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# **Tank Farm WM-182 and WM-183 Heel Slurry Samples PSD Results**

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## SUMMARY

Particle size distribution (PSD) analysis of INTEC Tank Farm WM-182 and WM-183 heel slurry samples were performed using a modified Horiba LA-300 PSD analyzer at the RAL facility. There were two types of testing performed: typical PSD analysis, and *settling rate* testing.

Although the heel slurry samples were obtained from two separate vessels, the particle size distribution results were quite similar. The slurry solids were from approximately a minimum particle size of 0.5  $\mu\text{m}$  to a maximum of 230  $\mu\text{m}$ —with about 90 % of the material between 2-to-133  $\mu\text{m}$ , and the cumulative 50% value at approximately 20  $\mu\text{m}$ . This testing also revealed that high frequency sonication with an ultrasonic element may break-up larger particles in the WM-182 and WM-183 tank farm heel slurries. This finding represents useful information regarding ultimate tank heel waste processing.

Settling rate testing results were also fairly consistent with material from both vessels in that it appears that most of the mass of solids settle to an agglomerated, yet easily redispersed layer at the bottom. A dispersed and suspended material remained in the “clear” layer above the settled layer after about one-half an hour of settling time. This material had a statistical mode of approximately 5  $\mu\text{m}$  and a maximum particle size of 30  $\mu\text{m}$ .

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# Tank Farm WM-182 and WM-183 Heel Slurry Samples PSD Results

## 1. INTRODUCTION AND BACKGROUND

As part of a sampling and physical characterization task, a laser diffraction (*classical light scattering*) particle size analyzer was used to determine particle size distribution characteristics of a radioactive slurry. Spent nuclear fuel was previously reprocessed at the INTEC (formerly recognized as the Idaho Chemical Processing Plant) utilizing liquid-liquid extraction processes. The acidic, radioactive aqueous streams from these processes were transferred to 300,000 gallon stainless steel storage vessels in the INTEC Tank Farm area, where each vessel sits below grade, and is totally enclosed in a concrete vault. This radioactive liquid was subsequently transferred to a solidification process. Due to the liquid transfer piping configuration in the tank farm vessels, 100 percent of this liquid could not be retrieved. Consequently, a liquid “heel” remains at the bottom of the “emptied” vessel. It is the particle size distribution (PSD) analysis of the solids in this radioactive heel slurry that is addressed in this report.

Heel slurry samples from INTEC tank farm vessels WM-182 and WM-183 were taken utilizing the Light Duty Utility Arm (LDUA) from October 1999 to January 2000. A description of this LDUA technology is presented by Patterson [1]. Tank farm samples were transferred to the INTEC Remote Analytical Laboratory (RAL) facility. Particle size analyses on these samples were performed in the RAL using a Horiba PSD analyzer which was modified for remote application. This technology provides rapid and simple PSD analysis, especially down in the fine and microscopic particle size regime. Particle size analysis of these radioactive slurries down in this smaller range was previously not achievable—making this technology far superior than the traditional particle sizing methods used before. Remote deployment and utilization of this technology is in an exploratory stage. In light of development of closure strategies for the INTEC tank farm within the auspices of the Draft High-Level Waste and Facility Disposition Environmental Impact Statement, these PSD analyses, in conjunction with other characterization analyses, are tremendously useful fundamental engineering data.

## 2. PSD ANALYSIS EQUIPMENT & METHODS

### 2.1 Remote PSD Analyzer and Equipment

Particle size distribution analysis of INTEC Tank Farm WM-182 and –183 heel slurry samples were performed using the modified Horiba Instruments Inc. Model LA-300 laser scattering particle size distribution analyzer; it has a 0.1 to 600 micron ( $\mu\text{m}$ ) measurement range and weighs 55 lbs. This instrument was chosen for this PSD analysis task primarily because it satisfied a 12 inch wide RAL transfer tunnel dimension restriction—and because of its smaller “footprint”. A description of this analyzer and some of the theory of this technology are presented in References 2 and 3.

The Horiba software generates the PSD as a discrete frequency distribution of particle volume percent versus the particle diameter. A frequency distribution is typically presented as a histogram. A differential frequency distribution, or in this case, a differential volume percent distribution curve can be approximated by drawing a smooth curve through the histogram[4]. In this way, the particle size distribution is easily grasped because the subtleties of the distribution are revealed (particularly when plotted on a logarithmic scale). Differential curves are better than histograms when comparing overlaid PSD's. The Horiba's 0.1 to 600 $\mu\text{m}$  particle size range is resolved into 64 logarithmically spaced channels. The channel volume percent value is matched with the channel center value. The particle size distribution and PSD statistics are calculated using the 64 {Vol. % , particle size} data pairs. For greater

flexibility of data handling and presentation purposes just described, all PSD analyses presented here were regenerated in EXCEL software by exporting the Horiba PSD data and generating a graph from this data. A cumulative volume percent plot can be obtained by summing the data (which necessarily sums to 100 %). An overlay of cumulative distributions is not as visually informative as an overlay of the differential distributions. Typically, solids-liquid-separation technologies use the cumulative 50 % particle size as the “nominal” particle size that is retained by the equipment; this is reported as the median in the data presented here.

A Jencons *PowerPette* battery-powered pipettor with a disposable 2.2 ml plastic pipette tip was used to draw small aliquots for remote PSD analyses of the tank farm slurry samples. A small aliquot is added to the Horiba sample dispersion/circulation tank. The circulating particles from this aliquot diffract/scatter some of the laser light. Typically a minimum of 5 % obscuration (or 95 % transmittance) of the light is required to ensure a diffraction/scatter pattern adequate for the analyzer to deconvolute the particle size distribution. Aliquots of slurry are added to the analyzer until satisfactory obscuration is achieved. Further technique details are presented in Reference 3. Prior to using the plastic pipettes in the RAL cell, the slurry-draw end of the tip was reamed out to approximately 2100 $\mu\text{m}$ . This opening is over three times the analyzer’s 600 $\mu\text{m}$  upper detection limit but it is not so large that it allows the aliquot to dribble out.

## 2.2 Analyzer Performance Check with Standards

Standards were used to demonstrate and verify analyzer performance during testing. These accuracy checks were performed during the metamorphosis of the modified analyzer and then during this tank farm slurry sample PSD analyses testing. Several Coulter Corporation particle size standards were used. A 35 $\mu\text{m}$  nominal mode garnet LS Control G35D (Lot: 1014) was used predominately throughout this testing. A mixture of 2.1 $\mu\text{m}$  modal polyvinyl toluene (Lot: 1630) and 20.8 $\mu\text{m}$  modal polystyrene microspheres (Lot: 5740), and a 0.3 $\mu\text{m}$  latex LS Size Control L300 (Lot: 1019) were also used. Typically the standards material was added directly to the Horiba sample dispersion/circulation tank.

## 2.3 Tank Farm Samples, PSD Analysis Method and Testing

The PSD analysis method sequence basically involved: 1) adding fresh water dispersant to the analyzer dispersion/circulation tank, 2) circulating and debubbling the water dispersant, 3) align the laser, 4) baseline (or “blank”) the instrument, 5) add sample aliquots and perform analysis; the details of this procedure are presented in References 3 and 5.

Actual sample locations (mapped by sample number...as was done for WM-188 [1]) within the WM-182 and –183 tanks was not available at time of publication. Supposedly, sample locations are in a similar sampling pattern as to those of WM-188 [6]. A concern was raised because it was felt that a representative cross-section of the tank solids is not achievable with this sampling pattern. However, the limitations of the LDUA reach were reiterated.

In any event, there were two types of PSD analyses testing performed using the WM-182 and –183 samples: 1) typical PSD analysis testing, and 2) *settling rate* testing. As described earlier, small aliquots were drawn from a sample dispersion until the amount of particles circulating in the analyzer were satisfactory for an analysis by the instrument. For at least one of the tests performed, aliquots were drawn directly from an intact, non-fractionated sample dispersion. However, most testing was performed with a redispersion of solids from the original tank farm sample. And for some tests, the solids were from a composite of fractionated solids from several tank farm samples.

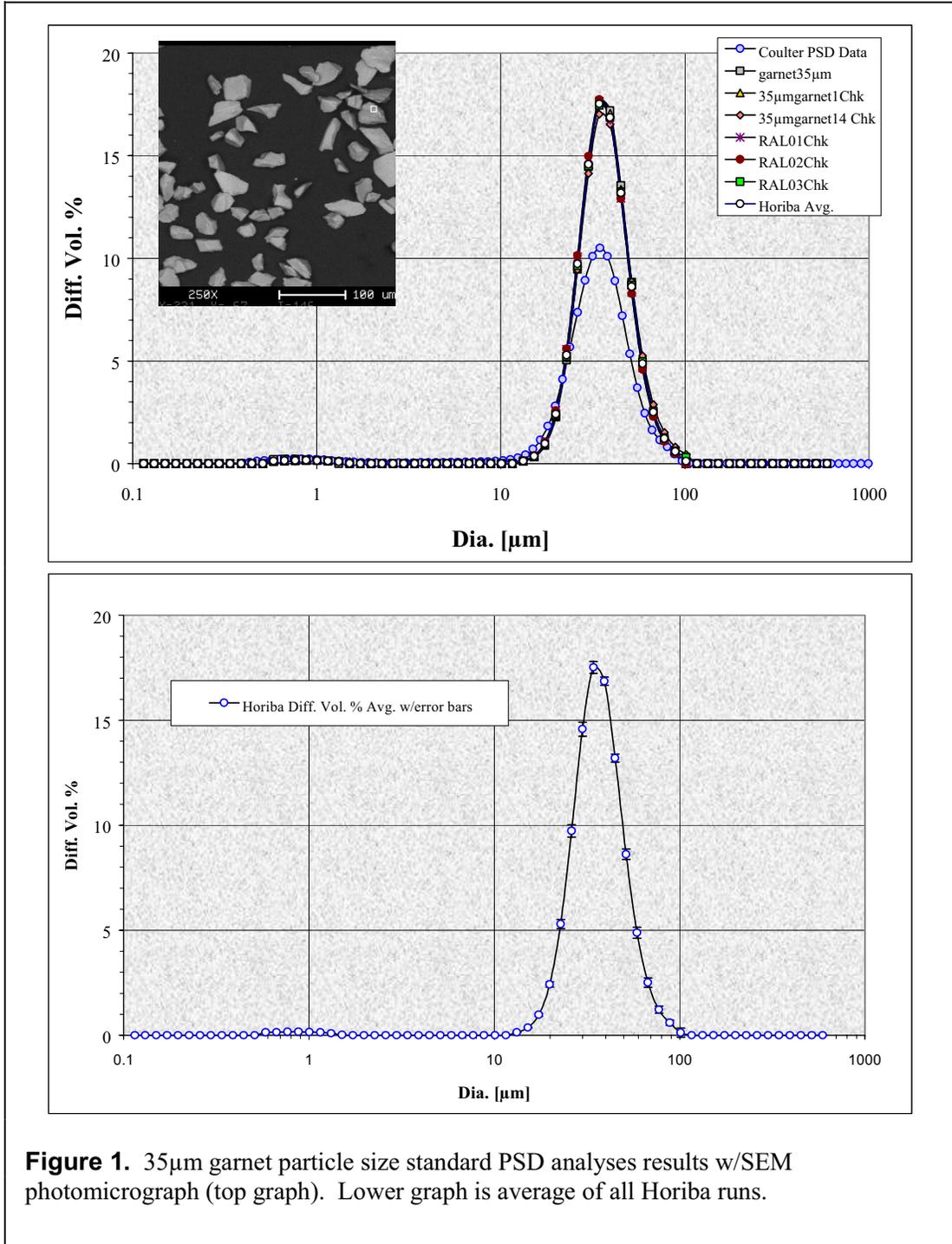
For the typical PSD analyses, aliquots were drawn from a just-agitated slurry sample dispersion container using the pipettor and an analysis run performed. Duplicate analysis runs for this sample dispersion were performed until reasonable repeatability and “trending” were observed between the runs. This qualitative judgement was made by noting the mode location and, the breadth and shape of the differential PSD profile curve from one run to the next. Often this may take only three runs to clearly establish the “true” sample PSD profile. The Horiba aliquot dispersion/circulation tank has a 13 W, 28 kHz ultrasonic element. It was observed that use of this high frequency ultrasonic element affected the PSD profile; this is discussed in the Results section.

For the settling rate testing, a quantity of solids was fully agitated/dispersed in a 250 ml glass graduated cylinder and then allowed to settle. At a predetermined settling time, aliquots were drawn from a point about 4” below the surface and the analysis quickly executed. This testing basically looked at the transient particle size distribution for the solids in the “clarifying” layer above the settled solids layer (at the bottom). As testing proceeded, it became apparent that the ultrasonic element should not be used for the settling rate testing PSD analyses; this is also discussed later. In this format, a settling rate PSD versus time plot was generated. Due to limitations, duplicate settling rate test runs were not performed.

### 3. RESULTS AND DISCUSSION

#### 3.1 Particle Size Standards Results

Results for the 35 $\mu\text{m}$  nominal mode garnet standard analyses performed over the duration of this testing are presented in Figure 1.



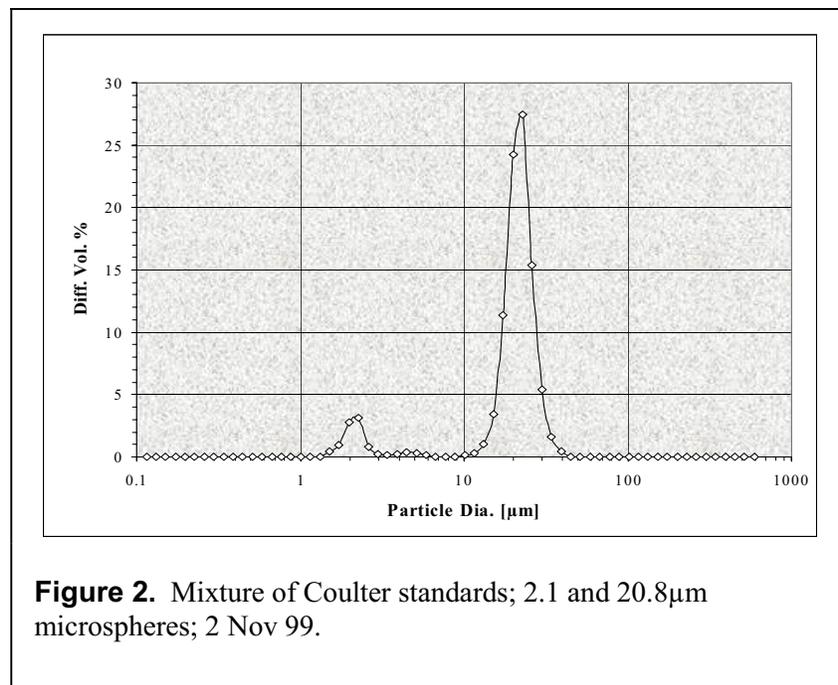
Run descriptions for these 35 $\mu\text{m}$  garnet runs are given in Table 1.

**Table 1.** Description of 35 $\mu\text{m}$  garnet standard runs.

Filename	Description	Date
garnet35 $\mu\text{m}$	performed upon receipt and setup of unit at INTEC.	26 Jul 99
35 $\mu\text{m}$ garnet1Chk	after completion of major modifications to unit	2 Nov 99
35 $\mu\text{m}$ garnet14Chk	upon final assembly of unit	29 Nov 99
RAL01Chk	first analysis performed with unit in RAL cell—just prior to first “hot” sample from WM-182	23 Dec 99
RAL02Chk	check instrument performance prior to continued analyses of tank farm samples	19 Jan 00
RAL03Chk	check instrument performance prior to continued analyses of tank farm samples	7 Feb 00

It is clear from these results with the garnet standard that the modifications to the unit for remote application at the RAL did not affect the analyzer, and the instruments level of repeatability remained high. However, it was noted that the Horiba consistently yielded a mode down around 32  $\mu\text{m}$  for this standard (see Appendix A.1; analyzer PSD data in the EXCEL spreadsheet format and statistics for WM-182 and the rest of the standards are in Appendix A.1). Analysis of this standard performed with a Coulter LS230 laser diffraction particle size analyzer is also shown in Figure 1 (top graph); the Coulter consistently yielded the mode at around 35  $\mu\text{m}$ . This raised a concern regarding the calibration of the Horiba.

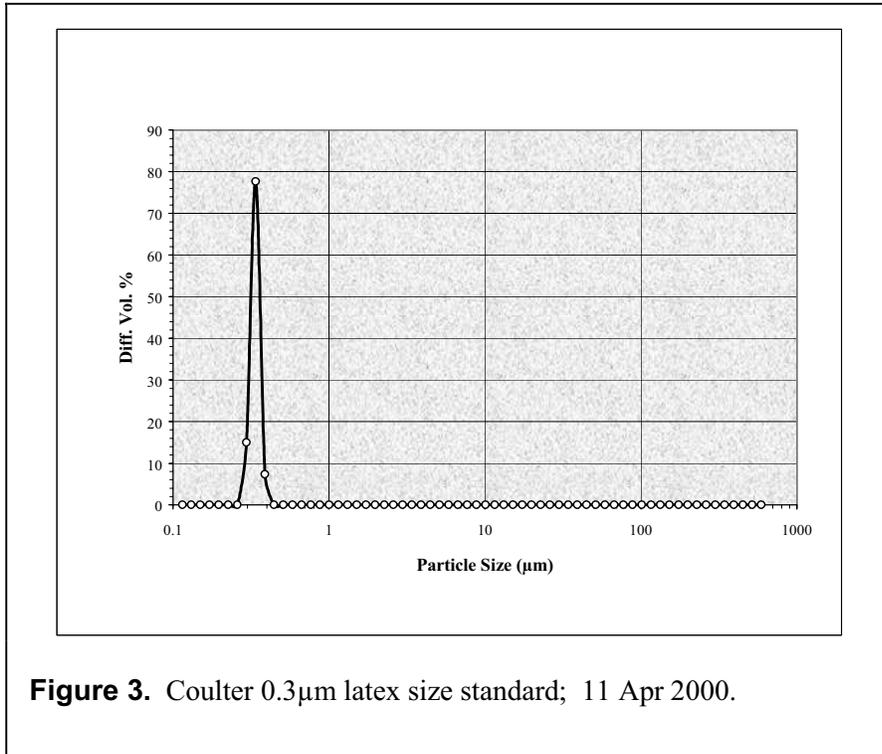
As a follow-on to this concern, a mixture of 2 and 21 $\mu\text{m}$  standards was analyzed in the Horiba before deployment of the analyzer in the RAL; the results for this are presented in Figure 2.



As can be seen, these results were quite satisfactory (see data table in Appendix A.1). It was decided at this juncture that the Horiba was operating within an acceptable reproducibility range, and that there was not a calibration discrepancy of such magnitude so as to preclude deployment of the Horiba in the RAL.

In the course of the tank farm testing, a curious observation was that the PSD's showed zero volume percent of material less than about 0.5  $\mu\text{m}$ . It was expected that some of the samples would show a non-zero volume percent down to the

instrument's 0.1 $\mu\text{m}$  lower limit. An analysis of the Coulter 0.3 $\mu\text{m}$  standard was performed to demonstrate that the instrument was detecting particles less than 0.5  $\mu\text{m}$ . The result for this test is presented in Figure 3. This result indicated that the Horiba was detecting particles less than 0.5  $\mu\text{m}$ .



**Figure 3.** Coulter 0.3 $\mu\text{m}$  latex size standard; 11 Apr 2000.

The overall results for the standards testing were satisfactory and demonstrated that the Horiba was performing with excellent repeatability and acceptable accuracy during the actual tank farm PSD testing.

In order to decrease the abrasive wear on the Horiba's glass sample cell, a move to a glass bead standard instead of the garnet is recommended. Continued use of the engineered monosize spheres is satisfactory for checking analyzer performance at specific sizes. Standard Reference Material such as glass bead standards are available

from the National Institute of Standards and Technology (NIST) for checking performance over a range of sizes; a range of from 34-to-120 $\mu\text{m}$  is recommended.

### 3.2 Tank Farm Heel Slurry Sample PSD Results

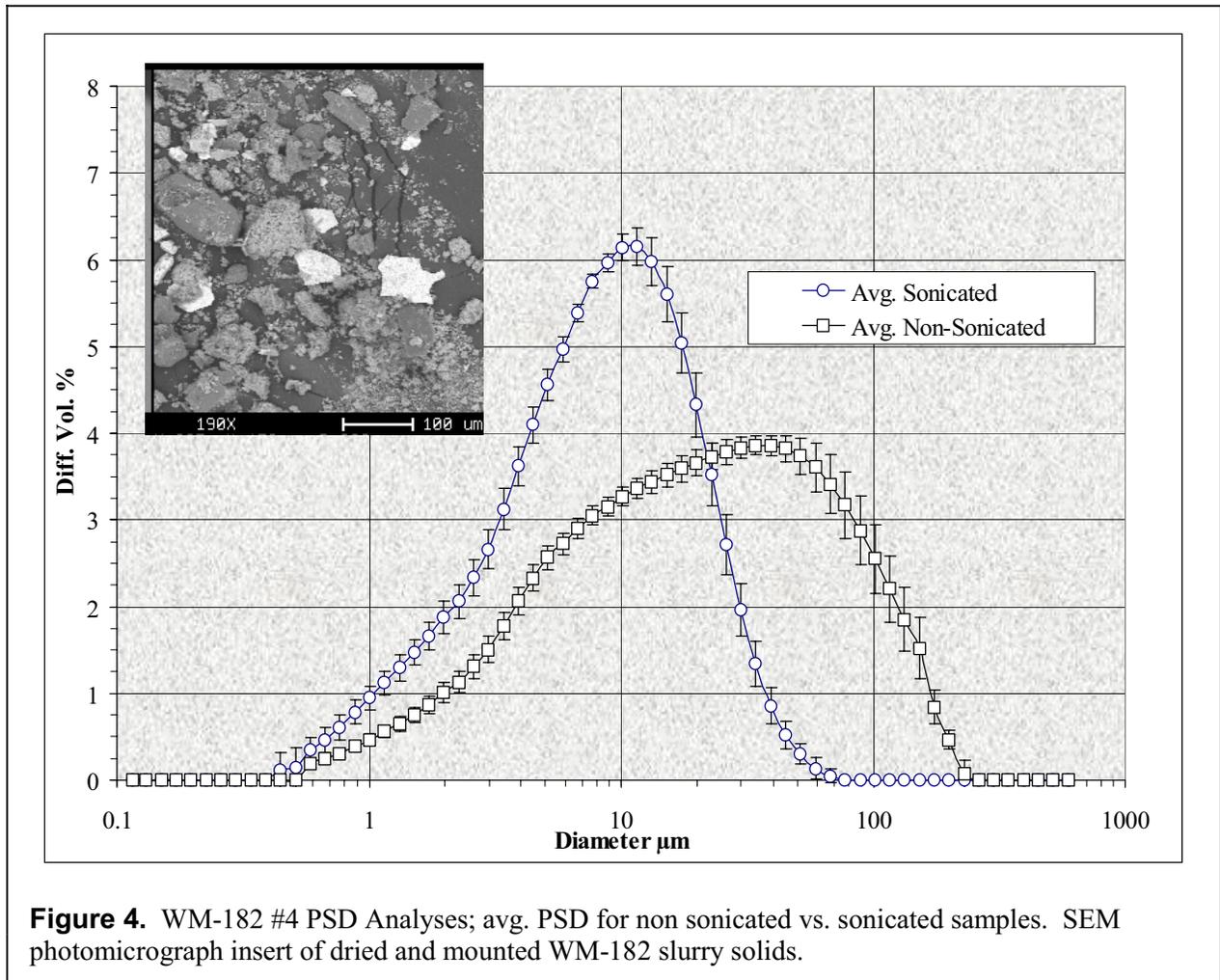
For the tank farm heel slurry sample typical PSD analysis testing, and the settling rate testing, there were seven sets of PSD data. These data sets are shown in Table 2.

