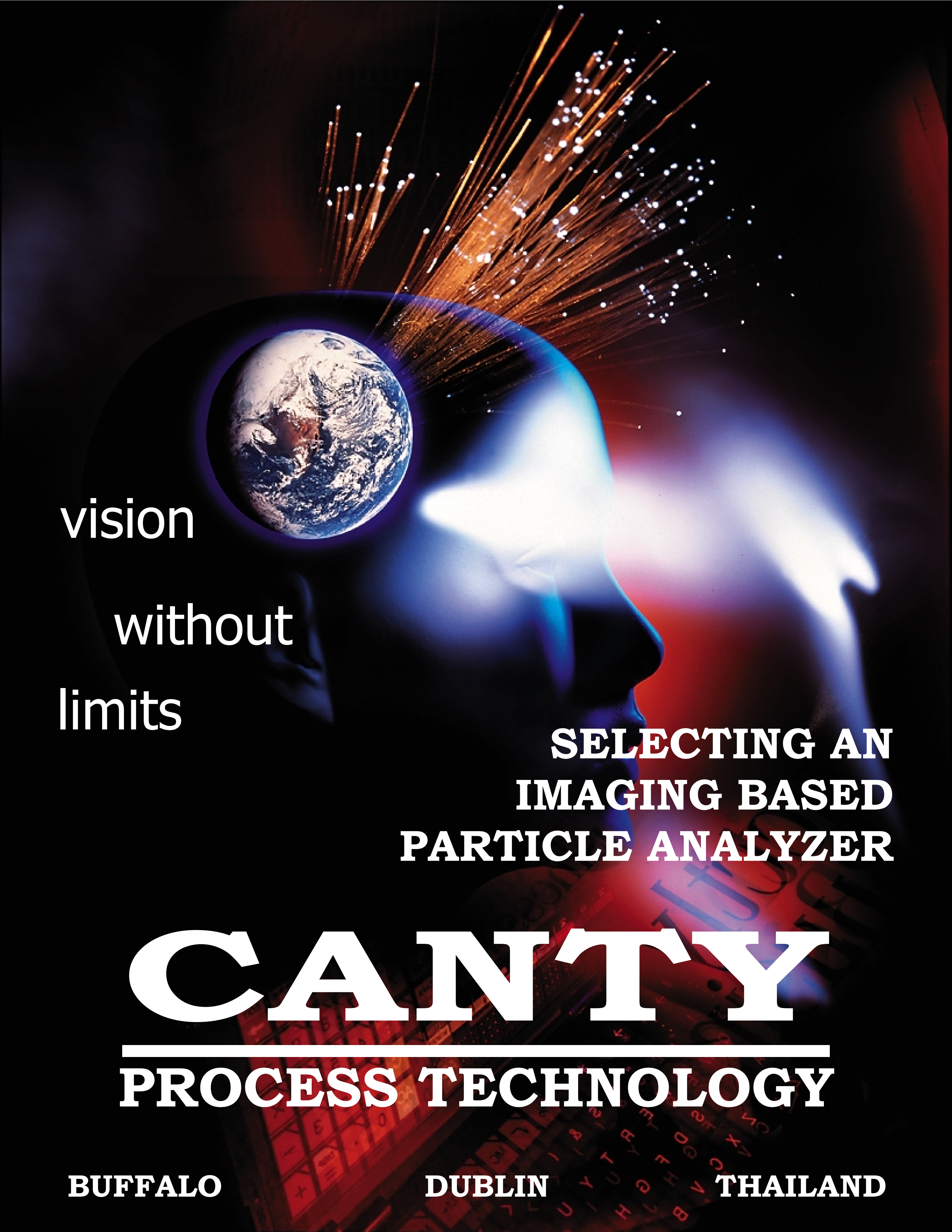


vision without limits

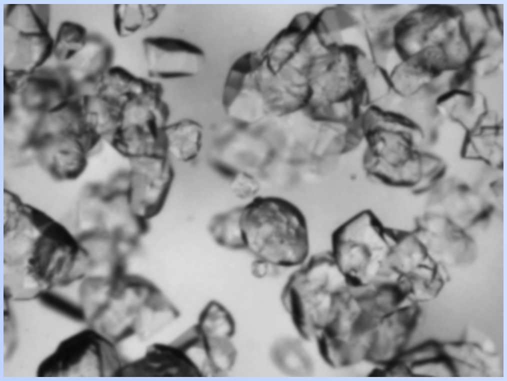
SELECTING AN IMAGING BASED PARTICLE ANALYZER

CANTY PROCESS TECHNOLOGY

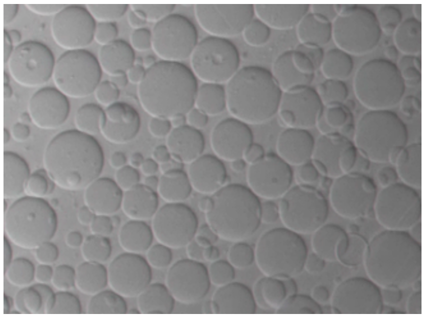
BUFFALO DUBLIN THAILAND

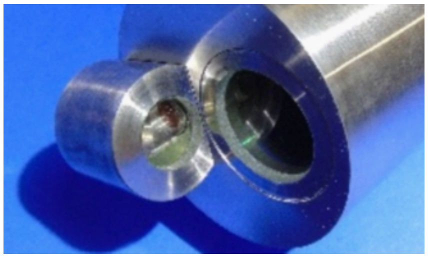
The Evolution of Imaging Based Particle Analysis

CANTY began by developing a unique fibre optic lighting and fused glass allowing for an excellent view inside of a process vessel. Soon afterwards, there was a rapid increase in automation, which developed a need for a remote view in the control room, that was now running the process. We realized that we could take the existing light port and provide a camera/light combination, giving a continuous remote view into the reactor. Our camera systems incorporated all the advantages of our fused glass technology and process lighting experience, to ensure the best view possible. This eliminated the need to have an operator walk to the plant area and communicate back to the control room on the condition inside the vessel, thus allowing for real time decisions to be made, and with less manpower resources used. We then took the next step and developed an image analyzer to measure level, foam and color.



Our first foray into the world of particle analysis was triggered by a visit to a sugar plant, where our fused glass sight glasses were already providing manual viewing of the sugar crystallization process. Here we noticed that the user had mounted the optical components from a static microscope to one of our sight glasses, in an attempt to periodically view the growing sugar crystals within their process. The optics and poor lighting arrangement meant that the user's view was of very poor quality, but an idea was born. A few months later we were back at the same site with our first particle monitoring camera. It's development relied heavily on our vast experience in optimizing process lighting, which we combined for the first time with microscopic optics, and the results were simply astounding. The user now had a constant live video stream of their sugar crystals, from the initial seeding stage right up to full crystal growth, allowing them to massively increase their process control and therefore their process yield.





