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Revision 0

PHYSICAL PROPERTIES OF KAOLIN/SAND SLURRY USED DURING SUBMERSIBLE MIXER PUMP TESTS AT TNX

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August 2004

Immobilization Technology Section
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Aiken, SC 29808

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EXECUTIVE SUMMARY

The purpose of this task is to characterize the physical properties of kaolin/sand slurry used to test the performance of a new submersible mixer pump (SMP) which is undergoing performance testing at the TNT Waste Tank mockup facility. Three different sample locations, the SMP cooling water exit (CWE), the SMP fluid flow field (FFF), and SMP effective cleaning radius (ECR) were used for sampling over the seven day test. The physical properties determinations for the kaolin/sand slurry samples include rheology, weight percent total solids (wt% TS), density, and particle size distribution (PSD) were requested, though not all these determinations were performed on all the samples.

The physical properties determinations are described in more detail in section 1.0. Measurements were performed at Savannah River National Laboratory (SRNL) in accordance with the Technical Assistance Request (TAR)[1].

The data, average of two measurements, is shown in the table below. This data clearly shows that the SMP-CWE samples contained more solids than those at other sample locations for a given sample day. The SMP-FFF and SMP-ECR were similar in solids content. The rheology of the samples is dependent on the wt% solids concentration and are all within the bounds stated in the TAR. The particle size distribution is discussed in section 1.4.

Sample location	Day Pulled	Average of Two Measurements			
		wt% T.S.	Density (g/mL)	Yield stress (dynes/cm^2)	Consistency (cP)
SMP-CWE	1	25.17	1.180	122.0	8.04
	2	24.04	1.171	107.9	7.52
	3	23.86	1.171	107.6	7.43
	4	23.89	1.173	109.2	7.42
	5	23.01	1.165	95.6	6.86
	6	23.02	1.164	99.0	7.03
	7	23.23	1.167	97.9	7.03
SMP-FFF	1	24.32	1.177	N/M	N/M
	2	23.72	1.167	N/M	N/M
	3	23.49	1.165	N/M	N/M
	4	23.41	1.169	N/M	N/M
	5	22.77	1.162	N/M	N/M
	6	22.69	1.161	N/M	N/M
	7	22.92	1.164	N/M	N/M
SMP-ECR	3	23.51	1.168	104.3	7.21
	6	22.06	1.157	83.3	6.39
	7	22.97	1.165	96.7	6.98

N/M = not measured

[1] Altman, D., "Testing and Sampling support at TNX for Submersible Mixer Pump (SPM) Test", HAL-TAR-2004-077, Rev. 1, July 21, 2004

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LIST OF ACRONYMS

ACTL	Aiken County Technology Laboratories
ADS	Analytical Developmental Section
CWE	Cooling Water Exit
DI	De-ionized
ECR	Effective Cleaning Radius
FFF	Fluid Flow Field
ITS	Immobilization Technology Section
NIST	National Institute of Standards and Technology
N/M	Not Measured
PSD	Particle Size Distribution
SMP	Submersible Mixer Pump
SRNL	Savannah River National Laboratory
TAR	Technical Assistance Request
WOW	Waste on Wheels
wt% TS	Weight Percent Total Solids

1.0 INTRODUCTION AND BACKGROUND

Waste on Wheels (WOW) engineering requested[1] SRNL Immobilization Technology Section (ITS) to perform physical characterization of the kaolin/sand slurry used to characterize the performance of a new SMP. The testing of the new SMP was performed at the TNX Waste Tank mockup facility. During the 7[2] day SMP test using the kaolin/sand slurry, samples were pulled from three different locations. The sampling day, sample location, and requested physical property analyses are shown in Table 1-1.

Table 1-1: Analysis Requested of Provided Samples

Day sample pulled		Day 1			Day 2			Day 3			Day 4			Day 5			Day 6			Day 7		
Sample Location		SMP-CWE	SMP-FFF	SMP-ECR	SMP-CWE	SMP-FFF	SMP-ECR	SMP-CWE	SMP-FFF	SMP-ECR	SMP-CWE	SMP-FFF	SMP-ECR	SMP-CWE	SMP-FFF	SMP-ECR	SMP-CWE	SMP-FFF	SMP-ECR	SMP-CWE	SMP-FFF	SMP-ECR
Analysis	Rheology	X			X			X		X	X			X			X		X	X		X
	Density	X	X		X	X		X	X	X	X	X		X	X		X	X	X	X	X	X
	wt% TS	X	X		X	X		X	X	X	X	X		X	X		X	X	X	X	X	X
	PSD									X	X	X							X	X	X	X

Blanks mean specified analysis was not requested for this sample.

The location and method of sampling is provided in Table 1-2. A 400 mL sample at each sample location per day was required to complete the necessary physical characterization.

Table 1-2: Sample Location and Method of Sampling for the SMP Test

Location	Sampling Method
SMP - Cooling Water Exit (CWE)	There are four discharge motor cooling streams leaving the motor housing. A clean stainless steel beaker will be used to gather a sample from the discharge and sample(s) poured into a sample bottle. The sample cup was wetted with the CWE prior to sampling.
SMP - Fluid Flow Field (FFF)	A pump was used to pull a sample from the discharge of the rotating SMP. The sample was pulled two feet from the bottom of the tank when the jet rotated into the sampling location.
SMP – Effective Cleaning Radius (ECR)	A dip sample (1 to 3 feet deep) was collected from a stagnant zone near the edge of the tank opposite of the SMP.

Once the samples were received at SRNL, samples that required PSD analysis were pulled and delivered to the Analytical Development Section (ADS) for analysis. Prior to pulling the sample, the sample bottles were homogenized. The remaining analyses occurred at Aiken County

[2] Kaolin/Sand slurry samples from the SMP testing were sampled from July 15th through July 21st, 2004.

Technology Laboratories (ACTL). The following sections describe the method used to perform the various analyses, the results, and any conclusions.

Prior to any measurement at ACTL, the samples were homogenized. Additional handling of the sample was performed prior to rheological measurements and is described in more detail in the rheology section.

1.1 Weight Percent Total Solids

Weight percent total solids were performed using a Mettler Toledo HR83 Halogen Moisture analyzer. This moisture analyzer uses a load cell that continuously measures the mass of the sample during the measurement and a halogen heat lamp that is controlled by an infrared thermometer. The mass of a sample pan is first measured and the weight tared. Approximately a 1.5 to 3 gram sub-sample of the kaolin/sand sample is placed onto the sample pan and this mass is recorded by the analyzer. The temperature of the sample is then ramped to 105°C and maintained at 105°C throughout the measurement. The temperature is maintained until the weight of the sample does not change more than 1 milligram over a 20 second period and this final mass is recorded by the analyzer. The wt% TS is then determined by taking the ratio of the final mass to initial mass and multiplying this value by 100%. The analyzer load cell is checked on a daily basis (when used) using a 2.0 gram weight and functionally checked using a 7.0 wt% salt solution.

For each sample that required wt% TS, two replicates were analyzed. The individual results, average and percent standard deviation are shown in Table 1-3. There were no limits provided in the TAR stating the range in which the wt% TS must be within. The SMP procurement specification[3] states wt% solids range of 0 to 17% (section 3.3.1.1) for tank environmental conditions and a 20 wt% TS (section 4.1.3) for SMP acceptance testing. In both case, the wt% TS of the kaolin/sand slurries exceeded these limits. The data does reveal that samples pulled on the same day, the CWE samples are slightly higher in wt% TS as compared to the FFF and ECR samples. The FFF and ECR samples pulled on the same days have similar wt% TS results.

[3] M-SPP-G-00302, "Procurement Specification – Submersible Mixer Pump", Rev. 1, May 23, 2003

Table 1-3: Kaolin/Sand Weight Percent Total Solids Data for the SMP

Sample location	Day Pulled	Weight Percent Total Solids			
		Sample 1	Sample 2	Average	% standard deviation
SMP-CWE	1	25.25	25.08	25.17	0.48%
	2	24.03	24.04	24.04	0.03%
	3	23.80	23.91	23.86	0.33%
	4	23.84	23.94	23.89	0.30%
	5	22.93	23.08	23.01	0.46%
	6	22.90	23.13	23.02	0.71%
	7	23.29	23.17	23.23	0.37%
SMP-FFF	1	24.22	24.42	24.32	0.58%
	2	23.84	23.60	23.72	0.72%
	3	23.48	23.49	23.49	0.03%
	4	23.44	23.38	23.41	0.18%
	5	22.71	22.82	22.77	0.34%
	6	22.81	22.56	22.69	0.78%
	7	22.90	22.94	22.92	0.12%
SMP-ECR	3	23.58	23.44	23.51	0.42%
	6	22.13	21.99	22.06	0.45%
	7	22.93	23.01	22.97	0.25%

1.2 Density

Densities were performed using an Anton Paar DMA 4500 Density analyzer. A sample is pushed in to the density analyzer u-tube, the sample temperature corrected to 25°C, a vibration is induced on one end of the u-tube and the frequency is measured at the other end. The density of the sample is determined on the measured frequency. The density analyzer is functionally checked on a daily basis (when used) with DI water.

For each sample that required density, two replicates were analyzed. The individual results, average and percent standard deviation are shown in Table 1-4. Specific gravity testing limits provided in the SMP procurement specification ranged from 1.0 to 1.5 (section 3.3.1.1)[3] for the supernatant but also specified testing the SMP using a kaolin slurry with a specific gravity of 1.14 (page 14)[4] for acceptance testing. The density of the kaolin/sand slurry samples were above the specific gravity for acceptance testing. The data reveals that samples pulled on the same day the CWE samples have a higher density as compared to the FFF and ECR samples and this is supported by the wt% TS data. The FFF and ECR samples pulled on the same day have similar density results.

[4] M-DCF-F-03629

Table 1-4: Kaolin/Sand Density Data for the SMP

Sample location	Day Pulled	Density (g/mL)			
		Sample 1	Sample 2	Average	% standard deviation
SMP-CWE	1	1.180	1.180	1.180	0.02%
	2	1.171	1.171	1.171	0.01%
	3	1.171	1.171	1.171	0.00%
	4	1.173	1.173	1.173	0.00%
	5	1.165	1.165	1.165	0.00%
	6	1.164	1.164	1.164	0.00%
	7	1.167	1.167	1.167	0.01%
SMP-FFF	1	1.177	1.177	1.177	0.00%
	2	1.167	1.167	1.167	0.00%
	3	1.165	1.165	1.165	0.00%
	4	1.169	1.169	1.169	0.00%
	5	1.162	1.162	1.162	0.01%
	6	1.161	1.161	1.161	0.01%
	7	1.164	1.164	1.164	0.00%
SMP-ECR	3	1.168	1.168	1.168	0.01%
	6	1.157	1.157	1.157	0.01%
	7	1.165	1.165	1.165	0.00%

1.3 Rheology

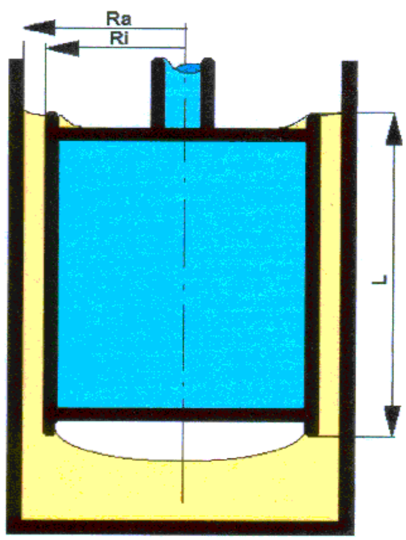
The Haake RS 600 rheometer was used for all rheological measurements performed in this task. Published RS600 specifications are shown in Table 1-5. The samples for rheological measurements were shaken for at least 1 minute prior to the initial measurement and the sample was shaken for at least 30 seconds prior to the second measurement.

Table 1-5: RS600 Measuring Head Specifications

Specification	Units	Value
Maximum Torque	N-m	0.5×10^{-7}
Minimum Torque (recommended)	N-m	0.2
Maximum Speed	RPM	1500
Minimum Speed	RPM	0.001

Flow curve measurements were obtained using a concentric (Z41) cylindrical rotor. The design is shown in Table 1-6. The Z41rotor is initially installed onto the RS600 and a zero reference point is determined by the rheometer. The Z41 rotor is then removed. A homogenized sample is then placed into the appropriate cup and lowered into a temperature/controlled cup holder, which controlled the temperature at 25°C. The RS600 rheometer can control the rate at which the rotor spins and measures both the rotational speed and the torque (the resistance to shear). The shear stress at the wall of the rotating rotor is then calculated (internally by the Haake software) based on the product of the measured torque and geometry (A-factor) of the rotor. The shear rate of the rotating rotor is calculated as the product of the measured speed and geometry (M-factor, assumes fluid is Newtonian) of the rotor. The A-factor, M-factor, shear rate range and the ramp up time, hold time at maximum shear rate, and ramp down time are provided in Table 1-6.

Table 1-6: Z41 Rotor Specifications and Ramp Rates

Design of Rotor	Z41 Rotor	
	Rotor radius (mm)	$R_i = 20.7$
	Cup Radius (mm)	$R_a = 21.7$
	Height of rotor (mm)	L = 55
	Sample Volume (cm^3)	V = 15
	A factor (Pa/(N·m))	6750
	M factor ($s^{-1}/(rad \cdot s^{-1})$)	22.40
	Measuring Range (s^{-1})	0 – 1000
	Ramp up time (min)	5
	Hold time (min)	1
	Ramp down time (min)	5

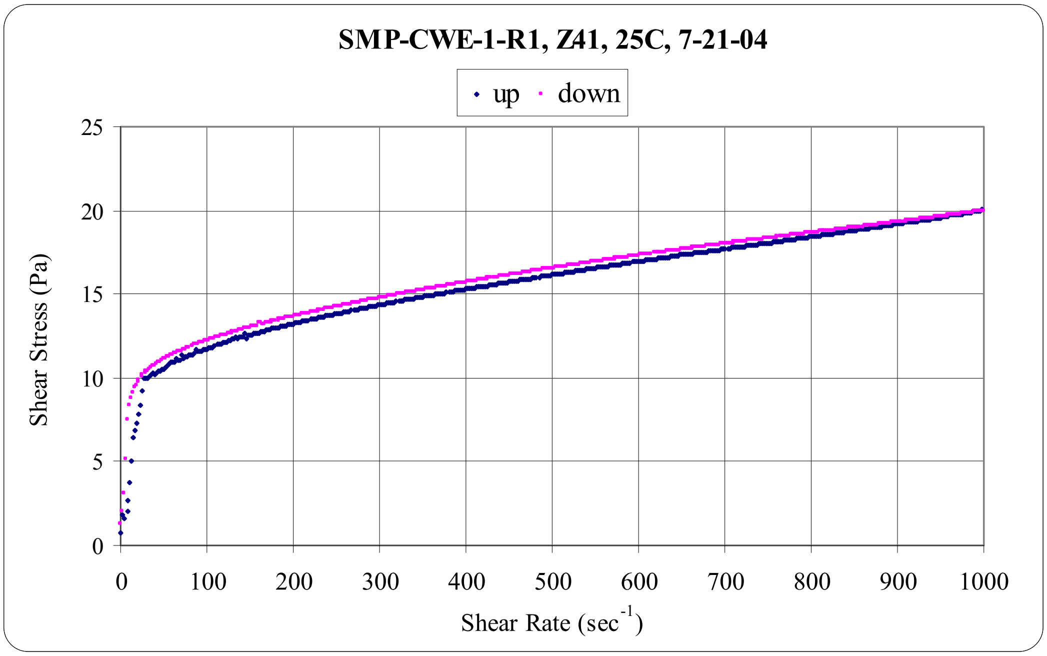
Prior to performing any flow curve measurement, the rotor and cup are inspected for visual damage that could potentially impact the flow measurement. National Institute of Standards and Technology (NIST) traceable Newtonian oil standards were used to verify the operability of the RS600 at a measurement temperature of 25°C. The viscosity of the NIST traceable Newtonian oil standards at 25°C is shown in Table 1-7. The flow curve for the NIST standard was analyzed as a Newtonian fluid and the calculated viscosity was compared to its NIST traceable Newtonian value. The rheometer is considered operable if the calculated viscosity is within $\pm$ 10% of the NIST traceable Newtonian oil standard viscosity as stated in Table 1-7. The measured viscosity of the NIST standard was 53.0 cP, well within the required range.

