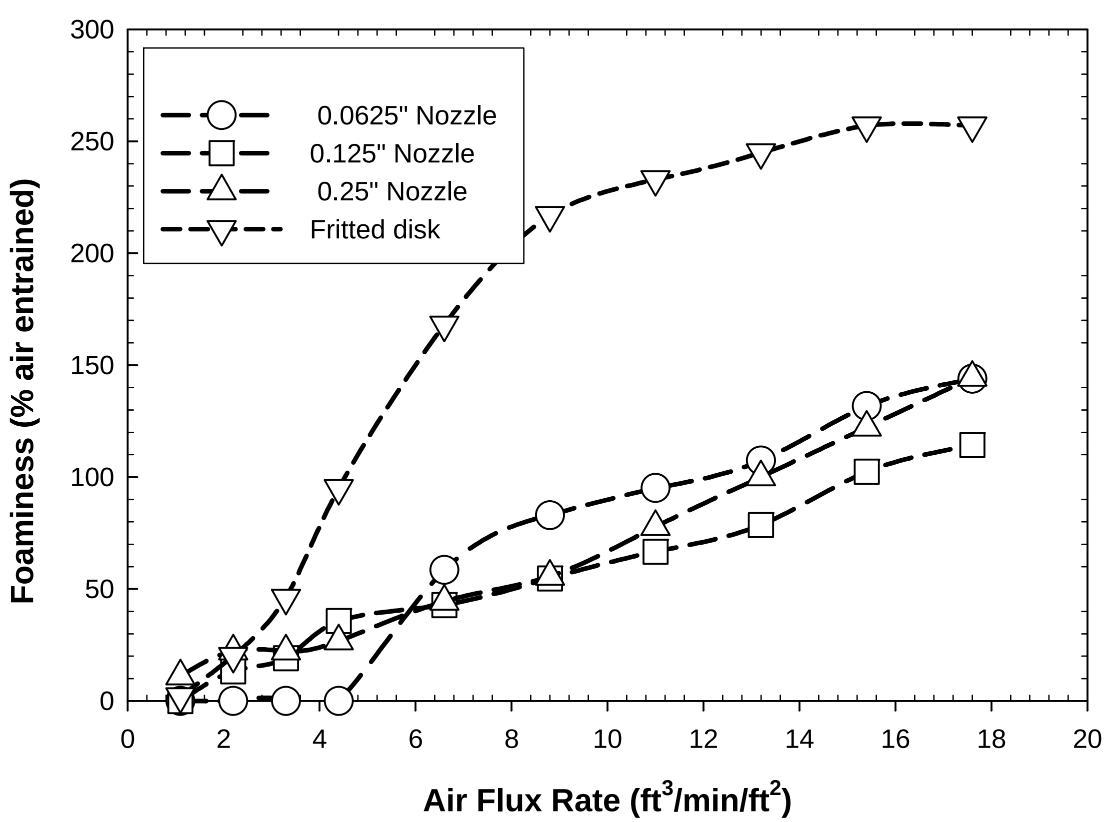


Figure 4. Effect of air sparge tube sizes on foaminess of AY-102/C-106 slurry (10 wt.% solids)

RADIATION AND CHEMICAL STABILITY OF Q2-3183A

The Q2-3183A antifoam has been found to degrade under radiation doses.[1] Samples of LAW simulants spiked with 1500 ppm Q2 were subjected to the maximum expected HLW radiation dose equivalent to a week of storage.[5]

Analysis of these samples by DOW indicated a normalized degradation rate which follows first order kinetic decay. The equation which describes this decay follows:

$$C = C_0 \exp^{(-0.0092t)}$$

Where C is the concentration of antifoam at some time , t (hrs)
C_0 is the initial concentration at time t=0 hrs
t is in total time exposed to the maximum dose in hours

NOTE: The equation above was developed with only minimal data (6 points) and further investigation into the radiation stability of Q2 antifoam is recommended before applying this type of analysis to the design of the antifoam system.

This equation predicts that 20% of the Q2 antifoam would degrade in 24 hours at the maximum radiation dose. To maintain the 1400 ppm concentration limit, an initial charge of 1400 ppm would be required as the tank is filled, and a charge of 350 ppm every 24 hours to offset the amount of Q2 destroyed by radiation. This addition strategy leads to a saw tooth pattern in antifoam concentration with a maximum at 1750 ppm and a minimum of 1400 ppm. **While analysis of this data indicates that an optimized antifoam addition strategy could be developed for the WTP pulse jet tanks, the data above was generated using maximum HLW dose rates on a limited number of LAW simulant samples.** A more prototypical dose rate will lead to increased levels of antifoam as addition of Q2 is added day after day. Additional irradiation studies will allow optimization of the antifoam addition.