Development and optimization for particle analysis requirements continued, with a significant milestone coming in the early 90s, in the eastern part of Germany not long after the Berlin Wall came down. During a visit to a buna rubber plant in Schkopau, Tod Canty met with the plant's research group, where a need was discovered for live monitoring and measurement of Expanded Polystyrene (EPS) Beads, during the formation and growth process. Following this meeting, Tod worked closely with the plant's scientists, and in CANTY's own lab, to determine the optimal optics and lighting arrangement for image capture. This resulted in the developed of the first ever on vessel system with insertion optics and a 90° lighting arrangement. The live images were spectacular, with the edges of the beads dramatically highlighted by the angled lighting arrangement. Image analysis software was developed in tandem with the hardware advances, allowing for automatic measurement of the beads as they formed and grew. This online measurement in EPS had never been done before, and no one has been able to replicate it since.

As successes in vessel particle analysis applications continued in the following years, so too did the development of a range on pipeline mounted particle analysis systems, where process liquid continuously flows These type of pipeline systems were marketed under the INFLOW™ name, and after initially being supplied to the chemical industry based on our previous successes there, the INFLOW™ was then (and continues to be) supplied across a wider variety of additional industries including oil & gas, pharmaceutical, mining and food, where online pipeline particle analysis is a common requirement to maximize process control.

By the early 2000s, CANTY had supplied more online particle analysis systems than all of our competitors combined. However at that time, we had not yet ventured into the lab analysis arena. Eventually, born out of the frustration of users with their non CANTY lab particle analyzers, versus the relative ease of use and comprehensive data provided by their CANTY online systems, we were convinced to enter this area.

In the years that followed, CANTY developed and optimized a series of lab based analyzers, initially for liquid or slurry sample analysis. However that changed when we were approached by one of the largest detergent manufacturers in the world, with a requirement for accurate, comprehensive and reliable particle analysis, on their dry powder product sample.