Table 1-7: Cole-Parmer NIST Traceable Newtonian Oil Standard

Standard Type	Viscosity (cP) at 25°C			Lot Number	Expiration Date
	-10%	Reported	+10%		
N35	46.34	51.49	56.64	130704	2/6/2006

For each sample that required rheology, two replicates were analyzed. A typical flow curve is shown in Figure 1-1. Inspection of this flow curve shows that the down curves were better defined at the lower shear rates and were slightly more viscous than the up curve, hence the down curves were selected as the curve to be analyzed for all samples. There is however, very little difference between the up and down curves.

Figure 1-1: Typical Kaolin/Sand Flow Curve of an SMP Sample



The down curves were analyzed as a Bingham Plastic fluid (equation 1-1) and the 1st measurements are fitted with the Bingham Plastic curves and are shown in Appendix A. All the flow curves were fitted with the Bingham Plastic model between a shear rate of 100 sec^{-1} to 1000 sec^{-1}. The down curve results for the Bingham Plastic yield stress and consistency include the individual measurements, average and percent standard deviation, and are summarized in Table 1-8. Limits provided in the TAR as well as in the procurement specification[3] for the Bingham Plastic parameters were 10 to 300 $dynes/cm^2$ for the yields stress and 3 to 50 cP for the consistency. In all cases, the kaolin/sand slurry samples Bingham Plastic yield stresses and consistencies were below 50% of the maximum yield stress and consistency values.

$$\tau = \tau_{BP} + \eta_{BP} \cdot \dot{\gamma} \qquad (1\text{-}1)$$

Where: τ = shear stress ($dynes/cm^2$) {Note 1 Pa = 10 $dynes/cm^2$)
$\dot{\gamma}$ = shear rate (sec^{-1})
τ_{BP} = Bingham Plastic yield stress ($dynes/cm^2$)
η_{BP} = Bingham Plastic Viscosity (or consistency) {centipose = cP}

Table 1-8: Kaolin/Sand Bingham Plastic Rheological Data for the SMP

Sample location	Day Pulled	Yield Stress (dynes/cm^2)				Consistency (cP)			
		Sample 1	Sample 2	Average	% standard deviation	Sample 1	Sample 2	Average	% standard deviation
SMP-CWE	1	122.4	121.7	122.0	0.38%	8.09	7.98	8.04	0.95%
	2	108.6	107.1	107.9	0.97%	7.58	7.46	7.52	1.07%
	3	108.7	106.6	107.6	1.37%	7.47	7.38	7.43	0.80%
	4	108.6	109.8	109.2	0.73%	7.39	7.45	7.42	0.52%
	5	95.4	95.9	95.6	0.39%	6.85	6.87	6.86	0.28%
	6	99.0	99.0	99.0	0.02%	7.04	7.01	7.03	0.34%
	7	98.8	96.9	97.9	1.42%	7.07	6.99	7.03	0.81%
SMP-ECR	3	103.6	105.1	104.3	1.05%	7.11	7.31	7.21	1.96%
	6	83.6	83.0	83.3	0.55%	6.41	6.38	6.39	0.32%
	7	96.1	97.3	96.7	0.87%	6.96	7.00	6.98	0.38%

This data reveals that the samples pulled on the same day from the CWE are more viscous when compared to the ECR samples. This is supported by the wt% TS and density data, were the CWE results are greater than that of the ECR results, indicating that the rheology should be more viscous for the CWE sample. The relationship between density, yield stress and consistency with that of wt% TS for the CWE and ECR samples is very linear between the wt% TS range tested here (22 to 25¼ wt% TS) and is shown in Figure 1-2, Figure 1-3, and Figure 1-4. These figures shows that SMP slurry samples pulled from the CWE and ECR locations are very similar in nature, given a wt% TS. Hence there were no additional physical analysis of the samples for wt% TS, density or rheology.

Figure 1-2: Density Versus Wt% TS For SMP

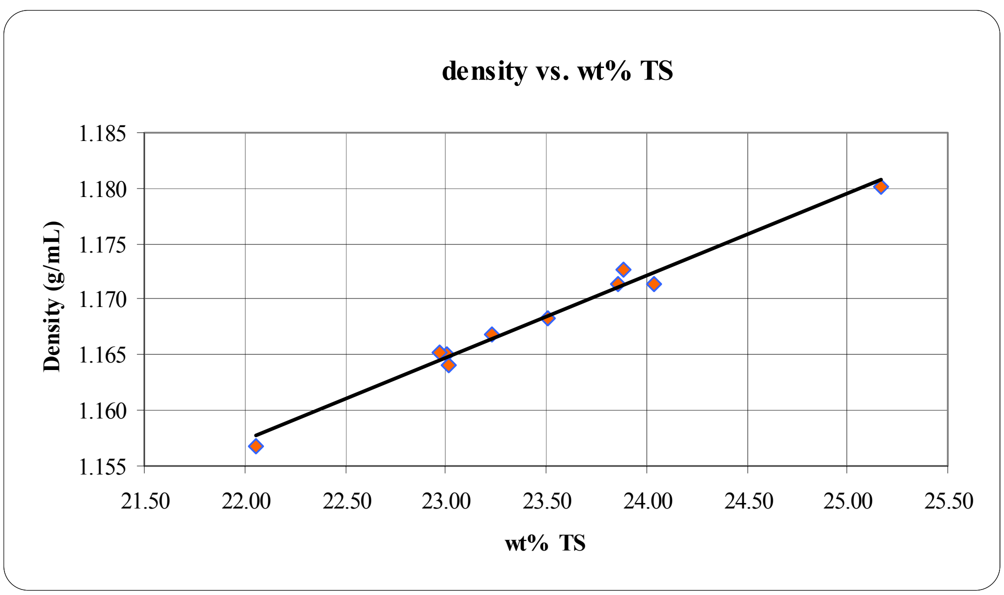


Figure 1-3: Bingham Plastic Yield Stress Versus Wt% TS For SMP

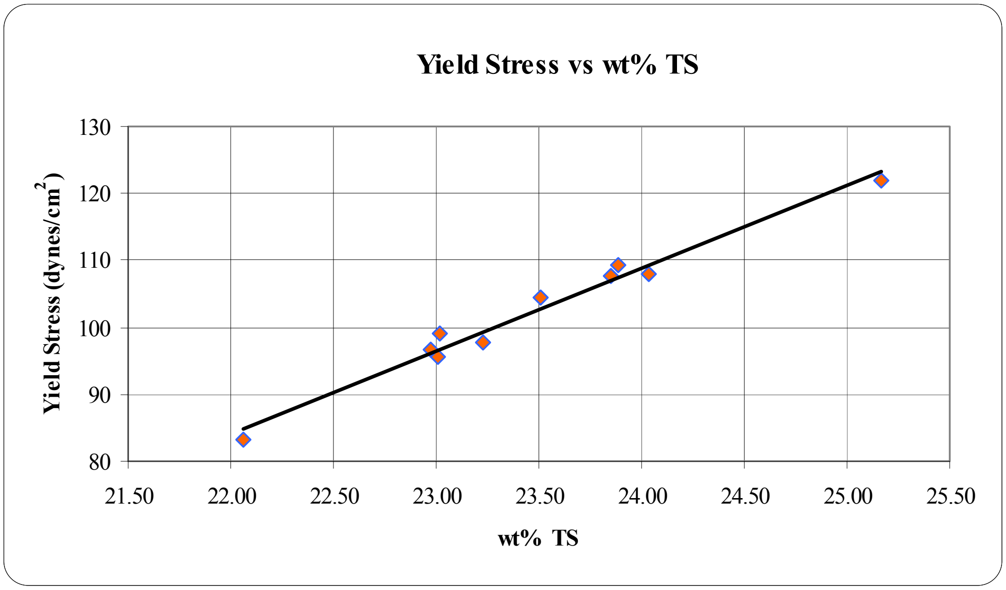
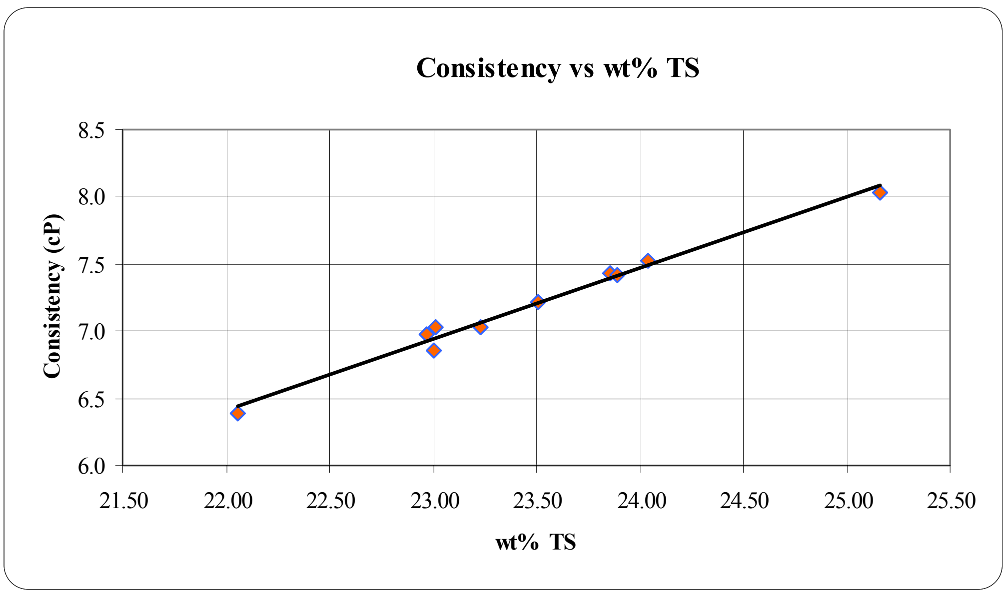


Figure 1-4: Bingham Plastic Consistency Versus Wt% TS For SMP



1.4 Particle Size Distribution

Appendix C contains selected technical data of the B-100 dry kaolin used in the SMP tests. The 2nd page of this appendix contains the particle size distribution (PSD), on an oxide mass basis, which indicates that 98 percent of the kaolin is smaller than 20 microns and 42 percent smaller than 0.5 microns. The results are summarized in Table 1-9.

Table 1-9: Unimin B-100 Kaolin PSD – Percent Weight on Oxide Basis

Bin	Size (microns)	% in Bin	% Cummulative
1	≥ 20	2	100
2	$10 \leq x < 20$	6	98
3	$5 \leq x < 10$	9	92
4	$2 \leq x < 5$	16	83
5	$1 \leq x < 2$	11	67
6	$0.5 \leq x < 1$	14	56
7	$x < 0.5$	42	42

The sand used during the SMP testing was an aggregate[5] used for masonry mortar. The nominal particle size distribution provided in the ASTM specification, for either natural or manufactured sand is shown in Table 1-10.

Table 1-10: ASTM Specification for Aggregate (Sand) Used in SMP Test

Sieve Size		Percent Passing	
		Natural Sand	Manufactured Sand
4.75 – mm	No. 4	100	100
2.36 - mm	No. 8	95 to 100	95 to 100
1.18 - mm	No. 16	70 to 100	70 to 100
600 - μm	No. 30	40 to 75	40 to 75
300 - μm	No. 50	10 to 35	20 to 40
150 - μm	No. 100	2 to 15	10 to 25
75 - μm	No. 200	0 to 5	0 to 10

A sample of the sand that was provided to SRNL was dried and the PSD was determined using an ATM Sonic Sifter, which utilizes ASTM sieves. The sonic sifter uses both vibration and pulsing to sieve the material through the selected ASTM sieves. The sieves used and results are provided in Table 1-11. Table 1-10 and Table 1-11 clearly show that the sand particles are much larger than that of the B-100 kaolin.

[5] ASTM C144-03, "Standard Specification For Aggregate for Masonry Mortar", 2003

Table 1-11: PSD of Aggregate (Sand) Provided to SRNL

Sieves		Sample				Average
Sieve Size	Micron	#1	#2	#3	#4	
425 µm	x ≥ 425	39.13%	33.31%	40.90%	31.16%	36.13%
250 µm	425 > x ≥ 250	40.00%	39.54%	39.84%	38.91%	39.57%
180 µm	250 > x ≥ 180	12.69%	16.31%	12.36%	15.64%	14.25%
125 µm	180 > x ≥ 125	6.24%	7.65%	5.50%	9.81%	7.30%
75 µm	125 > x ≥ 75	1.61%	2.63%	1.25%	3.65%	2.28%
45 µm	75 > x ≥ 45	0.20%	0.41%	0.11%	0.62%	0.33%
Fines Collector	x < 45	0.13%	0.14%	0.04%	0.22%	0.13%

A Microtrac S-3000 particle size analyzer was used to measure the PSD of the kaolin/sand samples. Prior to analyzing the sample, the kaolin/sand samples were diluted using DI water. The S-3000 particle size analyzer measures the particle diameters by measuring the scattered light from a laser beam projected through a stream of the fluid carrying the diluted sample. The amount and direction of the light scattered by the particles is measured by an optical detector array and then analyzed to determine the size distribution of the particles. The S-3000 measuring range is between 0.026 to 1408 µm and is functional checked using NIST traceable particle size standards. The sample is run three times and the values averaged. The particle size distribution, both volume (would be mass basis if only one type of material is being tested or if the different materials all have the same density) and number are provide in Appendix D for the requested data in Table 1-1. The mean volume and number diameters are provided in Table 1-12. The mean number diameters are fairly constant, stating that there are a lot of small particles, most likely from the kaolin. There are slight variations between the mean volume diameter and this is due to a large particle being measured (large particles can easily shift this distribution). It is hard to determine if the sand used in the slurry degraded to a smaller PSD due to pumping or if the larger sand particles settled out of the slurry and are laying on the bottom of the tank. There were no specifications for particle size in either the TAR or the SMP procurement specification.

