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Rheological and Physical Data Results for Tank 40 Radioactive Samples Compared to Nonradioactive Tank 40 Samples (U)

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1.0 INTRODUCTION AND SUMMARY

The high level liquid waste generated at Savannah River Site (SRS), during many years of producing nuclear materials for the USA, is stored in underground steel tanks as caustic slurries. These slurries are either a sludge of hydrous oxides or a nitrate/nitrite salt slurry. The Defense Waste Processing Facility (DWPF) is currently receiving and processing the radioactive sludge slurry into a durable borosilicate glass for permanent geological disposal.

The DWPF can receive radioactive sludge slurry from one of two 1.3 million gallon High Level Waste (HLW) feed tanks. These feed tanks are called Tank 51 and Tank 40. Currently DWPF is receiving sludge slurry from Tank 40. Tank 40 contains radioactive sludge slurry that was in the tank heel plus sludge slurry that has been transferred from Tank 8. The combination of these two sludge slurries formed Macro Batch 3 or Sludge Batch 2.

The Savannah River Technology Center (SRTC) has analyzed samples of Sludge Batch 2[1, 2] in the Shielded Cells Facility. These analyses were completed as part of DWPF process demonstrations and to meet the reporting requirements as specified in the Waste Form Compliance Plan[3] and the Department of Energy's (DOE) Waste Acceptance Product Specifications (WAPS)[4]. The analytical data collected from the process demonstration have been documented in technical reports[5, 6, 7, 8].

This report describes the rheological results obtained from samples of the sludge slurry, the Sludge Receipt and Adjustment Tank (SRAT) product, and the Slurry Mix Evaporator (SME) product from the Sludge Batch 2 demonstration. This report also presents the weight percent solids measurements, density determinations, and pH results. A comparison of the results for the nonradioactive Sludge Batch 2 samples to the results of the radioactive Sludge Batch 2 samples is also presented in this report. Highlights from this report are found below.

1. The flow curve for the radioactive sludge slurry sample exceeded the current DWPF operating region between a shear rate range of 140 s^{-1} to 640 s^{-1}.
2. The flow curves for the radioactive SRAT and SME samples were within the DWPF operating region.
3. The nonradioactive simulant data collected using the Haake Rotovisco model RV20 (sludge slurry and SME samples) or the ThermoHaake RS150 RheoStress rheometer (sludge slurry samples) could be curve fitted providing a yield stress and consistency dependency based on insoluble solids loading.
4. The nonradioactive simulants cannot be used to predict the behavior (yield stress and consistency) of radioactive samples analyzed in this report. More radioactive data is required at various weight percent insoluble solids and different pHs to confirm the results of the nonradioactive simulants.

RECOMMENDATION:

Since a portion of the radioactive sludge slurry flow curve exceeded the DWPF operating region; an evaluation of this data should be performed to determine the impacts to the current DWPF system.

SUGGESTED FUTURE WORK:

- Determine the differences between the nonradioactive data collected using the Haake Rotovisco model RV20 and ThermoHaake RS150 RheoStress rheometer. This task could be completed using available samples.

- Collect more data for the nonradioactive and radioactive sludge slurry, SRAT product, and SME product samples varying the pH and insoluble solids loading. Determine the yield stress and consistency dependency on the insoluble solids loading and pH. Use this data to help define an optimum operating region for the DWPF Chemical Processing Cell.

2.0 BACKGROUND INFORMATION FOR THE SLUDGE BATCH 2 SAMPLES AND A BRIEF DESCRIPTION OF TASK ACTIVITIES

Twelve dip samples (220 mL/each dip sample) were obtained from Tank 40 and sent to the SRTC Shielded Cells Facility. The samples were combined and an initial composition of the radioactive sludge slurry was obtained. Since the sludge slurry was unwashed and the Na concentration did not meet the DWPF acceptance criteria, a demonstration of the Tank Farm's Extended Sludge Processing (ESP) was performed by the Waste Processing Technology (WPT) group. The sludge slurry was washed to a target endpoint of 0.55M Na (± 0.05M Na) in the supernate to meet the acceptance criteria of the DWPF. Upon receipt of the washed sludge slurry from WPT, a demonstration of the DWPF "Sludge-Only" flow sheet was performed using approximately one liter of sludge slurry. The DWPF "Sludge-Only" Flow sheet calls for processing radioactive sludge slurry using nitric acid, concentrated formic acid, and frit 200 through the Chemical Processing Cell (CPC) of DWPF. During each step of this process, samples were pulled for characterization including samples for rheological measurement. Details of the CPC demonstration and the characterization of the samples have been published previously [5, 6].

3.0 ANALYSIS PERFORMED ON THE SLUDGE SLURRY SAMPLES

This section describes the analytical methods used to determine the weight percent total solids, weight percent dissolved solids in the supernate, and density measurements. This section also presents the calculated values for the insoluble and the soluble solids for the Sludge Batch 2 samples.

3.1 Total Weight Percent Solids Analysis and Density Determinations for Sludge Slurry, SRAT Product, and SME Product for Sludge Batch 2

In order to obtain the weight percent solids measurements for the sludge slurry, SRAT product, and SME product, quadruplicate samples of each mixed sample were pipetted out of each sample bottle and placed into labeled PMP® beakers. These PMP® beakers were weighed and then placed into a drying oven at 115ºC overnight. Triplicate samples of a 15 wt.% NaCl standard solution were also weighed and dried (in labeled PMP® beakers) along with the samples to check the accuracy and precision of the method. All of the samples were allowed to cool for ~5 minutes before they were weighed. The results of the standard solutions showed good reproducibility and good agreement with the known value of the standard (within 5 % of the known values). The averages of the calculated results of the weight percent solids for all of the samples are presented in Table 1. The standard deviations (StDev) and the percent relative standard deviation (%RSD) for the weight percent data are presented in parentheses next to each value in Table 1 respectively.

The density measurements for the sludge slurry, SRAT product, and SME product were completed remotely in the Shielded Cells Facility by using heat sealed pipette tips. The pipette tips are first sealed and then calibrated with water to obtain the volume. Four density measurements were completed for each sample. The sealed pipette tip was first weighed and then a mixed sample was pipetted into the sealed pipette tip. The sealed pipette tip containing the sample was weighed and a density calculated. The results of the density for the samples are presented in Table 1. The standard deviations and the percent relative standard deviations for the data are also presented in parentheses next to each value in Table 1 respectively.

Table 1 – Total Weight Percent Solids Analysis and Density Determinations for the Sludge Slurry, SRAT Product, and SME Product

	Weight Percent Total Solids[a]	Density Determination[b]
Sludge Slurry Results	18.4 wt.% (± 3.9E-02, 2.1E-01)	1.12 g/mL (± 2.3E-02, 2.1E00)
SRAT Product Results	20.2 wt.% (± 1.1E-01, 5.4E-01)	1.15 g/mL (± 4.0E-03, 3.0E-01)
SME Product Results	45.3 wt.% (± 5.2E-01, 1.1E00)	1.36 g/mL (± 3.5E-02, 2.6E00)

[a] Dried in an oven overnight at 115°C. Results are the average of four samples. The standard deviations and the percent relative standard deviations for the data are also presented in parentheses next to each value.
[b] Results are the average of four samples. The standard deviations and the percent relative standard deviations for the data are also presented in parentheses next to each value.

3.2 Weight Percent Dissolved Solids Analysis and Density Determinations for Sludge Slurry, SRAT Product, and SME Product Supernates for Sludge Batch 2

Mixed samples of the sludge slurry, SRAT product, and SME product were individually filtered through three separate 0.45μm Nalgene® filters resulting in clear supernates for all three samples. These supernate samples were used to complete the density and the weight percent solids measurements. See Section 3.1 for details concerning the weight percent solids and density measurements. The results of the weight percent solids and density measurements are reported in Table 2. The standard deviations and the percent relative standard deviations for the data are also presented in parentheses next to each value in Table 2 respectively.

Table 2 – Weight Percent Dissolved Solids Analysis and Density Determinations for the Sludge Slurry, SRAT Product, and SME Product Supernates

	Weight Percent Dissolved Solids[a]	Density Determination[b]
Sludge Slurry Results	3.39 wt.% (± 7.3E-02, 2.1E00)	1.03 g/mL (± 4.0E-03, 3.5E-01)
SRAT Product Results	6.08 wt.% (± 2.1E-01, 3.4E00)	1.04 g/mL (± 1.3E-02, 1.2E00)
SME Product Results	7.64 wt.% (± 6.2E-02, 8.1E-01)	1.04 g/mL (± 2.4E-03, 2.3E-01)

[a] Dried in an oven overnight at 115°C. Results are the average of four samples. The standard deviations

and the percent relative standard deviations for the data are also presented in parentheses next to each value.
[b] Results are the average of four samples. The standard deviations and the percent relative standard deviations for the data are also presented in parentheses next to each value.

3.3 Calculation of Insoluble Solids and Soluble Solids for the Slurry Sample, SRAT Product, and SME Product for Sludge Batch 2

Once the total weight percent solids and the weight percent dissolved solids values were obtained for the samples, the soluble and insoluble weight percent solids were calculated. These values are calculated by using the following equations[9]:

Equation 1: $W_{is} = (W_{ts} - W_{ds}) / (1- W_{ds})$ [9]

Equation 2: $W_{ss} = W_{ts} - W_{is}$ [9]

W_{ds} – Weight fraction of dissolved solids (weight of dissolved solids/weight of supernate)
W_{ts} – Weight fraction of total solids (weight of total solids/weight of sludge slurry)
W_{is} – Weight fraction of insoluble solids (weight of insoluble solids/weight of sludge slurry)
W_{ss} – Weight fraction of soluble solids (weight dissolved solids/weight of sludge slurry)

An example using the values obtained for the sludge slurry sample can be found below.

Substituting the values of the measured variables:

Sludge Slurry Sample
$W_{ds} = 0.0339$
$W_{ts} = 0.184$
$W_{is} = ?$
$W_{ss} = ?$

Solving Equation 1:
Combined Sludge Slurry Sample

$W_{is} = (0.184-0.0339) / (1-0.0339)$

$W_{is} = 0.1554$
Converting to weight percent (multiply 100):
Combined Sludge Slurry Sample

$W_{is} = 15.54$ wt %

Solving Equation 2:
Combined Sludge Slurry Sample

$W_{ss} = W_{ts} - W_{is}$

$W_{ss} = 0.184 – 0.1554$

$W_{ss} = 0.0286$

Converting to weight percent (multiply 100):
Combined Sludge Slurry Sample

W_{ss} = 2.86 wt. %
Table 3 presents the calculated values for the insoluble and soluble solids for the sludge slurry, SRAT product, and SME product for Sludge Batch 2.

Table 3 – Calculated Values for the Insoluble and Soluble Solids for the Sludge Slurry, SRAT Product, and SME Product for Sludge Batch 2

	Insoluble Solids	Soluble Solids
Sludge Slurry Results	15.54 wt.%	2.86 wt.%
SRAT Product Results	15.03 wt.%	5.17 wt.%
SME Product Results	40.78 wt.%	4.52 wt.%

3.4 pH Measurements for the Sludge Slurry, SRAT Product, and SME Product for Sludge Batch 2

Measurements of the pH were completed for the three samples. Prior to the pH measurements of the samples, the pH probe was calibrated with a 7 buffer solution and a 10 buffer solution and checked with a 4 buffer solution. This was completed to make sure the pH probe was responding as expected. The pH of the sludge slurry, SRAT product, and SME product samples were 11.2, 6.49, and 6.29, respectively.

4.0 RADIOACTIVE RHEOLOGICAL MEASUREMENTS OF SLUDGE SLURRY, SRAT PRODUCT, AND SME PRODUCT SAMPLES FOR SLUDGE BATCH 2

4.1 Overview

All of the rheological measurements for the sludge slurry samples were obtained using the Haake RV30/M5 system located in Cell 2 of the Shielded Cells Facility. The specifications for the instrument can be found in the section below called "Summary of the Instrument's Specifications Used to Complete the Rheological Measurements". A Newtonian oil standard (~29 cp @ 25°C) was used to check the instrument's response prior to the start of the sludge slurry measurements and after the last sludge slurry measurement. The oil standard check was performed to ensure that the instrument was responding as expected. The MVI rotor was used in all of the measurements obtained.

The MVI rotor was selected because it is primarily used for rheological measurements of fluids working in the medium shear rate range[10]. The MVI rotor has been traditionally used to quantify the flow properties of HLW sludge slurries. The gap between the rotor and the cup is large enough not to be impacted by the sludge particles. The top and bottom surfaces of the MVI rotor are recessed. When a sample is loaded for measurement, an air gap is retained in the bottom recess of the rotor. This air gap provides a momentum buffer between the fluid and the rotor, where no torque is measured, eliminating or minimizing "end effects" as long as the air gap is intact after the measurement is complete. A breach of this air gap is detected by visually inspecting the bottom recess for sample residue. The top surface of the rotor is recessed to accommodate excess sample when the sample is loaded for measurement. After each sludge slurry measurement, the bottom recess of the rotor was examined visually for sample residue. No sample residue was found in the bottom recess of the rotor, indicating the air gap remained intact during the measurement. All of the rheological measurements for this study were conducted at 27°C. Performing measurements at elevated temperatures above 27°C were not considered, due to the inability to prevent the evaporation of water from the samples.

4.2 Summary of the Instrument's Specifications Used to Complete the Rheological Measurements

The Haake RV30/M5 system is a controlled rate rheometer that can be operated remotely in the Shielded Cells environment. A water bath/circulator is used to supply water and maintain the temperature of the water jacket that surrounds the sample cup. The M5 measuring head can be equipped with different sample cups and rotors depending on the type of fluid to be analyzed. The technical specifications for the RV30/M5 system are listed in Table 4. The shear rate and shear stress ranges provided (in Table 4) are the capabilities of the various rotors that can be used with the M5 measuring head.

Table 4 – Technical Specifications for the System[10]

Speed Range:	5E-02 to 5E02 rpm
Shear Rate Range:	4E-03 to 4E04 s^{-1}
Shear Stress Range:	2E-01 to 7E04 Pa
Temperature Range:	Depends on Water Bath /Circulator
Torque Range:	0.049 to 4.9 Ncm

The error in the measured shear stress is 0.5% of full span (100% Tau) and the error for the measured shear rate is 0.5% of the reading. Table 5 provides the maximum shear rate, maximum shear stress, and physical dimensions associated with MVI rotor.

Table 5 – Maximum Shear Rate, Maximum Shear Stress, and Physical Dimensions Associated with the MVI Rotor[10]

<u>MVI Rotor – Maximum Tau (Pa) and D (1/s)</u>

100% Tau = 322 Pa
100% D = 1170 (1/s)

<u>MVI Rotor – Physical Dimensions</u>

Inner Cylinder (Rotor)
  Radius R_i – 20.04 mm
  Height L – 60 mm
Outer Cylinder (Cup)
  Radius R_a – 21 mm
Radii Ratio (R_a/ R_i) – 1.05
Gap Width – 0.96 mm

Cl factor (Torque correction factor which incorporates rotor end effects) – 1.0053

4.3 Programming of the RV30

Different programming times and shear rate ranges were selected based on the visual observations of the sludge slurry samples. Table 6 contains the different programming times and shear rate ranges for the sludge slurry samples and the oil standard. No hold times at the maximum shear rate were programmed for any of these measurements due to the nature of the samples and the time required to load the sample into the instrument.

Table 6 – Programming Times and Shear Rate Ranges Selected for the Sludge Slurry, SRAT Product, SME Product, and Standard Oil Samples

	Shear Rate Range and Time			
	Sludge Slurry	**SRAT Product**	**SME Product**	**Standard Oil**
Up Curve	0 – 800s^{-1}, 4 minutes	0 - 800s^{-1}, 4 minutes	0 – 1100s^{-1}, 5 minutes	0 – 1100s^{-1}, 3 minutes
Down Curve	800 – 0s^{-1}, 4 minutes	800 - 0s^{-1}, 4 minutes	1100 - 0s^{-1}, 5 minutes	1100 - 0s^{-1}, 3 minutes

4.4 Preparation of the Sludge Slurry, SRAT Product, and SME Product Samples for Measurement and the Results of the Uncorrected Flow Curves

To prepare the samples for measurement, each sample was mixed and poured into the measuring cup. While pouring the samples into the measuring cup, visual observations of the samples were noted. The sludge slurry sample and the SME product sample had a foamy appearance. Once the sample was poured into the measuring cup, the in-cell camera was used to look inside the cup. Several air bubbles appeared to be popping at the surface layer of the sample. Some of the air bubbles were large (~1/4 to 1/2 inches in diameter) while others were small (~1/16 inches in diameter). Upon the first initial attempt of measuring both of these samples, the results of the flow curves indicated that a continuum fluid was not present. These results could not be technically interpreted or fit to any rheological model. The reason for these atypical results was attributed to the air bubbles in the samples. To resolve this issue, the samples were mixed again and a pipette tip was used to carefully stir the samples to assist the larger air bubbles to come to the surface and pop. The measuring cup was loaded into the instrument and the measurements were completed successfully. No large air bubbles were noted for the SRAT product sample. Pictures of the sludge slurry, SRAT product, and SME product samples (in the measuring cup) were taken with the in-cell camera and are presented in Figure 1. From the pictures in Figure 1, one can see that there are distinct differences in the appearance of the surface of the samples. The changes in the surfaces of the samples were attributed to the various additions of acids and frit made during the DWPF process.

The raw data obtained from the rheometer (up flow curves only) for the sludge slurry, SRAT product, and SME product samples are plotted in Figure 2, Figure 3, and Figure 4 respectively. Figures 2 through 4 were curve fitted using the Bingham Plastic model and were plotted against the DWPF operating region for each sample. The DWPF operating region was created for each sample by using the Bingham Plastic model fit of the upper and lower ranges for consistency and yield stress for the sludge slurry, SRAT product, and SME product found in reference DPSTD-80-38-2[11]. Figure 5 compares the rheological results for the samples with each other. Oil standard results are found in Appendix A. Since the curve fit of the rheological data obtained for these samples were performed on the up curves, it was decided to omit all of the down curves for the samples. The down curves for the three samples were slightly lower than the up curves. This hysteresis could be due to solids settling out of the shearing zone or due to the structure of the fluid breaking down (thixotropic), or migration of the solids away from the rotating MVI rotor leaving a clear fluid interface.

