WEAR CHECK®
AFRICA
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TECHNICAL BULLETIN

ISSUE 24

Detecting particles in oil

(Part 1)

by Alistair Geach, B. Sc.

Wearcheck uses seven techniques to detect abnormal wear.

In simple terms, monitoring wear particles in used oil samples from plant and equipment enables specialists to decide whether they are normal or abnormal and what the likely consequences will be for the machine. In real terms, this is a fairly complicated process. This technical bulletin outlines some of the techniques used in Wearcheck's oil analysis laboratories to detect and quantify particle contamination, and discusses the value and limitations of these methods in detecting abnormal wear situations.

'Normal' and 'abnormal'

When one talks of contamination in oil sampled from a lubricated system, this can be 'anything' that was not or should not have been in the oil when it was added as 'fresh' oil to the system. Some contaminants are dissolved in the oil while others such as particulates are held in suspension. It is reasonable to expect to find particles in a used oil sample as machines are expected to wear out over an acceptable period of time. In doing so they generate wear particles and, while in a healthy condition, they continue to generate these particles at a fairly consistent rate. During this time of 'good health' the particles generated are expected to exhibit size and shape characteristics that are classified as normal for the machine. As these particles are generated continuously they need to be controlled so that they do not build up to levels where they themselves become problematic. Control is normally achieved through filtration and, where possible, monitoring the cleanliness of the oil.

When things go wrong with a machine or if it is becoming 'worn out' from prolonged use, accelerated wear starts taking place. This additional wear is typically accompanied by the appearance of 'new' and larger particles with shape and size characteristics that are classified as abnormal. An increase in the rate at which 'normal' particles are generated can also indicate the development of an abnormal wear situation. If an abnormal wear situation is left unchecked the remaining life of

Visual observation is important and inexpensive.

the machine will be drastically reduced and catastrophic failure is ultimately likely to occur.

The presence of abnormal wear particles in a sample is however not always cause for immediate concern. Some abnormal wear particles may be generated from time to time as a result of a temporary situation such as a change in machine application that does not persist long enough to threaten the health of the machine. It is therefore important and beneficial to monitor the appearance and build-up of any abnormal wear to decide if a harmful situation is developing. A new machine for example is expected to generate abnormal wear particles while it beds in but the rate at which these particles are generated is expected to reduce rapidly with time. After the first oil change when the bedding in process is essentially complete one should expect 'normal' wear particles to predominate as the machine settles into a normal wear state.

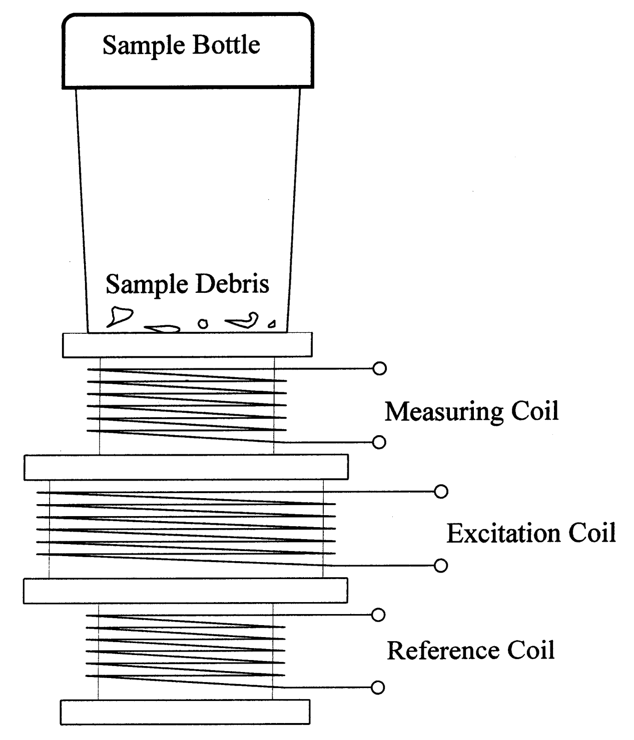


Figure 1. Debris sensor of particle quantifier

In monitoring particulate contamination in oil one should monitor all particulates from submicron particles up to particles of a few hundred microns in size. Wearcheck uses seven different techniques to do this, four of which will be covered in this bulletin.

1. Visual observation

An important and inexpensive test that should be conducted on all samples by both customer and laboratory technician, is a simple visual examination. Although often overlooked, a brief visual observation of the oil sample can yield information that is as important as that produced by sophisticated lab instrumentation. The oil colour and clarity should be noted and a brief examination carried out to see if free water or debris can be seen suspended in the oil. A quick look through the base of the sample bottle will also reveal if any large debris has settled out from the oil since sampling.

If debris is found to be present and additional equipment is available, a more detailed examination of the debris can be carried out by filtering the oil through a membrane filter to create a 'patch' or filtergram and examining the filtered particles in more detail through a microscope.

2. Ferrous debris monitor

Not all sample debris is clearly visible to the naked eye and many labs use ferrous debris monitors to detect samples that could have come from potentially problematic machinery. Ferrous debris monitors are limited by the fact that they are only able to detect magnetic debris but, at the same time, have the advantage of being extremely sensitive. Measurements are normally conducted by passing the sample over a sensor that detects the disturbing effect

Microscopic particle evaluation is quick and useful for trending.

that debris in the oil has on a standard magnetic field. Wearcheck uses a ferrous debris monitor called a particle quantifier that yields a number or 'index' indicative of the 'total iron' or 'total magnetic' content of the sample. This index is often referred to as the PQ or PQI of the sample and is measured by the instrument sensor through the base of the sample bottle. (Wearcheck's sample bottle was designed with a flat base and is injection molded to ensure a dimensional precision that facilitates a PQ measurement in this way.) The PQI is a 'total' measurement and provides no information on the actual size of the particles themselves. Some settling test procedures have been proposed to detect the presence of large particles but these tests are time-consuming and further complicated by settling rates that are influenced significantly by sample viscosity.