**Table 2.** WM-182 & 183 Heel Slurry PSD Data Sets.

	LDUA Sample	Description	Date
Sample PSD Analysis	WM-182 #4	<ul style="list-style-type: none"> <li>• Non-fractionated slurry from sample LN 9911082</li> <li>• Aliquot dispersion in Horiba was <u>not</u> sonicated.</li> </ul>	23 Dec 99
		<ul style="list-style-type: none"> <li>• Aliquot dispersion in Horiba was sonicated.</li> </ul>	11 Apr 00
	WM-183 #3	<ul style="list-style-type: none"> <li>• Solids redispersed from <i>suspended solids</i> fraction of sample LN 0001125.</li> <li>• Dispersion in Horiba was <u>not</u> sonicated</li> </ul>	19 Jan 00
		<ul style="list-style-type: none"> <li>• Dispersion in Horiba was sonicated.</li> </ul>	
WM-183 Composite of Sample #'s 1,2, and 3 (Composite A)	<ul style="list-style-type: none"> <li>• Solids composited and redispersed from <i>settled solids</i> fraction from sample LN's 0001056, 0001123 and 0001125. In this report, this composite is designated as Composite A.</li> <li>• Dispersion in Horiba was <u>not</u> sonicated.</li> </ul>	19 Jan 00	
	<ul style="list-style-type: none"> <li>• Dispersion in Horiba was sonicated.</li> </ul>		
WM-183 Composite of Sample #'s 4,5,6, and 7 (Composite B)	<ul style="list-style-type: none"> <li>• Similarly, solids composited and redispersed from <i>settled solids</i> fraction from sample LN's 0001175, 0001176, 0001191 and 0001192; this composite is designated as Composite B.</li> <li>• Dispersion in Horiba was <u>not</u> sonicated.</li> </ul>	7 Feb 00	
	<ul style="list-style-type: none"> <li>• Dispersion in Horiba was sonicated.</li> </ul>		
Setting Rate Testing	WM-182 #4	<ul style="list-style-type: none"> <li>• Non-segregated slurry from sample LN 9911082.</li> <li>• Aliquot dispersion in Horiba <u>was</u> sonicated.</li> </ul>	8 Feb 00
	WM-183 Composite A	<ul style="list-style-type: none"> <li>• Testing performed with Composite A material (as described above).</li> <li>• Aliquot dispersion in Horiba was <u>not</u> sonicated.</li> </ul>	8 Mar 00
	WM-183 Composite B	<ul style="list-style-type: none"> <li>• Testing performed with Composite B material (as described above).</li> <li>• Aliquot dispersion in Horiba was <u>not</u> sonicated.</li> </ul>	8Mar 00

### 3.2.1 WM-182#4 PSD Analysis

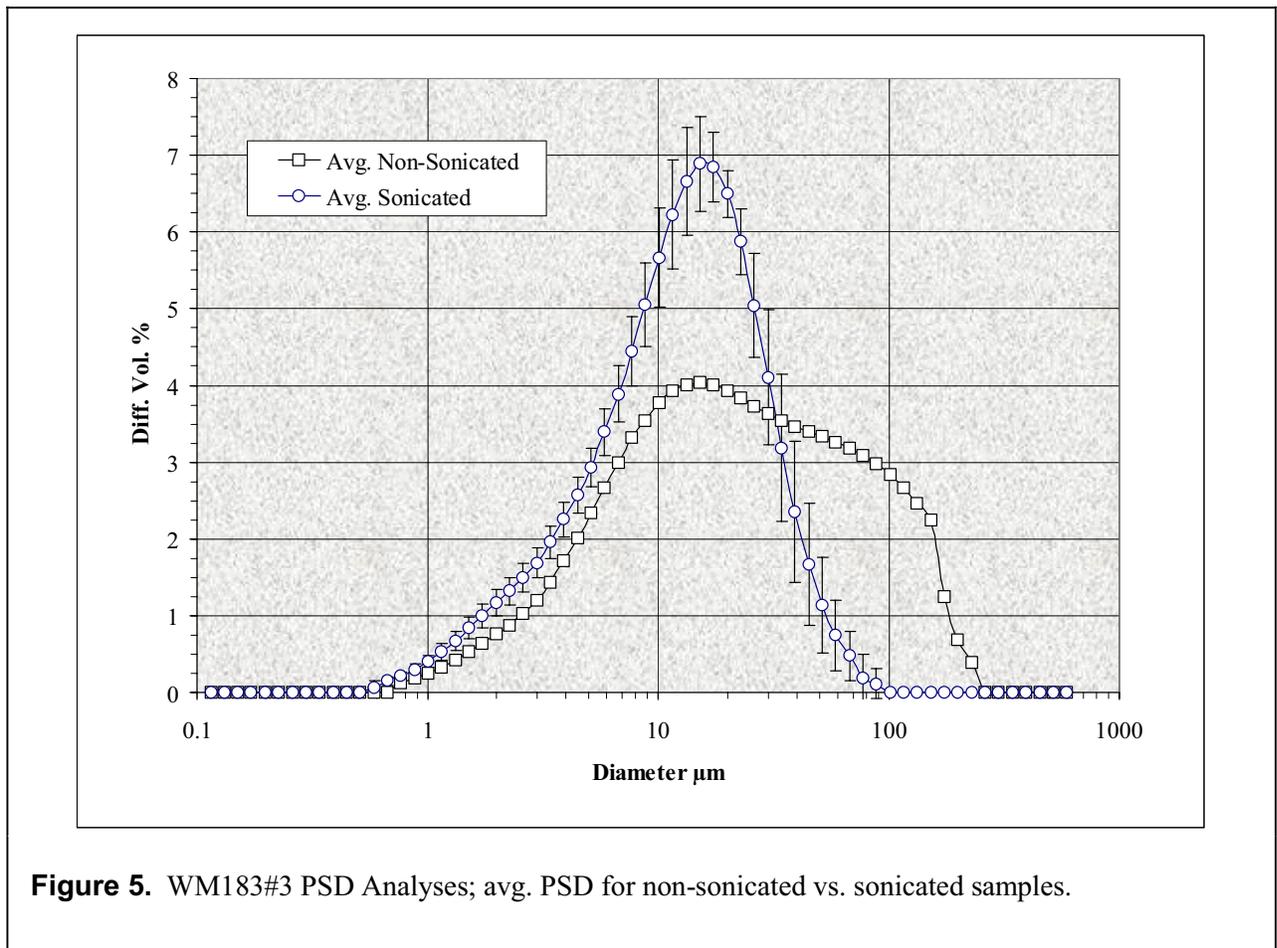
The WM-182 Sample #4 PSD analyses were the first performed on actual  $\gamma$  radiation material at the RAL with the newly installed Horiba. For the first five runs performed, the ultrasonic element (described previously in Section 2.3) which sonicates the liquid in the analyzer's aliquot dispersion/circulation tank, was not used. Sonication was used later and was found to significantly affect the PSD profile. The average PSD's for non-sonicated versus sonicated runs are presented in Figure 4. Initially, it was believed that sonication dispersed agglomerated particles and yielded the fundamental particle sizes in the sample. However at a later date, SEM photomicrographs of WM-182 solids (see Figure 4 insert) became available for inspection. It was then believed that the larger particles were not comprised of smaller, agglomerated particles. Moreover, the results for the unsonicated case represented the "as is" particle size distribution for the tank slurry sample (along the lines as what is seen in the SEM insert)—and the possibility that sonication is actually "breaking-up" larger particles was raised. This finding represents useful information regarding ultimate tank heel waste processing. Further investigation of sonication effects is needed and is recommended.



The particle sizes seen in the SEM photo compares with the non-sonicated PSD profile sizes in that there are particles on-the-order of 100 $\mu\text{m}$ , but none are seen of the size greater than 300 $\mu\text{m}$  (where the profile “zeroes-out” on the “big” end)—and the broad mode around 40 $\mu\text{m}$  can be easily supported. Obviously it can not be assumed that this photo represents the particle distribution that was “seen” by the Horiba (let alone, that of the slurry sample). Analyzer PSD data in the spreadsheet format for this WM-182#4 sample are provided in Appendix A.2 (as are all the remaining tank farm sample PSD data).

### 3.2.2 WM-183#3 PSD Analysis

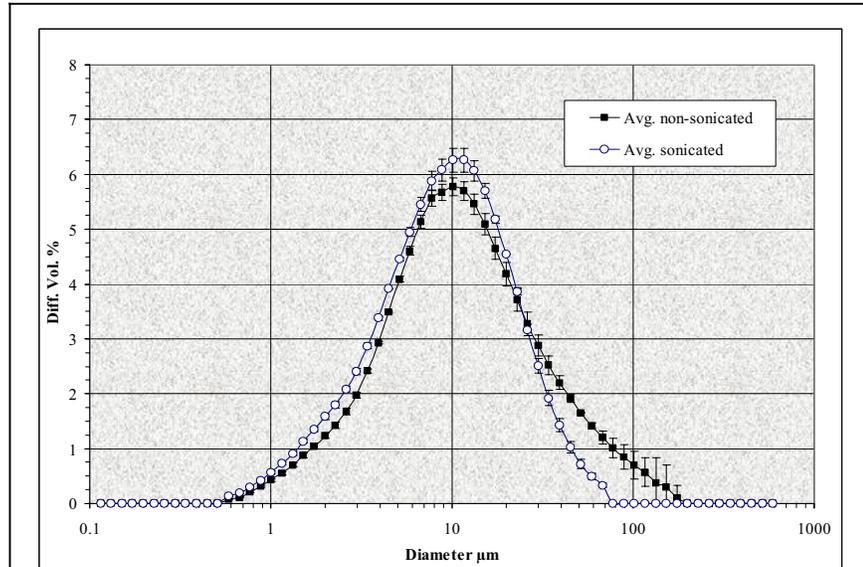
PSD analyses were performed with solids which were redispersed from the original *suspended solids* fraction of WM-183 Sample #3 (Log Number 0001125). The *suspended solids* fraction is decanted/separated off the top of the *settled solids* fraction of the sample. The effect of sonication was noted for these results also. The average PSD’s for non-sonicated versus sonicated runs are presented in Figure 5. Unlike the WM-182 results, an  $\sim 15\mu\text{m}$  mode shows up in both the unsonicated and the sonicated profile—albeit much less dominant in the non-sonicated case. Because this material was from the suspended solids fraction, the significant amount of larger size particles was not expected to be seen; further discussion of this is taken up later.



**Figure 5.** WM183#3 PSD Analyses; avg. PSD for non-sonicated vs. sonicated samples.

### 3.2.3 WM-183 Composite A PSD Analysis

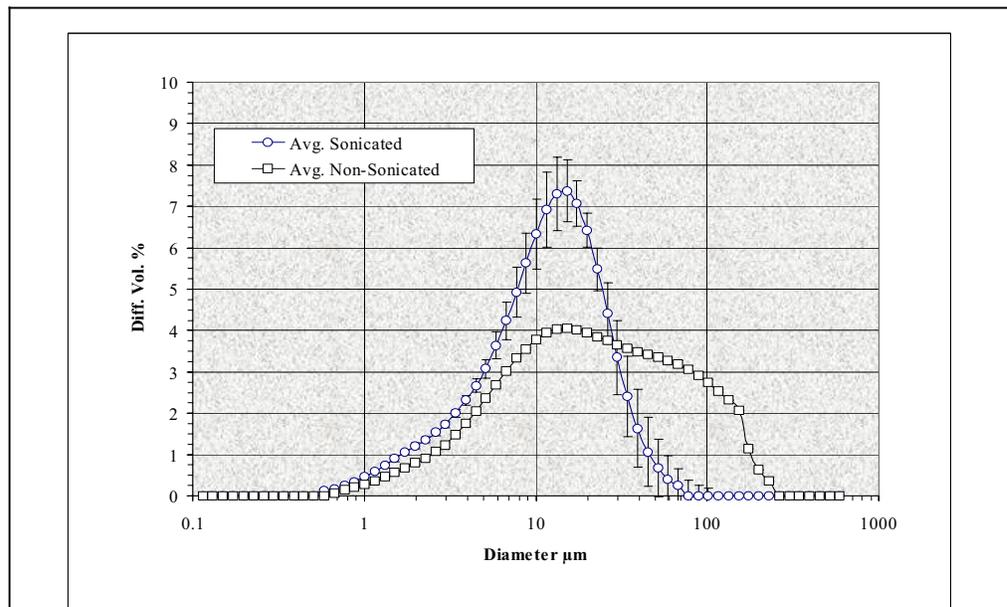
PSD analyses were performed with solids which were redispersed from a composite of the original *settled solids* fraction of WM183 Sample #'s 1, 2 and 3. The average PSD's for unsonicated versus sonicated runs are presented in Figure 6. Sonication had some effect on this sample. The unsonicated result shows larger particles out to  $\sim 200\mu\text{m}$ ; however, the mode at  $\sim 10\mu\text{m}$  is dominant, just like in the sonicated case. Because this material was from the settled solids fraction, a significant amount of larger size particles was expected to be seen; Again, further discussion to this is given later.



**Figure 6.** WM-183 Composite A PSD Analyses; avg. PSDs for non-sonicated vs. sonicated runs.

### 3.2.4 WM-183 Composite B PSD Analysis

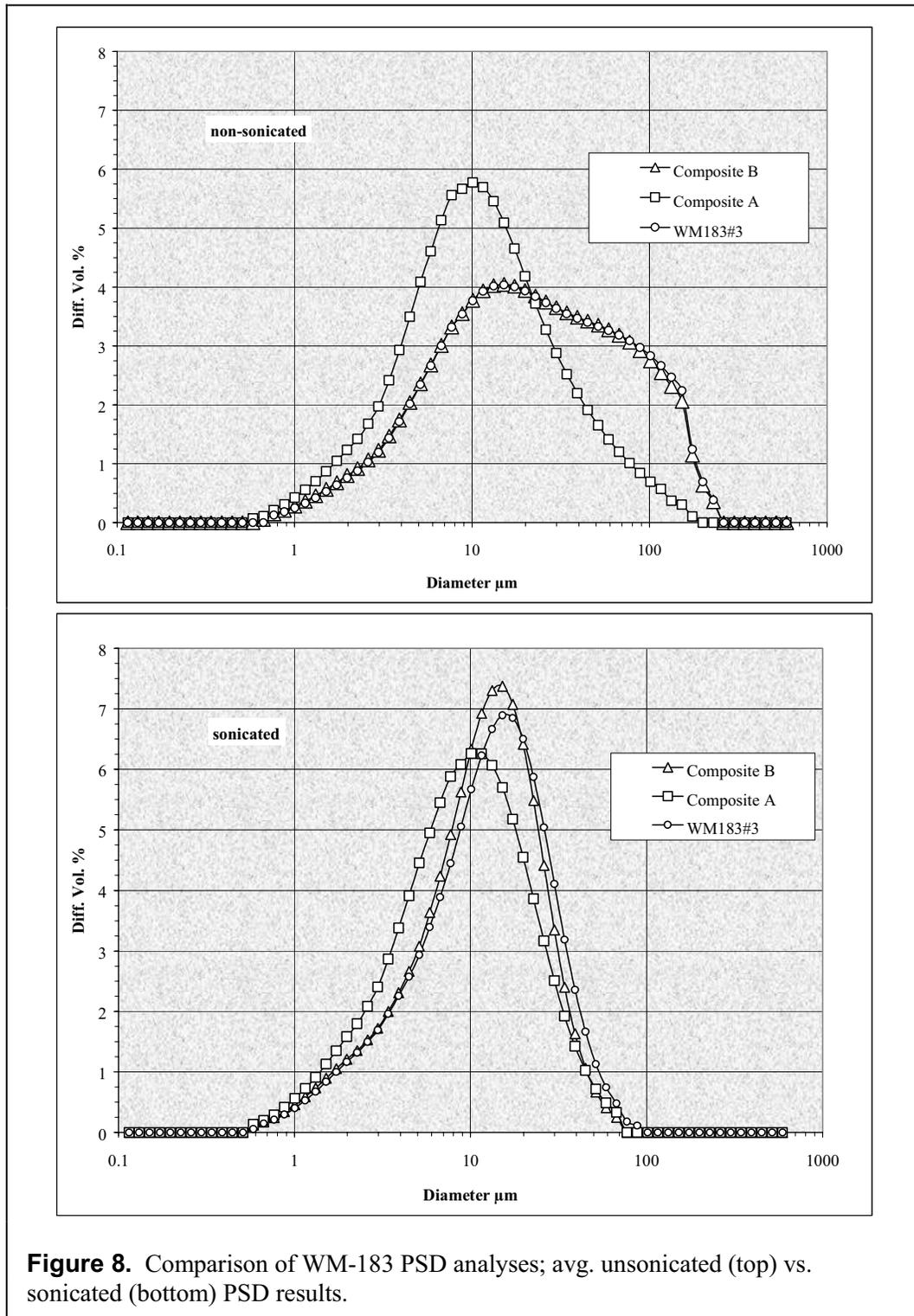
Similarly, PSD analyses were performed with solids which were redispersed from a composite of the original *settled solids* fraction of WM183 Sample #'s 4, 5, 6 and 7. The average PSD's for unsonicated versus sonicated runs are presented in Figure 7. The effect of sonication was similar to that noted for WM-183#3. This kind of distribution is what was expected for the settled fraction.



**Figure 7.** WM-183 Composite B PSD Analyses; avg. PSDs for non-sonicated vs. sonicated runs.

### 3.2.5 Comparison of WM-183 PSD Analyses

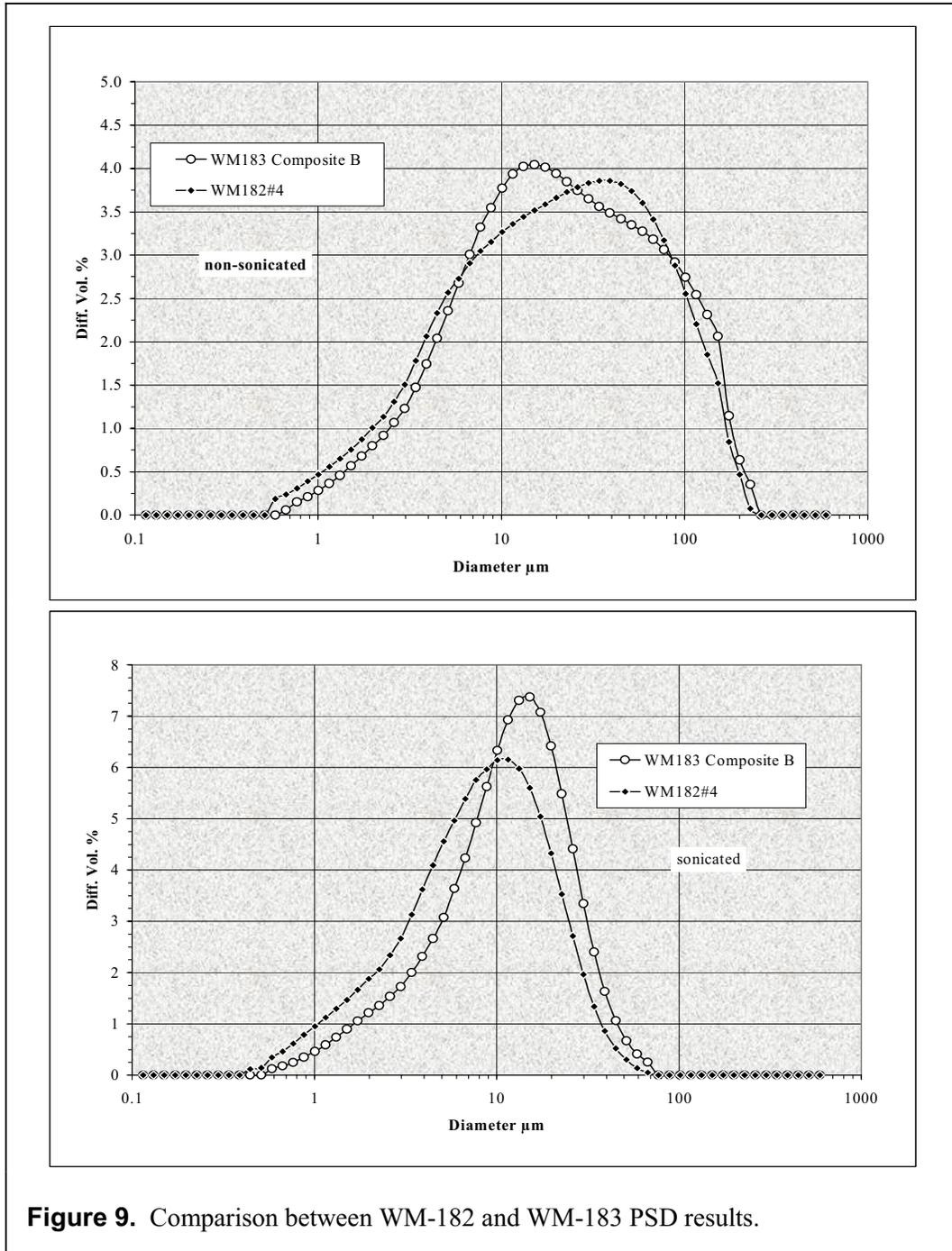
A comparison of the three WM-183 sample PSD analyses is presented in Figure 8 (unsonicated and sonicated results). Per the previous deferring discussions, only Composite B results seem reasonable for settled solids fraction material. WM183#3 and Composite A results appear to be reversed for their respective material as discussed earlier. However, concrete evidence to “correct” this anomaly has not been uncovered—the results stand as presented.



**Figure 8.** Comparison of WM-183 PSD analyses; avg. unsonicated (top) vs. sonicated (bottom) PSD results.

### 3.2.6 Comparison Between WM-182 and WM-183 PSD Analyses

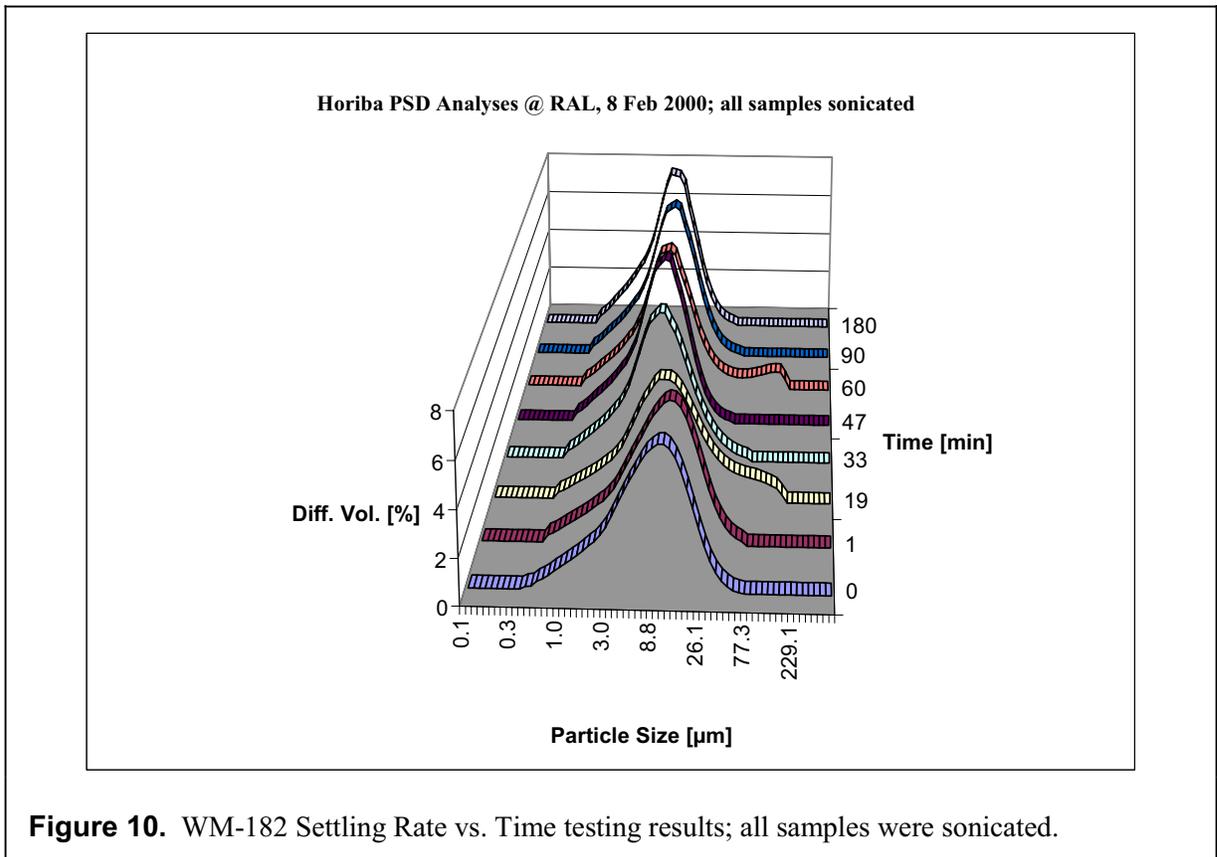
On one hand, the assumption that the PSD results for WM-182 and WM-183 represent the entire particle size distribution for their respective vessels is not at all statistically defensible. Conversely, considering the minute quantities used from the two separate vessels to obtain these results, the similarities between the results is noteworthy; as can be seen in Figure 9, this holds for both the non-sonicated and the sonicated case. Take note that, based on the discussion in the previous WM183 comparison section, WM183#3 and Composite A were not included in Figure 9.