Previous investigations into the stability of DOW Q2-3183A antifoam have demonstrated very good chemical stability with little or no degradation observed at 50°C in 3 molar caustic for periods as long as a week.[1] Chemical stability of Q2-3183A at temperatures above 50°C has not been investigated. Discussion with DOW technical personnel indicate that Q2-3183A will likely breakdown at temperatures above 80°C. Therefore, it should be assumed that during leaching operations the antifoam may have to be added continuously to the UFP tanks. Since this study did not address leaching, it is recommended that future R&T studies investigate the foaminess of leached HLW sludge and antifoam performance and degradation during chemical leaching of HLW sludge. The stability and the performance of Q2-3183A in acidic conditions are also unknown. Surfactants of this type are usually tailored for specific pH ranges.

These previous radiation and chemical stability tests indicate that a batch addition of Q2-3183A DOW antifoam added to the WTP slurry tanks every 24 hours is more than

sufficient to maintain the antifoam concentration at an acceptable level that will reduce the foaminess of the Hanford waste.

The fate of Q2-3183A across the WTP pretreatment process is currently being investigated as part of the Semi-Integrated Pilot Plant task and will be reported separate from this task.

FURTHER PROCESS DESIGN CONSIDERATIONS

1) Q2-3183A has a quoted viscosity of between 1800 – 3500 cps. While somewhat thick, it pours easily at room temperature. The antifoam behaves as a Newtonian fluid. No yield stress has been observed or measured by SRNL. The actual viscosity of the sample used by SRNL was 1000 cps at 25 °C.
2) DOW recommends that Q2-3183A be diluted with water 3-10 parts water to 1 part Q2. DOW also recommends that diluted antifoam be used immediately after mixing with water. The measured viscosity of 10/1 and 5/1 diluted antifoam was 1.5 and 2.2 cps, respectively. Dilution reduces the viscosity significantly, and allows fine silica solids to settle out of the suspension. The particles are readily suspended when agitated. However, if left standing in dead legs of transfer piping, the fine silica solids (mean particle size of 15 microns) may accumulate over time. Therefore, SRNL recommends that diluted antifoam transfer piping should be designed to minimize low points that may allow solids to accumulate over time.
3) No segregation has been observed with undiluted antifoam. Addition to the process without dilution should be considered.
4) The antifoam has a shelf life of 12 months when maintain at or below 32 °C.

SMALL-SCALE SIMULANT TEST RESULTS

Sixteen experiments of the small-scale simulant foam testing were completed and the data is now being analyzed. The last experiment of the test matrix (test #17- extended air sparging) is in progress. Figure 5 shows the results of the AY-102/C106 supernate simulant with different concentrations of insoluble solids from AY-102/C06 sludge. Experiments with AY-102/C016 supernate with no solid particles exhibited negligible foaming. Therefore, the foaminess in this simulant was due to the presence of insoluble solid particles. The amount of foaminess increases (as shown in Figure 5) with the increase in concentration of insoluble solids in solution. Also, the foaminess of the AY-102/C106 supernate with solid particles increased with air sparge rate. The foam generated was unstable and immediately collapsed after the air sparge was terminated.

