American Association of Drilling Engineers

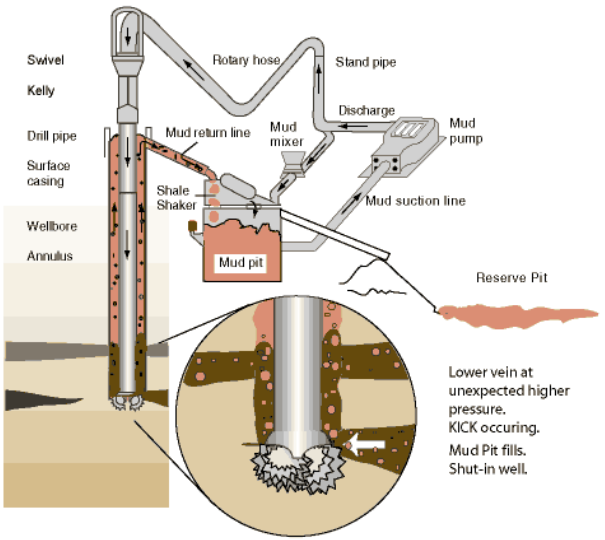
Rigsite Monitoring and Control of the size of Drilling Fluid Particulates:

"Imaging Analysis of Drilling Mud Particles for Real Time Control"

Tod Canty Sr., PE
JM Canty Inc

Particle Size Analysis of Drilling Fluids

- Introduction
  - Drilling muds or fluids are complex aqueous or oil-based suspensions designed to fulfill a number of important functions during the oil extraction process.
  - Main Functions
    - Provide hydrostatic pressure to prevent formation fluids from entering the well bore
    - Keep the drill bit cool and clean during drilling
    - Carry out drill cuttings
    - Suspending drill cuttings while drilling is paused and while drilling assembly is brought in and out of the hole
    - Avoid formation damage and limit corrosion



Typical Drilling Mud System

Why Drilling Fluid Particle Size Distribution is Important

- Mud performance controlled by manipulating the mud composition and the properties of the constituents through the addition of different additives.
- Particle size significantly affects the way in which the mud interacts with the surrounding geology.
- Particle size measurements play an important role in the formulation of high performance drilling muds.
- Particles smaller than the pore size of the surrounding geological formation will bridge rock pores during mud circulation, leading to the formation of a filter cake that prevents the egress of fluids from the well during drilling.
- This “filter cake” protects the surrounding rock from damage while simultaneously preventing fluid loss and achieving well stabilization.

Industry Techniques for Particle Size Analysis of Drilling Fluid

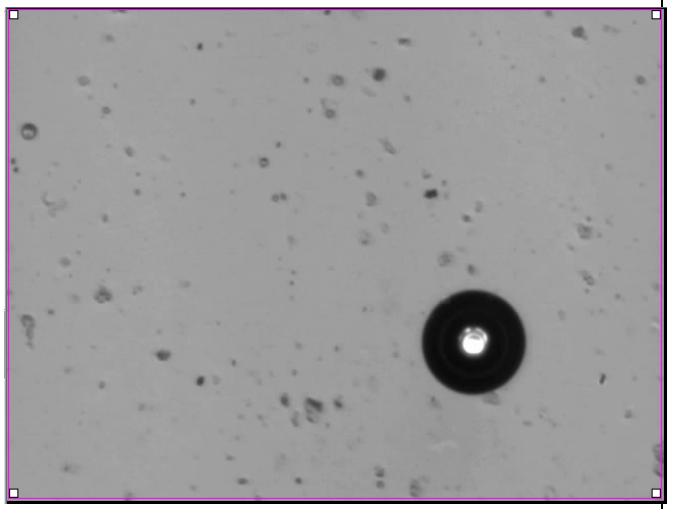
- History of various techniques
  - Sieves
  - Laser
  - Imaging

Industry Techniques for Particle Size Analysis of Drilling Fluid

- Sieve Analysis
  - Used for many years, simple & inexpensive
    - Disadvantages:
      - Time (Sedimentation and Sieving are both slow and time consuming processes)
      - Particle Size (Particles too small for separation by sieving to be practical)
      - Error (Over-energetic sieving causes attrition of the particles and thus changes the calculated particle size distribution)

Industry Techniques for Particle Size Analysis of Drilling Fluid

- Laser Diffraction
  - Quickness and ease of use
  - Disadvantages:
    - Water droplets (in oil based) Oil droplets (in water based) mud measured as particles.
    - Non-spherical objects (large discrepancy between laser measurements)
    - Laser 1D (equivalent sphere) and not recommended for large aspect ratio.
    - Distortion of Measurements (existence of “ghost” particles caused by sharp edges on the objects which produce high angle diffraction
    - Acicular particles (shows much larger sizes compared to laser diffraction, undercounts events generated by major chord
    - Laser diffraction intrinsically biased towards the smaller edge of spectrum.



Laser Sampling Problems

Laser diffraction typically only uses a sample size of around 1mL to 2mL. The problem with this is the steps necessary to break down a sample small enough for laser diffraction from the original sample gathered at the process line. Some possible issues are:

- Does the sample container harbor particles not wanted within the sample?
- By the time the sample is drawn have particles began to settle out of solution?
- Is there a large difference in particle density between a sample drawn from the top of the container to the bottom?
- Is a few mL sufficient for proper particle analysis?

    - **With the Canty Cross-Cut Sampling Valve none of these potential sampling issues come into play.**

Imaging Advantage

Drilling Mud System

- Canty's Drilling Mud particle Analysis system has many distinct advantages over Laser Diffraction systems and sieve
  - Real time 2Dimensional particle shape analysis.
  - The particles are oriented in the fluid dynamically designed flow cell to measure the largest length and widest section of the particles. All aspect ratios are measured correctly
  - Direct measure of particle area – a two dimensional measurement.
  - Direct measurement of particle perimeter – a two dimensional measurement.
  - Direct measure of major axis and minor axis – a two dimensional measurement.
  - Able to separately measure various particles separately water, barite, polymer using size shape and color data
  - Direct measurement of particle color.
  - Large particle range – 2" down to .7 micron

How it Works

- Fiber optic lighting
- Fused glass safety barrier
- EXP & ATEX available
- High pressure / temperature ratings
- Auto-dilution

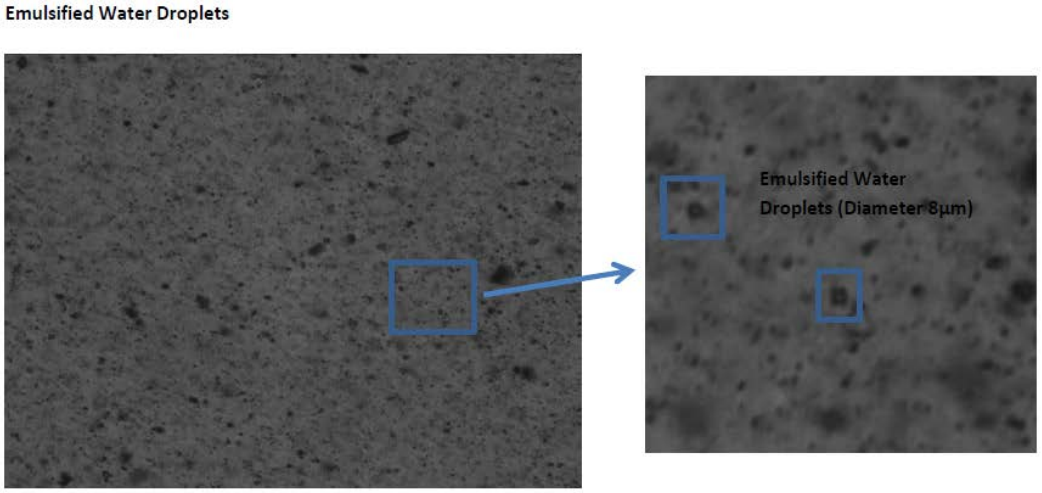


Figure 4: Figure 1 above displays both mud particulate and emulsified water droplets

How it Works

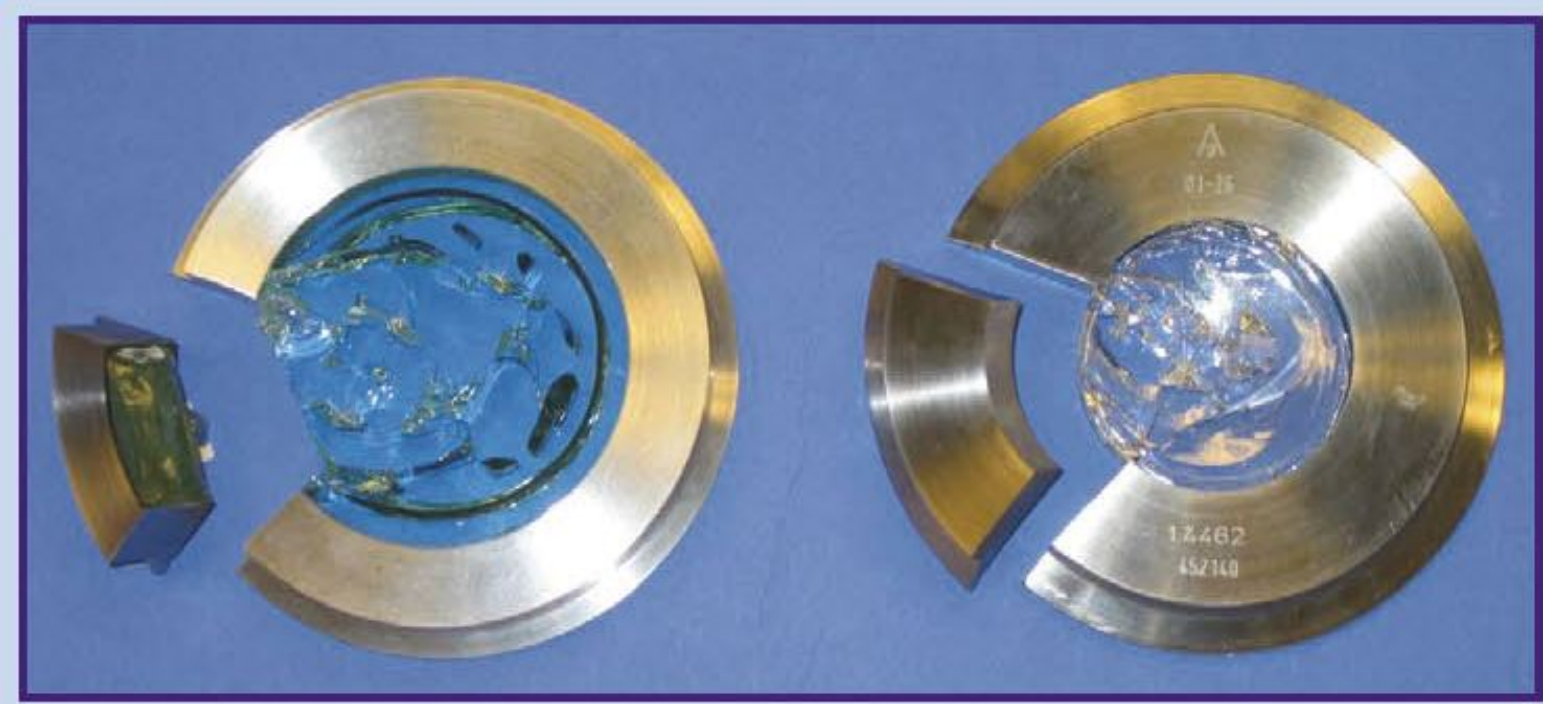
- Lighting is critical for any vision based system
- Canty have being doing process lighting for well over 30 years – part of our core business
- Would not be so confident in our vision based technique without our lighting expertise

