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WEARCHECK
CONDITION MONITORING THROUGH OIL ANALYSIS

WHY CHEAP OIL ANALYSIS MIGHT BE THE MORE EXPENSIVE OPTION

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Wearcheck provides its customers with a wide range of tests that cover most problems encountered in most types of equipment in most types of environments and applications. There are obviously a range of tests that some of our clients would like us to do but are cost prohibitive. Laboratory equipment, like earthmoving equipment, is expensive and we too have a weak Rand working against us. It is very difficult to justify spending a million Rand on a laboratory instrument if we are only going to use it for a few tests per month, and customers would not be prepared to pay a couple of thousand Rand per sample in order to make the equipment pay for itself. Having said that, every effort is made to outsource tests that we cannot do.

There needs to be a very careful balance between the service we can offer to our client base at an acceptable cost within a reasonable time frame. Wearcheck has been in business serving primarily the South African market for more than 30 years and has processed nearly 6 million samples in that time.

Wearcheck was formally launched in 1976 and the service comprised six elements, viscosity, water, fuel, sludge and debris analysis with no automation. The company employed 10 people and processed less than 500 samples per month. Today Wearcheck employs nearly 100 people and processes more than 35 000 samples per month. There is a high degree of automation as the majority of the staff are employed as customer and product support staff and only 10 people are actually employed in the laboratory. The number of tests performed has grown from less than 10 to more than 40.

The growth in the variety of service has been based predominantly on customer requests but also on trends and developments in other parts of the world. As new techniques are established and new instruments become available, they are carefully investigated. If they are found to be suitable and appropriate to our environment and can be introduced in a manner that is cost and time effective, then they will be. It is important in this business to keep abreast of technology, to be aware of what is on the cutting edge and what is taking place in other parts of the world. As this bulletin is being written both the managing director and the IT manager of Wearcheck are attending the annual Wearcheck International Conference, this year being held in Sydney, Australia.

This wealth of experience has led us to develop a number of test slates over the years based on several generic types of equipment. The types of equipment (we call them test classes) are listed below along with the tests that are carried out in each case.

There are four types of equipment in the Wearcheck hierarchy: automotive, industrial, marine and aircraft. The components that can exist on each of these equipment types fall into one of three very broad categories: engines, drivetrains and clean oil systems, and there are many sub-varieties for each of these categories.

Automotive components
Engines
Transmissions
Hydraulic systems
Gearboxes
Differentials
Final drives
Wheel hubs
Bearing components
Steering systems
Compressors
Auxiliary components

Table 1: Automotive components

Test	Engine	Drivetrain	Transmission	Hydraulics	Compressor
Elemental analysis	✓	✓	✓	✓	✓
Particle quantification	✓	✓	✓	✓	✓
Debris analysis	✓	✓	✓	✓	✓
Water	✓	✓	✓	✓	✓
Viscosity 40°C	✓	✓	✓	✓	✓
Viscosity 100°C	✓				
Fuel dilution	✓				
Combustion and oil degradation	✓				
Particle count			✓	✓	✓
Total Acid Number					✓
Total Base Number	✓				

Table 2: Tests for automotive components

Industrial components
Generator sets
Recirculating systems
Hydraulic systems
Compressors
Turbines
Couplings
Wheel hubs
Gearboxes
Drivetrains
Bearing compartments
Auxiliary components

Table 3: Industrial components

Test	Engine	Drivetrain	Compressors & turbines	Hydraulics
Elemental analysis	✓	✓	✓	✓
Particle quantification	✓	✓	✓	✓
Debris analysis	✓	✓	✓	✓
Water (in %)	✓	✓		✓
Water (in PPM)			✓	
Viscosity 40°C	✓	✓	✓	✓
Viscosity 100°C	✓			
Fuel dilution	✓			
Combustion and oil degradation	✓			
Particle count			✓	✓
Total Acid Number			✓	✓
Total Base Number	✓			

Table 4: Tests for industrial components

Ships are like large floating factories and follow the industrial format whilst boats are more akin to mobile equipment and follow that format, although each component will be treated on its own merits and tested accordingly. Aircraft samples are predominantly analysed on the basis of debris found in their filters and are beyond the scope of this bulletin. The same applies to fuels, coolants, transformer oils, greases and filters. They will not be covered in this bulletin, although the same attention to detail has been put into creating the test profiles.

