WEAR CHECK® AFRICA
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WEARCHECK
CONDITION MONITORING THROUGH OIL ANALYSIS




DIAGNOSTICS - DRIVEN TO DETECT DETERIORATION

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DIAGNOSE (verb):

1) To recognise by signs and symptoms, to make a diagnosis.
2) To analyse the cause or nature of.

WHAT DO THE RESULTS MEAN?

This is a very common question asked of the diagnosticians at WearCheck. The answer to this is to read the diagnosis because this is the distillation of all the inputs that the company receives. What the diagnostics department does every day as a service to customers, diagnosing sample results, comes easily when there are years of experience at hand and the diagnostic processes are designed in-house to streamline what could be a difficult, highly complex and time-consuming job. This diagnostic process is underpinned with many very sophisticated software systems that have all been specified by the department and written in-house. These processes run in the background and ensure that the diagnosis is made timeously, accurately and efficiently. This bulletin will shed some light on how the diagnostics department takes the multitude of information attached to each sample and uses it to supply the customer with a meaningful diagnosis.

THE DIAGNOSTICS TEAM

WearCheck can be likened to a well-run machine. It has various components (departments) all assembled together in a precise manner in order for each to do its job and to ensure the overall purpose of the machine is fulfilled. If WearCheck is the machine, then diagnostics is the engine with its many components being the six diagnosticians, two diagnostic assistants and one laboratory assistant. Headed up by the diagnostics manager, John Evans, each member brings their own set of skills and experience to the team.

The longest serving member of the team is Rowan Maartens who has 27 years of experience as a diagnostician. Rowan qualified as a diesel/petrol mechanic and joined WearCheck in 1982 after spending his first eight years with McCarthy Roadway working on heavy truck engines, then eight years at Alpine Motors in Pinetown, gaining valuable experience with automotive engines.

WearCheck's diagnostics team (from left) Daan Burger, Rowan Maartens, Steven Lara-Lee Lumley, Ravi Chetty, Michelle Allis and John Evans

John Evans, the diagnostics manager, holds a B.Sc. (Chemistry) from Southampton University in the UK and began his career with Caterpillar in Botswana before moving to De Beers, establishing oil analysis laboratories in various locations. He ran the Orapa laboratory for three years and was responsible for integrating oil analysis into the mine's maintenance planning system. He joined WearCheck in 1989 and is a highly experienced industrial chemist, involved in diagnostics, customer support, training and managing remote diagnostics facilities for companies running their own oil analysis laboratories. He has 26 years of oil analysis experience and co-authored a book on the subject in 2004.

Daan Burger holds a national diploma in electronic engineering and a diploma in diametrics. He worked for SAA for 13 years, gaining extensive experience in aircraft engineering before moving to Smiths Manufacturing in Durban where he worked on automotive air conditioners for six years. He joined WearCheck in 1994, specialising in aviation analysis and has been accredited by Honeywell Aerospace to diagnose oil and filters from Honeywell jet engines.

Steven Lara-Lee Lumley is the newest member of the team. She holds a national technical diploma in mechanical engineering and spent 14 years as a lube analyst for Spectracare in Johannesburg where she gained extensive experience in the analysis and diagnosis of oils and greases before joining WearCheck in 2008. She has accumulated 15 years of diagnostic experience.

Ravi Chetty joined WearCheck in 1994, starting off working for two years in the laboratory before spending another two years in the data processing department and then two years in the debris lab. He underwent a ten year mentorship programme and is now a fully qualified diagnostician. He is also accredited by Honeywell Aerospace to diagnose their jet engine oil and filter samples. Ravi has ten years of diagnostic experience.

