The Importance of Real-Time Cement Particle Size Characterization: How it Improves Your Bottom Line

Presented by:
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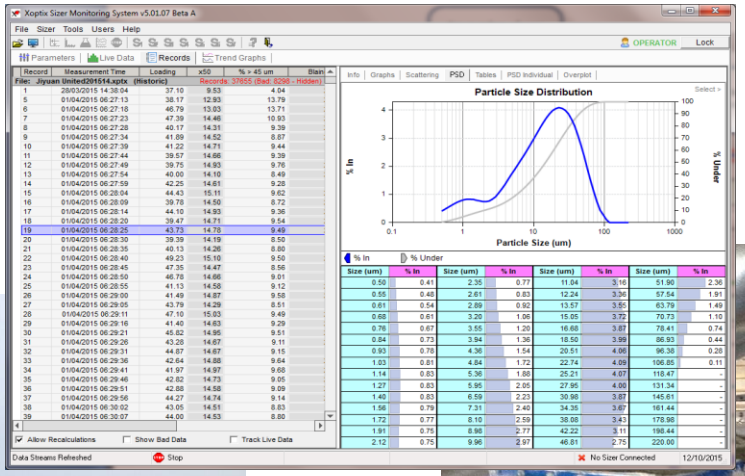
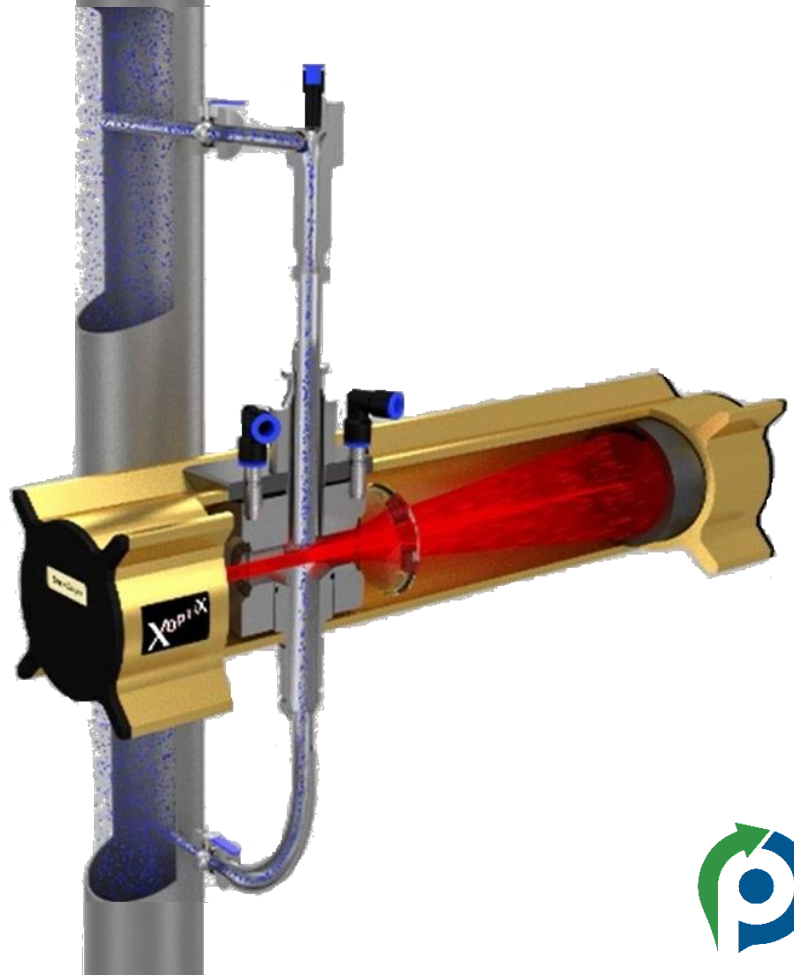
Preferred Process Solutions, LLC

38TH INTERNATIONAL CEMENT SEMINAR & EXHIBITION





Centrifuging

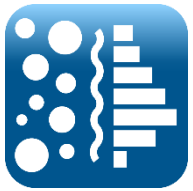
Screening

Milling

Sorting

Preferred Process Solutions

Air Classifying



Analyzing

Plant Design

Coating

Companies Represented

SWECO

- ✓ Screening Equipment
- ✓ Centrifuges
- ✓ Vibratory Mills

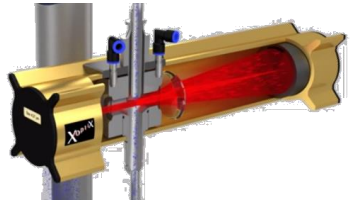
ecutec®

- ✓ Air Classifiers
- ✓ Grinding Mills
- ✓ Coating Systems
- ✓ Plant Design

TOMRA SORTING SOLUTIONS

- ✓ Sensor Based Sorters

XOptiX

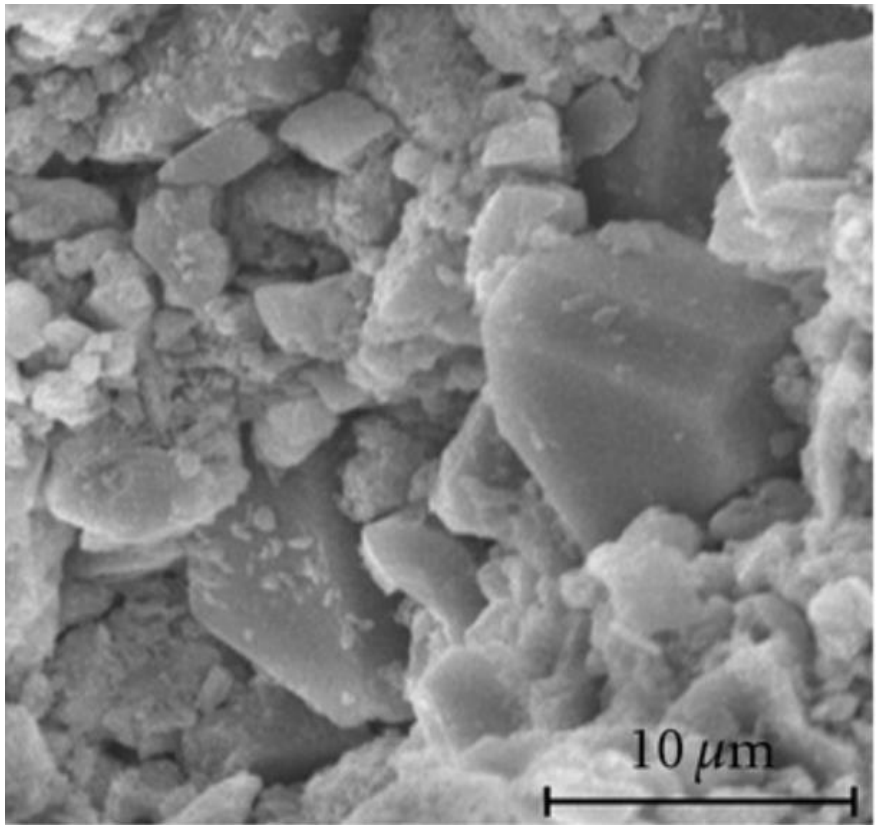


- ✓ In-Process Particle Size Analyzers

XOptiX

Why is Particle Size Important to the Cement Industry?

- Hydration rate increases with increasing surface area
- Early strength increases with increasing surface area
- Final strength increases with increasing surface area



Why is Particle Size Important to the Cement Industry?

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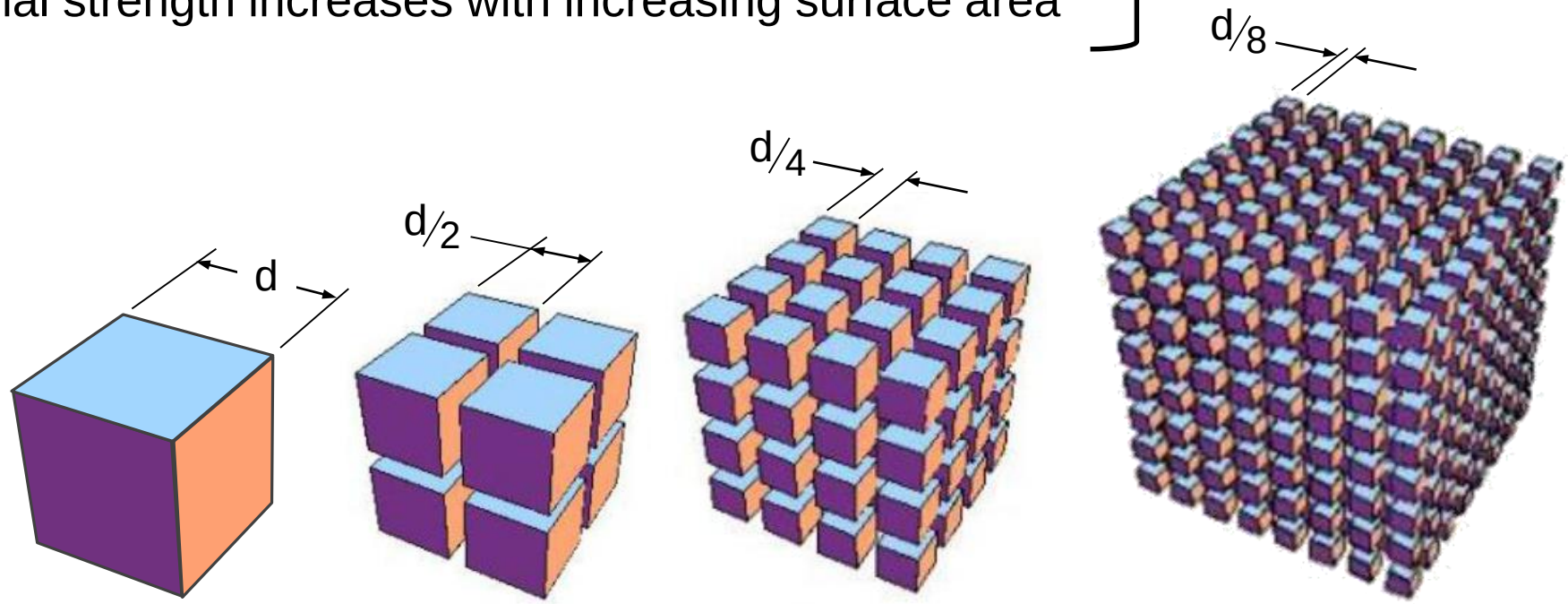
- Early strength increases with increasing surface area
- Final strength increases with increasing surface area