HOUR BAKE-ON TEST

CANTY COLD LIGHT

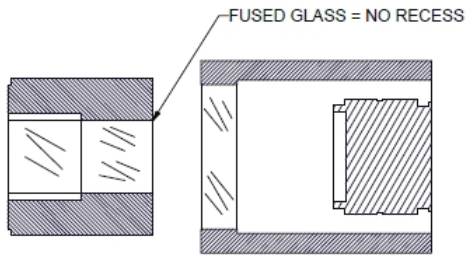
Canty's Fused Glass Technology

- Fusion of glass to metal – one piece construction
- Critical to our vision based technique
- Pressures to 10,000 PSI, Temp -450 to 800ºF

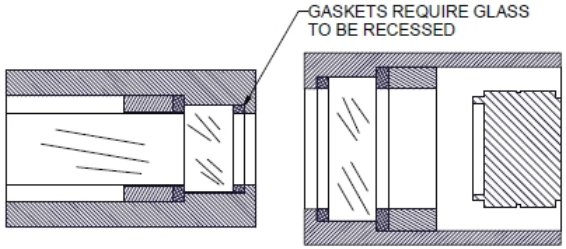


Importance of fused glass technology

- Hermetically sealed one piece construction means no recesses or gaps where product can adhere to and start to build up
- Self cleaning unit



CANTY FUSED GLASS



COMPETITION PLATE GLASS

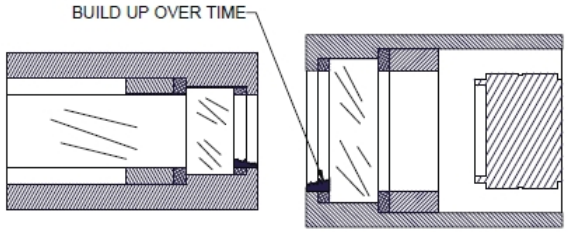
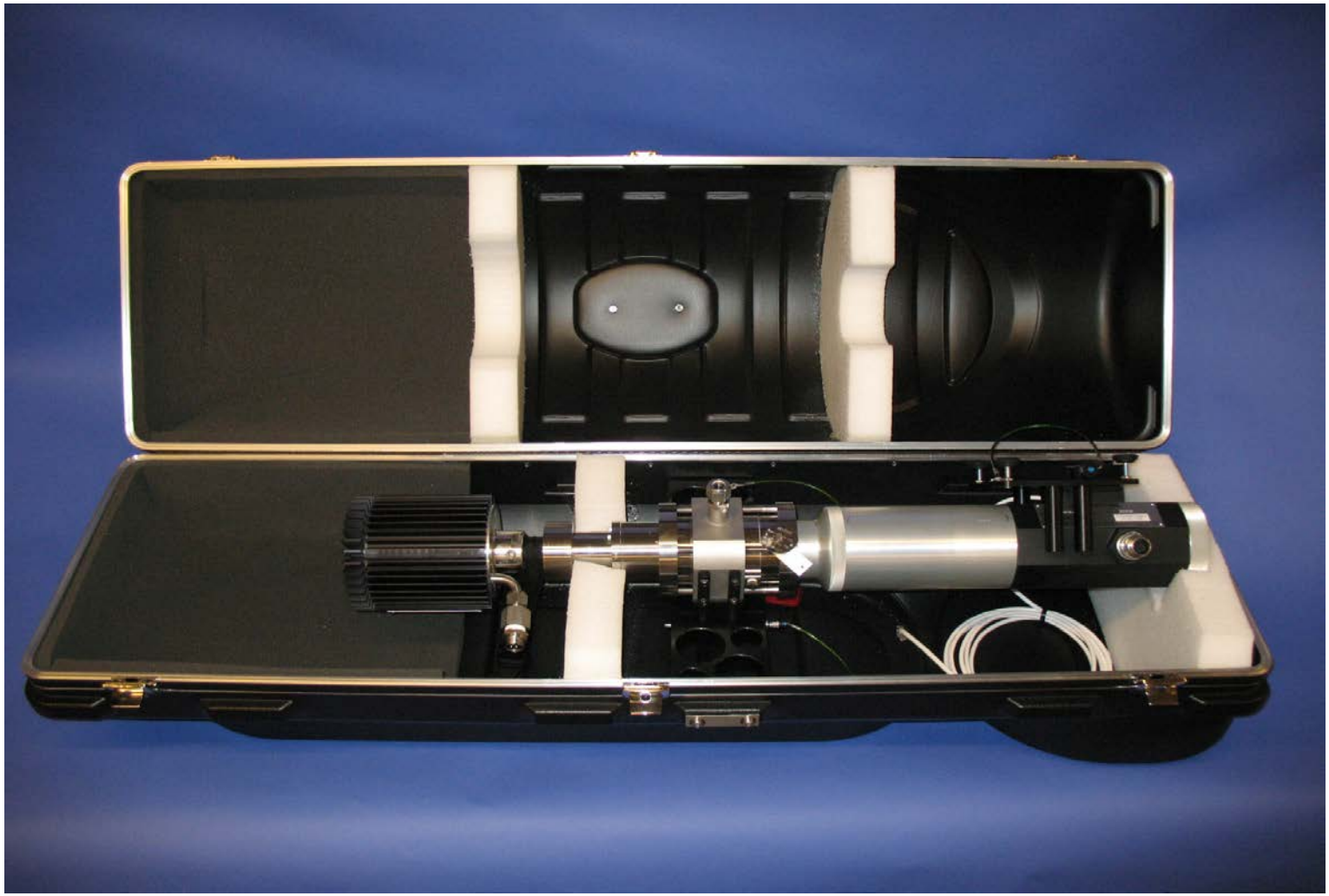
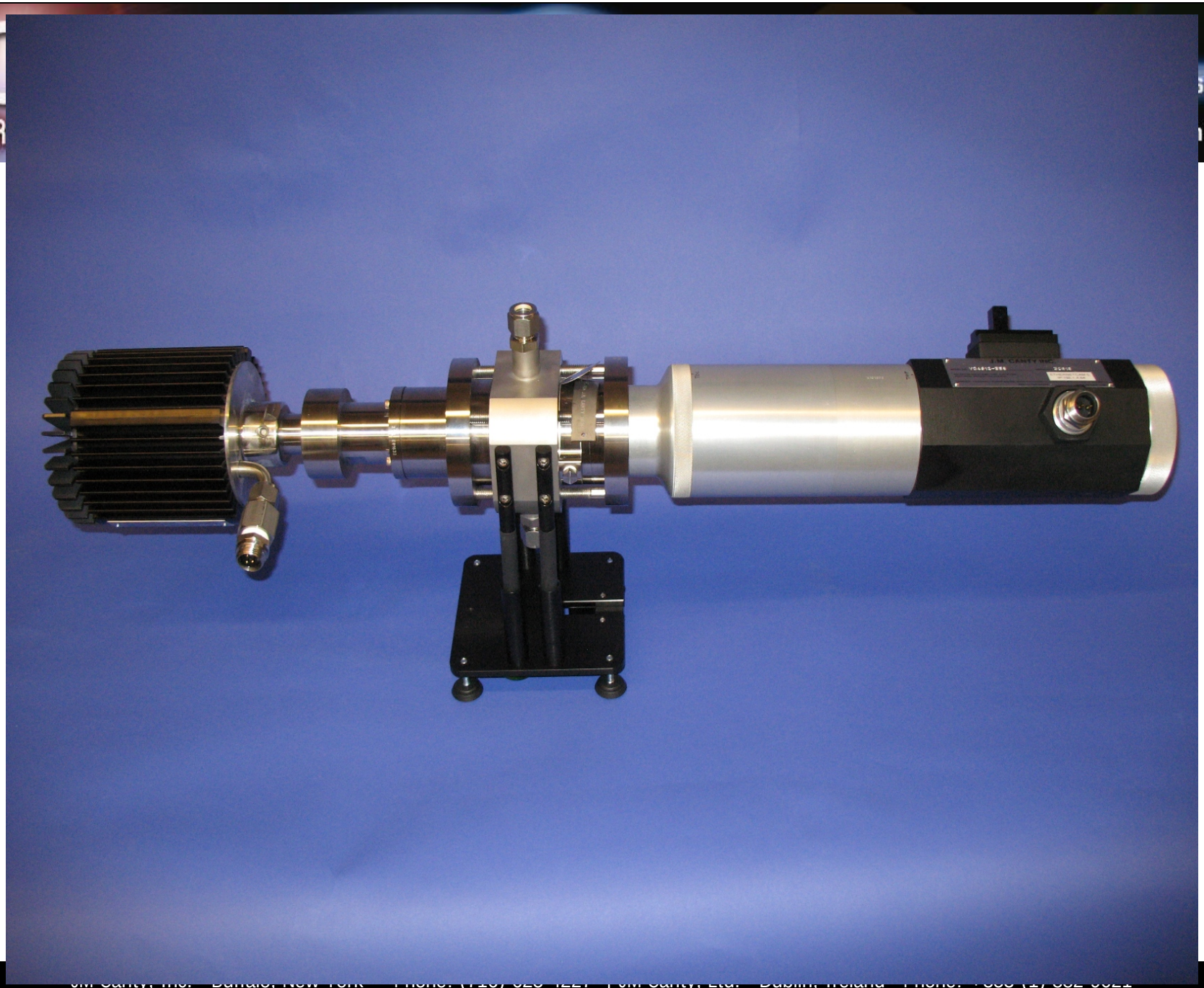