Figure 1 – Pictures of the Sludge Slurry, SRAT Product, and SME Product in the Measuring Cup

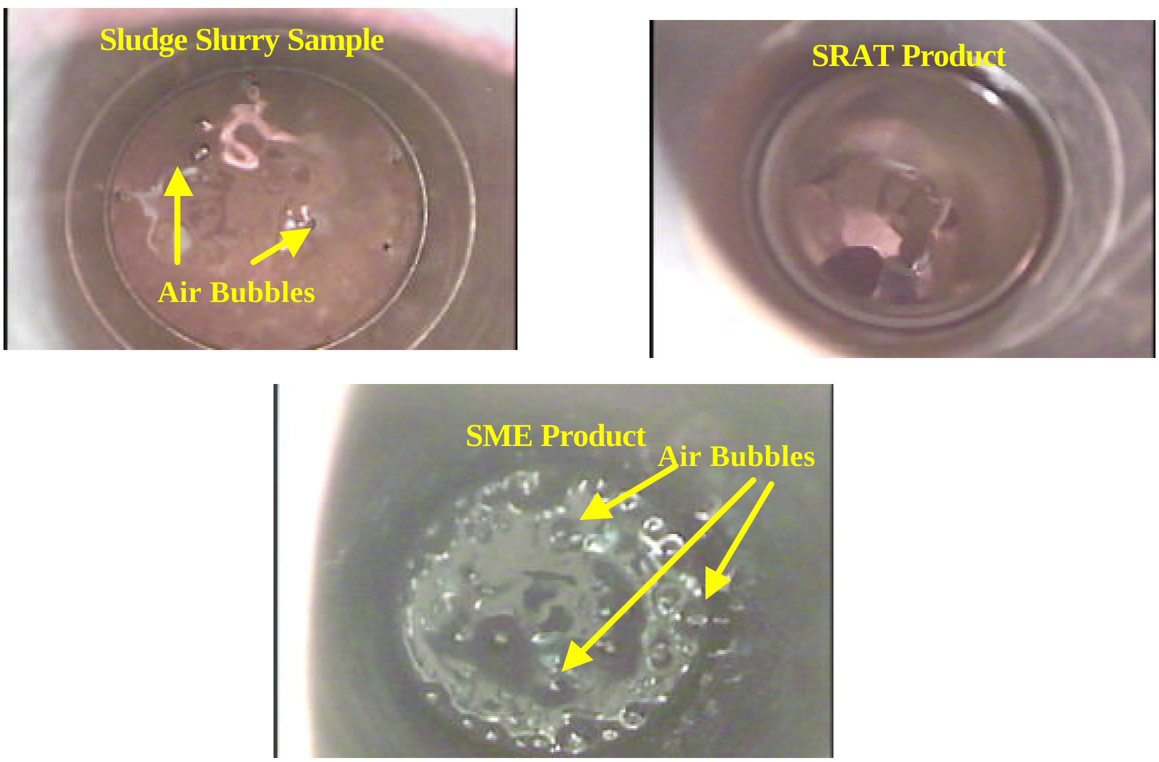
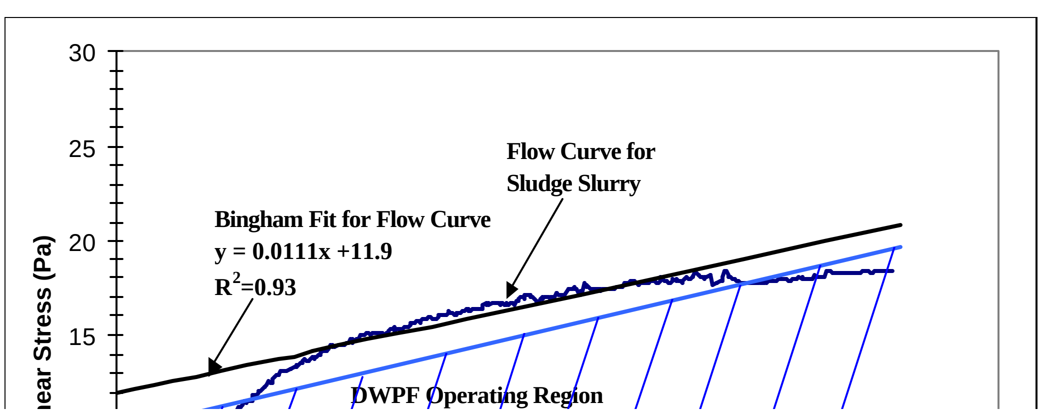


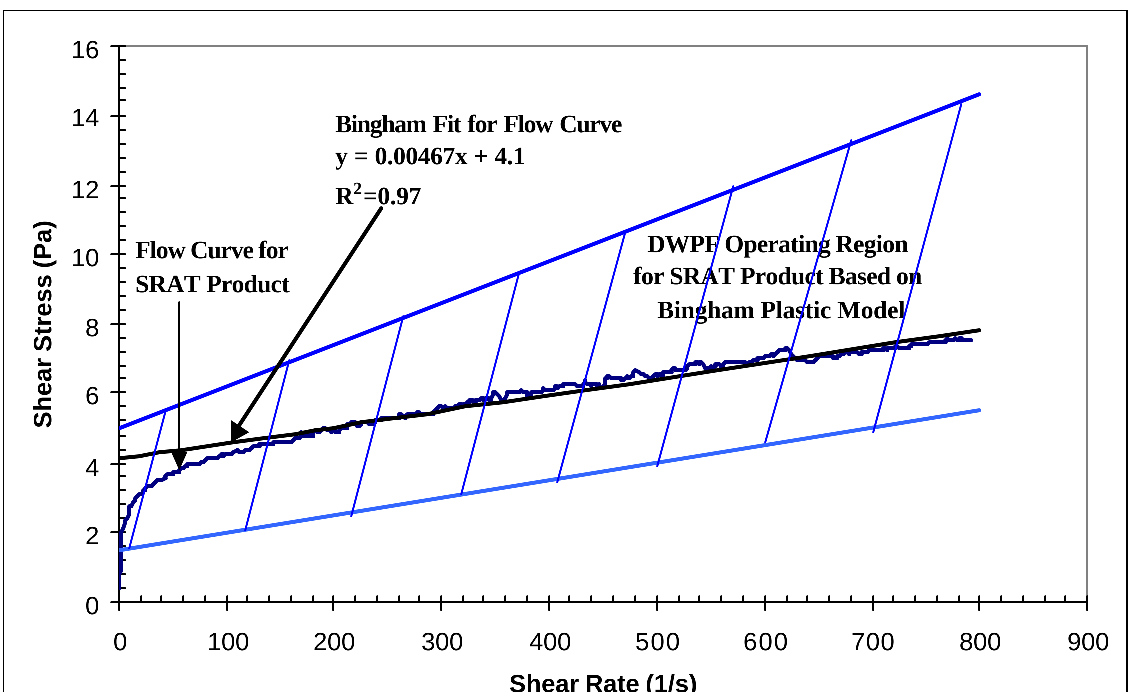
Figure 2 – Uncorrected Flow Curve for the Sludge Batch 2 Sludge Slurry Sample



The sludge slurry in the DWPF is pumped at a wide range of flow rates through pipes of various diameters. As seen in Figure 2, a portion (140 s^{-1} to 640 s^{-1}) of the flow curve is slightly outside of the DWPF operating region for the sludge slurry. This data will require further evaluation to determine the impact to the current DWPF processes handling sludge slurry. When performing this evaluation, the other variable to consider is the weight percent total solids of the incoming sample to DWPF. The weight percent total solids for the Shielded Cells sample (18.4 wt.%) is approaching the limit of 19 weight percent total solids for the incoming feed for DWPF. Any dilution to this sample would probably shift the flow curve down (lower yield stress) and to the right (lower consistency).

The Bingham Plastic model was used to curve fit the data set collected from 100s^{-1} to 800s^{-1} presented in Figure 2. Based on the data in Figure 2, the flow curve appears to climb the y-axis and then deviates from the y-axis at 25s^{-1}. Based on the deviation from the y-axis, the actual yield stress of the sample appears to be between 3-4 Pa versus 11.9 Pa obtained from the Bingham Plastic curve fit. In this particular case, selecting the Bingham Plastic model to fit the data is hydraulically conservative from a yield stress measurement standpoint. However, the Bingham Plastic model does not provide an accurate analysis for the data collected from 0s^{-1} to 140s^{-1}. To correct this problem, other rheological models could be used to account for the lower yield stress and fit the complete flow curve.

Figure 3 – Uncorrected Flow Curve for the Sludge Batch 2 SRAT Product Sample



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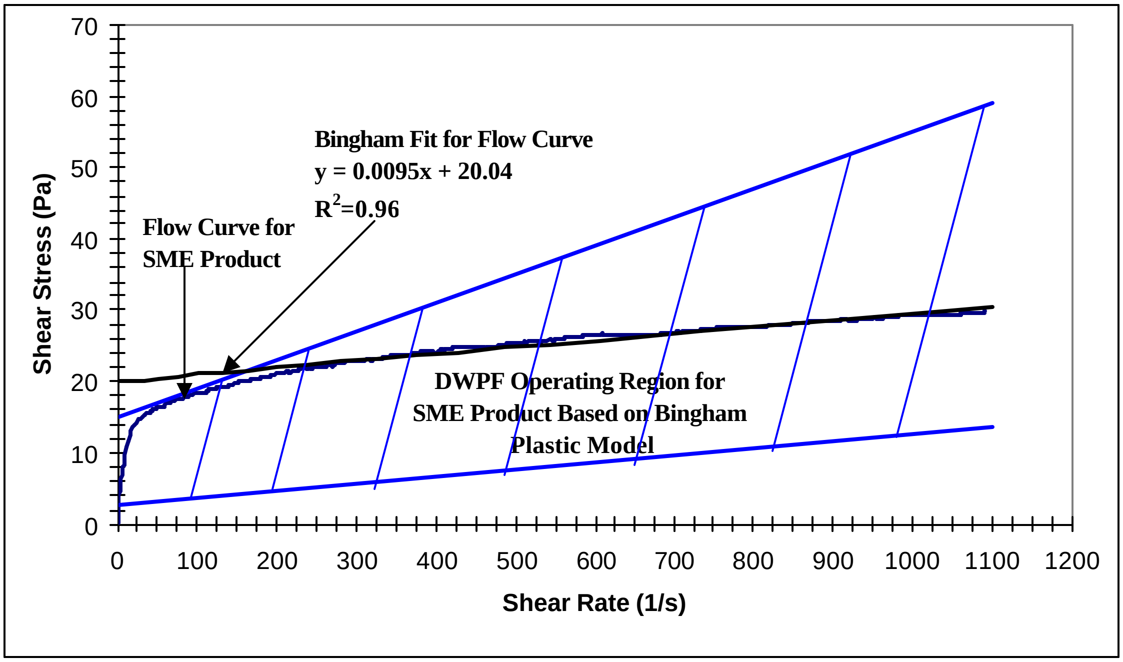
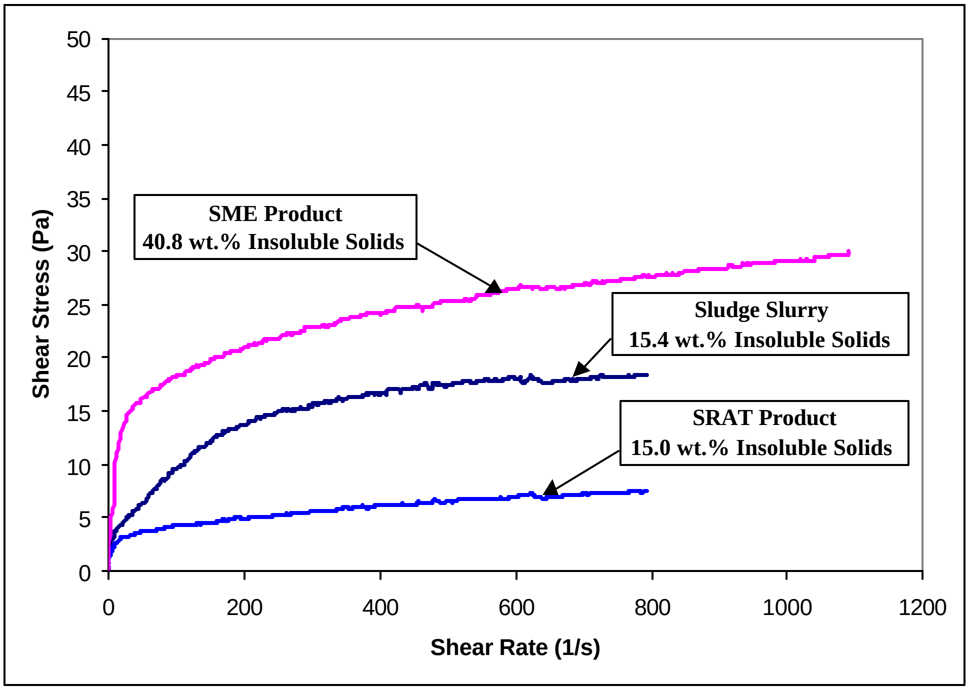
As seen in Figure 3, the Bingham Plastic model provided a good fit for the data collected from a shear rate range of 100 s^{-1} to 800 s^{-1}. The flow curve for the SRAT product sample is within the DWPF operating region for the SRAT product. Although the curve fit of the data predicted a higher yield stress, the Bingham Plastic model provided a better fit of the data than it did for Figure 2 and is hydraulically conservative.

Figure 4 – Uncorrected Flow Curve for Sludge Batch 2 SME Product Sample



The flow curve presented in Figure 4 is within the DWPF operating region for the SME product. The Bingham Plastic curve fit of the data from the shear rate range of 150 s^{-1} to 1100 s^{-1} indicates that the predicted yield stress has been exceeded. This is hydraulically conservative, because the actual yield stress of the sample appears to be lower than that predicted from the Bingham Plastic model and the flow curve never exceeded the expected operating region.

Figure 5 -Comparison of the Uncorrected Flow Curves for Sludge Slurry, SRAT Product, and SME Product Samples



Upon comparing the flow curves in Figure 5, a significant difference is noticed between the three samples. The major difference could be attributed to the pH of the samples (see Section 3.4) as well as the insoluble and soluble solids for each sample (see Table 3). As the insoluble solids increase, an increase in the shear stress is seen with increasing shear rate. D.C. Koopman has previously studied the effect of increasing insoluble solids for Sludge Batch 2 nonradioactive slurries[12]. D.C. Koopman's data for the sludge slurry, SRAT product, and SME product samples will be compared to the radioactive data collected for Sludge Batch 2 in Section 5.0.

Multiple flow curves were obtained for each sample. For all three samples, the first up curve obtained for each series of samples was used and is presented in the above figures. The other flow curves obtained for the sludge slurry and SRAT product samples were lower and repeatable, except for the SME product sample. In the case of the sludge slurry and SRAT product samples, the samples were not loaded into the cup each time for each measurement. The lower responses obtained for the sludge slurry and SRAT product measurements could be due to solids settling out over time or the break down of the initial structure of the sample (thixotropic). In the case of the SME product sample, it continually dropped after each measurement. This was due to the frit (vitrified glass formers) settling out over time. Upon pouring the SME sample back into the sample bottle, a lot of solids were noted at the bottom of the measuring cup. The data plotted in Figures 2 through 4 are not corrected (for non-Newtonian behavior) and are plotted as the raw data obtained from the instrument (treats fluids as Newtonian). The raw data for the up curves are provided in Appendix B. Appendix A contains the results of the up flow curves for the Newtonian oil standard used to check the operability of the instrument. No correction is required for the Newtonian oil standard. Presented below are the Bingham Plastic model fits for the data presented in Figure 2, Figure 3, and Figure 4. The Bingham plastic model is defined as:

$Tau = Tau_o + \eta D$ or $\{\tau = \tau_o + ?/100\ \dot{g}\ \}$

Where: Tau (τ) = Shear stress {Dynes/cm^2}
Tau$_o$ (τ_o)= Shear stress at D = 0 s^{-1} {Dynes/cm^2} or Yield Stress
η = Consistency {centipoise = cp}

D ($\dot{g}$) = shear rate {s^{-1}}

This model was linearly regressed to the following shear rate ranges for Figures 2, 3, and 4: 150 s^{-1} to 620 s^{-1} for Figure 2, 100 s^{-1} to 800 s^{-1} for Figure 3, and 150 s^{-1} to 1100 s^{-1} for Figure 4. The results of the Bingham Plastic model, for Figure 2 through Figure 4, are presented in Table 7.

Table 7 – Bingham Plastic Model Results for Figure 2, Figure 3, and Figure 4

Figure	Fitted Range (s^{-1})	t_0 (Dynes/cm^2)	? (cp)	R^2
2	150 – 620	119	11.1	0.93
3	100 – 800	41	4.67	0.97
4	150 – 1100	200	9.50	0.96

5.0 COMPARISON OF THE RADIOACTIVE SLUDGE BATCH 2 SAMPLES TO THE NONRADIOACTIVE SLUDGE BATCH 2 SAMPLES

As noted in Section 4.4, the majority of the measurements for Sludge Batch 2 nonradioactive samples have been completed and documented by D.C. Koopman[12]. The remainder of the nonradioactive Sludge Batch 2 measurements (sludge slurry and SRAT product) conducted by D.C. Koopman will be documented in this report. The unpublished flow curves and description of the instrument used to perform the remainder of the Sludge Batch 2 nonradioactive measurements (sludge slurry and SRAT product) can be found in Appendix C. The raw data for the up curves are presented in Appendix D. This section will compare the results obtained for the radioactive samples to the nonradioactive samples. No attempts have been made to correct either set of data for geometry, non-Newtonian behavior, slip, etc. The data presented in the tables below are the raw data obtained from the instrument fitted to a Bingham plastic model.

For the nonradioactive sludge slurry and SRAT product samples, the Haake Rotovisco model RV20 and ThermoHaake RS150 RheoStress rheometer were used with the MVI rotor/MV cup and Z41 cylinder/DZ43 cup respectively. The nonradioactive SME product samples used the Haake Rotovisco model RV20 with the MVII rotor/MV cup. The system and rotor selection for the radioactive samples is documented in Section 4.1.

Table 8, Table 9, and Table 10 present a summary of the sludge slurry, SRAT product, and SME product results, respectively, obtained from the nonradioactive and the radioactive samples. The results of these samples were then compared to the DWPF operating region in the tables. Each table includes weight percent solids, insoluble solids, yield stress, consistency, and pH. If a value is not available, “N/A” is used in the table.

Table 8 – Summary of the Results Obtained from the Nonradioactive and Radioactive Sludge Slurry Samples for Sludge Batch 2 Compared to the DWPF Operating Region

Sample ID	Total Solids (wt.%)	Insoluble Solids (wt.%)	Yield Stress (dynes/cm^2)	Consistency (cp)	pH
Tank 8/40 Blend [12] (nonradioactive sample)*	15.9	13.2	36	8.5	10.3
GFPS-SRAT-165-1 (nonradioactive sample)**	13.5	10.8	17	3.6	10.6
GFPS-SRAT-165-2 (nonradioactive sample)**	16.8	14.2	49	5.8	10.6
GFPS-SRAT-164-1 (nonradioactive sample)**	17.1	14.5	51	6.0	10.7
GFPS-SRAT-164-3 (nonradioactive sample)**	18.5	15.9	76	7.9	10.7
Sludge Batch 2 Sludge Slurry Sample (radioactive sample)	18.4	15.5	**119** [a]	11.1	11.2
DWPF Operating Region [11]	13 – 19	N/A	25 – 100	4 – 12	N/A

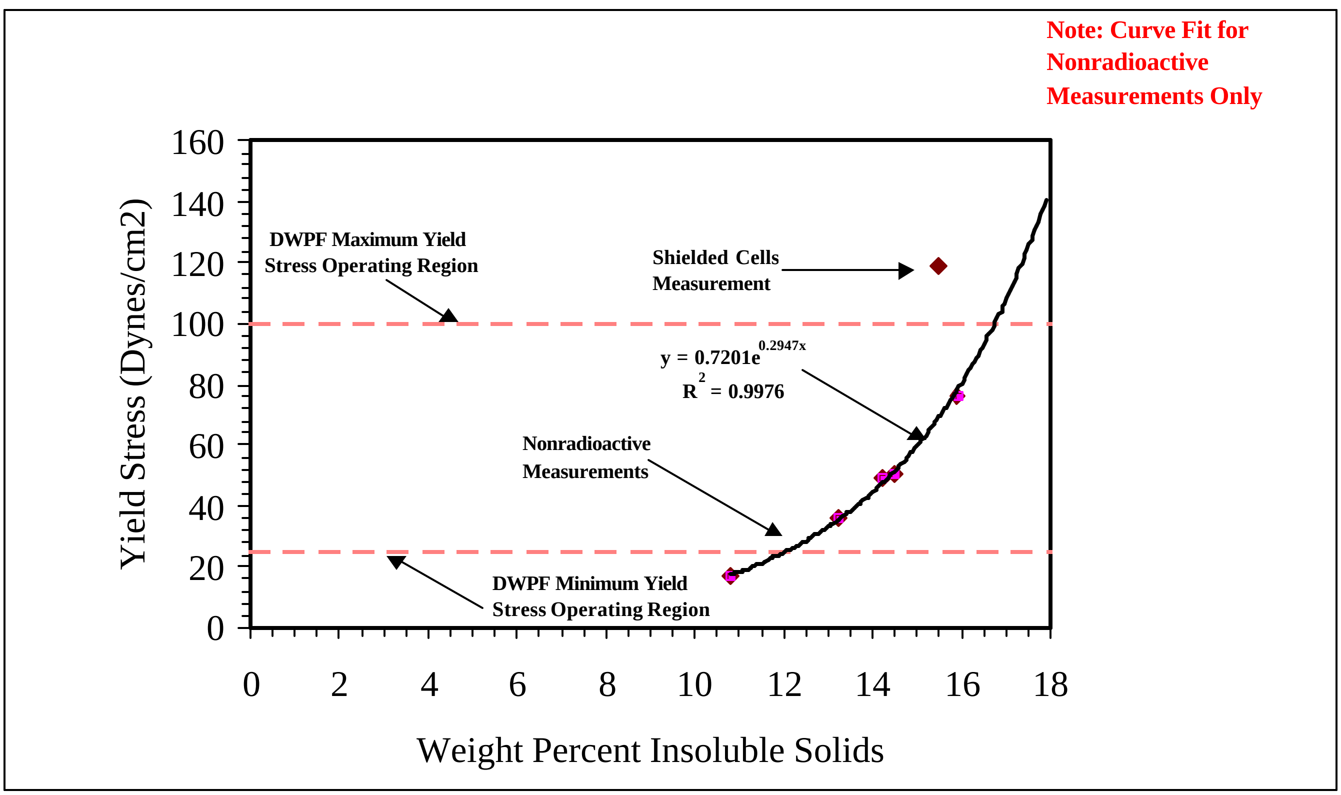
*Feed used for the small-scale nonradioactive runs at TNX
**GFPS - Glass Feed Preparation System
[a] Data is outside of the DWPF operating region

As seen in Table 8, it appears that the radioactive sample and all but one of the nonradioactive samples meet the DWPF operating region for consistency. However, a portion of the flow curve presented in Figure 2 for the radioactive sludge slurry exceeds the DWPF operating region (for a shear rate of 140 s^{-1} to 640 s^{-1}). This is a case where comparing the data using a tabular format could lead one to believe that the entire flow curve for the radioactive sample was outside the DWPF operating region. To avoid making erroneous assumptions, it is recommended that the flow curve generated for each type of sample (sludge slurry, SRAT product, and SME product) be plotted against the appropriate DWPF operating region (discussed in Section 4.4).