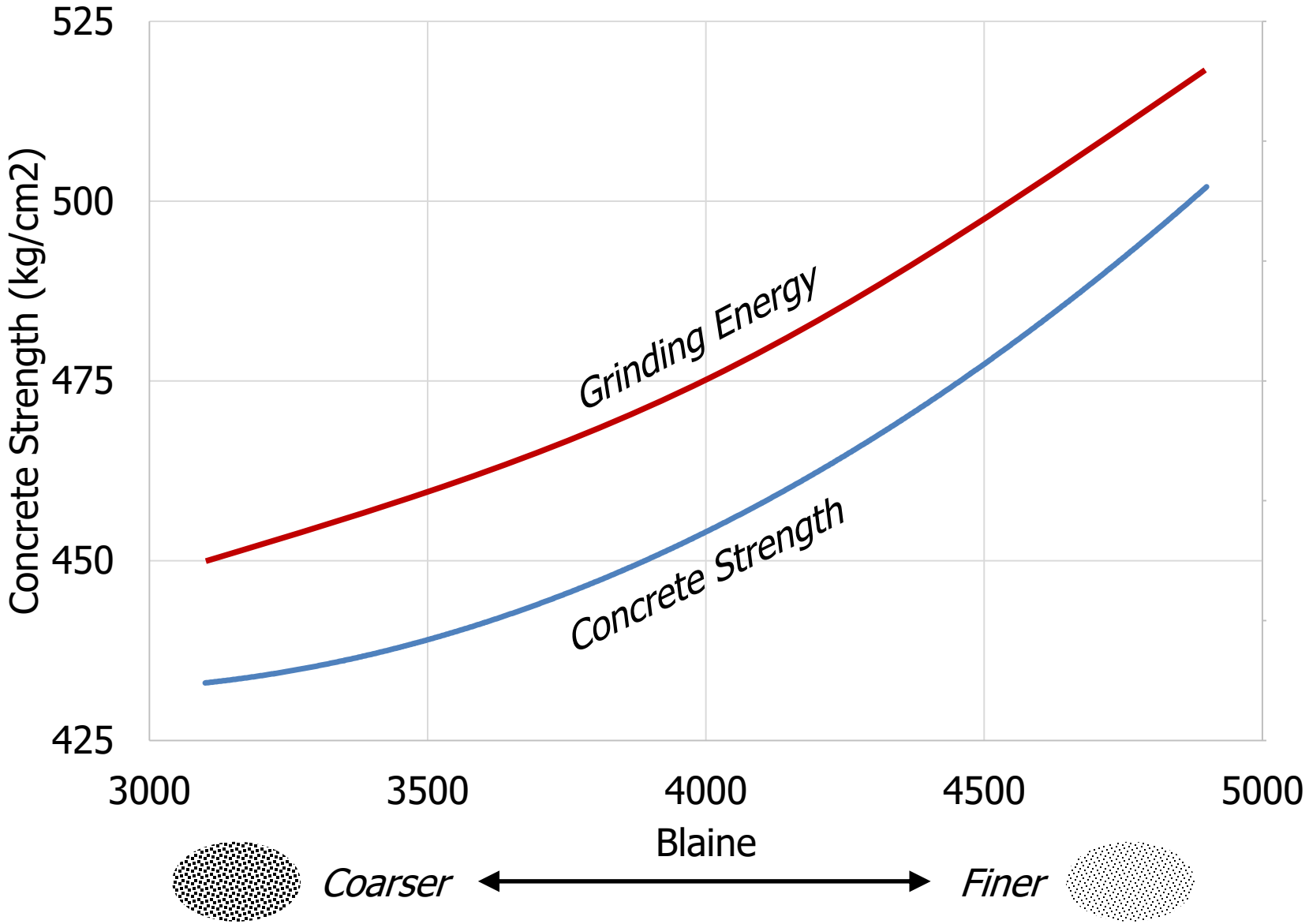
Finer cements have more surface area



n = 1	n = 8	n = 64	n = 512
area = $6d^2$	area = $12d^2$	area = $24d^2$	area = $48d^2$

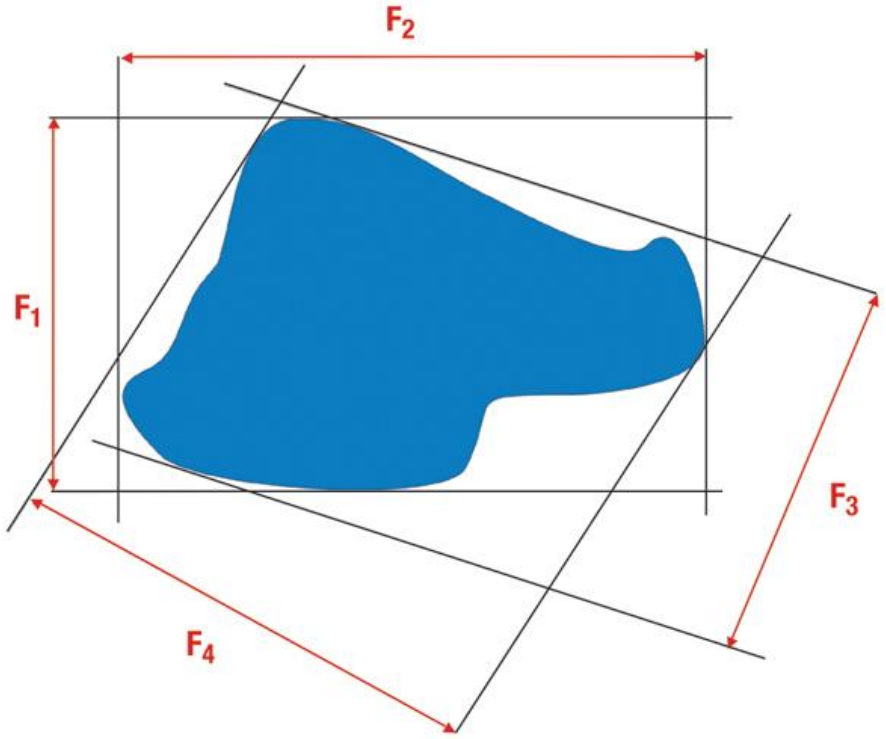
So as particle size decreases, specific surface area increases…

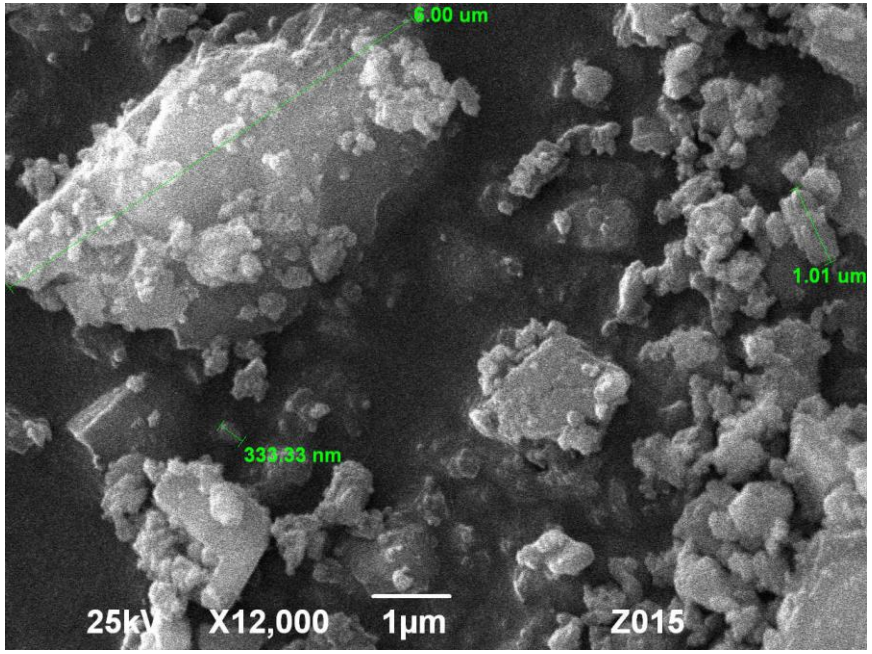
Effect of Particle Size on Concrete Strength



How Do We "Measure" a Particle's Size?

- Ground mineral particles are non-spherical.
- So how do we quantify the size of an irregularly shaped particle?





One Way to Measure Particle Size: Sieving

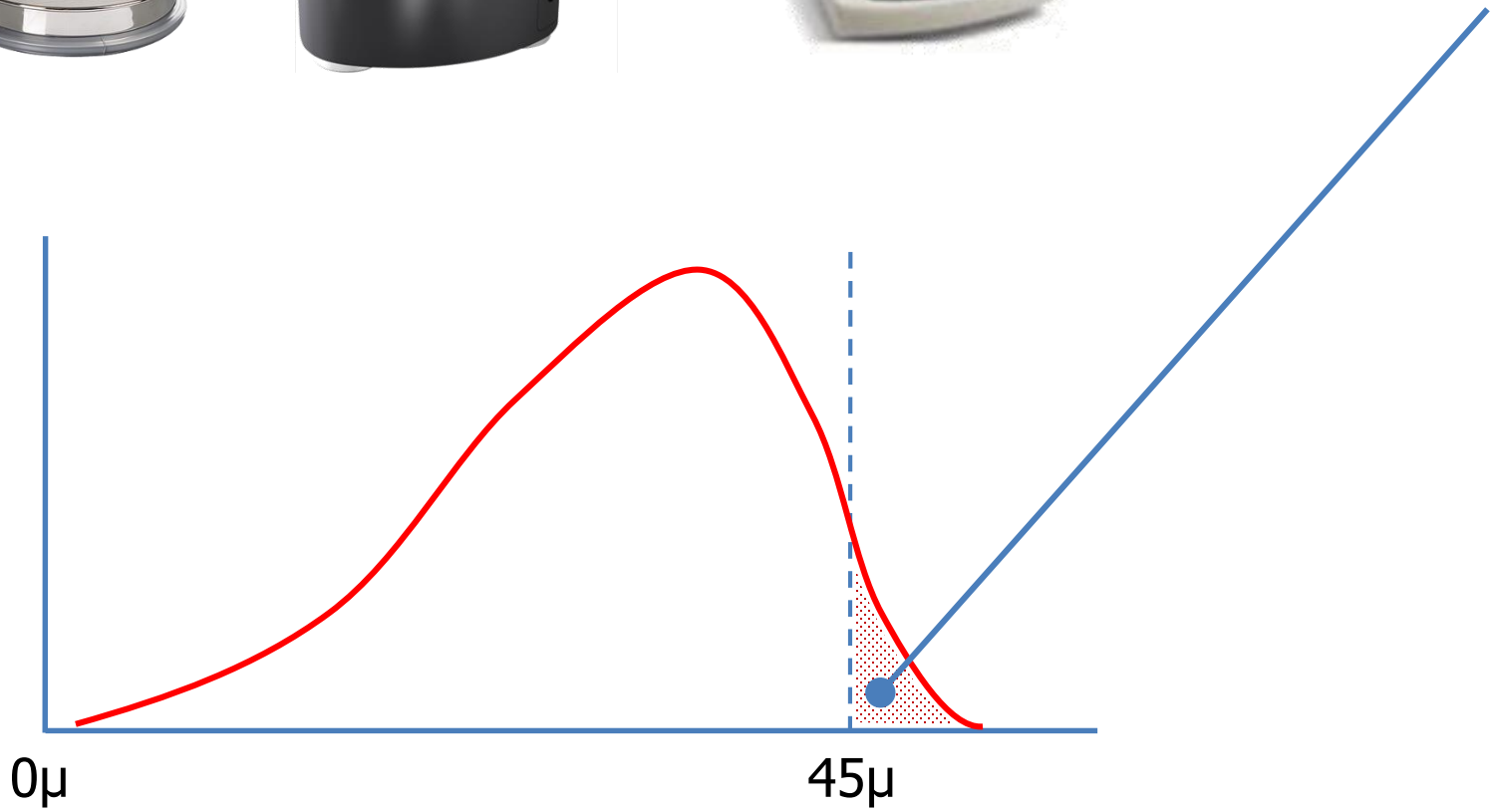
+

+

+

=

Percent Retained on #325 US Test Sieve (45 microns)

