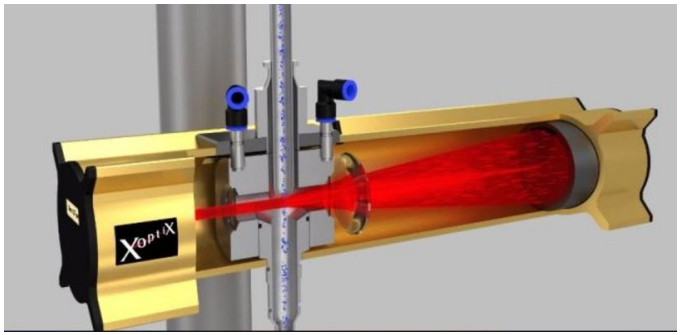
Industrial Minerals Association – North America
IMA-NA
Industrial Minerals Association North America
2019 Technology Workshop

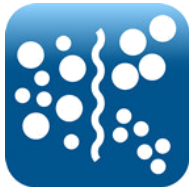
Size Matters… So How Do You Measure Up?

Particle Size Characterization Methods and Their Effect on Your Business

A.J. DeCenso
Preferred Process Solutions, LLC



Centrifuging



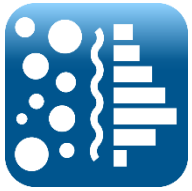
Screening

Milling

Sorting

Preferred Process Solutions

Air Classifying



Analyzing

Plant Design

Coating

Companies Represented

SWECO

- ✓ Screening Equipment
- ✓ Centrifuges
- ✓ Vibratory Mills

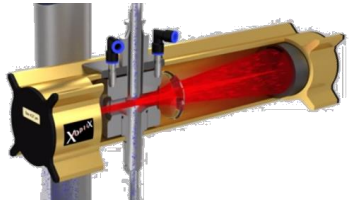
ecutec®

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

TOMRA SORTING SOLUTIONS

- ✓ Sensor Based Ore Sorters

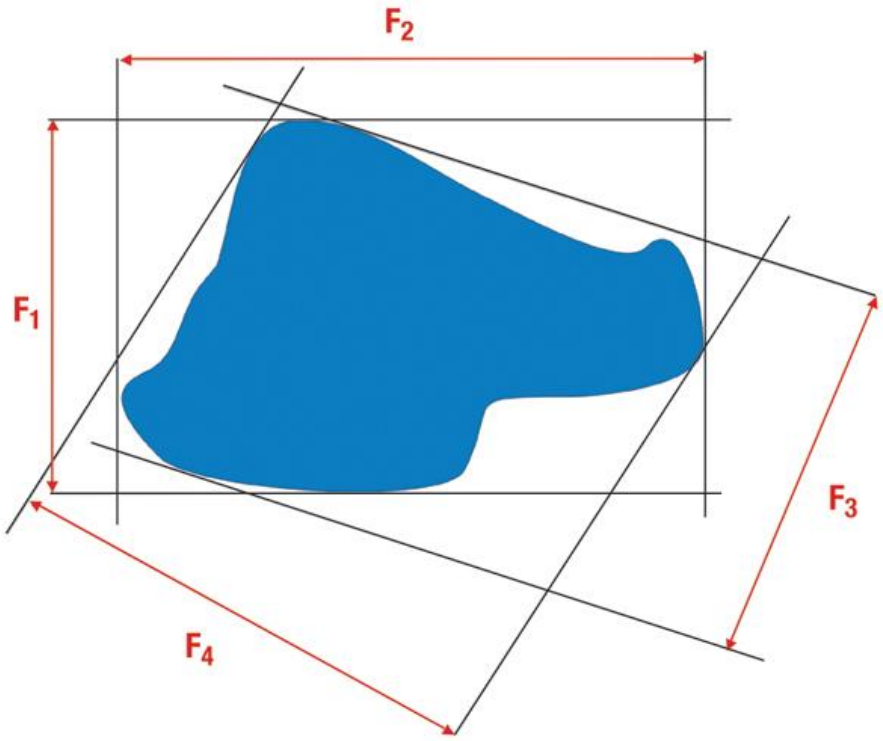
XoptiX

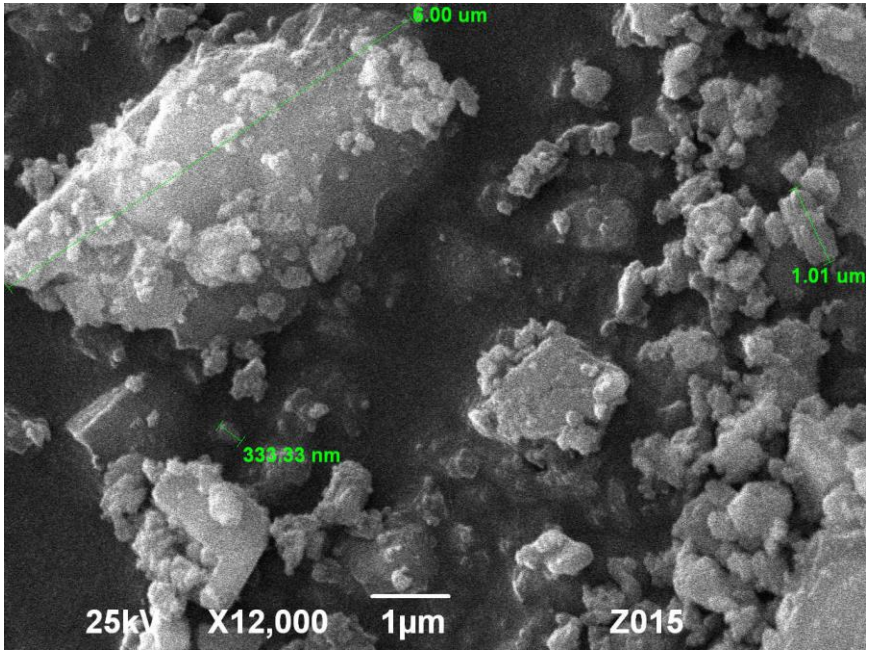


- ✓ On-Line Particle Size Analyzers

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

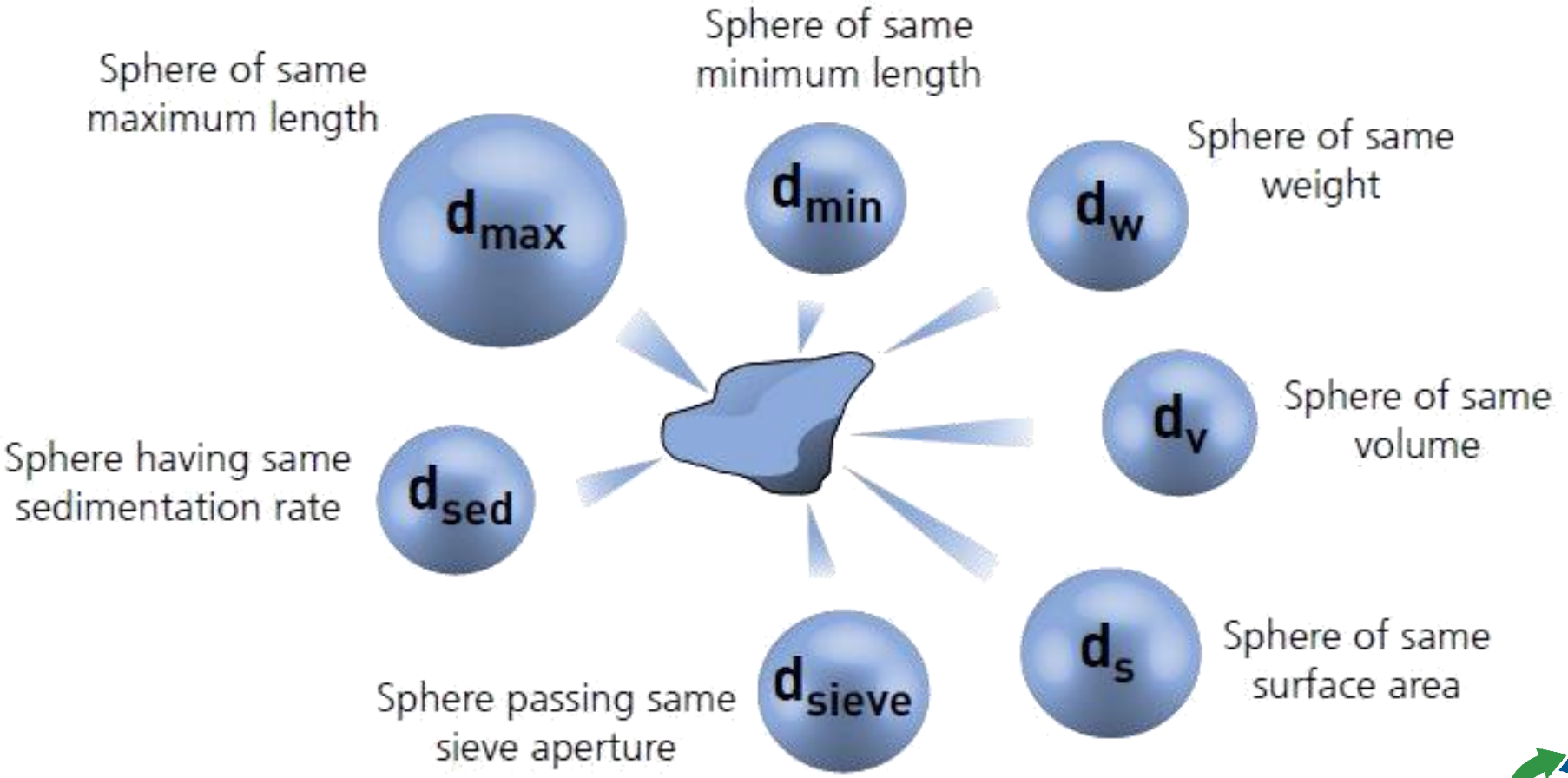
- The majority of industrial minerals particles are non-spherical.
- So how do we quantify the size of an irregularly shaped particle?





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

Most particle sizing techniques assume sphericity, as a sphere is the only object which can be characterized with one single parameter, its diameter.

