Using and Understanding the LNF as a Particle Counter

Introduction.

The LaserNet Fines was designed primarily as an automatic wear particle shape classifier and trending tool to assist users in the field of ferrography. However, because of its direct imagining capability it can also be used as an extremely accurate and reliable particle counter (ISO 4406:1999 compliant) without the need for any calibration. Because the direct imaging technique used by LNF differs greatly from the methods used by light blocking particle counters its use as a particle counter is often grossly misunderstood. To fully understand why the LaserNet Fines can be used as an accurate particle counter, and why direct imagining will give a more accurate result over an optical particle counter, we must first look at the calibration methodology that has been used and modified over the last thirty years.

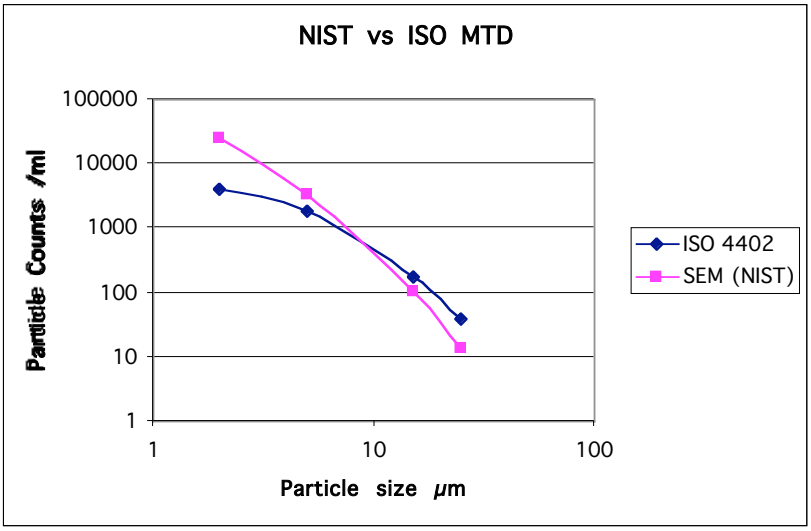
Background.

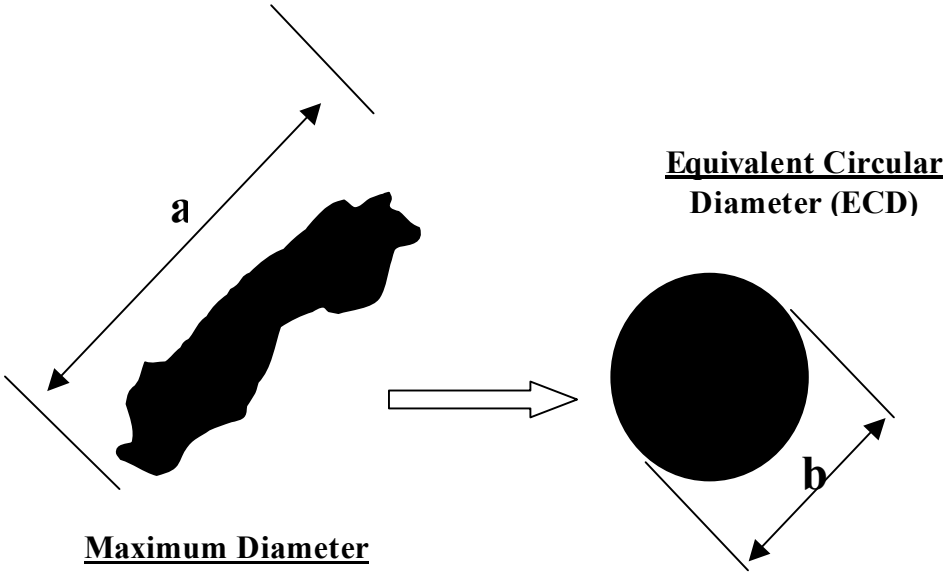
Automatic particle counters have generally replaced optical microscopy as the primary method for quantifying particulate contamination in fluid wetted systems. In the late 1960's a calibration procedure was developed to ensure that particle counts obtained with optical particle counters agreed as closely as possible with counts obtained by optical microscopy. AC Fine Test Dust supplied by AC Rochester had been used since the late 1960's to calibrate optical particle counters and ultimately became International Standard ISO 4402, it is still used today by most oil laboratories around the world. The ACFTD test dust size distribution was measured using a sieve and an optical microscope resulting in a size distribution based on maximum diameter (Figure 1). During the early 1990's, with the onset of more sophisticated scanning electron microscopes (SEM's) it was noticed that there was a substantial increase in the number of particles in the ACFTD (especially below 10µm) than that was previously reported by the optical microscopes given in ISO 4402. Also in 1992 AC Rochester stopped the manufacture of ACFTD so the ISO standards committee together with the National Fluid Power Association (NFPA) decided to develop a revised particle counter calibration method based on a new contaminant whose distribution was traceable to NIST (National Institute of Standards). ISO Medium Test Dust (MTD) was selected and was suspended in MIL-H-5606 hydraulic fluid, resulting in NIST Standard Reference Material SRM 2806.

What the results found?