**Figure 9.** Comparison between WM-182 and WM-183 PSD results.

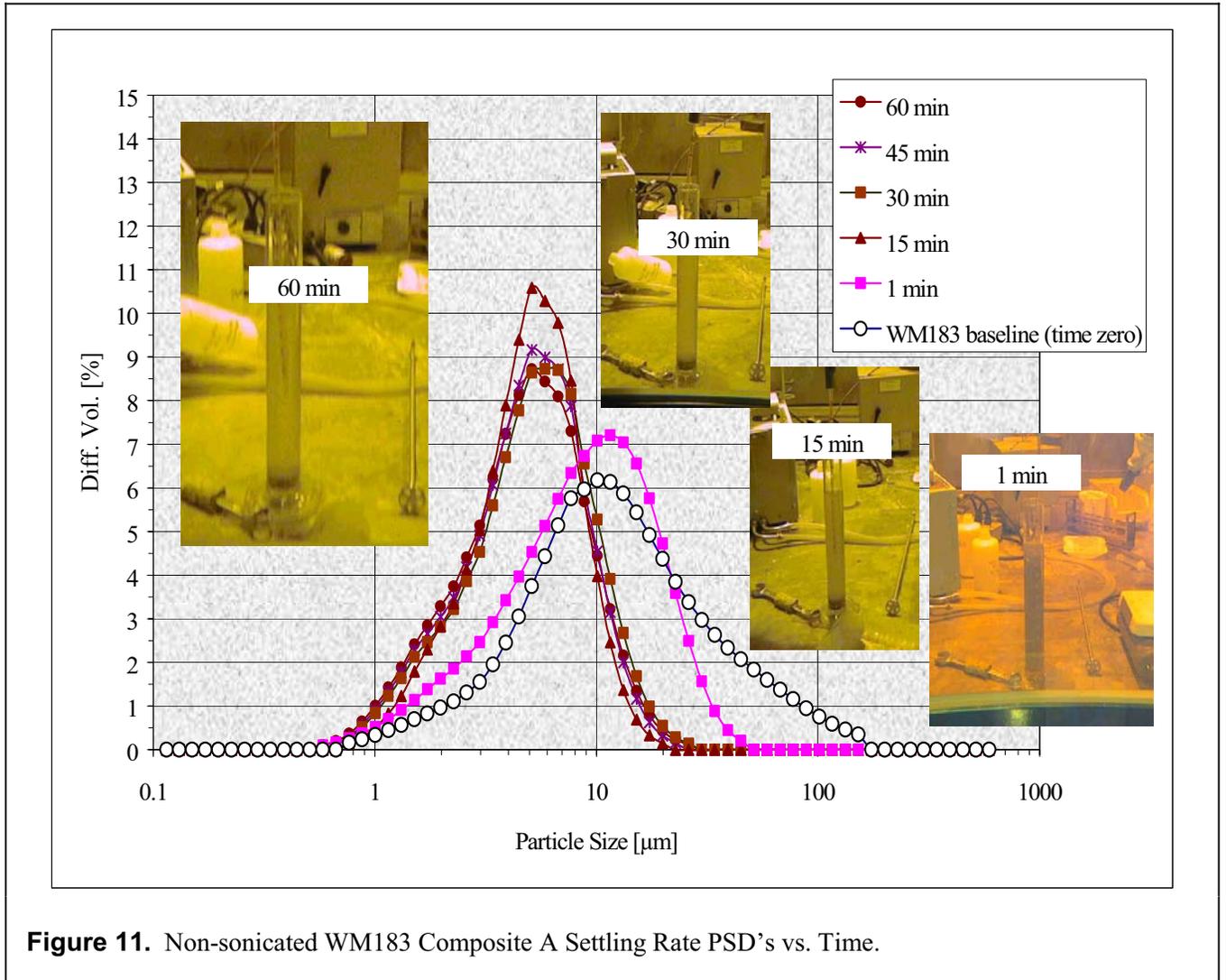
### 3.2.7 WM-182#4 Settling Rate Testing

Settling rate testing was performed with non-fractionated WM-182#4 sample material. The results are presented in Figure 10. For this case, a 3-D plot was generated (the overlay plot is presented in the Appendix). When the results of this testing were reviewed in conjunction with the WM182 SEM photomicrographs (shown earlier), it became apparent that sonication was significantly affecting the PSD's and probably do not represent those of the settling solids viewed in the graduated cylinder. It was at this juncture that the decision to not use sonication for the settling rate testing PSD analyses was made.

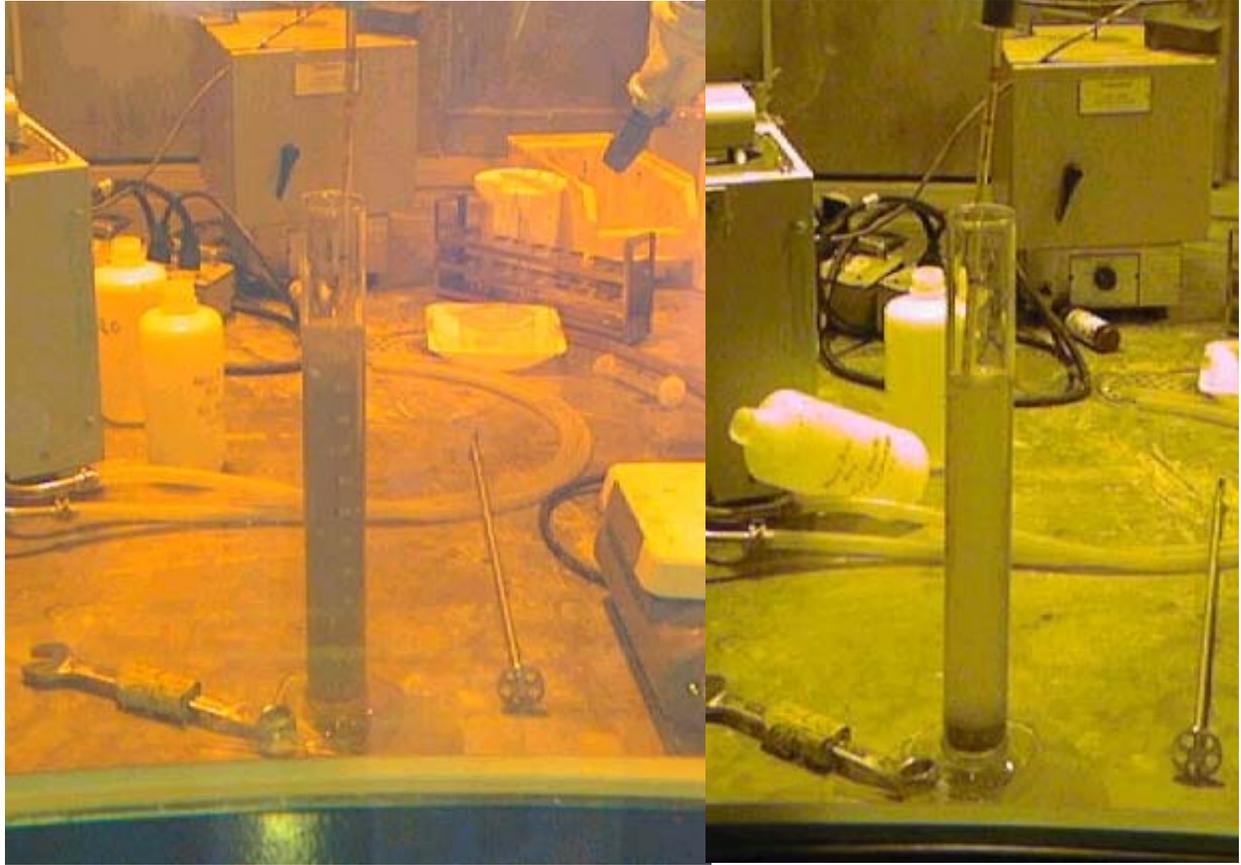


### 3.2.8 WM-183 Composite A Settling Rate Testing

Settling rate testing was performed with WM183 Composite A material under non-sonicated conditions. These results, along with some photographs taken during this testing are presented in Figure 11. Recall from Figure 6 that this sample showed this strong mode at  $\sim 10\mu\text{m}$  even for the unsonicated



case. These results show that after 15 minutes of settling time, the PSD has aligned into a distribution having a strong mode at  $\sim 5\mu\text{m}$  and maximum particle size of about  $30\mu\text{m}$ —this result was interestingly quite similar to the WM-182 settling test result which was performed under conditions of sonication. The one and the 30-minute photos are presented in Figure 12 for closer inspection; after 30 minutes, a distinct settled layer was observable.



**Figure 12.** WM-183 Composite A non-sonicated settling rate testing; 1 min. on left and 30 min. on right..

A full set of the photographs taken during this Composite A settling rate testing is provided in Appendix A.3 (as is the Composite B settling rate testing set). While inspecting these, keep in mind that these photos were taken through the RAL cell shielding window, which is optically equivalent to about 3 feet thick glass; this is the reason for the poor quality for some of these photos; also take note that there is a 1.7 $\times$  magnification through the window. Determination of a settling velocity and estimation of other solids physical characterization parameters (particle density, for example) were not in the scope of this work.

### 3.2.9 WM-183 Composite B Settling Rate Testing

Settling rate testing was performed with WM183 Composite B material under non-sonicated conditions. These results, along with some of the photographs taken during this testing are presented in Figure 13. This result is what was expected for these settling rate tests.

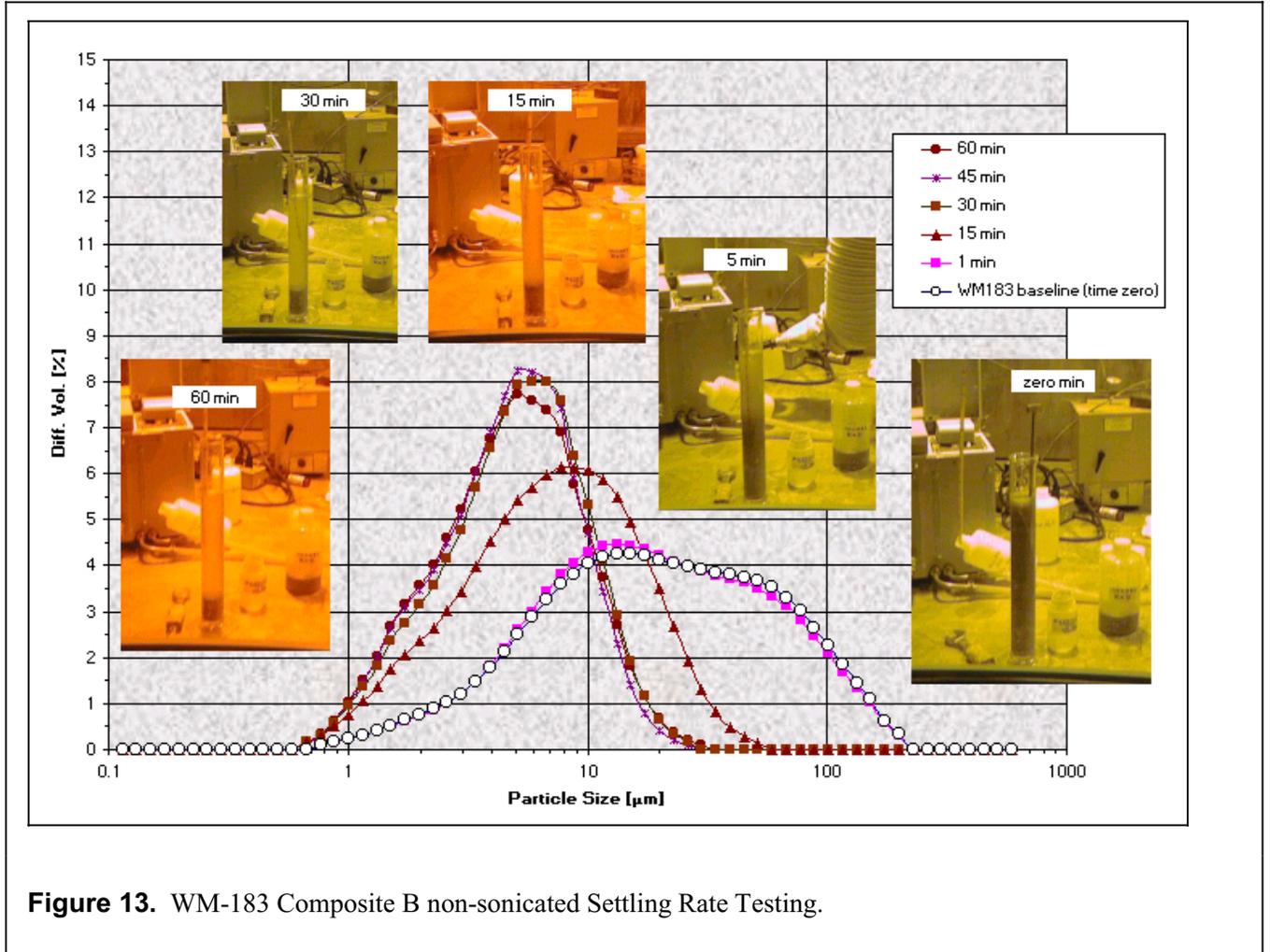


Figure 13. WM-183 Composite B non-sonicated Settling Rate Testing.

### 3.2.10 Comparison Between WM-182 and WM-183 Settling Rate Testing Results

In general, all settling rate testing results were fairly consistent in that it appears that most of the mass of solids settle to an agglomerated, yet easily redispersed layer at the bottom; and the ~5µm mode and maximum 30µm size material remains dispersed/suspended in the “clear” layer (see photos) at equilibrium (that is, after about ½ hr. settling time). Also, the non-sonicated PSD results represent the particle size of the settling material and the sonicated PSD results most likely do not.

Although a non-sonicated settling rate test was not performed with WM-182#4 sample material, the outcome would have most likely been quite similar to that observed for the WM-183 Composite B; that is, a broad distribution at one minute settling time and then alignment into the “equilibrium” PSD (described above) after 30 minutes or so.

### 3.2.11 PSD Results Closing Discussion

Use of non-fractionated slurry is recommended; this may be a problem in that it will require more sample volume. For future settling rate testing, suspended solids concentration (loading) data should be taken for a *detention test* analysis as detailed in Perry's [7]. Based on the experience gained from this work, smaller interval initial settling times are needed (at least two or three before the 15 minute mark); this may require duplicate PSD settling tests because of the sampling turnaround for the Horiba. If the settling times for both the solids loading testing and the Horiba PSD testing are matched, then these data can be coupled for more robust solids/liquid separation analyses. An approximate *bulk-settling rate* could be determined from the photos presented in this report (this was not done in this work). As alluded to before, WM-182 and -183 solids slurries appear to have a significant "unsettleable" solids fraction with a maximum size of about 30  $\mu\text{m}$  and an  $\sim 5\mu\text{m}$  mode.

Care must be taken in the use of this particle size data for slurry simulant formulation and in predicting slurry processing and processing equipment performance based on particle size data. Laser-based particle size differs from traditional screen size. Because most materials are not perfectly spherical, screen sizing biases toward the shortest particle dimension. The laser diffraction particle size instrument measures the particle dynamic average size between the longest and the shortest particle dimension. A traditional screen size distribution is based on mass percent; as alluded to earlier, laser size distribution is based on volume percent. Take note that in this report only laser instrument particle size is used. Although it can be a very crucial parameter, particle shape considerations are not addressed in this report. Comparison of these tank farm data presented here against laboratory testing data obtained with classical light scattering particle sizing technology will be the ideal case, and is recommended.

An interesting and fortuitous situation occurred in that—particle sizes greater than 300  $\mu\text{m}$  were not observed for any of these WM-182 and -183 samples. This may have been an artifact of the LDUA sampling procedure (the 2100 $\mu\text{m}$  pipette tip opening should have precluded a bias problem with the Horiba aliquoting procedure). Further investigation of this was not in the scope of this work. In the future, if tank farm sample particle sizes exceed the Horiba's 600 $\mu\text{m}$  upper limit, the sample will require a prescreening preparation to remove the larger sizes (referred to as "scalping"). The prescreen sieve data would require "splicing" to the laser diffraction sizing data to generate a continuous distribution.

## 4. CONCLUSIONS AND RECOMMENDATIONS

Particle size distribution analysis of the WM-182 and WM-183 tank farm heel slurry samples was performed with a modified Horiba LA 300 laser diffraction PSD analyzer. There were two types of testing performed: 1) typical PSD analysis, and 2) *settling rate* testing. Particle size standards were used to demonstrate and verify the performance of the analyzer during testing. The conclusions and recommendations based on the results of this work follow:

1. The overall results for the standards testing were satisfactory and demonstrated that the Horiba was performing with excellent repeatability and acceptable accuracy during the actual tank farm PSD testing.
2. Use of a NIST 34-to-120 $\mu\text{m}$  glass bead Standard Reference Material is recommended over the more abrasive 35 $\mu\text{m}$  garnet used during his testing. This glass bead standard is for checking over a range of sizes. Continued use of engineered monosize spheres is satisfactory for checking analyzer performance at specific sizes.
3. Particle size distribution analysis showed that for both the WM-182 and WM-183 samples, the particles range approximately from a minimum of 0.5 to a maximum of 230  $\mu\text{m}$ —with about 90 Volume % between approximately 2 to 133  $\mu\text{m}$ . The WM-182 sample had a moderate mode at 32  $\mu\text{m}$  while the WM-183 mode was at 14  $\mu\text{m}$ . On one hand, the assumption that the PSD results for WM-182 and WM-183 represent the entire particle size distribution for their respective vessels is not at all statistically defensible. Conversely, considering the minute quantities used from the two separate vessels to obtain these results, the similarities between the results is noteworthy.
4. High frequency sonication may be breaking-up larger particles in the WM-182 and WM-183 tank farm heel slurries. This finding represents useful information regarding ultimate tank heel waste processing. Further investigation of sonication effects is needed and is recommended.
5. Settling rate testing results were fairly consistent in that it appears that most of the mass of solids settle to an agglomerated, yet easily redispersed layer at the bottom; and the  $\sim 5\mu\text{m}$  mode and maximum 30 $\mu\text{m}$  size material remains dispersed/suspended in the “clear” layer after about  $\frac{1}{2}$  hr. settling time. For future settling rate testing, suspended solids concentration (loading) data should be taken for a *detention test* analysis as detailed in Perry’s. Use of non-fractionated slurry is recommended, however this may require more sample volume.
6. Care must be taken in the use of this particle size data for slurry simulant formulation and in predicting slurry processing and processing equipment performance based on particle size data. Laser-based particle size differs from traditional screen size. Comparison of these tank farm data presented here against laboratory testing data obtained with classical light scattering particle sizing technology will be the ideal case, and is recommended.

## 5. REFERENCES

1. M. Patterson, *Light Duty Utility Arm Deployment in Tank WM-188*, INEEL/EXT-99-1302, December 1999.
2. T. A. Batcheller, et al., *Remote Laser Diffraction PSD Analyzer*, INEEL/EXT-2000-479, June 2000.
3. INEEL Analytical Department Laboratory “Laser Light Scattering PSD Analysis” Method (in Draft), Spring 2000.
4. Terence Allen, *Particle Size Measurement*, 4<sup>th</sup> Edition, Chapman and Hall, New York, 1990
5. Horiba Instruction Manual, Laser Scattering Particle Size Distribution Analyzer LA-300, HORIBA, Ltd., Kyoto, Japan, 2<sup>nd</sup> Edition, September 1998.
6. Personal Conversation, M. Patterson, LDUA Project Manager, June 2000.
7. R. H. Perry, et al., *Perry’s Chemical Engineers’ Handbook*, 6<sup>th</sup> Edition, McGraw-Hill Book Company, New York, 1984.

**Appendix A**  
**Testing Results Data**

# Appendix A-1 Particle Size Standards Results Data

35 µm Modal Garnet Standard

Diameter [µm]	Cum. < Vol. % Avg of Runs	Horiba Data				Coulter Data					
		garnet35µm 26 Jul 99 Horiba Setup	35µmgarnet1 Chk 2 Nov 99 Post Mod	35µmgarnet14 Chk 29 Nov 99 Last Post Mod	Diff. Vol. %	FAL01Chk 23 Dec 99	FAL02Chk 19 Jan 00	FAL03Chk 7 Feb 00	1 STD EV	Diameter [µm]	Diff. Vol. % garnet35µm Coulter PSD Data
0.115	0	0	0	0	0	0	0	0	0.00	0.393	0.038
0.131	0	0	0	0	0	0	0	0	0.00	0.432	0.073
0.15	0	0	0	0	0	0	0	0	0.00	0.474	0.12
0.172	0	0	0	0	0	0	0	0	0.00	0.52	0.16
0.197	0	0	0	0	0	0	0	0	0.00	0.571	0.19
0.226	0	0	0	0	0	0	0	0	0.00	0.627	0.22
0.259	0	0	0	0	0	0	0	0	0.00	0.688	0.23
0.296	0	0	0	0	0	0	0	0	0.00	0.755	0.24
0.339	0	0	0	0	0	0	0	0	0.00	0.829	0.24
0.389	0	0	0	0	0	0	0	0	0.00	0.91	0.23
0.445	0	0	0	0	0	0	0	0	0.00	0.999	0.21
0.51	0	0	0	0	0	0	0	0	0.00	1.097	0.19
0.584	0.131	0.131	0.109	0.115	0.118	0.117	0.109	0.109	0.00	1.204	0.16
0.669	0.277	0.146	0.128	0.132	0.134	0.132	0.126	0.126	0.00	1.322	0.13
0.766	0.435	0.158	0.147	0.148	0.15	0.147	0.142	0.142	0.00	1.451	0.1
0.877	0.598	0.163	0.159	0.156	0.159	0.154	0.15	0.15	0.00	1.593	0.081
1.005	0.752	0.166	0.158	0.151	0.155	0.149	0.144	0.144	0.01	1.749	0.063
1.151	0.886	0.13	0.143	0.133	0.138	0.132	0.126	0.126	0.01	1.919	0.05
1.318	0.979	0.093	0.121	0.11	0.116	0.11	0.103	0.103	0.01	2.106	0.042
1.51	0.996	0.017	0.103	0.11	0.116	0.11	0.103	0.103	0.01	2.312	0.038
1.729	0.996	0	0	0	0	0	0	0	0.05	2.539	0.038
1.981	0.996	0	0	0	0	0	0	0	0.00	2.787	0.04
2.269	0.996	0	0	0	0	0	0	0	0.00	3.06	0.043
2.599	0.996	0	0	0	0	0	0	0	0.00	3.359	0.047
2.976	0.996	0	0	0	0	0	0	0	0.00	3.687	0.051
3.409	0.996	0	0	0	0	0	0	0	0.00	4.047	0.055
3.905	0.996	0	0	0	0	0	0	0	0.00	4.444	0.059
4.472	0.996	0	0	0	0	0	0	0	0.00	4.878	0.063
5.122	0.996	0	0	0	0	0	0	0	0.00	5.355	0.067
5.867	0.996	0	0	0	0	0	0	0	0.00	5.878	0.073

**35 µm Modal Garnet Standard**

Diameter [µm]	Cum. < Vol. %		Horiba Data				Horiba Data				Coulter Data	
	Avg o Pans		35µmgarnet1 Chk 2 Nov 99 Post Mod	35µmgarnet14 Chk 29 Nov 99 Last Post Mod	FAL01 Chk 23 Dec 99	FAL02 Chk 19 Jan 00	FAL03 Chk 7 Feb 00	1 STD EV	Diameter [µm]	Dff. Vol. % Coulter PSD Data		
	garnet35µm 26 Jul 99 Horiba Setup	Horiba Setup	0	0	0	0	0	0	0	0		
5.867	0.996	0.996	0	0	0	0	0	0	0	0.00	5.878	0.073
6.73	0.996	0.996	0	0	0	0	0	0	0	0.00	6.452	0.079
7.697	0.996	0.996	0	0	0	0	0	0	0	0.00	7.083	0.087
8.816	0.996	0.996	0	0	0	0	0	0	0	0.00	7.776	0.096
10.097	0.996	0.996	0	0	0	0	0	0	0	0.00	8.536	0.11
11.565	0.996	0.996	0	0	0	0	0	0	0	0.00	9.371	0.13
13.246	1.13	0.134	0.118	0.127	0.133	0.151	0.147	0.127	0.127	0.01	10.29	0.15
15.172	1.494	0.364	0.326	0.347	0.36	0.403	0.396	0.35	0.35	0.03	11.29	0.2
17.377	2.469	0.975	0.891	0.936	0.96	1.062	1.052	0.947	0.947	0.06	12.4	0.29
19.904	4.891	2.422	2.259	2.347	2.376	2.593	2.587	2.373	2.373	0.12	13.61	0.44
22.797	10.185	5.294	5.041	5.182	5.164	5.571	5.584	5.22	5.22	0.21	14.94	0.71
26.111	19.915	9.73	9.459	9.628	9.449	10.075	10.13	9.64	9.64	0.30	16.4	1.15
29.907	34.493	14.578	14.446	14.569	14.128	14.865	14.97	14.889	14.889	0.33	18	1.83
34.255	52.007	17.514	17.646	17.642	17.013	17.607	17.725	17.451	17.451	0.28	19.76	2.81
39.234	68.867	16.86	17.201	17.064	16.525	16.73	16.797	16.845	16.845	0.19	21.69	4.11
44.938	82.055	13.188	13.541	13.354	13.165	12.926	12.914	13.228	13.228	0.19	23.81	5.68
51.471	90.67	8.615	8.828	8.684	8.668	8.343	8.275	8.691	8.691	0.25	26.14	7.37
58.953	95.55	4.88	4.937	4.869	5.258	4.668	4.586	4.962	4.962	0.26	28.69	8.93
67.523	98.056	2.506	2.471	2.46	2.875	2.364	2.296	2.573	2.573	0.23	31.5	10.1
77.339	99.279	1.223	1.157	1.173	1.519	1.134	1.088	1.268	1.268	0.17	34.58	10.5
88.583	99.873	0.594	0.531	0.552	0.81	0.539	0.51	0.621	0.621	0.12	37.96	10.1
101.46	100	0.127	0	0	0.451	0	0	0.313	0.313	0.21	41.67	8.9
116.21	100	0	0	0	0	0	0	0	0	0.00	45.75	7.2
133.103	100	0	0	0	0	0	0	0	0	0.00	50.23	5.35
152.453	100	0	0	0	0	0	0	0	0	0.00	55.14	3.7
174.616	100	0	0	0	0	0	0	0	0	0.00	60.52	2.46
200	100	0	0	0	0	0	0	0	0	0.00	66.44	1.64
229.075	100	0	0	0	0	0	0	0	0	0.00	72.95	1.15
262.376	100	0	0	0	0	0	0	0	0	0.00	80.08	0.82
300.518	100	0	0	0	0	0	0	0	0	0.00	87.9	0.47
344.206	100	0	0	0	0	0	0	0	0	0.00	96.49	0.13
394.244	100	0	0	0	0	0	0	0	0	0.00	105.9	0.0084
451.556	100	0	0	0	0	0	0	0	0	0.00	116.3	0
517.2	100	0	0	0	0	0	0	0	0	0.00	127.6	0
592.387	100	0	0	0	0	0	0	0	0	0.00	140.1	0