Table 1-12: Mean Volume and Number Particle Size Diameters for SMP Samples

Sample location	Day Pulled	Mean volume (mm)	Mean Number (mm)
SMP-CWE	1	N/M	N/M
	2	N/M	N/M
	3	N/M	N/M
	4	6.709	0.651
	5	N/M	N/M
	6	N/M	N/M
	7	9.475	0.626
SMP-FFF	1	N/M	N/M
	2	N/M	N/M
	3	N/M	N/M
	4	6.799	0.639
	5	N/M	N/M
	6	N/M	N/M
	7	12.50	0.622
SMP-ECR	3	5.876	0.625
	6	14.02	0.622
	7	6.374	0.654

2.0 REFERENCE

WSRC-NB-2004-00122, Laboratory Notebook, “TNX Physical Properties of Kaolin”

APPENDIX A. 1ST SAMPLE DOWN FLOW CURVES FITTED TO BINGHAM PLASTIC MODEL

Figure A - 1: Down Flow Curve Sample SMP-CWE-1, Run 1

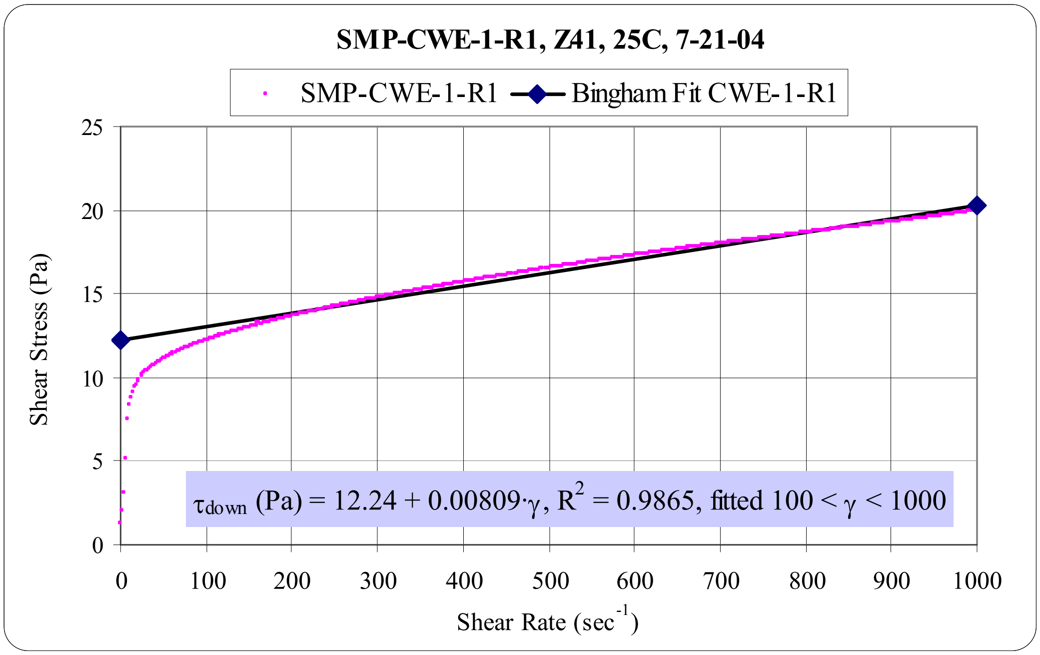


Figure A - 2: Down Flow Curve Sample SMP-CWE-2, Run 1

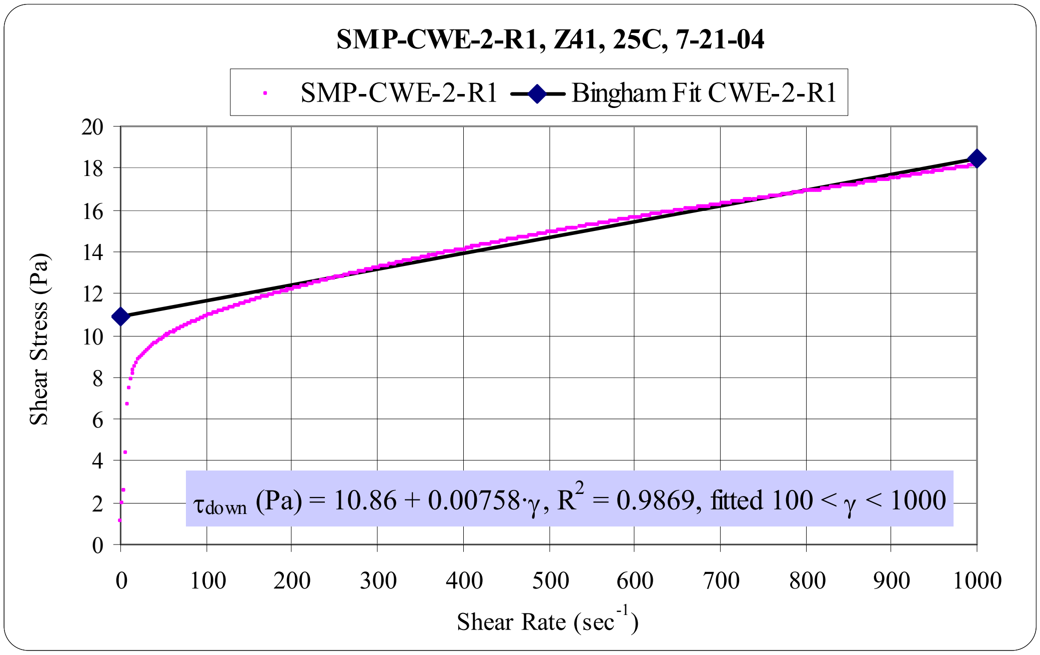


Figure A - 3: Down Flow Curve Sample SMP-CWE-3, Run 1

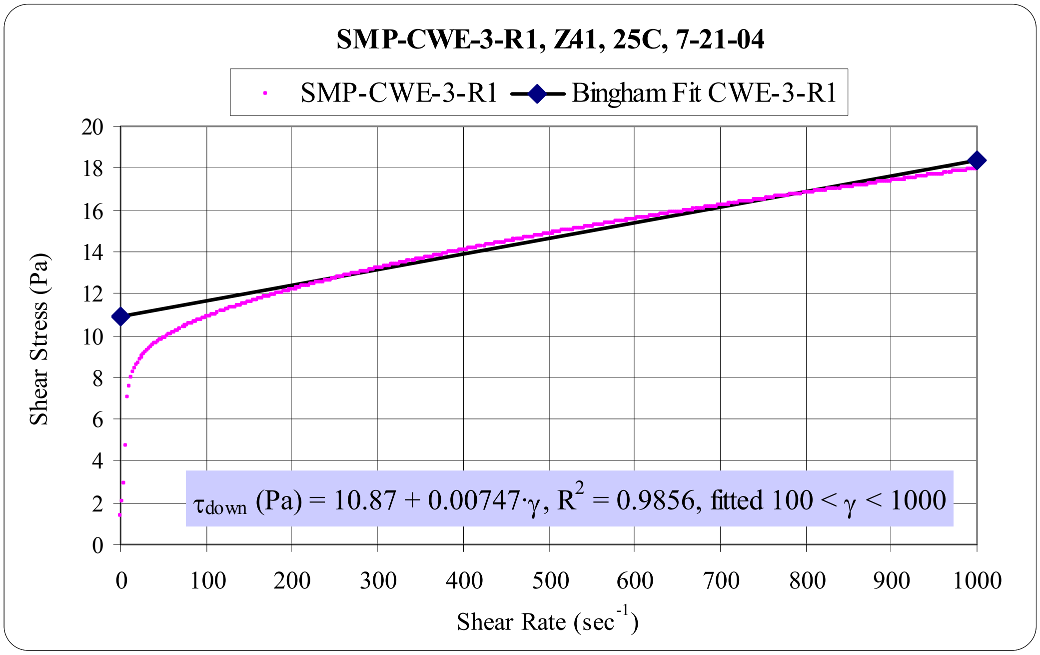


Figure A - 4: Down Flow Curve Sample SMP-CWE-4, Run 1

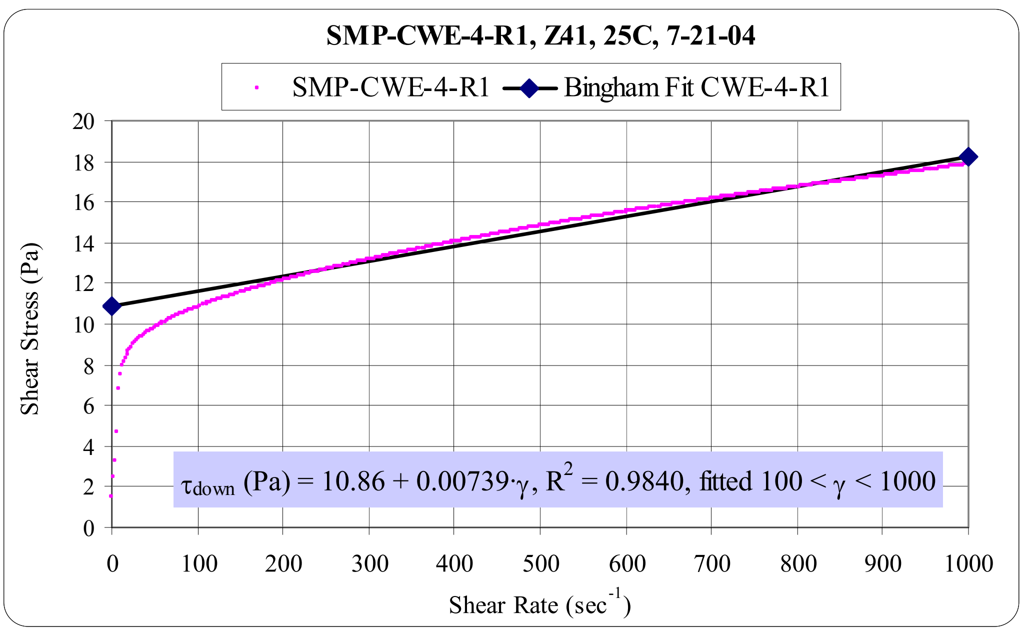


Figure A - 5: Down Flow Curve Sample SMP-CWE-5, Run 1

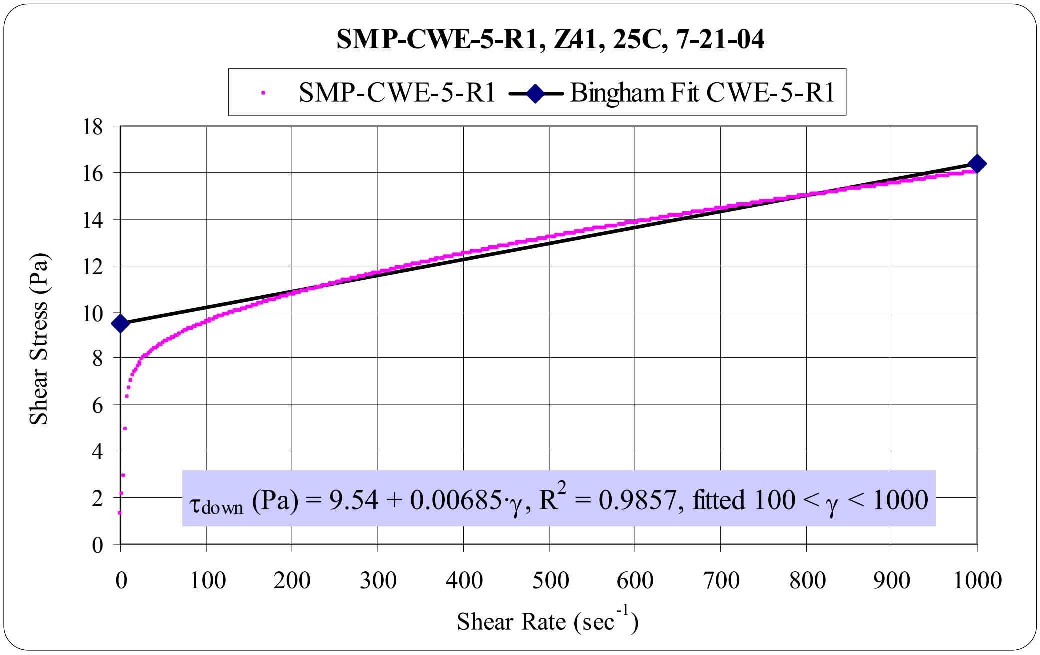


Figure A - 6: Down Flow Curve Sample SMP-CWE-6, Run 1

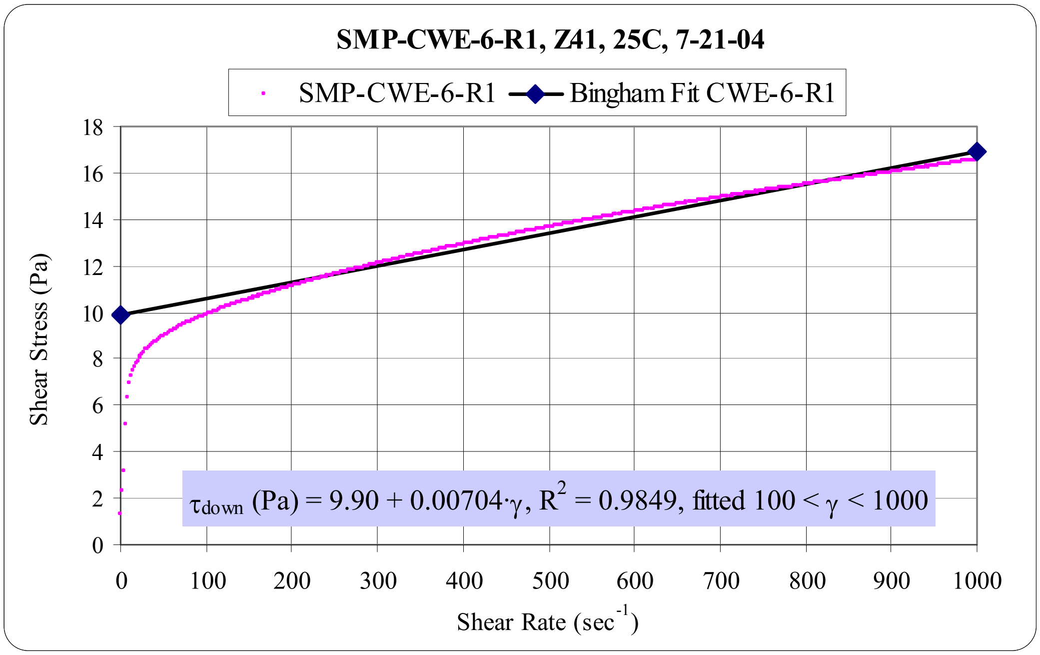


Figure A - 7: Down Flow Curve Sample SMP-CWE-7, Run 1

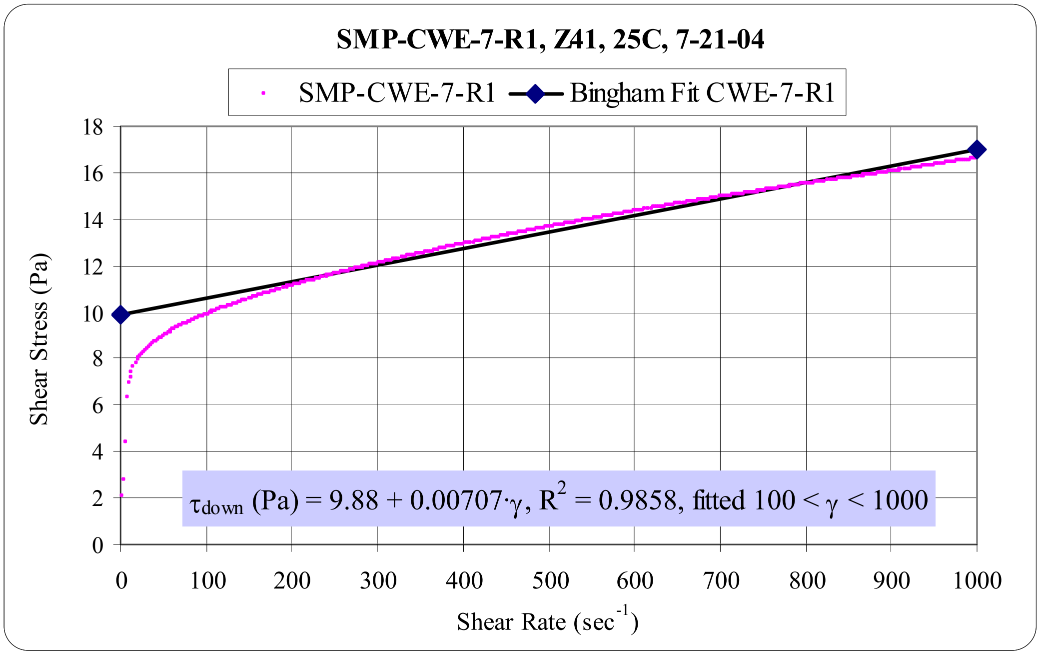


Figure A - 8: Down Flow Curve Sample SMP-ECR-3, Run 1

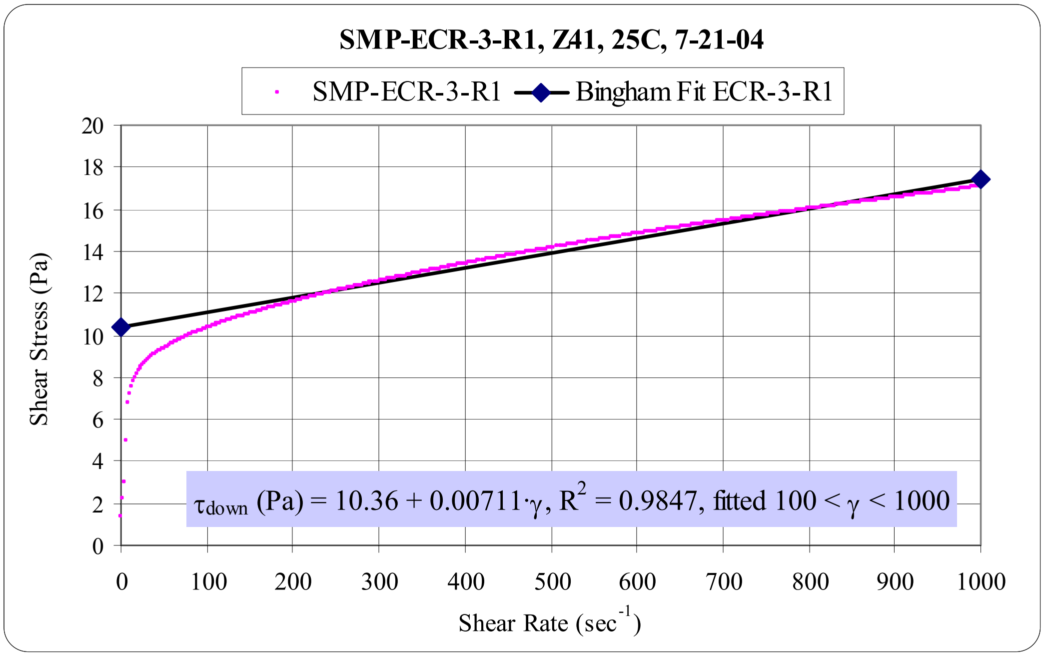


Figure A - 9: Down Flow Curve Sample SMP-CWE-6, Run 1

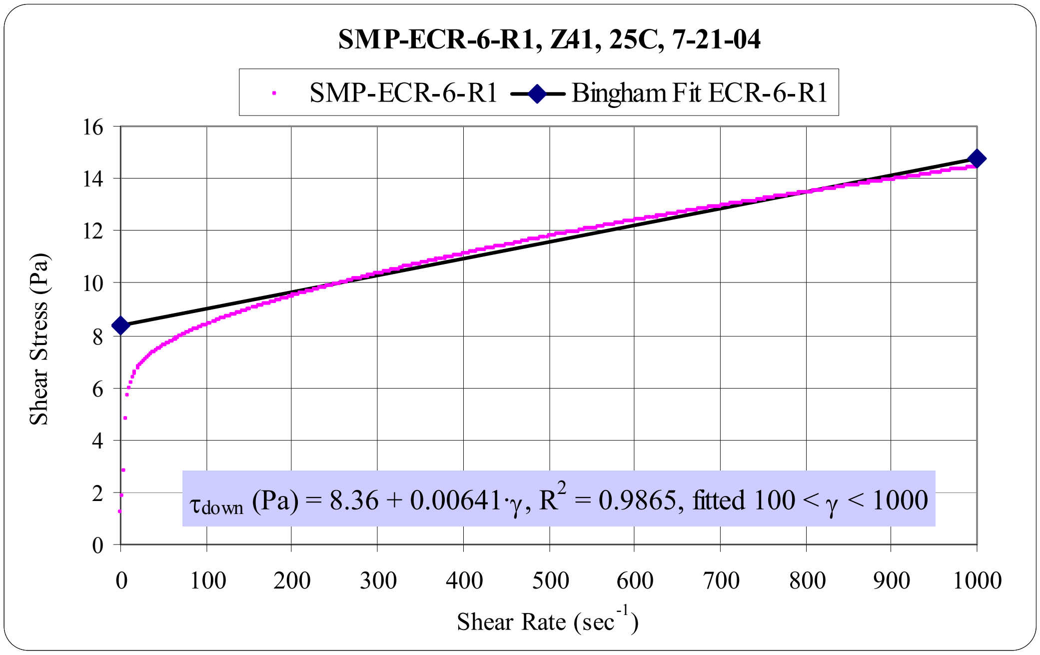
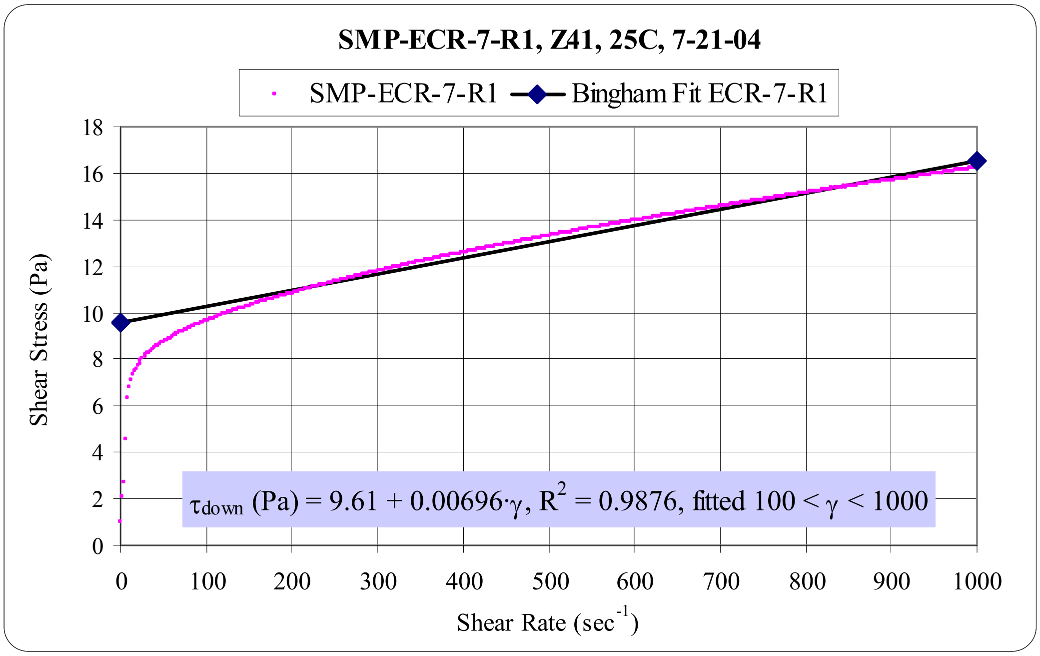
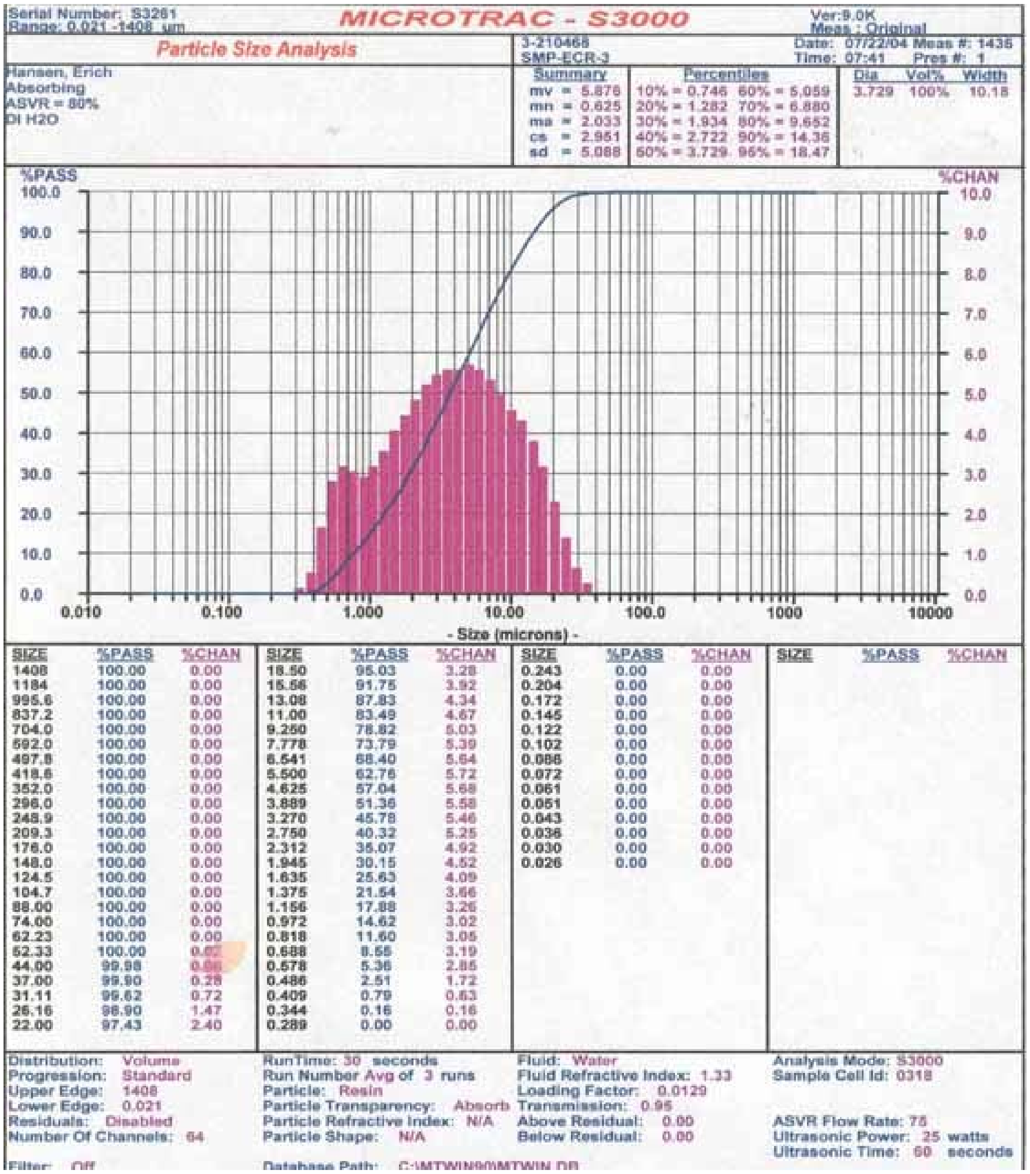


Figure A - 10: Down Flow Curve Sample SMP-CWE-3, Run 1



APPENDIX B. PARTICLE SIZE DISTRIBUTUION



Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Original

Particle Size Analysis

3-210468