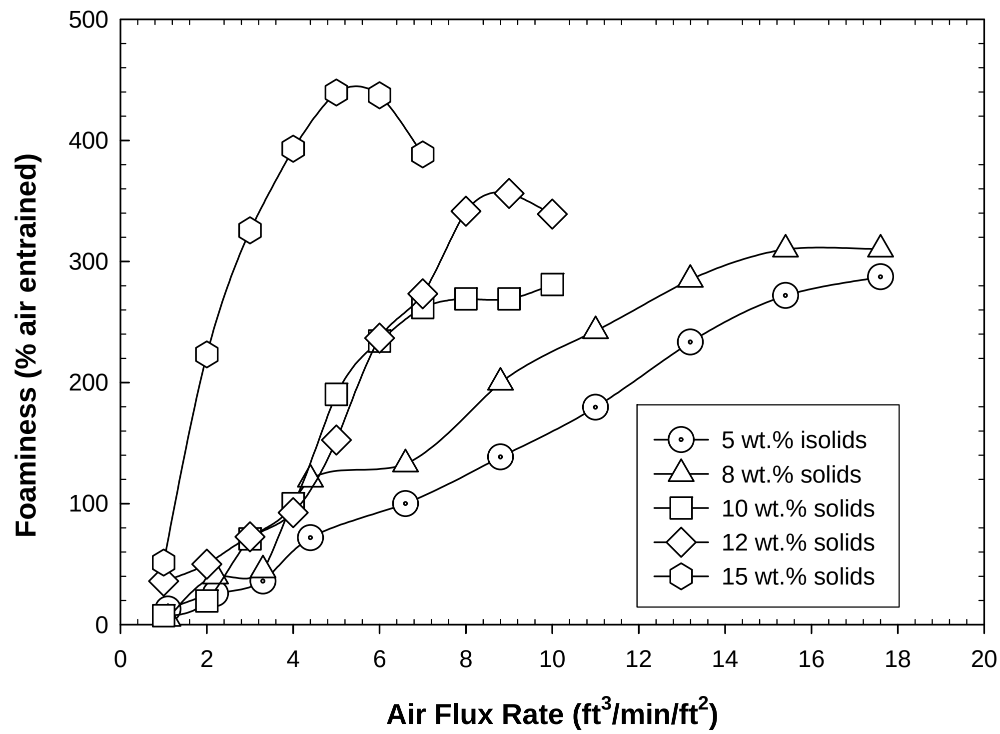


Figure 5. Effect of solid particles on foaminess of AY-102/C106 simulant

Figure 6 shows the results of the foam experiment with AP-101 simulant at various concentrations of AY102/C106 insoluble solids. The results show that foaminess of the simulant is affected by the presence of solid particles. An experiment with no solid particles exhibited no foaminess at the various flux rates studied. In the presence of solid particles, the foaminess of the AP-101 simulant increased in a somewhat linear fashion with the increase in air sparging rate. The foam was unstable and collapsed immediately after the air sparing was terminated.

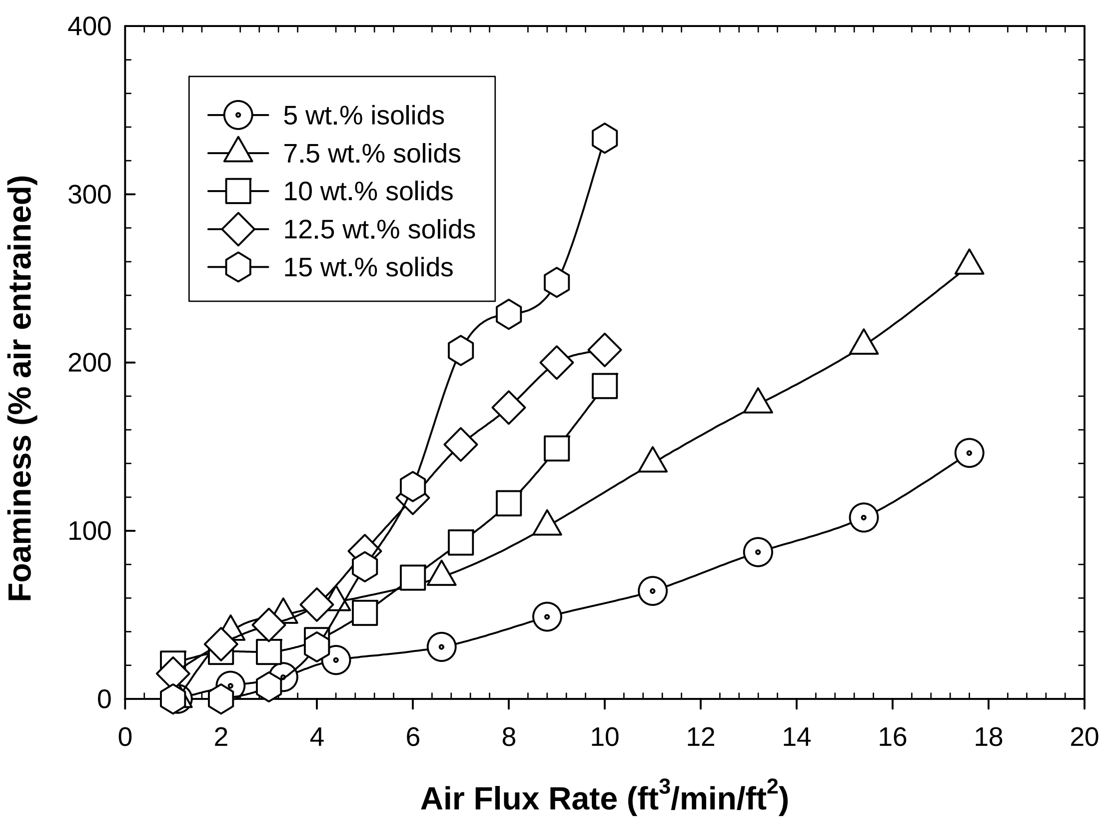


Figure 6. Effect of solid particles on foaminess of AP-101 simulant

Figure 7 shows the results of foaming experiment of air-sparged AN-104 simulant. The results indicate that foaminess (i.e., the volume percent of air incorporated) of the AN-104 simulant increased with the increase in the concentration of AY102/C106 solids particles from 3 to 9 wt. % solids only when the air flux rate exceeded 5 $ft^3/min/ft^2$. At air flux rates less than 5 $ft^3/min/ft^2$, the increase in the concentration of insoluble solids had limited effect on foaminess. At higher flux rates, the solution is concentrated due to evaporation and the wt.% insoluble solids may increase. The AN-104 simulant without insoluble solids exhibited negligible foaminess. In addition, the foam generated in the AP-101 simulant was unstable and collapsed within seconds after the air sparging of the system was terminated.