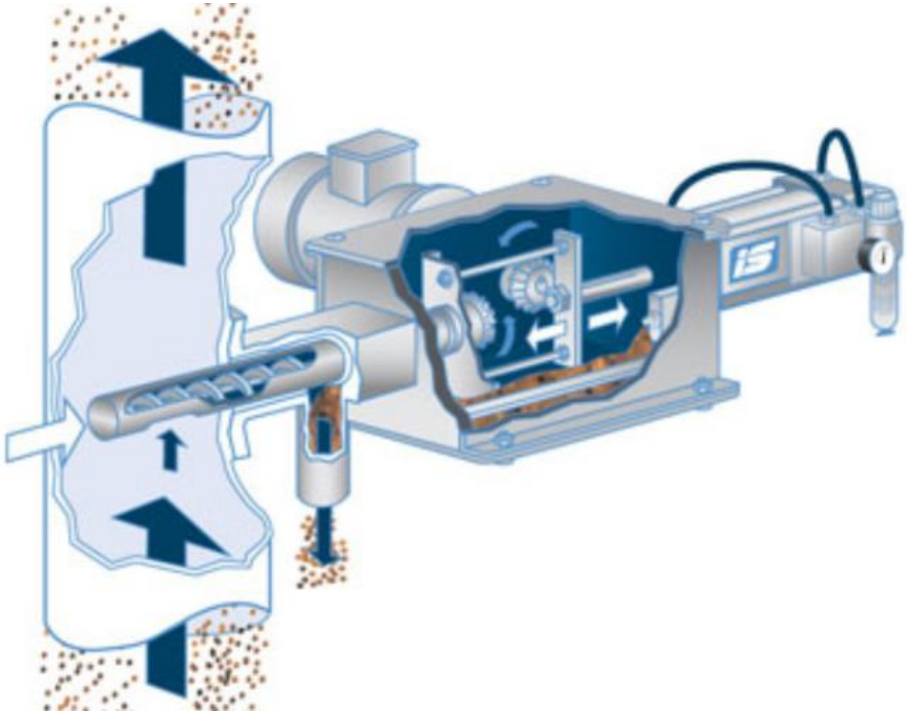


Sampling

- So now we've decided how to measure the size of one particle.
- But our process is producing trillions of particles per hour.
- We can't measure every one, so what do we do?

Not a good way to sample!

Automatic Sampler & Riffle Splitter



Sieving: How it works…

- Sieves are stacked coarsest to finest with a pan on the bottom.
- Sample placed on top (coarsest) test sieve.

- Sieve stack is exposed to motion to segregate particles onto each sieve.
- Stack is broken down and contents on each sieve and the pan is weighed.

Sieving: Typical Results

Sieve No.	Sieve Size	Wt. Retained (g)	% Retained	Cumulative Retained %	Com. % Passing
inch	mm		(wt. ret./ Total) 100%	Sum % Retained	100 - Com. Ret.
1"	25	10	0.5	0.5	99.5
3/4"	19	50	2.5	3	97
1/2"	12.5	140	7	10	90
3/8"	9.5	250	12.5	22.5	77.5
# 4	4.75	340	17	39.5	60.5
# 8	2.36	50	2.5	42	58
# 16	1.18	450	22.5	64.5	35.5
# 30	0.6	200	10	74.5	25.5
# 50	0.3	175	8.75	83.25	16.75
# 100	0.15	225	11.25	94.5	5.5
# 200	0.075	100	5	99.5	0.5
Pan	Pan	10	0.5	100	0

Sieving: Considerations…

Advantages:

- Very low initial investment

Disadvantages:

- Repeatability can be poor due to variability in operators' techniques
- Not appropriate for powders

Considerations:

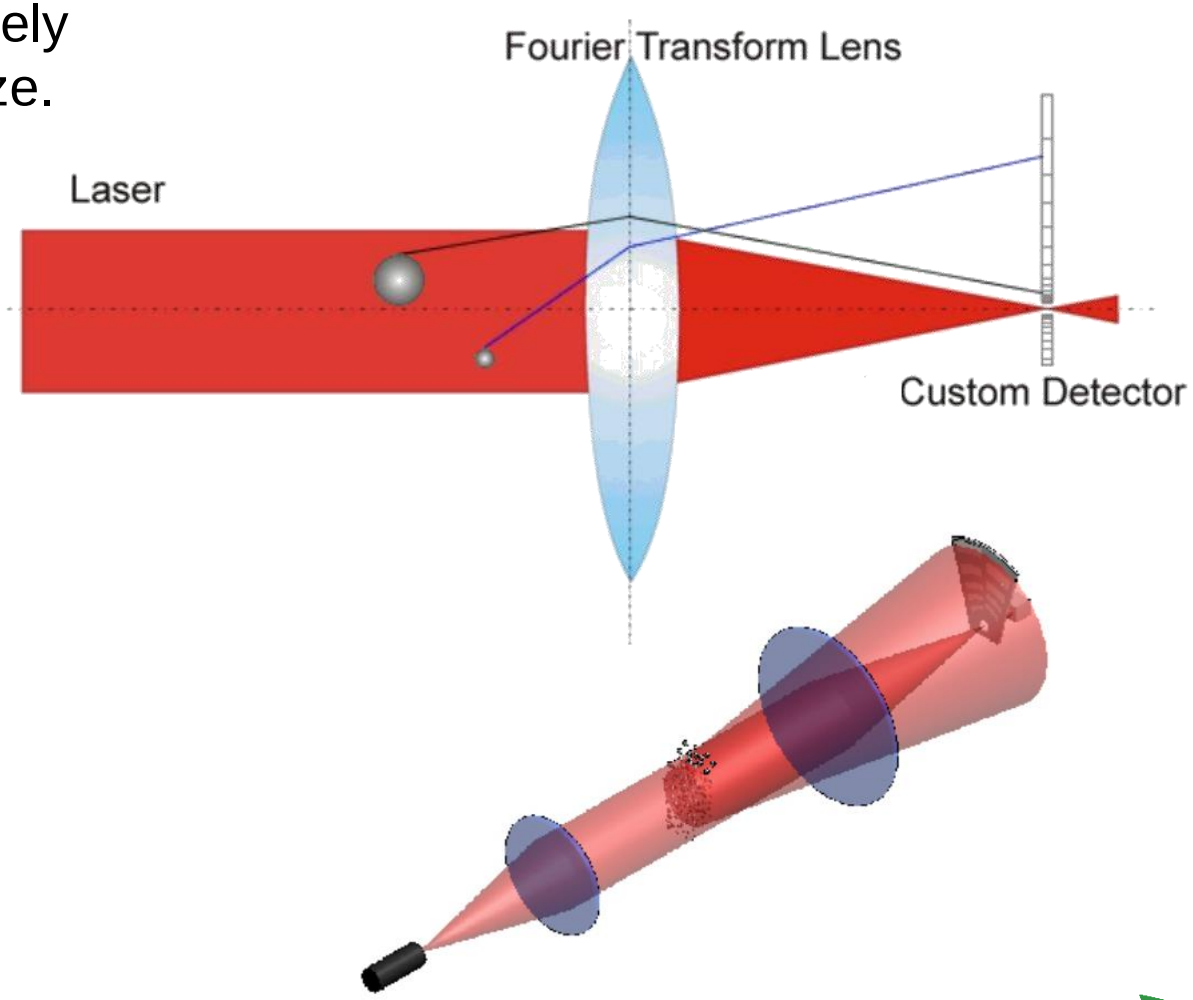
- Be sure to know the sieve standard: U.S. or Tyler?
- Sieving motion can degrade friable materials
- Elongated particles tend to upend and fall to finer sieve
- Fine sieves may require air assist or wet wash

Dirty little secret:

- All sieves are not the same!

Laser Diffraction: How it works…

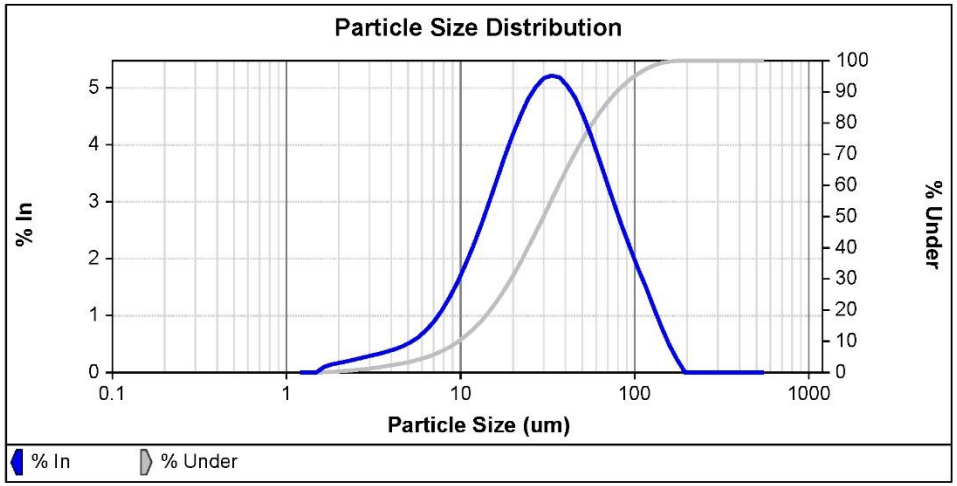
- Angular scattering of light from particles is inversely proportional to their size.



Laser Diffraction: Typical Results

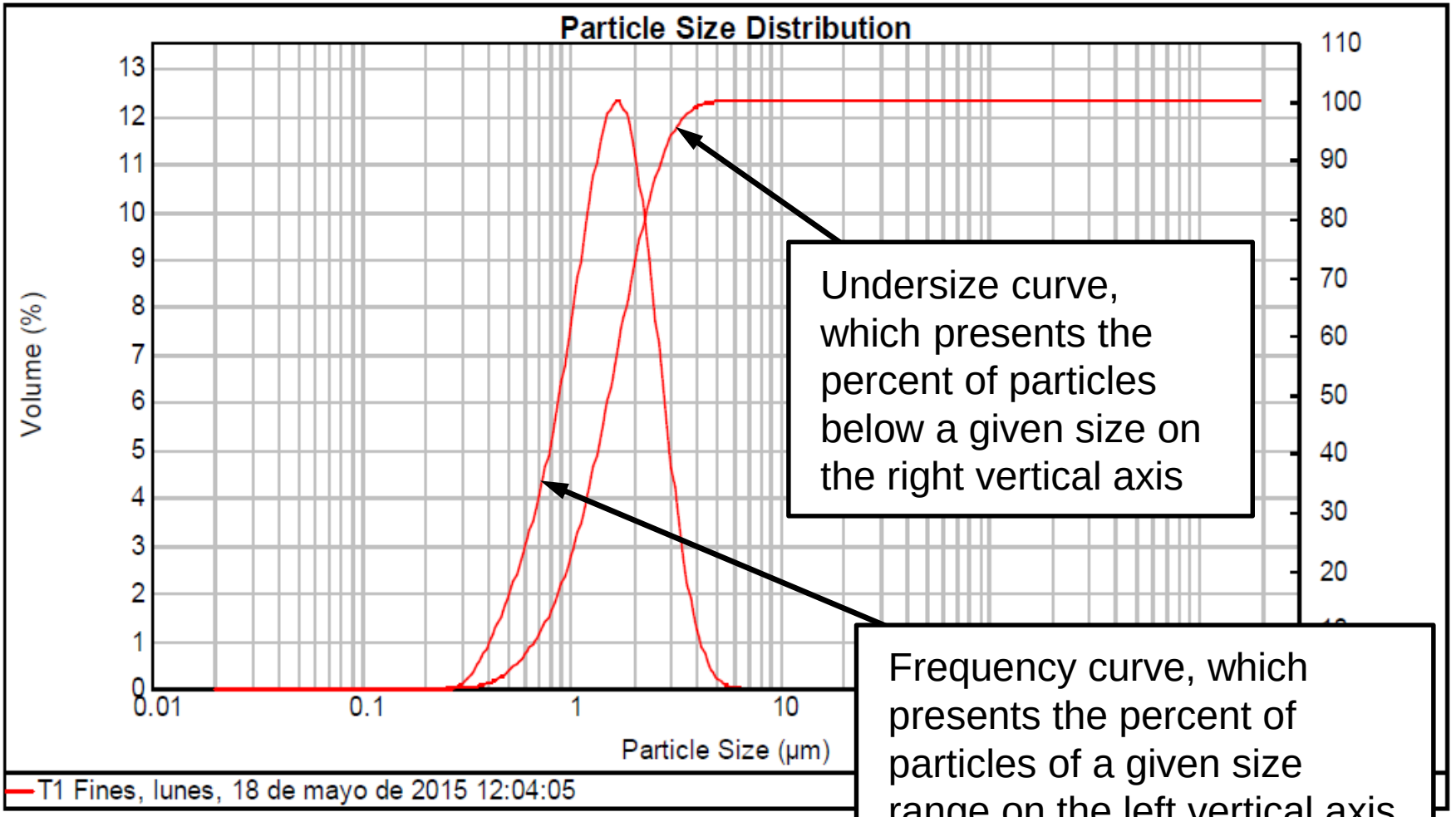
File Name:	graphene.xo		
Matrix File Name	XOFraunhofer_157_0i10_250_D(R	**Model:**	Free Mode
Sample Name:		**Dispersant Name**	
Sample Provider		**Operator:**	OPERATOR
Record Status:	OCL	**Notes:**	