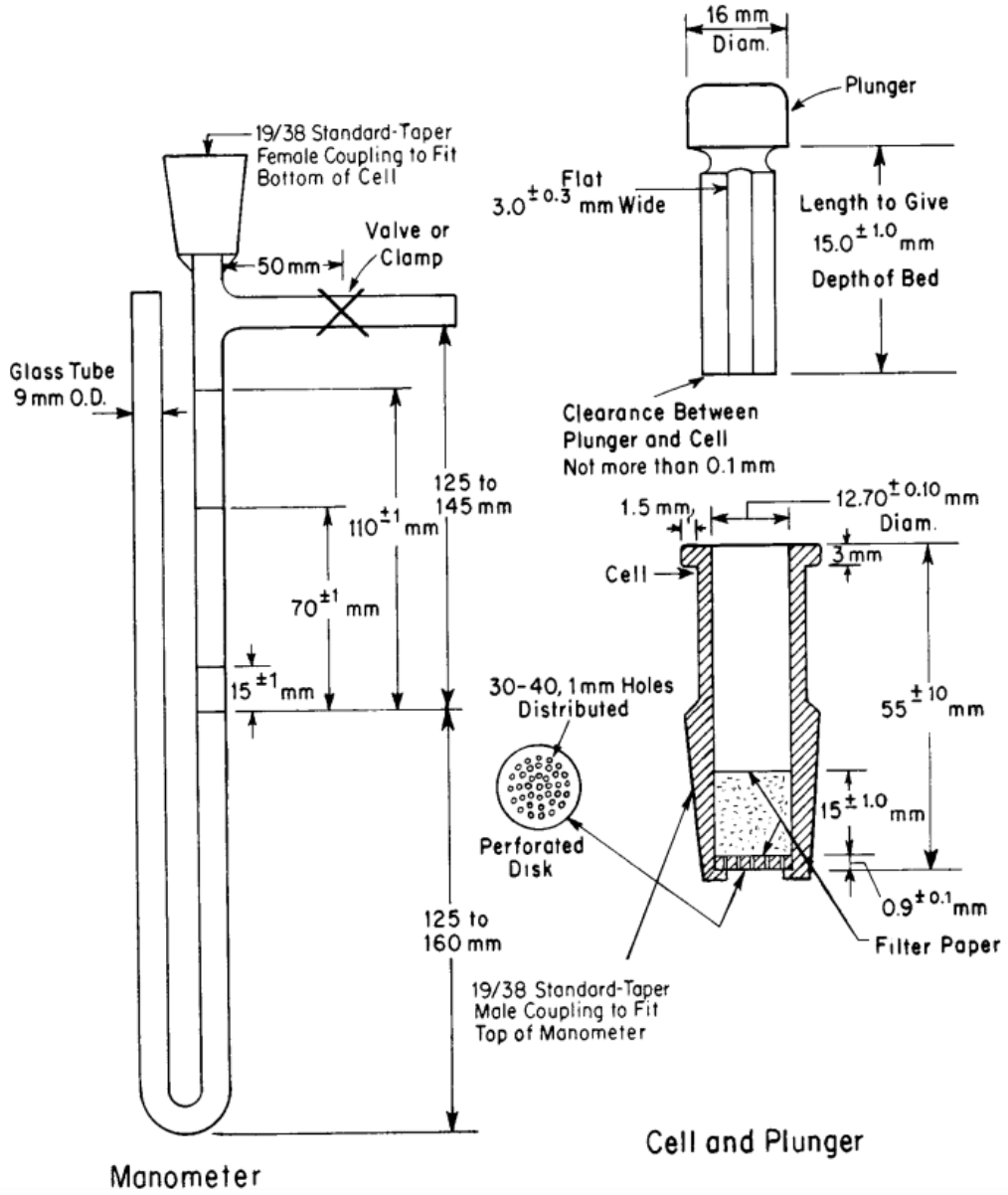


Another Way to Measure Particle Size: Blaine Air Permeability

The Blaine method consists of drawing a defined quantity of air through a bed of material.

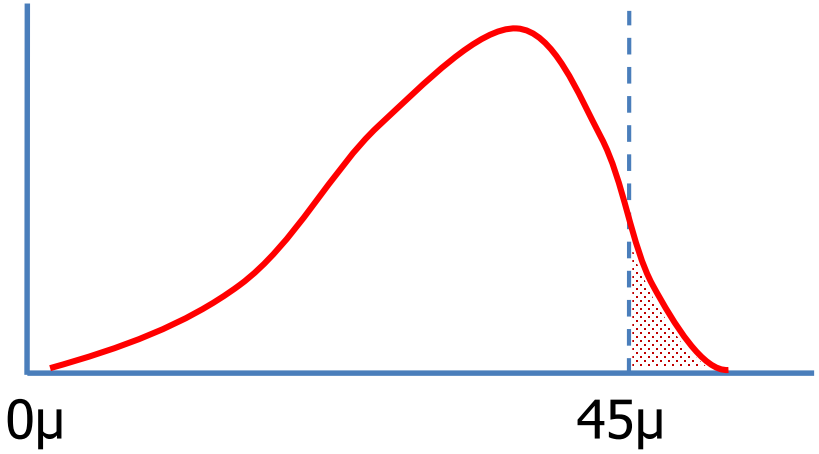
Particle characteristics, namely surface area, determine the rate of airflow through the bed.

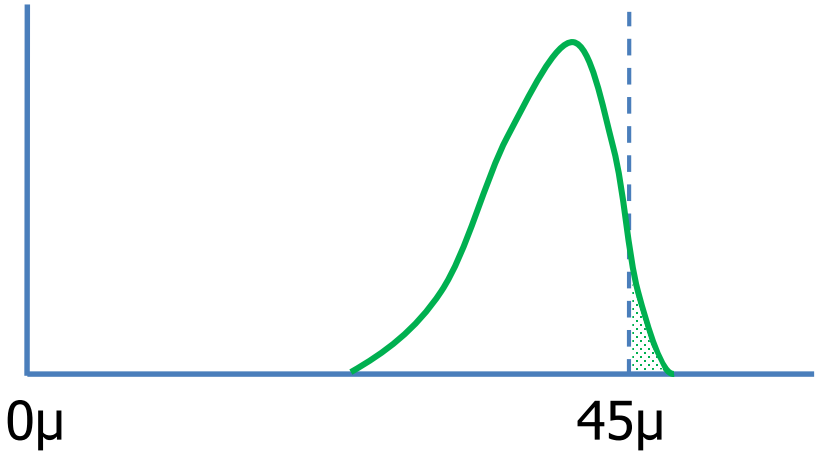
The result is not a PSD, but rather a single value such as 4000 m^2/kg.



