WEAR CHECK AFRICA
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CLEAN OIL SAVES MONEY

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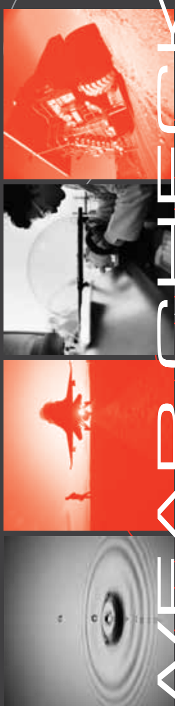
In our current economic age, companies are forced to pursue every avenue for cost saving to ensure that their chance of financial success is maximised. Lubricated mechanical equipment is a significant cost to many companies and, through careful management, significant savings can be achieved. This technical bulletin looks at particle counting, explains the jargon and technology, and shows you how by monitoring your oil's cleanliness you can reduce repairs, maintenance costs and downtime and save on your bottom line.

WHY PARTICLE COUNTING?

While many techniques are successfully implemented in an oil analysis programme, there are few, if any, that give as clear an understanding of the total particle contamination of the oil as particle counting. One of the reasons for the effectiveness of this technique (optical particle counting) is that it is a direct technique where actual individual particles are counted and sized.

Seventy percent of all machine wear takes place through abrasion, adhesion and corrosion. A staggering 90% of this is attributed to abrasion. For abrasion to take place, hard particles must break down the oil film between two moving solid surfaces leading to the grinding away of your machine's moving parts. If the particle count of the bulk oil that makes up the film is monitored, one is able to determine the amount of material that is causing abrasive wear.

Now, since abrasive particles can be measured and controlled through good housekeeping principles, one can actively decrease the rate of wear of components. This is proven to save money!



WEARCHECK
CONDITION MONITORING
THROUGH OIL ANALYSIS

UNDERSTANDING THE TECHNOLOGY OF PARTICLE COUNTING

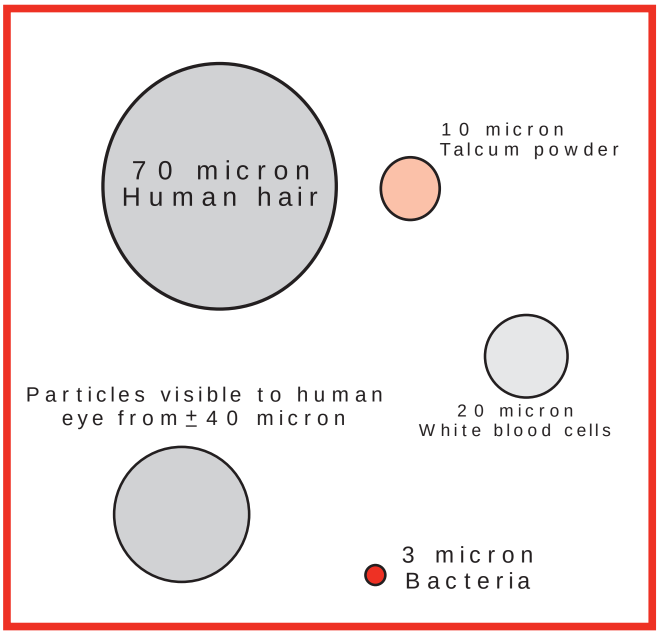
A brief history

Before the 1960's particle counting was done manually by filtering a fluid through a membrane. This was then examined under a microscope with a graticule (microscopic ruler), where each particle was manually counted and sized (usually based on the longest dimension of the particle). This manual process continues in a limited scope today and is defined by ISO 4407. The main drawback of this process is that it is extremely labour-intensive and hence prohibitively expensive. During the late 1960s the first automatic particle counters began replacing this manual process.

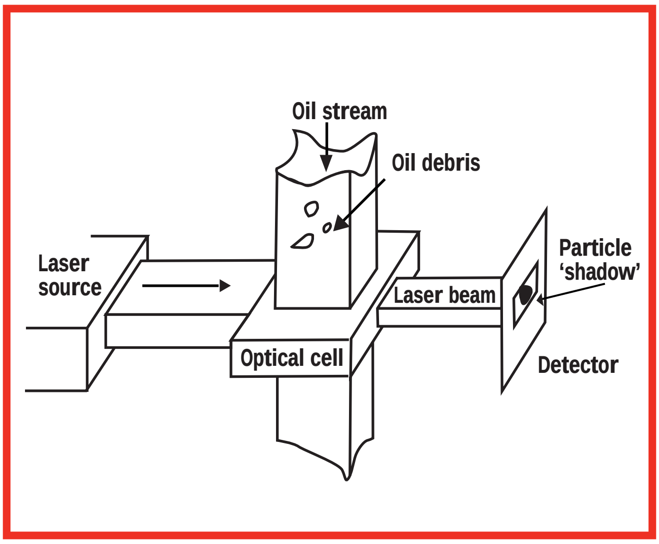
Modern methods of automatic particle counting

There are two main types of automatic particle counters: optical and pore blocking.