To make sure that the flow curves for the nonradioactive samples did not display the same behavior as the radioactive sample, the flow curves for the nonradioactive samples were plotted against the DWPF operating region. The plot for the nonradioactive samples can be found in Appendix C, Figure C - 2. The results plotted in Figure C - 2 indicate that all but one of the flow curves was within the DWPF operating region. The entire flow curve for Sample ID GFPS-SRAT-165-1 was found to be below the DWPF operating region. This could be attributed to the low weight percent total solids of the sample. The results presented in Figure C - 2 are also consistent with the results presented in Table 8.

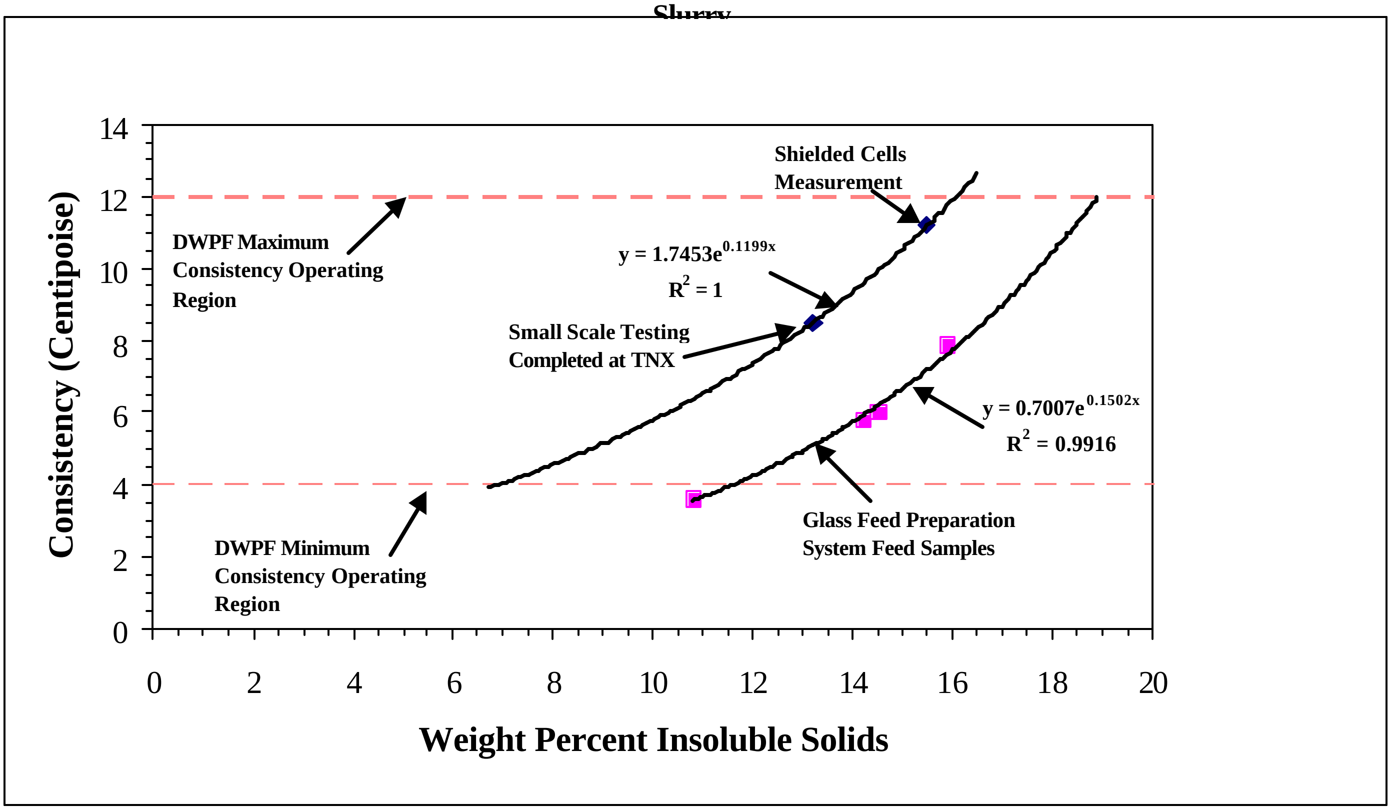
The yield stress measurements presented in Table 8 indicate that the radioactive sample exceeds the maximum DWPF operating region yield stress and Sample ID GFPS-SRAT-165-1 is below the minimum DWPF operating region yield stress. The reason for the radioactive sample exceeding the DWPF yield stress has been discussed previously in Section 4.4. The reason for the nonradioactive sample being below the DWPF yield stress is attributed to the low weight percent total solids of the sample. The other conclusion that can be made by studying the data in Table 8 is that as the insoluble solids content is increased the yield stress and the consistency also increase. These data are consistent with previous work completed on nonradioactive and radioactive sludge slurries.[13, 14] The yield stress data and consistency data for the nonradioactive and radioactive sludge slurry samples are depicted graphically in Figures 6 and 7 respectively.

Figure 6 – Yield Stress (Dynes/cm^2) Dependence on Insoluble Weight Percent Solids for the Sludge Slurry



The yield stress data for the nonradioactive rheological measurements were curve fitted. Since only one yield stress measurement was obtained for the radioactive sample, and it was clearly outside of the data set collected for the nonradioactive samples, it was not included in the curve fit. The curve fit of the nonradioactive data provided an equation to predict yield stress for those sludge slurry samples with an insoluble solids content of 10.8 to 15.9 weight percent. This equation can also be used to determine the weight percent insoluble solids of the sludge slurry sample at the DWPF minimum and maximum yield stress operating regions. Inputting the DWPF minimum yield stress (25 dynes/cm^2) value into the equation yielded a value of 12.0 wt.% insoluble solids. Although the equation has not been validated for a nonradioactive sludge slurry sample with an insoluble solids loading greater than 15.9, an extrapolation of the curve can be made to determine the insoluble solids loading at the maximum yield stress. Inputting the DWPF maximum yield stress (100 dynes/cm^2) value into the equation yielded a value of 16.7 wt.% insoluble solids. The data obtained at the DWPF maximum yield stress value should be used with caution and should be verified by a rheological measurement. Unfortunately, no correlation could be made for predicting the behavior of the yield stress for the radioactive sludge slurry sample using the available nonradioactive data. The reason for this was due to a lack of data for the radioactive sample at different weight percent insoluble solids.

Figure 7 – Consistency (Centipoise) Relationship to Insoluble Weight Percent Solids for the Sludge Slurry



Consistency data in Table 8 were fitted with two different curve fits and are shown in Figure 7. The data used to generate the bottom curve were collected using the ThermoHaake RS150 RheoStress rheometer. The data used to generate the top curve were collected using the Haake Rotovisco model RV20/M5 (nonradioactive sample) and the RV30/M5 systems (radioactive sample). These systems were exactly the same from a geometry perspective; the only difference was the controller (Haake RV20/RV30). Although only two data points were collected using these systems, the data points appear to yield higher consistency results than the ThermoHaake RS150 RheoStress rheometer used to obtain the GFPS data. The reason for this difference is unknown at this time and would require further investigation. For both curves, as the insoluble solids content increases the viscosity increases. Using the curve fit equations ($y = Ae^{Bx}$); the insoluble solids loading for a sample can be calculated based on the maximum and minimum DWPF consistency operating region. To perform these calculations both the top and bottom curves were extrapolated for the maximum case and only the top curve was extrapolated for the minimum case. The weight percent insoluble solids loading based on the maximum and minimum DWPF consistency for the top curve fit are 16.1 and 6.9, respectively. The weight percent insoluble solids loading based on the maximum and minimum DWPF consistency for the bottom curve fit are 18.9 and 11.6, respectively. The values obtained from the extrapolation of the curves should be used with caution since the results are outside the measured range.

To be able to predict the consistency for the radioactive sludge slurry sample, from the data shown in Figure 7, more data are required. More data are also required to investigate the differences for the results obtained from the Haake Rotovisco model RV20 (nonradioactive sample) and the RV30 system (radioactive sample) versus ThermoHaake RS150 RheoStress rheometer.

Table 9 - Summary of the Results Obtained from the Nonradioactive and Radioactive SRAT Product Samples for Sludge Batch 2

Sample ID	Total Solids (wt.%)	Insoluble Solids (wt.%)	Yield Stress (dynes/cm^2)	Consistency (cp)	pH
3B[12] (nonradioactive sample)	**16.5[a]**	11.7	**55[a]**	8.3	6.50
SB2-1[12] (nonradioactive sample)	**16.4[a]**	11.2	35	9.4	6.81
GFPS*-SRAT-174-2 (nonradioactive sample)	**17.7[a]**	12.4	**51[a]**	5.9	7.57
GFPS*-SRAT-196-1 (nonradioactive sample)	18.2	13.0	**61[a]**	5.0	7.55
GFPS*-SRAT-174-3 (nonradioactive sample)	20.2	15.1	**135[a]**	11.2	7.57
Sludge Batch 2 SRAT Product Sample (radioactive sample)	20.2	15.0	41	**4.7[a]**	6.49
DWPF Operating Region[11]	18 – 25	N/A	15 – 50	5 – 12	N/A

* GFPS - Glass Feed Preparation System
[a] Data is outside of the DWPF Operating Region

As can be seen from Table 9, the nonradioactive samples meet the DWPF operating region for consistency. Four out of the five nonradioactive samples in Table 9 exceed the DWPF operating region for yield stress. The yield stress for the radioactive sample meets the criteria for the DWPF operating region, but the results for the consistency do not. To avoid making erroneous assumptions based on the data presented in Table 9; the flow curves for the SRAT product samples were plotted against the DWPF operating region for the SRAT product. The results for the radioactive sample can be found in Figure 3 and the nonradioactive data can be found in Appendix C, Figure C - 4. All of the SRAT products were within the DWPF operating region except for one; sample ID GFPS-SRAT-174-3. This entire flow curve was outside of the DWPF operating region.

The SRAT product rheology appears to be dependent upon many factors. The two factors that appear to affect the SRAT rheology, for the data set presented in Table 9, are insoluble solids content and the pH of the samples. As the pH is lowered for a sample having the same weight percent insoluble solids, it appears that the consistency and yield stress are lower. Upon plotting similar curves (as seen in Figure 6 and Figure 7) for the SRAT product samples in Table 9, no correlations between rheology and pH could be determined for these data sets. The reason for this is attributed to the ending pH values of the individual SRAT products. To be able to predict the behavior (i.e. consistency and yield stress) of the radioactive SRAT product from an insoluble solids and pH basis, more data will be required. The nonradioactive data for the SRAT product in Table 9 does not appear to provide any insight on the rheological behavior of the radioactive SRAT product.

Table 10 - Summary of the Results Obtained from the Nonradioactive and Radioactive SME Product Samples for Sludge Batch 2

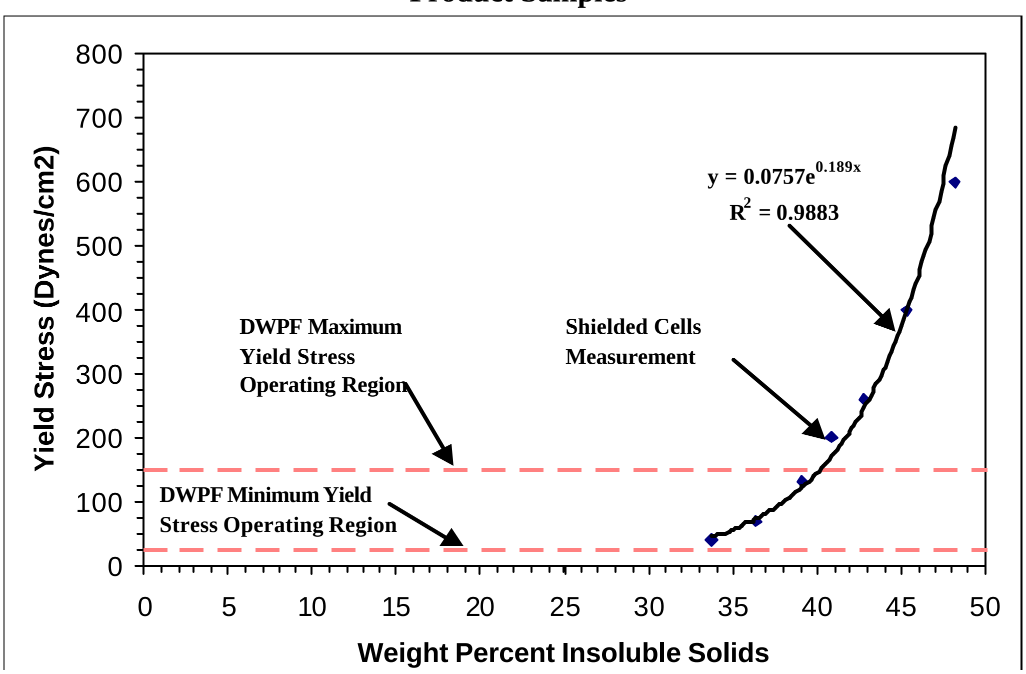
Sample ID	Total Solids (wt.%)	Insoluble Solids (wt.%)	Yield Stress (dynes/cm²)	Consistency (cp)	pH
SME-1 [12]	37.8	33.7	40	13	6.9
SME- 2[12]	41.0	36.4	70	18	6.8
SME-3[12]	44.2	39.1	130	17	6.8
SME- 4[12]	48.9	42.8	**260**[a]	34	7.0
SME-5[12]	**51.7**[a]	45.3	**400**[a]	**41**[a]	6.9
SME-6[12]	**55.0**[a]	48.2	**600**[a]	**67**[a]	7.0
Sludge Batch 2 SME Product Sample (radioactive sample)	45.3	40.8	**200**[a]	9.5	6.29
DWPF Operating Region [11]	40-50	N/A	25 – 150	10 – 40	N/A

[a] Data is outside of the DWPF operating region

As seen in Table 10, there are cases in which the SME samples are not within the DWPF operating region for yield stress and consistency. The data for the radioactive sample were collected using the MVI rotor which has a different geometry then the MVII rotor (MVII has a larger gap size between the cup and rotor). The MVII rotor was used to collect all of the nonradioactive data reported in Table 10. Another conclusion that can be made from the data in Table 10, was that as the insoluble solids content was increased the yield stress and the consistency also increased while the pH remained constant for the nonradioactive samples. This is depicted graphically in Figures 8 and 9 below.

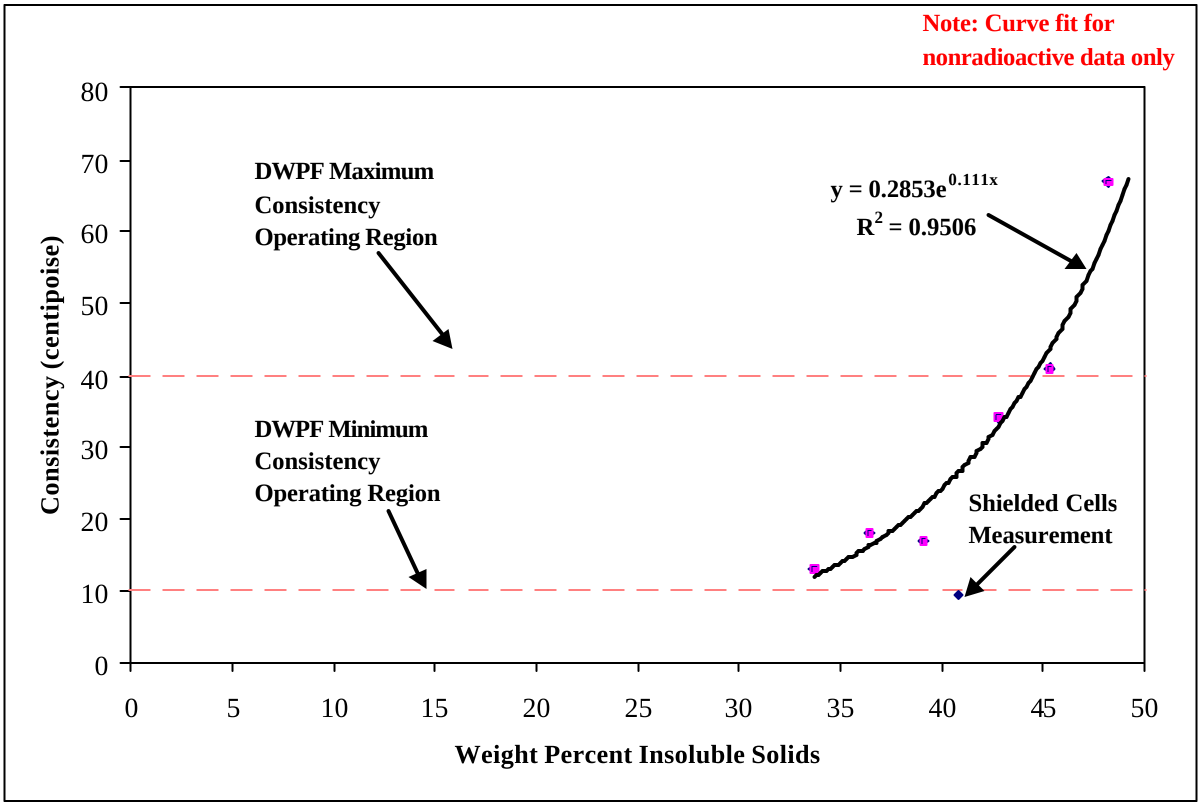
All of the data in Table 10 were compared to the DWPF operating region for the SME product. The radioactive data are plotted in Figure 4 and the nonradioactive data are plotted in Appendix C, Figure C - 5. The flow curves for Sample IDs SME-1 through SME-3 and the radioactive SME sample (see Figure 4) are within the DWPF operating region. The flow curves for Sample IDs SME-4 through SME-6 are outside of the DWPF operating region.