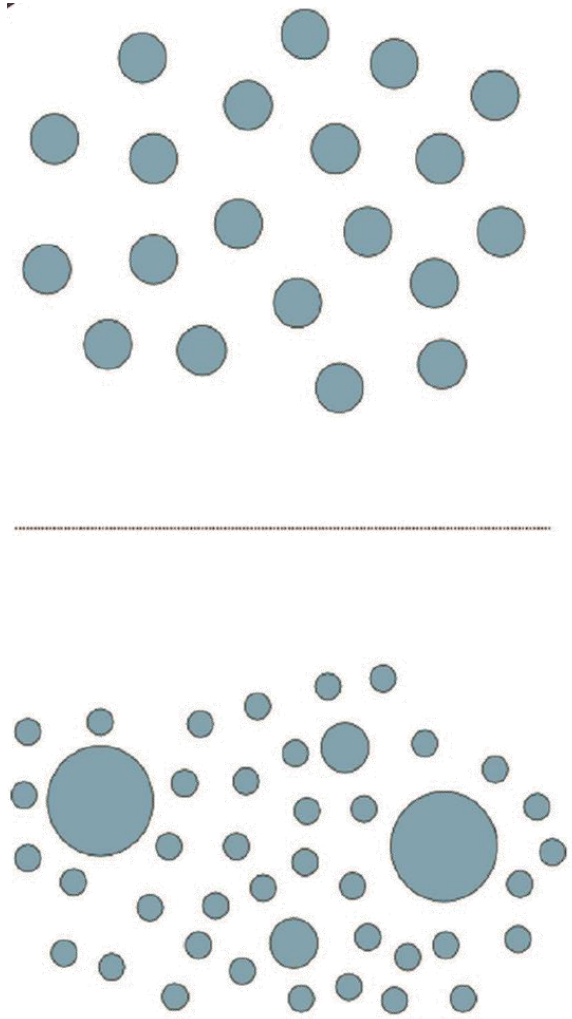
Limitations of Sieve and Blaine Methods

Both of these PSD's have the same % retained on a 45µ sieve

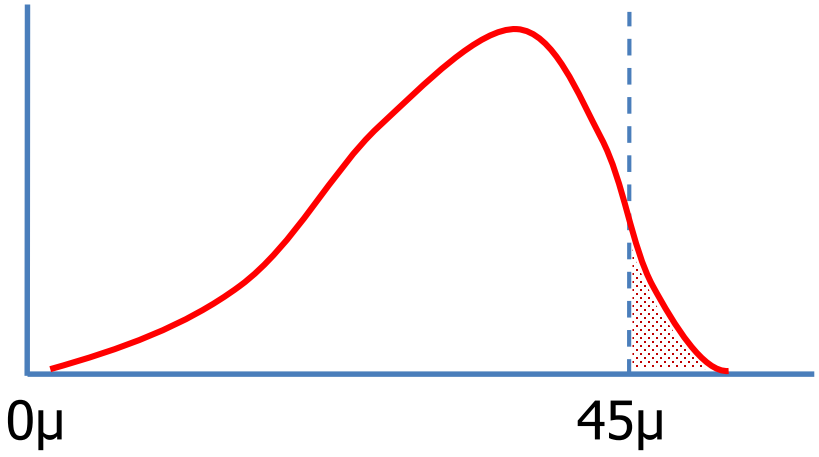


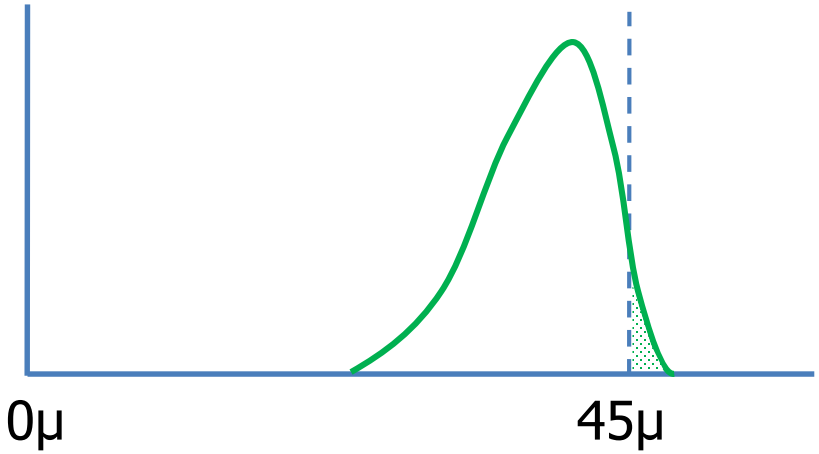


Both of these PSD's have the same Blaine number



Why Shape of the PSD Curve Matters

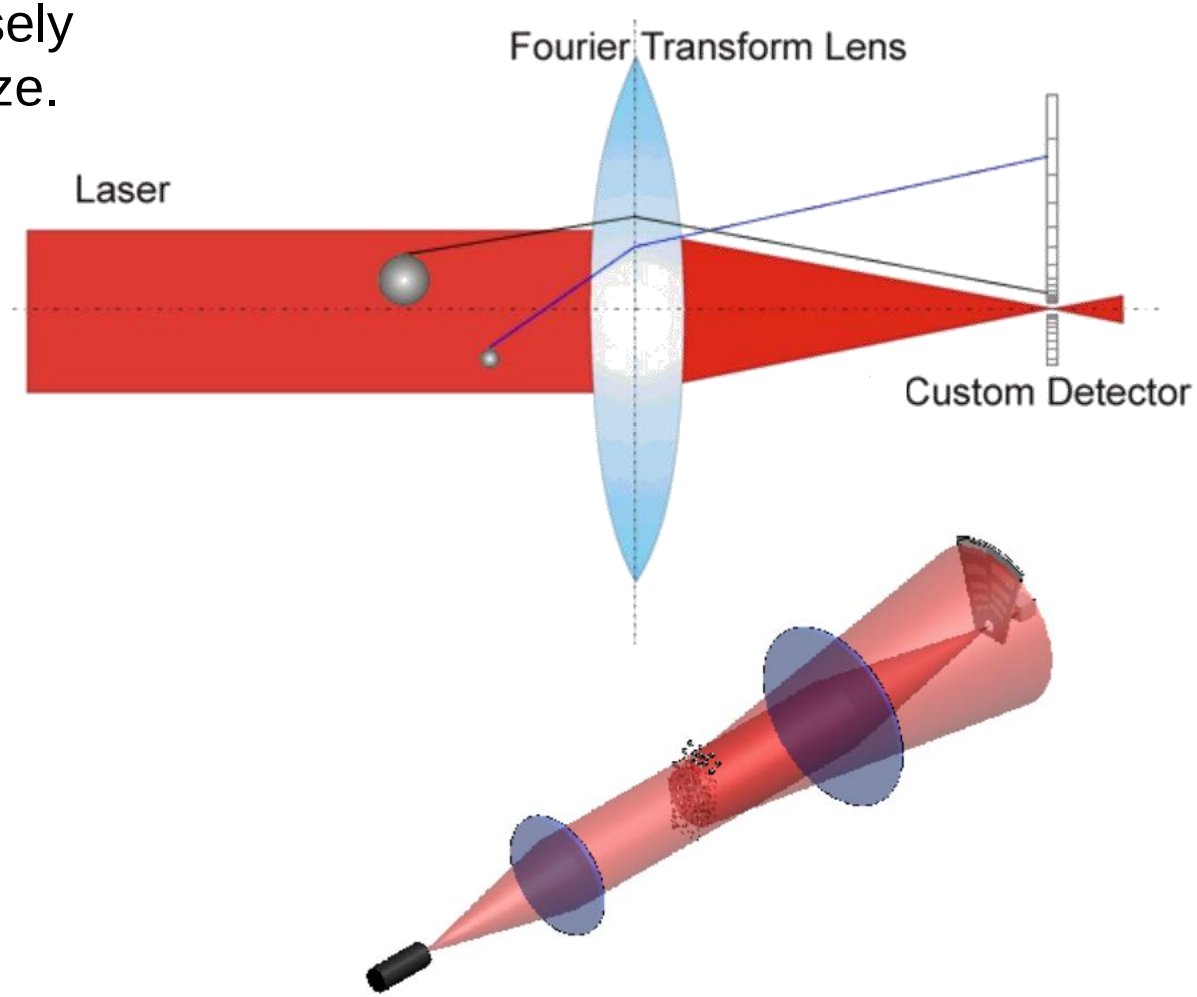




- Particles larger than 50 microns will react so slowly that they may never fully hydrate even with long curing periods and sufficient water.
- An excess of particles less than 3 microns can cause the cement to cure exothermally, which may result in cracking.
- Cements with narrower particle size distributions will have the higher compressive strength as a result of more consistent hydration.

A Better Way to Measure Particle Size: Laser Diffraction

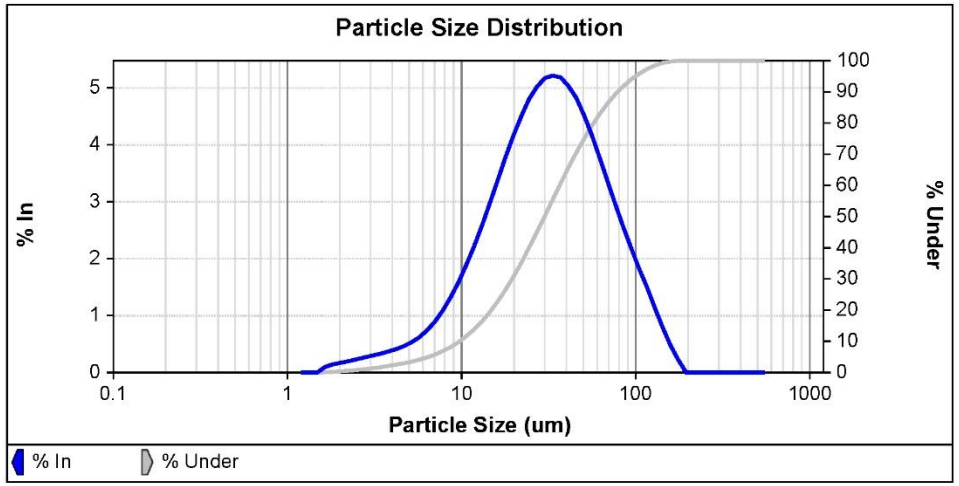
- Angular scattering of light from particles is inversely proportional to their size.



Laser Diffraction: Typical Results

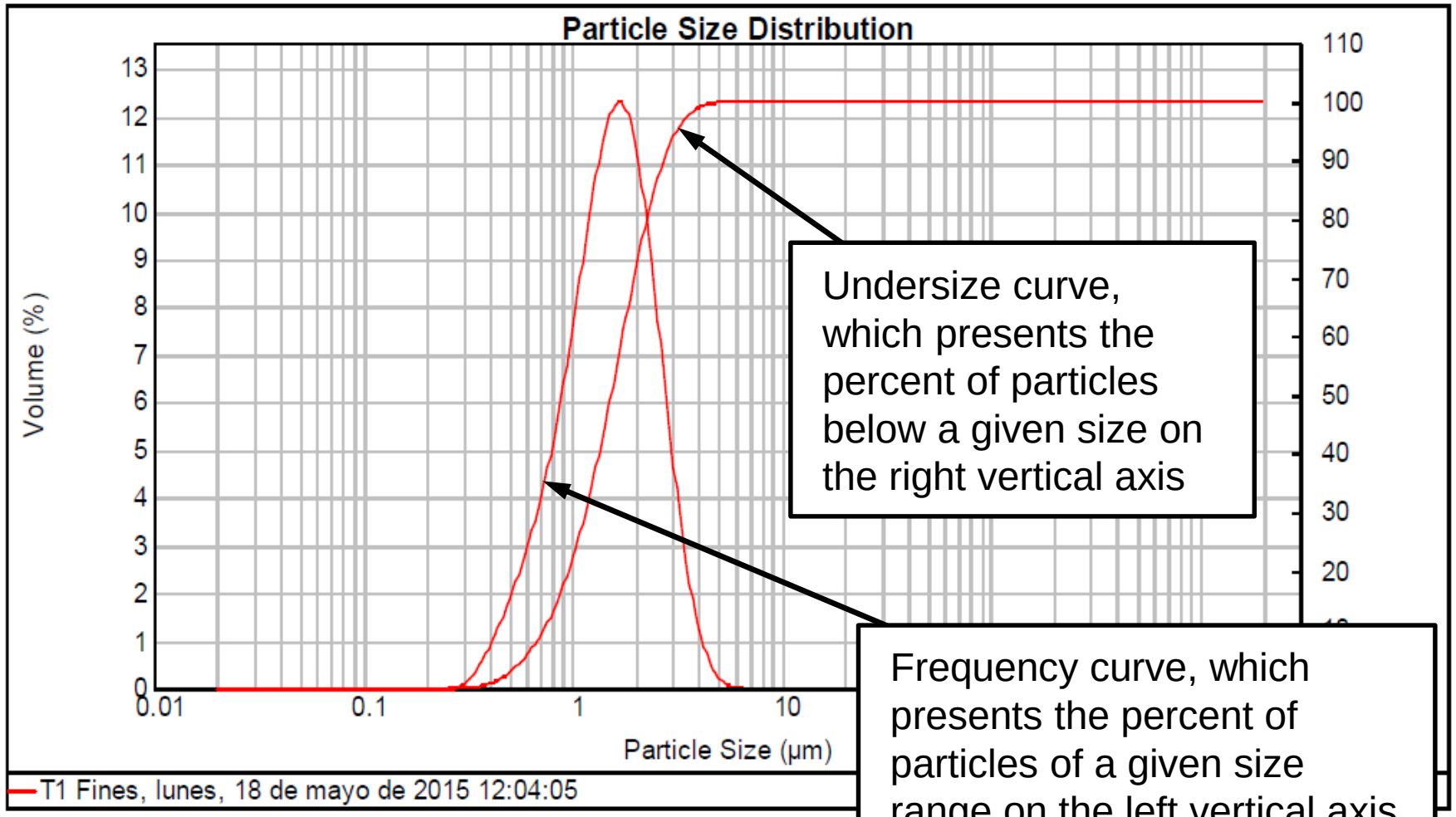
File Name:	graphene.xo		
Matrix File Name	XOFraunhofer_157_0i10_250_D(Re	**Model:**	Free Mode
Sample Name:		**Dispersant Name**	
Sample Provider		**Operator:**	OPERATOR
Record Status:	OCL	**Notes:**	

Record Number:	5 in Total				
Measure Time:	See Extended Info Pages				
Loading:	36.33 %	**x50:**	29.88 um	**x90:**	78.73 um
x99:	137.17 um	**x10:**	9.72 um	**x98:**	122.77 um



Size (um)	% In	% Under	Size (um)	% In	% Under	Size (um)	% In	% Under	Size (um)	% In	% Under
1.20	-	-	5.70	0.62	4.13	27.06	5.02	45.06	128.50	1.14	98.50
1.33	-	-	6.32	0.74	4.87	30.02	5.17	50.23	142.56	0.79	99.29
1.48	-	-	7.01	0.90	5.77	33.31	5.22	55.44	158.16	0.48	99.77
1.64	0.10	0.10	7.78	1.08	6.85	36.95	5.19	60.63	175.47	0.23	100.00
1.82	0.14	0.24	8.63	1.32	8.17	41.00	5.04	65.67	194.68	-	100.00
2.02	0.17	0.41	9.58	1.58	9.75	45.48	4.83	70.50	215.98	-	100.00
2.24	0.20	0.61	10.63	1.89	11.64	50.46	4.52	75.02	239.62	-	100.00
2.48	0.23	0.84	11.79	2.22	13.86	55.98	4.17	79.19	265.85	-	100.00
2.75	0.26	1.11	13.08	2.59	16.44	62.11	3.77	82.96	294.94	-	100.00
3.06	0.30	1.40	14.51	2.97	19.42	68.91	3.36	86.32	327.22	-	100.00
3.39	0.33	1.74	16.10	3.38	22.79	76.45	2.95	89.27	363.03	-	100.00
3.76	0.37	2.10	17.86	3.78	26.57	84.82	2.55	91.82	402.76	-	100.00
4.17	0.41	2.52	19.82	4.16	30.73	94.10	2.20	94.02	446.84	-	100.00
4.63	0.46	2.98	21.98	4.50	35.24	104.40	1.83	95.85	495.74	-	100.00
5.14	0.53	3.51	24.39	4.80	40.04	115.82	1.50	97.35	550.00	-	100.00