35µm Modal Garnet Standard

Diameter [µm]	Horiba Data				Counter Data		
	game35µm 26 Jul 99 Horiba Setup	35µmgarnet1 Chk 2 Nov 99 Post Mod	35µmgarnet14 Chk 29 Nov 99 Last Post Mod	RAL01 Chk 23 Dec 99	RAL02 Chk 19 Jan 00	RAL03 Chk 7 Feb 00	Diff. Vol. % game35µm Counter PSD Data
392.387	0	0	0	0	0	0	140.1
							153.8
							168.8
							183.3
							203.5
							223.4
							245.2
							269.2
							293.5
							324.3
							356.1
							390.9
							429.2
							471.1
							517.2
							567.8
							623.3
							684.2
							751.1
							824.5
							905.1
							993.5
							1091
							1198
							1315
							1443
							1584
							1739
							1909

```

Filename :35µgarChkAvg<C>
ID# :199912231311060
Circulation Speed :6
Ultra sonic :00.05
Laser T% :77.9(%)
Form of Distribution:Standard
Calc. Level :30
R.R.Index :1.35-0.101
Sample Name :35µgarChkAvg
Material :35 micron modal Garnet
Lot Number :1014
Dispersion Medium :RAL demin water
Remarks 1 :6 Jul 2000
Remarks 2 :Avg of garnet stand
Mean :35.493854(µm)
Variance :149.516983
S.D. :12.227714(µm)
Mode :32.291405(µm)
Geo. Mean :32.847691(µm)
    
```

```

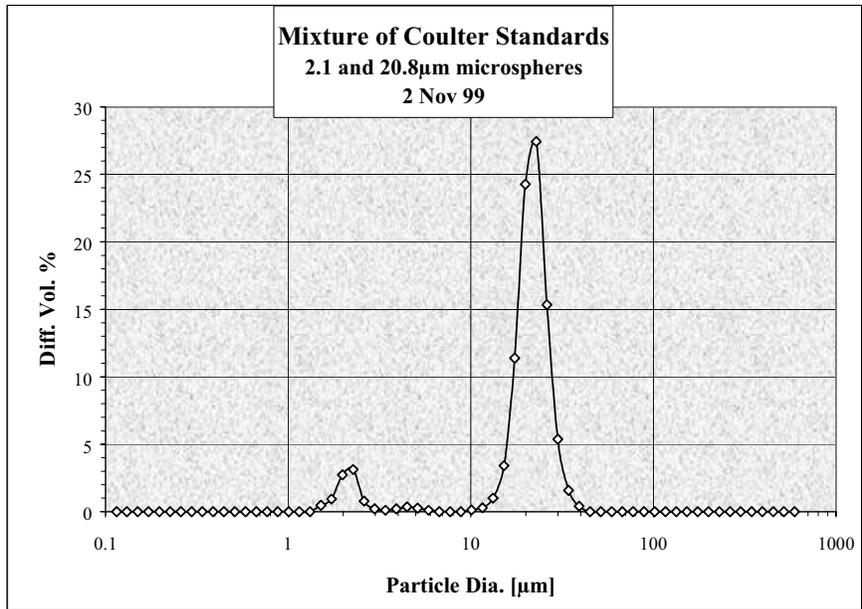
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File name: gar35@6.$01
From 0.375
To 2000
Volume 100
Mean: 35.13
Median: 33.75
Mean/Median 1.041
Ratio:
Mode: 34.58
95% Conf. Limits: 6.376
95% Conf. Limits: 63.87
S.D.: 14.67
Variance: 215.2
Skewness: 0.57
Kurtosis: 1.491
    
```

## 2 & 21µm Microsphere Standards Mixture

Diameter [µm]	Frequency (%)	Undersize (%)
0.115	0	0
0.131	0	0
0.15	0	0
0.172	0	0
0.197	0	0
0.226	0	0
0.259	0	0
0.296	0	0
0.339	0	0
0.389	0	0
0.445	0	0
0.51	0	0
0.584	0	0
0.669	0	0
0.766	0	0
0.877	0	0
1.005	0	0
1.151	0	0
1.318	0	0
1.51	0.472	0.472
1.729	0.942	1.414
1.981	2.735	4.149
2.269	3.125	7.274
2.599	0.796	8.07
2.976	0.215	8.285
3.409	0.121	8.406
3.905	0.211	8.617
4.472	0.357	8.975
5.122	0.27	9.244
5.867	0.113	9.358
6.72	0	9.358
7.697	0	9.358
8.816	0	9.358
10.097	0.127	9.485
11.565	0.298	9.783
13.246	1.009	10.792
15.172	3.402	14.194
17.377	11.39	25.584
19.904	24.272	49.856
22.797	27.436	77.293
26.111	15.345	92.638
29.907	5.374	98.012
34.255	1.578	99.589
39.234	0.411	100
44.938	0	100
51.471	0	100
58.953	0	100
67.523	0	100
77.339	0	100
88.583	0	100
101.46	0	100
116.21	0	100
133.103	0	100
152.453	0	100
174.616	0	100
200	0	100
229.075	0	100
262.376	0	100
300.518	0	100
344.206	0	100
394.244	0	100
451.556	0	100
517.2	0	100
592.387	0	100

```

Filename      :1mmPSCchk                      Mean       :18.969900(µm)
ID#           :199911020856019                Variance   :42.976208
Circulation Speed :4                          S.D.       :6.555624(µm)
Ultra sonic    :OFF                            Mode       :20.836029(µm)
Laser T%      :90.0(%)                        Geo. Mean  :16.468813(µm)
Form of Distribution:Standard
Calc. Level   :30
R.R.Index     :PSL-mm
Sample Name   :1mmPSCchk
Material      :mixture polysty microsphrs
Source       :Coulter Standrds; 2µ & 21µ mix
Lot Number    :6130 & 5740 (respectively)
Dispersion Medium :aqua
Remarks      :TAB operator
Remarks 1    :2 Nov 99
Remarks 2    :polystyrne mixtre of standrds
    
```

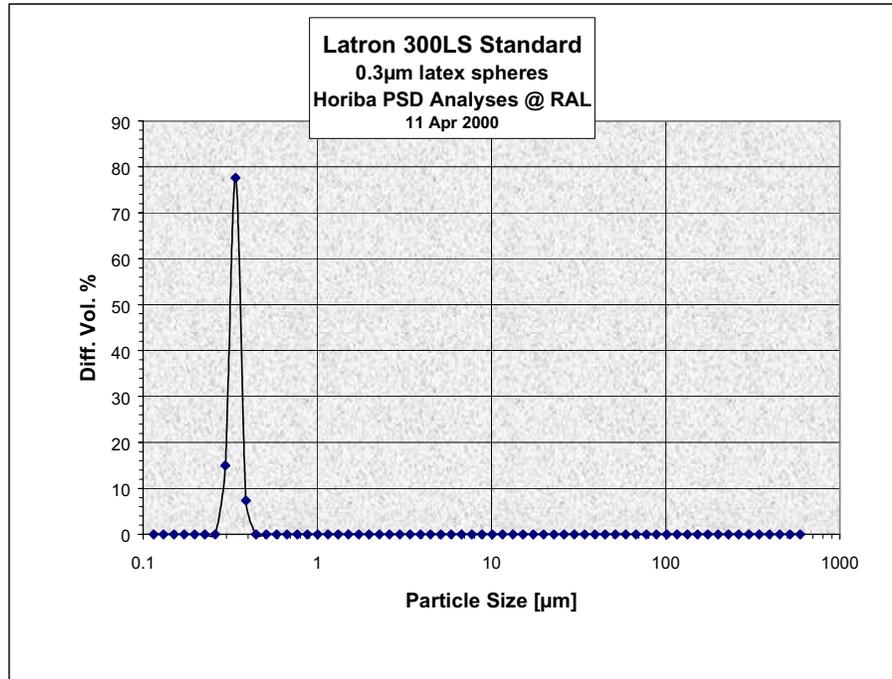


**Latron 300LS Standard**  
**0.3 µm latex spheres**  
**Horiba PSD Analysis @ RAL**  
**11 Apr 2000**

Diameter [µm]	Frequency (%)	Undersize (%)
0.115	0	0
0.131	0	0
0.15	0	0
0.172	0	0
0.197	0	0
0.226	0	0
0.259	0	0
0.296	15.004	15.004
0.339	77.638	92.642
0.389	7.358	100
0.445	0	100
0.51	0	100
0.584	0	100
0.669	0	100
0.766	0	100
0.877	0	100
1.005	0	100
1.151	0	100
1.318	0	100
1.51	0	100
1.729	0	100
1.981	0	100
2.269	0	100
2.599	0	100
2.976	0	100
3.409	0	100
3.905	0	100
4.472	0	100
5.122	0	100
5.867	0	100
6.72	0	100
7.697	0	100
8.816	0	100
10.097	0	100
11.565	0	100
13.246	0	100
15.172	0	100
17.377	0	100
19.904	0	100
22.797	0	100
26.111	0	100
29.907	0	100
34.255	0	100
39.234	0	100
44.938	0	100
51.471	0	100
58.953	0	100
67.523	0	100
77.339	0	100
88.583	0	100
101.46	0	100
116.21	0	100
133.103	0	100
152.453	0	100
174.616	0	100
200	0	100
229.075	0	100
262.376	0	100
300.518	0	100
344.206	0	100
394.244	0	100
451.556	0	100

```

Filename      :P3µLatex           Mean       : 0.314347(µm)
ID#          :200004112025109    Variance   : 0.000392
Circulation Speed :2             S.D.       : 0.019802(µm)
Ultra sonic    :OFF             Mode        : 0.314881(µm)
Laser T%      :96.3(%)         Geo. Mean  : 0.313720(µm)
Form of Distribution:Sharp
Calc. Level   :150
Distribution Base :Volume
R.R.Index     :PSL
Sample Name   :P3µLatex
Material      :0.3µm latex spheres standard
Source       :Coulter Latron 300LS
Lot Number    :1019
Dispersion Medium :RAL demin water
Remarks     :GMH operator
  
```



# Appendix A-2

## Tank Farm Slurry Sample PSD Results Data

### WM182 PSD Analysis

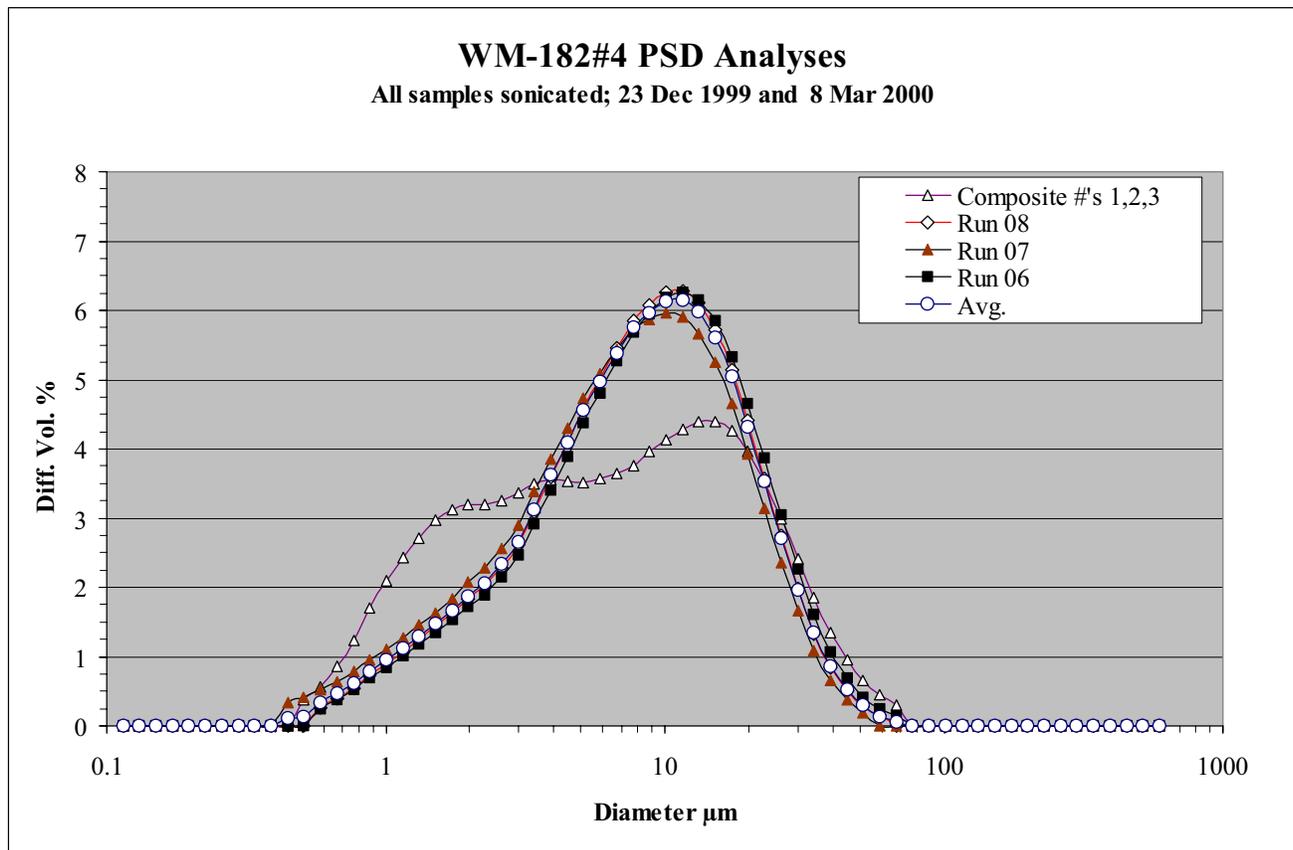
Diameter	WM182#4 sonicated runs					WM182#4 non-sonicated runs					1	STDEV	Run 01
	Avg o Runs	Diff. Frequency (%)				Avg o Runs	Diff. Frequency %						
		Run 06	Run 07	Run 08	Run 09		Run 01	Run 02	Run 03	Run 04			
0.115	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
0.131	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
0.15	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
0.172	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
0.197	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
0.226	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
0.259	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
0.296	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
0.339	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
0.389	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
0.445	0.114	0	0.343	0	0.20	0	0	0	0	0	0	0.00	0
0.51	0.14	0	0.419	0	0.24	0	0	0	0	0	0	0.00	0.369
0.584	0.342	0.248	0.517	0.261	0.15	0.185	0.189	0.173	0.137	0.271	0.157	0.05	0.567
0.669	0.462	0.366	0.636	0.385	0.15	0.239	0.247	0.229	0.187	0.322	0.21	0.05	0.853
0.766	0.612	0.515	0.778	0.543	0.14	0.307	0.32	0.3	0.251	0.387	0.276	0.05	1.238
0.877	0.787	0.687	0.946	0.728	0.14	0.389	0.408	0.385	0.327	0.469	0.355	0.05	1.701
1.005	0.949	0.846	1.101	0.9	0.13	0.469	0.494	0.466	0.4	0.555	0.43	0.06	2.091
1.151	1.121	1.01	1.278	1.074	0.14	0.556	0.585	0.552	0.476	0.659	0.509	0.07	2.429
1.318	1.297	1.175	1.466	1.25	0.15	0.652	0.685	0.646	0.559	0.774	0.596	0.08	2.706
1.51	1.469	1.343	1.629	1.435	0.15	0.754	0.793	0.749	0.653	0.881	0.692	0.09	2.977
1.729	1.664	1.524	1.837	1.63	0.16	0.873	0.917	0.867	0.76	1.018	0.803	0.10	3.116
1.981	1.877	1.718	2.076	1.836	0.18	1.008	1.057	1.001	0.88	1.176	0.927	0.12	3.201
2.269	2.059	1.889	2.273	2.014	0.20	1.133	1.185	1.125	0.994	1.316	1.043	0.13	3.199
2.599	2.336	2.153	2.565	2.289	0.21	1.307	1.364	1.3	1.159	1.505	1.208	0.14	3.245
2.976	2.66	2.463	2.905	2.613	0.22	1.506	1.567	1.5	1.346	1.72	1.396	0.15	3.362
3.409	3.126	2.917	3.378	3.084	0.23	1.779	1.846	1.776	1.612	2.004	1.657	0.16	3.492
3.905	3.618	3.405	3.859	3.59	0.23	2.063	2.134	2.065	1.899	2.286	1.934	0.16	3.552
4.472	4.094	3.889	4.307	4.085	0.21	2.329	2.401	2.336	2.177	2.534	2.197	0.15	3.541
5.122	4.556	4.37	4.727	4.571	0.18	2.568	2.641	2.581	2.433	2.747	2.436	0.14	3.509
5.867	4.964	4.807	5.081	5.004	0.14	2.727	2.805	2.749	2.605	2.879	2.599	0.12	3.571
6.72	5.386	5.264	5.442	5.451	0.11	2.906	2.988	2.936	2.796	3.029	2.78	0.11	3.639
7.697	5.754	5.677	5.74	5.845	0.08	3.05	3.14	3.09	2.947	3.145	2.927	0.11	3.749
8.816	5.964	5.947	5.875	6.072	0.10	3.152	3.257	3.203	3.043	3.229	3.03	0.11	3.96
10.097	6.139	6.184	5.971	6.263	0.15	3.267	3.385	3.329	3.153	3.323	3.144	0.11	4.131
11.565	6.152	6.265	5.908	6.284	0.21	3.361	3.496	3.434	3.238	3.401	3.236	0.12	4.287
13.246	5.977	6.157	5.668	6.107	0.27	3.442	3.595	3.524	3.308	3.471	3.313	0.13	4.389
15.172	5.603	5.845	5.243	5.721	0.32	3.517	3.687	3.605	3.371	3.538	3.382	0.14	4.394
17.377	5.041	5.333	4.65	5.14	0.35	3.589	3.777	3.681	3.437	3.605	3.447	0.15	4.262
19.904	4.327	4.653	3.927	4.402	0.37	3.66	3.86	3.749	3.51	3.672	3.51	0.15	3.971
22.797	3.525	3.864	3.138	3.574	0.37	3.727	3.934	3.806	3.592	3.734	3.57	0.15	3.533
26.111	2.713	3.043	2.357	2.739	0.34	3.786	3.991	3.848	3.683	3.786	3.625	0.14	2.991
29.907	1.966	2.269	1.656	1.974	0.31	3.833	4.022	3.869	3.783	3.819	3.672	0.13	2.406
34.255	1.34	1.601	1.083	1.336	0.26	3.86	4.019	3.865	3.886	3.824	3.707	0.11	1.844
39.234	0.859	1.072	0.658	0.848	0.21	3.86	3.969	3.831	3.984	3.79	3.725	0.11	1.354
44.938	0.521	0.685	0.37	0.508	0.16	3.822	3.862	3.76	4.062	3.706	3.72	0.15	0.958
51.471	0.301	0.42	0.194	0.288	0.11	3.739	3.694	3.649	4.1	3.565	3.685	0.21	0.66
58.953	0.135	0.25	0	0.156	0.13	3.604	3.464	3.497	4.074	3.367	3.617	0.28	0.448
67.523	0.049	0.147	0	0	0.08	3.414	3.179	3.305	3.959	3.115	3.512	0.34	0.304
77.339	0	0	0	0	0.00	3.171	2.853	3.075	3.736	2.823	3.368	0.38	0
88.583	0	0	0	0	0.00	2.88	2.503	2.808	3.398	2.506	3.186	0.40	0
101.46	0	0	0	0	0.00	2.553	2.148	2.508	2.959	2.182	2.967	0.40	0
116.21	0	0	0	0	0.00	2.204	1.806	2.18	2.454	1.867	2.712	0.39	0
133.103	0	0	0	0	0.00	1.852	1.488	1.839	1.937	1.572	2.425	0.37	0
152.453	0	0	0	0	0.00	1.52	1.205	1.508	1.466	1.304	2.117	0.36	0
174.616	0	0	0	0	0.00	0.844	0.67	0.838	0.814	0.725	1.176	0.20	0
200	0	0	0	0	0.00	0.469	0.372	0.465	0.452	0.403	0.654	0.11	0
229.075	0	0	0	0	0.00	0.073	0	0	0	0	0.363	0.16	0
262.376	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
300.518	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
344.206	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
394.244	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
451.556	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
517.2	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0
592.387	0	0	0	0	0.00	0	0	0	0	0	0	0.00	0

Filename :9911082WM182#4-savg<C>  
 ID# :200003081413108  
 Circulation Speed :6  
 Ultra sonic :00:13  
 Laser T% : 87.2(%)  
 Form of Distribution:Standard  
 Calc. Level :30  
 R.R.Index :1.35-0.10i  
 Material :WM182#4  
 Source :  
 Lot Number :  
 Dispersion Medium :RAL demin water + usonic  
 Remarks :GMH operator  
 Remarks 1 :8 Mar 2000  
 Remarks 2 :Avg of Runs 06 to 08

Mean :10.023014( $\mu\text{m}$ )  
 Variance :69.660103  
 S.D. : 8.346263( $\mu\text{m}$ )  
 Mode :10.786839( $\mu\text{m}$ )  
 Geo. Mean : 6.977938( $\mu\text{m}$ )

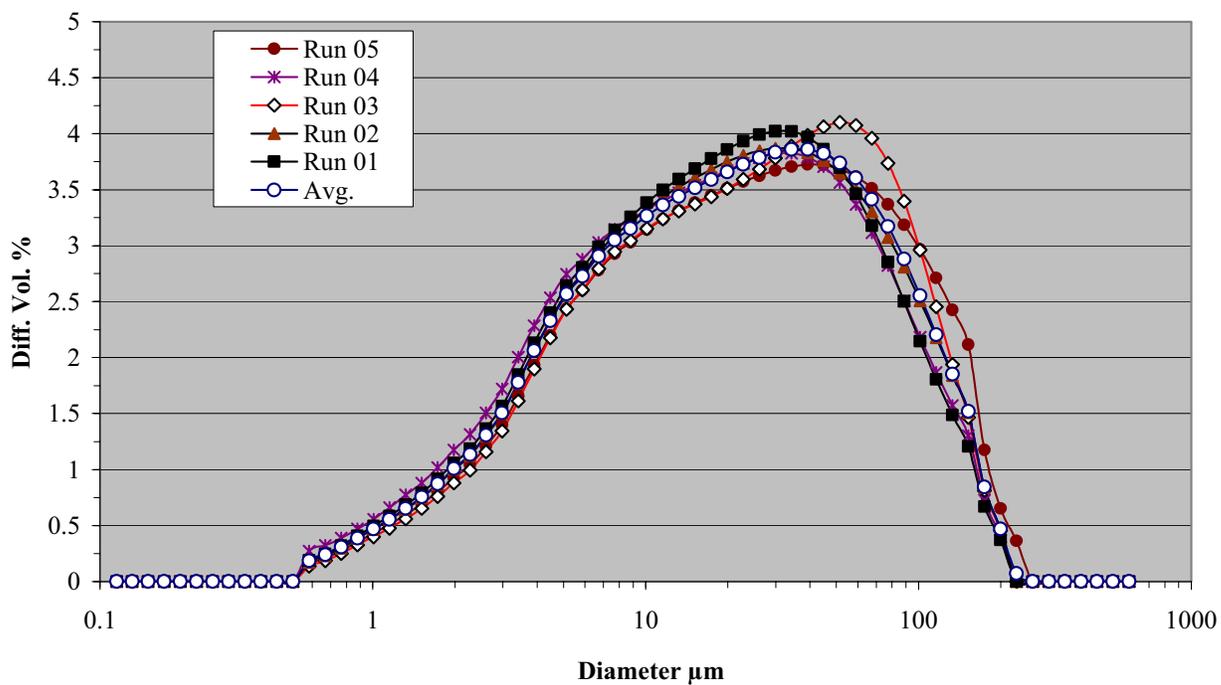
Filename :9911082WM182#4-nsavg<C>  
 ID# :199912231337061  
 Circulation Speed :6  
 Ultra sonic :OFF  
 Laser T% : 73.8(%)  
 Form of Distribution:Standard  
 Calc. Level :30  
 R.R.Index :1.35-0.10i  
 Material :WM182 #4 Slurry  
 Source :  
 Lot Number :  
 Dispersion Medium :RAL demin water  
 Remarks :GMH/TAB operators  
 Remarks 1 :23 Dec 99  
 Remarks 2 :Avg of Runs 01 to 05

Mean :33.539398( $\mu\text{m}$ )  
 Variance :1352.909424  
 S.D. :36.781918( $\mu\text{m}$ )  
 Mode :32.022137( $\mu\text{m}$ )  
 Geo. Mean :17.479652( $\mu\text{m}$ )