Figure 8 - Yield Stress (Dynes/cm^2) Dependence on Insoluble Weight Percent Solids for the SME Product Samples



The curve fit of the data in Figure 8 provided an equation to predict yield stress based on insoluble solids content for the SME samples. Using this equation and the DWPF minimum and maximum values for yield stress, an insoluble solids loading for the SME samples were calculated at 30.7 and 40.2 weight percent, respectively. It also appears from the data in Figure 8, that a yield stress could be predicted for the radioactive sample. This should be used with caution, due to the different geometry used to obtain the measurements and the lack of radioactive measurements at different insoluble solids loading to verify the curve fit.

Figure 9 - Consistency (Centipoise) Relationship to Insoluble Weight Percent Solids for the SME Product Samples



In Figure 9, the consistency data for the radioactive SME sample were outside of the data set collected for the nonradioactive samples, so it was not included in curve fit. The curve fit of the nonradioactive data provided an equation to predict consistency based on insoluble solids content for those SME samples. Using this equation and inputting the DWPF maximum and minimum values for consistency, yielded an insoluble solids loading of 32.0 and 44.5 weight percent, respectively. The nonradioactive data for the SME product does not appear to provide any insight on predicting the consistency for the radioactive SME product sample. This could be due to the different geometry used to obtain the data and the radioactive measurements at different insoluble solids loading, or it could be that the nonradioactive simulant was not very representative.

6.0 CONCLUSIONS

1. From visual inspection of the samples, the sludge slurry and SME product samples appeared to entrain air readily whereas the SRAT product sample did not.

2. A DWPF operating region was created for each sample by using the Bingham Plastic model fit of the upper and lower ranges for consistency and yield stress for the sludge slurry, SRAT product, and SME product.

3. The radioactive sludge slurry sample exceeded the DWPF operating region from a shear rate range of 140 s^{-1} to 640 s^{-1}. This data should be further evaluated to determine the impacts to the current DWPF system.

4. The flow curves for the radioactive SRAT product and SME product samples were within the DWPF operating region.

5. The rheological data (uncorrected), for the radioactive Sludge Batch 2 sludge slurry sample, are modeled using the Bingham Plastic model between the shear rates of 150 s^{-1} to 620 s^{-1}. The results for the calculated yield stress and the consistency are 119 dynes/cm^2 and 11.1 centipoise, respectively.

6. The rheological data (uncorrected), for the radioactive Sludge Batch 2 SRAT product sample was modeled using the Bingham Plastic model between the shear rates of 100 s^{-1} to 800 s^{-1}. The results for the calculated yield stress and the consistency are 41 dynes/cm^2 and 4.67 centipoise, respectively.

7. The rheological data (uncorrected), for the radioactive Sludge Batch 2 SME product sample was modeled using the Bingham Plastic model between the shear rates of 150 s^{-1} to 1100 s^{-1}. The results for the calculated yield stress and the consistency are 200 dynes/cm^2 and 9.5 centipoise, respectively.

8. The nonradioactive data collected using the Haake Rotovisco model RV20 or the ThermoHaake RS150 RheoStress rheometer could be curve fitted providing a yield stress and consistency dependency based on insoluble solids loading for those samples.

9. Nonradioactive simulants cannot be used to predict the behavior (yield stress and consistency) of radioactive samples for this report. More radioactive data are required at various weight percent insoluble solids and different pHs to confirm the results of the nonradioactive simulants.

10. There were differences in the data collected using the Haake Rotovisco model RV20 versus the ThermoHaake RS150 RheoStress rheometer for the nonradioactive samples. The reasons for these differences are unknown at this time, but should be investigated.

7.0 QUALITY ASSURANCE

All data and records generated from this task will be maintained in laboratory notebooks. Testing of the rheometer was completed under a TTR from DWPF[1].

8.0 REFERENCES

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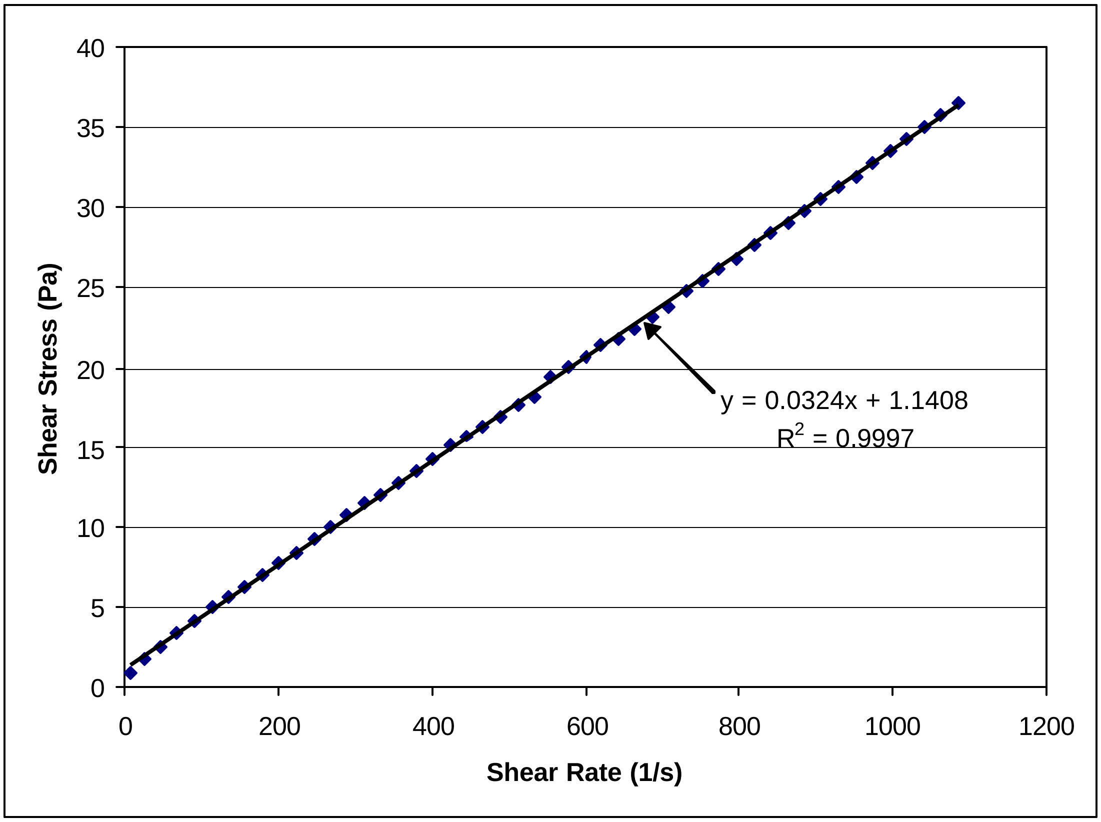
APPENDIX A – STANDARD OIL RESULTS (UP FLOW CURVES ONLY)

Date : 08-12-2002 Test date : 02-08-2002
Substance :
Test number :
Operator :
Sensor : MV1 Meas. system : M5
%Tau : 1% %D : 100%
Factor A : 3.220 Factor M : 11.700 Gap : 0.000 mm
Data stored in file C:\WINDOWS\DESKTOP\DATA\S20812.ROT

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
6.633	0.843	820.2	27.68
25.24	1.728	842	28.46
46.38	2.537	863.9	29.06
68.26	3.326	885.6	29.83
90.39	4.108	907.5	30.52
113.2	4.952	930.6	31.32
135.1	5.639	952.5	31.95
157.1	6.258	974.2	32.79
178.8	6.972	996.2	33.52
200.7	7.769	1018	34.31
224.4	8.367	1042	35.04
246.1	9.275	1063	35.73
267.8	9.91	1085	36.51
289.5	10.67		
311.5	11.51		
333.4	12.02		
356.8	12.75		
378.8	13.52		
400.5	14.2		
422.4	15.02		
444.1	15.71		
465.9	16.36		
489.3	16.97		
511	17.69		
532.8	18.16		
554.5	19.47		
576.6	20.08		
599.9	20.73		
621.8	21.38		
643.5	21.84		
665.2	22.41		
687.2	23.12		
708.9	23.85		
732.5	24.8		
754.5	25.38		
774.9	26.19		
798.5	26.82		

Figure A - 1 - Flow Curve for Standard Oil at 23°C



Known value for standard at 23°C: 32.63 cp

Date : 06-29-2002 Test date : 05-07-2002
Substance :
Test number :
Operator :
Sensor : MV1 Meas. system : M5
%Tau : 1% %D : 100%
Factor A : 3.220 Factor M : 11.700 Gap : 0.000 mm
Data stored in file C:\WINDOWS\DESKTOP\DATA\56OL35T1.ROT

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
0	0.101	81.2	6.054
0	0.198	82.92	6.164
0.782	0.424	85.43	6.337
2.135	0.641	87.13	6.384
3.202	0.776	89.65	6.578
5.07	0.964	92.18	6.736
6.405	1.083	93.9	6.851
8.635	1.256	96.47	6.961
10.96	1.423	98.99	7.108
12.47	1.522	100.7	7.229
14.83	1.691	103.2	7.407
17.27	1.859	104.9	7.565
18.87	1.974	107.5	7.701
21.37	2.158	110	7.869
23.06	2.275	112.1	7.963
25.5	2.416	113.8	8.084
27.98	2.562	116.1	8.273
29.85	2.684	117.8	8.394
32.4	2.858	120.3	8.577
34.12	2.979	122.9	8.756
36.43	3.121	124.7	8.829
38.98	3.274	127.1	9.007
40.66	3.394	129.8	9.123
43.23	3.573	131.5	9.27
45.8	3.725	133.8	9.411
47.46	3.835	135.5	9.495
49.98	4.003	138	9.684
51.66	4.123	140.7	9.894
54.23	4.275	142.2	9.957
56.8	4.438	144.7	10.08
58.5	4.527	147.3	10.23
60.96	4.685	149.1	10.4
63.48	4.884	151.5	10.54
65.17	4.968	153.3	10.65
67.73	5.146	155.5	10.8
69.4	5.272	158.2	10.91
71.94	5.43	159.9	11.03
74.45	5.587	162.4	11.13
76.11	5.702	164.9	11.33
78.67	5.881	166.6	11.44
		169.1	11.6

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
170.8	11.75	283.3	18.47
173.3	11.88	285.9	18.5
175.9	12.06	288.2	18.69
177.5	12.17	289.9	18.81
180.1	12.3	292.6	19.1
182.4	12.47	295.1	19.26
184.1	12.57	296.8	19.36
186.6	12.75	299.3	19.53
188.3	12.88	300.8	19.51
191	13.02	303.5	19.69
193.7	13.16	305.9	19.89
195.2	13.19	307.7	19.97
197.9	13.4	310.1	20.09
199.6	13.49	312.8	20.13
202.1	13.7	314.3	20.33
204.7	13.91	316.8	20.48
206.2	13.94	318.5	20.67
208.9	14.06	321	20.81
210.8	14.18	323.7	21.04
213.5	14.27	325.4	21.12
215	14.43	327.7	21.31
217.9	14.56	330.5	21.43
219.6	14.65	332.1	21.55
221.9	14.86	334.5	21.65
224.5	14.99	337	21.77
226.1	15.1	338.7	21.85
228.7	15.23	341.4	22.1
230.5	15.32	343.1	22.19
232.7	15.64	345.4	22.29
235.4	15.73	347.9	22.45
237.1	15.78	349.6	22.57
239.6	15.91	352.3	22.69
242.3	16.05	354.5	22.81
243.8	16.18	356.5	22.97
246.5	16.3	359.1	23.1
248	16.33	360.6	23.22
250.5	16.47	363.1	23.39
253.1	16.62	365.6	23.61
254.9	16.72	367.3	23.7
257.3	16.81	369.8	23.98
259.6	17.04	372.3	24.11
261.3	17.12	374	24.17
264	17.28	376.5	24.29
265.7	17.37	378	24.49
268.2	17.54	380.9	24.67
270.7	17.72	383.1	24.8
272.2	17.84	384.9	24.95
274.9	17.95	387.5	25.07
277.3	18.12	390	25.17
279.1	18.24	391.7	25.26
281.7	18.45	394	25.54

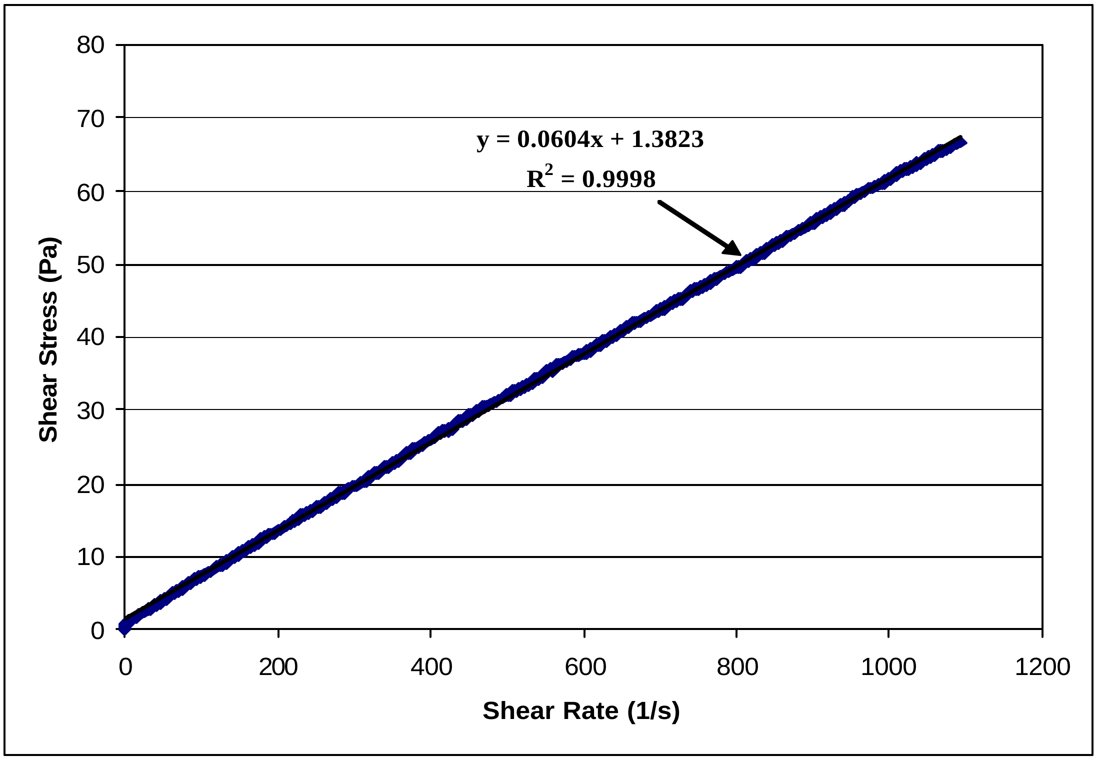
D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
395.7	25.69	508.4	32.58
399.1	25.9	510.9	32.74
400.1	25.95	512.6	32.74
402.6	26.18	515.2	32.84
405.1	26.38	517.5	32.89
407	26.52	519.2	33
409.4	26.72	521.9	33.15
411.2	26.81	523.4	33.21
413.6	26.93	526.1	33.36
416.1	27.12	528.8	33.57
417.6	27.13	530.3	33.68
420.3	27.18	533	33.84
423	27.31	535.2	33.99
424.5	27.38	537	34.15
427.2	27.46	539.4	34.26
428.9	27.56	541.2	34.31
431.2	28	543.8	34.47
433.7	28.17	546.1	34.62
435.6	28.27	547.8	34.78
438	28.42	550.3	35.15
440.5	28.55	553	35.25
442.2	28.62	554.7	35.31
444.9	28.72	557.2	35.46
446.6	28.73	558.7	35.41
448.9	28.96	561.4	35.62
451.6	29.18	563.8	35.88
453.3	29.25	565.6	36.04
455.8	29.37	568	36.2
457.5	29.54	570.5	36.35
460	29.82	572.2	36.35
462.6	29.87	574.7	36.51
464.1	29.92	576.4	36.56
466.6	30.11	579.1	36.67
469.1	30.22	581.6	36.88
471	30.3	583.1	36.98
473.5	30.51	585.6	37.3
475.6	30.69	588	37.4
477.5	30.69	589.8	37.51
479.8	30.74	592.4	37.46
481.5	30.85	594.1	37.56
484.2	31	596.4	37.77
486.6	31.16	598.9	37.77
488.4	31.27	600.4	37.88
490.6	31.37	603.3	37.93
493.5	31.53	605	38.09
495	31.63	607.9	38.24
497.5	31.79	609.6	38.4
500	32.11	611.9	38.51
501.7	32.21	614.2	38.77
504.4	32.26	616.1	38.87
505.9	32.42	618.7	39.03

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
621.2	39.03	733.1	45.64
622.7	39.19	735	45.69
625.4	39.35	737.5	45.9
627.1	39.45	740	46.16
629.6	39.5	741.9	46.27
632.1	39.76	744.4	46.43
633.6	39.82	746.8	46.53
636.3	39.97	748.5	46.58
638.8	40.08	751	46.69
640.5	40.24	752.7	46.74
642.9	40.34	755.2	46.9
644.7	40.5	757.7	47.11
647.3	40.66	759.4	47.16
649.6	40.76	761.9	47.21
651.3	40.81	764.6	47.37
653.8	40.97	766.1	47.53
656.3	41.18	768.6	47.69
658	41.29	770.3	47.84
660.5	41.55	772.9	47.9
662.2	41.55	775.4	48.16
664.7	41.71	777.1	48.32
667.3	41.81	779.6	48.47
668.9	41.97	782.3	48.63
671.3	42.07	783.8	48.63
673.8	42.18	786.3	48.79
675.5	42.34	788	48.79
678.2	42.49	790.3	49.05
680.5	42.65	793.2	49.21
682.2	42.65	794.9	49.26
684.9	42.81	797.2	49.42
686.6	42.96	799.8	49.57
689.1	43.12	801.3	49.68
691.6	43.28	804	49.78
693.3	43.44	805.7	49.89
695.9	43.54	808	50.05
696.5	43.59	810.7	50.2
700.1	43.8	812.4	50.36
701.8	43.91	814.9	50.52
704.7	43.91	817.4	50.68
706	44.07	818.9	50.68
708.1	44.22	821.6	50.83
711.8	44.49	823.3	50.99
712.5	44.59	825.7	51.15
715.6	44.75	828.2	51.31
718	44.85	829.9	51.41
719	44.96	832.6	51.57
721.7	45.01	834.9	51.62
723.6	45.17	836.6	51.73
726.2	45.33	839.1	51.94
729.1	45.27	840.6	52.09
730.8	45.43	843.5	52.25