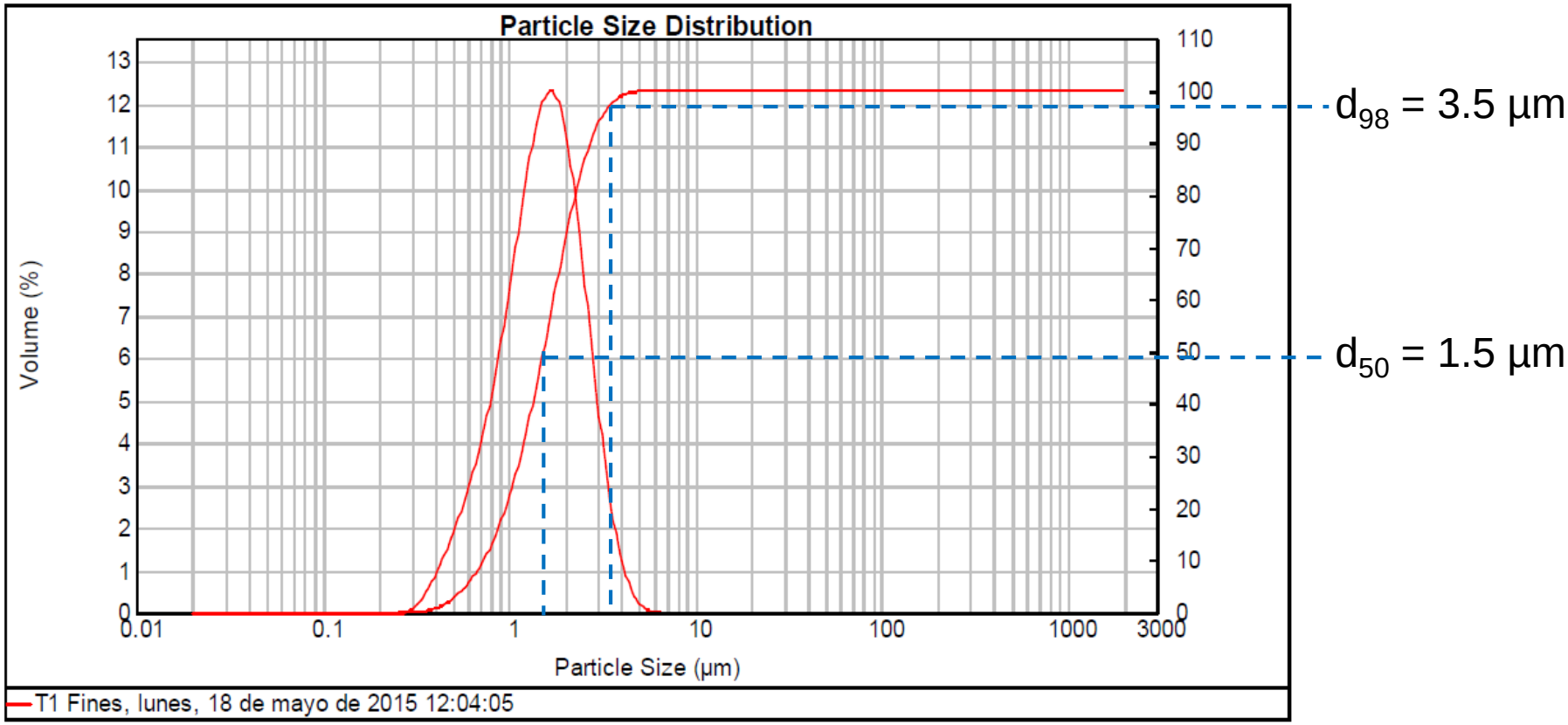
Two Ways to Present PSD Data



Points on the PSD Curve: d_{98} d_{50}

Typical values to define the PSD are "d_X", which is the diameter which x% of the sample's mass is finer than. For example…

- d_{98} = 3.5µm means that 98% of the sample's mass is finer than 3.5µ
- d_{50} = 1.5µm means that 50% of the sample's mass is finer than 1.5µm



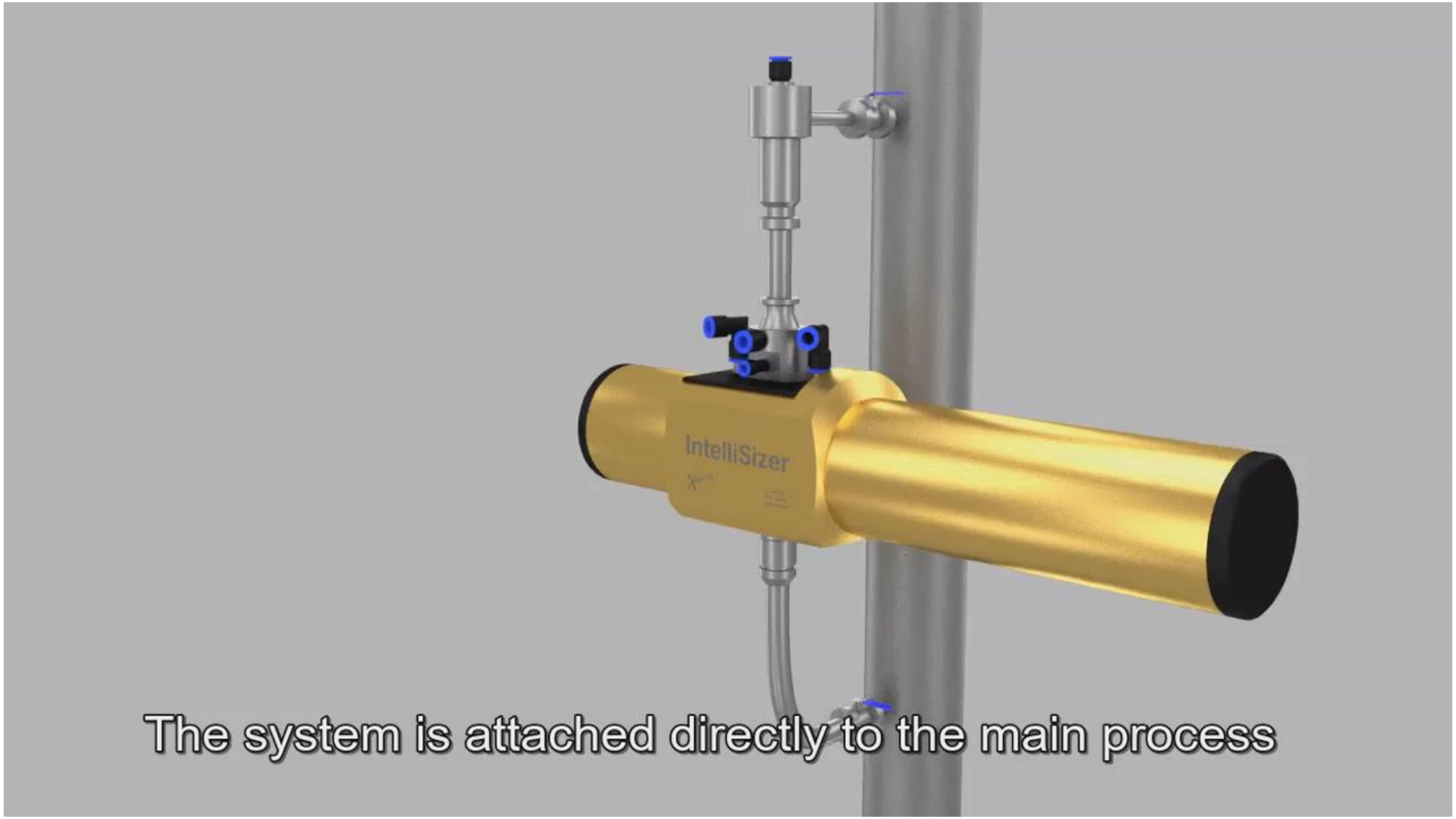
Limitations Shared by All Laboratory Based Analysis Methods

1. ***Variability in operator's sampling technique***

2. ***Variability in lab technician's analysis technique***

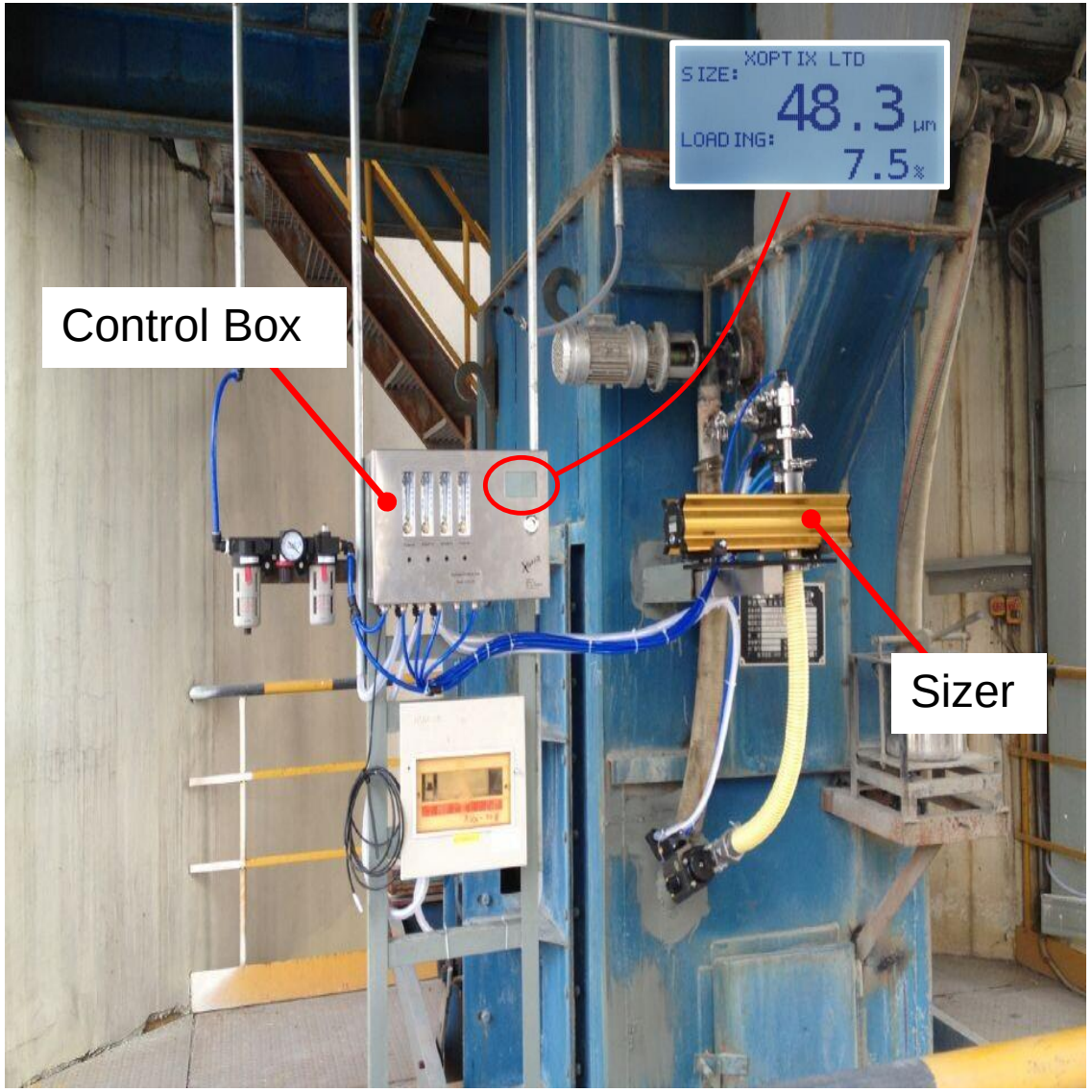
3. ***Time lag to get results…often 2 hours or more***