SMP-ECR-3

Date: 07/22/04 Meas #: 1435
Time: 07:41 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Vol%	Width
mv = 5.876	10% = 0.746	60% = 5.059	3.729	100%	10.18
mn = 0.625	20% = 1.282	70% = 6.880			
ma = 2.033	30% = 1.934	80% = 9.652			
cs = 2.951	40% = 2.722	90% = 14.36			
sd = 5.088	50% = 3.729	95% = 18.47			

SIZE	%PASS	%CHAN
1408	100.00	0.00
1184	100.00	0.00
995.6	100.00	0.00
837.2	100.00	0.00
704.0	100.00	0.00
592.0	100.00	0.00
497.8	100.00	0.00
418.6	100.00	0.00
352.0	100.00	0.00
296.0	100.00	0.00
248.9	100.00	0.00
209.3	100.00	0.00
176.0	100.00	0.00
148.0	100.00	0.00
124.5	100.00	0.00
104.7	100.00	0.00
88.00	100.00	0.00
74.00	100.00	0.00
62.23	100.00	0.00
52.33	100.00	0.02
44.00	99.98	0.08
37.00	99.90	0.28
31.11	99.62	0.72
26.16	98.90	1.47
22.00	97.43	2.40
18.50	95.03	3.28
15.56	91.75	3.92
13.08	87.83	4.34
11.00	83.49	4.67
9.250	78.82	5.03
7.778	73.79	5.39
6.541	68.40	5.64
5.500	62.76	5.72
4.625	57.04	5.68
3.889	51.36	5.58
3.270	45.78	5.46
2.750	40.32	5.25
2.312	35.07	4.92
1.945	30.15	4.52
1.635	25.63	4.09
1.375	21.54	3.66
1.156	17.88	3.26
0.972	14.62	3.02
0.818	11.60	3.05
0.688	8.55	3.19
0.578	5.36	2.85
0.486	2.51	1.72
0.409	0.79	0.63
0.344	0.16	0.16
0.289	0.00	0.00
0.243	0.00	0.00
0.204	0.00	0.00
0.172	0.00	0.00
0.145	0.00	0.00
0.122	0.00	0.00
0.102	0.00	0.00
0.086	0.00	0.00
0.072	0.00	0.00
0.061	0.00	0.00
0.051	0.00	0.00
0.043	0.00	0.00
0.036	0.00	0.00
0.030	0.00	0.00
0.026	0.00	0.00

Distribution: Volume
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64
Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0129
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318
ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure B - 1: SMP-ECR-3 Volume Distribution

Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Recalc

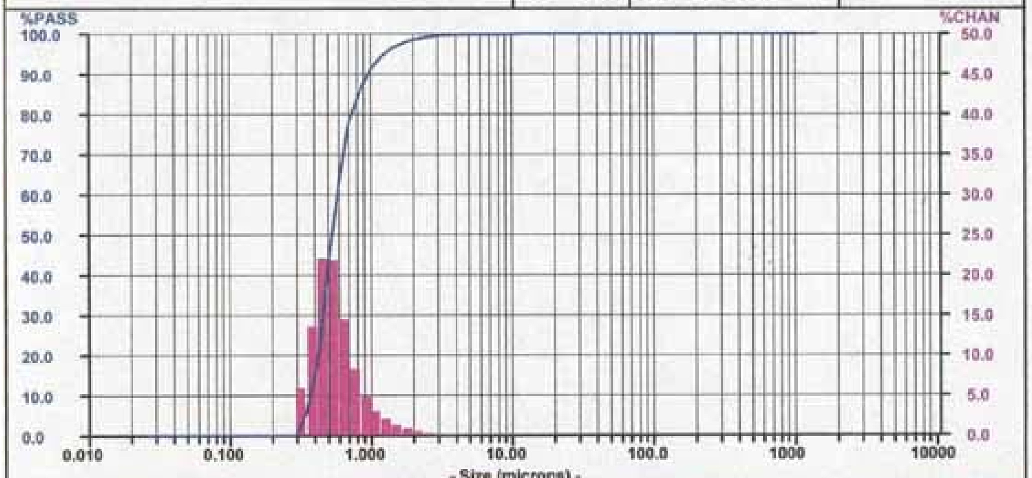
Particle Size Analysis

3-210468
SMP-ECR-3

Date: 07/22/04 Meas #: 1436
Time: 07:42 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Num%	Width
mv = 5.876	10% = 0.367	60% = 0.562	0.518	100%	0.380
mn = 0.625	20% = 0.411	70% = 0.620			
ma = 2.033	30% = 0.446	80% = 0.713			
cs = 2.951	40% = 0.481	90% = 0.932			
sd = 0.190	50% = 0.518	95% = 1.237			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	100.00	0.00	0.243	0.00	0.00			
1184	100.00	0.00	15.56	100.00	0.00	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	100.00	0.00	0.172	0.00	0.00			
837.2	100.00	0.00	11.00	100.00	0.01	0.145	0.00	0.00			
704.0	100.00	0.00	9.250	99.99	0.01	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.98	0.02	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	99.96	0.03	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	99.93	0.05	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	99.88	0.08	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	99.80	0.14	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	99.66	0.23	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	99.43	0.37	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	99.06	0.59	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	98.47	0.91	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	97.56	1.38						
104.7	100.00	0.00	1.375	96.18	2.08						
88.00	100.00	0.00	1.156	94.10	3.12						
74.00	100.00	0.00	0.972	90.98	4.85						
62.23	100.00	0.00	0.818	86.13	8.24						
52.33	100.00	0.00	0.688	77.89	14.54						
44.00	100.00	0.00	0.578	63.35	21.81						
37.00	100.00	0.00	0.486	41.54	22.10						
31.11	100.00	0.00	0.409	19.44	13.61						
26.16	100.00	0.00	0.344	5.83	5.83						
22.00	100.00	0.00	0.289	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64

Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0129
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318

ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure B - 2: SMP-ECR-3 Number Distribution

Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Original

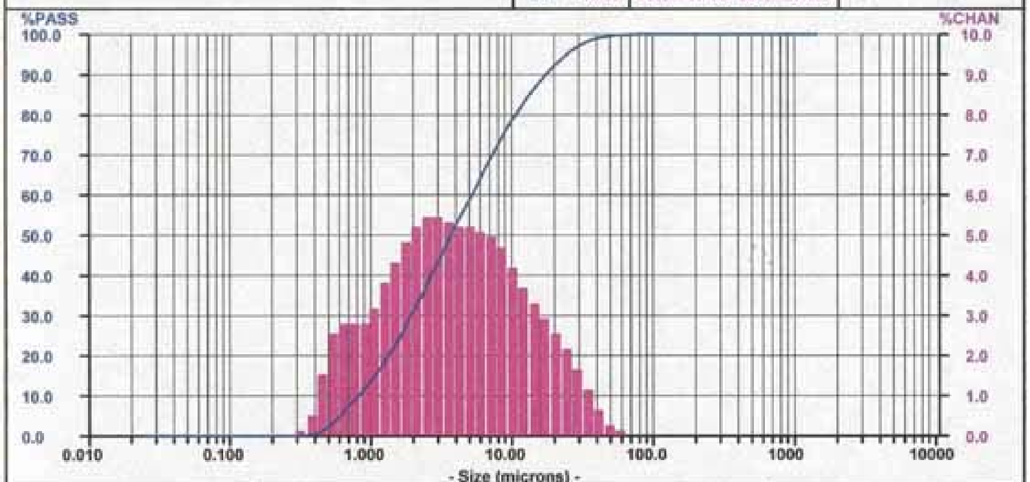
Particle Size Analysis

3-210469
SMP-FFF-4

Date: 07/22/04 Meas #: 1439
Time: 07:52 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Vol%	Width
mv = 6.799	10% = 0.791	60% = 5.146	3.705	100%	11.41
mn = 0.639	20% = 1.340	70% = 7.213			
ma = 2.103	30% = 1.951	80% = 10.48			
cs = 2.853	40% = 2.701	90% = 17.22			
sd = 5.707	50% = 3.705	95% = 24.15			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	91.18	2.95	0.243	0.00	0.00			
1184	100.00	0.00	15.56	88.23	3.33	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	84.90	3.77	0.172	0.00	0.00			
837.2	100.00	0.00	11.00	81.13	4.26	0.145	0.00	0.00			
704.0	100.00	0.00	9.250	76.87	4.71	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	72.16	5.01	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	67.15	5.15	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	62.00	5.21	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	56.79	5.29	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	51.50	5.41	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	46.09	5.51	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	40.58	5.45	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	35.13	5.22	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	29.91	4.88	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	25.03	4.42						
104.7	100.00	0.00	1.375	20.61	3.87						
88.00	100.00	0.00	1.156	16.74	3.29						
74.00	100.00	0.05	0.972	13.45	2.90						
62.23	99.95	0.14	0.818	10.55	2.83						
52.33	99.81	0.32	0.688	7.72	2.91						
44.00	99.49	0.67	0.578	4.81	2.57						
37.00	98.82	1.16	0.486	2.24	1.54						
31.11	97.66	1.70	0.409	0.70	0.56						
26.16	95.96	2.19	0.344	0.14	0.14						
22.00	93.77	2.59	0.289	0.00	0.00						

Distribution: Volume
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64

Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0153
Transmission: 0.94
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318

ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure B - 3: SMP-FFF-4 Volume Distribution

Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Recalc

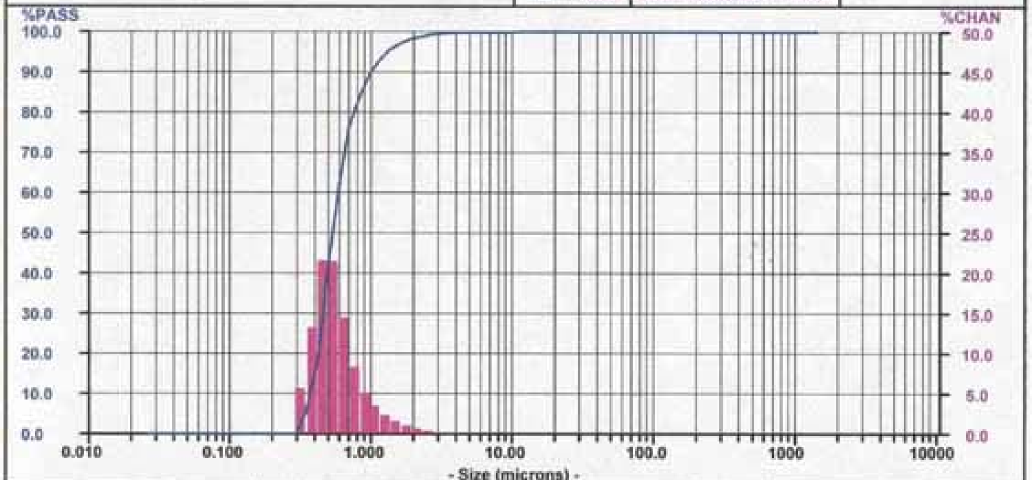
Particle Size Analysis

3-210469
SMP-FFF-4

Date: 07/22/04 Meas #: 1439
Time: 07:52 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Num%	Width
mv = 6.799	10% = 0.369	60% = 0.569	0.523	100%	0.407
mn = 0.639	20% = 0.414	70% = 0.630			
ma = 2.103	30% = 0.450	80% = 0.734			
cs = 2.853	40% = 0.485	90% = 0.983			
sd = 0.204	50% = 0.523	95% = 1.310			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	100.00	0.00	0.243	0.00	0.00			
1184	100.00	0.00	15.56	100.00	0.00	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	100.00	0.00	0.172	0.00	0.00			
837.2	100.00	0.00	11.00	100.00	0.01	0.145	0.00	0.00			
704.0	100.00	0.00	9.250	99.99	0.01	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.98	0.02	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	99.96	0.03	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	99.93	0.05	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	99.88	0.09	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	99.79	0.15	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	99.64	0.25	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	99.39	0.42	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	98.97	0.68	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	98.29	1.07	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	97.22	1.63						
104.7	100.00	0.00	1.375	95.59	2.40						
88.00	100.00	0.00	1.156	93.19	3.44						
74.00	100.00	0.00	0.972	89.75	5.08						
62.23	100.00	0.00	0.818	84.67	8.34						
52.33	100.00	0.00	0.688	76.33	14.48						
44.00	100.00	0.00	0.578	61.85	21.47						
37.00	100.00	0.00	0.486	40.38	21.60						
31.11	100.00	0.00	0.409	18.78	13.21						
26.16	100.00	0.00	0.344	5.57	5.57						
22.00	100.00	0.00	0.289	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64
Filter: Off

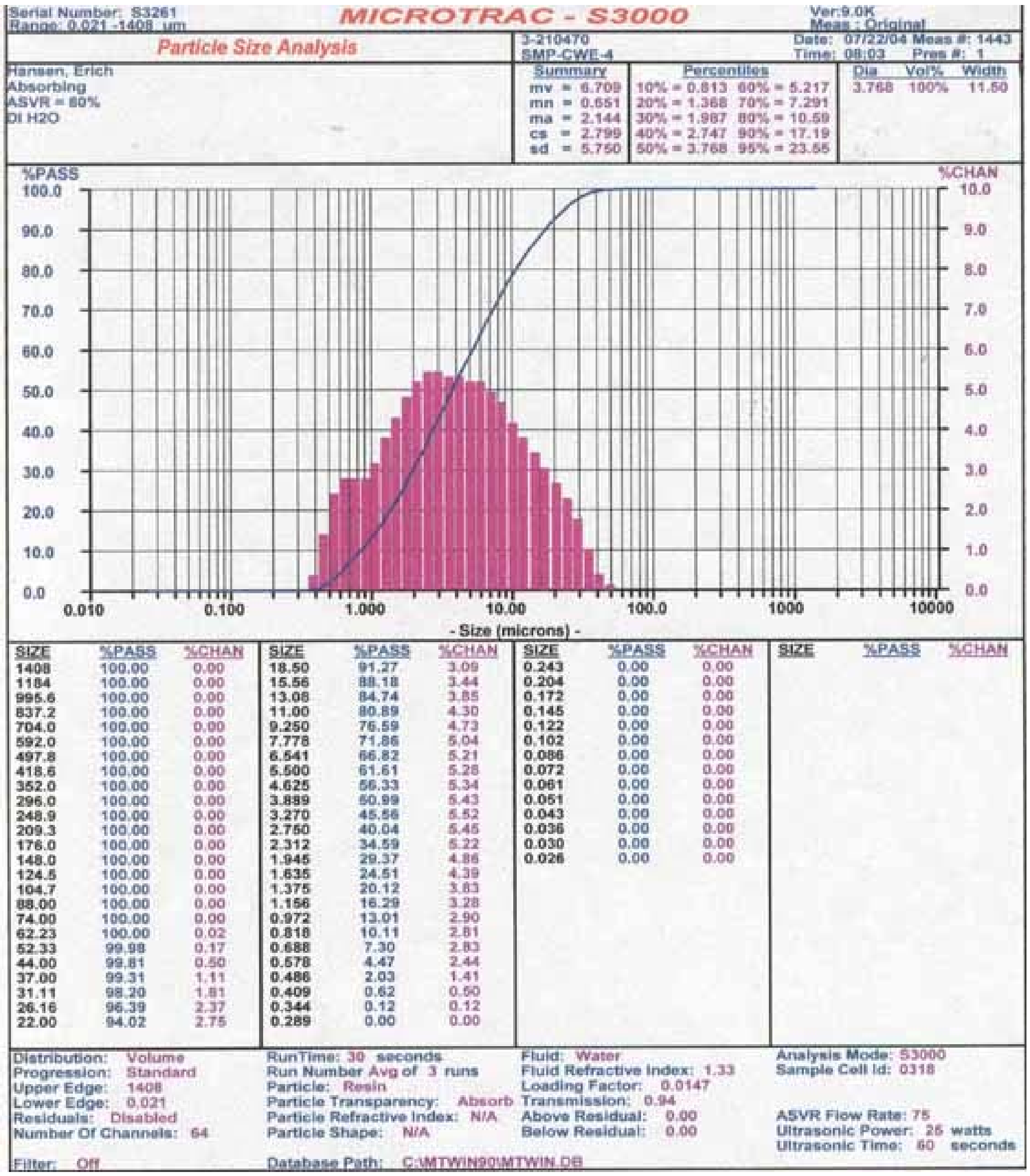
RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0153
Transmission: 0.94
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318

ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure B - 4: SMP-FFF-4 Number Distribution



Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Original

Particle Size Analysis

3-210470
SMP-CWE-4

Date: 07/22/04 Meas #: 1443
Time: 08:03 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Vol%	Width
mv = 6.709	10% = 0.813	60% = 5.217	3.768	100%	11.50
mn = 0.551	20% = 1.368	70% = 7.291			
ma = 2.144	30% = 1.987	80% = 10.59			
cs = 2.799	40% = 2.747	90% = 17.19			
sd = 5.750	50% = 3.768	95% = 23.55			

SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	91.27	3.09	0.243	0.00	0.00			
1184	100.00	0.00	15.56	88.18	3.44	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	84.74	3.85	0.172	0.00	0.00			
837.2	100.00	0.00	11.00	80.89	4.30	0.145	0.00	0.00			
704.0	100.00	0.00	9.250	76.59	4.73	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	71.86	5.04	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	66.82	5.21	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	61.61	5.28	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	56.33	5.34	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	50.99	5.43	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	45.56	5.52	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	40.04	5.45	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	34.59	5.22	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	29.37	4.86	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	24.51	4.39						
104.7	100.00	0.00	1.375	20.12	3.83						
88.00	100.00	0.00	1.156	16.29	3.28						
74.00	100.00	0.00	0.972	13.01	2.90						
62.23	100.00	0.02	0.818	10.11	2.81						
52.33	99.98	0.17	0.688	7.30	2.83						
44.00	99.81	0.50	0.578	4.47	2.44						
37.00	99.31	1.11	0.486	2.03	1.41						
31.11	98.20	1.81	0.409	0.62	0.50						
26.16	96.39	2.37	0.344	0.12	0.12						
22.00	94.02	2.75	0.289	0.00	0.00						

Distribution: Volume
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64

Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0147
Transmission: 0.94
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318

ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure B - 5: SMP-CWE-4 Volume Distribution

Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Recalc

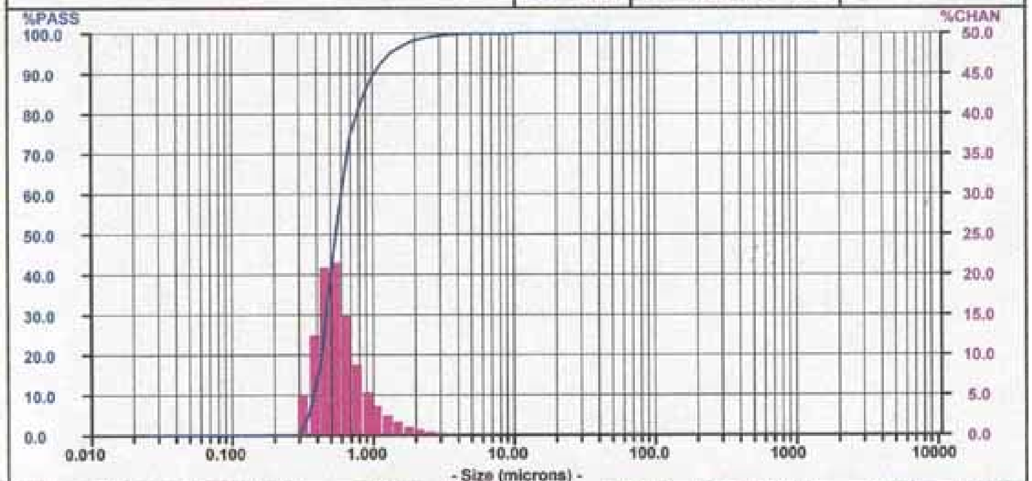
Particle Size Analysis

3-210470
SMP-CWE-4

Date: 07/22/04 Meas #: 1443
Time: 08:04 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Num%	Width
mv = 6.709	10% = 0.374	60% = 0.577	0.531	100%	0.421
mn = 0.551	20% = 0.418	70% = 0.642			
ma = 2.144	30% = 0.456	80% = 0.750			
cs = 2.799	40% = 0.492	90% = 1.006			
sd = 0.210	50% = 0.531	95% = 1.339			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	100.00	0.00	0.243	0.00	0.00			
1184	100.00	0.00	15.56	100.00	0.00	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	100.00	0.00	0.172	0.00	0.00			
837.2	100.00	0.00	11.00	100.00	0.01	0.145	0.00	0.00			
704.0	100.00	0.00	9.250	99.99	0.01	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.98	0.02	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	99.96	0.03	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	99.93	0.05	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	99.88	0.09	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	99.79	0.16	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	99.63	0.27	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	99.36	0.45	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	98.91	0.72	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	98.19	1.13	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	97.06	1.72						
104.7	100.00	0.00	1.375	95.34	2.52						
88.00	100.00	0.00	1.156	92.82	3.63						
74.00	100.00	0.00	0.972	89.19	5.39						
62.23	100.00	0.00	0.818	83.80	8.78						
52.33	100.00	0.00	0.688	75.02	14.92						
44.00	100.00	0.00	0.578	60.10	21.59						
37.00	100.00	0.00	0.486	38.51	20.95						
31.11	100.00	0.00	0.409	17.56	12.50						
26.16	100.00	0.00	0.344	5.06	5.06						
22.00	100.00	0.00	0.289	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64

Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0147
Transmission: 0.94
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318

ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure B - 6: SMP-CWE-4 Number Distribution

Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Original

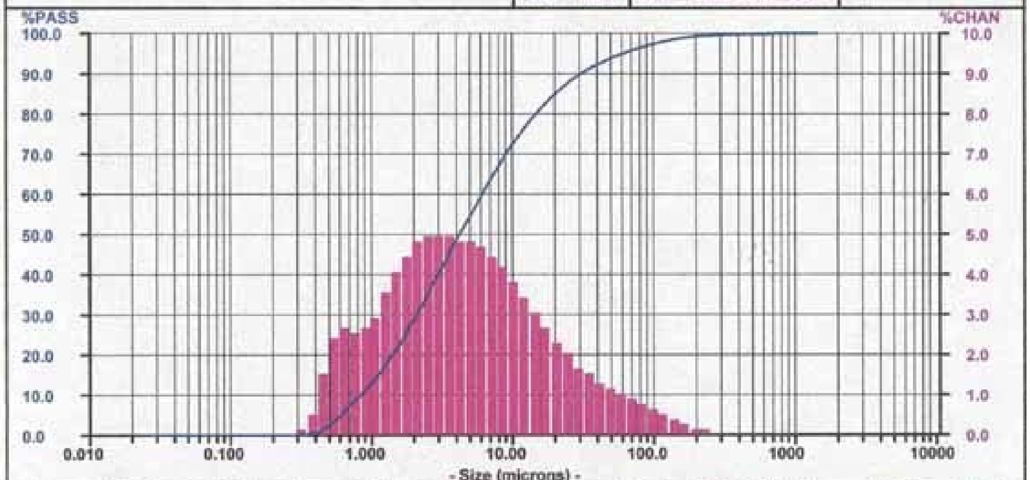
Particle Size Analysis

3-210471
SMP-ECR-6

Date: 07/22/04 Meas #: 1447
Time: 08:15 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Vol%	Width
mv = 14.02	10% = 0.815	60% = 6.055	4.225	100%	17.28
mn = 0.622	20% = 1.418	70% = 8.907			
ma = 2.238	30% = 2.100	80% = 14.43			
cs = 2.681	40% = 2.977	90% = 30.29			
sd = 8.641	50% = 4.225	95% = 59.44			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	84.04	2.73	0.243	0.00	0.00			
1184	100.00	0.00	15.56	81.31	3.09	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	78.22	3.46	0.172	0.00	0.00			
837.2	100.00	0.00	11.00	74.76	3.86	0.145	0.00	0.00			
704.0	100.00	0.03	9.250	70.90	4.25	0.122	0.00	0.00			
592.0	99.97	0.04	7.778	66.65	4.55	0.102	0.00	0.00			
497.8	99.93	0.07	6.541	62.10	4.74	0.086	0.00	0.00			
418.6	99.86	0.08	5.500	57.36	4.82	0.072	0.00	0.00			
352.0	99.78	0.09	4.625	52.54	4.88	0.061	0.00	0.00			
296.0	99.69	0.12	3.889	47.66	4.95	0.051	0.00	0.00			
248.9	99.57	0.17	3.270	42.71	5.00	0.043	0.00	0.00			
209.3	99.40	0.24	2.750	37.71	4.99	0.036	0.00	0.00			
176.0	99.16	0.35	2.312	32.72	4.82	0.030	0.00	0.00			
148.0	98.81	0.48	1.945	27.90	4.50	0.026	0.00	0.00			
124.5	98.33	0.61	1.635	23.40	4.08						
104.7	97.72	0.72	1.375	19.32	3.55						
88.00	97.00	0.82	1.156	15.77	3.03						
74.00	96.18	0.92	0.972	12.74	2.68						
62.23	95.26	1.02	0.818	10.06	2.61						
52.33	94.24	1.15	0.688	7.45	2.69						
44.00	93.09	1.31	0.578	4.76	2.43						
37.00	91.78	1.52	0.486	2.33	1.53						
31.11	90.26	1.77	0.409	0.80	0.62						
26.16	88.49	2.06	0.344	0.18	0.18						
22.00	86.43	2.39	0.289	0.00	0.00						

Distribution: Volume
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64

Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

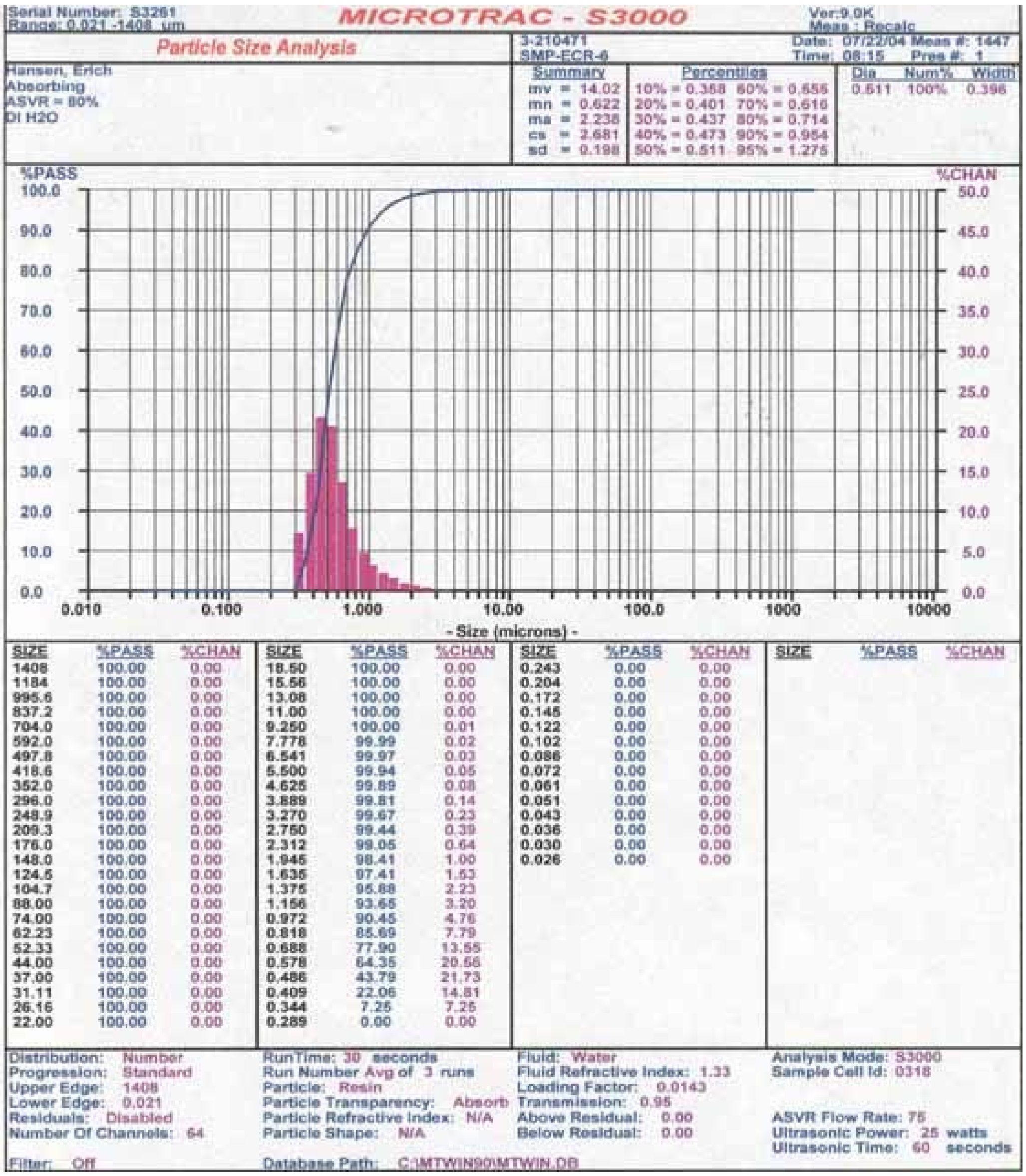
Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0143
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318

ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure B - 7: SMP-ECR-6 Volume Distribution



Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Recalc

Particle Size Analysis

3-210471
SMP-ECR-6

Date: 07/22/04 Meas #: 1447
Time: 08:15 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Num%	Width
mv = 14.02	10% = 0.368	60% = 0.556	0.511	100%	0.396
mn = 0.622	20% = 0.401	70% = 0.616			
ma = 2.238	30% = 0.437	80% = 0.714			
cs = 2.681	40% = 0.473	90% = 0.954			
sd = 0.198	50% = 0.511	95% = 1.275			

SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	100.00	0.00	0.243	0.00	0.00			
1184	100.00	0.00	15.56	100.00	0.00	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	100.00	0.00	0.172	0.00	0.00			
837.2	100.00	0.00	11.00	100.00	0.00	0.145	0.00	0.00			
704.0	100.00	0.00	9.250	100.00	0.01	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.99	0.02	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	99.97	0.03	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	99.94	0.05	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	99.89	0.08	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	99.81	0.14	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	99.67	0.23	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	99.44	0.39	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	99.05	0.64	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	98.41	1.00	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	97.41	1.53						
104.7	100.00	0.00	1.375	95.88	2.23						
88.00	100.00	0.00	1.156	93.65	3.20						
74.00	100.00	0.00	0.972	90.45	4.76						
62.23	100.00	0.00	0.818	85.69	7.79						
52.33	100.00	0.00	0.688	77.90	13.55						
44.00	100.00	0.00	0.578	64.35	20.56						
37.00	100.00	0.00	0.486	43.79	21.73						
31.11	100.00	0.00	0.409	22.06	14.81						
26.16	100.00	0.00	0.344	7.25	7.25						
22.00	100.00	0.00	0.289	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0143
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318
ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Filter: Off
Database Path: C:\MTWIN90\MTWIN.DB

Figure B - 8: SMP-ECR-6 Number Distribution

Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Original

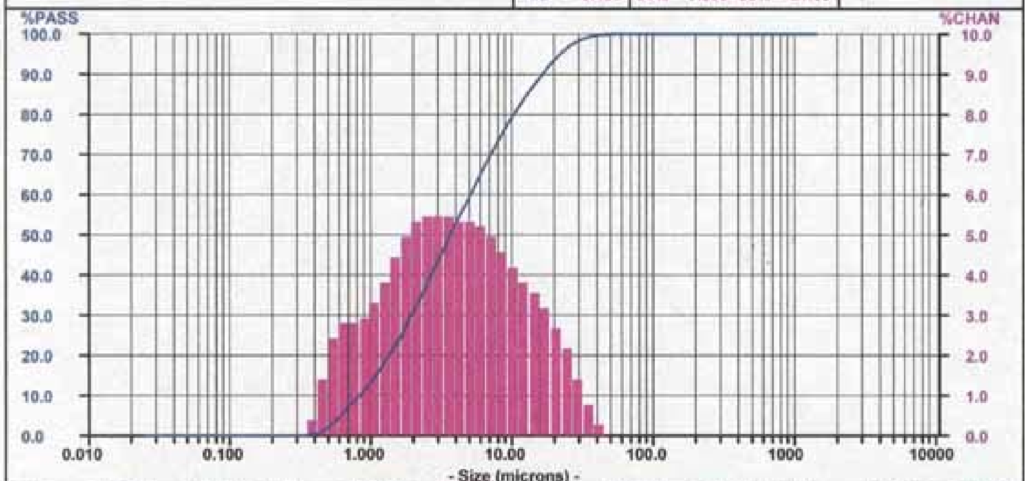
Particle Size Analysis

3-210472
SMP-ECR-7

Date: 07/22/04 Meas #: 1451
Time: 08:26 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Vol%	Width
mv = 6.374	10% = 0.807	60% = 5.045	3.666	100%	10.98
mn = 0.654	20% = 1.365	70% = 7.023			
ma = 2.117	30% = 1.952	80% = 10.20			
cs = 2.834	40% = 2.682	90% = 16.19			
sd = 5.492	50% = 3.666	95% = 21.69			