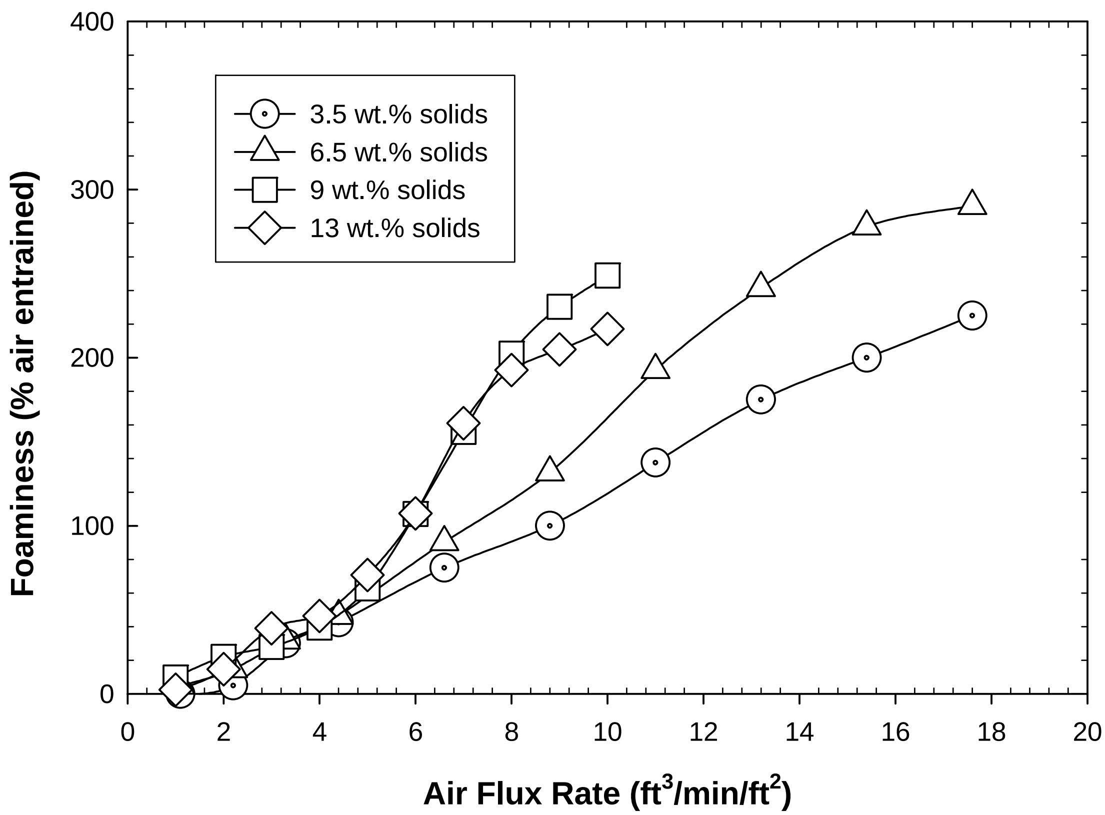


Figure 7. Effect of solid particles on foaminess of AN-104 simulant

Figure 8 shows the results of the foaming experiments with washed AZ-101 sludge (nominal) simulant. To prepare the AZ-101 solution at different initial concentrations of insoluble solids, the AZ-101 sludge system was diluted with inhibited water. The effect of the solid particles on the foaminess of the AZ-101 sludge system is clearly seen only after the air flux rate exceeded 4.4 $ft^3/min/ft^2$. The foaminess of this sample generally increased with air sparge rate. It is problematic to measure the height of the air entrained liquid for this sludge as it tended to cling to the internal walls of the foam column.