PLATE GLASS WITH BUILD UP

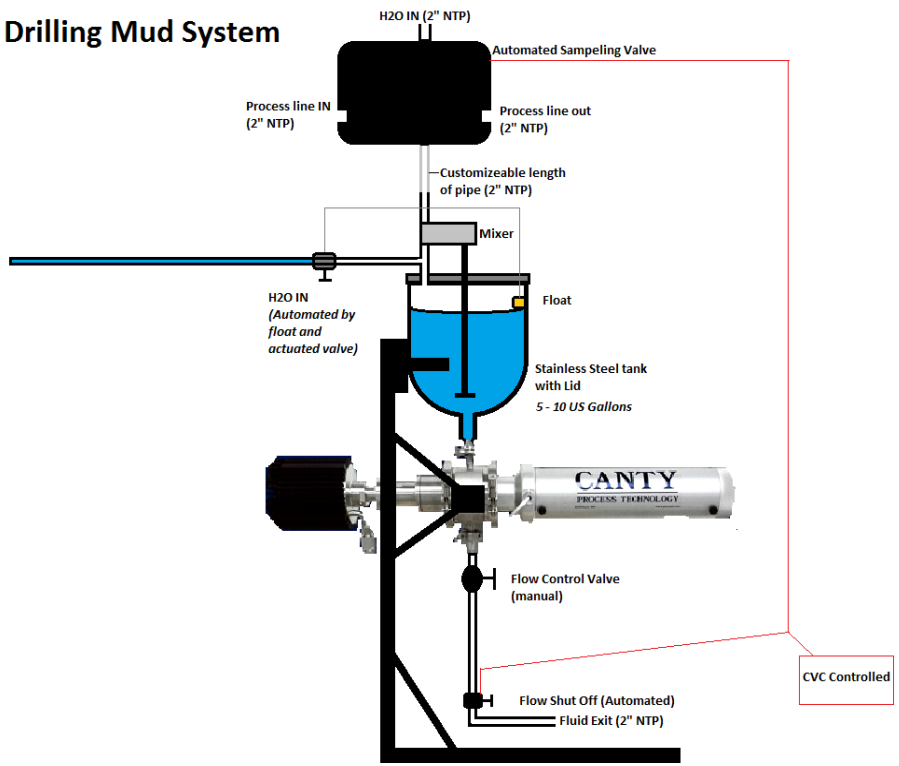
CANTY MICROFLOW
Portable / Lab System

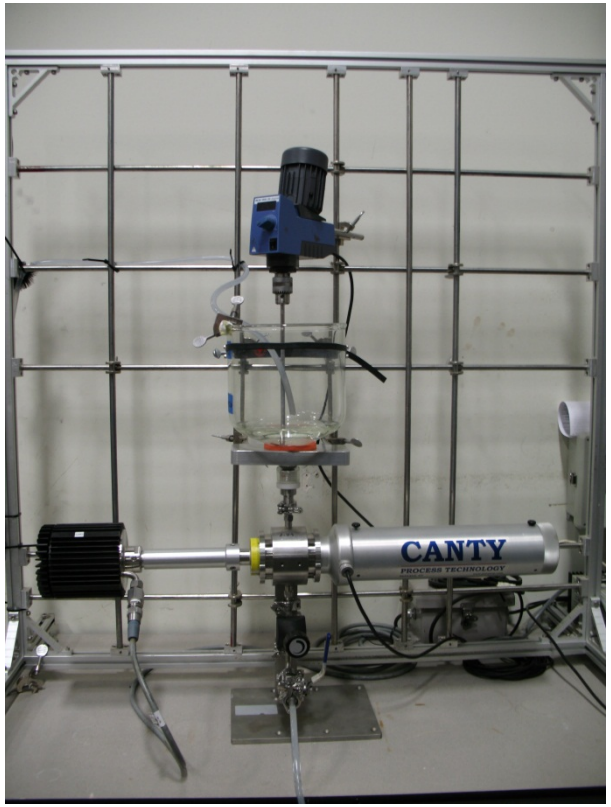
"How it works"



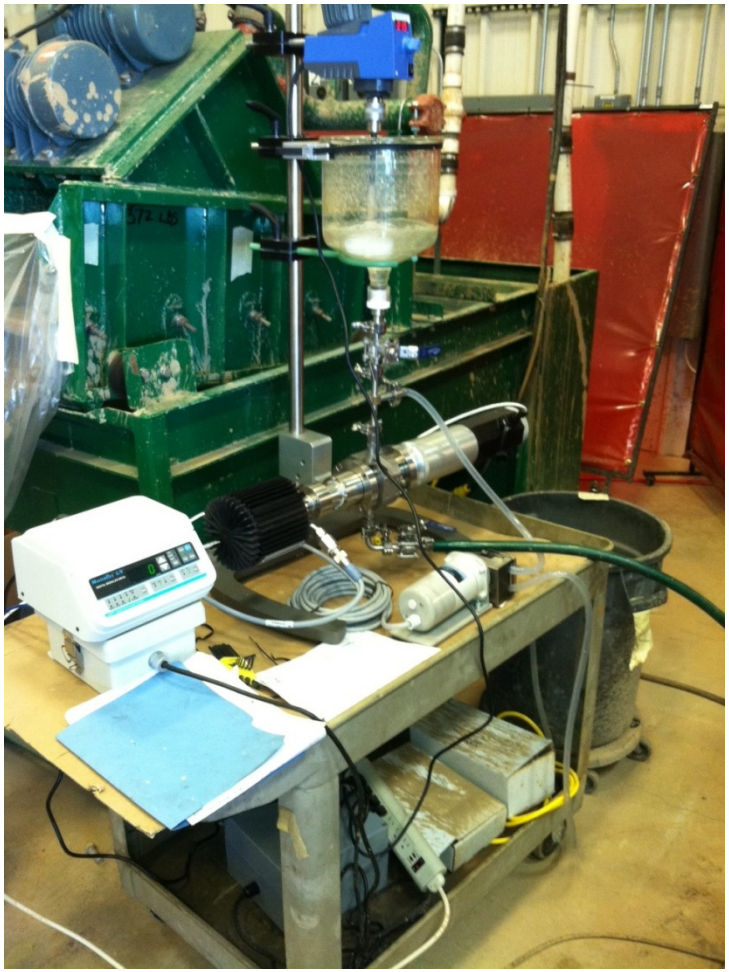


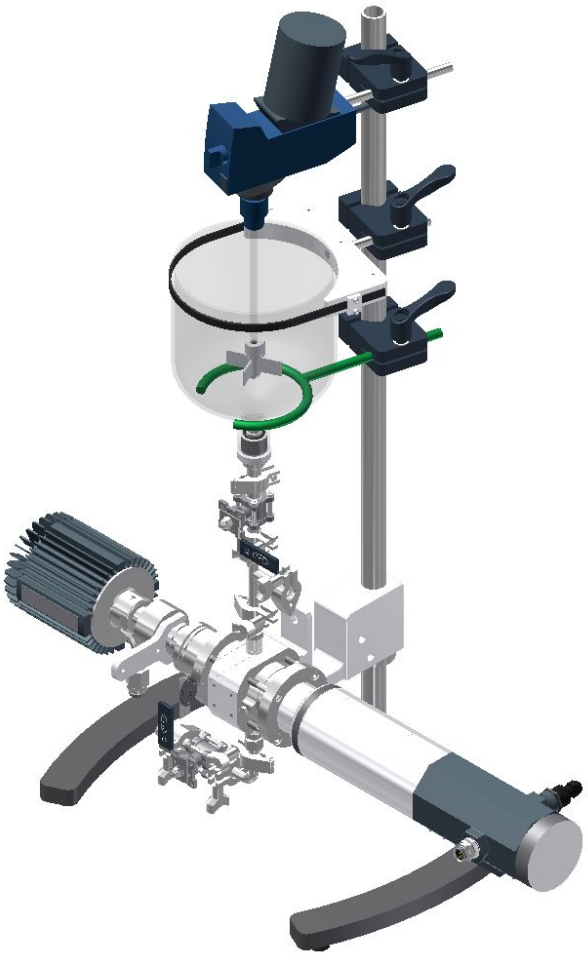
Canty Laboratory Drilling Fluid System



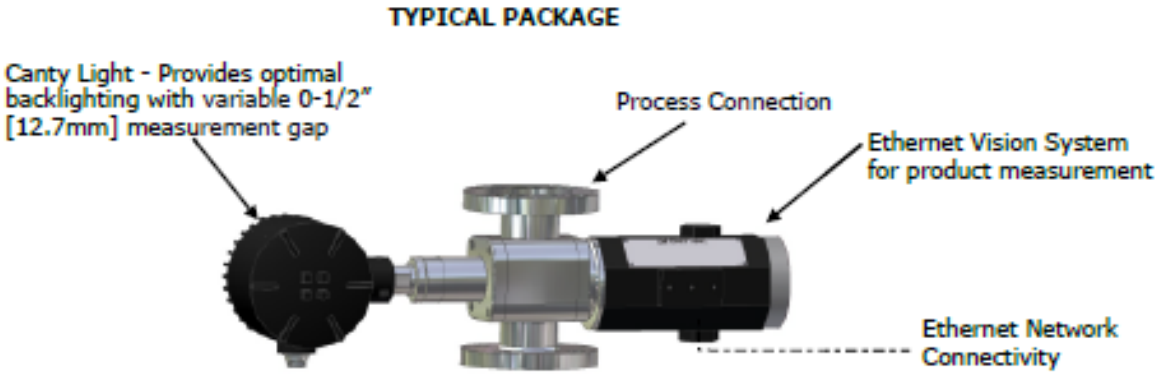


Lab = Online





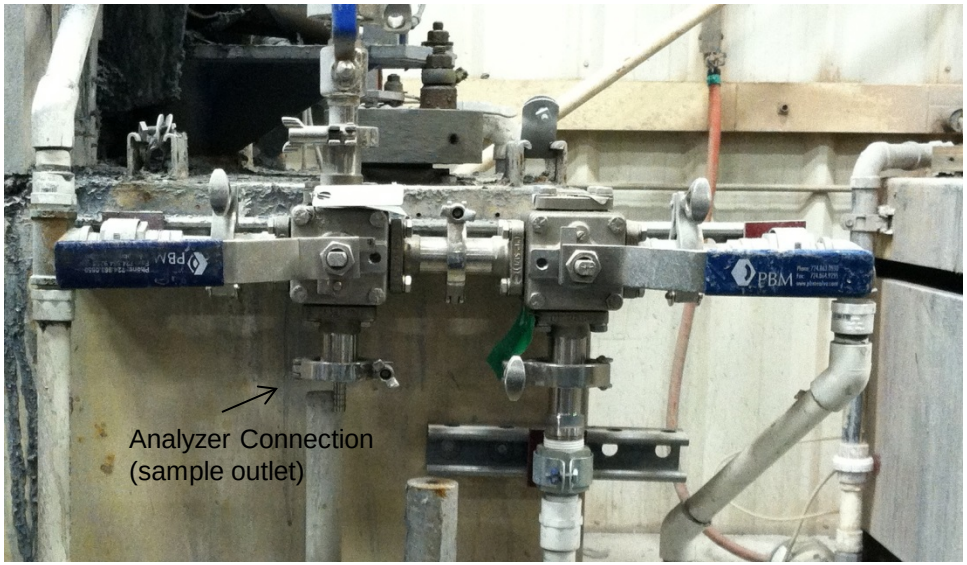
Canty In-Line Drilling Fluid System



- The Canty In-Line Drilling Fluid System allows for the analysis of drilling fluids by a direct in-line process connection.