It is important to note that over the years new tests have been added, such as infra red spectroscopy and particle counting, and these have been brought on line at no extra cost as they have been deemed essential to the test slate. Virtually no extra tests carry a supplemental charge and, on the few that do, there is always a reliable screening test in place as part of the standard test profile.

We are sometimes asked if it is not possible to get fewer tests at a reduced cost. This is not a policy that Wearcheck subscribes to. We feel that if there is a chance that a potentially serious problem might be missed by not carrying out a particular test for the sake of saving a few Rand, then it is not worth the risk. If you are going to do the job, then do it properly. The other problem with these requests is that the laboratory has been designed around the test slates used, so it is actually more difficult to do fewer tests and can actually cost more on occasion.

It is interesting to look at the three broad component categories, the percentage of problems encountered, the type of problems found and the tests required to either find or confirm that a particular problem exists.

Component category	% samples with problems
Engines	23.3
Drivetrains	21.6
Clean oil systems	19.9

Table 5: Percentage of problems by component category

Problem	Engines	Drivetrains	Clean oil systems
Dust entry including coarse dirt	ICP & MPE 15.3%	ICP & MPE 15.7%	ICP, MPE & PC 24.3%
Water bulk (%) and trace (PPM) levels	KF, FTIR & CH 5.5%	KF, CRCK, & CH 8.5%	KF, CRCK & CH 12.7%
Fuel dilution	GC & VIS 17.7%	N/A	N/A
Poor combustion	FTIR & VIS 7.7%	N/A	N/A
Abnormal wear	ICP, MPE & PQ 38.6%	CP, MPE & PQ 19.8%	ICP, MPE & PQ 9.1%
Visible wear debris	Included in abnormal wear	ICP, MPE & PQ 49.3%	ICP, MPE, PQ & PC 49.3%
Degraded oil	All techniques 3.4%	ICP, TAN & VIS 6.4%	ICP, TAN & VIS 3.6%
Overheating and overcooling	TBN, FTIR, ICP & VIS 4.5%	ICP, VIS & TAN 0.3%	ICP, VIS & TAN 0.8%
Internal coolant leaks	KF, FTIR, CH & ICP 4.8%	N/A	N/A
High oil consumption	ICP & FTIR 2.5%	Generally reported by customer	Generally reported by customer

Table 6: Percentage occurrence of problems

Wearcheck tracks and statistically analyses 19 different problem categories, but for these purposes, we will combine some of them to produce ten 'things' that can go wrong with either the machine, the oil or both, including various forms of contamination. We can then look at the percentage of each type of problem for each class of component, and what techniques are used to determine and confirm the presence of a particular problem.

The percentages in the table on the previous page refer to the percentage occurrence of the particular problem within the total number of problems for the specified class of components. Note that more than one problem can occur on the same sample so these figures cannot be related back to the overall percentage of samples that are not considered normal. Problem severity has not been considered either.

It is salutary to note that these figures do not differ dramatically from what other oil analysis companies find in other parts of the world.

Below is a list of the abbreviations used and the particular instrument or technique that is used in determining the presence of a problem.

This shows very clearly how each test forms part of the whole and that the whole is greater than the sum of its parts. No specific test should be left out as it may either totally remove the ability of oil analysis to detect a particular problem category, or provide confirmation that a problem already exists. The diagnosis of oil analysis results is an holistic process and is covered in other technical bulletins - it is only by looking at the bigger picture that a truly meaningful assessment can be made.

Name	Explanation
ICP	Inductively Coupled Plasma: a spectrometer that measures the elemental concentration of wear metals, contaminants and additives.
MPE	Microscopic Particle Examination: oil is filtered through a membrane and examined under a microscope.
PC	Particle Count: a method of measuring general oil cleanliness without identifying the contaminants.
KF	Karl Fischer: a method for very accurately measuring very low levels of water contamination.
FTIR	Fourier Transform Infra Red spectroscopy: a spectroscopic method for measuring combustion efficiency, contamination and oil degradation. Also used to screen for water.
CH	Calcium Hydride: a method for testing for water in the % range rather than at PPM levels.
CRCK	Crackle test: a cheap and fast method for screening for water.
GC	Gas Chromatography: a method for detecting fuel dilution based on boiling point.
VIS	Kinematic viscosity of the oil at either 40° or 100°C.
PQ	Particle Quantifier: measures the bulk magnetic index of the oil and detects large wear particles.
TAN	Total Acid Number: measures the total acidity of the oil.
TBN	Total Base Number: measures the reserve alkalinity of engine oils.