A Better Way to Sample and Analyze Powders: Xoptix



See the video at: https://www.youtube.com/watch?v=USCmPrQGwuE&t=2s

Typical Installation

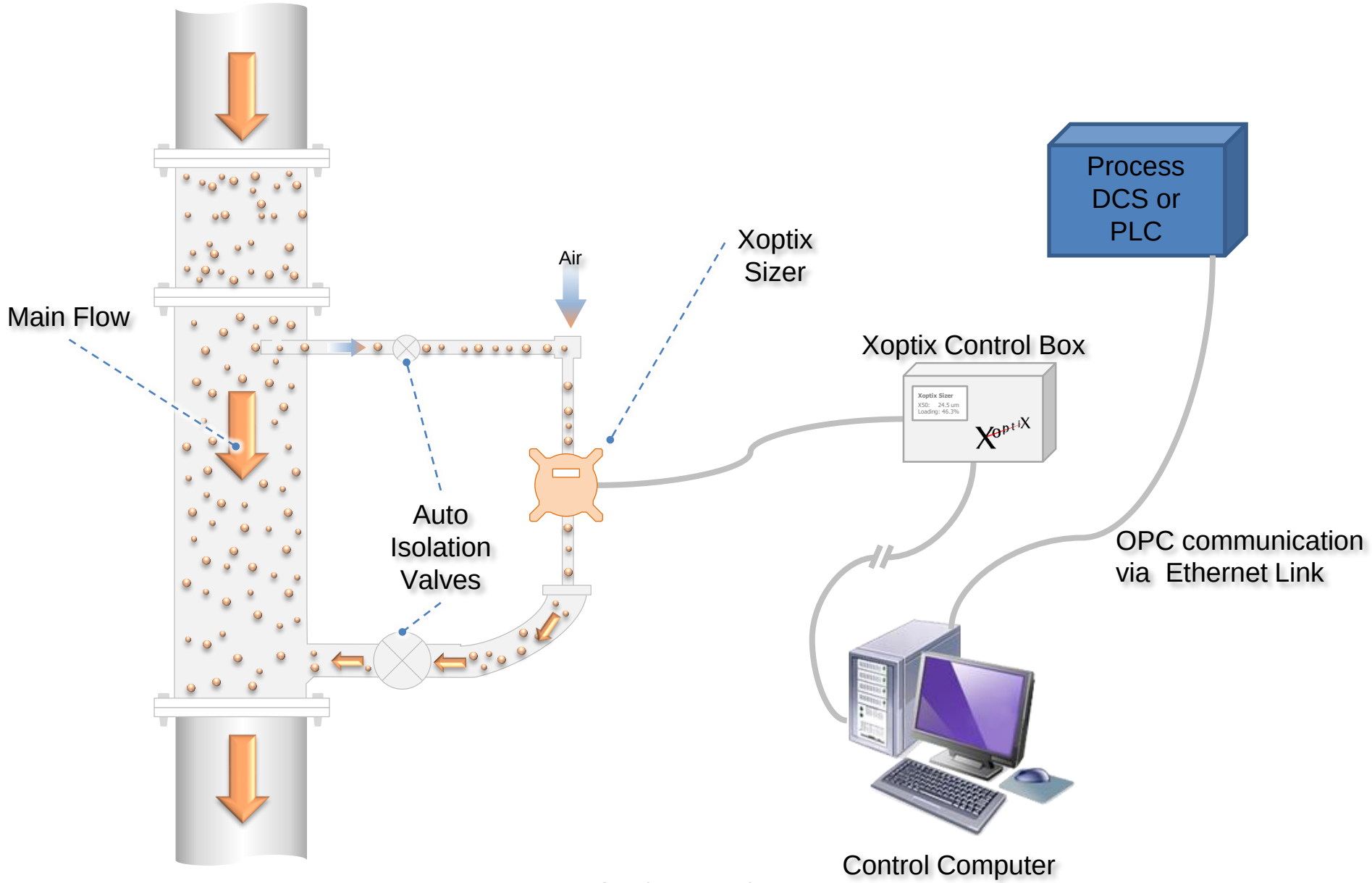


The Sizer and the Control Box are mounted near the sample point.

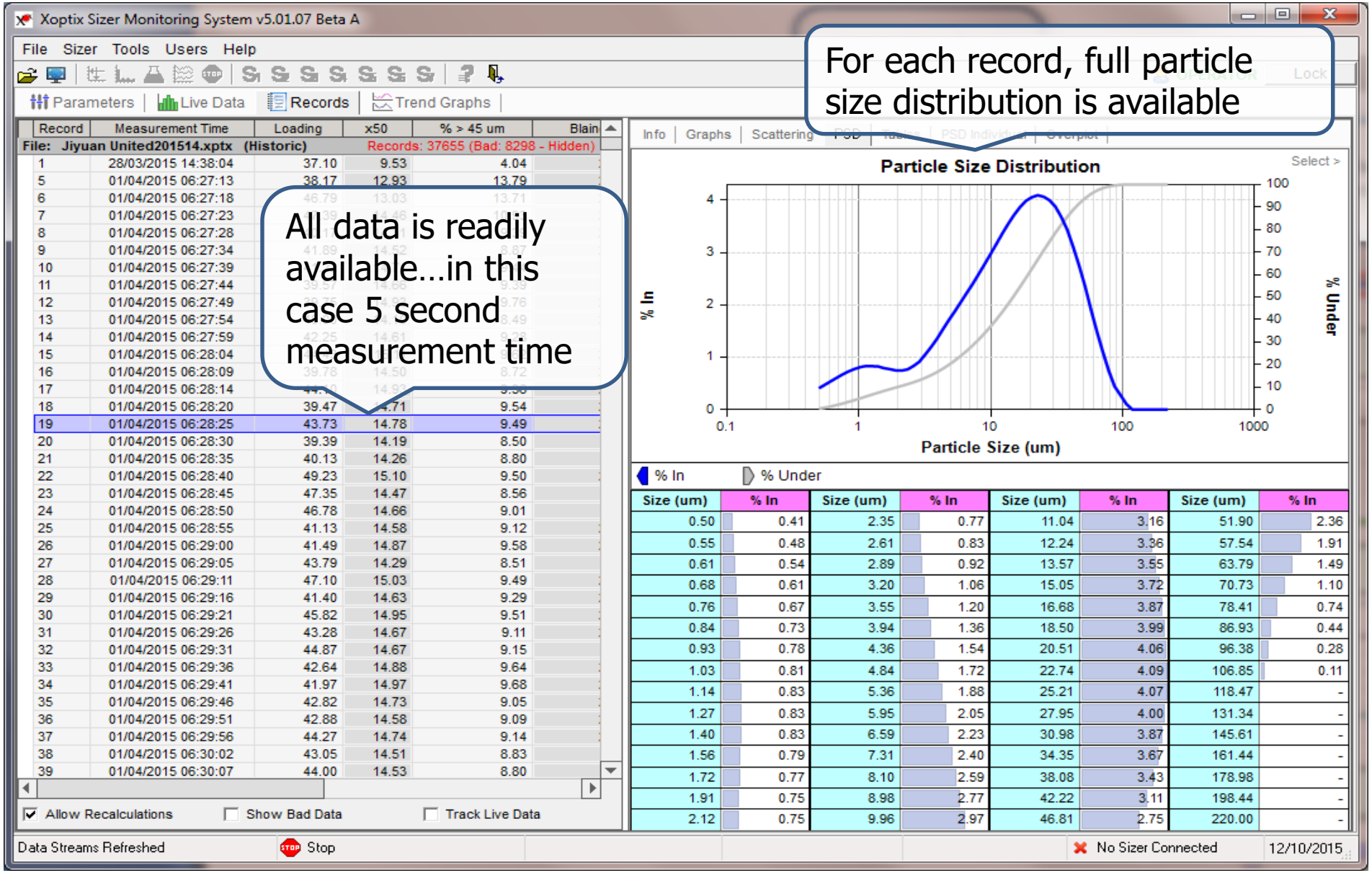
The Control Box has a small display that can read out any one of a number of parameters, such as the d_{50} value.

For full PSD characterization, trend tracking and data logging a separate PC is required.
It can be either a local touch screen industrial PC at the sample point or a standard desktop PC located remotely and connected via an RS422 serial link.