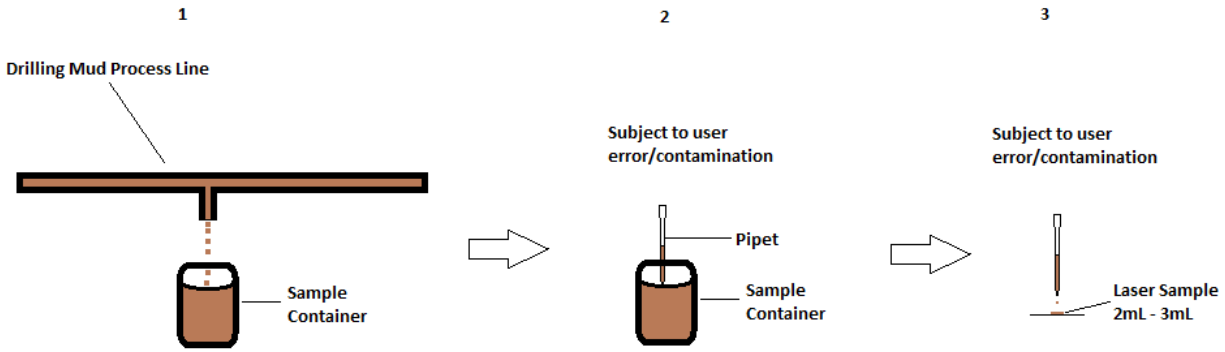
Canty Cross-Cut Sampling Valve

- Canty's cross-cut sampling valve system allows for quick consistent and repeatable sampling of a drilling fluid process line.
- The valve system directly samples a cut of fluid from the center of a process line.
- That full "cut" is then diluted in water and directly run through the analysis equipment.
- This method allows for direct testing of a representative "cut" of drilling fluid.

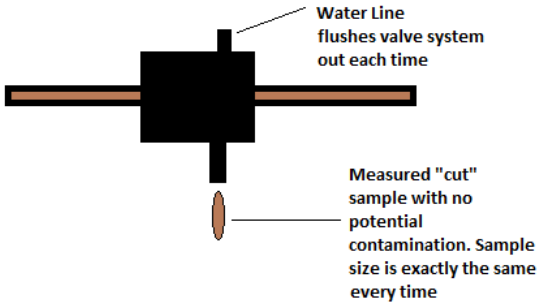


Sample Extraction Comparison

Laser Sample Extraction



Canty Cross-Cut Sampling Valve System



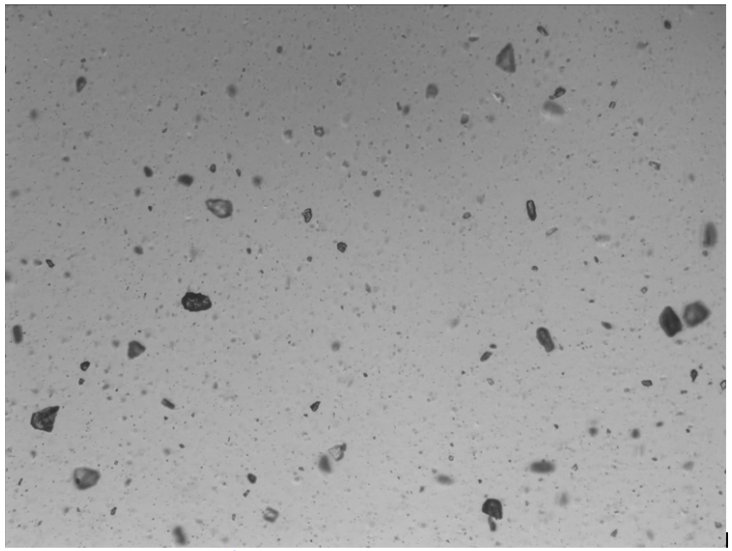


Figure 2 - SAM2529-A2 – 4212µm x 3172µm FOV

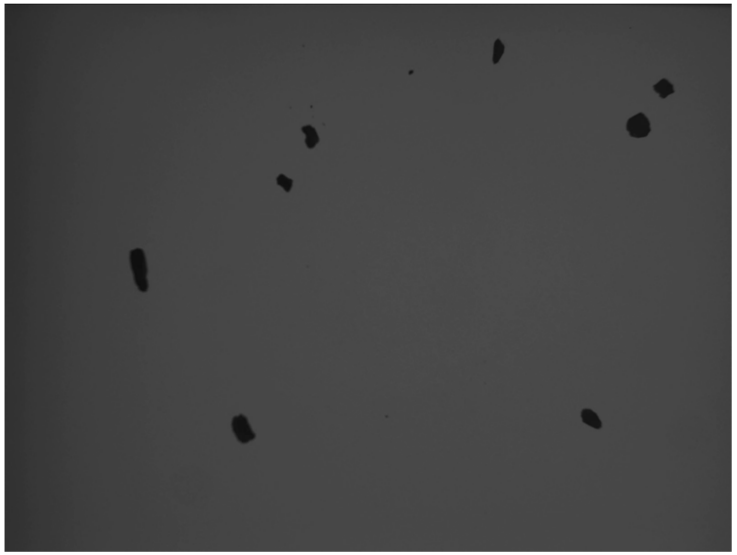
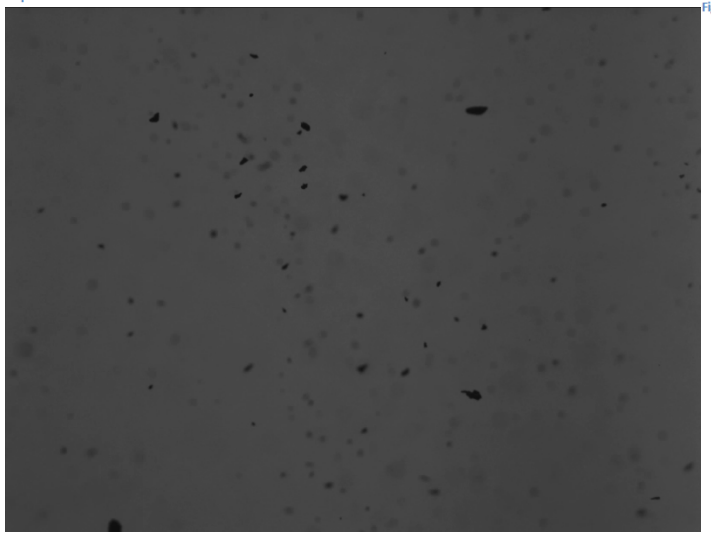


Figure 4 - SAM2529-A4 – 89.10mm x 67.10mm FOV



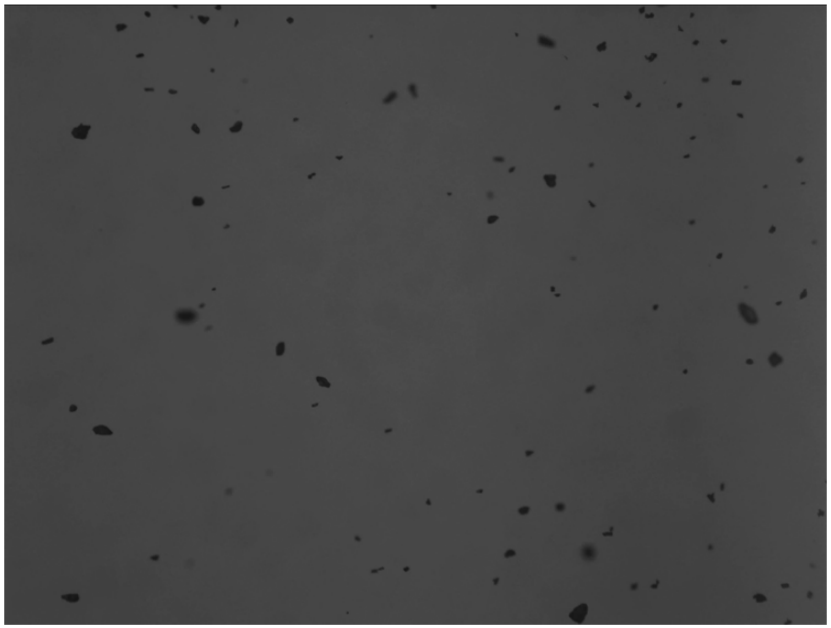
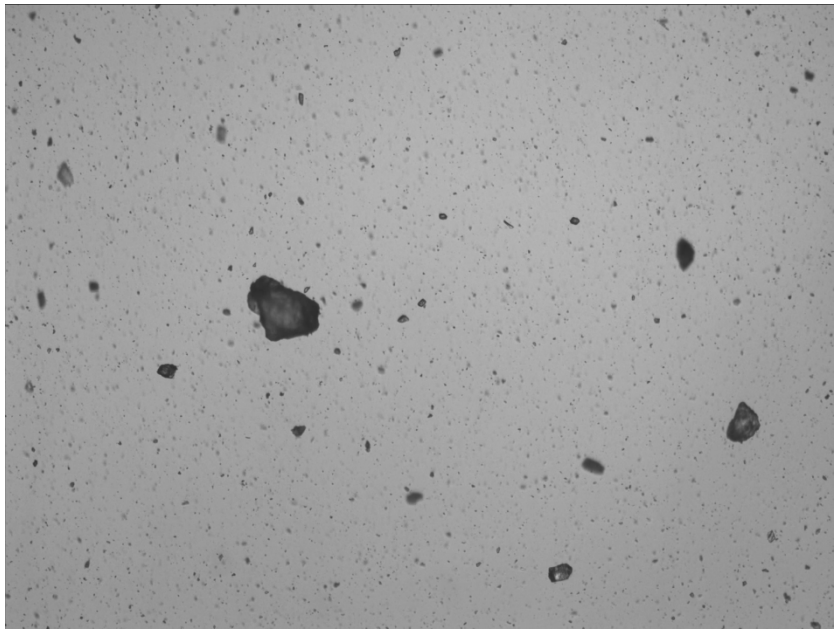