### WM-182#4 PSD Analyses

Samples not sonicated; 23 Dec 99



### WM183#3 PSD Analysis

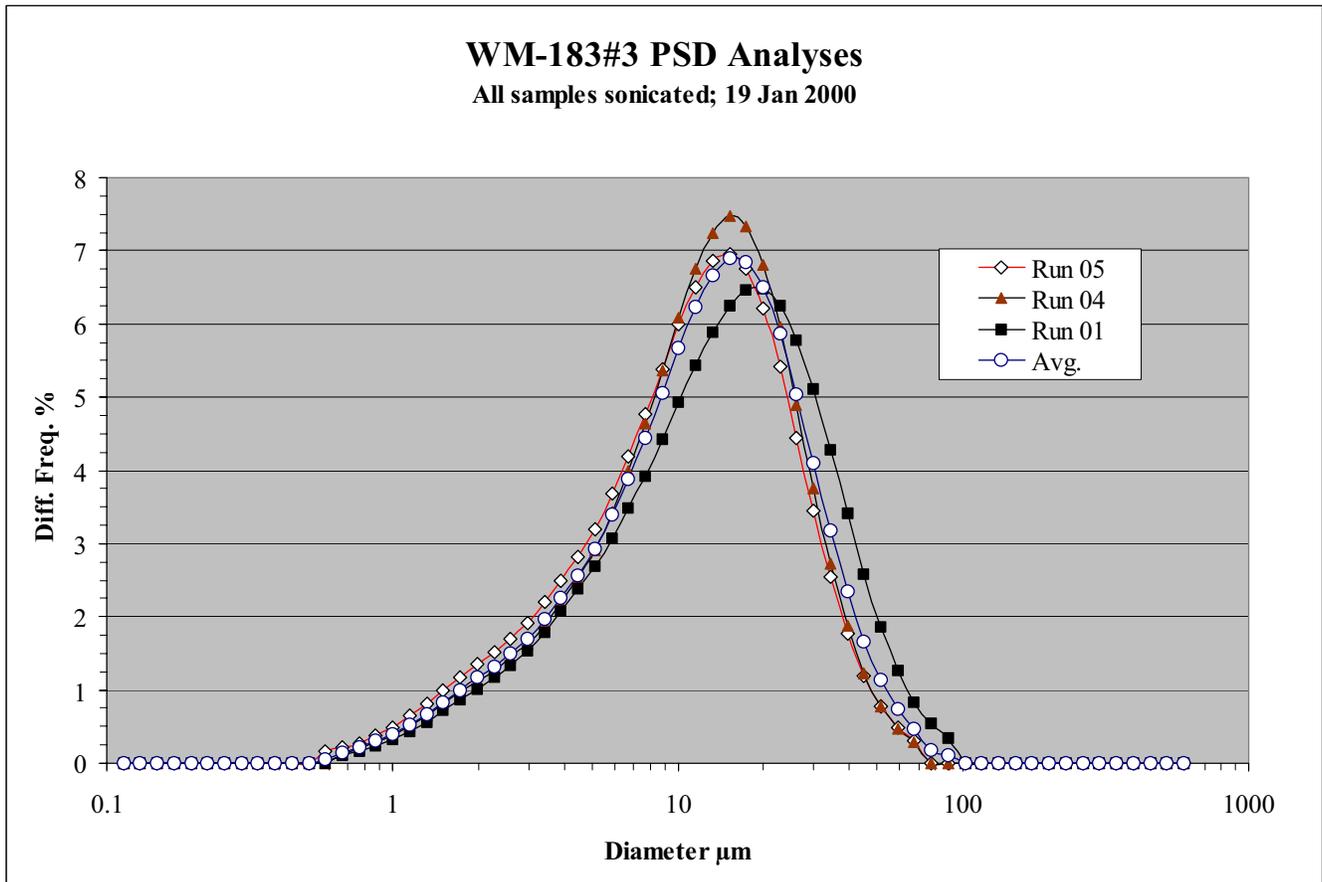
Diameter	WM183#3 sonicated runs					WM183#3 non-sonicated runs				
	Avg o Runs	Diff. Frequency (%)				Avg o Runs	Diff. Frequency %			
	Run 01	Run 04	Run 05	1	STDEV	Run 02	Run 03	Run 06	1	STDEV
0.115	0	0	0	0	0	0	0	0	0	0
0.131	0	0	0	0	0.000	0	0	0	0	0.000
0.15	0	0	0	0	0.000	0	0	0	0	0.000
0.172	0	0	0	0	0.000	0	0	0	0	0.000
0.197	0	0	0	0	0.000	0	0	0	0	0.000
0.226	0	0	0	0	0.000	0	0	0	0	0.000
0.259	0	0	0	0	0.000	0	0	0	0	0.000
0.296	0	0	0	0	0.000	0	0	0	0	0.000
0.339	0	0	0	0	0.000	0	0	0	0	0.000
0.389	0	0	0	0	0.000	0	0	0	0	0.000
0.445	0	0	0	0	0.000	0	0	0	0	0.000
0.51	0	0	0	0	0.000	0	0	0	0	0.000
0.584	0.055	0	0	0.164	0.095	0	0	0	0	0.000
0.669	0.15	0.11	0.131	0.21	0.053	0	0	0	0	0.000
0.766	0.212	0.162	0.194	0.279	0.060	0.128	0.13	0.134	0.12	0.007
0.877	0.298	0.237	0.282	0.375	0.070	0.184	0.185	0.192	0.174	0.009
1.005	0.404	0.329	0.388	0.494	0.084	0.25	0.252	0.261	0.239	0.011
1.151	0.53	0.438	0.511	0.642	0.103	0.329	0.329	0.342	0.314	0.014
1.318	0.674	0.563	0.649	0.81	0.125	0.418	0.417	0.436	0.402	0.017
1.51	0.839	0.716	0.815	0.986	0.137	0.527	0.524	0.549	0.509	0.020
1.729	1	0.865	0.971	1.165	0.152	0.639	0.634	0.664	0.619	0.023
1.981	1.166	1.02	1.128	1.351	0.169	0.759	0.752	0.788	0.736	0.027
2.269	1.319	1.168	1.273	1.516	0.179	0.876	0.868	0.909	0.852	0.029
2.599	1.497	1.342	1.444	1.706	0.188	1.027	1.017	1.063	1.001	0.032
2.976	1.691	1.532	1.63	1.913	0.198	1.193	1.182	1.232	1.166	0.034
3.409	1.96	1.792	1.892	2.196	0.210	1.435	1.423	1.476	1.406	0.037
3.905	2.254	2.075	2.189	2.499	0.219	1.712	1.7	1.753	1.684	0.036
4.472	2.573	2.375	2.52	2.824	0.229	2.016	2.004	2.053	1.989	0.033
5.122	2.931	2.698	2.904	3.19	0.247	2.342	2.332	2.373	2.319	0.028
5.867	3.392	3.074	3.424	3.677	0.303	2.663	2.656	2.686	2.648	0.020
6.72	3.887	3.481	3.987	4.193	0.366	3	2.995	3.012	2.993	0.010
7.697	4.447	3.927	4.64	4.774	0.455	3.317	3.314	3.317	3.321	0.004
8.816	5.053	4.416	5.357	5.386	0.552	3.539	3.534	3.526	3.555	0.015
10.097	5.667	4.926	6.085	5.989	0.643	3.767	3.762	3.742	3.797	0.028
11.565	6.228	5.427	6.749	6.508	0.704	3.927	3.92	3.89	3.97	0.040
13.246	6.663	5.882	7.248	6.86	0.704	4.014	4.005	3.969	4.069	0.051
15.172	6.892	6.245	7.472	6.958	0.616	4.035	4.023	3.984	4.098	0.058
17.377	6.847	6.46	7.336	6.746	0.447	4.002	3.987	3.949	4.07	0.062
19.904	6.5	6.475	6.813	6.211	0.302	3.93	3.913	3.879	3.999	0.062
22.797	5.872	6.251	5.955	5.41	0.427	3.836	3.817	3.79	3.9	0.057
26.111	5.04	5.784	4.887	4.448	0.681	3.733	3.715	3.696	3.789	0.049
29.907	4.108	5.106	3.765	3.454	0.878	3.635	3.619	3.608	3.677	0.037
34.255	3.185	4.286	2.731	2.539	0.958	3.545	3.533	3.532	3.571	0.022
39.234	2.354	3.413	1.874	1.776	0.918	3.467	3.459	3.468	3.475	0.008
44.938	1.665	2.579	1.225	1.19	0.792	3.398	3.395	3.413	3.386	0.014
51.471	1.131	1.852	0.772	0.77	0.624	3.331	3.334	3.358	3.301	0.029
58.953	0.744	1.271	0.473	0.487	0.457	3.261	3.271	3.297	3.216	0.041
67.523	0.477	0.839	0.287	0.305	0.314	3.182	3.199	3.221	3.127	0.049
77.339	0.18	0.54	0	0	0.312	3.087	3.111	3.122	3.029	0.051
88.583	0.114	0.342	0	0	0.197	2.972	3.002	2.994	2.919	0.046
101.46	0	0	0	0	0.000	2.832	2.867	2.836	2.793	0.037
116.21	0	0	0	0	0.000	2.665	2.702	2.645	2.648	0.032
133.103	0	0	0	0	0.000	2.467	2.502	2.421	2.478	0.042
152.453	0	0	0	0	0.000	2.24	2.269	2.171	2.281	0.060
174.616	0	0	0	0	0.000	1.245	1.261	1.206	1.267	0.034
200	0	0	0	0	0.000	0.691	0.7	0.67	0.704	0.019
229.075	0	0	0	0	0.000	0.384	0.389	0.372	0.391	0.010
262.376	0	0	0	0	0.000	0	0	0	0	0.000
300.518	0	0	0	0	0.000	0	0	0	0	0.000
344.206	0	0	0	0	0.000	0	0	0	0	0.000
394.244	0	0	0	0	0.000	0	0	0	0	0.000
451.556	0	0	0	0	0.000	0	0	0	0	0.000
517.2	0	0	0	0	0.000	0	0	0	0	0.000
592.387	0	0	0	0	0.000	0	0	0	0	0.000

Filename :000112-5WM183#3 s -avg<C>  
 ID# :200001191105068  
 Circulation Speed :5  
 Ultra sonic :00:06  
 Laser T% : 78.4(%)  
 Form of Distribution:Standard  
 Calc. Level :30  
 R.R.Index :1.35-0.10i  
 Material :WM183 Suspended Solids  
 Source :  
 Lot Number :  
 Dispersion Medium :RAL demin water  
 Remarks :GMH/TAB operators  
 Remarks 1 :19 Jan 2000  
 Remarks 2 :Avg o Runs 1, 4 & 5 (w/ultrasonic)

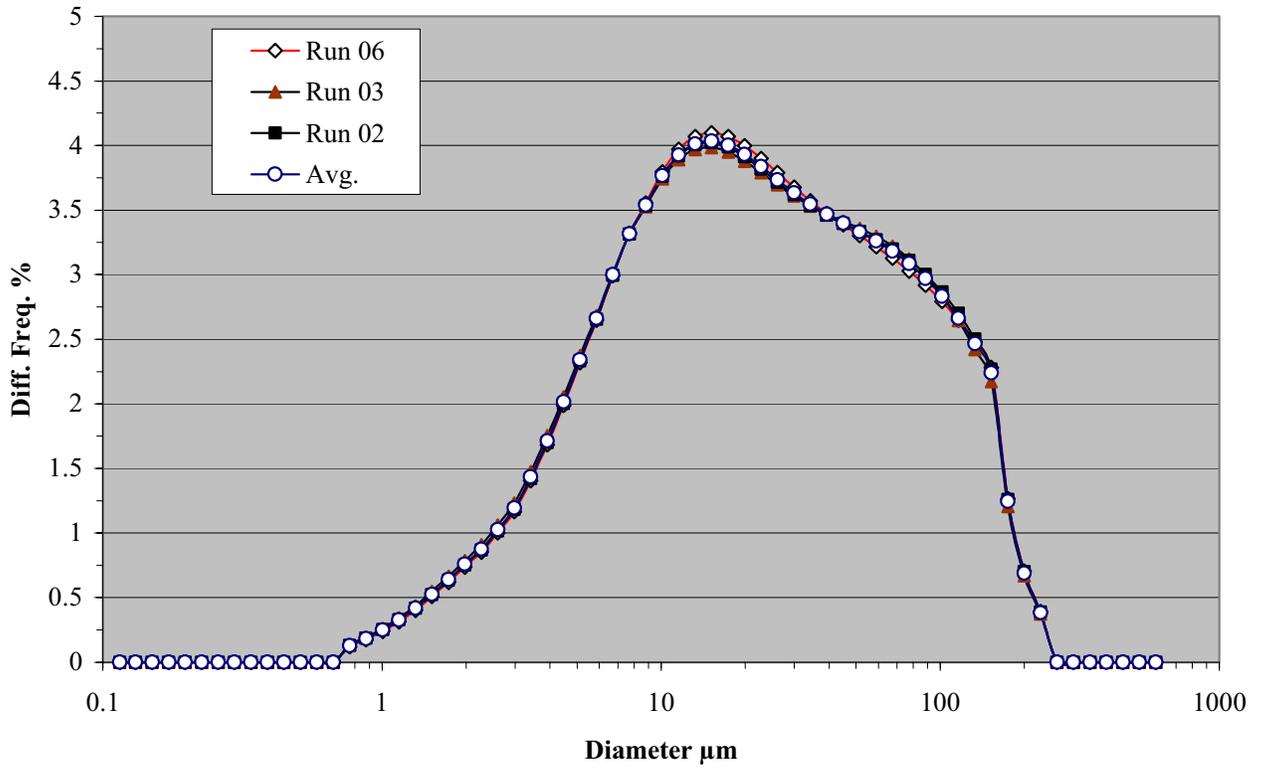
Mean :14.761811( $\mu\text{m}$ )  
 Variance :136.578308  
 S.D. :11.686672( $\mu\text{m}$ )  
 Mode :14.202041( $\mu\text{m}$ )  
 Geo. Mean :10.592593( $\mu\text{m}$ )

Filename :000112-5WM183#3 ns-avg<C>  
 ID# :200001191115069  
 Circulation Speed :5  
 Ultra sonic :OFF  
 Laser T% : 80.8(%)  
 Form of Distribution:Standard  
 Calc. Level :30  
 R.R.Index :1.35-0.10i  
 Material :WM183 Suspended Solids  
 Source :  
 Lot Number :  
 Dispersion Medium :RAL demin water  
 Remarks :GHH/TAB operators  
 Remarks 1 :19 Jan 2000  
 Remarks 2 :Avg. 2,3,6 non-sonic

Mean :37.176636( $\mu\text{m}$ )  
 Variance :1703.956299  
 S.D. :41.279007( $\mu\text{m}$ )  
 Mode :14.173473( $\mu\text{m}$ )  
 Geo. Mean :19.812233( $\mu\text{m}$ )



**WM-183#3 PSD Analyses**  
**Samples not sonicated; 19 Jan 2000**



### WM183Composite 1,2,3 PSD Analysis

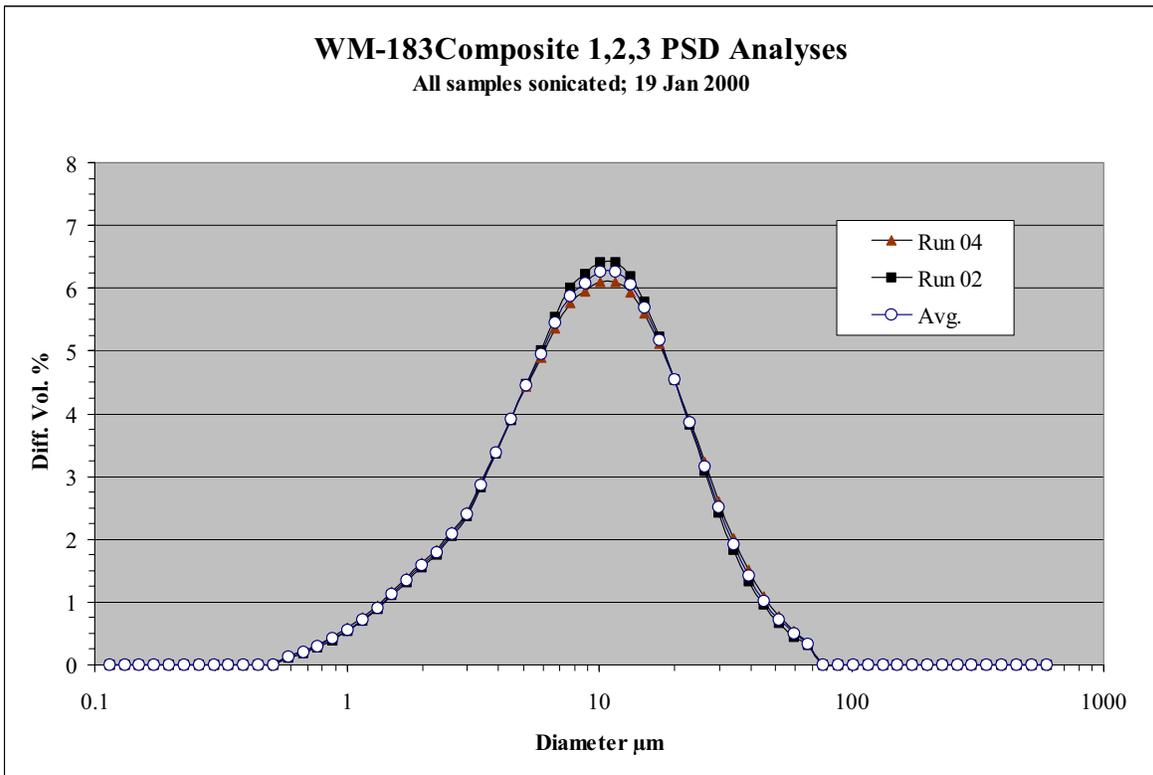
Diameter	WM183Com 1,2,3 sonicated runs				WM183Com123 non-sonicated runs			
	Avg o Runs	Diff. Vol (%)			Avg o Runs	Diff. Vol. %		
		Run 02	Run 04	1 STDEV		Run 01	Run 03	1 STDEV
0.115	0	0	0	0	0	0	0	0
0.131	0	0	0	0.000	0	0	0	0.000
0.15	0	0	0	0.000	0	0	0	0.000
0.172	0	0	0	0.000	0	0	0	0.000
0.197	0	0	0	0.000	0	0	0	0.000
0.226	0	0	0	0.000	0	0	0	0.000
0.259	0	0	0	0.000	0	0	0	0.000
0.296	0	0	0	0.000	0	0	0	0.000
0.339	0	0	0	0.000	0	0	0	0.000
0.389	0	0	0	0.000	0	0	0	0.000
0.445	0	0	0	0.000	0	0	0	0.000
0.51	0	0	0	0.000	0	0	0	0.000
0.584	0.134	0.119	0.149	0.021	0.074	0.105	0.118	0.009
0.669	0.197	0.18	0.214	0.024	0.11	0.156	0.173	0.012
0.766	0.29	0.271	0.309	0.027	0.214	0.231	0.252	0.015
0.877	0.417	0.397	0.438	0.029	0.312	0.334	0.362	0.020
1.005	0.563	0.542	0.584	0.030	0.426	0.453	0.487	0.024
1.151	0.727	0.703	0.751	0.034	0.555	0.587	0.63	0.030
1.318	0.911	0.884	0.939	0.039	0.701	0.739	0.792	0.037
1.51	1.131	1.104	1.158	0.038	0.871	0.925	0.987	0.044
1.729	1.349	1.319	1.38	0.043	1.046	1.118	1.189	0.050
1.981	1.582	1.547	1.617	0.049	1.236	1.331	1.409	0.055
2.269	1.797	1.758	1.835	0.054	1.419	1.535	1.618	0.059
2.599	2.083	2.044	2.122	0.055	1.677	1.819	1.899	0.057
2.976	2.404	2.365	2.444	0.056	1.97	2.14	2.215	0.053
3.409	2.867	2.832	2.903	0.050	2.414	2.614	2.672	0.041
3.905	3.38	3.356	3.404	0.034	2.929	3.154	3.18	0.018
4.472	3.911	3.906	3.917	0.008	3.493	3.723	3.702	0.015
5.122	4.453	4.474	4.432	0.030	4.089	4.298	4.222	0.054
5.867	4.948	5.002	4.894	0.076	4.606	4.75	4.634	0.082
6.72	5.449	5.538	5.361	0.125	5.133	5.209	5.048	0.114
7.697	5.881	6.003	5.759	0.173	5.559	5.557	5.361	0.139
8.816	6.081	6.22	5.942	0.197	5.665	5.619	5.409	0.148
10.097	6.259	6.412	6.106	0.216	5.773	5.687	5.457	0.163
11.565	6.257	6.408	6.106	0.214	5.696	5.599	5.353	0.174
13.246	6.067	6.197	5.936	0.185	5.455	5.377	5.117	0.184
15.172	5.697	5.792	5.602	0.134	5.09	5.051	4.778	0.193
17.377	5.176	5.225	5.127	0.069	4.651	4.66	4.372	0.204
19.904	4.547	4.547	4.547	0.000	4.18	4.234	3.934	0.212
22.797	3.859	3.816	3.903	0.062	3.715	3.799	3.494	0.216
26.111	3.165	3.089	3.24	0.107	3.276	3.373	3.074	0.211
29.907	2.508	2.415	2.6	0.131	2.877	2.965	2.689	0.195
34.255	1.921	1.826	2.017	0.135	2.519	2.581	2.344	0.168
39.234	1.425	1.337	1.513	0.124	2.199	2.22	2.041	0.127
44.938	1.025	0.952	1.097	0.103	1.912	1.882	1.779	0.073
51.471	0.717	0.662	0.772	0.078	1.652	1.569	1.553	0.011
58.953	0.49	0.452	0.529	0.054	1.415	1.284	1.361	0.054
67.523	0.33	0.305	0.355	0.035	1.201	1.03	1.198	0.119
77.339	0	0	0	0.000	1.01	0.811	1.06	0.176
88.583	0	0	0	0.000	0.841	0.629	0.943	0.222
101.46	0	0	0	0.000	0.694	0.483	0.839	0.252
116.21	0	0	0	0.000	0.569	0.369	0.742	0.264
133.103	0	0	0	0.000	0.369	0	0.648	0.458
152.453	0	0	0	0.000	0.303	0	0.556	0.393
174.616	0	0	0	0.000	0.103	0	0.309	0.218
200	0	0	0	0.000	0	0	0	0.000
229.075	0	0	0	0.000	0	0	0	0.000
262.376	0	0	0	0.000	0	0	0	0.000
300.518	0	0	0	0.000	0	0	0	0.000
344.206	0	0	0	0.000	0	0	0	0.000
394.244	0	0	0	0.000	0	0	0	0.000
451.556	0	0	0	0.000	0	0	0	0.000
517.2	0	0	0	0.000	0	0	0	0.000
592.387	0	0	0	0.000	0	0	0	0.000

Filename :000105-6WM183-1,2,3,com s-avg<C>  
 ID# :200001191515075  
 Circulation Speed :5  
 Ultra sonic :00:24  
 Laser T% :90.3(%)  
 Form of Distribution:Standard  
 Calc. Level :30  
 R.R.Index :1.35-0.10i  
 Material :WM183 Solids Composite  
 Source :  
 Lot Number :  
 Dispersion Medium :RAL demin water + usonic  
 Remarks :GHH/TAB operators  
 Remarks 1 :19 Jan 2000  
 Remarks 2 :Avg Runs 2, 4

Mean :11.579919( $\mu\text{m}$ )  
 Variance :100.125282  
 S.D. :10.006262( $\mu\text{m}$ )  
 Mode :9.452659( $\mu\text{m}$ )  
 Geo. Mean :8.138731( $\mu\text{m}$ )

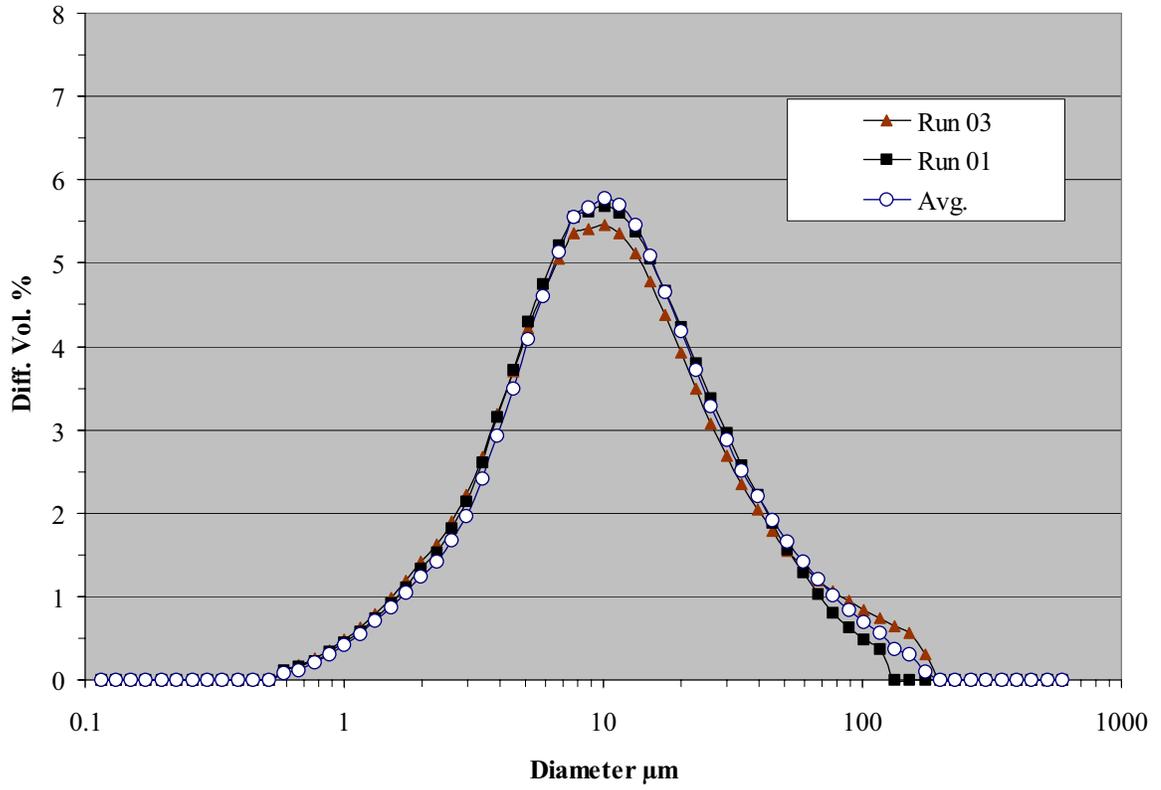
Filename :000105-6 ns WM183-avg<C>  
 ID# :200003081011101  
 Circulation Speed :6  
 Ultra sonic :OFF  
 Laser T% :92.0(%)  
 Form of Distribution:Standard  
 Calc. Level :30  
 R.R.Index :1.35-0.10i  
 Material :WM183Compos1,2,3  
 Source :  
 Lot Number :  
 Dispersion Medium :RAL demin water  
 Remarks :GMH operator  
 Remarks 1 :8 Mar 2000  
 Remarks 2 :