From that need, our range of SolidSizer™ systems was developed which allowed for dry powder samples to be analyzed without the need for any of the sample preparation required with other lab based analyzers, and in a much shorter timeframe than traditional methods such as manual sieving. Development of the SolidSizer™ range continued, with a significant addition coming in the form of adding a color or black speck analysis option, which meant that the system could not only analyze the size and shape of the particles, but could also be used to determine if there are certain types on contaminants present in the powder, or if mixing ratios of 2 different powder products was correct. As with a most of our product evolutions, this addition stemmed from a need of one of our largest end user companies, who also happens to be one of the biggest chemical companies in the world.

- **1971** CANTY established with focus on fibre optic lighting & fused glass
- **1986** CANTY develops combined camera and lighting system
- **1989** First particle analyzer is developed for the sugar industry
- **1994** First on vessel EPS particle sizing system developed
- **1995** INFLOW™ for in pipeline particle analysis released
- **2000** CANTY begins development of lab based analyzers, initially for liquid samples, then dry solids
- **NOW** CANTY is a world leader for both online and lab based dynamic imaging particle analysis

Since the beginning, we have continuously strived to innovate and evolve our product range to react to the ever changing needs of the industries that we are involved in. More recent developments have included the CANTY MiniCell, which is used in diverse applications ranging from cell count and viability analysis in the biotech industry to wear particle analysis in lubrication oil samples, our Skid INFLOW™ with Automatic Cleaning System for continuous Oil and TSS in Water analysis within the oil & gas industry, and our INFLOW™ with Automatic Dilution for high concentration particle analysis applications across the pharmaceutical, mining and offshore drilling industries. The common denominator throughout our history in particle analysis, is our extremely strong fundamentals in fused glass, lighting, and camera optics. This, coupled with our ever advancing image analysis software, has allowed us to lead the way in the past, and will allow us to continue to lead the way into the future.

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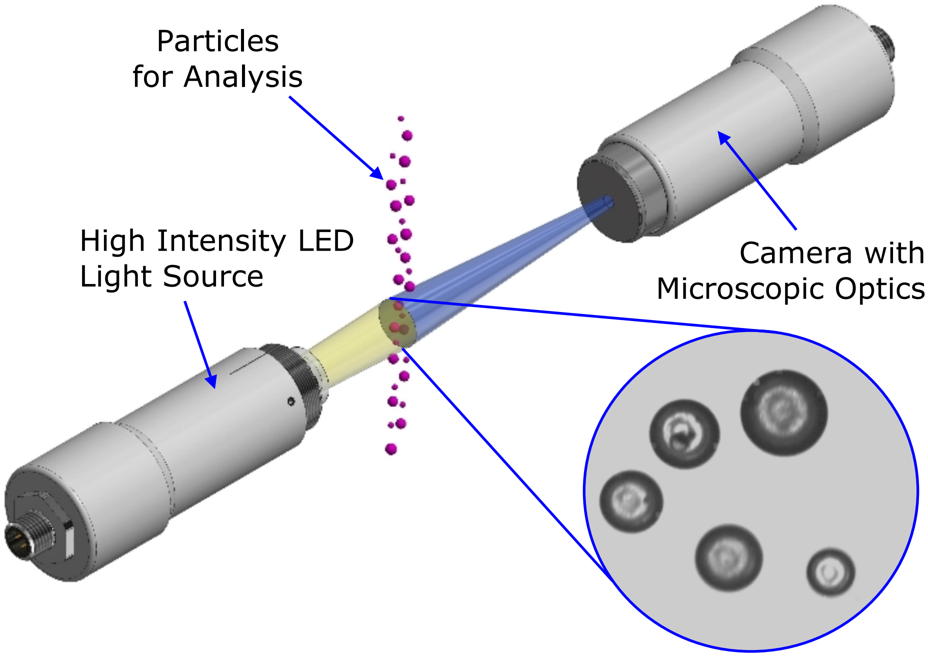
Dynamic Imaging Based Particle Analysis