Optical particle counting is defined by ISO 11500. This is the technology that Wearcheck Africa uses. A sample is moved at a constant speed though a viewing cell using an automated sampler. A light beam, usually a laser beam, is transmitted at 90 degrees through the cell. If no particles are present, the beam remains constant in intensity as it falls on the detector. When a particle passes though the beam, light blockage occurs and this is detected by a photocell. The bigger the particle, the bigger the drop in light intensity and the bigger the response from the detector. In this way both the particle size and count is determined.



Understanding particle size



Conceptual drawing of an optical particle counter

The benefits of optical particle counting are that it is accurate over a wide range of particle sizes and counts, and it is a direct technique. For good reason it is the most popular technique in particle counting. It has some drawbacks in that it counts droplets of water and air bubbles. This leads to a deceptively higher particle count should appreciable amounts of air bubbles and / or free water be present.

The technique is also not applicable to very dark samples. Furthermore heavily contaminated samples with >100 000 particles per ml or very viscous samples would have to be diluted with a clean solvent or oil. This step can lead to inaccurate results and is time consuming, hence expensive. Samples with a viscosity of greater than 320 cSt at 40 degrees Celsius cannot be processed because pressures required to flow the sample through the sensor are greater than the design specifications of the equipment. For these reasons Wearcheck limits the use of the particle count test to hydraulic, transmission and compressor systems where the test yields the maximum benefits.

Pore blocking particle counting is defined by BS 3406 and works on the principle of passing a fluid through a screen of a known pore size. This pore size is normally 10 micron (1/100 of a mm). Here the pressure drop across the mesh is measured over time and the results are compared with a standard calibration. Through extrapolation a particle count is estimated (a two number code only). This method is an indirect method and is based on the assumption that the particle size distribution is the same for all oils which is not the case in reality. The technique also has a more limited range in terms of analysing heavily contaminated samples. On a positive note, pore blocking particle counting is insensitive to entrained air and water droplets and can be performed on dark and sooted samples. The main drawback of the method is the amount of data extrapolation which must be done which leads to inaccurate results in all samples except those with the most standard of particle size distributions. If two or more screens (eg. 6 and 14 micron pore size) are used, more accurate results can be achieved. This method cannot be used to quote a three number ISO code (ISO 4406:1999) unless at least 3 screens are used. New models being introduced into the market are starting to offer multiple screens.

STANDARDS FOR PARTICLE COUNTING

Standards are essential to ensure that a result is worth anything. In an ideal world every particle counter would give an identical result if the same sample were analysed on all of them. Standards move an imperfect world closer to this ideal. A standard for particle counting is a fluid whose particle sizes and counts are well characterised.

For many years Air Cleaner Fine Test Dust (ACFTD) was the industry reference standard for particle counting relating to hydraulic and lubrication fluids. It was used in the primary calibration of liquid automatic particle counters. It was sold by AC Rochester Division of General Motors but is no longer available. This material was used in the implementation of ISO 4402 which was for the calibration of automatic particle counters. This went hand in glove with ISO 4406:1987 which gave rise to the two number ISO code. All particles greater than 5 micron were counted and a number was given from table 1. All the particles greater than 15 micron were counted and a number was given from this same table. The two numbers were separated with a virgule for example, 17/12.

TABLE 1 Number of Particles per ml		
More than	Up to & including	Scale number
80,000	160,000	24
40,000	80,000	23
20,000	40,000	22
10,000	20,000	21
5,000	10,000	20
2,500	5,000	19
1,300	2,500	18
640	1,300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5	9
1.3	2.5	8
0.64	1.3	7

The cessation of ACFTD led to the rise of new reference material, the ISO Medium Test Dust which is the new industry standard. As ISO 4402 and ISO 4406:1987 were based on ACFTD, these standards also had to be revised. ISO 11171 replaced ISO 4402 and ISO 4406:1999 replaced ISO 4406:1987. The advantage of ISO MTD over ACFTD is that it is more traceable and the particle size distribution is far more precisely known. This is due to size and shape classification, which is done using electron microscopy. This has resulted in the following size correlation table.