Schematic for a Typical Dry Installation



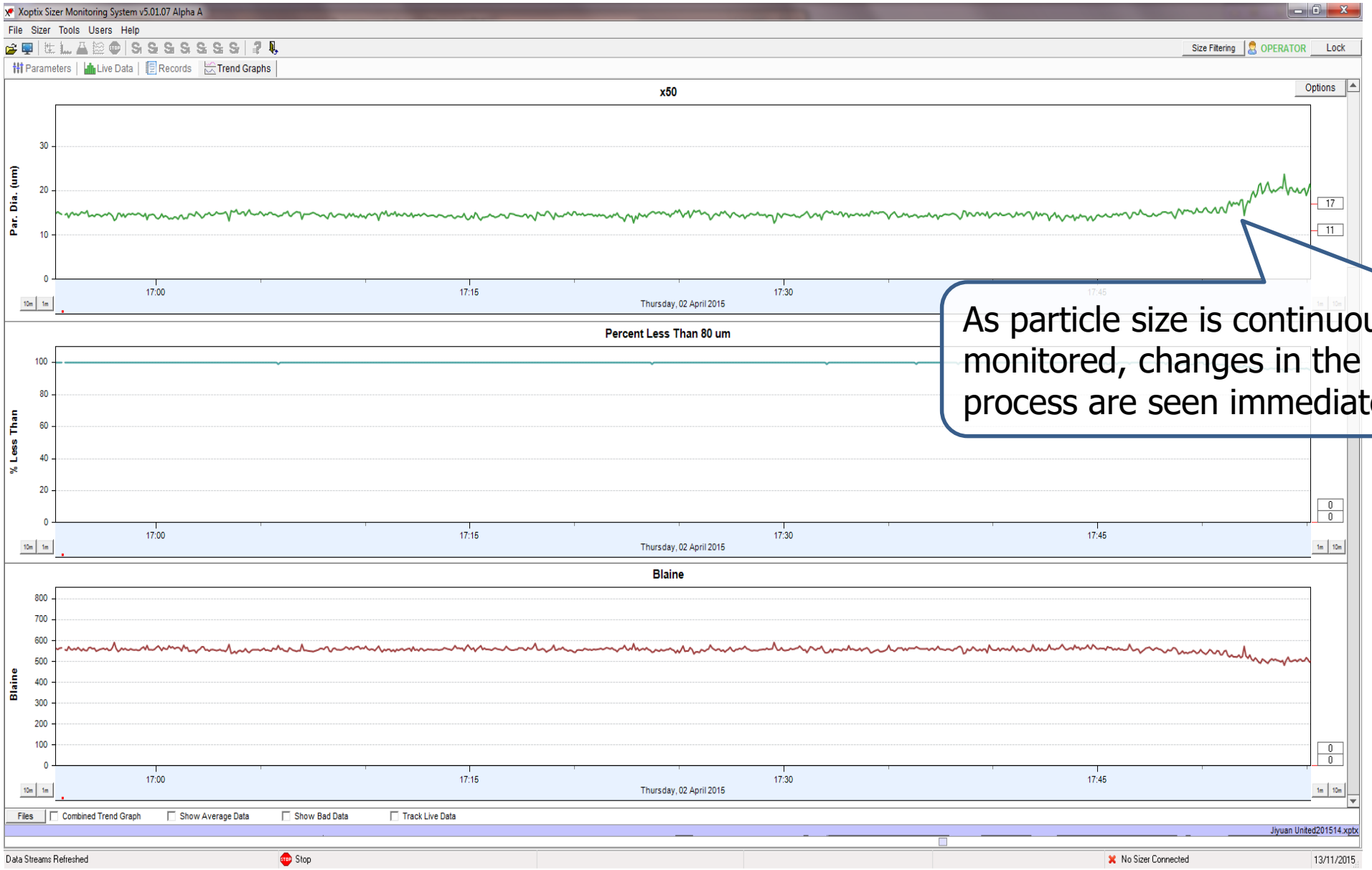
Records Screen



Record	Measurement Time	Loading	x50	% > 45 um	Blain
File: Jiyuan United201514.xptx (Historic)			Records: 37655 (Bad: 8298 - Hidden)		
1	28/03/2015 14:38:04	37.10	9.53	4.04	
5	01/04/2015 06:27:13	38.17	12.93	13.79	
6	01/04/2015 06:27:18	46.79	13.03	13.71	
7	01/04/2015 06:27:23	39.38	14.66	9.39	
8	01/04/2015 06:27:28	39.75	14.83	9.76	
9	01/04/2015 06:27:34	41.89	14.52	8.87	
10	01/04/2015 06:27:39	41.32	14.81	8.49	
11	01/04/2015 06:27:44	39.57	14.66	9.39	
12	01/04/2015 06:27:49	39.75	14.83	9.76	
13	01/04/2015 06:27:54	41.32	14.81	8.49	
14	01/04/2015 06:27:59	42.25	14.61	8.72	
15	01/04/2015 06:28:04	39.78	14.50	8.72	
16	01/04/2015 06:28:09	39.78	14.50	8.72	
17	01/04/2015 06:28:14	44.00	14.99	9.58	
18	01/04/2015 06:28:20	39.47	14.71	9.54	
19	01/04/2015 06:28:25	43.73	14.78	9.49	
20	01/04/2015 06:28:30	39.39	14.19	8.50	
21	01/04/2015 06:28:35	40.13	14.26	8.80	
22	01/04/2015 06:28:40	49.23	15.10	9.50	
23	01/04/2015 06:28:45	47.35	14.47	8.56	
24	01/04/2015 06:28:50	46.78	14.66	9.01	
25	01/04/2015 06:28:55	41.13	14.58	9.12	
26	01/04/2015 06:29:00	41.49	14.87	9.58	
27	01/04/2015 06:29:05	43.79	14.29	8.51	
28	01/04/2015 06:29:11	47.10	15.03	9.49	
29	01/04/2015 06:29:16	41.40	14.63	9.29	
30	01/04/2015 06:29:21	45.82	14.95	9.51	
31	01/04/2015 06:29:26	43.28	14.67	9.11	
32	01/04/2015 06:29:31	44.87	14.67	9.15	
33	01/04/2015 06:29:36	42.64	14.88	9.64	
34	01/04/2015 06:29:41	41.97	14.97	9.68	
35	01/04/2015 06:29:46	42.82	14.73	9.05	
36	01/04/2015 06:29:51	42.88	14.58	9.09	
37	01/04/2015 06:29:56	44.27	14.74	9.14	
38	01/04/2015 06:30:02	43.05	14.51	8.83	
39	01/04/2015 06:30:07	44.00	14.53	8.80	

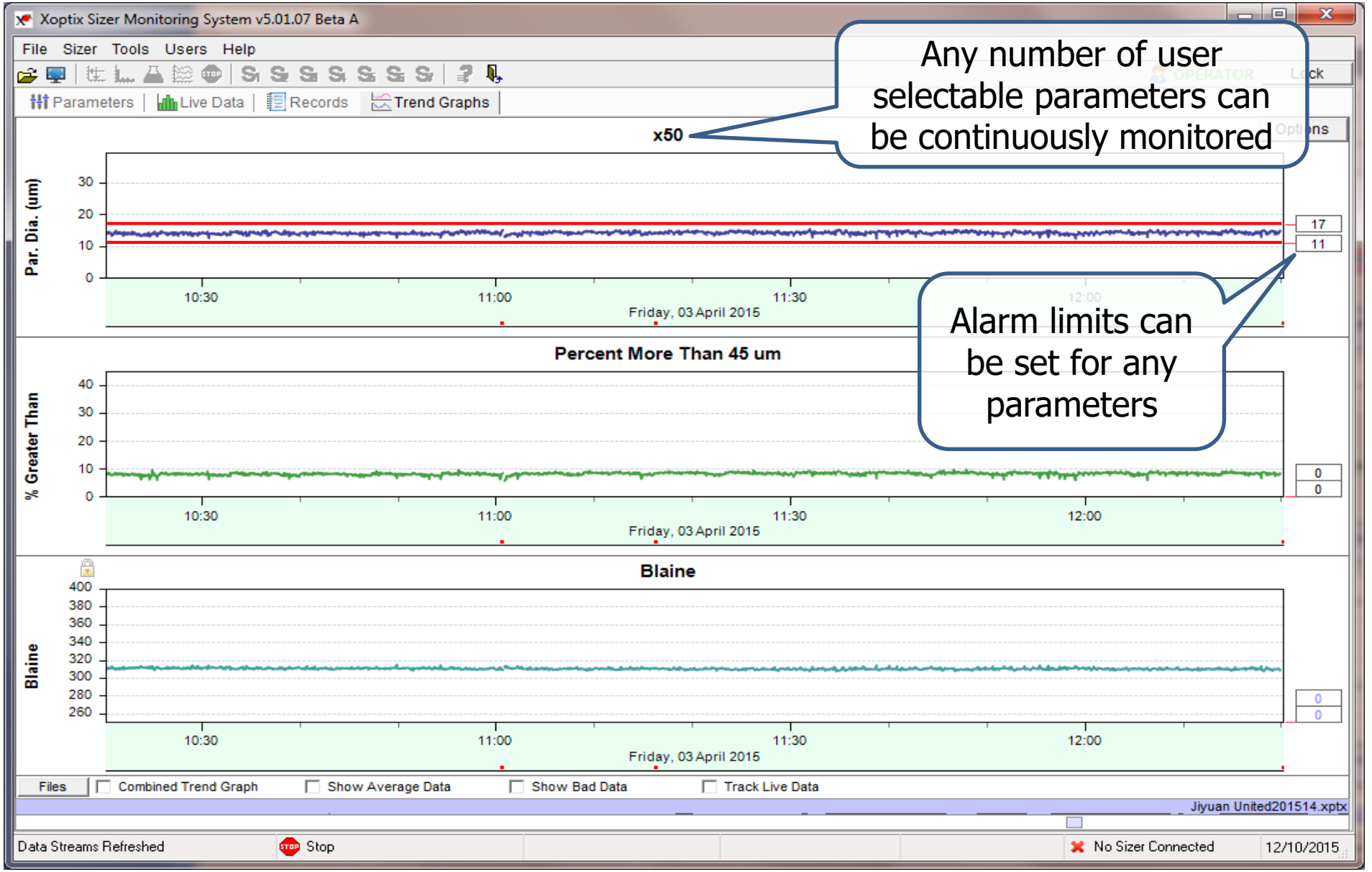
Size (um)	% In	Size (um)	% In	Size (um)	% In	Size (um)	% In
0.50	0.41	2.35	0.77	11.04	3.16	51.90	2.36
0.55	0.48	2.61	0.83	12.24	3.36	57.54	1.91
0.61	0.54	2.89	0.92	13.57	3.55	63.79	1.49
0.68	0.61	3.20	1.06	15.05	3.72	70.73	1.10
0.76	0.67	3.55	1.20	16.68	3.87	78.41	0.74
0.84	0.73	3.94	1.36	18.50	3.99	86.93	0.44
0.93	0.78	4.36	1.54	20.51	4.06	96.38	0.28
1.03	0.81	4.84	1.72	22.74	4.09	106.85	0.11
1.14	0.83	5.36	1.88	25.21	4.07	118.47	-
1.27	0.83	5.95	2.05	27.95	4.00	131.34	-
1.40	0.83	6.59	2.23	30.98	3.87	145.61	-
1.56	0.79	7.31	2.40	34.35	3.67	161.44	-
1.72	0.77	8.10	2.59	38.08	3.43	178.98	-
1.91	0.75	8.98	2.77	42.22	3.11	198.44	-
2.12	0.75	9.96	2.97	46.81	2.75	220.00	-

Trend Graphs Screen Showing Change in PSD

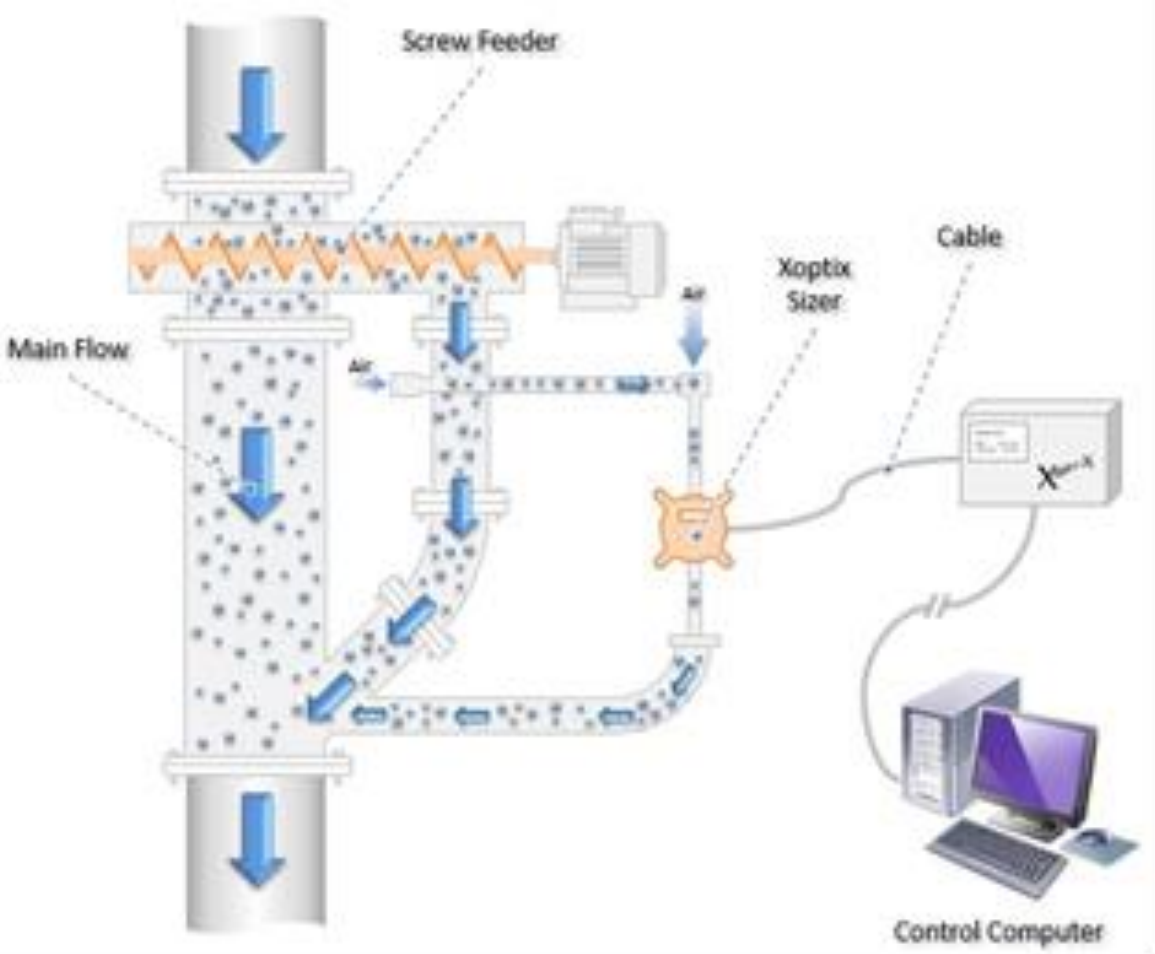


As particle size is continuously monitored, changes in the process are seen immediately