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

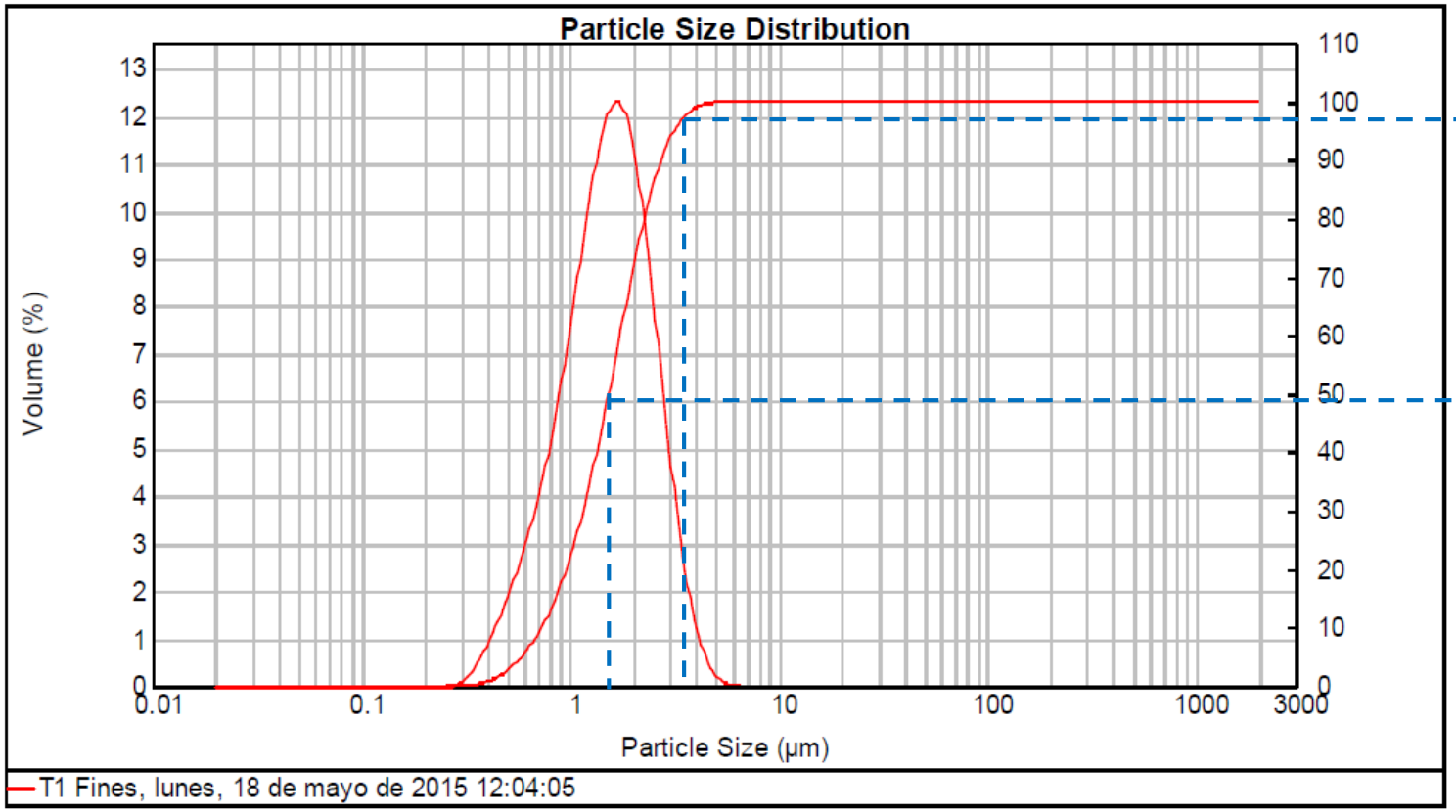
Two Ways to Present PSD Data



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



d_{98} = 3.5 µm

d_{50} = 1.5 µm

Laser Diffraction: Considerations…

Advantages:

- Excellent choice for powders and fine granules
- High repeatability

Disadvantages:

- Equipment is costly
- Not appropriate for flat or needle-like particles

Considerations:

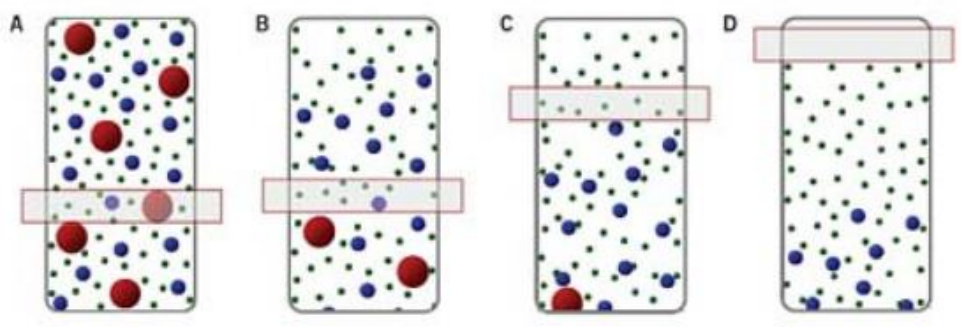
- Proper sample preparation, i.e. dispersion, is critical
- Optical properties for each material must be properly selected
- Different equipment models can give different results