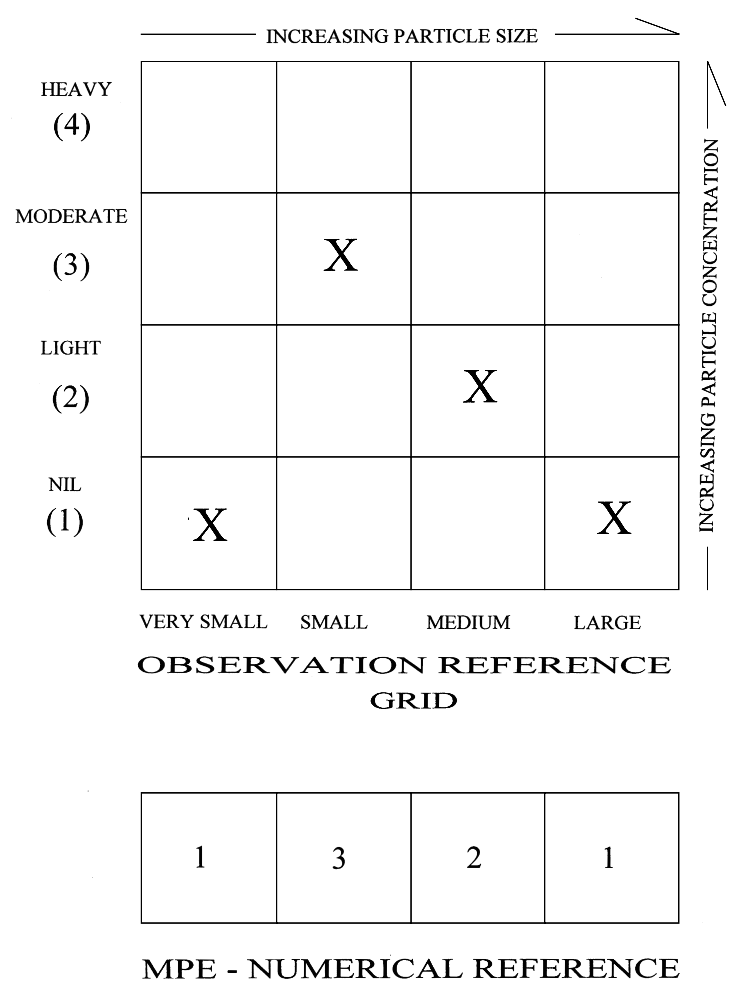


Figure 2.
MPE observation reference grid and numerical reference

Wearcheck primarily uses the PQ to provide data for trending purposes and as a screening method to detect samples containing significant levels of magnetic particles. Samples identified as being suspect are automatically scheduled for an additional test that results in a microscopic particle examination of the wear debris filtered from the sample.

3. Microscopic examination

Looking at the quantity, size, shape, and colour of sample debris can be done very quickly using a good microscope fitted with a measuring graticule. This relatively quick assessment is referred to as a microscopic particle evaluation or MPE and can provide clues to the source of the debris and the potential seriousness of a problem that may be causing it. No attempt is made to analyse individual particles in an MPE but observations are recorded as a number for trending purposes derived from a size and concentration reference grid. In reporting MPE observations, particles are generally referred to in non-specific terms such as small, medium and large for particle size and heavy, medium and light for concentration or contamination levels. MPE grid numbers can be trended if standardised preparation and grading techniques are employed to produce and analyse the 'patch' but considerable practical experience in interpreting the visual data is also required for the early detection of abnormal wear.

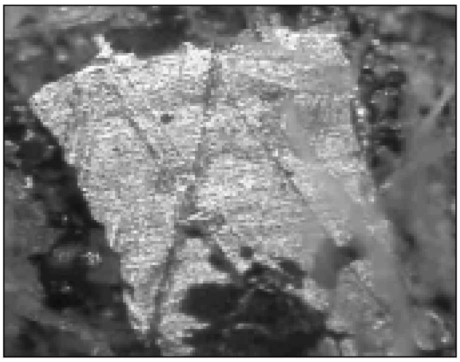
4. Analytical ferrography

To take visual observations further when abnormal wear is suspected, analytical ferrography can be employed. This involves special magnetic separation techniques that separate particles roughly by size, followed by the identification and categorisation of the larger particles according to the active wear that produces them. The analysis requires considerable skill and is carried out by examining the size, shape, colour and surface characteristics of particles in significant concentrations that are 15µ or greater in size. The term ferrography is possibly a little misleading because, although magnetic techniques are used to remove and separate magnetic particles from the oil, many non-metallic particles are also trapped in the process and, more often than not, references to these particles are included in ferrographic reports. By regularly monitoring the size, shape and concentration of particles present in a lubricated system one can tell a great deal about the wear that is taking place and make an accurate assessment of its mechanical health.

Analytical ferrography is powerful but costly.

Although analytical ferrography is a powerful technique its benefits are seldom realised in oil analysis programmes because of cost constraints. Ideally, analytical ferrography needs to be performed regularly on oil samples from the same machine to allow baseline trends under normal wear conditions to be established and to facilitate the early detection of the onset of abnormal wear. Unfortunately, regular analytical ferrography is costly to perform owing to the specialised equipment and skilled personnel required to perform this time-consuming yet powerful analysis.

■ The remaining three techniques for monitoring particulate contamination in oil will be discussed in the next Technical Bulletin.



An abnormal wear particle separated from an engine oil using ferrographic techniques.

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