Mean :17.159410( $\mu\text{m}$ )  
 Variance :438.032654  
 S.D. :20.929230( $\mu\text{m}$ )  
 Mode :9.438090( $\mu\text{m}$ )  
 Geo. Mean :10.284929( $\mu\text{m}$ )



# WM-183 Composite 1,2,3 PSD Analyses

Samples not sonicated; 19 Jan 2000



### WM183 Composite B PSD Analysis

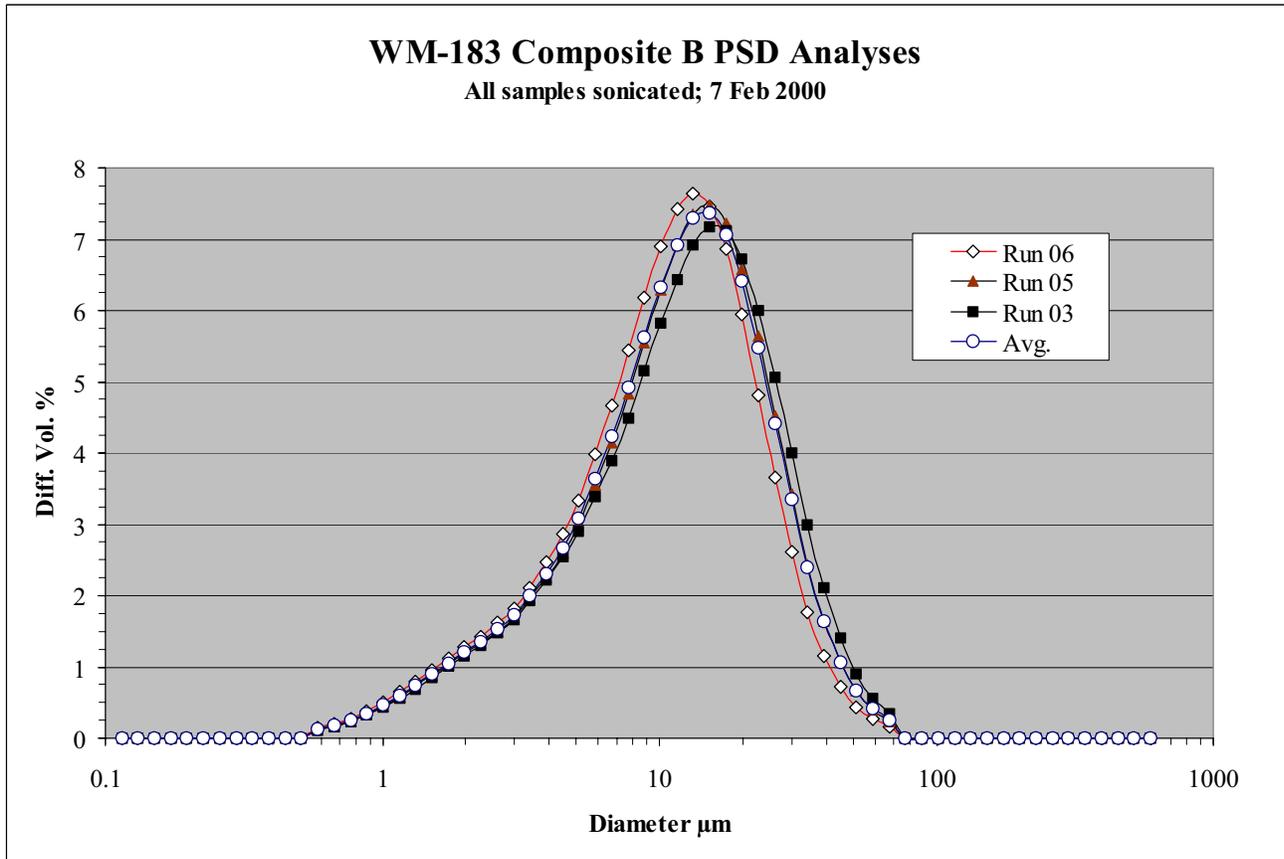
Diameter	sonicated runs						non-sonicated runs				
	Avg o Runs	Diff. Frequency (%)					1 STDEV	Diff. Frequency %			
		Run 01	Run 03	Run 05	Run 06	1 STDEV		Avg o Runs	Run 02	Run 04	1 STDEV
0.115	0	0	0	0	0	0	0	0	0	0	
0.131	0	0	0	0	0	0.000	0	0	0	0.000	
0.15	0	0	0	0	0	0.000	0	0	0	0.000	
0.172	0	0	0	0	0	0.000	0	0	0	0.000	
0.197	0	0	0	0	0	0.000	0	0	0	0.000	
0.226	0	0	0	0	0	0.000	0	0	0	0.000	
0.259	0	0	0	0	0	0.000	0	0	0	0.000	
0.296	0	0	0	0	0	0.000	0	0	0	0.000	
0.339	0	0	0	0	0	0.000	0	0	0	0.000	
0.389	0	0	0	0	0	0.000	0	0	0	0.000	
0.445	0	0	0	0	0	0.000	0	0	0	0.000	
0.51	0	0	0	0	0	0.000	0	0	0	0.000	
0.584	0.125	0.121	0.111	0.12	0.143	0.014	0	0	0	0.000	
0.669	0.176	0.163	0.159	0.169	0.199	0.018	0.058	0.117	0	0.083	
0.766	0.248	0.223	0.227	0.241	0.278	0.025	0.152	0.162	0.142	0.014	
0.877	0.347	0.306	0.32	0.338	0.384	0.034	0.212	0.224	0.2	0.017	
1.005	0.461	0.404	0.429	0.451	0.505	0.043	0.283	0.297	0.269	0.020	
1.151	0.592	0.521	0.554	0.579	0.642	0.051	0.365	0.383	0.348	0.025	
1.318	0.735	0.654	0.692	0.72	0.792	0.058	0.459	0.481	0.438	0.030	
1.51	0.898	0.801	0.853	0.882	0.959	0.066	0.568	0.591	0.545	0.033	
1.729	1.054	0.952	1.006	1.036	1.119	0.070	0.68	0.707	0.654	0.037	
1.981	1.212	1.111	1.161	1.191	1.283	0.072	0.801	0.831	0.772	0.042	
2.269	1.354	1.258	1.303	1.331	1.429	0.072	0.917	0.949	0.884	0.046	
2.599	1.531	1.437	1.474	1.503	1.615	0.077	1.067	1.102	1.032	0.049	
2.976	1.721	1.633	1.66	1.689	1.816	0.081	1.231	1.269	1.194	0.053	
3.409	1.998	1.904	1.923	1.956	2.115	0.096	1.471	1.511	1.431	0.057	
3.905	2.311	2.197	2.214	2.258	2.46	0.121	1.744	1.784	1.703	0.057	
4.472	2.663	2.504	2.534	2.599	2.857	0.161	2.04	2.078	2.002	0.054	
5.122	3.076	2.832	2.898	3	3.33	0.221	2.358	2.392	2.324	0.048	
5.867	3.635	3.203	3.379	3.55	3.975	0.331	2.677	2.706	2.648	0.041	
6.72	4.235	3.599	3.899	4.143	4.664	0.451	3.009	3.031	2.986	0.032	
7.697	4.92	4.019	4.493	4.826	5.44	0.597	3.323	3.339	3.308	0.022	
8.816	5.627	4.448	5.148	5.553	6.18	0.726	3.546	3.557	3.536	0.015	
10.097	6.33	4.889	5.815	6.283	6.893	0.845	3.775	3.779	3.771	0.006	
11.565	6.924	5.298	6.433	6.918	7.421	0.908	3.935	3.935	3.936	0.001	
13.246	7.304	5.644	6.917	7.352	7.642	0.882	4.024	4.02	4.029	0.006	
15.172	7.372	5.892	7.175	7.475	7.465	0.753	4.046	4.038	4.054	0.011	
17.377	7.072	6.007	7.126	7.218	6.873	0.552	4.014	4.003	4.024	0.015	
19.904	6.415	5.956	6.729	6.577	5.939	0.412	3.942	3.928	3.955	0.019	
22.797	5.483	5.721	6.008	5.634	4.807	0.516	3.848	3.831	3.865	0.024	
26.111	4.412	5.305	5.056	4.529	3.651	0.732	3.746	3.725	3.767	0.030	
29.907	3.346	4.737	4.004	3.422	2.613	0.899	3.65	3.623	3.676	0.037	
34.255	2.399	4.064	2.986	2.438	1.773	0.969	3.563	3.531	3.595	0.045	
39.234	1.633	3.347	2.104	1.647	1.15	0.941	3.488	3.449	3.527	0.055	
44.938	1.064	2.647	1.408	1.063	0.72	0.840	3.42	3.374	3.465	0.064	
51.471	0.669	2.015	0.902	0.662	0.441	0.699	3.351	3.3	3.403	0.073	
58.953	0.41	1.484	0.56	0.403	0.267	0.550	3.275	3.219	3.331	0.079	
67.523	0.249	1.064	0.341	0.243	0.163	0.414	3.181	3.124	3.239	0.081	
77.339	0	0.749	0	0	0	0.375	3.064	3.009	3.118	0.077	
88.583	0	0.524	0	0	0	0.262	2.918	2.871	2.966	0.067	
101.46	0	0.368	0	0	0	0.184	2.744	2.708	2.781	0.052	
116.21	0	0	0	0	0	0.000	2.542	2.518	2.565	0.033	
133.103	0	0	0	0	0	0.000	2.312	2.302	2.322	0.014	
152.453	0	0	0	0	0	0.000	2.062	2.064	2.061	0.002	
174.616	0	0	0	0	0	0.000	1.146	1.147	1.145	0.001	
200	0	0	0	0	0	0.000	0.637	0.637	0.636	0.001	
229.075	0	0	0	0	0	0.000	0.354	0.354	0.353	0.001	
262.376	0	0	0	0	0	0.000	0	0	0	0.000	
300.518	0	0	0	0	0	0.000	0	0	0	0.000	
344.206	0	0	0	0	0	0.000	0	0	0	0.000	
394.244	0	0	0	0	0	0.000	0	0	0	0.000	
451.556	0	0	0	0	0	0.000	0	0	0	0.000	
517.2	0	0	0	0	0	0.000	0	0	0	0.000	
592.387	0	0	0	0	0	0.000	0	0	0	0.000	

Filename :000117-5WM183ComB s avg<C>  
 ID# :200002071150080  
 Circulation Speed :5  
 Ultra sonic :01:15  
 Laser T% :72.1(%)  
 Form of Distribution:Standard  
 Calc. Level :30  
 R.R.Index :1.35-0.10i  
 Material :WM183 Solids Composite B  
 Source :  
 Lot Number :  
 Dispersion Medium :RAL demin water + usonic  
 Remarks :GHH/TAB operators  
 Remarks 1 :07 Feb 2000  
 Remarks 2 :Avg. Runs 3,5,6

Mean :13.214108( $\mu\text{m}$ )  
 Variance :97.520866  
 S.D. :9.875265( $\mu\text{m}$ )  
 Mode :14.146187( $\mu\text{m}$ )  
 Geo. Mean :9.731933( $\mu\text{m}$ )

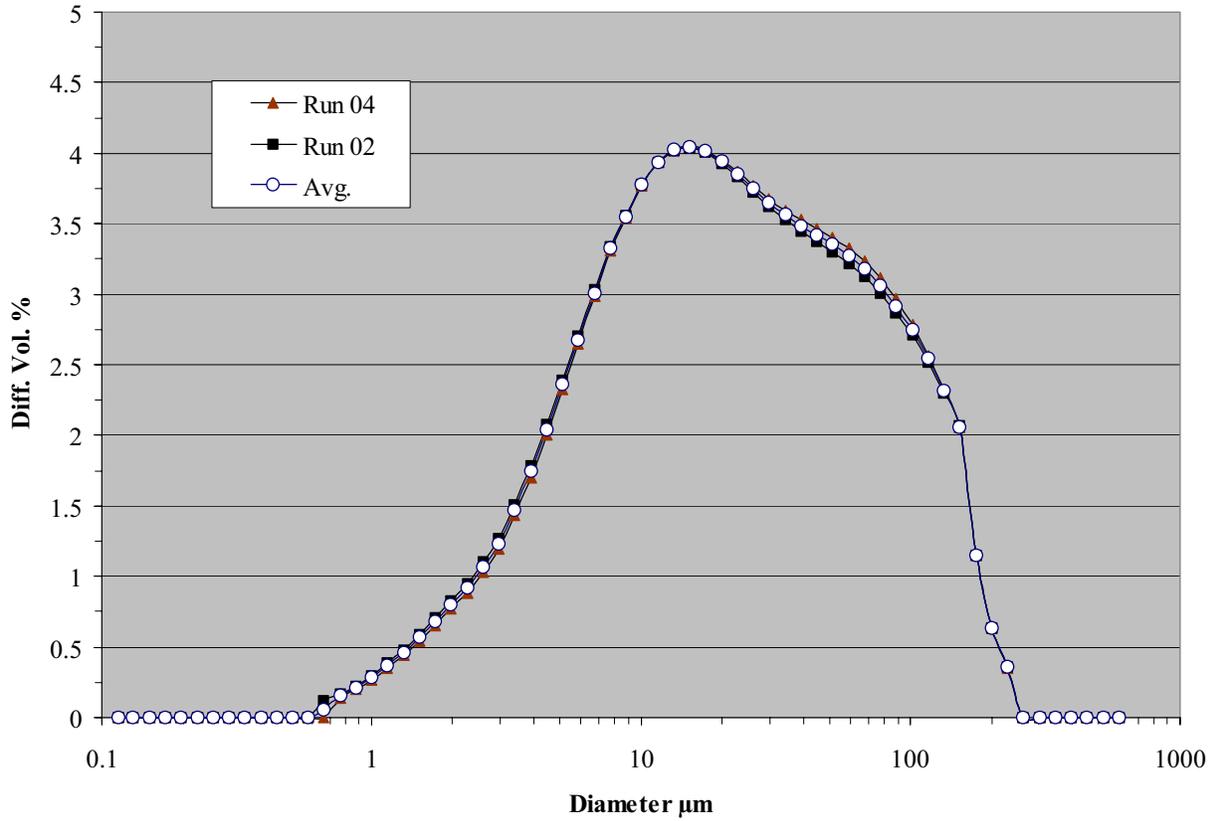
Filename :000117-5WM183ComB ns avg<C>  
 ID# :200002071130079  
 Circulation Speed :5  
 Ultra sonic :OFF  
 Laser T% :68.2(%)  
 Form of Distribution:Standard  
 Calc. Level :30  
 R.R.Index :1.35-0.10i  
 Material :WM183 Solids Composite B  
 Source :  
 Lot Number :  
 Dispersion Medium :RAL demin water + usonic  
 Remarks :GHH/TAB operators  
 Remarks 1 :07 Feb 2000  
 Remarks 2 :Avg Runs 2,4

Mean :36.193790( $\mu\text{m}$ )  
 Variance :1631.289551  
 S.D. :40.389225( $\mu\text{m}$ )  
 Mode :14.173810( $\mu\text{m}$ )  
 Geo. Mean :19.242262( $\mu\text{m}$ )



# WM-183 Composite B PSD Analyses

Samples not sonicated; 7 Feb 2000

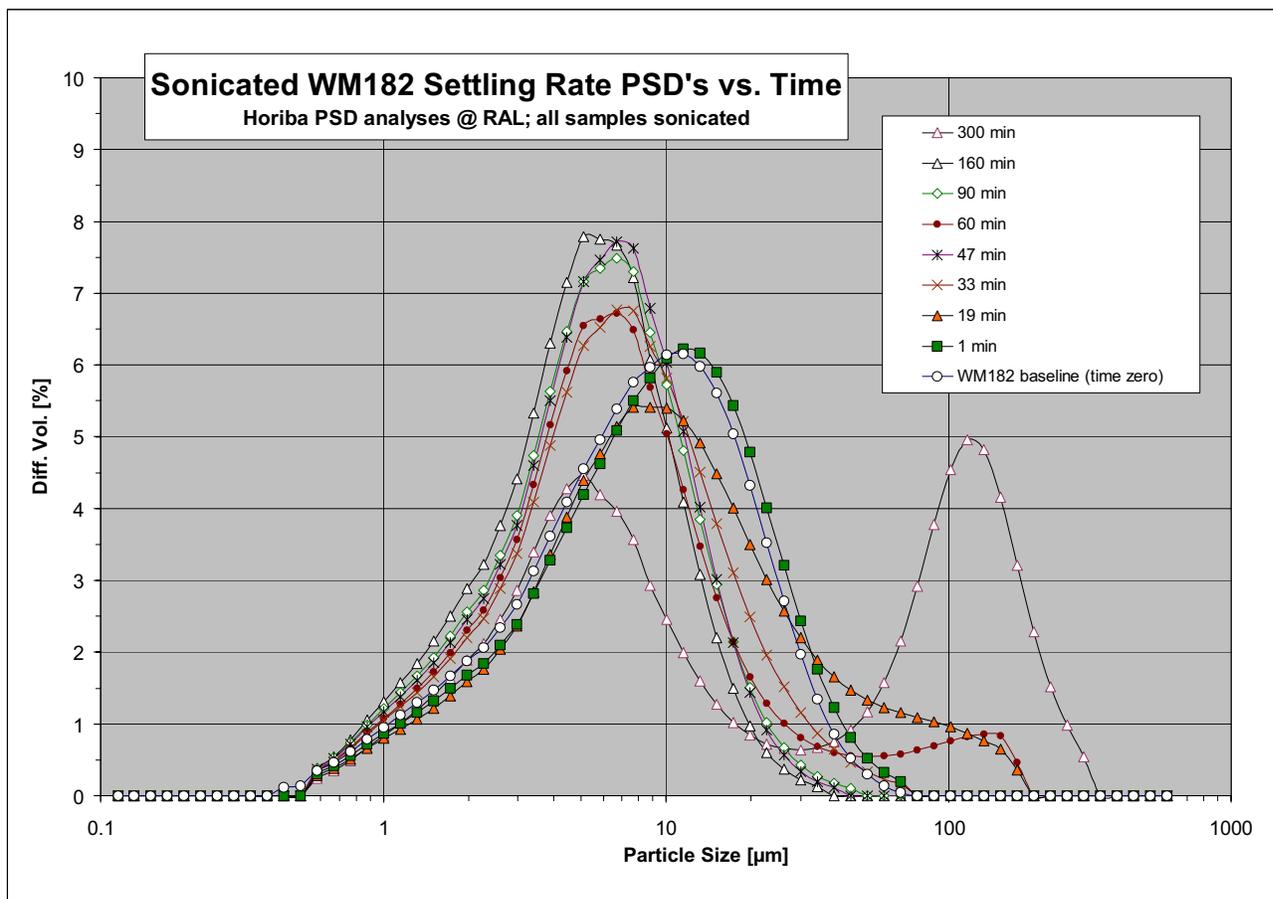


**WM182 Settling Rate PSD vs. Time Testing Data**  
**Horiba PSD Analyses Diff. Freq %; @ RAL, 8 Feb 2000; all samples sonicated**

Time [min]	Diameter [µm]									
	Frequency (%)									
	0	1	19	33	47	60	90	160	300	
0.115	0	0	0	0	0	0	0	0	0	0
0.131	0	0	0	0	0	0	0	0	0	0
0.15	0	0	0	0	0	0	0	0	0	0
0.172	0	0	0	0	0	0	0	0	0	0
0.197	0	0	0	0	0	0	0	0	0	0
0.226	0	0	0	0	0	0	0	0	0	0
0.259	0	0	0	0	0	0	0	0	0	0
0.296	0	0	0	0	0	0	0	0	0	0
0.339	0	0	0	0	0	0	0	0	0	0
0.389	0	0	0	0	0	0	0	0	0	0
0.445	0.114	0	0	0	0	0	0	0	0	0
0.51	0.14	0	0	0	0	0	0	0	0	0
0.584	0.342	0.303	0.276	0.336	0.37	0.343	0.378	0.376	0.241	
0.669	0.462	0.415	0.381	0.475	0.525	0.484	0.537	0.547	0.349	
0.766	0.612	0.555	0.512	0.653	0.724	0.667	0.742	0.775	0.492	
0.877	0.787	0.718	0.664	0.863	0.96	0.885	0.988	1.054	0.669	
1.005	0.949	0.864	0.799	1.052	1.174	1.083	1.211	1.315	0.836	
1.151	1.121	1.007	0.93	1.237	1.384	1.279	1.432	1.573	1.006	
1.318	1.297	1.155	1.068	1.435	1.606	1.49	1.667	1.848	1.19	
1.51	1.469	1.317	1.222	1.658	1.854	1.727	1.929	2.16	1.403	
1.729	1.664	1.49	1.395	1.911	2.133	1.996	2.223	2.499	1.635	
1.981	1.877	1.683	1.593	2.203	2.458	2.309	2.562	2.885	1.894	
2.269	2.059	1.847	1.767	2.463	2.745	2.588	2.861	3.226	2.125	
2.599	2.336	2.102	2.044	2.882	3.219	3.038	3.344	3.77	2.462	
2.976	2.66	2.392	2.364	3.37	3.771	3.565	3.91	4.411	2.863	
3.409	3.126	2.816	2.84	4.09	4.6	4.337	4.742	5.336	3.394	
3.905	3.618	3.276	3.364	4.873	5.509	5.163	5.634	6.3	3.901	
4.472	4.094	3.734	3.886	5.616	6.388	5.923	6.464	7.15	4.273	
5.122	4.556	4.192	4.39	6.264	7.165	6.542	7.16	7.79	4.462	
5.867	4.964	4.628	4.763	6.525	7.465	6.641	7.342	7.747	4.194	
6.72	5.386	5.083	5.141	6.769	7.716	6.715	7.487	7.673	3.961	
7.697	5.754	5.507	5.408	6.761	7.619	6.484	7.299	7.219	3.566	
8.816	5.964	5.814	5.408	6.26	6.785	5.694	6.455	6.072	2.936	
10.097	6.139	6.09	5.396	5.819	6.036	5.036	5.719	5.126	2.458	
11.565	6.152	6.219	5.224	5.212	5.071	4.266	4.813	4.085	1.998	
13.246	5.977	6.165	4.91	4.513	4.02	3.482	3.852	3.078	1.596	
15.172	5.603	5.903	4.488	3.793	3.008	2.761	2.939	2.198	1.269	
17.377	5.041	5.433	4.004	3.109	2.13	2.147	2.144	1.494	1.021	
19.904	4.327	4.783	3.5	2.493	1.432	1.656	1.503	0.971	0.842	
22.797	3.525	4.015	3.014	1.963	0.918	1.282	1.016	0.607	0.724	
26.111	2.713	3.206	2.576	1.522	0.566	1.009	0.668	0.368	0.658	
29.907	1.966	2.436	2.201	1.162	0.338	0.816	0.429	0.218	0.638	
34.255	1.34	1.766	1.894	0.874	0.197	0.686	0.272	0.128	0.667	
39.234	0.859	1.224	1.653	0.646	0.114	0.604	0.171	0	0.753	
44.938	0.521	0.815	1.469	0.469	0	0.558	0.107	0	0.912	
51.471	0.301	0.523	1.332	0.334	0	0.542	0	0	1.175	
58.953	0.135	0.326	1.232	0.234	0	0.551	0	0	1.578	
67.523	0.049	0.199	1.157	0.161	0	0.582	0	0	2.156	
77.339	0	0	1.095	0	0	0.633	0	0	2.915	
88.583	0	0	1.034	0	0	0.698	0	0	3.774	
101.46	0	0	0.962	0	0	0.768	0	0	4.542	
116.21	0	0	0.873	0	0	0.826	0	0	4.954	
133.103	0	0	0.765	0	0	0.852	0	0	4.815	
152.453	0	0	0.649	0	0	0.83	0	0	4.155	
174.616	0	0	0.36	0	0	0.461	0	0	3.215	
200	0	0	0	0	0	0	0	0	2.281	
229.075	0	0	0	0	0	0	0	0	1.522	
262.376	0	0	0	0	0	0	0	0	0.983	
300.518	0	0	0	0	0	0	0	0	0.546	
344.206	0	0	0	0	0	0	0	0	0	
394.244	0	0	0	0	0	0	0	0	0	
451.556	0	0	0	0	0	0	0	0	0	
517.2	0	0	0	0	0	0	0	0	0	
592.387	0	0	0	0	0	0	0	0	0	

