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WHITE PAPER

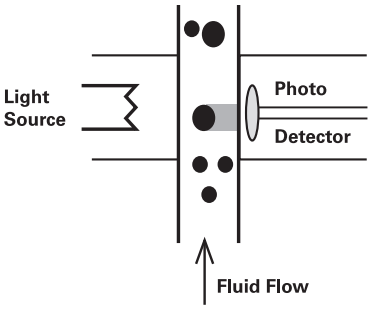
# Guide to Particle Measurement Techniques

## Background

Particle counting is a critical aspect of any machine conditioning program and there are many tools out there available to monitor and track the quantity and severity of the contamination, be it due to external contamination or machine wear. The specific application and type of particles will often govern what is the best particle counting technique for the job at hand. The continuous cleanliness of a hydraulic system, for instance, is very critical and even very low levels of dirt ingress can clog actuators and valves leading to premature failure. On the flip side gear and transmission systems with lots of moving parts coming together will be able to tolerate many more wear particles than a clean hydraulic system.

## What techniques are available?

### LIGHT BLOCKAGE PARTICLE COUNTERS




HIAC ROYCO 8011 OPC

Laser light blocking particle counters, or optical particle counters (OPC's) are the traditional instruments used for in-service oil analysis. The working principle of traditional light blockage particle counters is depicted below. A light source, typically a laser, passes through a sample. The light is partially blocked by particles so less light reaches the photodetector array, resulting in a change in voltage proportional to the area of the particles. The photo detector technology is the same principle used in garage door openers.

ADVANTAGES
- Accurate for contamination control
- Portable
- Easy to automate

DISADVANTAGES
- Easily affected by water & soot
- Coincidence errors
- Periodic calibrations required

Traditional light blockage particle counters have several inherent design limitations. The photo detector results contain measurement errors caused by the presence of water and air bubbles within the oil sample. Properly preparing your sample by using ultrasonic agitation helps reduce the impact of air bubbles on particle count. For water containing samples (an oil sample that is 'milky' contains water), it is common to need 'water stripping' solvents to get a more accurate count. The presence of water results in a significant error in the reported particle count.

Rockwell digital CONTAM-ALERT

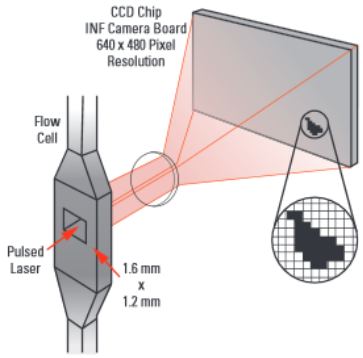
## PORE BLOCKAGE

Pore blockage particle counters are used as on-site particle counters for in-service machinery oils. They employ a fine mesh whereby particulate accumulates on the mesh. These particle counters are based upon either a constant flow or constant pressure design. Constant flow instruments measure the pressure drop across the mesh while holding flow constant. The constant pressure designs measure the change in flow rate while holding the pressure constant.

In both cases, the particle count distribution is estimated by extrapolation. A typical pore blockage mesh design yields one or two ISO codes. Pore blockage particle counters are rarely used by commercial laboratories due to the limited data generated but can be of great use where interference from water, soot or additives is highly prevalent in the samples.

ADVANTAGES
- No interference from additives or water
- No interference from soot
- No degassing to remove air bubbles

DISADVANTAGES
- Only measures a single size channel
- Pore density is NOT one size fits all
- Very distribution dependent at the pore size being measured




LaserNet Fines Q230 Series

## DIRECT IMAGING PARTICLE COUNTERS

Direct imaging systems incorporate a solid-state laser configured with a CCD array to create a direct imaging particle counter as depicted in the illustration at left.

The laser illuminates the sample, and an optical lens magnifies the laser light. A CCD video camera captures the images of the sample and stores them in memory.

These images are analyzed for size and shape. An equivalent circular diameter or ECD is calculated for each image and particle count and size distribution is reported along with ISO codes. Along with particle shape morphology, direct imaging systems provide other particle counting output formats but ISO 4406 is the most common.

The capability of direct imaging systems to capture the actual wear particle silhouette allows for an 'Automated Ferrography' capability for wear particle classification. All particles larger than 20 µ are classified by a neural network in the categories of cutting, fatigue, severe sliding, non-metallic, free water and fibers. Identifying the type of wear particle and providing particle count, size distribution and severity of each of the abnormal wear mechanisms complements information provided by other instrumentation technologies such as ferrous monitoring and analytical ferrography. This capability is implemented on the Spectro LNF Q220 and Q230 instruments and is described in more detail on spectrosci.com and in other documentation.

ADVANTAGES
- No coincidence effects – below 5 million p/ml
- Accurate to 1um resolution
- No calibration required (intrinsically correct)
- Additional shape classification

DISADVANTAGES
- Heavy oils >320cst require dilution
- Sooted oils >2% require dilution
- Interference from additives and water below the classification threshold (20um)

Imaging systems can distinguish between solid particles, water droplets and air bubbles in oil for all particles greater than 20 µ. Water and air bubble counts are subtracted from the measured particle count to yield a true net particle count.

## Summary

As we have shown, there are three main techniques in the field of particle analysis; pore blockage, optical light blocking and direct imaging. Each has its own unique advantages and disadvantages and it depends on the specific application being monitored which technique will offer the best value for the end user. Particle analysis is a very important aspect of machine condition monitoring and the type of tool you choose will depend upon whether you intend to use it for machine specific wear particle analysis or basic particle counting cleanliness control tasks. The concentration and severity of interfering objects, such as: water, additives and soot should also be taken into consideration and will influence the choice.

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