There is a significant difference between the two distributions and this can be shown when an automatic particle counter calibrated with ACFTD measures an ISO MTD as measured with a scanning electron microscope (Figure 1). The results showed that below about 10 µm, NIST showed significantly more particles than with the ACFTD calibration. This can be explained because of the increased sensitivity of scanning electron microscopy compared to optical microscopy carried out in the 1960's. The opposite occurs above 10µm, fewer particles were observed by NIST compared to the ACFTD calibration. This is because the equivalent circular diameter used by NIST for its particle distribution is smaller than the maximum diameter used in the ACFTD. (Figure 2)

Figure 1





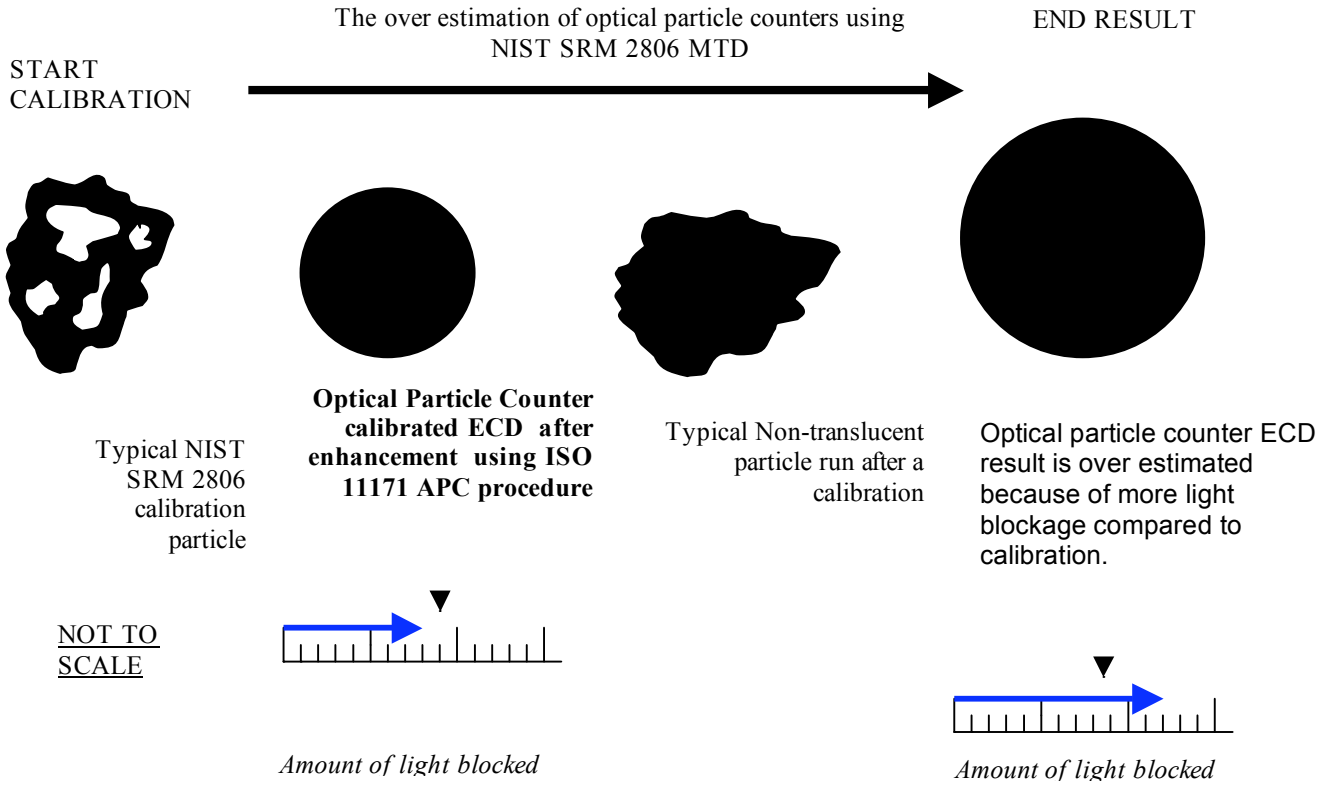
Note for long elongated particles a>b

Figure 2

The two distributions intersect around the 10µm region. The revised method was approved on December 9, 1999, as ISO/FDIS 11171 for automatic particle counters. The procedure includes many other enhancements to enable optical particle counters to be traceable to NIST. On December 2, 1999 ISO modified the ISO 4406 code numbers from >,5,15µm to a 3-digit code > 4µm(c),6µm(c),14µm(c) to reflect the new calibration procedure using the NIST standard. The sizes 6 and 14 were chosen so that no significant shift in code numbers occurs due to changes in the particle counter calibration method. Some organizations had previously introduced their own 3-digit form of the ISO 4406 coding method with the third digit representing 2µm. (equivalent to 4.6µm NIST).

Limitations of optical particle counters calibrated with NIST SRM 2806.

The NIST SRM 2806 used to calibrate optical particle counters is a dust which consists of particles which are partially transparent. The certified distribution is measured using a scanning electron microscope and the equivalent circular diameter is calculated from the total area of the particle. Optical particle counters which use a light blocking technique cannot perform a calibration which will be traceable to NIST with SRM 2806 IMTD without following the enhancements which are documented in procedure ISO/FDIS11171. This is because the particles in the distribution have varying degrees of transparency and the sensing method used by these counters is light blockage. Once a particle counter is calibrated using the new ISO MTD the size of any solid particulate sensed will be over estimated because it will be blocking more light than a particle of the same diameter with transparent areas with which it was calibrated with, see figure 3 below.



The LaserNet Fines does not require calibration using NIST SRM 2806 because it directly images the particles in real time. It fills in any translucent areas of fibers or oxides which it may encounter in a sample, and calculates both the equivalent circular diameter and maximum diameter values for the hydraulic cleanliness (ISO CODES) and wear particle trending respectively. Because the LNF instrument records the total size resolution of all the particles which it records, it is able to report NAS and NAVAIR cleanliness codes. NAS 1638 was developed by the Aerospace Industries Association of America, and is similar to ISO 4406 in that it classifies cleanliness according to pre-defined particle counts of certain particle sizes. NAVAIR 01-1A-17 is the navy standard for particulate cleanliness.

The LaserNet Fines has been shown to be traceable to NIST SRM 2806 and is hence an ISO compliant instrument.