SIZE	%PASS	%CHAN
1408	100.00	0.00
1184	100.00	0.00
995.6	100.00	0.00
837.2	100.00	0.00
704.0	100.00	0.00
592.0	100.00	0.00
497.8	100.00	0.00
418.6	100.00	0.00
352.0	100.00	0.00
296.0	100.00	0.00
248.9	100.00	0.00
209.3	100.00	0.00
176.0	100.00	0.00
148.0	100.00	0.00
124.5	100.00	0.00
104.7	100.00	0.00
88.00	100.00	0.00
74.00	100.00	0.00
62.23	100.00	0.00
52.33	100.00	0.11
44.00	99.89	0.31
37.00	99.58	0.76
31.11	98.82	1.44
26.16	97.38	2.17
22.00	95.21	2.76
18.50	92.45	3.21
15.56	89.24	3.55
13.08	85.69	3.88
11.00	81.81	4.25
9.250	77.56	4.64
7.778	72.92	5.00
6.541	67.92	5.25
5.500	62.67	5.37
4.625	57.30	5.43
3.889	51.87	5.50
3.270	46.37	5.56
2.750	40.81	5.55
2.312	35.26	5.37
1.945	29.89	5.02
1.635	24.87	4.51
1.375	20.36	3.90
1.156	16.46	3.30
0.972	13.16	2.93
0.818	10.23	2.85
0.688	7.38	2.89
0.578	4.49	2.48
0.486	2.01	1.41
0.409	0.60	0.48
0.344	0.12	0.12
0.289	0.00	0.00
0.243	0.00	0.00
0.204	0.00	0.00
0.172	0.00	0.00
0.145	0.00	0.00
0.122	0.00	0.00
0.102	0.00	0.00
0.086	0.00	0.00
0.072	0.00	0.00
0.061	0.00	0.00
0.051	0.00	0.00
0.043	0.00	0.00
0.036	0.00	0.00
0.030	0.00	0.00
0.026	0.00	0.00

SIZE	%PASS	%CHAN

Distribution: Volume
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64

Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0140
Transmission: 0.94
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318

ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure B - 9: SMP-ECR-7 Volume Distribution

Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Recalc

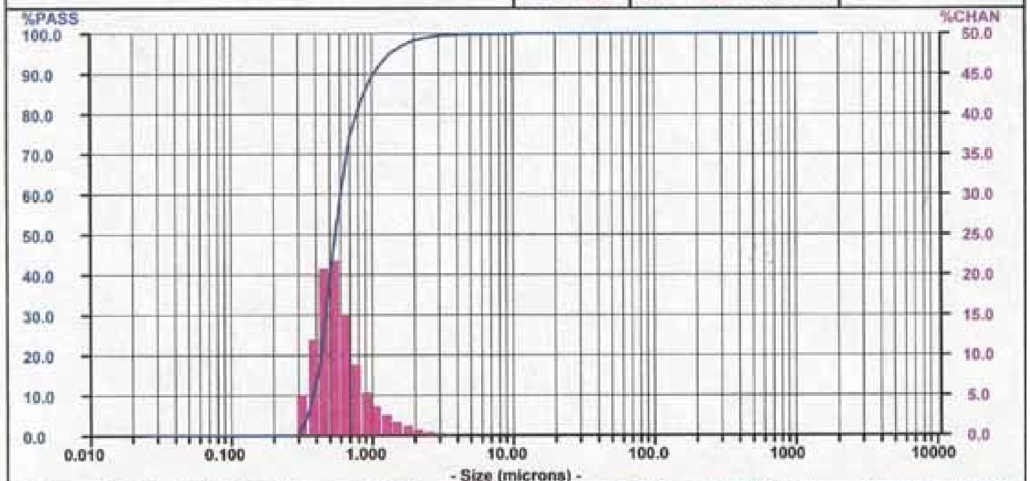
Particle Size Analysis

3-210472
SMP-ECR-7

Date: 07/22/04 Meas #: 1451
Time: 08:27 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Num%	Width
mv = 6.374	10% = 0.375	60% = 0.580	0.534	100%	0.421
mn = 0.654	20% = 0.421	70% = 0.645			
ma = 2.117	30% = 0.458	80% = 0.753			
cs = 2.834	40% = 0.494	90% = 1.011			
sd = 0.211	50% = 0.534	95% = 1.350			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	100.00	0.00	0.243	0.00	0.00			
1184	100.00	0.00	15.56	100.00	0.00	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	100.00	0.00	0.172	0.00	0.00			
837.2	100.00	0.00	11.00	100.00	0.01	0.145	0.00	0.00			
704.0	100.00	0.00	9.250	99.99	0.01	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.98	0.02	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	99.96	0.03	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	99.93	0.05	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	99.88	0.09	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	99.79	0.16	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	99.63	0.27	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	99.36	0.45	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	98.91	0.74	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	98.17	1.16	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	97.01	1.76						
104.7	100.00	0.00	1.375	95.25	2.55						
88.00	100.00	0.00	1.156	92.70	3.63						
74.00	100.00	0.00	0.972	89.07	5.41						
62.23	100.00	0.00	0.818	83.66	8.86						
52.33	100.00	0.00	0.688	74.80	15.15						
44.00	100.00	0.00	0.578	59.65	21.85						
37.00	100.00	0.00	0.486	37.80	20.84						
31.11	100.00	0.00	0.409	16.96	11.93						
26.16	100.00	0.00	0.344	5.03	5.03						
22.00	100.00	0.00	0.289	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64

Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0140
Transmission: 0.94
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318

ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure B - 10: SMP-ECR-7 Number Distribution

Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Original

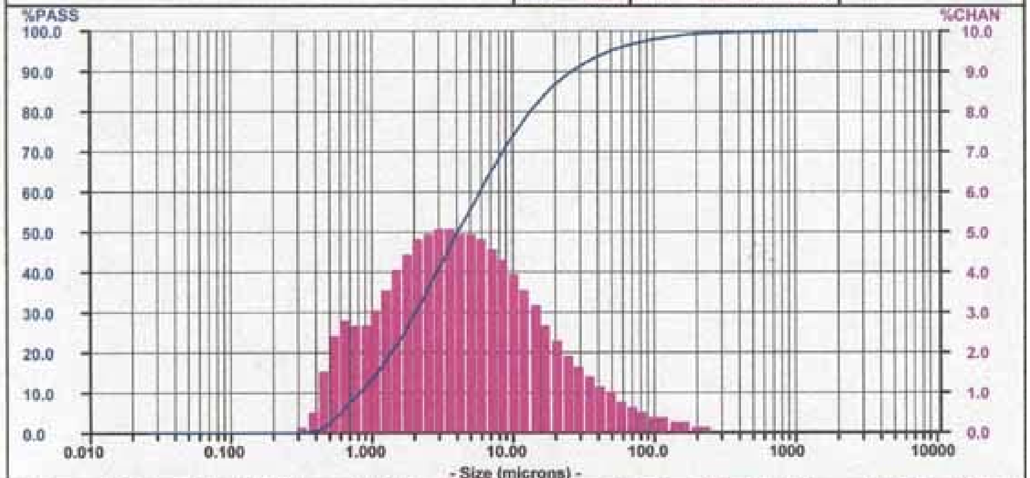
Particle Size Analysis

3-210473
SMP-FFF-7

Date: 07/22/04 Meas #: 1455
Time: 08:37 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Vol%	Width
mv = 12.50	10% = 0.795	60% = 5.783	4.074	100%	15.30
mn = 0.622	20% = 1.380	70% = 8.402			
ma = 2.184	30% = 2.048	80% = 13.15			
cs = 2.747	40% = 2.896	90% = 25.80			
sd = 7.652	50% = 4.074	95% = 47.80			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	85.84	2.76	0.243	0.00	0.00			
1184	100.00	0.00	15.56	83.08	3.18	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	79.90	3.58	0.172	0.00	0.00			
837.2	100.00	0.00	11.00	76.32	3.96	0.145	0.00	0.00			
704.0	100.00	0.01	9.250	72.36	4.32	0.122	0.00	0.00			
592.0	99.99	0.04	7.778	68.04	4.62	0.102	0.00	0.00			
497.8	99.95	0.06	6.541	63.42	4.83	0.086	0.00	0.00			
418.6	99.89	0.07	5.500	58.59	4.94	0.072	0.00	0.00			
352.0	99.82	0.09	4.625	53.65	5.00	0.061	0.00	0.00			
296.0	99.73	0.11	3.889	48.65	5.07	0.051	0.00	0.00			
248.9	99.62	0.15	3.270	43.58	5.09	0.043	0.00	0.00			
209.3	99.47	0.21	2.750	38.49	5.05	0.036	0.00	0.00			
176.0	99.26	0.29	2.312	33.44	4.86	0.030	0.00	0.00			
148.0	98.97	0.37	1.945	28.58	4.54	0.026	0.00	0.00			
124.5	98.60	0.44	1.635	24.04	4.12						
104.7	98.16	0.50	1.375	19.92	3.62						
88.00	97.66	0.58	1.156	16.30	3.10						
74.00	97.08	0.70	0.972	13.20	2.76						
62.23	96.38	0.86	0.818	10.44	2.71						
52.33	95.52	1.04	0.688	7.73	2.80						
44.00	94.48	1.23	0.578	4.93	2.53						
37.00	93.25	1.43	0.486	2.40	1.59						
31.11	91.82	1.67	0.409	0.81	0.63						
26.16	90.15	1.97	0.344	0.18	0.18						
22.00	88.18	2.34	0.289	0.00	0.00						

Distribution: Volume
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64

Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A

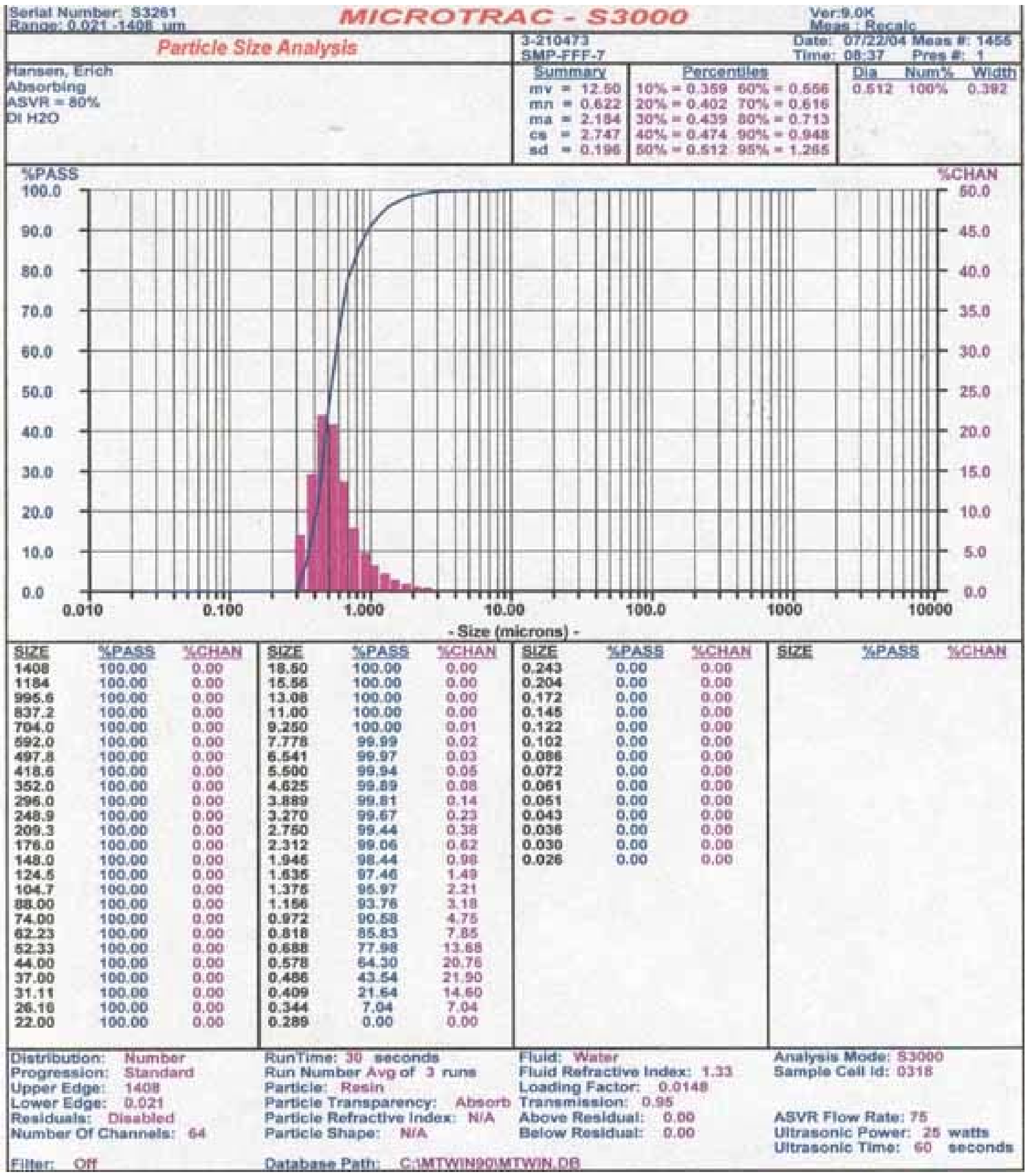
Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0148
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318

ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure B - 11: SMP-FFF-7 Volume Distribution



Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Recalc

Particle Size Analysis

3-210473
SMP-FFF-7

Date: 07/22/04 Meas #: 1455
Time: 08:37 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Num%	Width
mv = 12.50	10% = 0.359	60% = 0.556	0.512	100%	0.392
mn = 0.622	20% = 0.402	70% = 0.616			
ma = 2.184	30% = 0.439	80% = 0.713			
cs = 2.747	40% = 0.474	90% = 0.948			
sd = 0.196	50% = 0.512	95% = 1.265			

SIZE	%PASS	%CHAN
1408	100.00	0.00
1184	100.00	0.00
995.6	100.00	0.00
837.2	100.00	0.00
704.0	100.00	0.00
592.0	100.00	0.00
497.8	100.00	0.00
418.6	100.00	0.00
352.0	100.00	0.00
296.0	100.00	0.00
248.9	100.00	0.00
209.3	100.00	0.00
176.0	100.00	0.00
148.0	100.00	0.00
124.5	100.00	0.00
104.7	100.00	0.00
88.00	100.00	0.00
74.00	100.00	0.00
62.23	100.00	0.00
52.33	100.00	0.00
44.00	100.00	0.00
37.00	100.00	0.00
31.11	100.00	0.00
26.16	100.00	0.00
22.00	100.00	0.00

SIZE	%PASS	%CHAN
18.50	100.00	0.00
15.56	100.00	0.00
13.08	100.00	0.00
11.00	100.00	0.00
9.250	100.00	0.01
7.778	99.99	0.02
6.541	99.97	0.03
5.500	99.94	0.05
4.625	99.89	0.08
3.889	99.81	0.14
3.270	99.67	0.23
2.750	99.44	0.38
2.312	99.06	0.62
1.945	98.44	0.98
1.635	97.46	1.49
1.375	95.97	2.21
1.156	93.76	3.18
0.972	90.58	4.75
0.818	85.83	7.85
0.688	77.98	13.68
0.578	64.30	20.76
0.486	43.54	21.90
0.409	21.64	14.60
0.344	7.04	7.04
0.289	0.00	0.00