Filename :9911082WM182#3A-01 Set Vel 1 min	Filename :9911082WM182#3A-01 Set Vel 19 min
ID# :200002080935085	ID# :200002080953086
Circulation Speed :5	Circulation Speed :5
Ultra sonic :00:21	Ultra sonic :00:21
Laser T% : 84.2(%)	Laser T% : 88.5(%)
Form of Distribution:Standard	Form of Distribution:Standard
Calc. Level :30	Calc. Level :30
R.R.Index :1.35-0.10i	R.R.Index :1.35-0.10i
Material :WM182 Samp 3A	Material :WM182 Solids Sam 3A
Source :	Source :
Lot Number :	Lot Number :
Dispersion Medium :RAL demin water + usonic	Dispersion Medium :RAL demin water + usonic
Remarks :GMH operator	Remarks :GMH operators
Remarks 1 :08 Feb 2000	Remarks 1 :08 Feb 2000
Remarks 2 :Run #1	Remarks 2 :Run #2
Mean :11.140379( $\mu$ m)	Mean :17.622223( $\mu$ m)
Variance :88.970901	Variance :643.727295
S.D. : 9.432439( $\mu$ m)	S.D. :25.371782( $\mu$ m)
Mode :10.814984( $\mu$ m)	Mode : 7.215792( $\mu$ m)
Geo. Mean : 7.715176( $\mu$ m)	Geo. Mean : 9.138258( $\mu$ m)
Filename :9911082WM182#3A-01 Set Vel 33 min	Filename :9911082WM182#3A-01 Set Vel 47 min
ID# :200002081008087	ID# :200002081021088
Circulation Speed :5	Circulation Speed :5
Ultra sonic :00:22	Ultra sonic :00:20
Laser T% : 91.6(%)	Laser T% : 89.5(%)
Form of Distribution:Standard	Form of Distribution:Standard
Calc. Level :30	Calc. Level :30
R.R.Index :1.35-0.10i	R.R.Index :1.35-0.10i
Material :WM182 Solids Sam 3A	Material :WM182 Solids Sam 3A
Source :	Source :
Lot Number :	Lot Number :
Dispersion Medium :RAL demin water + usonic	Dispersion Medium :RAL demin water + usonic
Remarks :GMH operators	Remarks :GMH operators
Remarks 1 :08 Feb 2000	Remarks 1 :08 Feb 2000
Remarks 2 :Run #3	Remarks 2 :Run #4
Mean : 8.391519( $\mu$ m)	Mean : 6.556015( $\mu$ m)
Variance :63.008438	Variance :23.448687
S.D. : 7.937786( $\mu$ m)	S.D. : 4.842384( $\mu$ m)
Mode : 6.293754( $\mu$ m)	Mode : 6.287407( $\mu$ m)
Geo. Mean : 5.855623( $\mu$ m)	Geo. Mean : 5.007885( $\mu$ m)

Filename :9911082WM182#3A-01 Set Vel 60 min	Filename :9911082WM182#3A-01 Set Vel 90 min
ID# :200002081035089	ID# :200002081105090
Circulation Speed :5	Circulation Speed :5
Ultra sonic :00:20	Ultra sonic :00:20
Laser T% : 89.5(%)	Laser T% : 89.0(%)
Form of Distribution:Standard	Form of Distribution:Standard
Calc. Level :30	Calc. Level :30
R.R.Index :1.35-0.10i	R.R.Index :1.35-0.10i
Material :WM182 Solids Sam 3A	Material :WM182 Solids Sam 3A
Source :	Source :
Lot Number :	Lot Number :
Dispersion Medium :RAL demin water + usonic	Dispersion Medium :RAL demin water + usonic
Remarks :GMH operators	Remarks :GMH operators
Remarks 1 :08 Feb 2000	Remarks 1 :08 Feb 2000
Remarks 2 :Run #5	Remarks 2 :Run #6
Mean :13.417995( $\mu\text{m}$ )	Mean : 6.600207( $\mu\text{m}$ )
Variance :633.813354	Variance :26.895119
S.D. :25.175650( $\mu\text{m}$ )	S.D. : 5.186050( $\mu\text{m}$ )
Mode : 6.268930( $\mu\text{m}$ )	Mode : 6.276420( $\mu\text{m}$ )
Geo. Mean : 6.355613( $\mu\text{m}$ )	Geo. Mean : 4.959979( $\mu\text{m}$ )
Filename :9911082WM182#3A-01 Set Vel 160 min	Filename :9911082WM182#3A-01 Set Vel 5.0 hr.
ID# :200002081216091	ID# :200002081439092
Circulation Speed :5	Circulation Speed :5
Ultra sonic :00:26	Ultra sonic :00:20
Laser T% : 92.2(%)	Laser T% : 93.9(%)
Form of Distribution:Standard	Form of Distribution:Standard
Calc. Level :30	Calc. Level :30
R.R.Index :1.35-0.10i	R.R.Index :1.35-0.10i
Material :WM182 Solids Sam 3A	Material :WM182 Solids Sam 3A
Source :	Source :
Lot Number :	Lot Number :
Dispersion Medium :RAL demin water + usonic	Dispersion Medium :RAL demin water + usonic
Remarks :GMH operators	Remarks :GMH operators
Remarks 1 :08 Feb 2000	Remarks 1 :08 Feb 2000
Remarks 2 :Run #7	Remarks 2 :Run #8
Mean : 5.837456( $\mu\text{m}$ )	Mean :50.771538( $\mu\text{m}$ )
Variance :18.252897	Variance :4015.596191
S.D. : 4.272341( $\mu\text{m}$ )	S.D. :63.368732( $\mu\text{m}$ )
Mode : 4.811123( $\mu\text{m}$ )	Mode :108.991638( $\mu\text{m}$ )
Geo. Mean : 4.506188( $\mu\text{m}$ )	Geo. Mean :16.119543( $\mu\text{m}$ )

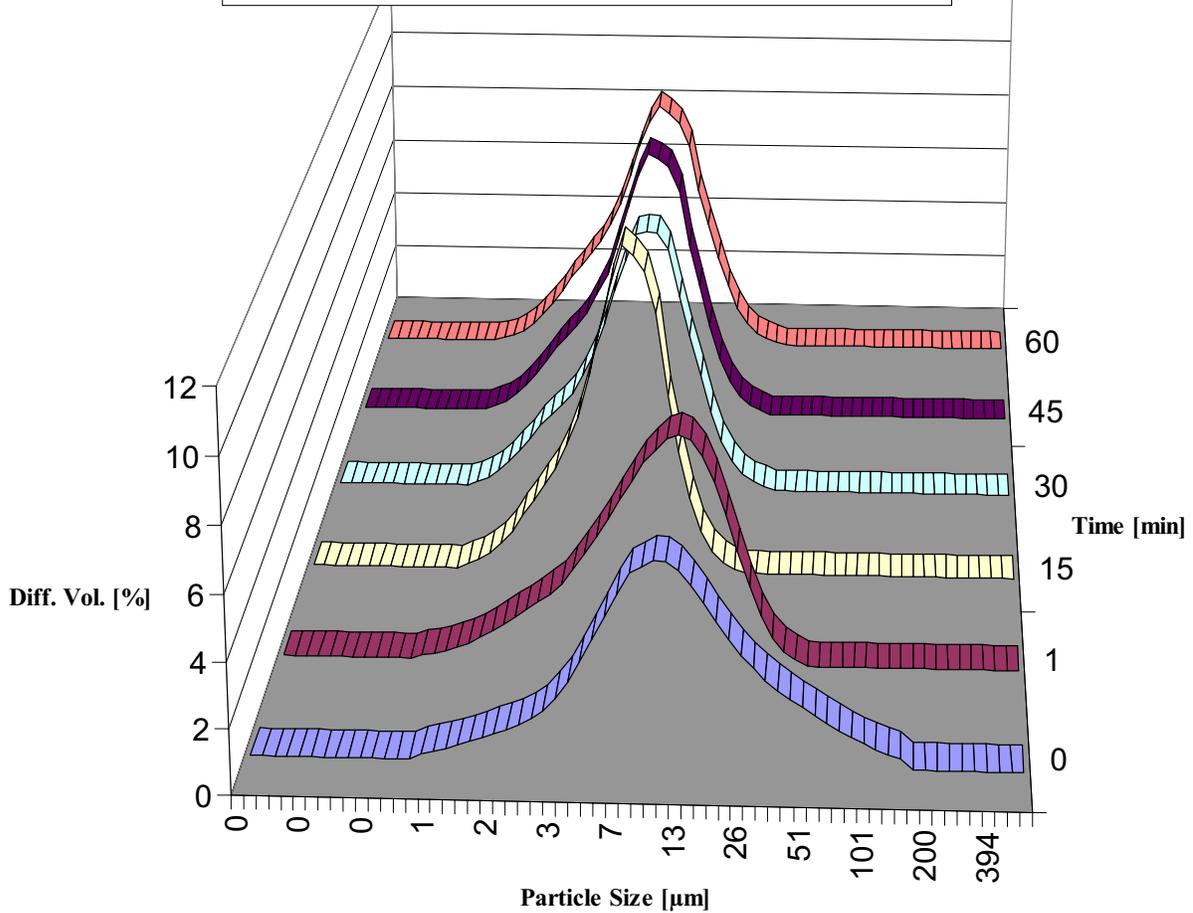


**WM183 Composite A Settling Rate PSD's vs. Time**

Time [min]	Diameter [µm]		Frequency (%)			
	0	1	15	30	45	60
0.115	0	0	0	0	0	0
0.131	0	0	0	0	0	0
0.15	0	0	0	0	0	0
0.172	0	0	0	0	0	0
0.197	0	0	0	0	0	0
0.226	0	0	0	0	0	0
0.259	0	0	0	0	0	0
0.296	0	0	0	0	0	0
0.339	0	0	0	0	0	0
0.389	0	0	0	0	0	0
0.445	0	0	0	0	0	0
0.51	0	0	0	0	0	0
0.584	0	0.105	0	0	0	0.101
0.669	0	0.165	0	0.125	0.144	0.197
0.766	0.16	0.253	0.141	0.266	0.3	0.37
0.877	0.241	0.376	0.285	0.51	0.567	0.647
1.005	0.337	0.525	0.514	0.842	0.923	1.005
1.151	0.45	0.703	0.832	1.23	1.337	1.426
1.318	0.57	0.906	1.235	1.644	1.778	1.883
1.51	0.699	1.144	1.795	2.123	2.288	2.416
1.729	0.832	1.385	2.303	2.463	2.659	2.847
1.981	0.968	1.63	2.829	2.815	3.047	3.289
2.269	1.106	1.859	3.359	3.225	3.493	3.745
2.599	1.314	2.141	4.128	3.86	4.181	4.405
2.976	1.555	2.464	5.035	4.531	4.915	5.133
3.409	1.956	2.92	6.39	5.602	6.074	6.199
3.905	2.454	3.427	7.895	6.702	7.247	7.236
4.472	3.052	3.962	9.397	7.774	8.346	8.13
5.122	3.748	4.532	10.587	8.64	9.162	8.721
5.867	4.435	5.131	10.284	8.725	8.993	8.432
6.72	5.142	5.746	9.785	8.704	8.721	8.092
7.697	5.759	6.336	8.456	8.149	7.871	7.297
8.816	5.966	6.735	5.777	6.558	5.974	5.689
10.097	6.175	7.085	3.984	5.276	4.542	4.446
11.565	6.136	7.207	2.458	3.913	3.155	3.22
13.246	5.872	7.04	1.366	2.674	2.004	2.161
15.172	5.442	6.552	0.693	1.687	1.17	1.348
17.377	4.92	5.757	0.327	0.99	0.633	0.787
19.904	4.373	4.727	0.147	0.544	0.323	0.433
22.797	3.851	3.588	0	0.285	0.157	0.228
26.111	3.382	2.491	0	0.144	0	0.117
29.907	2.977	1.567	0	0	0	0
34.255	2.632	0.886	0	0	0	0
39.234	2.336	0.449	0	0	0	0
44.938	2.074	0.205	0	0	0	0
51.471	1.832	0	0	0	0	0
58.953	1.602	0	0	0	0	0
67.523	1.377	0	0	0	0	0
77.339	1.158	0	0	0	0	0
88.583	0.95	0	0	0	0	0
101.46	0.761	0	0	0	0	0
116.21	0.597	0	0	0	0	0
133.103	0.46	0	0	0	0	0
152.453	0.352	0	0	0	0	0
174.616	0	0	0	0	0	0
200	0	0	0	0	0	0
229.075	0	0	0	0	0	0
262.376	0	0	0	0	0	0
300.518	0	0	0	0	0	0
344.206	0	0	0	0	0	0
394.244	0	0	0	0	0	0
451.556	0	0	0	0	0	0
517.2	0	0	0	0	0	0
592.387	0	0	0	0	0	0

Filename :000105-6 SV time zero	Filename :000105-6 SV 1 min
ID# :200003081011101	ID# :200003080854096
Circulation Speed :6	Circulation Speed :6
Ultra sonic :OFF	Ultra sonic :OFF
Laser T% : 92.0(%)	Laser T% : 85.5(%)
Form of Distribution:Standard	Form of Distribution:Standard
Calc. Level :30	Calc. Level :30
R.R.Index :1.35-0.10i	R.R.Index :1.35-0.10i
Material :WM183Compos1,2,3	Material :WM183Compos1,2,3
Source :	Source :
Lot Number :	Lot Number :
Dispersion Medium :RAL demin water	Dispersion Medium :RAL demin water + usonic
Remarks :GMH operator	Remarks :GMH operator
Remarks 1 :8 Mar 2000	Remarks 1 :8 Mar 2000
Remarks 2 :	Remarks 2 :
Mean :18.189390( $\mu$ m)	Mean : 9.917294( $\mu$ m)
Variance :450.924561	Variance :48.605122
S.D. :21.234983( $\mu$ m)	S.D. : 6.971737( $\mu$ m)
Mode : 9.452181( $\mu$ m)	Mode :10.801532( $\mu$ m)
Geo. Mean :11.246674( $\mu$ m)	Geo. Mean : 7.535396( $\mu$ m)
Filename :000105-6 SV 15 min	Filename :000105-6 SV 30 min
ID# :200003080912097	ID# :200003080924098
Circulation Speed :6	Circulation Speed :6
Ultra sonic :OFF	Ultra sonic :OFF
Laser T% : 98.1(%)	Laser T% : 98.2(%)
Form of Distribution:Standard	Form of Distribution:Standard
Calc. Level :30	Calc. Level :30
R.R.Index :1.35-0.10i	R.R.Index :1.35-0.10i
Material :WM183Compos1,2,3	Material :WM183Compos1,2,3
Source :	Source :
Lot Number :	Lot Number :
Dispersion Medium :RAL demin water	Dispersion Medium :RAL demin water
Remarks :GMH operator	Remarks :GMH operator
Remarks 1 :8 Mar 2000	Remarks 1 :8 Mar 2000
Remarks 2 :	Remarks 2 :
Mean : 5.100872( $\mu$ m)	Mean : 5.618893( $\mu$ m)
Variance : 7.270061	Variance :12.310927
S.D. : 2.696305( $\mu$ m)	S.D. : 3.508693( $\mu$ m)
Mode : 4.813475( $\mu$ m)	Mode : 5.484677( $\mu$ m)
Geo. Mean : 4.408837( $\mu$ m)	Geo. Mean : 4.610907( $\mu$ m)
Filename :000105-6 SV 45 min	Filename :000105-6 SV 60 min
ID# :200003080941099	ID# :200003080956100
Circulation Speed :6	Circulation Speed :6
Ultra sonic :OFF	Ultra sonic :OFF
Laser T% : 98.2(%)	Laser T% : 97.8(%)
Form of Distribution:Standard	Form of Distribution:Standard
Calc. Level :30	Calc. Level :30
R.R.Index :1.35-0.10i	R.R.Index :1.35-0.10i
Material :WM183Compos1,2,3	Material :WM183Compos1,2,3
Source :	Source :
Lot Number :	Lot Number :
Dispersion Medium :RAL demin water	Dispersion Medium :RAL demin water
Remarks :GMH operator	Remarks :GMH operator
Remarks 1 :8 Mar 2000	Remarks 1 :8 Mar 2000
Remarks 2 :	Remarks 2 :
Mean : 5.219898( $\mu$ m)	Mean : 5.221494( $\mu$ m)
Variance : 9.859966	Variance :11.266287
S.D. : 3.140058( $\mu$ m)	S.D. : 3.356529( $\mu$ m)
Mode : 4.809167( $\mu$ m)	Mode : 4.797433( $\mu$ m)
Geo. Mean : 4.332213( $\mu$ m)	Geo. Mean : 4.256260( $\mu$ m)

**Non-Sonicated WM183 (Composite 1,2&3)**  
**Settling Rate PSD's vs. Time**  
Horiba PSD analyses @ RAL, 8 Mar 2000; all samples not sonicated

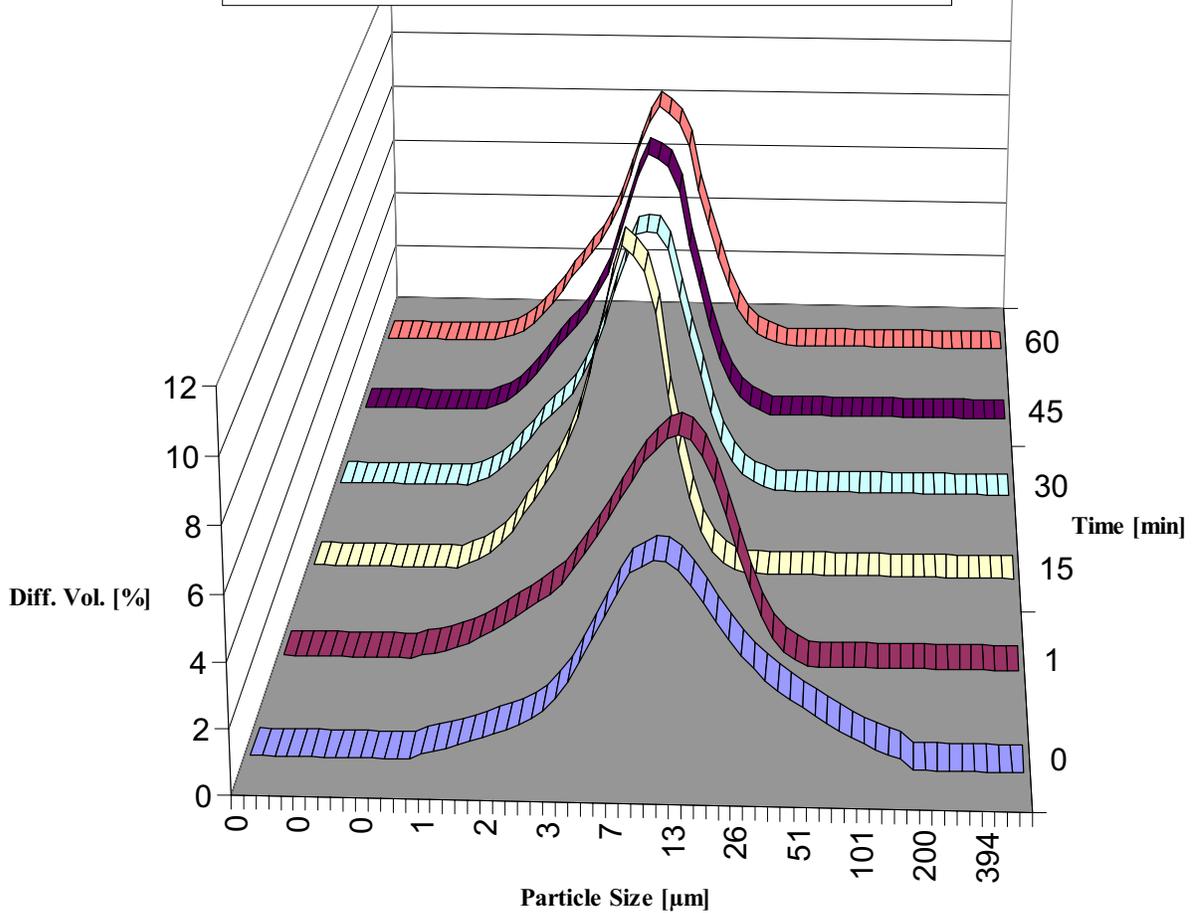


**WM183 Composite A Settling Rate PSD's vs. Time**

Time [min]	Diameter [µm]	Frequency (%)					
		0	1	15	30	45	60
	0.115	0	0	0	0	0	0
	0.131	0	0	0	0	0	0
	0.15	0	0	0	0	0	0
	0.172	0	0	0	0	0	0
	0.197	0	0	0	0	0	0
	0.226	0	0	0	0	0	0
	0.259	0	0	0	0	0	0
	0.296	0	0	0	0	0	0
	0.339	0	0	0	0	0	0
	0.389	0	0	0	0	0	0
	0.445	0	0	0	0	0	0
	0.51	0	0	0	0	0	0
	0.584	0	0.105	0	0	0	0.101
	0.669	0	0.165	0	0.125	0.144	0.197
	0.766	0.16	0.253	0.141	0.266	0.3	0.37
	0.877	0.241	0.376	0.285	0.51	0.567	0.647
	1.005	0.337	0.525	0.514	0.842	0.923	1.005
	1.151	0.45	0.703	0.832	1.23	1.337	1.426
	1.318	0.57	0.906	1.235	1.644	1.778	1.883
	1.51	0.699	1.144	1.795	2.123	2.288	2.416
	1.729	0.832	1.385	2.303	2.463	2.659	2.847
	1.981	0.968	1.63	2.829	2.815	3.047	3.289
	2.269	1.106	1.859	3.359	3.225	3.493	3.745
	2.599	1.314	2.141	4.128	3.86	4.181	4.405
	2.976	1.555	2.464	5.035	4.531	4.915	5.133
	3.409	1.956	2.92	6.39	5.602	6.074	6.199
	3.905	2.454	3.427	7.895	6.702	7.247	7.236
	4.472	3.052	3.962	9.397	7.774	8.346	8.13
	5.122	3.748	4.532	10.587	8.64	9.162	8.721
	5.867	4.435	5.131	10.284	8.725	8.993	8.432
	6.72	5.142	5.746	9.785	8.704	8.721	8.092
	7.697	5.759	6.336	8.456	8.149	7.871	7.297
	8.816	5.966	6.735	5.777	6.558	5.974	5.689
	10.097	6.175	7.085	3.984	5.276	4.542	4.446
	11.565	6.136	7.207	2.458	3.913	3.155	3.22
	13.246	5.872	7.04	1.366	2.674	2.004	2.161
	15.172	5.442	6.552	0.693	1.687	1.17	1.348
	17.377	4.92	5.757	0.327	0.99	0.633	0.787
	19.904	4.373	4.727	0.147	0.544	0.323	0.433
	22.797	3.851	3.588	0	0.285	0.157	0.228
	26.111	3.382	2.491	0	0.144	0	0.117
	29.907	2.977	1.567	0	0	0	0
	34.255	2.632	0.886	0	0	0	0
	39.234	2.336	0.449	0	0	0	0
	44.938	2.074	0.205	0	0	0	0
	51.471	1.832	0	0	0	0	0
	58.953	1.602	0	0	0	0	0
	67.523	1.377	0	0	0	0	0
	77.339	1.158	0	0	0	0	0
	88.583	0.95	0	0	0	0	0
	101.46	0.761	0	0	0	0	0
	116.21	0.597	0	0	0	0	0
	133.103	0.46	0	0	0	0	0
	152.453	0.352	0	0	0	0	0
	174.616	0	0	0	0	0	0
	200	0	0	0	0	0	0
	229.075	0	0	0	0	0	0
	262.376	0	0	0	0	0	0
	300.518	0	0	0	0	0	0
	344.206	0	0	0	0	0	0
	394.244	0	0	0	0	0	0
	451.556	0	0	0	0	0	0
	517.2	0	0	0	0	0	0
	592.387	0	0	0	0	0	0