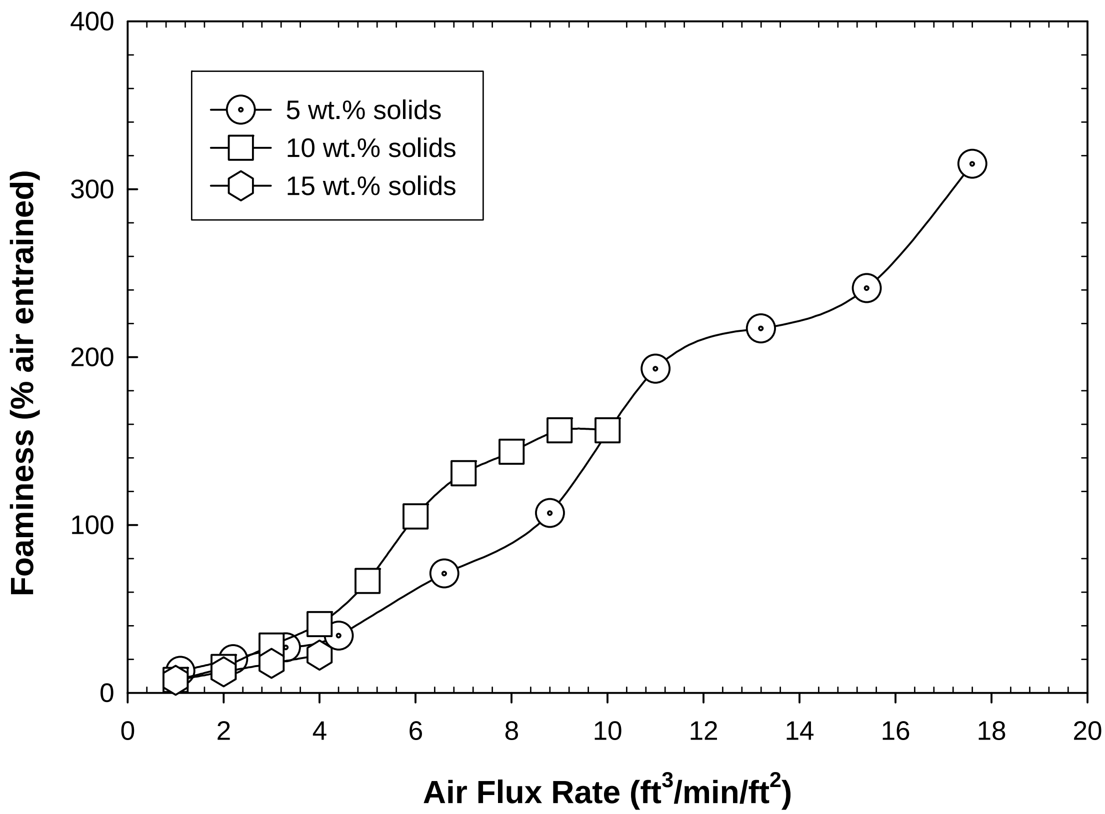


Figure 8. Effect of solid particles on foaminess of washed AZ-101 (nominal) simulant

SMALL-SCALE RADIOACTIVE TEST RESULTS

Figure 9 shows the results of the foaminess experiment with actual Hanford waste (pretreated AN-104/SBS recycle solution) sparged with air at different flux rates. The "as received" AN-104/SBS recycle has a quoted 1 wt.% insoluble solids. Experiments with the "as received" samples exhibited a strong tendency to foam; a maximum foaminess of 138% was observed with this sample at a flux rate of 4.4 $ft^3/min/ft^2$. A steady increase of the foaminess of the AN-104/SBS recycle solution with increase in the concentration of the solid particles was noted at flux rates below 4.4 $ft^3/min/ft^2$. The foaminess of the system at different wt.% insoluble solids loadings decreased as the flux rate exceeded 4.4 $ft^3/min/ft^2$. The cause of this behavior for the real waste vs. simulant is not yet understood. The foam generated during the AN-104/SBS recycle testing was unstable and collapsed quickly upon termination of air sparing.