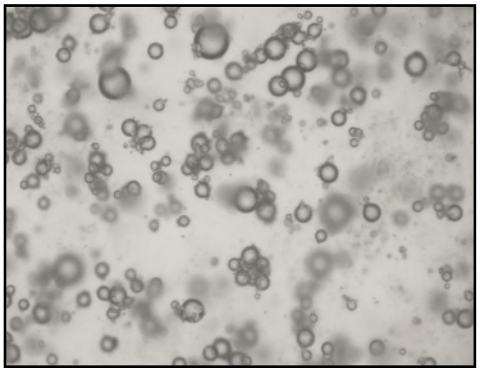
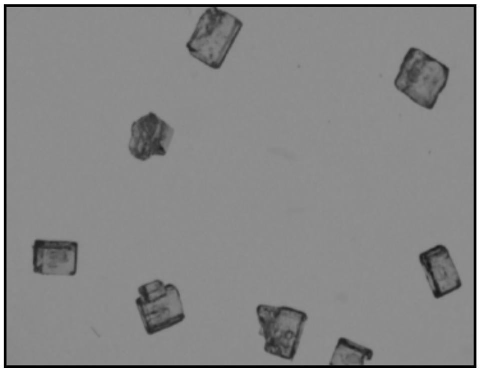
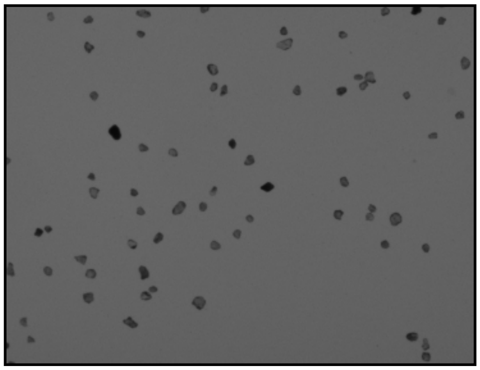
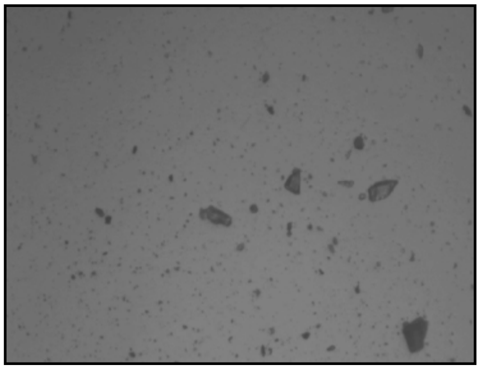
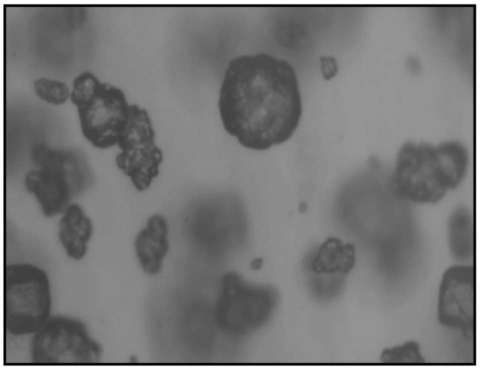
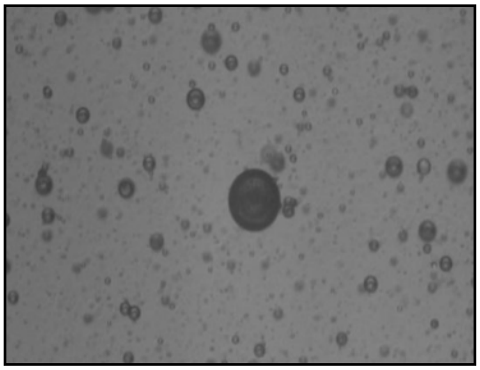
Whether analyzing a liquid suspension or dry particle sample, CANTY's Dynamic Imaging technique works on the same fundamental principle, of passing the particles between a camera fitted with micro or macroscopic optics, and high intensity LED lighting system. This allows for high resolution image capture of the particles, with the boundary of those particles highlighted against the brighter image background, making them ideally suited for size and shape measurement through image analysis.



The real time analysis of the captured images, is performed by CANTY's suite of CANTYVISION software packages, running on the provided VCM (Vector Control Module).

The powerful image analysis software uses a thresholding algorithm to identify the individual particles, and then measures each under 30+ different size & shape parameters including the most commonly used minor axis, major axis, and equivalent ellipse.

The high performance processor of the VCM means that multiple images can be analyzed per second, and allows for the automatically generated size or shape distribution information, or concentration data, to be provided instantly to the user.