Table 7: Explanation of tests performed

For example maybe the gas chromatography (GC) test could be left out and let's say 5% saved on the total oil analysis bill. We have already established that 23.3% of all engine samples have some kind of problem. Of all the engine problems encountered, 17.7% involve an unacceptable level of fuel dilution.

You have to ask yourself, is it worth saving a few Rand when a significant percentage of these problems will go undetected? Any one of those fuel dilution problems could result in a catastrophic engine failure.

The GC is a good example as it could be argued that a low viscosity can be used to indicate fuel dilution. Granted, viscosity does go down as fuel goes up, but a low viscosity could also be caused by additive shear, thermal cracking or an oil mixture. You now have a situation of knowing you have a problem but not what it is or what is causing it. Likewise, fuel dilution accompanied with poor combustion will result in no viscosity change. It's simply not worth it.

A number of oil analysis companies will offer a pared down service at a lower price, then add on supplemental tests for a supplemental charge, particularly when it comes to the question of debris analysis. Wearcheck carries out quite a number of supplemental tests, but the customer will be totally unaware of this because the results are considered as a matter of course, they are included in the report and are used in the diagnosis at no extra charge.

Historically Wearcheck has charged extra for TBN, water by Karl Fischer and viscosity at 100°C. A very reliable screening test is done on all engine samples using the FTIR and only if this fails is an actual TBN done (this is not a supplemental test). Viscosity at 100°C is now carried out on all engine samples free of charge and all samples are screened for water at 0.1%. A turbine/compressor oil sample kit is available for customers who need to know water content down to the PPM range.

Debris analysis is often considered to be an 'extra' and it is perhaps one of the most vital tests that an oil analysis laboratory can do. The spectrometer that measures wear metals and contaminants is limited to the size of particle that it can 'see'. An upper limit of eight micron is often quoted and even this is probably a little generous. It is quite possible for there to be lumps of gear teeth and collapsed bearings in the oil without any excess iron registering on the spectrometer. Here the PQ comes into play by making a bulk magnetic measurement of the sample from which the total ferrous content can be inferred, irrespective of size. But even that does not give you the full picture; the oil needs to be filtered, examined microscopically and assessed by a diagnostic expert with many years of experience.

Approximately 20% of all samples going through the Wearcheck laboratory are subjected to debris analysis. This can be automatically triggered in the laboratory by a high PQ, a high particle count, the inability to perform any one of the standard tests for whatever reason, or simply based on observations made by the laboratory technicians. A debris analysis can also be requested by the diagnostician for any reason including comments supplied by the customer. If you go back to the statistics on problem types it is clear that nearly 50% of all drivetrain and clean oil system problems are detected in this manner. Clearly this is a test that should not be an add-on. It should be an integral part of any oil analysis programme and there should not be an charge extra for it. In the very near future an image of these debris analyses will be included with the sample reports.

It can be argued that maybe some sort of cheap screening test be employed instead of a full oil analysis programme and, only if these results look suspect, should more testing be done at extra cost. There is some merit in this but you are still left with a result that does not provide the full story. The laboratory then either has to contact the customer to get permission (and an order number) to carry out further testing or the report goes out to the customer and the onus for further investigation is now transferred to the client. This is time consuming, inefficient and misses one very vital issue with oil analysis, and that is the question of trend analysis. Wear limits have their place but most oil analysis is carried out by treating each component on its own merits. It is very difficult to draw a trend when you only have a complete history on abnormal samples.

It has already been mentioned that oil analysis is an holistic process and every test that can be carried out within economic reason should be carried out. Test slates should be designed around a large body of knowledge and experience. These tests should also be able to be carried out and reported within a 24 hour period at best and 48 hours at worst, barring unforeseen breakdowns (even oil analysis laboratories need a little maintenance now and again). In the words of an ancient English saying, it would be a shame to spoil the 'ship for a hap'worth of tar' (curiously the ship was in fact a sheep and tar was used to cauterise wounds) or to paraphrase William Shakespeare in Richard III '. . . my kingdom, my kingdom for a horse. . .'

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