Trend Graphs Screen with Alarm Limits



Case History: China United Cement Company Limited



Xoptix Trend Lines During Mill Speed Adjustment

Improvements Attributable to Xoptix In-Process Monitoring

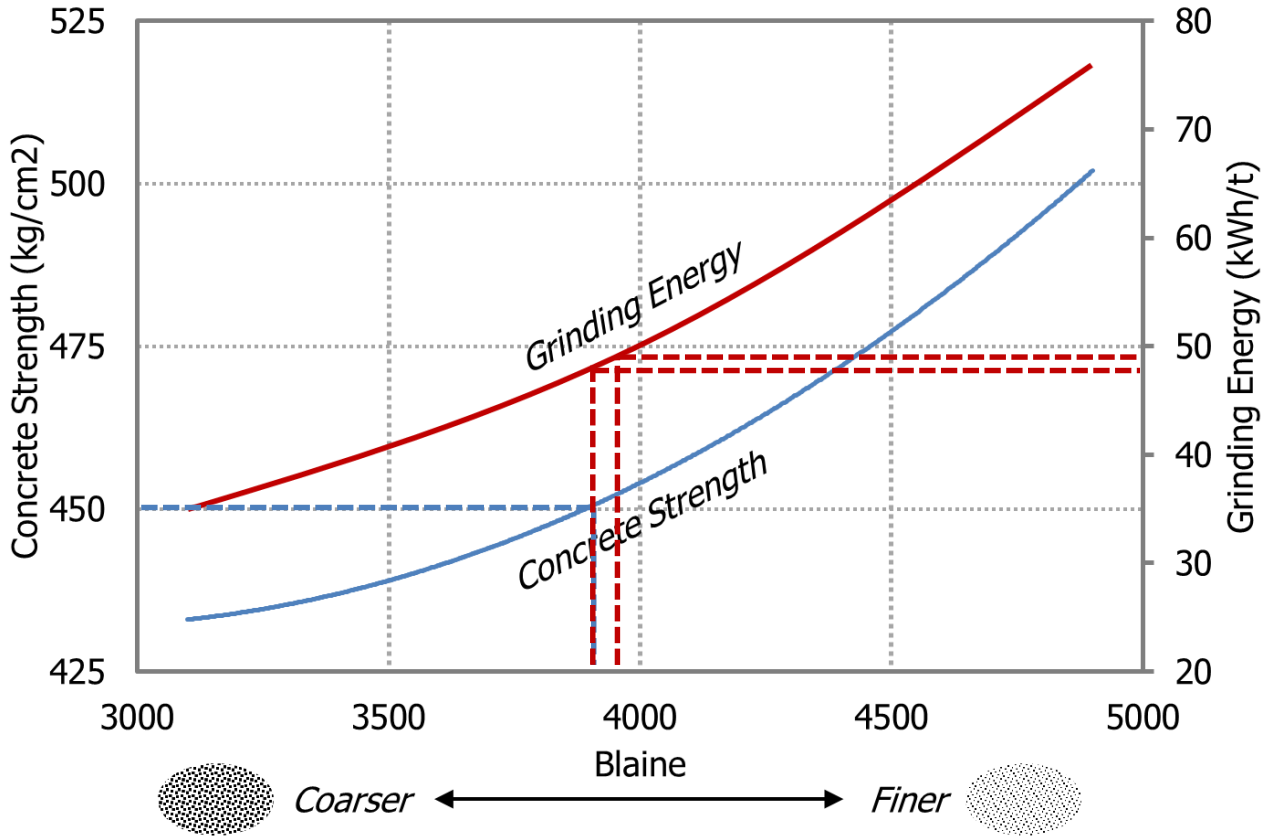
	Throughput	3 Day Cement Strength	28 Day Cement Strength	Standard Deviation of 28 Day Cement Strength
Before Xoptix	182 t/h	16.5 MPa	38.4 MPa	1.63
After Xoptix	188 t/h	16.9 MPa	39.1 MPa	0.46

Benefits of Xoptix In-Process Monitoring

✓ ***Higher throughout***

Assume 2MW Ball Mill…

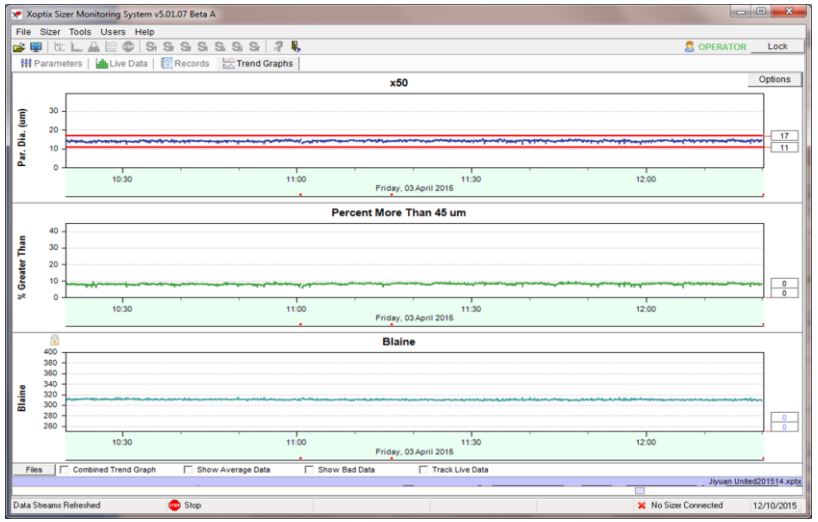
	Manual	Xoptix
Grinding Energy	49 kWh/t	48 kWh/t
Throughput	40.8 t/h	41.7 t/h



Benefits of Xoptix In-Process Monitoring

✓ *Higher throughout*

✓ ***Improved product quality & consistency***



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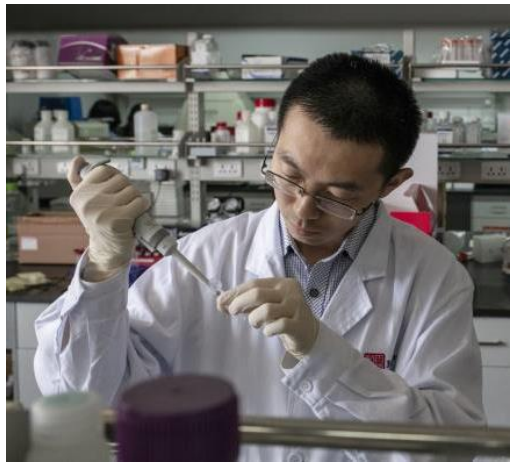
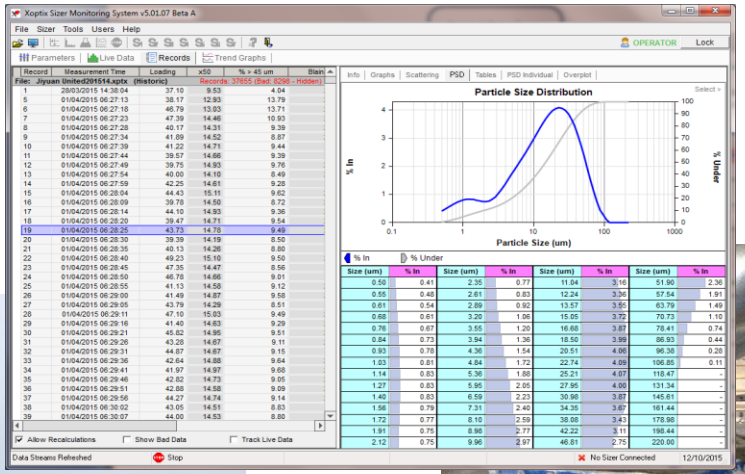
✓ *Improved product quality & consistency*

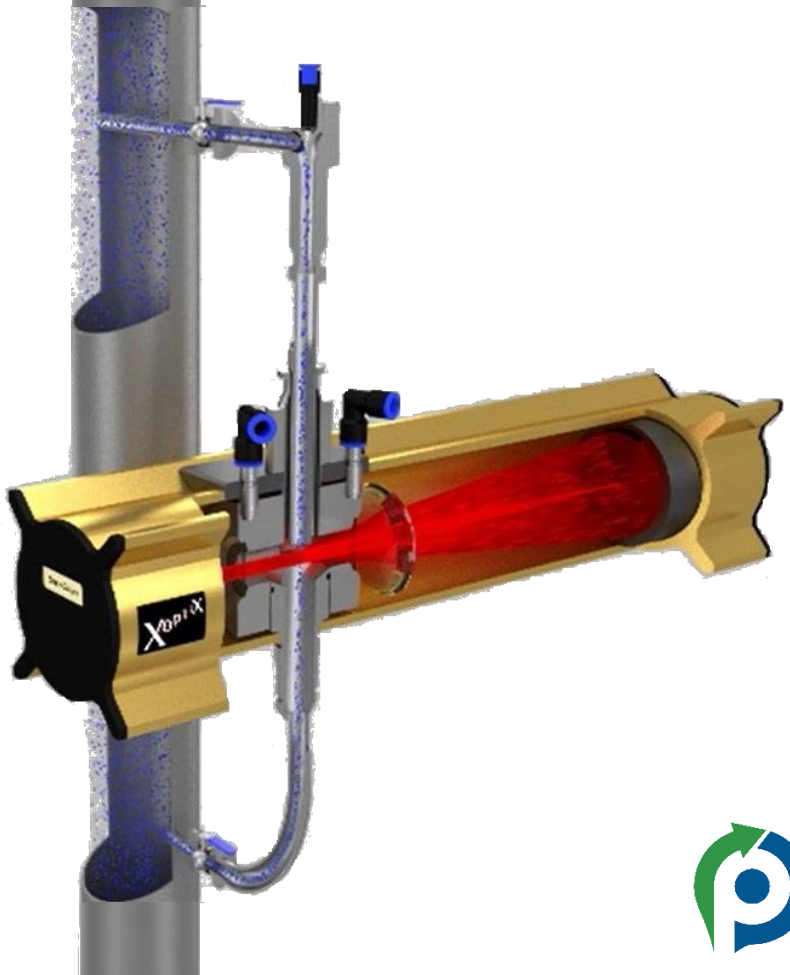


✓ ***Reduced laboratory expenses***

Live Demonstration – Booth 204

Questions…





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