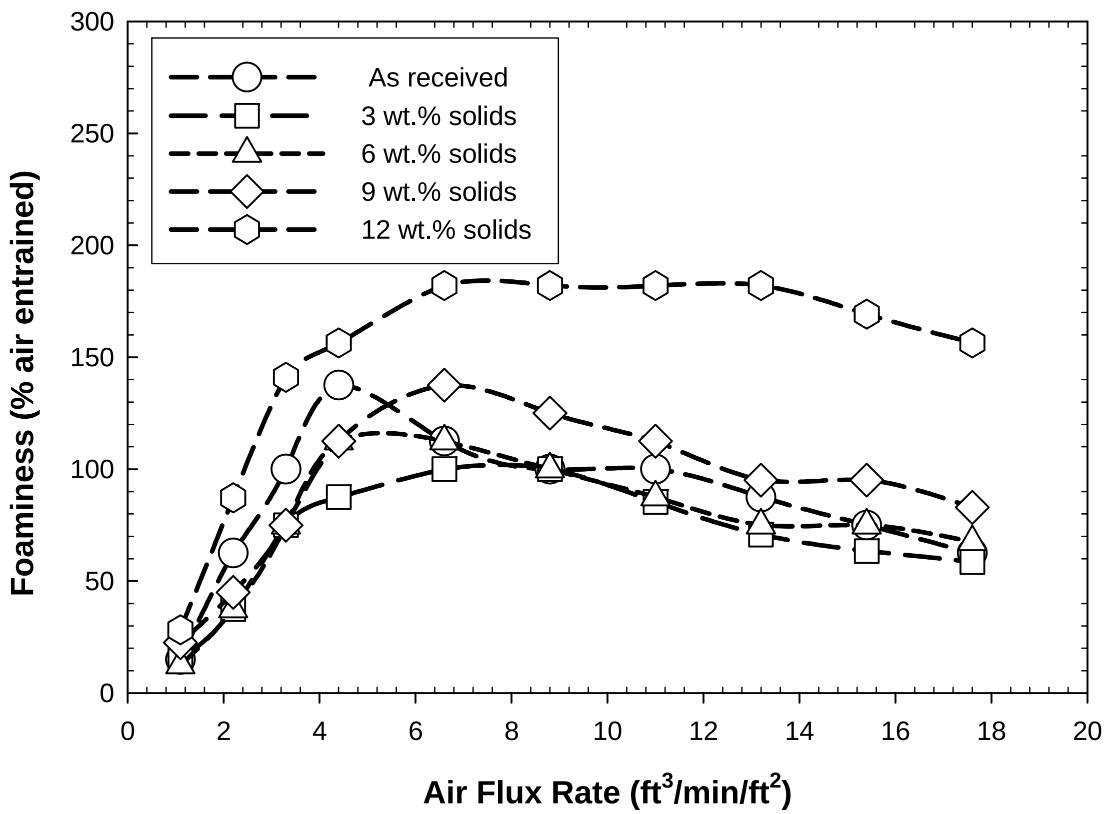


Figure 9. Effect of solid particles on foaminess of actual Hanford waste (pretreated AN-104/SBS recycle solution)

Q2 ANTIFOAM TEST RESULTS

Figure 10 shows the effect of Q2 antifoam in air-sparged Hanford waste (pretreated AN-104/SBS recycle) at a flux rate of 4.4 $ft^3/mn/ft^2$. The results indicate that the foaminess was reduced by 50 % after addition of about 400 ppm of Q2-3183A. The foaminess of the solution was reduced at or below 20% after incremental addition of up to 1400 ppm Q2 antifoam in AN-104/SBS recycle. A second test with the charge of initial 1400 ppm Q2 in the AN-104/SBS recycle has just been completed (data not included here). Further testing of antifoam effectiveness with real Hanford waste (pretreated AN-104 post IX solution) is continuing.