Filename :000105-6 SV time zero	Filename :000105-6 SV 1 min
ID# :200003081011101	ID# :200003080854096
Circulation Speed :6	Circulation Speed :6
Ultra sonic :OFF	Ultra sonic :OFF
Laser T% : 92.0(%)	Laser T% : 85.5(%)
Form of Distribution:Standard	Form of Distribution:Standard
Calc. Level :30	Calc. Level :30
R.R.Index :1.35-0.10i	R.R.Index :1.35-0.10i
Material :WM183Compos1,2,3	Material :WM183Compos1,2,3
Source :	Source :
Lot Number :	Lot Number :
Dispersion Medium :RAL demin water	Dispersion Medium :RAL demin water + usonic
Remarks :GMH operator	Remarks :GMH operator
Remarks 1 :8 Mar 2000	Remarks 1 :8 Mar 2000
Remarks 2 :	Remarks 2 :
Mean :18.189390( $\mu$ m)	Mean : 9.917294( $\mu$ m)
Variance :450.924561	Variance :48.605122
S.D. :21.234983( $\mu$ m)	S.D. : 6.971737( $\mu$ m)
Mode : 9.452181( $\mu$ m)	Mode :10.801532( $\mu$ m)
Geo. Mean :11.246674( $\mu$ m)	Geo. Mean : 7.535396( $\mu$ m)
Filename :000105-6 SV 15 min	Filename :000105-6 SV 30 min
ID# :200003080912097	ID# :200003080924098
Circulation Speed :6	Circulation Speed :6
Ultra sonic :OFF	Ultra sonic :OFF
Laser T% : 98.1(%)	Laser T% : 98.2(%)
Form of Distribution:Standard	Form of Distribution:Standard
Calc. Level :30	Calc. Level :30
R.R.Index :1.35-0.10i	R.R.Index :1.35-0.10i
Material :WM183Compos1,2,3	Material :WM183Compos1,2,3
Source :	Source :
Lot Number :	Lot Number :
Dispersion Medium :RAL demin water	Dispersion Medium :RAL demin water
Remarks :GMH operator	Remarks :GMH operator
Remarks 1 :8 Mar 2000	Remarks 1 :8 Mar 2000
Remarks 2 :	Remarks 2 :
Mean : 5.100872( $\mu$ m)	Mean : 5.618893( $\mu$ m)
Variance : 7.270061	Variance :12.310927
S.D. : 2.696305( $\mu$ m)	S.D. : 3.508693( $\mu$ m)
Mode : 4.813475( $\mu$ m)	Mode : 5.484677( $\mu$ m)
Geo. Mean : 4.408837( $\mu$ m)	Geo. Mean : 4.610907( $\mu$ m)
Filename :000105-6 SV 45 min	Filename :000105-6 SV 60 min
ID# :200003080941099	ID# :200003080956100
Circulation Speed :6	Circulation Speed :6
Ultra sonic :OFF	Ultra sonic :OFF
Laser T% : 98.2(%)	Laser T% : 97.8(%)
Form of Distribution:Standard	Form of Distribution:Standard
Calc. Level :30	Calc. Level :30
R.R.Index :1.35-0.10i	R.R.Index :1.35-0.10i
Material :WM183Compos1,2,3	Material :WM183Compos1,2,3
Source :	Source :
Lot Number :	Lot Number :
Dispersion Medium :RAL demin water	Dispersion Medium :RAL demin water
Remarks :GMH operator	Remarks :GMH operator
Remarks 1 :8 Mar 2000	Remarks 1 :8 Mar 2000
Remarks 2 :	Remarks 2 :
Mean : 5.219898( $\mu$ m)	Mean : 5.221494( $\mu$ m)
Variance : 9.859966	Variance :11.266287
S.D. : 3.140058( $\mu$ m)	S.D. : 3.356529( $\mu$ m)
Mode : 4.809167( $\mu$ m)	Mode : 4.797433( $\mu$ m)
Geo. Mean : 4.332213( $\mu$ m)	Geo. Mean : 4.256260( $\mu$ m)

**Non-Sonicated WM183 (Composite 1,2&3)**  
**Settling Rate PSD's vs. Time**  
Horiba PSD analyses @ RAL, 8 Mar 2000; all samples not sonicated

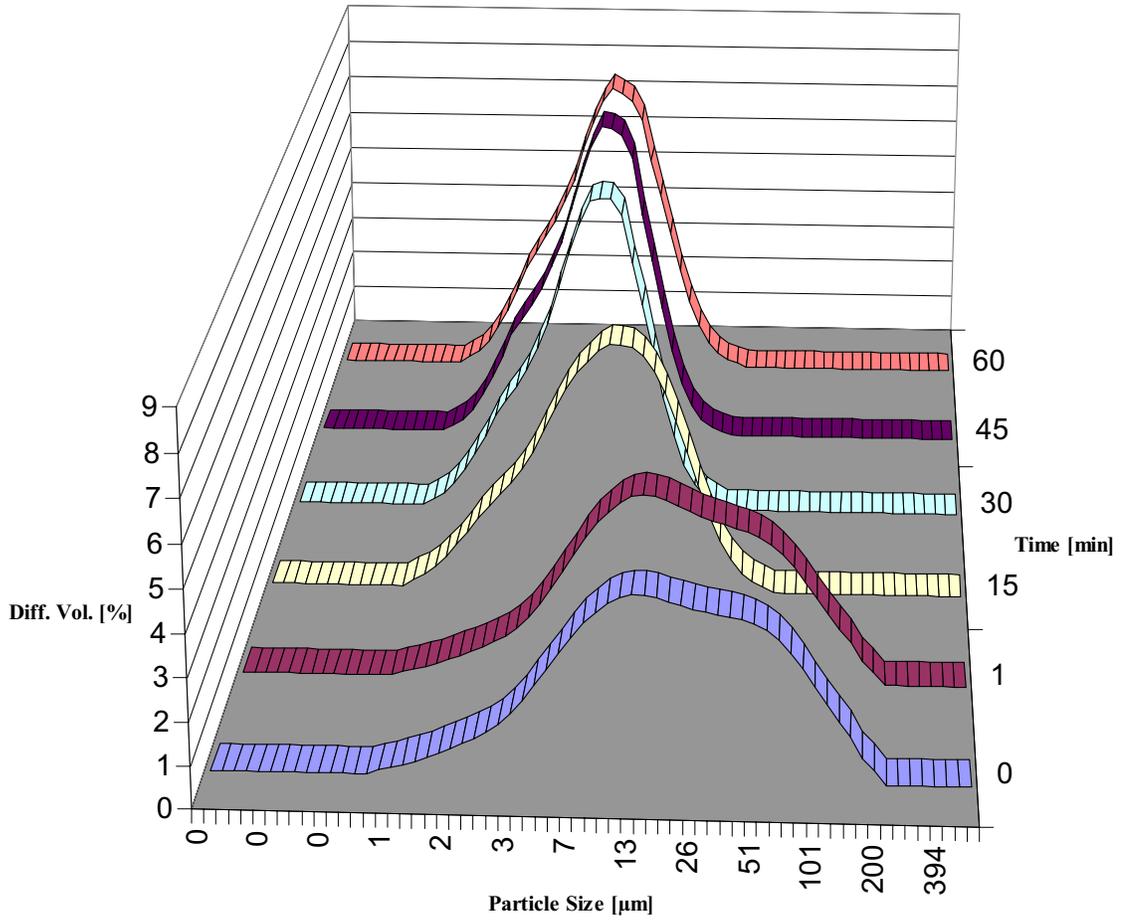


**Non-Sonicated WM183 Composite B**  
**Settling Rate PSD's vs. Time**  
**8 Mar 2000**

Time [min]	Diameter [µm]		Frequency (%)			
	0	1	15	30	45	60
0.115	0	0	0	0	0	0
0.131	0	0	0	0	0	0
0.15	0	0	0	0	0	0
0.172	0	0	0	0	0	0
0.197	0	0	0	0	0	0
0.226	0	0	0	0	0	0
0.259	0	0	0	0	0	0
0.296	0	0	0	0	0	0
0.339	0	0	0	0	0	0
0.389	0	0	0	0	0	0
0.445	0	0	0	0	0	0
0.51	0	0	0	0	0	0
0.584	0	0	0	0	0	0
0.669	0	0	0.17	0.156	0.136	0.166
0.766	0.101	0.104	0.304	0.317	0.294	0.332
0.877	0.157	0.159	0.511	0.589	0.579	0.618
1.005	0.227	0.228	0.768	0.95	0.984	1.013
1.151	0.313	0.312	1.063	1.374	1.479	1.499
1.318	0.41	0.407	1.38	1.828	2.017	2.036
1.51	0.524	0.516	1.757	2.368	2.656	2.679
1.729	0.639	0.627	2.061	2.763	3.079	3.147
1.981	0.757	0.742	2.353	3.147	3.472	3.583
2.269	0.878	0.859	2.645	3.561	3.9	4.026
2.599	1.035	1.018	3.015	4.142	4.494	4.591
2.976	1.215	1.2	3.422	4.77	5.115	5.202
3.409	1.484	1.479	3.982	5.681	6.042	6.038
3.905	1.796	1.808	4.518	6.551	6.911	6.774
4.472	2.143	2.183	5	7.329	7.689	7.364
5.122	2.519	2.597	5.408	7.919	8.251	7.731
5.867	2.881	2.998	5.683	7.994	8.19	7.591
6.72	3.259	3.418	5.958	7.984	8.017	7.395
7.697	3.607	3.804	6.139	7.591	7.411	6.89
8.816	3.825	4.034	6.12	6.371	5.918	5.755
10.097	4.054	4.277	6.07	5.31	4.702	4.787
11.565	4.2	4.421	5.861	4.103	3.432	3.728
13.246	4.264	4.468	5.485	2.925	2.295	2.708
15.172	4.261	4.435	4.945	1.923	1.408	1.831
17.377	4.21	4.347	4.264	1.167	0.796	1.153
19.904	4.131	4.228	3.487	0.659	0.42	0.68
22.797	4.046	4.1	2.682	0.35	0.21	0.379
26.111	3.968	3.981	1.929	0.178	0.102	0.202
29.907	3.904	3.878	1.296	0	0	0.105
34.255	3.855	3.792	0.814	0	0	0
39.234	3.811	3.712	0.483	0	0	0
44.938	3.754	3.624	0.274	0	0	0
51.471	3.665	3.507	0.151	0	0	0
58.953	3.52	3.34	0	0	0	0
67.523	3.304	3.109	0	0	0	0
77.339	3.011	2.812	0	0	0	0
88.583	2.651	2.46	0	0	0	0
101.46	2.25	2.077	0	0	0	0
116.21	1.84	1.692	0	0	0	0
133.103	1.452	1.335	0	0	0	0
152.453	1.114	1.025	0	0	0	0
174.616	0.619	0.57	0	0	0	0
200	0.344	0.316	0	0	0	0
229.075	0	0	0	0	0	0
262.376	0	0	0	0	0	0
300.518	0	0	0	0	0	0
344.206	0	0	0	0	0	0
394.244	0	0	0	0	0	0
451.556	0	0	0	0	0	0

Filename :000107-5 SV time zero	Filename :000107-5 SV 1 min
ID# :200003081352107	ID# :200003081243102
Circulation Speed :6	Circulation Speed :6
Ultra sonic :00:02	Ultra sonic :OFF
Laser T% : 89.4(%)	Laser T% : 89.7(%)
Form of Distribution:Standard	Form of Distribution:Standard
Calc. Level :30	Calc. Level :30
R.R.Index :1.35-0.10i	R.R.Index :1.35-0.10i
Material :WM183Compos4,5,6,7	Material :WM183Compos4,5,6,7
Source :	Source :
Lot Number :	Lot Number :
Dispersion Medium :RAL demin water	Dispersion Medium :RAL demin water
Remarks :GMH operator	Remarks :GMH operator
Remarks 1 :8 Mar 2000	Remarks 1 :8 Mar 2000
Remarks 2 :	Remarks 2 :
Mean :31.263231( $\mu$ m)	Mean :30.018270( $\mu$ m)
Variance :1125.904663	Variance :1068.056641
S.D. :33.554504( $\mu$ m)	S.D. :32.681137( $\mu$ m)
Mode :12.389057( $\mu$ m)	Mode :12.379803( $\mu$ m)
Geo. Mean :17.809643( $\mu$ m)	Geo. Mean :17.189219( $\mu$ m)
Filename :000107-5 SV 15 min	Filename :000107-5 SV 30 min
ID# :200003081258103	ID# :200003081314104
Circulation Speed :6	Circulation Speed :6
Ultra sonic :OFF	Ultra sonic :OFF
Laser T% : 97.8(%)	Laser T% : 98.2(%)
Form of Distribution:Standard	Form of Distribution:Standard
Calc. Level :30	Calc. Level :30
R.R.Index :1.35-0.10i	R.R.Index :1.35-0.10i
Material :WM183Compos4,5,6,7	Material :WM183Compos4,5,6,7
Source :	Source :
Lot Number :	Lot Number :
Dispersion Medium :RAL demin water	Dispersion Medium :RAL demin water
Remarks :GMH operator	Remarks :GMH operator
Remarks 1 :8 Mar 2000	Remarks 1 :8 Mar 2000
Remarks 2 :	Remarks 2 :
Mean : 8.716022( $\mu$ m)	Mean : 5.623658( $\mu$ m)
Variance :50.123974	Variance :13.637858
S.D. : 7.079829( $\mu$ m)	S.D. : 3.692947( $\mu$ m)
Mode : 7.204556( $\mu$ m)	Mode : 5.484972( $\mu$ m)
Geo. Mean : 6.319472( $\mu$ m)	Geo. Mean : 4.527143( $\mu$ m)
Filename :000107-5 SV 45 min	Filename :000107-5 SV 60 min
ID# :200003081329105	ID# :200003081344106
Circulation Speed :6	Circulation Speed :6
Ultra sonic :OFF	Ultra sonic :OFF
Laser T% : 98.5(%)	Laser T% : 98.0(%)
Form of Distribution:Standard	Form of Distribution:Standard
Calc. Level :30	Calc. Level :30
R.R.Index :1.35-0.10i	R.R.Index :1.35-0.10i
Material :WM183Compos4,5,6,7	Material :WM183Compos4,5,6,7
Source :	Source :
Lot Number :	Lot Number :
Dispersion Medium :RAL demin water	Dispersion Medium :RAL demin water
Remarks :GMH operator	Remarks :GMH operator
Remarks 1 :8 Mar 2000	Remarks 1 :8 Mar 2000
Remarks 2 :	Remarks 2 :
Mean : 5.252161( $\mu$ m)	Mean : 5.444707( $\mu$ m)
Variance :11.454658	Variance :14.334759
S.D. : 3.384473( $\mu$ m)	S.D. : 3.786127( $\mu$ m)
Mode : 4.805934( $\mu$ m)	Mode : 4.795689( $\mu$ m)
Geo. Mean : 4.268958( $\mu$ m)	Geo. Mean : 4.326528( $\mu$ m)

**Non-Sonicated WM183 (Composite B [4,5,6&7])**  
**Settling Rate PSD's vs. Time**  
Horiba PSD analyses @ RAL, 8 Mar 2000; all samples not sonicated



## Appendix A-3 Settling Rate Testing Photographs

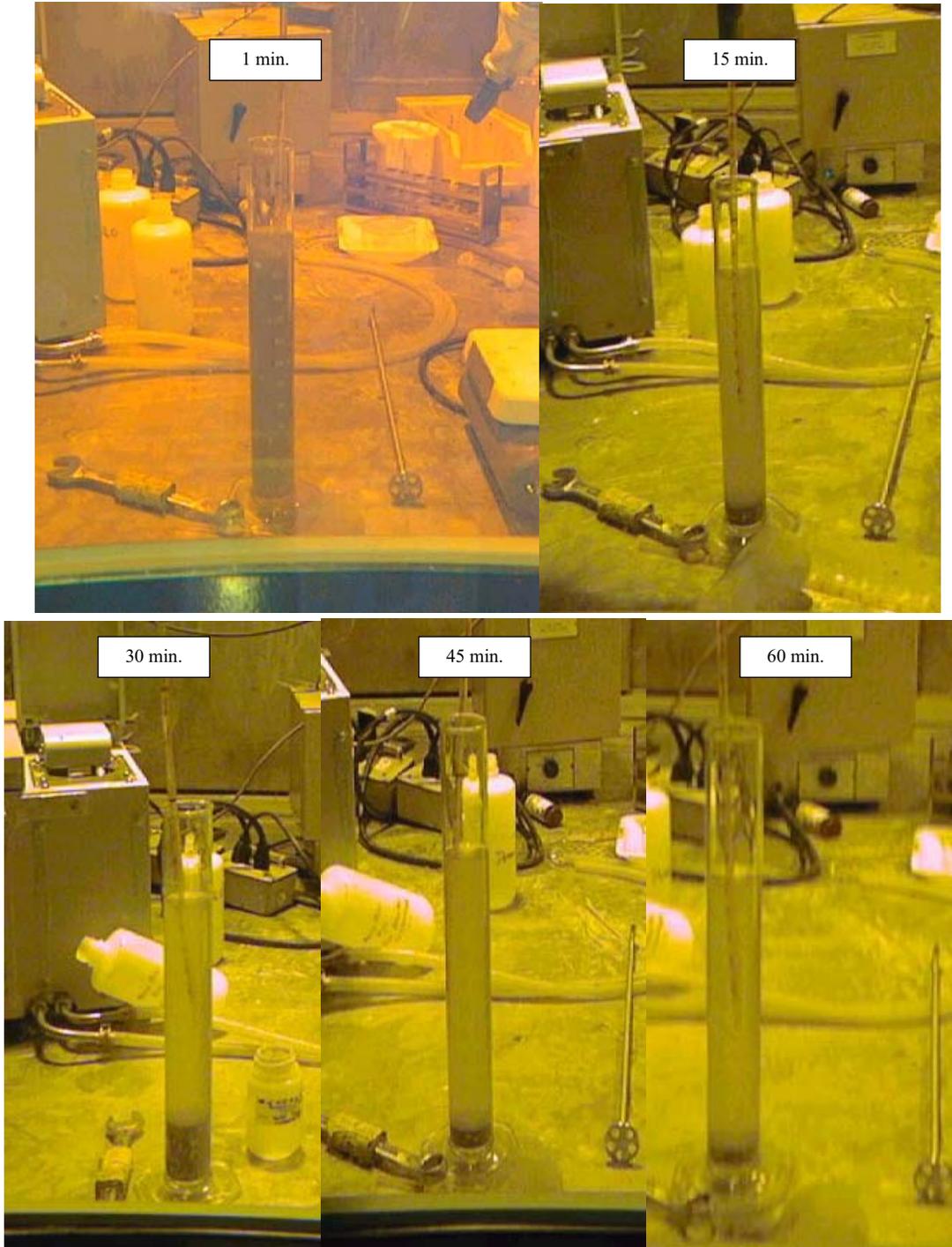


Figure A-3a. WM-183 Composite A settling rate testing photographs.

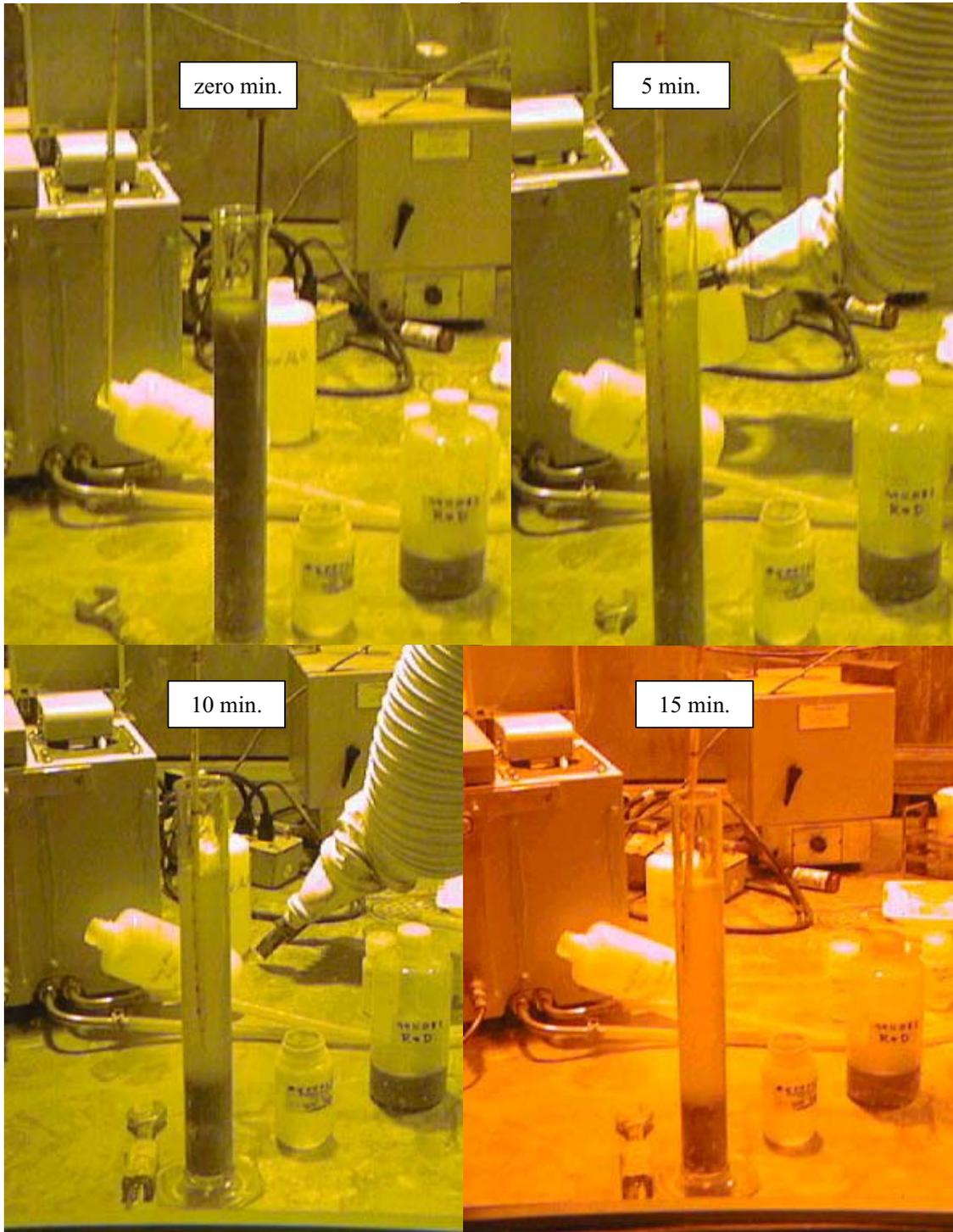


Figure A-3b. WM-183 Composite B settling rate testing photographs.

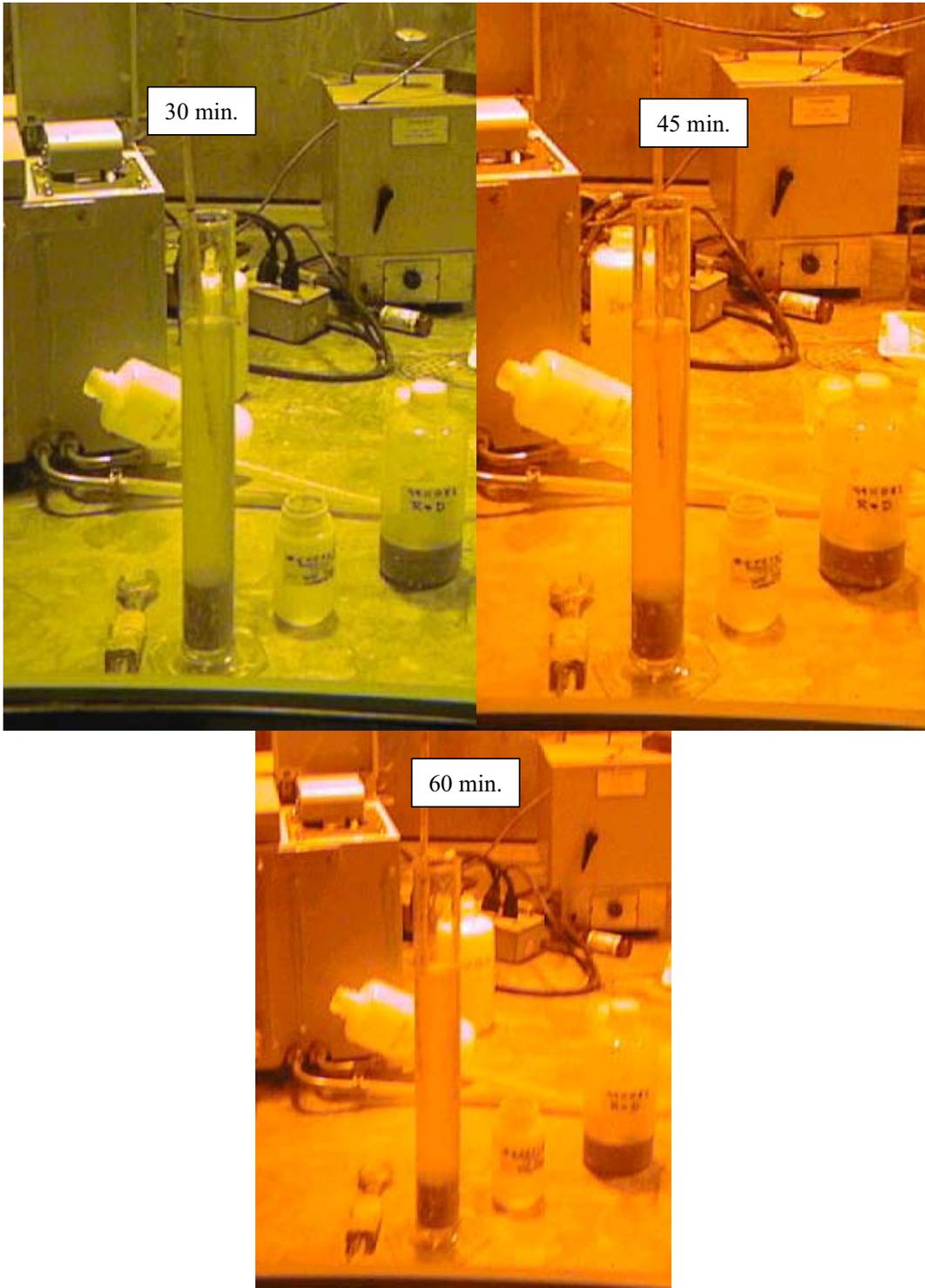


Figure A-3b. (continued). WM-183 Composite B settling rate testing photographs.