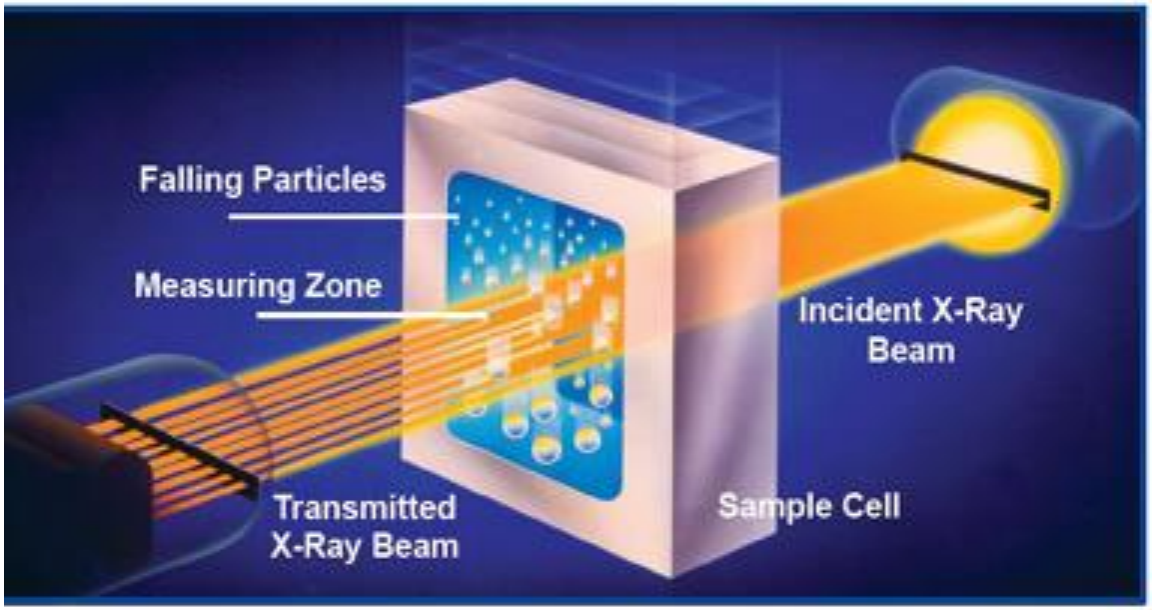
Dirty little secret:

- The tips of the curves are not real…they are educated guesses!

X-Ray Sedimentation: How it works…

- Settling rate of spheres in a fluid is a function of particle size.
- Attenuation of X-radiation is proportional to the mass of the absorber (sample particles).





X-ray sedimentation uses both principles to measure the time-dependant change in mass concentration of solids settling from a suspension of particles.

X-Ray Sedimentation: Considerations…

Advantages:

- Best method for platey materials like talc

Disadvantages:

- Very expensive equipment
- Can be quite slow

Considerations:

- Sample prep and dispersion is critical, even more so than with laser
- Because it affects settling, density must be properly entered
- Not appropriate for blends of different materials

Dirty little secret:

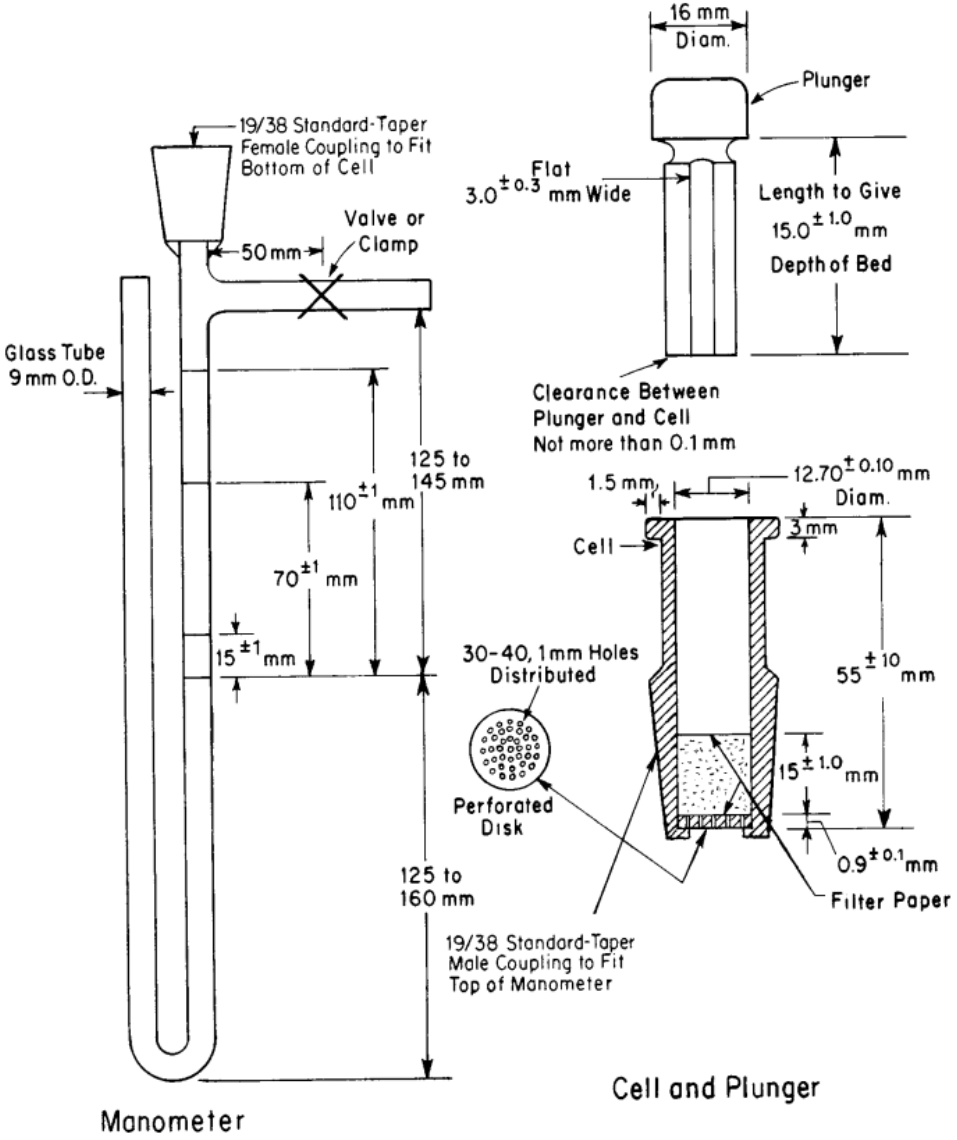
- Some analyses can take as long as 15 hours!

Blaine: How it works…

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 400 m^2/kg.



Blaine: Considerations…

Advantages:

- Inexpensive equipment

Disadvantages:

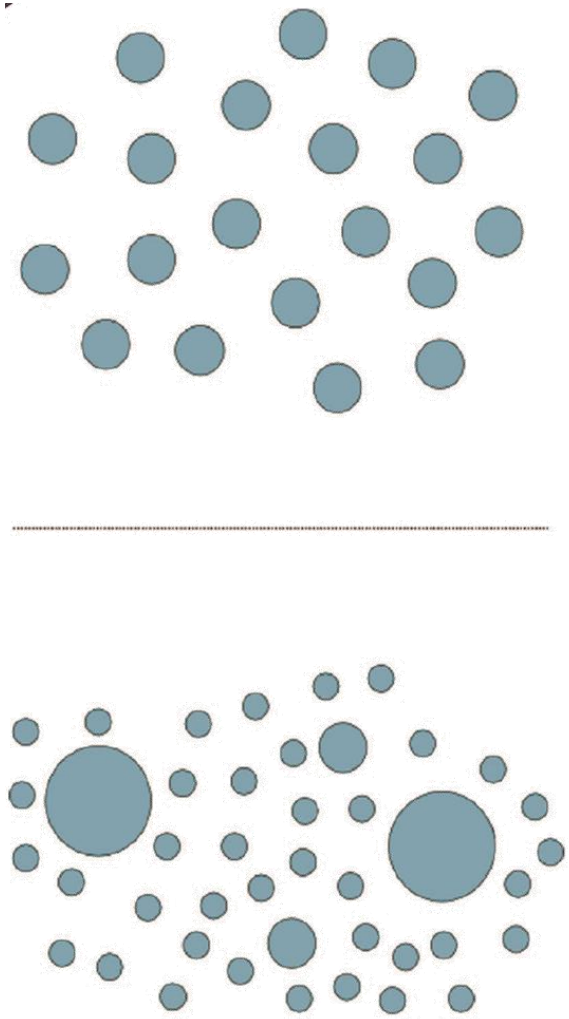
- Requires proper calibration and operator expertise