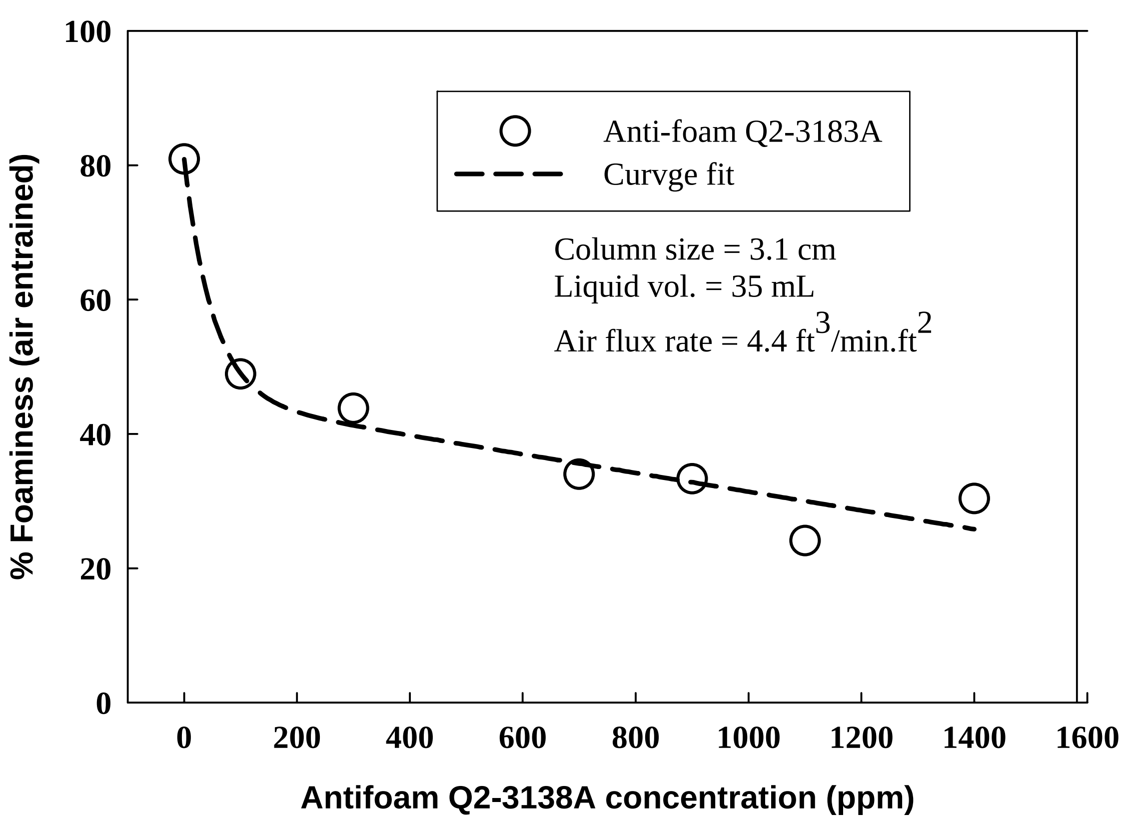


Figure 10. Effect of Q2 antifoam on actual Hanford waste (pretreated AN-104/SBS recycle solution)

Figure 11 shows the foam bubbles generated in the Hanford waste during the sparging test. The picture to the left shows the foam height of air-sparged AN-104/SBS recycle sample (as received) at 4.4 $ft^3/mn/ft^2$ prior to the addition of the Q2 antifoam. To the right, the picture shows the same solution after addition of 1100 ppm Q2 antifoam.

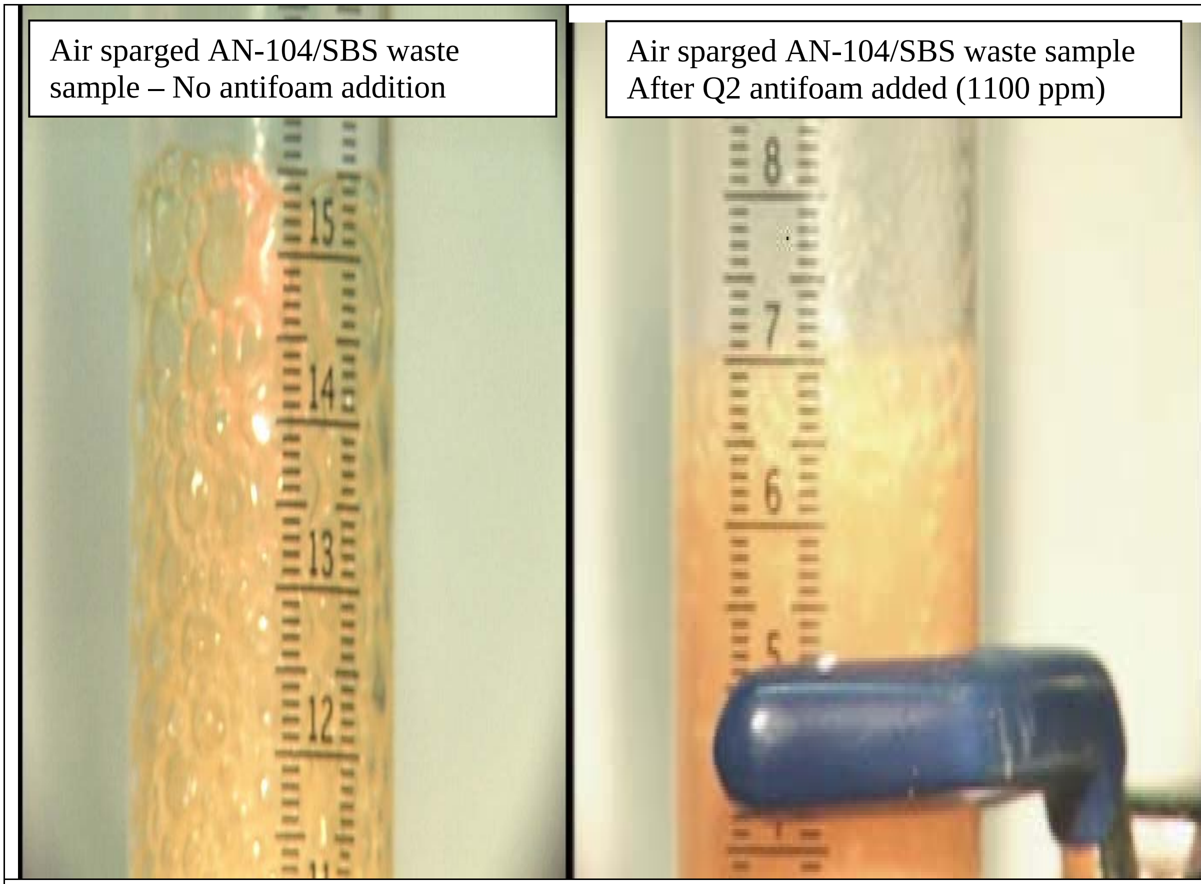


Figure 11. Side view photograph of foam bubbles during the actual AN-104/SBS Q2 antifoam test