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
846	52.46	958.4	59.33
847.7	52.57	960.1	59.49
850.3	52.72	962.4	59.54
852.1	52.77	964.3	59.7
854.3	52.88	967	59.86
857	53.04	969.5	59.96
858.5	53.14	971	60.12
861.2	53.25	973.7	60.28
863.7	53.51	976.1	60.38
865.2	53.51	977.9	60.43
867.9	53.82	980.3	60.54
869.6	53.82	981.9	60.59
872.1	54.09	984.5	60.75
874.5	54.14	987	60.85
876.3	54.3	988.9	60.96
878.7	54.51	991.6	61.12
881.2	54.61	993.3	61.27
882.9	54.72	995.2	61.38
885.4	54.82	882.9	54.72
887.1	54.98	885.4	54.82
889.8	55.14	887.1	54.98
892.1	55.35	889.8	55.14
893.8	55.4	892.1	55.35
896.5	55.56	893.8	55.4
898.9	55.66	896.5	55.56
900.7	55.77	898.9	55.66
902.9	56.08	900.7	55.77
904.9	56.18	902.9	56.08
907.3	56.34	904.9	56.18
909.8	56.39	907.3	56.34
911.5	56.5	909.8	56.39
913.8	56.66	911.5	56.5
916.7	56.81	913.8	56.66
918.4	56.97	916.7	56.81
920.7	57.02	918.4	56.97
922.4	57.13	920.7	57.02
925.1	57.29	922.4	57.13
927.5	57.55	925.1	57.29
929.3	57.6	927.5	57.55
931.5	57.76	929.3	57.6
934.2	57.92	931.5	57.76
935.9	58.07	934.2	57.92
938.4	58.13	935.9	58.07
940.1	58.23	938.4	58.13
942.6	58.39	940.1	58.23
945.3	58.55	942.6	58.39
946.8	58.65	945.3	58.55
949.3	58.76	946.8	58.65
951.6	58.97	949.3	58.76
953.5	59.07	951.6	58.97
956.1	59.17	953.5	59.07

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
956.1	59.17	1068	65.42
958.4	59.33	1070	65.42
960.1	59.49	1073	65.63
962.4	59.54	1075	65.73
964.3	59.7	1077	65.84
967	59.86	1079	65.94
969.5	59.96	1082	66.15
971	60.12	1084	66.26
973.7	60.28	1086	66.41
976.1	60.38	1089	66.52
977.9	60.43	1090	66.68
980.3	60.54	1093	66.78
981.9	60.59		
984.5	60.75		
987	60.85		
988.9	60.96		
991.6	61.12		
993.3	61.27		
995.2	61.38		
997.9	61.54		
1000	61.69		
1002	61.8		
1004	61.9		
1007	62.17		
1009	62.22		
1011	62.38		
1013	62.58		
1016	62.74		
1017	62.79		
1020	62.95		
1022	63		
1024	63.06		
1026	63.11		
1029	63.32		
1031	63.37		
1033	63.53		
1035	63.58		
1037	63.74		
1040	63.79		
1042	63.9		
1044	64.05		
1046	64.21		
1048	64.37		
1051	64.47		
1052	64.53		
1055	64.68		
1058	64.84		
1059	64.89		
1062	65.16		
1064	65.31		
1066	65.31		

Figure A - 2 - Flow Curve for Standard Oil at 25°C



Known value for standard at 25°C: 55.7 cp

APPENDIX B – RAW DATA FOR THE RADIOACTIVE SLUDE BATCH 2 SAMPLES (UP FLOW CURVES ONLY)

Date : 06-29-2002 Test date : 02-13-2002
Substance : Tank 40 Radioactive Sludge Slurry Sample @ 18.4 wt.% total solids
Test number :
Operator :
Sensor : MV1 Meas. system : M5
%Tau : 1% %D : 100%
Factor A : 3.220 Factor M : 11.700 Gap : 0.000 mm
Data stored in file C:\WINDOWS\DESKTOP\DATA\TK40SL8.ROT

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
0	0.177	51.07	6.479
0.019	0.209	52.88	6.599
0.477	1.139	54.74	6.741
0.877	1.582	55.64	6.804
1.449	2.048	57.47	6.94
3.279	2.732	59.34	7.145
3.927	2.944	61.15	7.219
4.746	3.029	62.05	7.229
6.195	3.326	63.91	7.381
6.919	3.452	65.74	7.465
8.54	3.651	67.57	7.68
10.2	3.887	68.49	7.685
11.91	4.003	70.34	7.764
12.75	4.076	72.17	7.979
14.68	4.244	74.04	8.121
16.43	4.349	74.97	8.095
17.33	4.365	76.8	8.32
19.14	4.454	78.63	8.504
20.89	4.59	80.46	8.499
22.72	4.674	81.37	8.509
23.6	4.795	83.24	8.635
25.41	4.889	85.05	8.735
27.26	5.031	86.94	8.955
29.07	5.115	87.84	9.007
29.96	5.131	89.67	9.081
31.79	5.22	91.53	9.196
33.64	5.335	93.36	9.438
35.45	5.514	94.26	9.438
36.41	5.582	96.13	9.532
38.2	5.676	97.98	9.574
40.03	5.786	99.86	9.674
41.88	5.823	100.8	9.784
42.77	5.938	102.6	9.784
44.62	6.217	104.4	9.789
46.49	6.332	106.3	9.962
48.28	6.358	107.2	9.973
49.22	6.384	109.1	10.07

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
110.9	10.15	190.2	13.63
112.1	10.27	192.1	13.7
114	10.44	194	13.68
114.8	10.47	195.8	13.67
116.7	10.56	196.7	13.68
118.8	10.77	198.6	13.69
119.7	10.85	200.3	13.78
121.4	10.85	202.2	13.76
123.3	11	203.2	13.89
125.2	11.21	204.9	13.9
126	11.26	206.8	13.98
128.1	11.27	208.7	13.98
129.8	11.35	209.5	14.05
131.5	11.46	211.4	14.11
132.7	11.44	213.3	14.17
132.7	11.44	215	14.21
134.4	11.52	216	14.21
136.1	11.59	217.9	14.3
138	11.58	219.6	14.41
139	11.62	221.3	14.34
140.7	11.78	222.4	14.42
142.6	11.82	224.2	14.38
144.5	11.95	226.1	14.47
145.2	12.02	227.8	14.43
147.2	12.07	228.7	14.41
149.1	12.15	230.6	14.55
151	12.28	232.4	14.54
151.7	12.29	234.3	14.58
153.6	12.39	236.2	14.62
155.5	12.58	237.1	14.63
157.3	12.51	239	14.74
158.2	12.54	240.7	14.64
160.1	12.67	242.5	14.74
161.8	12.81	243.4	14.7
163.5	12.89	245.3	14.81
164.5	12.89	247	14.79
166.4	12.89	248.9	15.03
168.1	13.12	249.9	14.97
170.2	13.11	251.6	15.02
171	13.05	253.3	15.02
172.7	13.12	255.4	15.05
174.6	13.18	256.2	15.09
176.5	13.27	258.1	15.12
177.3	13.24	260	15
179.2	13.27	261.7	15.04
181.1	13.35	262.5	15.06
183	13.35	264.4	15.09
183.8	13.41	266.3	15.05
185.7	13.35	268.2	15.08
187.6	13.45	269.1	15.04
189.3	13.58	270.9	15.04

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
272.8	14.99	354.2	16.29
274.5	15.03	356.1	16.29
275.4	15.1	357.8	16.39
277.3	15.18	358.9	16.41
279.1	15.21	360.6	16.28
281	15.3	362.6	16.27
281.9	15.32	364.3	16.39
283.6	15.37	365.2	16.38
285.5	15.27	367.1	16.33
287.3	15.28	368.8	16.44
288.2	15.31	370.7	16.44
290.1	15.34	371.5	16.43
291.8	15.2	373.4	16.47
293.7	15.48	375.1	16.6
294.7	15.45	377	16.64
296.6	15.51	378	16.57
298.5	15.5	379.7	16.68
300.2	15.55	381.4	16.62
301	15.62	383.5	16.73
303.1	15.65	384.3	16.71
304.8	15.65	386.2	16.73
306.5	15.68	388.1	16.74
307.5	15.71	389.8	16.73
309.4	15.63	390.8	16.61
311.1	15.79	392.7	16.66
313	15.87	394.6	16.77
313.9	15.86	396.3	16.58
315.7	15.89	397.2	16.61
317.6	15.91	399.1	16.65
319.3	15.93	400.9	16.62
320.2	15.94	402.6	16.67
322.1	15.85	403.7	16.69
323.9	15.89	405.4	16.68
325.8	15.85	407.2	16.62
326.7	15.88	409.1	16.8
328.4	15.96	410	16.86
330.3	16	411.7	16.93
332.2	16.02	413.6	17.02
333.2	16.07	415.5	16.98
335.1	16.15	416.3	16.95
336.8	16.11	418.2	17.19
338.5	16.18	420.1	17.14
339.7	16.25	422	17.19
341.4	16.19	423.2	17.06
343.1	16.16	424.9	16.96
345	16.03	427	16.94
346	16.03	427.9	16.8
347.7	16.17	429.8	16.76
349.6	16.21	431	16.78
351.3	16.22	432.9	16.93
352.3	16.24	434.6	16.99

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
436.3	16.95	518.1	17.71
437.5	16.99	519.8	17.75
439.2	16.97	520.6	17.79
441.1	16.98	522.7	17.8
442.8	16.95	524.4	17.86
443.8	17	526.1	17.88
445.7	17.05	527.1	17.86
447.4	17.09	529	17.85
449.3	17.22	530.7	17.79
450.2	17.22	532.6	17.67
452	17.19	533.5	17.67
453.9	17.12	535.4	17.69
455.8	17.03	537	17.69
456.5	17.09	539.1	17.76
458.4	17.15	539.8	17.74
460.3	17.37	541.7	17.79
462.1	17.36	543.6	17.81
463	17.36	545.4	17.91
464.9	17.39	546.1	17.89
466.6	17.54	548	17.87
468.3	17.49	550.1	17.87
469.5	17.48	551.8	17.83
471.2	17.25	552.8	17.81
473.1	17.12	554.7	17.89
474.8	17.29	556.4	18.01
475.8	17.29	558.3	17.98
477.7	17.71	559.3	17.91
479.6	17.53	561	17.84
481.5	17.64	562.9	17.86
482.1	17.58	564.8	17.83
484	17.47	565.6	17.83
485.9	17.51	567.5	17.87
487.8	17.51	569.2	17.93
488.5	17.49	571.3	17.91
490.6	17.41	572	17.92
492.4	17.45	573.9	17.87
494.1	17.42	575.9	17.84
495.2	17.35	577.6	17.82
496.9	17.49	578.5	17.85
498.7	17.5	580.4	17.93
500.6	17.48	582.1	18.03
501.5	17.46	583.9	17.96
503.2	17.46	585	17.99
505.1	17.43	586.7	18.01
506.8	17.46	588.4	18.07
507.8	17.47	590.1	18.27
509.7	17.54	591.1	18.25
511.4	17.57	593	18.17
513.3	17.57	594.9	18.16
514.3	17.58	596.6	18.14
516.2	17.57	598.3	18.01

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
601.2	18.05	682.8	17.98
603.1	18.04	684.5	17.93
605	18.19	686.2	17.89
605.8	18.13	688.1	17.9
607.7	18.17	689.1	17.9
609.4	17.63	690.8	17.93
611.3	17.76	692.5	17.96
612.3	17.77	694.6	17.97
614	17.82	695.4	17.97
615.9	17.87	697.3	18
617.6	17.89	699.2	17.99
618.7	18.04	700.9	18
620.5	18.43	701.8	17.99
622.2	18.4	703.8	17.96
624.3	18.22	705.7	17.98
625	18.15	707.4	17.99
626.9	18.04	708.3	17.99
628.7	17.98	710	17.97
630.6	17.94	712	18.16
631.5	17.94	713.7	18.13
633.2	17.9	714.6	18.15
634.9	17.86	716.5	18.11
636.8	17.83	718.2	18.09
638	17.8	720.1	18.1
639.7	17.73	721.1	18.11
641.4	17.76	722.8	18.07
643.3	17.77	724.7	18.37
644.3	17.76	726.6	18.43
646	17.73	727.4	18.39
647.9	17.73	729.3	18.35
649.6	17.72	731.2	18.31
650.8	17.77	732.9	18.26
652.5	17.76	733.9	18.27
654.2	17.82	735.8	18.24
656.1	17.84	737.5	18.26
657.1	17.82	739.4	18.3
658.8	17.81	740.4	18.29
660.7	17.8	742.3	18.26
662.4	17.87	744	18.26
663.3	17.83	745.7	18.29
665.2	17.86	746.8	18.28
667	17.85	748.5	18.29
668.9	17.85	750.3	18.29
669.6	17.86	752.4	18.28
671.5	17.89	753.1	18.28
673.4	17.85	754.8	18.29
675.4	17.96	756.7	18.27
676.3	17.96	758.7	18.29
678	17.93	759.4	18.29
679.9	17.92	761.3	18.33
681.6	17.92	763	18.32

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
765.1	18.33		
765.9	18.36		
767.8	18.36		
769.7	18.31		
771.4	18.29		
772.2	18.29		
774.3	18.32		
776	18.38		
777.9	18.39		
778.9	18.42		
780.6	18.42		
782.3	18.41		
784.4	18.44		
785.1	18.46		
787.1	18.47		
789	18.42		
790.7	18.42		
791.6	18.44		

Date : 06-29-2002 Test date : 02-19-2002
Substance : Tank 40 Radioactive SRAT Product @ 20.2 wt.% total solids
Test number :
Operator :
Sensor : MV1 Meas. system : M5
%Tau : 1% %D : 100%
Factor A : 3.220 Factor M : 11.700 Gap : 0.000 mm
Data stored in file C:\WINDOWS\DESKTOP\DATA\TK40SR1.ROT

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
0	0.37	24.27	3.226
0.076	0.465	25.18	3.247
0.343	0.672	27.03	3.289
0.763	0.917	28.82	3.321
1.696	1.377	30.65	3.363
2.211	1.556	31.59	3.394
3.431	1.872	33.4	3.426
4.784	2.116	35.23	3.462
6.214	2.306	37.06	3.483
6.977	2.389	37.93	3.499
8.54	2.553	39.8	3.525
10.37	2.685	41.65	3.573
11.21	2.752	43.48	3.594
12.94	2.843	44.41	3.62
14.7	2.938	46.24	3.651
16.45	3.014	48.07	3.672
17.35	3.051	49.92	3.683
18.91	3.09	50.82	3.698
20.66	3.137	52.65	3.719
22.47	3.184	54.48	3.735

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
56.31	3.772	136.9	4.517
57.26	3.814	138.8	4.533
59.09	3.84	140.7	4.538
60.92	3.866	142.6	4.533
62.77	3.893	143.5	4.517
63.68	3.908	145.4	4.601
65.51	3.924	147.3	4.58
67.36	3.919	149.3	4.585
69.17	3.919	150	4.59
70.11	3.94	152.1	4.548
71.98	3.966	153.8	4.585
73.81	3.982	155.5	4.59
75.64	4.013	156.5	4.58
76.59	4.024	158.4	4.632
78.4	4.024	160.1	4.632
80.25	4.06	162	4.669
82.1	4.102	163	4.679
83.03	4.102	164.7	4.695
84.86	4.144	166.6	4.711
86.67	4.134	168.5	4.8
88.52	4.176	169.3	4.868
89.46	4.16	171.2	4.79
91.32	4.171	172.9	4.779
93.13	4.192	174.8	4.8
95	4.202	175.7	4.805
95.92	4.234	177.5	4.832
97.8	4.223	179.6	4.8
99.65	4.249	181.3	4.874
101.5	4.26	183	4.91
102.5	4.255	184.1	4.868
104.3	4.27	185.9	4.884
106.1	4.286	187.8	4.926
108.7	4.354	189.5	5.01
109.7	4.354	190.4	5.01
110.7	4.349	192.1	4.973
114.9	4.307	194	4.921
115.5	4.365	196	4.942
116.7	4.359	196.9	4.9
120.7	4.349	198.8	4.91
121.4	4.391	200.7	4.889
122.6	4.422	202.4	4.874
123.7	4.449	203.4	4.889
127.5	4.464	205.1	4.874
128.7	4.475	207	4.984
129.8	4.48	208.7	4.968
130.8	4.506	209.7	4.994
131.9	4.517	211.6	4.984
132.9	4.527	213.3	5.094
133.8	4.517	215.2	5.12
135	4.496	216.2	5.162
135.9	4.522	217.9	5.141

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
219.6	5.136	301.4	5.561
221.5	5.099	303.1	5.587
222.4	5.052	305	5.556
224.4	5.094	305.9	5.577
226.3	5.152	307.7	5.55
228	5.125	309.6	5.545
228.7	5.125	311.3	5.556
230.8	5.157	312.2	5.587
232.6	5.104	314.1	5.655
234.5	5.162	315.9	5.697
235.4	5.12	317	5.687
237.1	5.125	318.7	5.629
239	5.188	320.6	5.702
240.7	5.251	322.5	5.708
241.7	5.236	323.5	5.755
243.6	5.262	325.2	5.76
245.3	5.272	327.1	5.781
247	5.288	328.8	5.75
248.2	5.277	329.8	5.75
249.9	5.272	331.7	5.739
251.6	5.309	333.4	5.781
253.5	5.304	334.5	5.765
254.5	5.272	336.2	5.855
256.2	5.272	338.5	5.886
258.3	5.304	339.5	5.839
260	5.309	341.6	5.855
261	5.367	343.5	5.828
262.9	5.319	344.3	5.849
264.6	5.319	346.2	5.891
266.5	5.304	348.1	6.033
267.4	5.346	349.8	6.022
269.1	5.419	350.7	5.98
271.1	5.43	352.6	5.975
272.8	5.398	354.5	5.834
273.7	5.388	356.3	5.844
275.6	5.382	357.2	5.813
277.3	5.466	358.9	5.86
279.3	5.419	360.8	6.017
280.2	5.388	362.6	6.012
282.1	5.372	363.5	6.012
283.8	5.367	365.4	6.017
285.7	5.424	367.1	5.986
286.5	5.43	369	6.033
288.4	5.414	370	6.028
290.3	5.419	371.7	6.017
292.2	5.43	373.6	6.08
293	5.445	375.3	5.996
294.9	5.54	376.3	5.991
296.8	5.592	378.2	6.028
298.5	5.603	379.9	5.938
299.6	5.629	381.8	5.907

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
382.8	5.959	465.1	6.416
384.7	6.064	466.1	6.4
386.6	6.022	468	6.369
388.3	6.017	469.9	6.411
389	6.022	471.6	6.479
391	6.017	472.3	6.489
392.9	6.064	474.3	6.458
394.6	6.127	476.2	6.489
395.7	6.112	478.1	6.531
397.4	6.101	478.8	6.652
399.1	6.091	480.7	6.647
401.1	6.101	482.6	6.594
402	6.112	484.5	6.547
403.7	6.117	486.3	6.558
405.8	6.18	487.2	6.547
407.7	6.164	488.9	6.5
408.3	6.143	490.6	6.5
410.2	6.175	492.6	6.39
412.1	6.196	493.5	6.39
413.8	6.264	495.4	6.442
414.8	6.253	497.1	6.51
416.7	6.248	499	6.552
418.6	6.279	500	6.526
420.3	6.243	501.9	6.573
421.3	6.243	503.8	6.573
423.2	6.253	505.5	6.5
424.9	6.196	506.5	6.578
426.6	6.211	508.4	6.61
427.7	6.185	510.1	6.62
429.5	6.19	512	6.615
431.4	6.18	512.8	6.594
433.3	6.363	514.7	6.715
434	6.327	516.6	6.71
435.7	6.274	518.5	6.678
437.7	6.253	519.2	6.662
439.6	6.211	521.1	6.668
440.3	6.227	522.9	6.683
442.2	6.258	524.8	6.678
444.1	6.19	525.5	6.694
446	6.248	527.6	6.736
446.8	6.19	529.3	6.762
448.7	6.154	531.1	6.825
450.6	6.232	532	6.841
452.3	6.274	533.9	6.83
453.3	6.3	535.8	6.815
455.2	6.505	537.5	6.872
456.9	6.474	538.5	6.836
458.6	6.458	540.4	6.862
459.8	6.463	542.1	6.888
461.5	6.447	543.8	6.746
463.2	6.432	545	6.741