Considerations:

- Some laser diffraction analyzers can emulate Blaine

Dirty little secret…

Both of these PSD's have the same Blaine number



Comparison of Results from Various Methods

Talc

	d50	d98	d100
Malvern Mastersizer 3000	3.76	10.5	16.3
Sedigraph III Plus	1.33	3.51	-

Calcium Carbonate

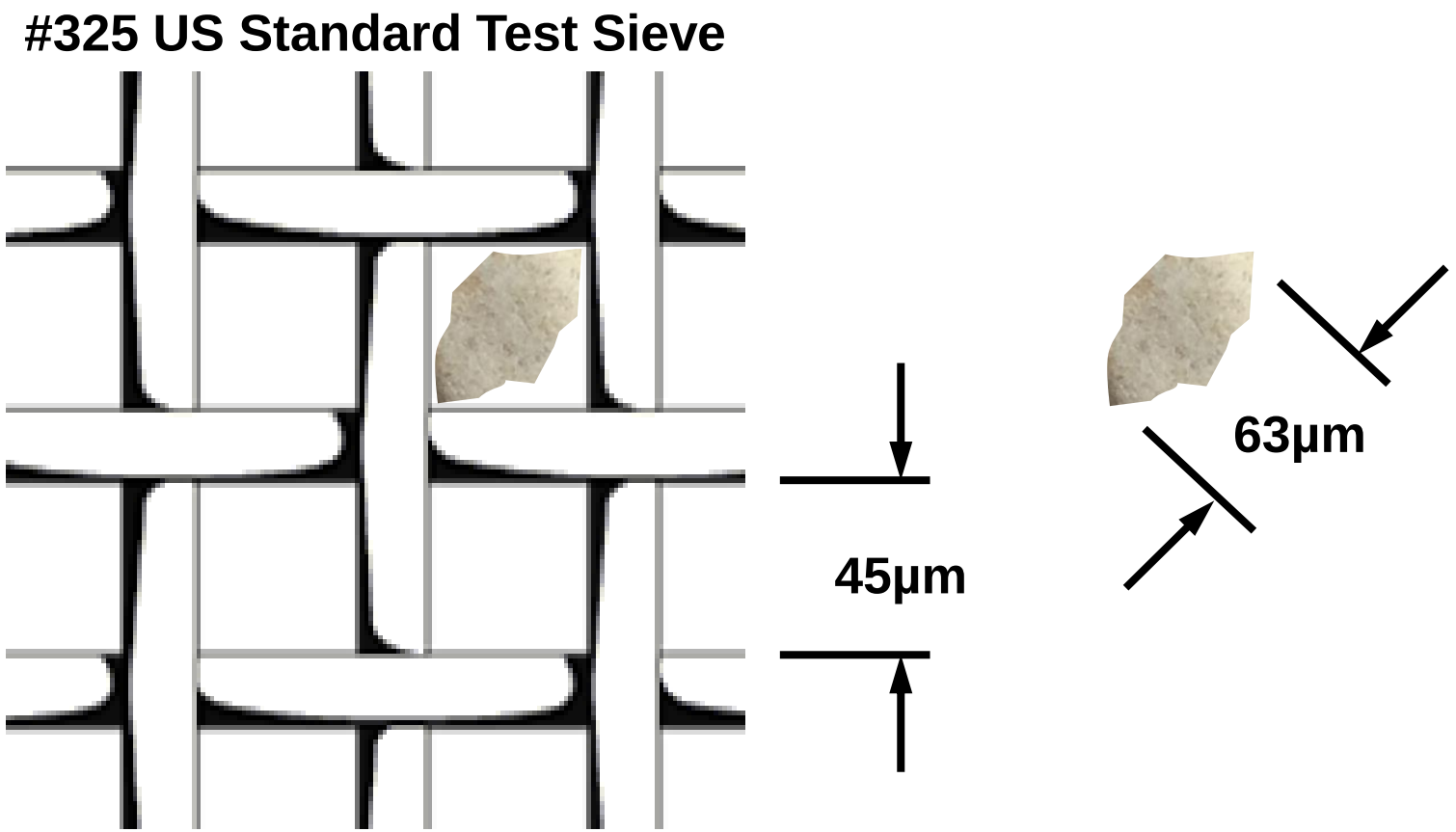
	d50	d98	d100
Malvern Mastersizer 2000	2.95	10.4	17.9
Malvern Mastersizer 3000	3.33	12.8	21.1

Silica Flour

	d50	d98	% > 45 mm
Malvern Mastersizer 3000	20.0	77.5	15.1 %
#325 test sieve (45µm)	-	-	3.2 %

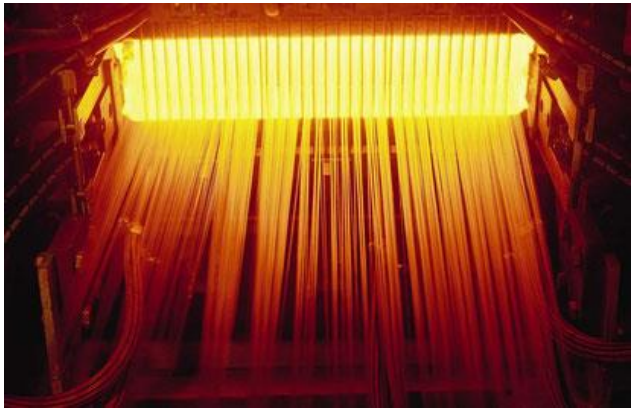
Silica Flour on #325 US Standard Test Sieve

	d50	d98	% > 45 mm
Malvern Mastersizer 3000	20.0	77.5	15.1 %
#325 test sieve (45µm)	-	-	3.2 %



Impact on Bottom Line – Example: Silica Flour

- Used in fiberglass production
- Produced in ball mill / classifier circuits



- Typical spec is 96% minimum passing #325 US test sieve.
- Operator must maintain spec or risk the possibility of customer rejecting shipment.