REFERENCES

1. Baich, M. A., Stone, M. E., White, T. L., Calloway, T. B. July 2003, "Waste Treatment Plant Evaporation: Antifoam Performance (U)", WSRC-TR-2003-00216, Rev. 0, Westinghouse Savannah River Company, Aiken SC 29808.

2. Calloway, T. B., Baich, M. A. & Lambert, D. P., March 31, 2001, "Fate of IIT B52 Antifoam Agent Across the Small Tank Tetraphenylborate Process", WSRC-TR-2001-00102, Westinghouse Savannah River Company, Aiken SC 29808.

3. Crowder, M.L., E.K. Hansen, C.L. Crawford, W.E. Daniel, Jr., R.F. Schumacher, P. R. Burket, and J.L. Siler**, "**Evaporation, Rheology and Vitrification of a Radioactive Hanford Tank AN-104 Sample Mixed with Recycle", WSRC-TR-2004-00232 (SRNL-RPP-2004-00044), Westinghouse Savannah River Company, Aiken, SC 29808 (in press, expected June 2004).

4. Pilon, L., Fedrov, A. G., Viskanat, R. (2001) "Steady State Foam Thickness of Liquid-Gas Foams", Journal of Colloidal and Interface Science, 242, 425-436.

5. Kirkbride, et. al. "Tank Farm Contractor Operation and Utilization Plan", HNF-SD-WM-SP-012 Rev. 3, Numatec Hanford Corporation & others, Richland WA, October 2001, Table D-5.

6. Poirier, M. R., Burket, P. & Siler, J. L., "Filtration of a Hanford AN-104 Sample (U)", WSRC-TR-2003-00295 Rev. 0, Westinghouse Savannah River Company, Aiken, SC 29808, September 2003.

CD-ROM ENCLOSURES

The enclosed CD-ROM contains photographs and video of the experiments in progress. Included on the CD-ROM are video clips of the following tests:

Simulant Tests

- AY-102 (10 wt.% insoluble solids) Air Sparge at 8.8 $ft^3/min/ft^2$ air flux rate
- AY-102 (10 wt.% insoluble solids) Air Sparge with 100 ppm Q2-3183A added
- AY-102 (10 wt.% insoluble solids) Single Nozzle (0.0625" bore) Air Sparge
- AY-102 (10 wt.% insoluble solids) Single Nozzle (0.125" bore) Air Sparge
- AY-102 (10 wt.% insoluble solids) Single Nozzle (0.25" bore) Air Sparge

Rad Solution Tests

- AN-104/SBS (No Solids Added) Baseline Air Sparge at 4.4 $ft^3/min/ft^2$ air flux
- AN-104/SBS (No Solids Added) w/ 100 ppm Q2-3183A added Air Sparge at 4.4 $ft^3/min/ft^2$ air flux
- AN-104/SBS (No Solids Added) w/ 300 ppm Q2-3183A added Air Sparge at 4.4 $ft^3/min/ft^2$ air flux
- AN-104/SBS (No Solids Added) w/ 700 ppm Q2-3183A added Air Sparge at 4.4 $ft^3/min/ft^2$ air flux
- AN-104/SBS (No Solids Added) w/ 900 ppm Q2-3183A added Air Sparge at 4.4 $ft^3/min/ft^2$ air flux
- AN-104/SBS (No Solids Added) w/ 1100 ppm Q2-3183A added Air Sparge at 4.4 $ft^3/min/ft^2$ air flux

A spreadsheet showing the air flow basis and tanks configuration (height to overflow) is also included. The original spreadsheet was provided by WTP R&T and was modified to calculate the % allowable foaminess (or free board) in each tank.

The CD-ROM should start automatically within 30 seconds when placed in your CD-ROM drive on an IBM compatible PC. If it does not, then do the following:

1. Double-left-click on MyComputer icon on your desktop
2. Right-click on your CD drive icon
3. Left-click on AutoPlay

The recommended minimum computer system is as follows:

- Pentium II running at 233 MHz
- 32 MB ram
- Windows 95 or later.