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
546.7	6.731	628.1	7.066
548.6	6.752	630	6.961
550.5	6.757	631.7	6.956
551.3	6.746	633.6	6.961
553.4	6.794	634.6	6.956
554.9	6.804	636.5	6.94
556.8	6.841	638.2	6.956
557.7	6.841	639.9	6.904
559.6	6.752	641	6.893
561.6	6.83	642.8	6.909
563.3	6.872	644.5	6.925
564	6.867	646.4	6.946
565.9	6.904	647.3	6.951
567.8	6.883	649	7.014
569.8	6.888	651	7.035
570.7	6.893	652.7	7.061
572.4	6.919	653.6	7.03
574.1	6.893	655.3	7.056
576	6.893	657.4	7.035
577	6.925	659.1	7.056
578.7	6.919	659.9	7.045
580.6	6.919	661.8	7.061
582.3	6.904	663.7	7.014
583.3	6.836	665.6	7.003
585.2	6.878	666.4	7.014
586.9	6.883	668.3	7.03
588.6	6.904	670.2	7.098
589.6	6.94	671.9	7.119
591.5	6.946	672.9	7.119
593.2	6.967	674.8	7.192
595.1	6.998	676.5	7.177
596.1	7.009	678.2	7.161
598	7.024	679.4	7.177
599.9	7.056	681.1	7.166
601.6	7.04	683	7.166
602.5	7.056	684.9	7.177
604.3	7.103	685.6	7.177
606.2	7.124	687.6	7.156
607.9	7.129	689.5	7.129
608.8	7.093	691.2	7.135
610.7	7.203	691.9	7.166
612.4	7.203	693.8	7.166
614.4	7.213	695.6	7.198
615.3	7.208	697.7	7.234
617	7.213	698.4	7.213
618.7	7.208	700.3	7.239
620.8	7.344	702	7.234
621.6	7.287	703.9	7.219
623.5	7.224	704.9	7.219
625.4	7.135	706.8	7.213
627.1	7.114	708.5	7.219

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
710.2	7.234	751.6	7.413
711.4	7.281	753.5	7.449
713.1	7.245	755.4	7.465
714.8	7.26	756.4	7.455
716.7	7.271	758.1	7.46
717.7	7.271	760.2	7.449
719.4	7.302	761.1	7.449
721.3	7.318	763	7.476
723.4	7.329	764.8	7.465
724.1	7.365	766.7	7.465
726.1	7.26	767.8	7.465
728	7.302	769.7	7.57
729.7	7.334	771.4	7.591
730.6	7.339	772.4	7.559
732.5	7.323	774.3	7.559
734.3	7.339	776.2	7.57
736.2	7.381	777.9	7.58
737.1	7.371	778.9	7.539
738.8	7.407	780.6	7.533
740.7	7.434	782.3	7.575
742.4	7.428	784.2	7.586
743.4	7.423	785.1	7.507
745.3	7.413	787.1	7.497
747	7.428	789	7.528
749.1	7.413	790.9	7.544
749.7	7.413	791.6	7.565

Date : 06-12-2002 Test date : 05-20-2002
Substance : Tank 40 Radioactive SME Product @ 45 wt.% Total Solids
Test number :
Operator :
Sensor : MV1 Meas. system : M5
%Tau : 1% %D : 100%
Factor A : 3.220 Factor M : 11.700 Gap : 0.000 mm
Data stored in file C:\DATA\TK40SM1.ROT

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
0.00E+00	1.60E-01	2.68E+01	1.46E+01
2.67E-01	7.44E-01	2.88E+01	1.48E+01
5.72E-01	1.31E+00	3.08E+01	1.50E+01
2.36E+00	3.99E+00	3.28E+01	1.52E+01
2.97E+00	4.72E+00	3.48E+01	1.53E+01
3.72E+00	5.39E+00	3.68E+01	1.55E+01
6.06E+00	7.25E+00	3.99E+01	1.57E+01
7.78E+00	8.45E+00	4.19E+01	1.58E+01
9.53E+00	9.58E+00	4.39E+01	1.59E+01
1.13E+01	1.07E+01	4.59E+01	1.61E+01
1.31E+01	1.15E+01	4.79E+01	1.62E+01
1.60E+01	1.25E+01	5.10E+01	1.63E+01
1.80E+01	1.30E+01	5.30E+01	1.64E+01
1.99E+01	1.35E+01	5.50E+01	1.65E+01
2.19E+01	1.39E+01	5.70E+01	1.66E+01

2.39E+01	1.42E+01	5.90E+01	1.67E+01

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
6.21E+01	1.69E+01	1.78E+02	2.05E+01
6.41E+01	1.69E+01	1.79E+02	2.05E+01
6.61E+01	1.70E+01	1.80E+02	2.06E+01
6.81E+01	1.71E+01	1.84E+02	2.06E+01
7.02E+01	1.71E+01	1.86E+02	2.06E+01
7.22E+01	1.72E+01	1.87E+02	2.06E+01
7.52E+01	1.73E+01	1.89E+02	2.06E+01
7.73E+01	1.74E+01	1.91E+02	2.07E+01
7.93E+01	1.75E+01	1.93E+02	2.07E+01
8.13E+01	1.76E+01	1.95E+02	2.08E+01
8.33E+01	1.77E+01	1.98E+02	2.09E+01
8.64E+01	1.78E+01	2.01E+02	2.10E+01
8.84E+01	1.79E+01	2.03E+02	2.10E+01
9.04E+01	1.80E+01	2.05E+02	2.11E+01
9.24E+01	1.80E+01	2.07E+02	2.12E+01
9.45E+01	1.81E+01	2.10E+02	2.13E+01
9.75E+01	1.83E+01	2.12E+02	2.14E+01
9.96E+01	1.83E+01	2.14E+02	2.14E+01
1.02E+02	1.84E+01	2.16E+02	2.13E+01
1.04E+02	1.84E+01	2.18E+02	2.13E+01
1.06E+02	1.84E+01	2.21E+02	2.14E+01
1.09E+02	1.85E+01	2.23E+02	2.15E+01
1.11E+02	1.85E+01	2.25E+02	2.15E+01
1.12E+02	1.86E+01	2.27E+02	2.15E+01
1.14E+02	1.87E+01	2.29E+02	2.17E+01
1.16E+02	1.88E+01	2.32E+02	2.16E+01
1.19E+02	1.89E+01	2.34E+02	2.18E+01
1.21E+02	1.90E+01	2.36E+02	2.17E+01
1.24E+02	1.90E+01	2.38E+02	2.18E+01
1.25E+02	1.91E+01	2.40E+02	2.18E+01
1.28E+02	1.92E+01	2.42E+02	2.17E+01
1.30E+02	1.93E+01	2.45E+02	2.17E+01
1.33E+02	1.92E+01	2.47E+02	2.18E+01
1.34E+02	1.93E+01	2.49E+02	2.18E+01
1.37E+02	1.93E+01	2.51E+02	2.19E+01
1.38E+02	1.94E+01	2.53E+02	2.20E+01
1.41E+02	1.95E+01	2.56E+02	2.21E+01
1.44E+02	1.96E+01	2.58E+02	2.21E+01
1.45E+02	1.96E+01	2.60E+02	2.21E+01
1.48E+02	1.97E+01	2.62E+02	2.22E+01
1.50E+02	1.98E+01	2.64E+02	2.24E+01
1.53E+02	1.98E+01	2.67E+02	2.23E+01
1.55E+02	1.99E+01	2.69E+02	2.22E+01
1.57E+02	2.00E+01	2.71E+02	2.23E+01
1.59E+02	2.00E+01	2.73E+02	2.24E+01
1.63E+02	2.01E+01	2.75E+02	2.25E+01
1.64E+02	2.01E+01	2.77E+02	2.25E+01
1.65E+02	2.02E+01	2.80E+02	2.25E+01
1.67E+02	2.02E+01	2.83E+02	2.25E+01
1.70E+02	2.03E+01	2.84E+02	2.26E+01

1.71E+02	2.04E+01	2.86E+02	2.26E+01
1.77E+02	2.05E+01	2.88E+02	2.29E+01
D[1/s]	**Tau (Pa)**	**D[1/s]**	**Tau (Pa)**
2.92E+02	2.29E+01	4.06E+02	2.42E+01
2.93E+02	2.28E+01	4.08E+02	2.44E+01
2.96E+02	2.28E+01	4.10E+02	2.43E+01
2.98E+02	2.29E+01	4.12E+02	2.44E+01
3.00E+02	2.29E+01	4.15E+02	2.45E+01
3.03E+02	2.29E+01	4.17E+02	2.45E+01
3.04E+02	2.28E+01	4.19E+02	2.45E+01
3.07E+02	2.29E+01	4.21E+02	2.46E+01
3.09E+02	2.29E+01	4.23E+02	2.47E+01
3.11E+02	2.30E+01	4.26E+02	2.47E+01
3.14E+02	2.31E+01	4.28E+02	2.47E+01
3.16E+02	2.31E+01	4.30E+02	2.48E+01
3.18E+02	2.31E+01	4.32E+02	2.49E+01
3.20E+02	2.30E+01	4.34E+02	2.48E+01
3.22E+02	2.31E+01	4.37E+02	2.49E+01
3.24E+02	2.31E+01	4.39E+02	2.48E+01
3.26E+02	2.31E+01	4.41E+02	2.47E+01
3.29E+02	2.31E+01	4.43E+02	2.47E+01
3.31E+02	2.32E+01	4.45E+02	2.47E+01
3.33E+02	2.32E+01	4.47E+02	2.47E+01
3.35E+02	2.33E+01	4.50E+02	2.48E+01
3.37E+02	2.33E+01	4.52E+02	2.49E+01
3.40E+02	2.34E+01	4.54E+02	2.50E+01
3.42E+02	2.34E+01	4.56E+02	2.50E+01
3.44E+02	2.36E+01	4.58E+02	2.49E+01
3.46E+02	2.36E+01	4.61E+02	2.49E+01
3.48E+02	2.37E+01	4.63E+02	2.45E+01
3.50E+02	2.36E+01	4.65E+02	2.47E+01
3.53E+02	2.36E+01	4.67E+02	2.47E+01
3.55E+02	2.36E+01	4.70E+02	2.49E+01
3.57E+02	2.38E+01	4.72E+02	2.49E+01
3.60E+02	2.39E+01	4.74E+02	2.49E+01
3.62E+02	2.39E+01	4.76E+02	2.48E+01
3.64E+02	2.38E+01	4.78E+02	2.49E+01
3.65E+02	2.39E+01	4.80E+02	2.51E+01
3.69E+02	2.39E+01	4.82E+02	2.51E+01
3.71E+02	2.40E+01	4.86E+02	2.51E+01
3.73E+02	2.40E+01	4.87E+02	2.52E+01
3.75E+02	2.40E+01	4.90E+02	2.52E+01
3.77E+02	2.40E+01	4.91E+02	2.54E+01
3.80E+02	2.40E+01	4.94E+02	2.53E+01
3.82E+02	2.41E+01	4.97E+02	2.53E+01
3.84E+02	2.42E+01	4.99E+02	2.53E+01
3.86E+02	2.42E+01	5.01E+02	2.54E+01
3.88E+02	2.42E+01	5.03E+02	2.53E+01
3.91E+02	2.43E+01	5.05E+02	2.54E+01
3.93E+02	2.43E+01	5.08E+02	2.54E+01
3.95E+02	2.42E+01	5.10E+02	2.54E+01
3.97E+02	2.42E+01	5.12E+02	2.55E+01

3.99E+02	2.41E+01	5.14E+02	2.54E+01
4.01E+02	2.40E+01	5.16E+02	2.55E+01
4.04E+02	2.42E+01	5.19E+02	2.55E+01

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
5.21E+02	2.55E+01	6.35E+02	2.65E+01
5.23E+02	2.55E+01	6.37E+02	2.65E+01
5.25E+02	2.55E+01	6.40E+02	2.64E+01
5.27E+02	2.56E+01	6.42E+02	2.65E+01
5.29E+02	2.55E+01	6.44E+02	2.65E+01
5.32E+02	2.54E+01	6.46E+02	2.65E+01
5.34E+02	2.55E+01	6.48E+02	2.66E+01
5.36E+02	2.56E+01	6.50E+02	2.66E+01
5.38E+02	2.56E+01	6.53E+02	2.66E+01
5.40E+02	2.57E+01	6.55E+02	2.66E+01
5.44E+02	2.59E+01	6.57E+02	2.66E+01
5.45E+02	2.59E+01	6.59E+02	2.65E+01
5.47E+02	2.58E+01	6.61E+02	2.65E+01
5.49E+02	2.58E+01	6.64E+02	2.65E+01
5.51E+02	2.59E+01	6.66E+02	2.65E+01
5.53E+02	2.60E+01	6.68E+02	2.66E+01
5.55E+02	2.60E+01	6.70E+02	2.66E+01
5.58E+02	2.60E+01	6.72E+02	2.65E+01
5.60E+02	2.60E+01	6.75E+02	2.66E+01
5.62E+02	2.60E+01	6.77E+02	2.66E+01
5.64E+02	2.61E+01	6.79E+02	2.66E+01
5.66E+02	2.61E+01	6.81E+02	2.67E+01
5.68E+02	2.61E+01	6.83E+02	2.67E+01
5.71E+02	2.62E+01	6.85E+02	2.68E+01
5.73E+02	2.62E+01	6.88E+02	2.68E+01
5.75E+02	2.62E+01	6.90E+02	2.68E+01
5.77E+02	2.63E+01	6.92E+02	2.68E+01
5.79E+02	2.63E+01	6.94E+02	2.68E+01
5.82E+02	2.63E+01	6.96E+02	2.68E+01
5.84E+02	2.63E+01	6.99E+02	2.69E+01
5.86E+02	2.63E+01	7.01E+02	2.69E+01
5.88E+02	2.65E+01	7.03E+02	2.69E+01
5.90E+02	2.64E+01	7.05E+02	2.70E+01
5.93E+02	2.64E+01	7.07E+02	2.69E+01
5.95E+02	2.64E+01	7.10E+02	2.70E+01
5.97E+02	2.64E+01	7.12E+02	2.70E+01
5.99E+02	2.64E+01	7.14E+02	2.70E+01
6.01E+02	2.64E+01	7.16E+02	2.71E+01
6.03E+02	2.65E+01	7.18E+02	2.70E+01
6.06E+02	2.67E+01	7.21E+02	2.71E+01
6.08E+02	2.68E+01	7.23E+02	2.70E+01
6.11E+02	2.67E+01	7.25E+02	2.70E+01
6.12E+02	2.67E+01	7.27E+02	2.70E+01
6.15E+02	2.67E+01	7.29E+02	2.71E+01
6.18E+02	2.66E+01	7.31E+02	2.70E+01
6.20E+02	2.66E+01	7.34E+02	2.71E+01
6.22E+02	2.66E+01	7.36E+02	2.72E+01
6.24E+02	2.66E+01	7.38E+02	2.72E+01
6.26E+02	2.65E+01	7.40E+02	2.72E+01
6.29E+02	2.67E+01	7.42E+02	2.73E+01

6.31E+02	2.66E+01	7.45E+02	2.73E+01
6.33E+02	2.66E+01	7.47E+02	2.73E+01
D[1/s]	**Tau (Pa)**	**D[1/s]**	**Tau (Pa)**
7.49E+02	2.73E+01	8.64E+02	2.82E+01
7.51E+02	2.73E+01	8.66E+02	2.82E+01
7.54E+02	2.73E+01	8.68E+02	2.82E+01
7.56E+02	2.74E+01	8.71E+02	2.83E+01
7.59E+02	2.74E+01	8.73E+02	2.83E+01
7.61E+02	2.74E+01	8.75E+02	2.83E+01
7.63E+02	2.74E+01	8.77E+02	2.84E+01
7.65E+02	2.74E+01	8.79E+02	2.84E+01
7.67E+02	2.74E+01	8.82E+02	2.84E+01
7.70E+02	2.75E+01	8.84E+02	2.83E+01
7.71E+02	2.75E+01	8.86E+02	2.83E+01
7.74E+02	2.75E+01	8.88E+02	2.84E+01
7.76E+02	2.75E+01	8.90E+02	2.84E+01
7.78E+02	2.76E+01	8.92E+02	2.85E+01
7.81E+02	2.76E+01	8.95E+02	2.85E+01
7.83E+02	2.76E+01	8.97E+02	2.85E+01
7.85E+02	2.76E+01	8.99E+02	2.85E+01
7.87E+02	2.76E+01	9.01E+02	2.85E+01
7.89E+02	2.77E+01	9.03E+02	2.85E+01
7.92E+02	2.76E+01	9.06E+02	2.85E+01
7.94E+02	2.76E+01	9.08E+02	2.85E+01
7.96E+02	2.77E+01	9.10E+02	2.85E+01
7.98E+02	2.76E+01	9.12E+02	2.87E+01
8.00E+02	2.76E+01	9.14E+02	2.87E+01
8.03E+02	2.76E+01	9.17E+02	2.87E+01
8.05E+02	2.76E+01	9.19E+02	2.86E+01
8.07E+02	2.77E+01	9.21E+02	2.86E+01
8.09E+02	2.78E+01	9.24E+02	2.86E+01
8.11E+02	2.78E+01	9.25E+02	2.86E+01
8.13E+02	2.78E+01	9.28E+02	2.86E+01
8.16E+02	2.78E+01	9.30E+02	2.86E+01
8.18E+02	2.79E+01	9.33E+02	2.87E+01
8.20E+02	2.79E+01	9.34E+02	2.88E+01
8.22E+02	2.80E+01	9.37E+02	2.87E+01
8.25E+02	2.79E+01	9.39E+02	2.87E+01
8.27E+02	2.79E+01	9.42E+02	2.88E+01
8.29E+02	2.79E+01	9.44E+02	2.88E+01
8.31E+02	2.80E+01	9.46E+02	2.87E+01
8.33E+02	2.79E+01	9.48E+02	2.88E+01
8.36E+02	2.79E+01	9.50E+02	2.88E+01
8.38E+02	2.79E+01	9.53E+02	2.89E+01
8.40E+02	2.79E+01	9.55E+02	2.88E+01
8.42E+02	2.79E+01	9.57E+02	2.88E+01
8.44E+02	2.80E+01	9.59E+02	2.88E+01
8.46E+02	2.80E+01	9.61E+02	2.88E+01
8.49E+02	2.81E+01	9.64E+02	2.88E+01
8.51E+02	2.81E+01	9.66E+02	2.89E+01
8.53E+02	2.81E+01	9.68E+02	2.89E+01
8.55E+02	2.82E+01	9.70E+02	2.89E+01

8.57E+02	2.81E+01	9.72E+02	2.89E+01
8.60E+02	2.82E+01	9.74E+02	2.90E+01
8.62E+02	2.82E+01	9.77E+02	2.90E+01

D[1/s]	Tau (Pa)	D[1/s]	Tau (Pa)
9.79E+02	2.90E+01	1.04E+03	2.92E+01
9.81E+02	2.90E+01	1.04E+03	2.93E+01
9.83E+02	2.90E+01	1.04E+03	2.94E+01
9.85E+02	2.91E+01	1.04E+03	2.94E+01
9.87E+02	2.91E+01	1.05E+03	2.94E+01
9.90E+02	2.91E+01	1.05E+03	2.94E+01
9.92E+02	2.91E+01	1.05E+03	2.95E+01
9.94E+02	2.91E+01	1.05E+03	2.95E+01
9.96E+02	2.91E+01	1.05E+03	2.95E+01
9.98E+02	2.91E+01	1.06E+03	2.95E+01
1.00E+03	2.91E+01	1.06E+03	2.95E+01
1.00E+03	2.92E+01	1.06E+03	2.95E+01
1.01E+03	2.92E+01	1.06E+03	2.96E+01
1.01E+03	2.92E+01	1.07E+03	2.96E+01
1.01E+03	2.91E+01	1.07E+03	2.96E+01
1.01E+03	2.91E+01	1.07E+03	2.96E+01
1.01E+03	2.92E+01	1.07E+03	2.96E+01
1.02E+03	2.92E+01	1.07E+03	2.96E+01
1.02E+03	2.92E+01	1.08E+03	2.97E+01
1.02E+03	2.93E+01	1.08E+03	2.97E+01
1.02E+03	2.92E+01	1.08E+03	2.97E+01
1.03E+03	2.93E+01	1.08E+03	2.97E+01
1.03E+03	2.93E+01	1.09E+03	2.97E+01
1.03E+03	2.93E+01	1.09E+03	2.98E+01
1.03E+03	2.93E+01	1.09E+03	2.98E+01
1.03E+03	2.92E+01	1.09E+03	3.00E+01

APPENDIX C – DESCRIPTION OF THE INSTRUMENT USED TO PERFORM THE GFPS NONRADIAOCTIVE RHEOLOGY MEASUREMENTS AND FLOW CURVES OBTAINED FOR THE SLUDGE SLURRY AND SRAT PRODUCT

The ThermoHaake RS150 RheoStress rheometer was used for recent measurements of SB2 simulant rheological properties. The general features of this rheometer have been discussed elsewhere, e.g. WSRC-TR-2002-00186. Items specific to the recent measurements are described here. The Z41 cylinder with the DZ43 cup was selected to give a vertical, concentric cylinder geometry that is very similar to the MVI configuration on the RV20 and RV30 rheometers. This configuration is preferred when particles of frit size are not a major issue.