- Manual sampling and sieve analysis is too slow to allow fine tuning of milling circuit.
- Therefore operators invariably error on the side of making a product that is too fine.
- Finer product = lower production rates

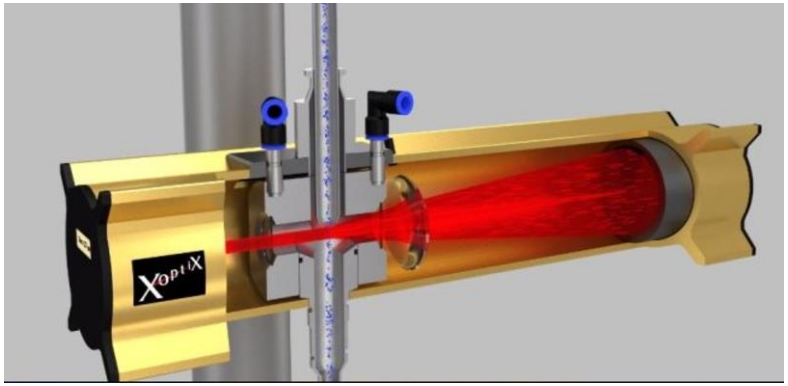
Impact on Bottom Line – Example: Frac Sand

- Produced in screen towers
- Quality is a function of feed rate to screens

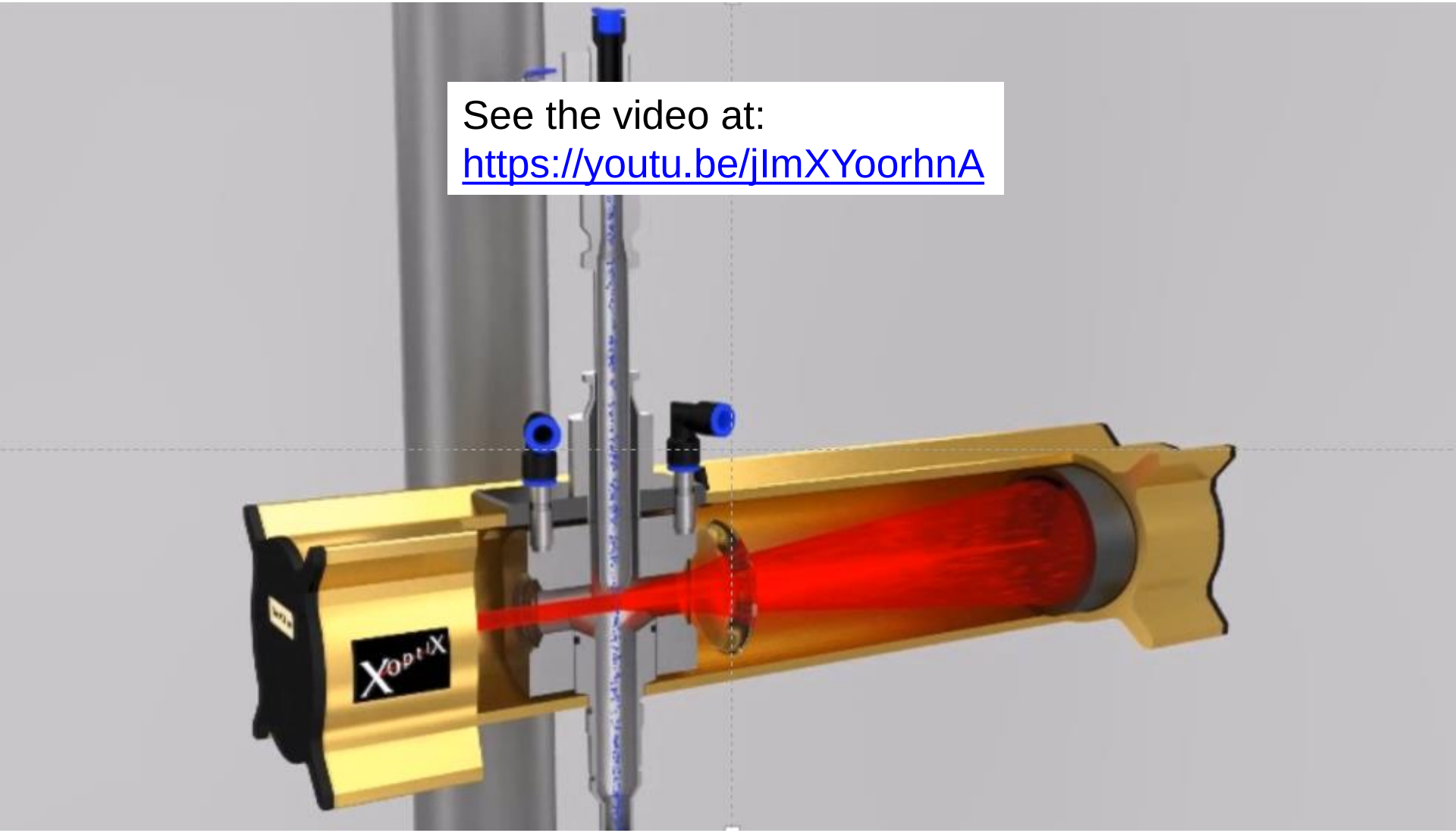
- If feed rate is too high, fines can carry over and throw product out of spec.
- Over time screens blind or tear and throw product out of spec.

- Manual sampling and sieve analysis is too slow to allow fine tuning of screen feed rates.
- Therefore operators invariably error on the side of less than optimal feed rates.