Figure 3 - SAM2529-A3 – 22.68mm x 17.08mm FOV



Data

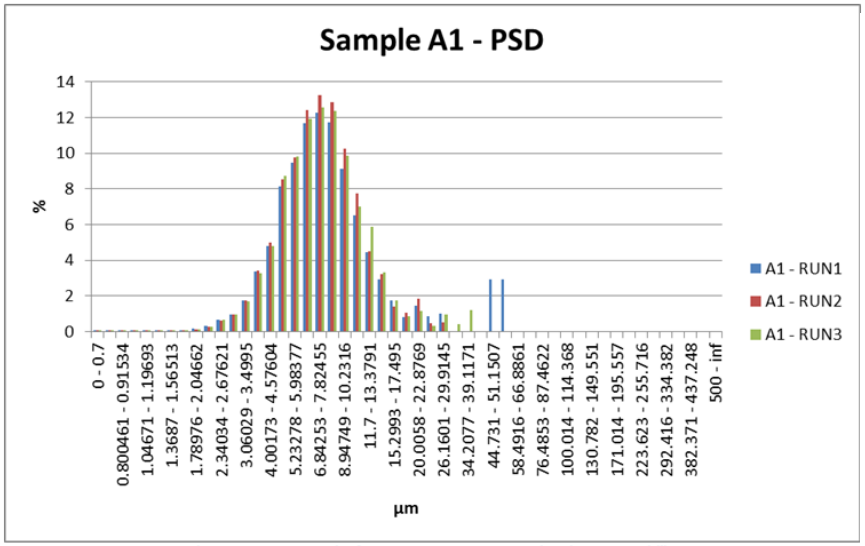


Figure 8 – Canty Results for SAM2529-A1 – Run x3 showing repeatability

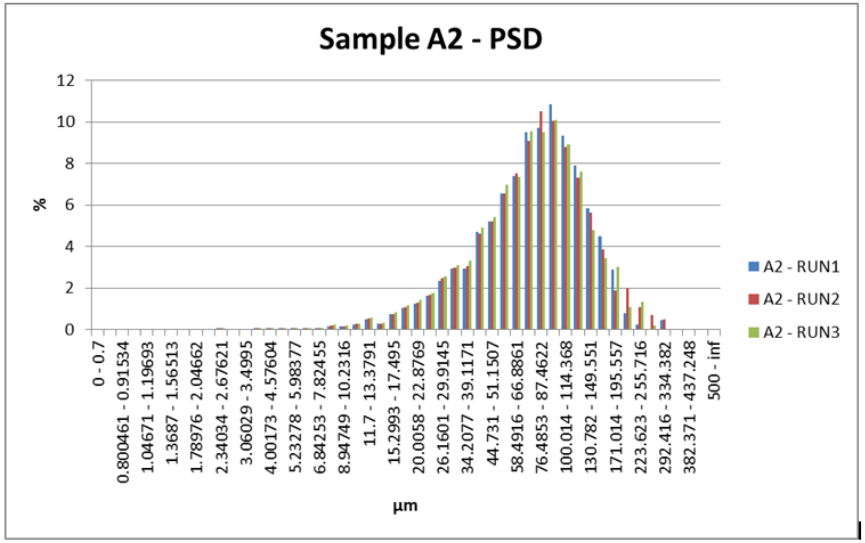


Figure 9 – Canty Results for SAM2529-A2 – Run x3 showing repeatability

A1

Dv10:	4.30248
Dv20:	5.22998
Dv30:	5.9224
Dv40:	6.61973
Dv50:	7.31678
Dv60:	8.12143
Dv70:	9.04212
Dv80:	10.3373
Dv90:	12.6688
Dv100:	27.5662

A2

Dv10:	32.3875
Dv20:	46.3585
Dv30:	57.8698
Dv40:	68.5946
Dv50:	79.2649
Dv60:	90.1894
Dv70:	102.944
Dv80:	118.996
Dv90:	143.287
Dv100:	305.163

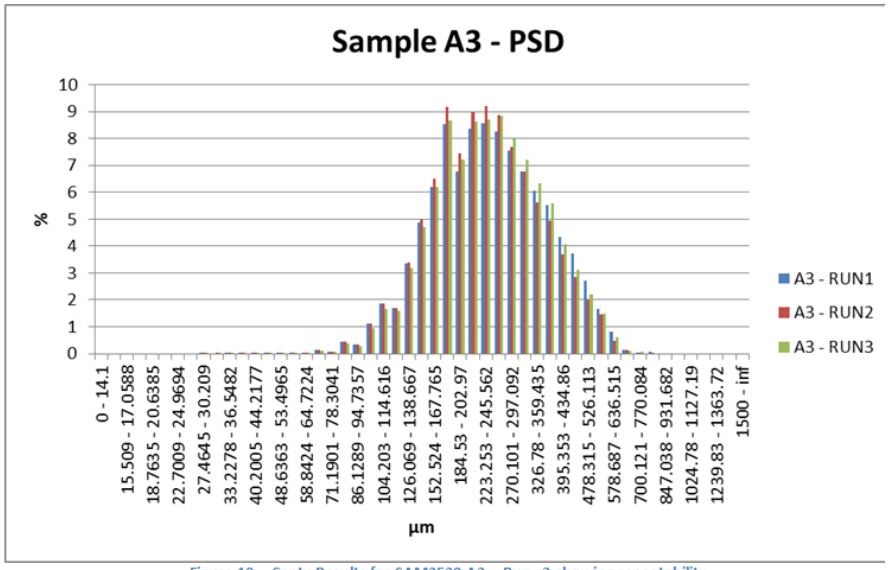


Figure 10 – Canty Results for SAM2529-A3 – Run x3 showing repeatability

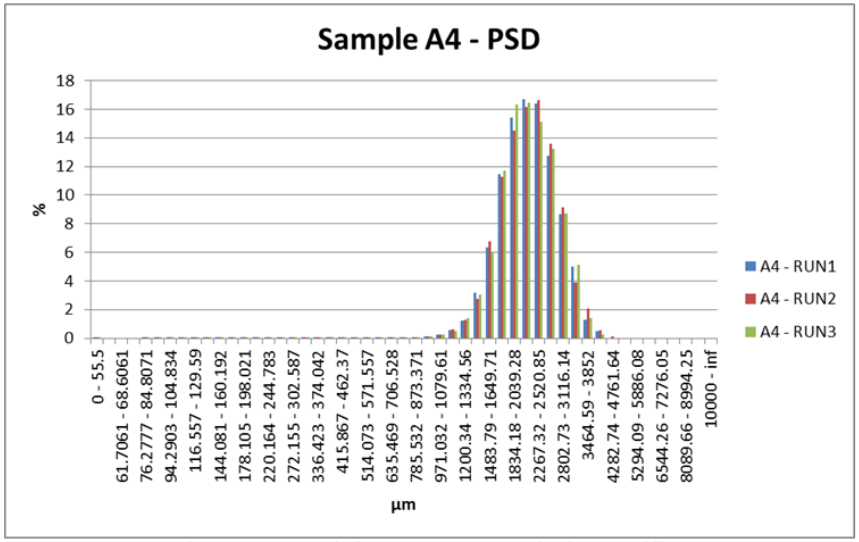


Figure 11 – Canty Results for SAM2529-A4 – Run x3 showing repeatability

A3

Dv10:	140.659
Dv20:	167.35
Dv30:	190.488
Dv40:	212.794
Dv50:	239.155
Dv60:	267.347
Dv70:	305.662
Dv80:	352.042
Dv90:	424.994
Dv100:	814.097

A4

Dv10:	1610.79
Dv20:	1785.41
Dv30:	1925.19
Dv40:	2062.45
Dv50:	2189.72
Dv60:	2328.35
Dv70:	2480.81
Dv80:	2674.92
Dv90:	2966.01
Dv100:	4067.25