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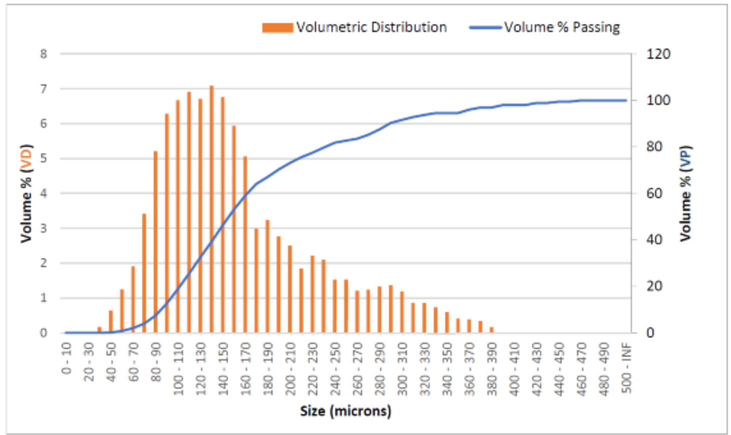
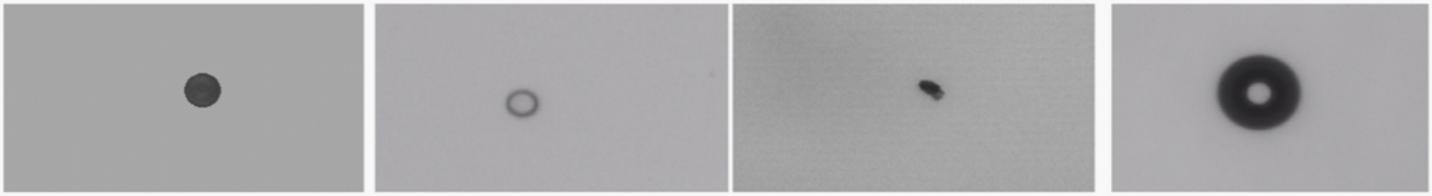
Through the intuitive CANTYVISION software interface, the user can decide which of the 30+ measurements for each particle, that the distribution is based on.

They can also tailor the automatically outputted reports to suit their specific needs, whether that is getting summary data, the specific measurements for each and every particle measured, or even industry or standard specific reporting formats such as ISO4406 or ASTM D8072

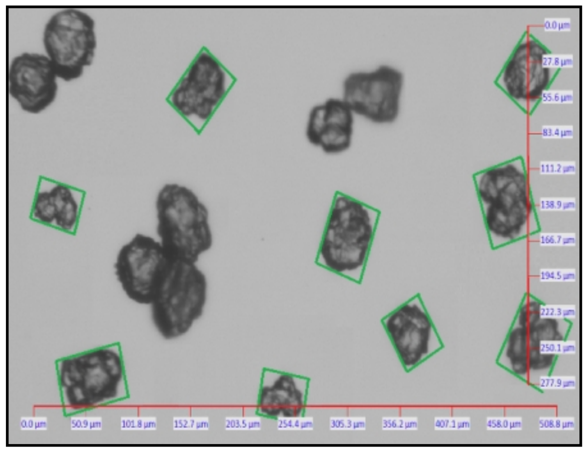


HEAVY OIL		LIGHT OIL / CONDENSATE		SOLID PARTICLE		GAS BUBBLE	

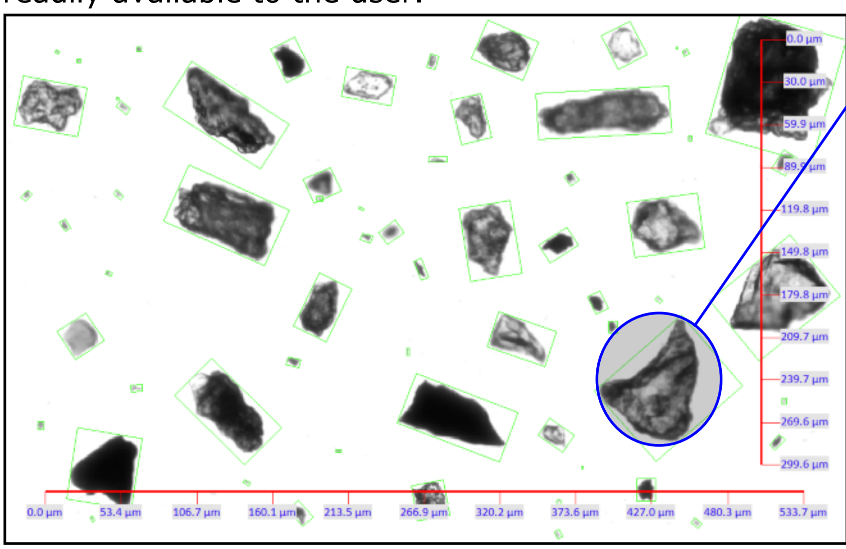


Shape Parameter	Value	Shape Parameter	Value	Shape Parameter	Value	Shape Parameter	Value
Circularity	.95	Circularity	.13	Circularity	.70	Circularity	.33
Aspect Ratio	1.0	Aspect Ratio	1.0	Aspect Ratio	2.23	Aspect Ratio	1.0
% Holes Area	0%	% Holes Area	92.5%	% Holes Area	0%	% Holes Area	25.5%

The CANTYVISION software also includes a particle classification feature. The system's AI can apply a multi level classification to differentiate particle types within a single sample, meaning that different types of particles that may be present within a single sample, can be separately classified, analyzed and reported.