SIZE	%PASS	%CHAN
0.243	0.00	0.00
0.204	0.00	0.00
0.172	0.00	0.00
0.145	0.00	0.00
0.122	0.00	0.00
0.102	0.00	0.00
0.086	0.00	0.00
0.072	0.00	0.00
0.061	0.00	0.00
0.051	0.00	0.00
0.043	0.00	0.00
0.036	0.00	0.00
0.030	0.00	0.00
0.026	0.00	0.00

SIZE	%PASS	%CHAN

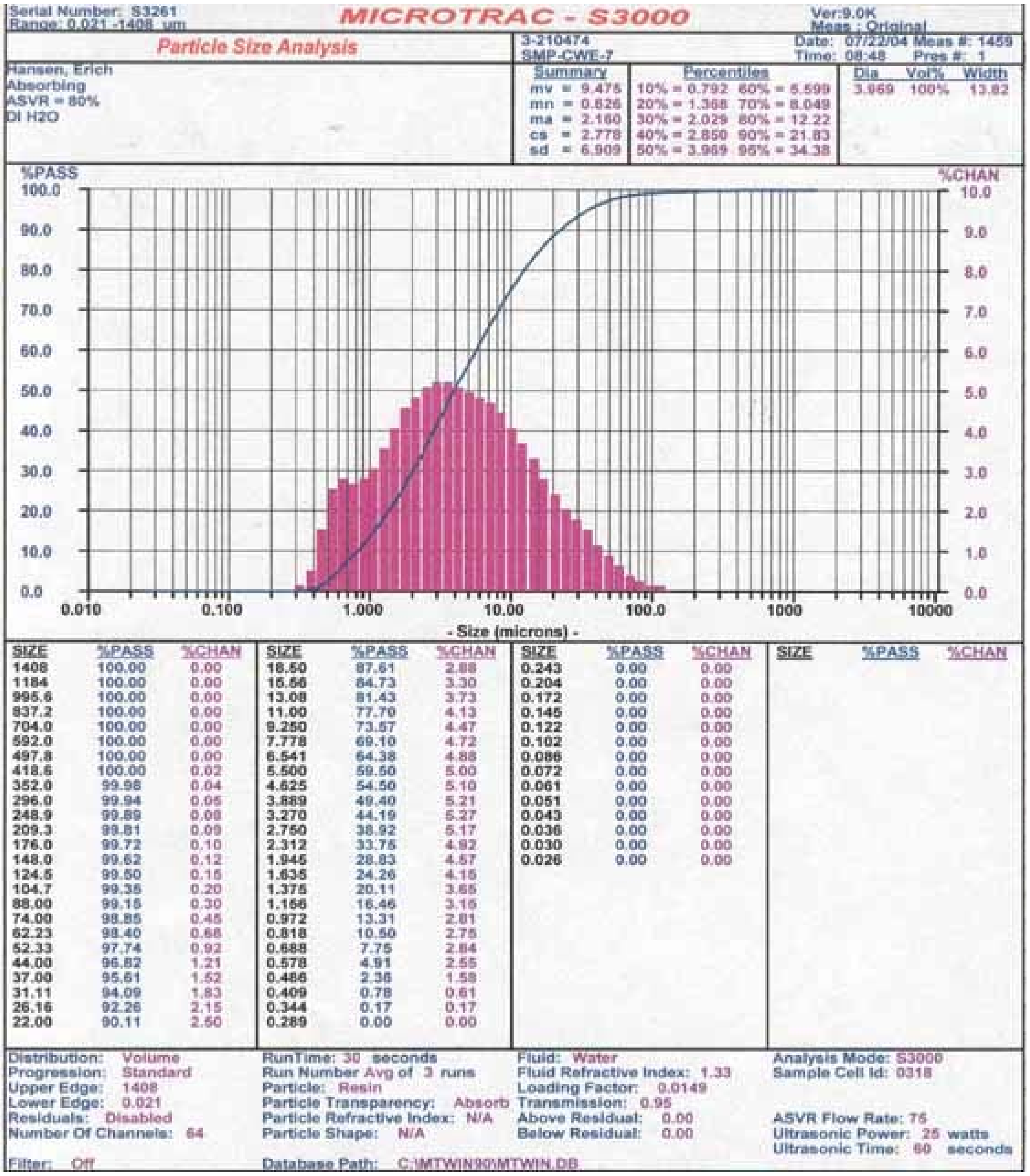
Distribution: Number
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64
Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0148
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318
ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure B - 12: SMP-FFF-7 Number Distribution



Serial Number: S3261
Range: 0.021 -1408 um

MICROTRAC - S3000

Ver:9.0K
Meas : Original

Particle Size Analysis

3-210474
SMP-CWE-7

Date: 07/22/04 Meas #: 1459
Time: 08:48 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Vol%	Width
mv = 9.475	10% = 0.792	60% = 5.599	3.969	100%	13.82
mn = 0.626	20% = 1.368	70% = 8.049			
ma = 2.160	30% = 2.029	80% = 12.22			
cs = 2.778	40% = 2.850	90% = 21.83			
sd = 6.909	50% = 3.969	95% = 34.38			

SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	87.61	2.88	0.243	0.00	0.00			
1184	100.00	0.00	15.56	84.73	3.30	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	81.43	3.73	0.172	0.00	0.00			
837.2	100.00	0.00	11.00	77.70	4.13	0.145	0.00	0.00			
704.0	100.00	0.00	9.250	73.57	4.47	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	69.10	4.72	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	64.38	4.88	0.086	0.00	0.00			
418.6	100.00	0.02	5.500	59.50	5.00	0.072	0.00	0.00			
352.0	99.98	0.04	4.625	54.50	5.10	0.061	0.00	0.00			
296.0	99.94	0.05	3.889	49.40	5.21	0.051	0.00	0.00			
248.9	99.89	0.08	3.270	44.19	5.27	0.043	0.00	0.00			
209.3	99.81	0.09	2.750	38.92	5.17	0.036	0.00	0.00			
176.0	99.72	0.10	2.312	33.75	4.92	0.030	0.00	0.00			
148.0	99.62	0.12	1.945	28.83	4.57	0.026	0.00	0.00			
124.5	99.50	0.15	1.635	24.26	4.15						
104.7	99.35	0.20	1.375	20.11	3.65						
88.00	99.15	0.30	1.156	16.46	3.15						
74.00	98.85	0.45	0.972	13.31	2.81						
62.23	98.40	0.66	0.818	10.50	2.75						
52.33	97.74	0.92	0.688	7.75	2.84						
44.00	96.82	1.21	0.578	4.91	2.55						
37.00	95.61	1.52	0.486	2.36	1.58						
31.11	94.09	1.83	0.409	0.78	0.61						
26.16	92.26	2.15	0.344	0.17	0.17						
22.00	90.11	2.60	0.289	0.00	0.00						

Distribution: Volume
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64
Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0149
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318
ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure B - 13: SMP-CWE-7 Volume Distribution

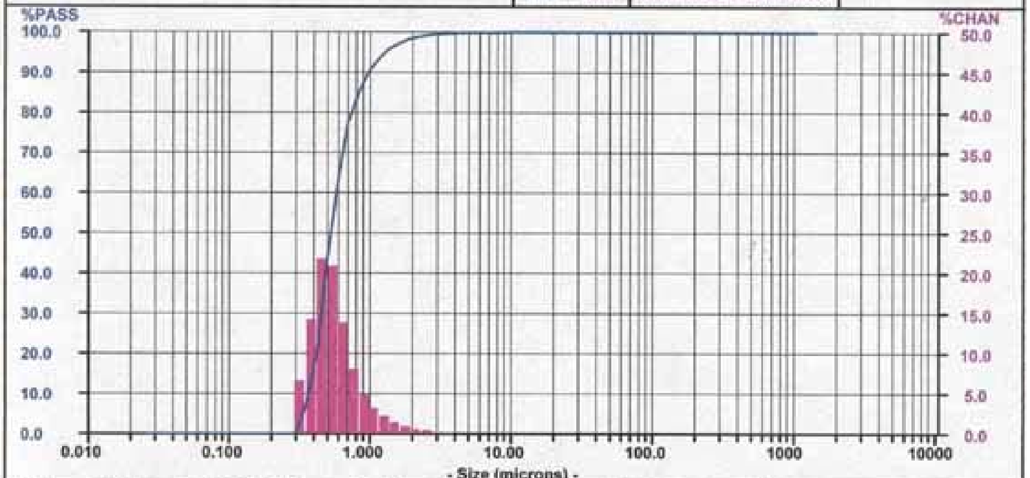
Serial Number: S3261 **MICROTRAC - S3000** Ver:9.0K
Range: 0.021 -1408 um Meas : Recalc

Particle Size Analysis

3-210474 Date: 07/22/04 Meas #: 1459
SMP-CWE-7 Time: 08:48 Pres #: 1

Hansen, Erich
Absorbing
ASVR = 80%
DI H2O

Summary	Percentiles		Dia	Num%	Width
mv = 9.475	10% = 0.362	60% = 0.559	0.515	100%	0.395
mn = 0.626	20% = 0.405	70% = 0.619			
ma = 2.160	30% = 0.442	80% = 0.718			
cs = 2.778	40% = 0.477	90% = 0.955			
sd = 0.197	50% = 0.515	95% = 1.273			



SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN	SIZE	%PASS	%CHAN
1408	100.00	0.00	18.50	100.00	0.00	0.243	0.00	0.00			
1184	100.00	0.00	15.56	100.00	0.00	0.204	0.00	0.00			
995.6	100.00	0.00	13.08	100.00	0.00	0.172	0.00	0.00			
837.2	100.00	0.00	11.00	100.00	0.00	0.145	0.00	0.00			
704.0	100.00	0.00	9.250	100.00	0.01	0.122	0.00	0.00			
592.0	100.00	0.00	7.778	99.99	0.02	0.102	0.00	0.00			
497.8	100.00	0.00	6.541	99.97	0.03	0.086	0.00	0.00			
418.6	100.00	0.00	5.500	99.94	0.05	0.072	0.00	0.00			
352.0	100.00	0.00	4.625	99.89	0.08	0.061	0.00	0.00			
296.0	100.00	0.00	3.889	99.81	0.14	0.051	0.00	0.00			
248.9	100.00	0.00	3.270	99.67	0.24	0.043	0.00	0.00			
209.3	100.00	0.00	2.750	99.43	0.40	0.036	0.00	0.00			
176.0	100.00	0.00	2.312	99.03	0.63	0.030	0.00	0.00			
148.0	100.00	0.00	1.945	98.40	0.99	0.026	0.00	0.00			
124.5	100.00	0.00	1.635	97.41	1.51						
104.7	100.00	0.00	1.375	95.90	2.23						
88.00	100.00	0.00	1.156	93.67	3.24						
74.00	100.00	0.00	0.972	90.43	4.85						
62.23	100.00	0.00	0.818	85.58	7.99						
52.33	100.00	0.00	0.688	77.59	13.92						
44.00	100.00	0.00	0.578	63.67	20.99						
37.00	100.00	0.00	0.486	42.68	21.83						
31.11	100.00	0.00	0.409	20.85	14.18						
26.16	100.00	0.00	0.344	6.67	6.67						
22.00	100.00	0.00	0.289	0.00	0.00						

Distribution: Number
Progression: Standard
Upper Edge: 1408
Lower Edge: 0.021
Residuals: Disabled
Number Of Channels: 64
Filter: Off

RunTime: 30 seconds
Run Number Avg of 3 runs
Particle: Resin
Particle Transparency: Absorb
Particle Refractive Index: N/A
Particle Shape: N/A
Database Path: C:\MTWIN90\MTWIN.DB

Fluid: Water
Fluid Refractive Index: 1.33
Loading Factor: 0.0149
Transmission: 0.95
Above Residual: 0.00
Below Residual: 0.00

Analysis Mode: S3000
Sample Cell Id: 0318
ASVR Flow Rate: 75
Ultrasonic Power: 25 watts
Ultrasonic Time: 60 seconds

Figure B - 14: SMP-CWE-7 Number Distribution

APPENDIX C: KAOLIN VENDOR B-100 SPECIFICATIONS

TECHNICAL DATA

VANTAGE™
REFRACTORY GRADE KAOLIN

FEATURES AND BENEFITS

HEPHZIBAH, GA

VANTAGE™ refractory grade clays are custom blends of highly refractive kaolinite. These plastic clays can be employed as the primary component of cast bodies , but are most commonly used to enhance the performance of calcined kaolinic clays. Their excellent plasticity and dry strength improve the production rate and shape retention of the refractory, and a high PCE value helps to extend refractory service life.

VANTAGE™ finds application in a variety of intermediate to high duty firebricks, shapes, insulating bricks and saggars where good shape retention and spalling resistance is required. VANTAGE also serves as the plastic component in monolithic refractories including castable, ramming and gunning mixes and mortars. Of critical importance in these applications is a high alumina to alkali ratio to produce durable, highly refractory materials with excellent stability. VANTAGE particle size distributions will also help to minimize drying shrinkage prior to installation.

All VANTAGE™ fire clays are mined and processed under rigid QIP[sm] statistical quality assurance programs. The result is consistent mineralogy, chemical and physical properties, predictable results in demanding refractory applications.

CHEMICAL AND ANALYTICAL DATA

Mean Values. These Do Not Represent A Specification.

		B-100	HT100	LT100	SLURRY C	B-150
Silicon Dioxide	(SiO_2)	45.00	44.50	44.70	44.70	45.40
Aluminum Oxide	(Al_2O_3)	38.00	38.60	38.50	38.60	39.25
Titanium Dioxide	(TiO_2)	1.54	1.45	1.62	1.68	1.54
Iron Oxide	(Fe_2O_3)	.77	.40	.32	.34	.66
Calcium Oxide	(CaO)	.04	.04	.03	.04	.02
Magnesium Oxide	(MgO)	.08	.05	.13	.13	.14
Potassium Oxide	(K_2O)	.51	.28	.10	.09	.24
Sodium Oxide	(Na_2O)	.06	.03	.08	.08	.06
Loss on Ignition	(LOI)	13.50	13.70	13.70	14.00	13.70
			HIGH TEMP SP100	LOW TEMP SP100	Sodium Polyacrylate Dispersant	
M.B.I (meq/100g)		3.2	2.6-3.0	1.9-2.4	1.8-2.2	3.4
SSA m^2/g		15.5	13.0-14.5	10.2-12.0	10.6	15.3
pH @10% Solids		4.5-5.5	4.5-5.5	4.5-5.5	4.8-5.8	4.5-5.5
M.O.R. (Dried @ 230°F) lbf/in^2		200-300	100-200	100-200	100-200	100-200
% Water Absorption	1120°C	24.1	23.2	23.4	22.5	22.3
	1220°C	15.5	16.3	15.4	16.4	16.1
%Linear Shrinkage Dry-Fired	1120°C	3.9	4.2	4.0	3.9	4.4
	1220°C	5.2	5.6	5.9	4.9	6.0

TECHNICAL DATA

VANTAGE™

PARTICLE SIZE ANALYSIS AND PROPERTIES
Mean Values. These Do Not Represent A Specification

Mean Percent By Weight on Oxide Basis

	MICRONS	B-100	HT100	LT100	SLURRY C	B-150
% Finer	<20μ	98	98	97	97	98
	<10μ	92	92	88	89	90
	<5μ	83	81	76	75	77
	<2μ	67	58	56	54	58
	<1μ	56	42	40	39	47
	<0.5μ	42	26	22	24	32

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Kaolin/Silica Containing

Hephzibah – Vantage 08/01