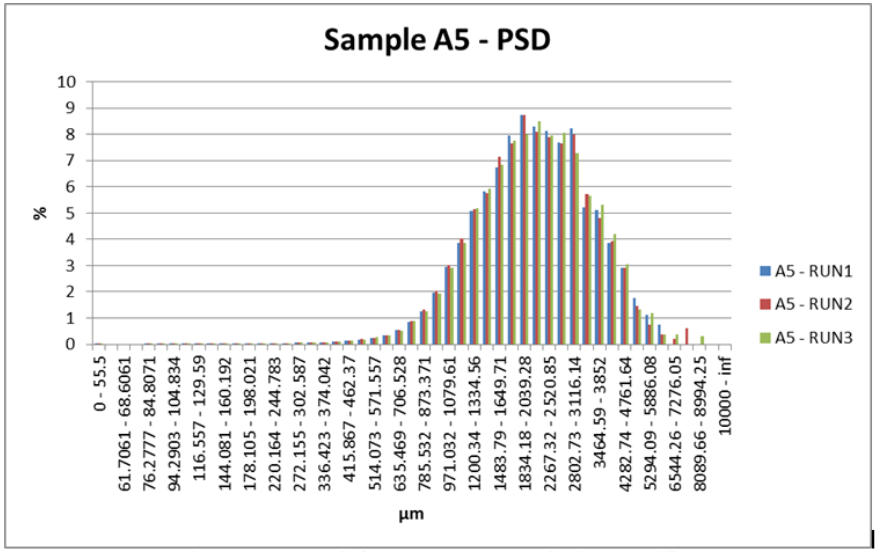


Figure 12 – Canty Results for SAM2529-A5 – Run x3 showing repeatability

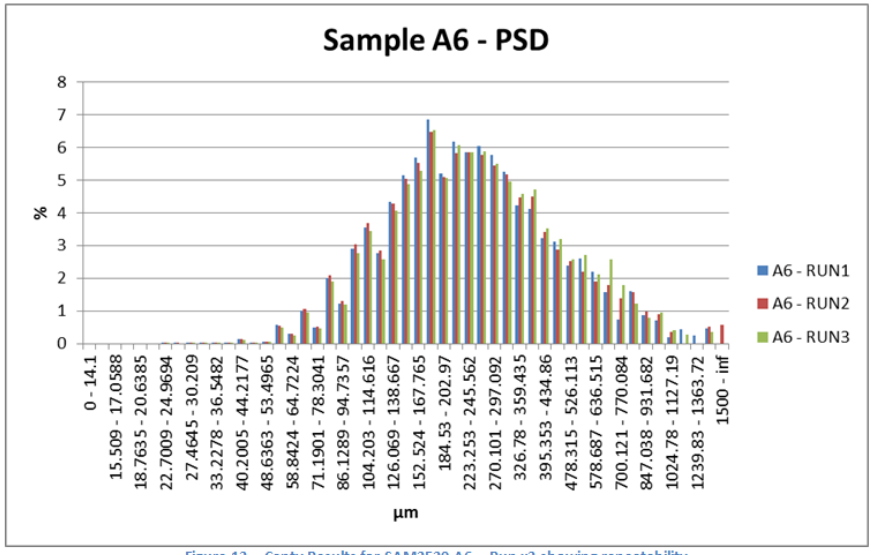


Figure 13 – Canty Results for SAM2529-A6 – Run x3 showing repeatability

A5

Dv10:	1114.83
Dv20:	1389.18
Dv30:	1644.05
Dv40:	1875.7
Dv50:	2125.38
Dv60:	2411.56
Dv70:	2750.31
Dv80:	3157.38
Dv90:	3879.91
Dv100:	6380.82

A6

Dv10:	112.012
Dv20:	140.227
Dv30:	167.317
Dv40:	196.686
Dv50:	228.406
Dv60:	268.017
Dv70:	319.571
Dv80:	399.095
Dv90:	558.778
Dv100:	1466.51

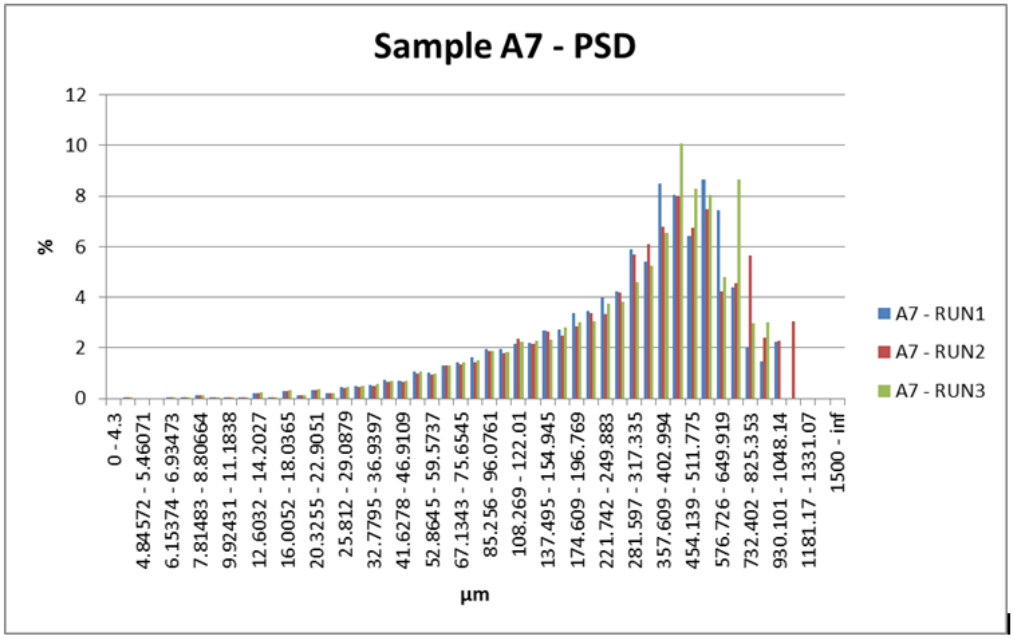


Figure 14 – Canty Results for SAM2529-A7 – Run x3 showing repeatability

A7	
Dv10:	80.797
Dv20:	143.156
Dv30:	210.942
Dv40:	283.319
Dv50:	347.314
Dv60:	404.698
Dv70:	479.288
Dv80:	554.591
Dv90:	646.791
Dv100:	966.67

LCM Data

Sample	Circularity	Aspect Ratio	DV50	Average Length	Average Width
A1	0.645118	1.54769	7.51416	5.33018	4.38413
A2	0.765093	1.58019	79.2649	24.8171	19.807
A3	0.845846	1.56903	239.155	199.259	158.837
A4	0.850825	1.53341	2189.72	2028.52	1707.78
A5	0.783272	1.74953	2125.38	1122.23	838.133
A6	0.822686	1.60664	228.406	143.751	110.268
A7	0.79645	1.54956	347.314	26.0251	21.0355

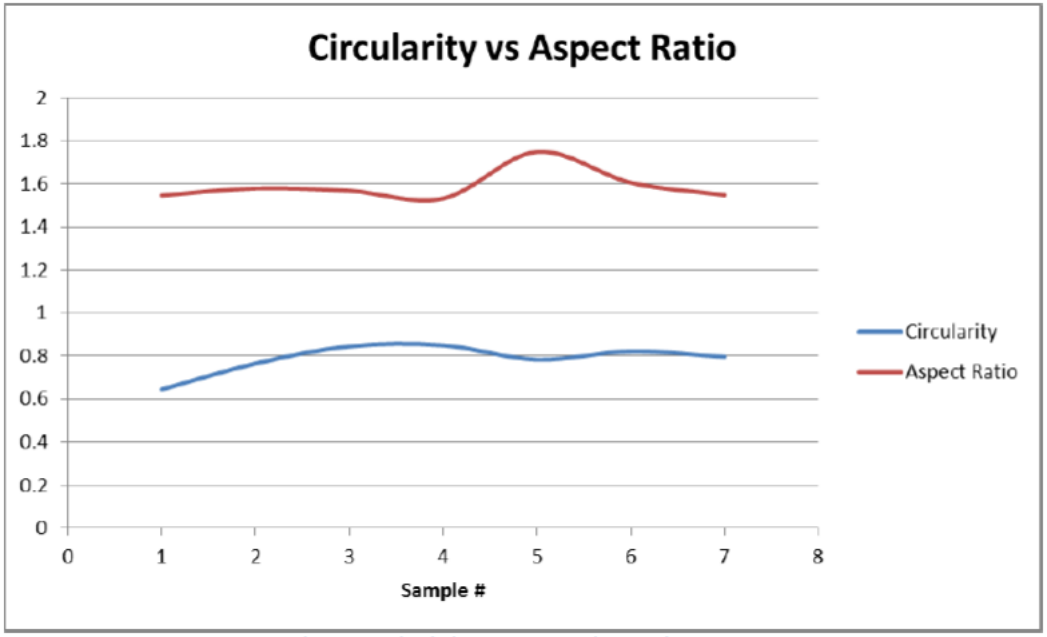


Figure 15 – Circularity vs. Aspect Ratio, Samples A1 – A7

LCM Data

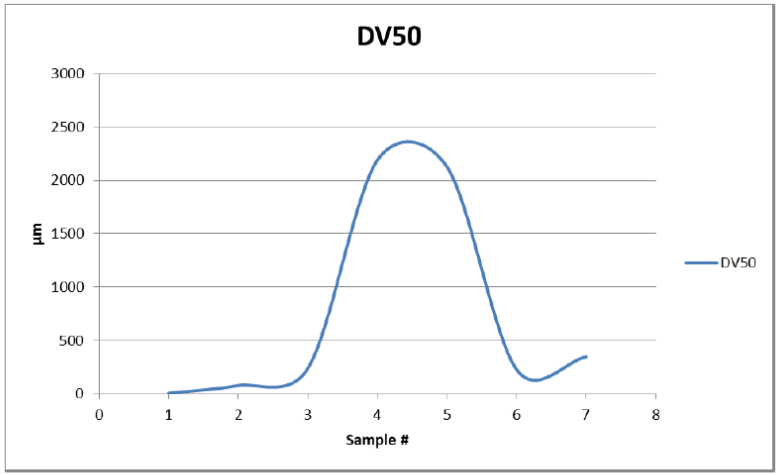
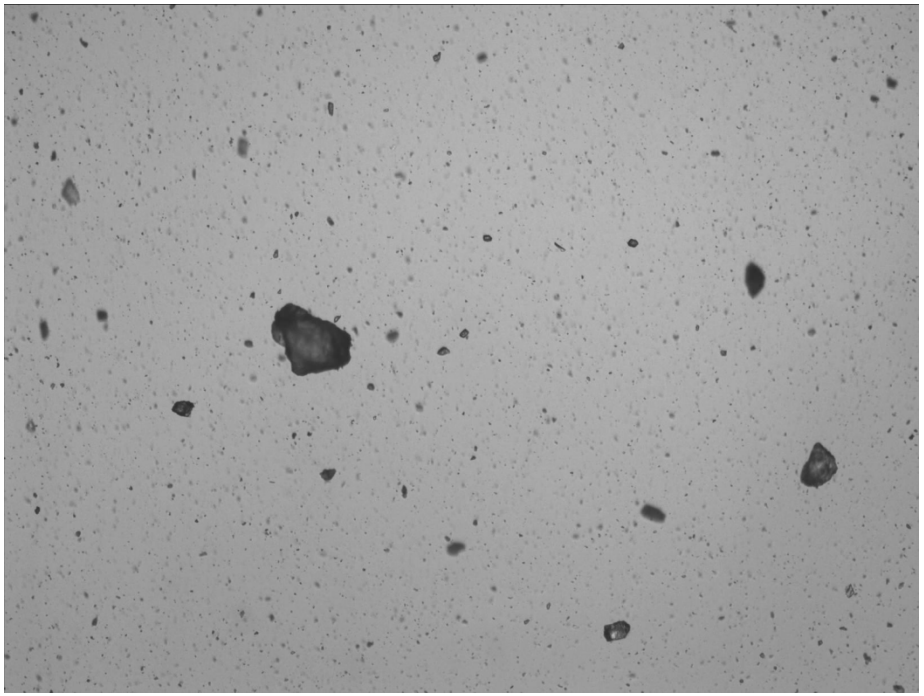