The effective sample geometry is an annulus with inner and outer radii of 20.710-mm and 21.700-mm, with a length of 55-mm. The Z41 cylinder is hollowed out on the bottom like the MVI. Loading the cylinder into the sample creates a large air bubble on the underside of the sample. Consequently, very little of the measured torque is due to contact of the bottom of the cylinder with fluid in the bottom of the cup. Visual inspection following a measurement generally showed a dry, shiny surface on the bottom of the cylinder. In rare cases there was a drop of sludge on the underside, with the balance clean and shiny. Samples were also trimmed at the top if necessary. Even with trimming, there was generally a meniscus in the annular gap that may have extended one millimeter above the top of the 55-mm contact surface on the inner cylinder. This could cause a slightly higher torque reading than if the meniscus were not present. The fact that the cylinder is 55-mm long is primarily to mitigate this effect by minimizing the magnitude of meniscus torque relative to that of the torque being drawn to overcome resistance within the annular gap.

Samples were linearly ramped in shear rate from 0 sec^{-1} to 990 sec^{-1} (the upper limit of the RS150 in the Z41 configuration). The ramping occurred over a five minute period. Samples were then held at 990 sec^{-1} for one minute. Then the samples were linearly ramped down in shear rate to 0 sec^{-1} over five minutes. Little variation was seen between up and down ramp data for the individual SB2 simulated, washed sludge samples. The sample at 13.5 wt. % total solids showed evidence of Taylor vortices at about 870 sec^{-1}. Slightly larger variations were seen between up and down ramp SRAT product simulant data. The up ramp curves were not as smooth as, and slightly above, the down ramp curves. There was a more noticeable separation between the up and down ramp data, though it was still not unusual compared to past data. Measurements were made at 25°C.

The uncorrected flow curves obtained for the sludge slurry samples are presented in Figure C - 1. Figure C - 2 is a comparison of the flow curves for the nonradioactive sludge slurry samples to the DWPF operating region.

The uncorrected flow curves for the SRAT product samples are presented in Figure C - 3. Figure C - 4 is a comparison of the flow curves for the nonradioactive SRAT samples to the DWPF operating region.

Figure C - 5 is a comparison of the flow curves for the nonradioactive SME samples to the DWPF operating region.

Figure C - 1 – Uncorrected Flow Curves for the Sludge Slurry Samples from the GFPS

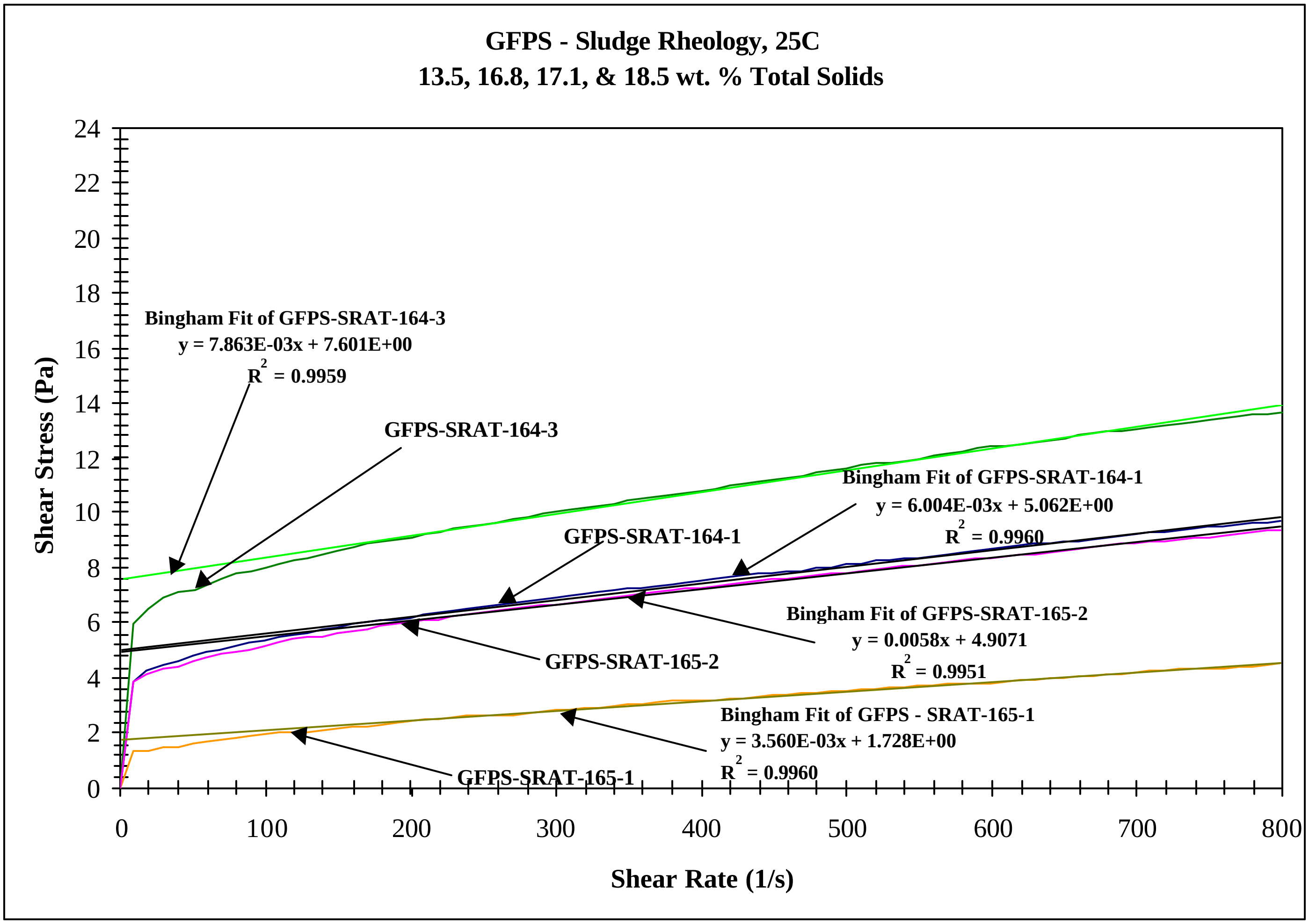


Figure C - 2 – Comparison of the Uncorrected Flow Curves for the GFPS Sludge Slurry Samples to the DWPF Operating Region

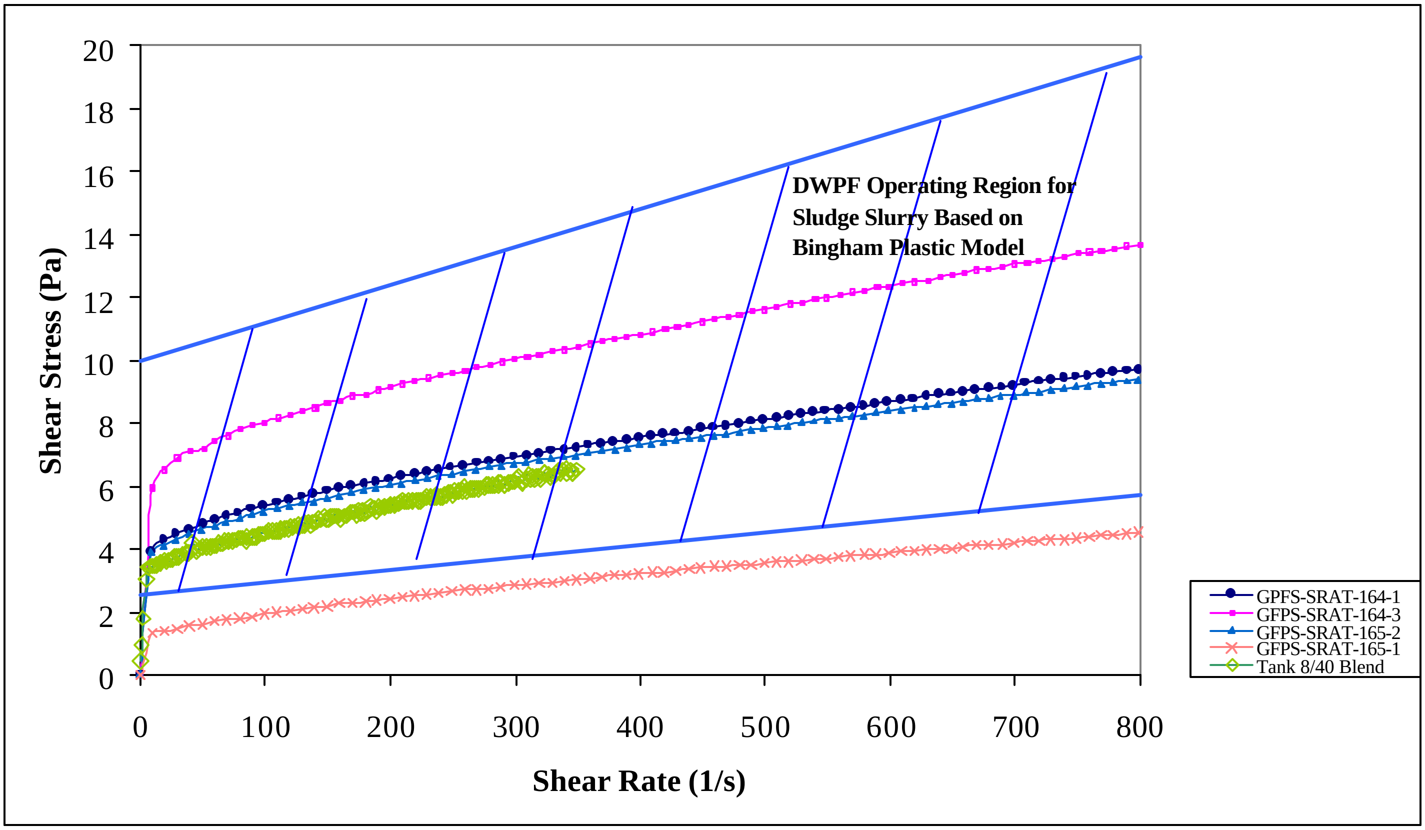


Figure C - 3 – Uncorrected Flow Curves for the SRAT Product Samples from the GFPS

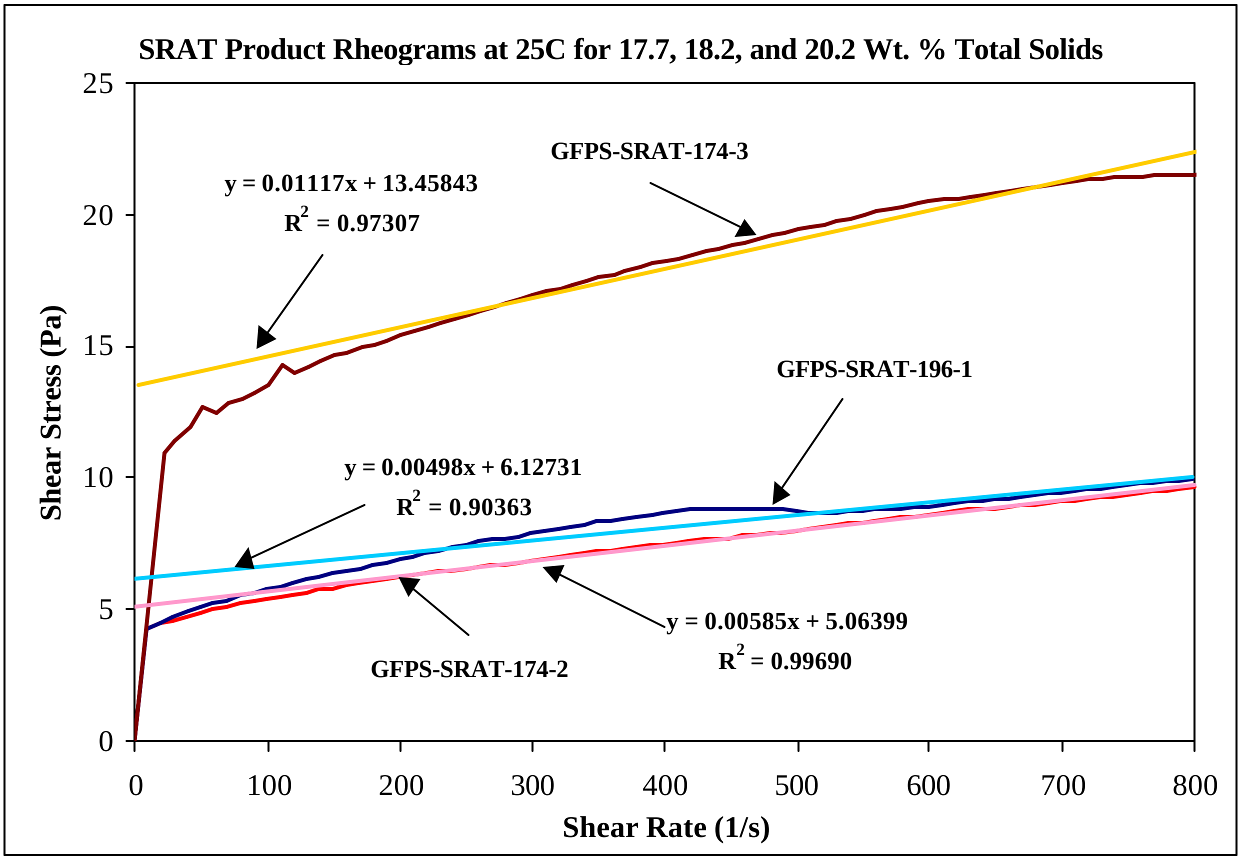


Figure C - 4 – Comparison of the Uncorrected Flow Curves for the GFPS SRAT Samples to the DWPF Operating Region

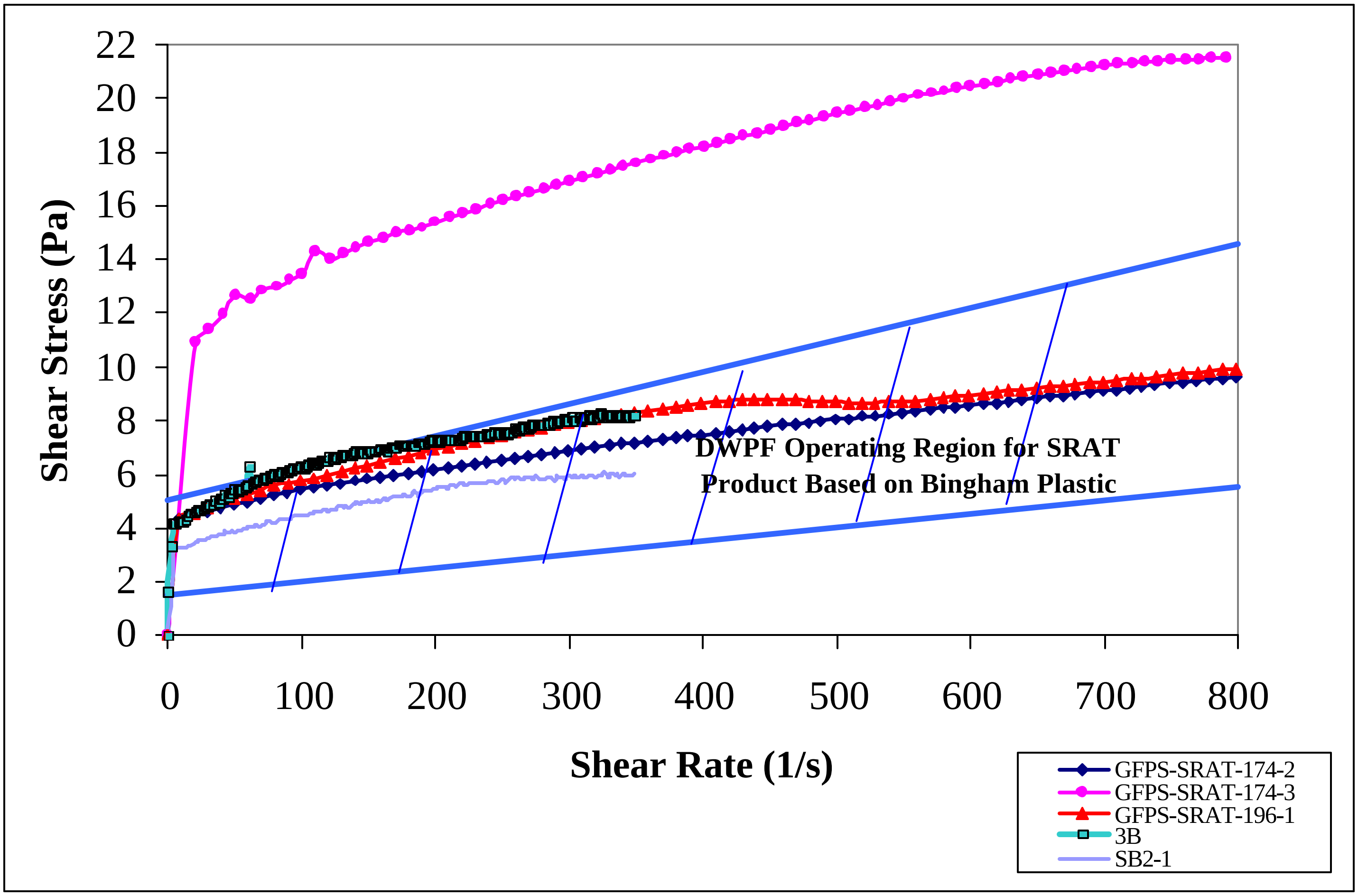
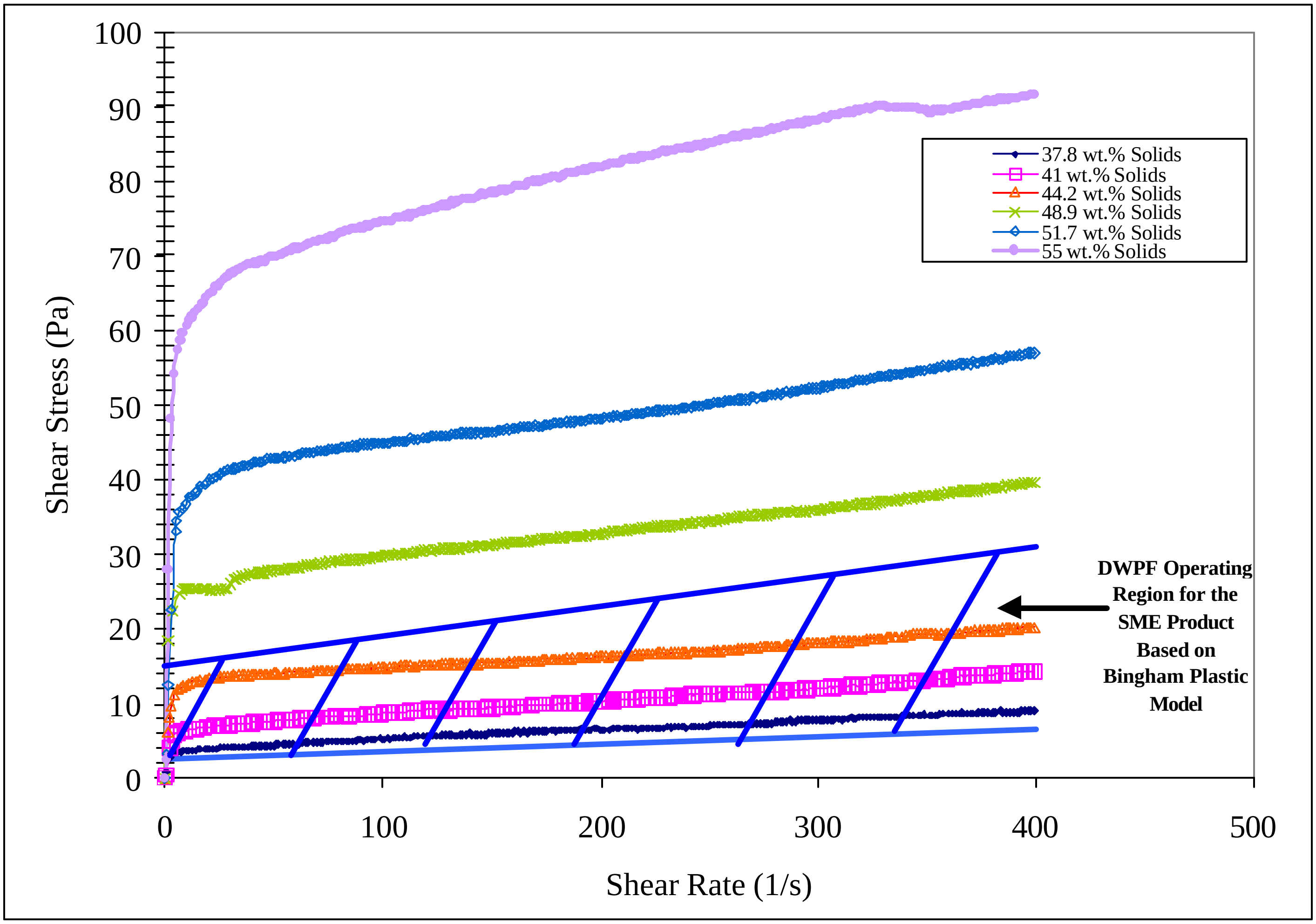