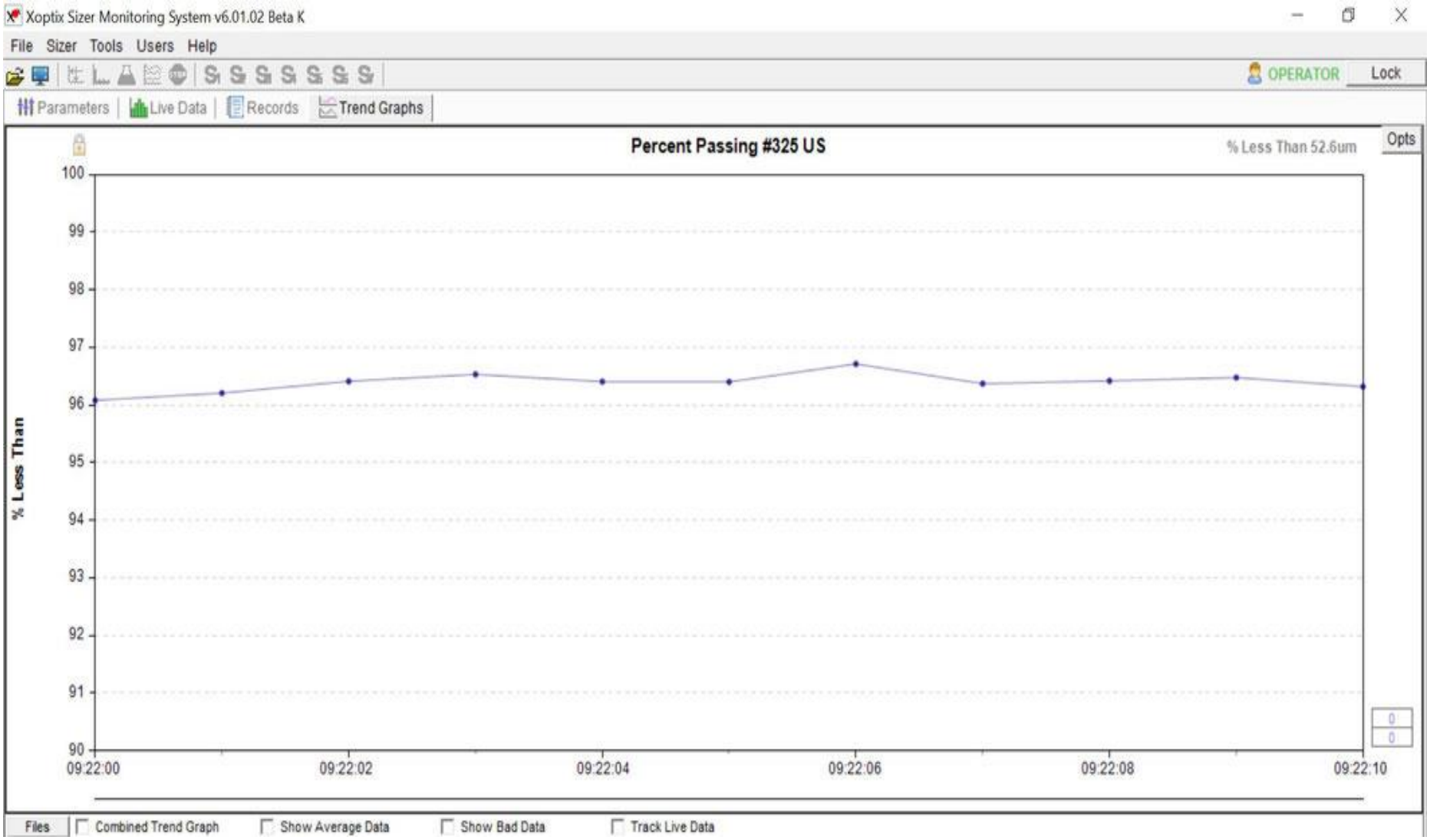
Xoptix On-Line Particle Size Analyzer



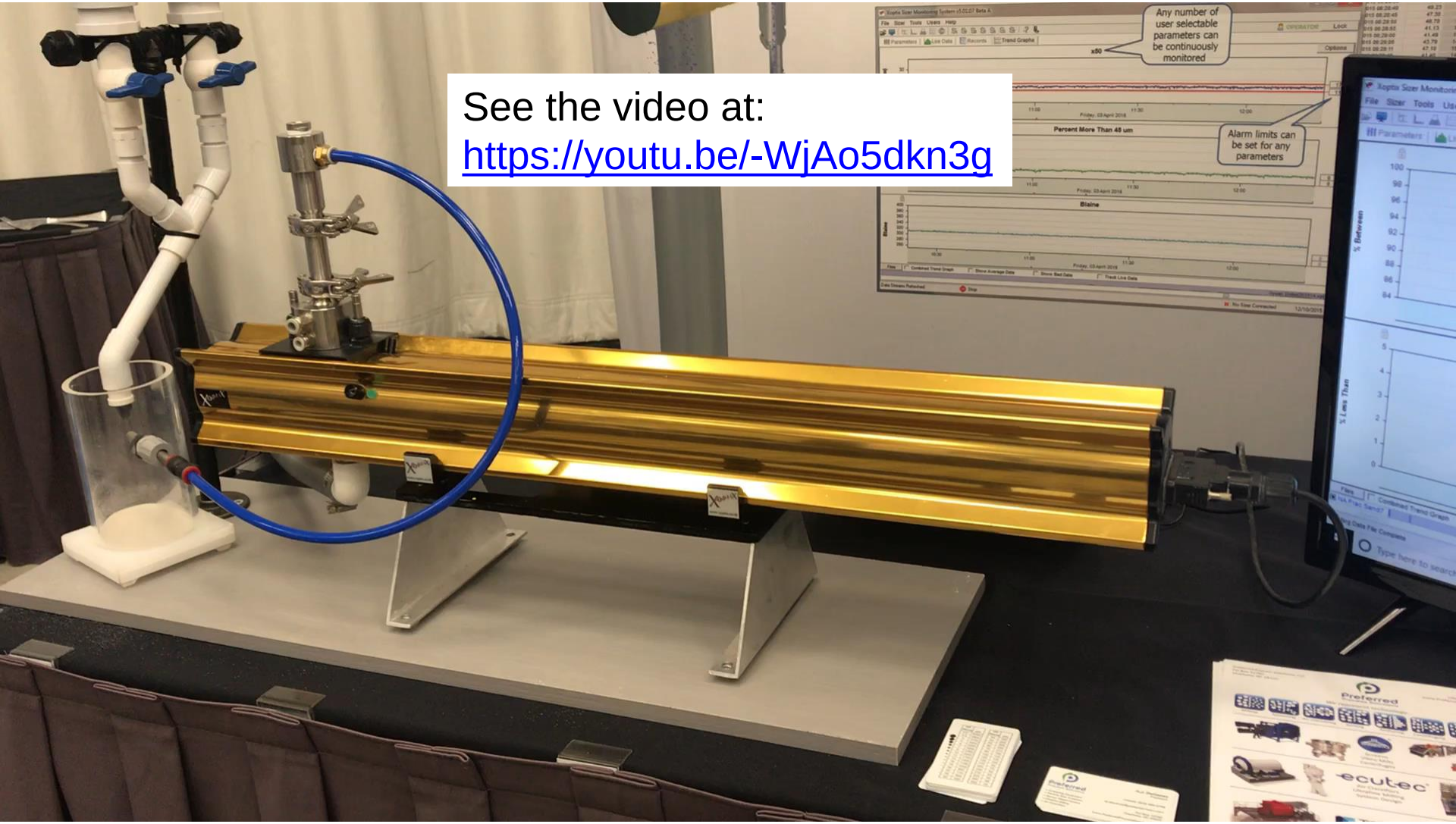
Xoptix How it Works Video



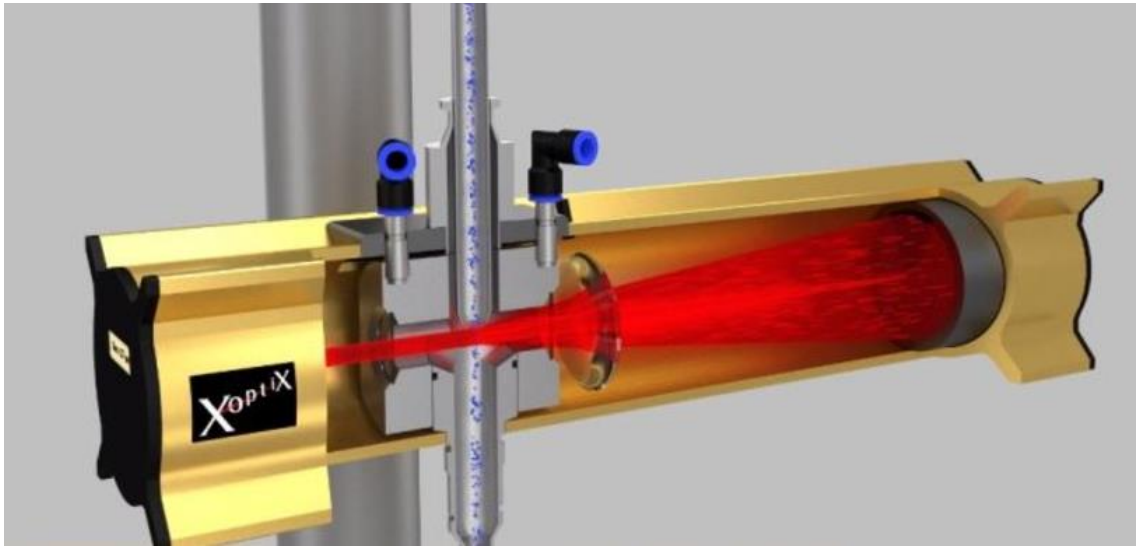
Xoptix Real Time Analysis of Silica Flour Production



Frac Sand Demo



Q & A...



Preferred Process Solutions, LLC
PO Box 12762
Charlotte, NC 28220 USA
www.PreferredProcessSolutions.com

A.J. DeCenso
President
phone: 803-389-0768
email: aj.decenso@preferred-team.com