Figure 16 – DV50, Samples A1 – A7



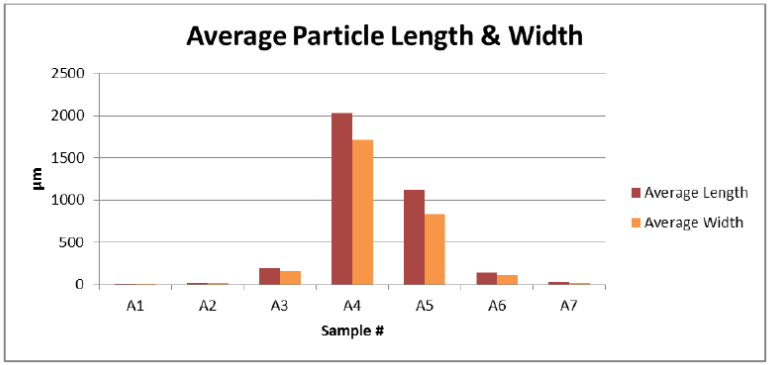


Figure 17 – Average Particle Length (mean fiber length) & Width (mean minor axis)

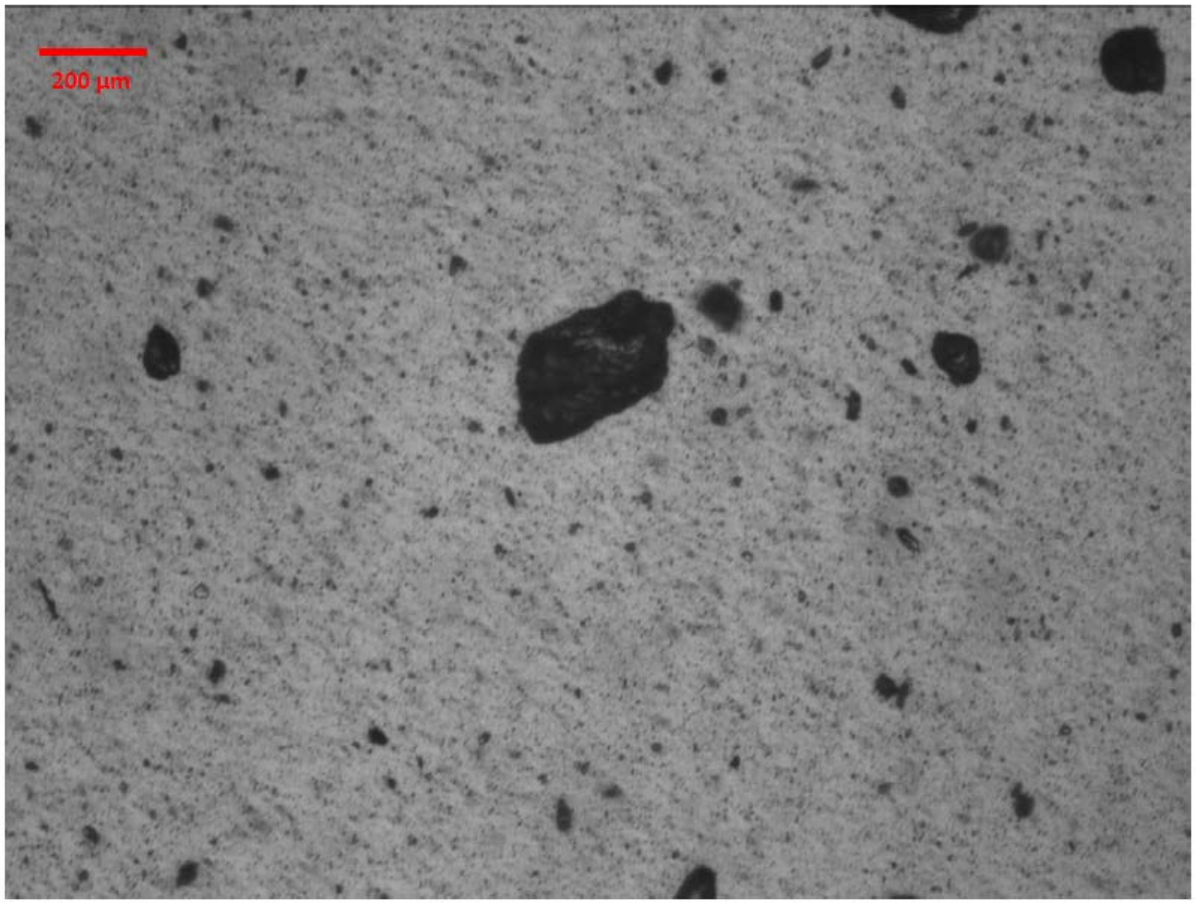


Figure 9 Live Image of VK50 + Baracarb 150. PSF = 1.4µm per pixel. FOV = 2.27mm in Horizontal Direction

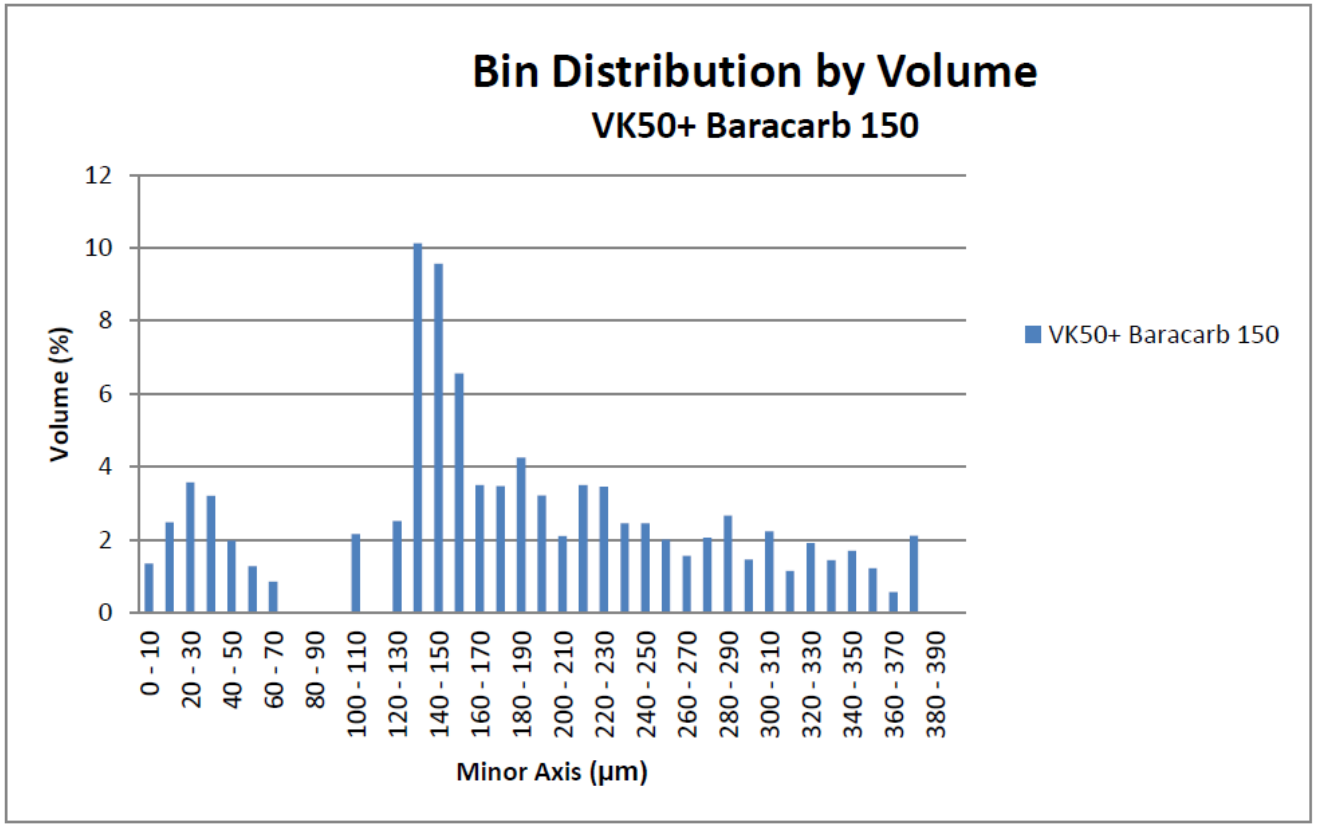
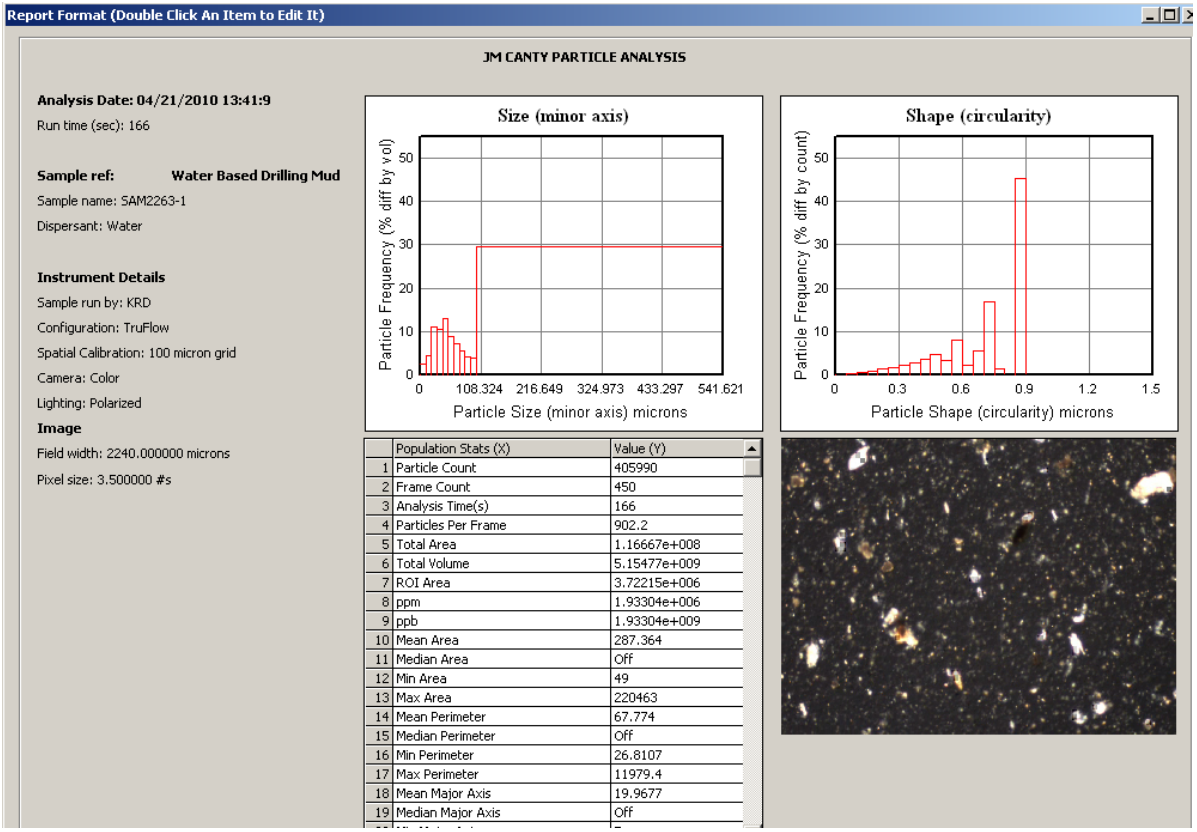