Figure C - 5 - Comparison of the Uncorrected Flow Curves for the Nonradioactive SME Samples to the DWPF Operating Region



APPENDIX D - RAW DATA FOR THE GFPS SLUDE SLURRY SAMPLES AND SRAT PRODUCT SAMPLES (UP FLOW CURVES ONLY)

GFPS-SRAT-164-1 (decanted sludge at 17.1 wt. % TS)
ThermoHaake RheoWin 3/14/02 / 1:08 PM
Company: SRS Operator: dck
Date: 14.03.2002 Time: 12:53:40 PM Version: RheoWin Pro 291
Substance: 164 Sample no: 1

D [1/s]	Tau [Pa]	D [1/s]	Tau [Pa]
0	0	499.1	8.12
0	0	509	8.17
0	0	519.8	8.239
8.647	3.894	528.9	8.283
18.79	4.279	539.1	8.341
28.77	4.494	548.7	8.409
39.17	4.642	559.1	8.453
49.49	4.797	568.9	8.51
59.06	4.922	578.8	8.559
68.56	5.033	588.7	8.637
78.82	5.153	598.8	8.698
88.93	5.274	608.8	8.738
98.82	5.374	618.6	8.796
109.2	5.463	628.6	8.848
118.6	5.572	639.3	8.897
128.9	5.657	648.9	8.964
138.7	5.742	659	9.015
149.2	5.843	668.7	9.059
158.9	5.927	678.8	9.119
168.9	6.004	689.1	9.157
178.7	6.076	699.3	9.221
189.1	6.15	709	9.27
199.2	6.222	719.1	9.321
209.2	6.305	729	9.371
219.2	6.386	739	9.428
229.2	6.447	748.4	9.475
239	6.526	758.9	9.53
248.5	6.581	768.9	9.579
258.7	6.65	778.8	9.632
268.9	6.727	789.3	9.69
279.1	6.782	798.7	9.724
288.9	6.855	809.8	9.785
299.2	6.927	818.6	9.82
309.3	6.989	829	9.892
318.9	7.051	838.8	9.939
328.9	7.126	848.8	9.983
339.6	7.177	858.7	10.04
348.9	7.235	868.8	10.08
358.8	7.298	879.2	10.14
369.3	7.355	888.8	10.19
379	7.417	898.8	10.25
389	7.474	908.8	10.29
398.6	7.529	918.7	10.34
408.5	7.588	928.7	10.39
418.8	7.648	938.7	10.44
428.7	7.703	949.2	10.48

438.9	7.758	959.4	10.55
448.6	7.826	969	10.59
458.7	7.881	978.6	10.63
469	7.926	989.3	10.74
479.1	7.994	990	10.7
488.7	8.046		

GFPS-SRAT-165-1 13.5 wt. % TS
Equivalent sample to 164 in time and place, but never decanted
ThermoHaake RheoWin 3/14/02 / 8:35 AM
Company: SRS Operator: dck
Date: 14.03.2002 Time: 8:19:10 AM Version: RheoWin Pro 291
Substance: 165 Sample no: 1

D [1/s]	Tau [Pa]	D [1/s]	Tau [Pa]
0.0007168	0	499.7	3.534
0	0.004212	509	3.579
0.001434	0	519.1	3.601
9.568	1.309	529.2	3.632
19.49	1.366	539.3	3.674
29.3	1.447	548.8	3.691
39.45	1.545	559.2	3.734
49.39	1.618	569.1	3.77
59.19	1.685	579.2	3.81
69.33	1.755	589.3	3.816
79.68	1.806	599	3.851
89.24	1.862	609.4	3.899
99.55	1.921	619.3	3.923
109	1.976	629.2	3.96
119.7	2.045	639.2	4.005
129.1	2.085	649	4.033
139	2.131	659	4.064
149.4	2.189	669.2	4.085
159.1	2.244	679.4	4.113
169.3	2.272	689.2	4.155
180.4	2.327	699.2	4.185
189.1	2.365	709.3	4.227
199.3	2.418	719.2	4.259
209.5	2.463	729.1	4.29
219.1	2.5	739.4	4.308
229.6	2.54	749	4.361
239	2.601	759.2	4.378
249.1	2.631	769.5	4.421
259.5	2.671	779	4.444
269.2	2.703	789.4	4.496
279.4	2.754	799.3	4.527
288.9	2.788	809.1	4.552
299.4	2.84	819.5	4.585
308.7	2.866	829.3	4.616
319.3	2.91	839.1	4.656
329.8	2.946	849.4	4.689
339.5	2.982	859.5	4.731
349.1	3.031	869.4	4.763
359.4	3.054	879.1	4.778
369.4	3.106	889.2	4.851
379.5	3.138	899.1	4.917
389.3	3.172	909.2	5.051
399.2	3.205	919.3	5.181
409.1	3.246	929.3	5.302
419.2	3.266	939.5	5.426
429	3.309	949.2	5.518

439.3	3.335	959.4	5.65
449.2	3.375	969.1	5.742
459.3	3.42	979	5.851
469.1	3.438	989.1	6.011
479.2	3.486	990	5.966
489.4	3.502		

GFPS-SRAT-165-2
decanted since GFPS-SRAT-165-1 to ~16.8 wt. % TS
ThermoHaake RheoWin 3/21/02 / 1:15 PM
Company: SRS Operator: dck
Date: 21.03.2002 Time: 12:59:02 PM Version: RheoWin Pro 291
Substance: 165 Sample no: 2

D [1/s]	Tau [Pa]	D [1/s]	Tau [Pa]
0.0004301	0	508.7	7.889
0.00003584	0	519	7.944
0.0009319	0	529	7.996
8.68	3.88	538.8	8.055
18.92	4.12	549	8.106
29.02	4.294	559	8.163
38.8	4.461	569.3	8.215
49.09	4.6	578.8	8.271
59.06	4.739	589	8.336
68.69	4.842	598.7	8.378
79.01	4.973	608.8	8.432
88.8	5.071	619.1	8.483
98.74	5.178	629.1	8.533
108.7	5.279	638.9	8.588
118.7	5.378	649	8.65
128.9	5.449	658.8	8.685
138.7	5.54	668.9	8.753
149	5.624	678.9	8.795
159.2	5.721	689	8.847
169.1	5.799	698.9	8.885
178.9	5.885	708.7	8.945
189	5.951	718.7	8.983
199.3	6.019	729	9.043
209.2	6.092	739.1	9.096
219.1	6.164	748.8	9.143
228.7	6.231	758.9	9.192
238.8	6.304	768.7	9.246
249.2	6.382	778.9	9.285
259	6.449	789.1	9.333
268.8	6.513	799.1	9.382
278.8	6.581	808.7	9.427
288.8	6.643	818.9	9.475
299.1	6.692	828.8	9.528
309.1	6.756	839	9.582
319.2	6.832	849.1	9.621
329	6.894	859.2	9.671
338.7	6.94	868.9	9.708
349.1	7.002	879.3	9.778
358.9	7.067	888.9	9.82
368.7	7.125	899	9.866
379.3	7.185	908.9	9.912
389	7.234	918.9	9.981
398.9	7.298	928.8	10.02
408.9	7.354	938.8	10.07
418.9	7.412	948.9	10.1
429	7.466	958.8	10.15

438.8	7.52	969.1	10.2
448.8	7.567	979	10.26
459	7.611	988.9	10.35
468.8	7.661	990	10.3
479	7.734		
489.1	7.79		
498.7	7.823		

GFPS-SRAT-164-3
Decanted more since runs 1 & 2, ~18.54 wt. % TS
ThermoHaake RheoWin 3/21/02 / 12:52 PM
Company: SRS Operator: dck
Date: 21.03.2002 Time: 12:37:35 PM Version: RheoWin Pro 291
Substance: 164 Sample no: 3

D [1/s]	Tau [Pa]	D [1/s]	Tau [Pa]
0	0.000002371	509.7	11.71
0	0	519.5	11.77
0.0002509	0	529.7	11.85
9.337	5.951	540.6	11.93
19.57	6.509	549.9	12
29.19	6.9	560	12.09
40.37	7.106	570	12.17
51	7.165	579.8	12.24
59.55	7.434	589.9	12.31
69.71	7.601	599.5	12.38
79.76	7.817	609.5	12.45
89.84	7.912	619.8	12.5
99.94	8.039	629.7	12.57
109.8	8.169	640.1	12.66
119.8	8.278	649.9	12.72
129.6	8.4	659.8	12.79
139.8	8.513	669.8	12.86
149.9	8.625	679.5	12.92
159.9	8.739	689.7	12.99
169.8	8.851	699.5	13.06
180.1	8.937	709.5	13.11
189.8	9.051	719.5	13.18
200.1	9.136	729.5	13.23
209.5	9.229	739.8	13.31
219.6	9.317	749.6	13.38
229.8	9.418	759.7	13.44
239.7	9.508	769.5	13.5
249.6	9.597	779.7	13.56
259.5	9.68	789.7	13.62
269.8	9.776	799.8	13.68
279.8	9.854	809.8	13.75
290.1	9.944	819.6	13.81
299.5	10.03	829.8	13.89
309.5	10.1	839.6	13.94
319.7	10.19	849.8	14.01
329.8	10.28	859.8	14.06
339.5	10.35	869.7	14.12
349.8	10.44	879.6	14.18
359.6	10.52	889.8	14.25
369.5	10.59	900.3	14.3
379.5	10.67	909.8	14.38
389.8	10.74	919.5	14.43
399.7	10.82	929.6	14.51
409.4	10.89	939.6	14.56
419.7	10.99	949.5	14.63
429.5	11.06	959.9	14.68

439.4	11.14	970.1	14.75
449.9	11.21	979.7	14.8
459.6	11.3	988.9	14.92
469.8	11.38	990	14.87
479.9	11.47		
489.9	11.54		
499.4	11.61		

GFPS-SRAT-174-2 Z41 Concentric cylinder
17.67 wt. % TS, 5.24 wt. % SS
ThermoHaake RheoWin 3/18/02 / 3:09 PM
(no sign of bubbles at end of run)
Company: SRS Operator: dck
Date: 18.03.2002 Time: 14:53:23 PM Version: RheoWin Pro 291
Substance: GFPS-SRAT-174 Sample no: 2

D [1/s]	Tau [Pa]	D [1/s]	Tau [Pa]
0.001075	0	499.3	8.018
0	0.007654	509.2	8.07
0	0	518.8	8.154
8.847	4.314	528.9	8.195
19.1	4.515	538.7	8.265
28.88	4.606	549.1	8.312
38.8	4.737	558.9	8.357
49.34	4.875	569.2	8.441
58.73	4.972	579	8.492
68.97	5.091	588.7	8.528
79.14	5.208	598.9	8.593
88.82	5.303	609.3	8.641
98.94	5.404	619	8.686
109	5.489	629.2	8.751
118.9	5.573	639	8.794
128.8	5.667	649.1	8.862
139.3	5.755	659	8.915
148.7	5.821	668.9	8.966
159.1	5.912	679.1	9.012
168.9	5.995	689.4	9.071
178.9	6.063	699.4	9.124
189.4	6.129	709.2	9.175
198.8	6.204	718.8	9.216
209.5	6.284	728.9	9.273
219.4	6.354	738.6	9.317
229.3	6.421	748.8	9.388
239	6.48	758.7	9.438
249.3	6.545	768.9	9.485
259.8	6.627	778.8	9.535
268.7	6.688	789.1	9.58
279.3	6.741	799.3	9.639
289.1	6.809	808.9	9.676
298.7	6.866	819	9.74
309	6.936	828.8	9.772
318.7	6.982	839.5	9.828
329.3	7.054	848.9	9.894
339	7.122	859	9.931
348.8	7.184	869	9.987
359	7.237	879.1	10.05
369	7.285	889.1	10.11
379.3	7.356	899.6	10.16
389	7.401	908.8	10.19
398.7	7.454	919.5	10.24
409	7.525	928.9	10.29
419	7.582	938.9	10.34
429.1	7.63	948.8	10.39

438.7	7.69	959.1	10.45
448.9	7.74	969.3	10.5
458.7	7.822	979.2	10.58
469.2	7.858	988.9	10.64
479.2	7.914	990	10.6
488.6	7.96		

GFPS-SRAT-174-3
~20.2 wt. % TS, ~6.1 wt. % SS
ThermoHaake RheoWin 3/26/02 / 9:27 AM
Company: SRS Operator: dck
Date: 26.03.2002 Time: 9:12:36 AM Version: RheoWin Pro 291
Substance: 174 Sample no: 3

D [1/s]	Tau [Pa]	D [1/s]	Tau [Pa]
0	0	510.4	19.55
0	0	521	19.65
0	0	530.6	19.76
20.68	10.93	540.6	19.86
30.47	11.41	550.5	19.98
41.23	11.96	560.8	20.11
50.56	12.68	570.7	20.21
61.5	12.51	580.7	20.3
70.7	12.86	590.8	20.4
80.98	12.99	600.5	20.49
90.67	13.24	611	20.56
101.2	13.5	620.6	20.64
110.4	14.29	630.7	20.73
120.7	14.01	640.6	20.8
130.8	14.23	650.7	20.87
140.8	14.42	660.7	20.95
150.7	14.62	670.9	21.02
160.8	14.76	680.6	21.1
171.2	14.97	691	21.16
180.8	15.08	700.9	21.21
190.6	15.22	710.8	21.28
200.6	15.41	721	21.34
211.1	15.59	730.8	21.38
220.7	15.75	740.6	21.41
230.7	15.91	750.5	21.44
240.8	16.08	761.2	21.46
250.7	16.23	770.6	21.48
260.5	16.36	781.1	21.5
270.6	16.52	791.1	21.51
280.9	16.65	800.5	21.51
290.9	16.79	810.9	21.54
300.5	16.92	820.8	21.56
310.4	17.05	830.5	21.57
321.1	17.21	841.2	21.58
330.5	17.35	851.1	21.58
340.8	17.49	860.9	21.6
350.8	17.61	870.9	21.63
361.1	17.74	881	21.66
370.6	17.86	890.7	21.66
381	18	900.8	21.7
390.7	18.12	910.7	21.73
400.8	18.25	920.7	21.77
410.6	18.36	930.7	21.79
420.8	18.49	940.7	21.82
430.7	18.61	950.9	21.86
440.8	18.72	960.8	21.91

450.9	18.83	970.8	21.96
461	18.96	980.6	21.99
471	19.08	990	22.05
480.6	19.19		
490.9	19.32		
500.7	19.43		

GFPS-SRAT-196-1 Z41 Concentric cylinder
18.2 wt. % TS, 5.2 wt. % SS (Run 2 SRAT Product)
ThermoHaake RheoWin 3/26/02 / 10:13 AM
Company: SRS Operator: dck
Date: 26.03.2002 Time: 9:53:08 AM Version: RheoWin Pro 291
Substance: 196 Sample no: 1

D [1/s]	Tau [Pa]	D [1/s]	Tau [Pa]
0	0	499.1	8.708
0	0.00001793	509.5	8.677
0.0007527	0	519	8.678
8.914	4.319	528.9	8.678
18.94	4.535	539.2	8.701
28.95	4.74	549.1	8.735
39.3	4.93	559	8.761
49.13	5.097	569.4	8.806
58.74	5.235	579.3	8.853
69.18	5.392	589.2	8.91
79.04	5.549	598.9	8.96
88.98	5.648	609.3	9.004
99.23	5.753	619	9.047
109.1	5.87	629.1	9.11
119.3	5.987	639.1	9.157
129.3	6.113	649.1	9.209
139.2	6.235	659.7	9.249
149	6.338	669.1	9.308
159.2	6.462	679.2	9.339
169.6	6.577	689.3	9.393
179	6.695	699.3	9.446
189.4	6.805	708.8	9.491
199.3	6.921	719.4	9.553
209.3	7.033	728.9	9.587
219.1	7.139	739	9.65
228.9	7.23	749.2	9.705
239.4	7.343	758.9	9.753
249.4	7.435	769.4	9.792
259	7.536	779	9.83
268.9	7.636	789.2	9.89
279.3	7.725	798.8	9.929
289.3	7.815	809.1	9.993
299.1	7.9	818.9	10.03
309	7.991	829.3	10.06
319.3	8.078	839	10.13
329.1	8.173	849.1	10.15
339.1	8.246	858.9	10.21
349.6	8.322	869.2	10.25
359	8.391	878.8	10.28
369.2	8.458	889.1	10.34
379.2	8.526	898.9	10.38
389.5	8.599	909	10.43
398.9	8.645	919.1	10.49
409.1	8.721	929	10.52
419.3	8.761	938.8	10.56
428.9	8.808	949.1	10.6

439	8.812	959.1	10.65
448.9	8.815	968.9	10.69
458.8	8.798	978.9	10.75
469.1	8.77	989.3	10.83
479.2	8.756	989.8	10.8
489.2	8.752	990	10.79