TABLE 2	
ACFTD (ISO4402)	ISO-MTD (ISO 11171 - NIST traceable)
<1 micron	4 micron
4.3 micron	6 micron
15.5 micron	14 micron

The new codes (ISO 11171 and ISO 4406:1999) also implemented a requirement of industry. The counting of smaller particles, over three ranges, is now included and the ranges were redefined from 5/15 to 4/6/14 micron.

IMPLICATIONS OF THE NEW STANDARDS

The new standards have imparted better control and reproducibility between laboratories performing particle counting. The new codes report an additional number correlating to smaller particles in the silt range. However the change from 5/15 to 6/14 has not resulted in significant changes to the numbers being reported. In a study two samples were run both on the new and old codes. The first sample was reported as 17/13 (old) and 20/17/13 (new). The second sample was reported as 12/09 (old) and 14/12/08 (new). As can be seen, the second and third numbers of the new code correlate very closely to the two numbers of the old code.

SUMMARISING THE JARGON

By this point a number of codes and abbreviations have been used. These are understandably confusing to someone new to the field and are summarised here to help bring a little clarity.

ACFTD	Air Cleaner Fine Test Dust – the old standard
BS 3406	British Standard: Method for determination of particle size distribution Part 9. Recommendations for the filter blockage method (mesh obscuration)
ISO	International Organisation for Standardisation
ISO 11171:1999	Calibration of automatic particle counters for liquids
ISO 11500:1997	Determination of particulate contamination by automatic counting using the light extinction principle (optical particle counting)
ISO 4402	Calibration of automatic-count instruments for particles suspended in liquids: Method using classified AC Fine Test Dust contaminant
ISO 4406:1999	Method for coding the level of contamination by solid particles
ISO 4407	Determination of particulate contamination by the counting method using an optical microscope
MTD	Medium test dust – the new standard
NIST	US National Institute of Standards and Technology

COUNTING THE SAVINGS

So how does all this technical talk add up to rands saved? It is aimed at giving a background on how the ISO 4406 code is generated. This section aims at applying this code into major cost savings.

If a hydraulic pump were pumping oil at a rate of 250L an hour and the oil had an ISO code of 21/18, then 4375 kg of dirt would be pumped over a period of one year.

The pump would have a life expectancy of only two years. If the oil being pumped had an ISO code of 14/11, then only 25 kg of dirt would be pumped in a year and the life expectancy of the pump would have increased to 14 years. This clearly results in massive savings. The life extension factors in Table 3 below are well documented.

TABLE 3

	2x	3x	4x	5x	6x	7x	8x	9x	10x
26/23	23/21	22/19	21/18	20/17	20/17	19/16	19/15	18/15	18/15
25/22	23/19	21/18	20/17	19/16	19/15	18/15	18/14	17/14	17/14
24/21	21/18	20/17	19/16	19/15	18/14	17/14	17/13	16/13	16/13
23/20	20/17	19/16	18/15	17/14	17/13	16/13	16/12	15/12	
22/19	19/16	18/15	17/14	16/13	16/12	15/12	14/11		
21/18	18/15	17/14	16/13	15/12	15/11	13/10			
20/17	17/14	16/13	15/12	14/11	13/11				
19/16	16/13	15/12	14/11	13/10					
18/15	15/12	14/11	13/10						
17/14	14/11	13/10							
16/13	13/10								

Existing ISO cleanliness codes
Target ISO cleanliness codes
Life extension factor

MAKING IT WORK FOR YOU

Before progress can genuinely be made, good sampling techniques must be followed:

- Store empty sample bottles in a clean place with the lids still on the bottles.
- Select the sampling point carefully to ensure that the oil sampled is representative of the oil in the wearing components.
- Keep the sampling point as clean as possible and flush it before taking a sample.
- Flush the sample bottle with oil, discard the oil, then take the sample.
- Do not sample cold equipment. The system being sampled should ideally be running at equilibrium.

Once you receive your sample report check the ISO code of your hydraulic / transmission/ compressor equipment.

Implement good housekeeping:

- Filter new oils before use. Just because they are new does not mean they are clean.
- Control the headspace of lubricant chambers by using effective breathers.
- Fit transfer hoses with quick couplers to control contamination and reduce spills and wastage.

The component should be re-sampled periodically and the change in the ISO code tracked. As the ISO code decreases, your oil cleanliness is increasing and so are your savings.

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