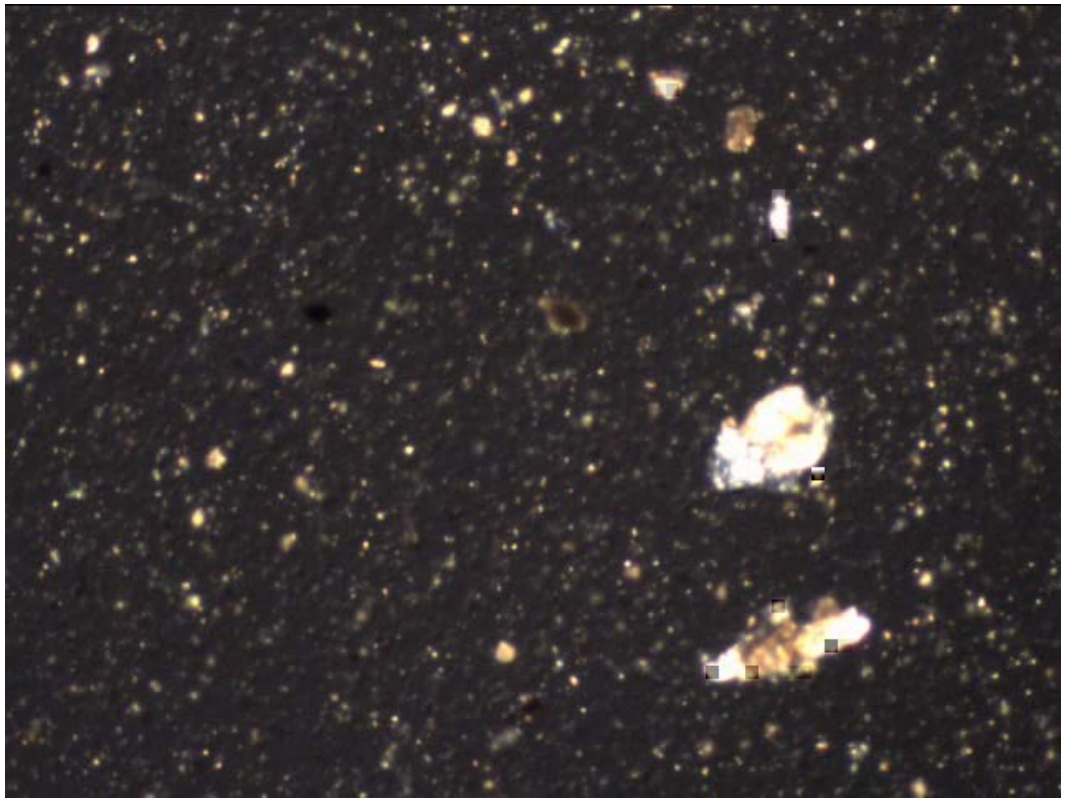
Figure 10 Bimodal distribution observed for sample VK50 and Baracarb 150, which have two distinct particle size distribution

Drilling Mud Testing



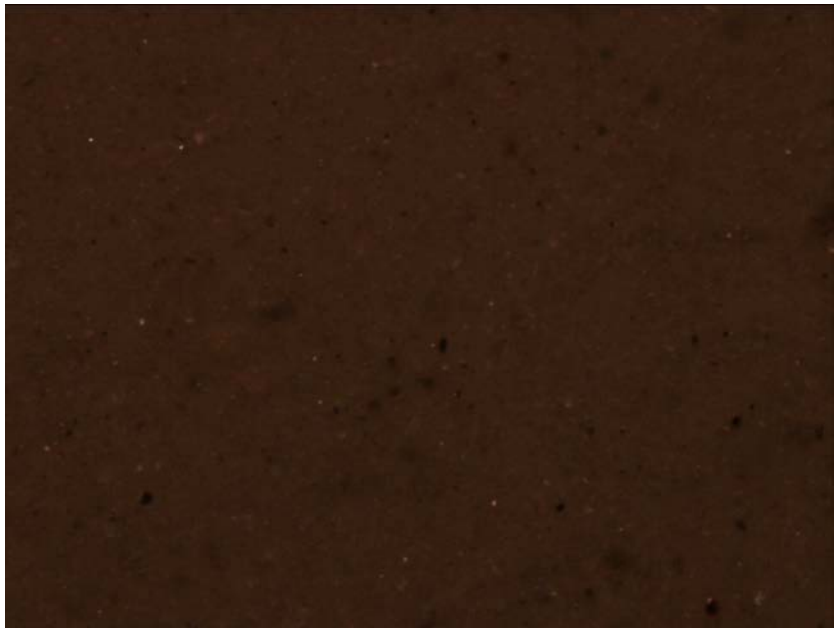
Drilling mud spiked with Barite + Mica + Gseal + LCF + Carb + Poly
(Cross-polarized lighting used to optimize difference in particles types)

Drilling Mud Testing

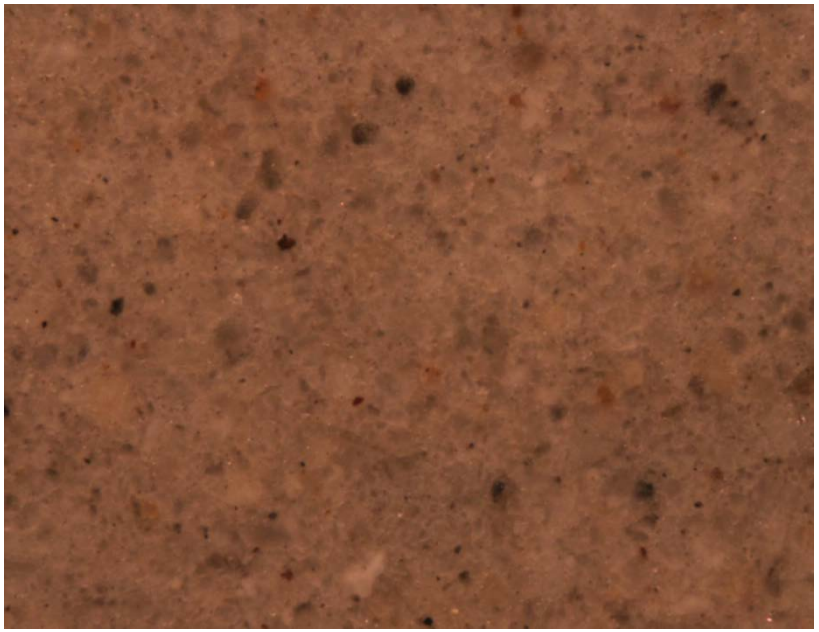


640 x 480 color image oil based drilling mud
(Cross-polarized lighting used to optimize difference in particles types)

Drilling Mud Testing

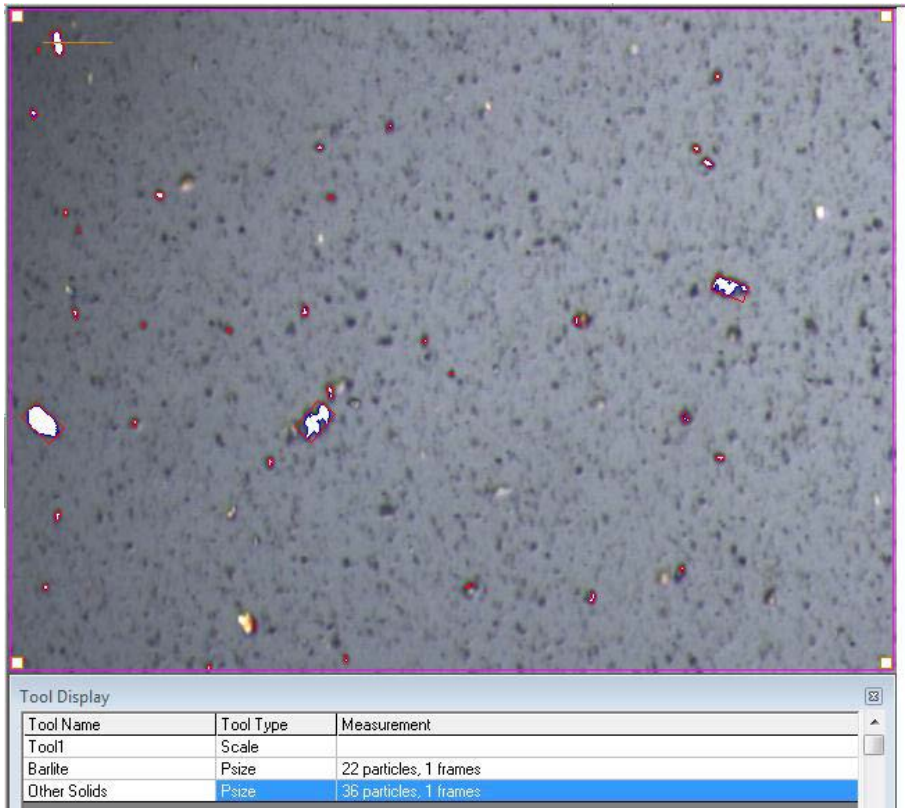


Water based mud



Water based mud spiked with – carb
Notice increase in “white” particles

Canty Software Analysis



Canty Vision Software Package Individually analyzes particles
(water based drilling mud / polarized lighting)

Conclusion

- Canty's Drilling Fluid Particle Analyzer is a system capable of high precision drilling fluid analysis. Our analyzers offers many unique advantages over laser diffraction technology.
- With the ability for high resolution color analysis the Canty Drilling Mud System can be a unique tool for drilling fluid engineers to aide in the microscopic examination of drill cuttings.

Questions?