The classification feature interface also allows for the detection (and optional removal from the data) of particle agglomerates if they are present. Detailed examination of the size and shape data of individual particles is also possible, with the 30+ measurements for each particle readily available to the user.



Particle Data Display

Particle Number 800

Particle Data	Micrometer
MAJOR AXIS	193.547
MINOR AXIS	157.751
AREA	19047.173
PERIMETER	598.739
DIAGONAL AXIS	249.692
ELONGATION FACTOR	1.928
CIRCULARITY	0.817
MAX FERET DIAMETER	208.619
SPHERICITY	0.668
CONVEXITY	0.844

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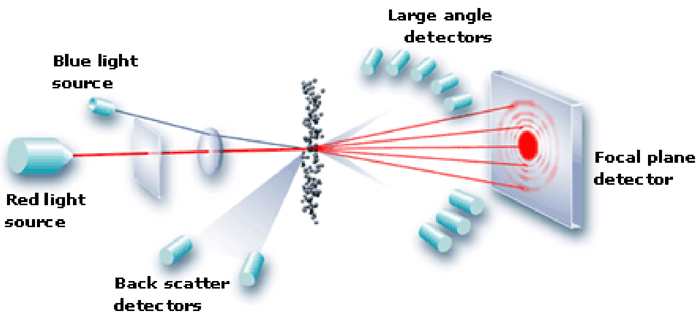
Imaging Based Particle Analysis vs Laser Diffraction

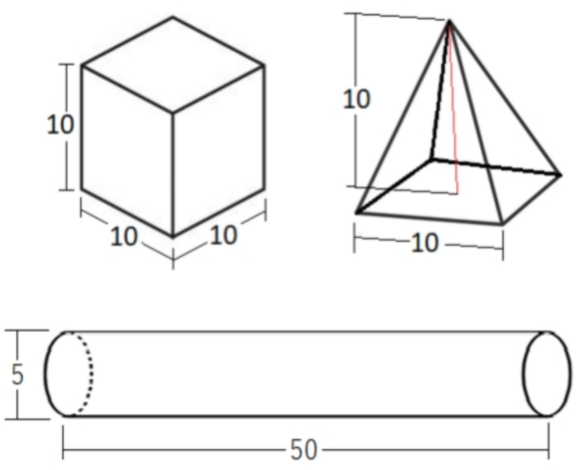
Laser light diffraction or laser light scattering, is an alternative method to CANTY's Dynamic Imaging based analyzers. However there are some very important points to note when comparing the two technologies.

This laser based technique involves passing the particles through a laser beam, which causes that laser light to scatter or diffract. The angle of that diffraction is proportional to the volume of the particle, which is then used to back calculate an Equivalent Spherical Diameter (ESD), which is reported as the particle size.



There is of course a very obvious flaw to this. Unless dealing with particles that are actually spherical in shape (which is relatively rare), **<u>the number reported as the particle size is not actually any physical dimension of that particle</u>**.

Take for example a cube of 10µm sides. An imaging system will measure the width as 10 µm. Theoretically, the laser based system would measure the volume (1000 cubic µm), and back calculate to give an ESD of 12.4µm, which is 24% larger than the actual width.

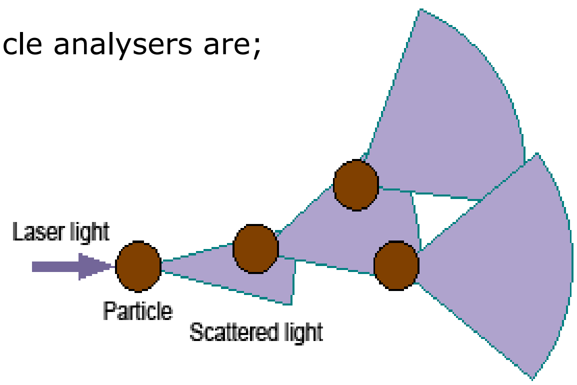


Conversely, considering a square based pyramid of 10µm sides and height, an imaging system will measure the width as 10µm. A laser based system would indirectly measure the volume (333 cubic µm), and back calculate to give and ESD and reported particle size of 8.6µm, which is 14% lower than the actual width.

Elongated or needle shaped particles also present a big issue for laser based systems. A 50µm x 5µm needle for example, would have both dimensions measured and reported by an imaging system. A laser system would look at the volume of 982µm, and back calculate an ESD of 12.3µm. It would say that the cube and cylinder shown on the graphic opposite, are practically the same size!

Other common issues which plague any laser based particle analysers are;

- Multiple scattering, particularly in higher concentration samples, as shown in the image opposite. The laser light that has been scattered by the first particle, can be subjected to additional diffraction if it meets additional particles before reaching the detectors.
- Angular or sharp edged particles, causing the laser light beam to scatter or diffract at an angle not at all related to the volume of the particle.



Unlike Dynamic Imaging based systems, there is no visual verification, so the user has no way to determine if either of these issues is affecting the data produced.

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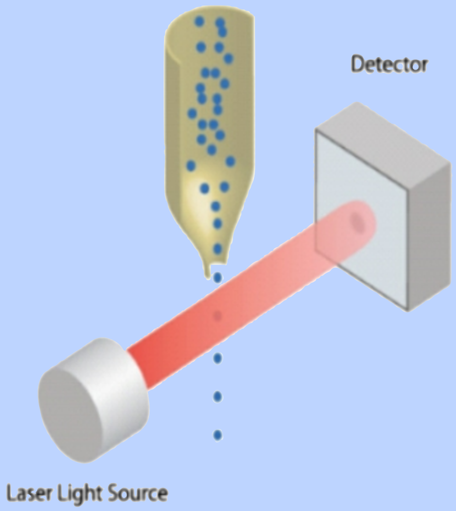
Imaging Based Particle Analysis vs Light Obscuration

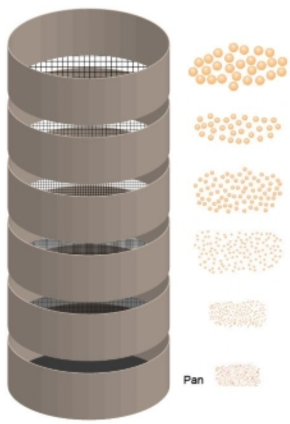


The technology works by passing a dilute stream of particles in a liquid suspension between a light source and detector. The passing of the particles results in a shadow or blockage of light, which is measured by the detector. The reduction in light intensity is proportional to the volume of the particle, and similar to the laser scattering systems, that volume is the used to back calculate an Equivalent Spherical Diameter (ESD), which is then reported as the particle size.

The flaws in this type of back calculation from a volume to an ESD which are covered in the page opposite, are also applicable here, so unless you are measuring spherical particles, the number reported as the particle size is not any physical dimension of the particles being analysed.

Imaging Based Particle Analysis vs Manual Sieving

Sieve analysis is the simplest technique for particle size measurement, and is performed by introducing the sample to the top level of a sieve stack, where each sieve has a smaller aperture size than that of the sieve above it. Once the sample is introduced, the sieve stack shaken for a specific period of time, to allow particles to pass through the different sieve levels if possible, until they are eventually retained by one with an aperture size smaller than the particle size. Each sieve is then weighed to determine how much material has been retained, and the size distribution can therefore be calculated.



Unlike laser diffraction or light obscuration techniques, sieving does produce a size distribution based on a physical dimension of the particles (the width as this is the dimension and therefor determines whether the particle can pass through the sieve or not).

However, there are some distinct disadvantages over sieving. The technique is very manual and is therefore a labour intensive process requiring a lot of input from the user. It is also quite a time consuming technique, with a single sample typically taking 20-30 to process and generate the required data. Over time the accuracy can also be reduced, as the apertures in the sieves become worn or distorted through normal operation and cleaning. It is also known to struggle with rod or needle shaped particles, as the sieve shaking may not be enough to get these type of particles into the right orientation to pass through a particular sieve opening.

	CANTY Imaging	Laser Diffraction	Light Obscuration	Manual Sieving
Direct / Relative Measurement	DIRECT	RELATIVE	RELATIVE	DIRECT
Multi Dimension Size Measurement	YES	NO - 1D	NO - 1D	NO - 1D
Shape Characterisation	YES	NO	NO	NO
Differentiation of Particle Types	YES	NO	NO	NO
Visual Verification	YES	NO	NO	LIMITED

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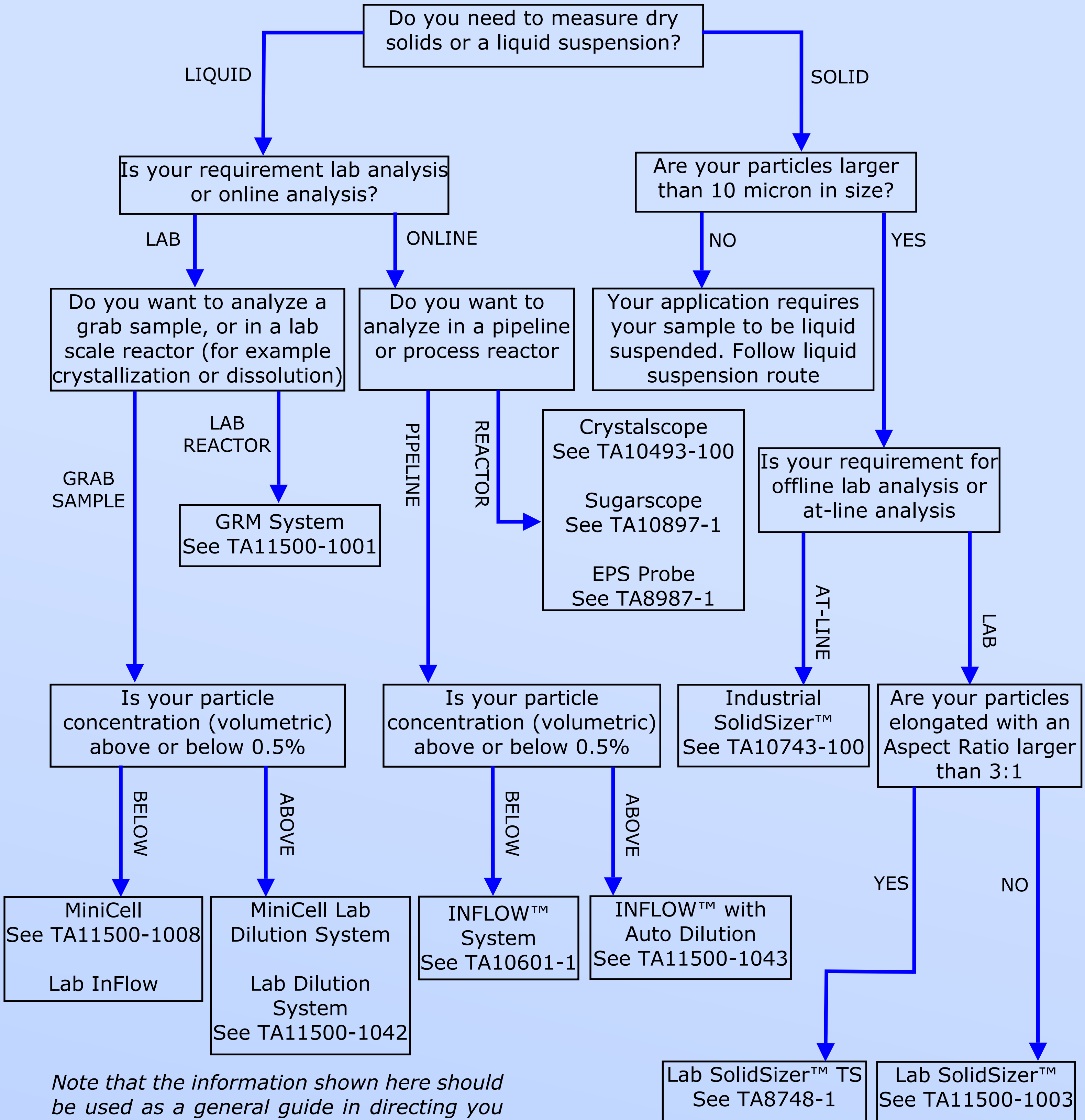
Selecting a Suitable Imaging Based Particle Analyzer



Note that the information shown here should be used as a general guide in directing you towards a system suitable for your needs, but it is always recommended to also discuss your requirement in detail with CANTY.

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CANTY
PROCESS TECHNOLOGY

CANTY'S GOAL IS TO PROVIDE EQUIPMENT TO ENHANCE PROCESS UNDERSTANDING AND CONTROL. WE ACCOMPLISH THIS BY DESIGNING, MANUFACTURING AND SERVICING THE FINEST EQUIPMENT IN THE WORLD

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