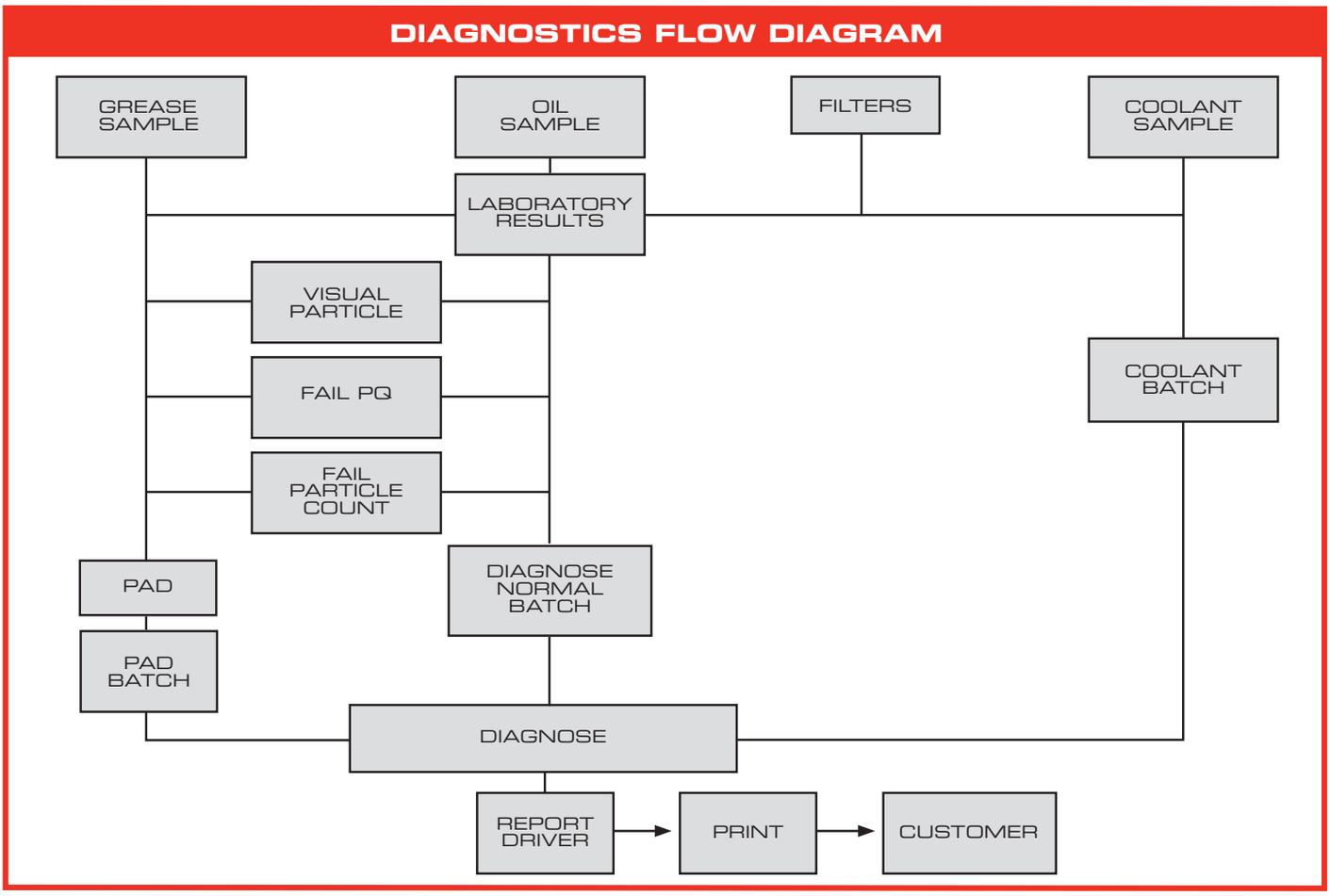
Michelle Allis completed her B.Sc. in Mechanical Engineering in 1996, gaining experience with Acrylic Products (AECI) in the design and commissioning of their new R30 million plant before joining WearCheck in 1997. She is also accredited by Honeywell Aerospace to diagnose their jet engine oil and filter samples and has accumulated 11 years of diagnostic experience.

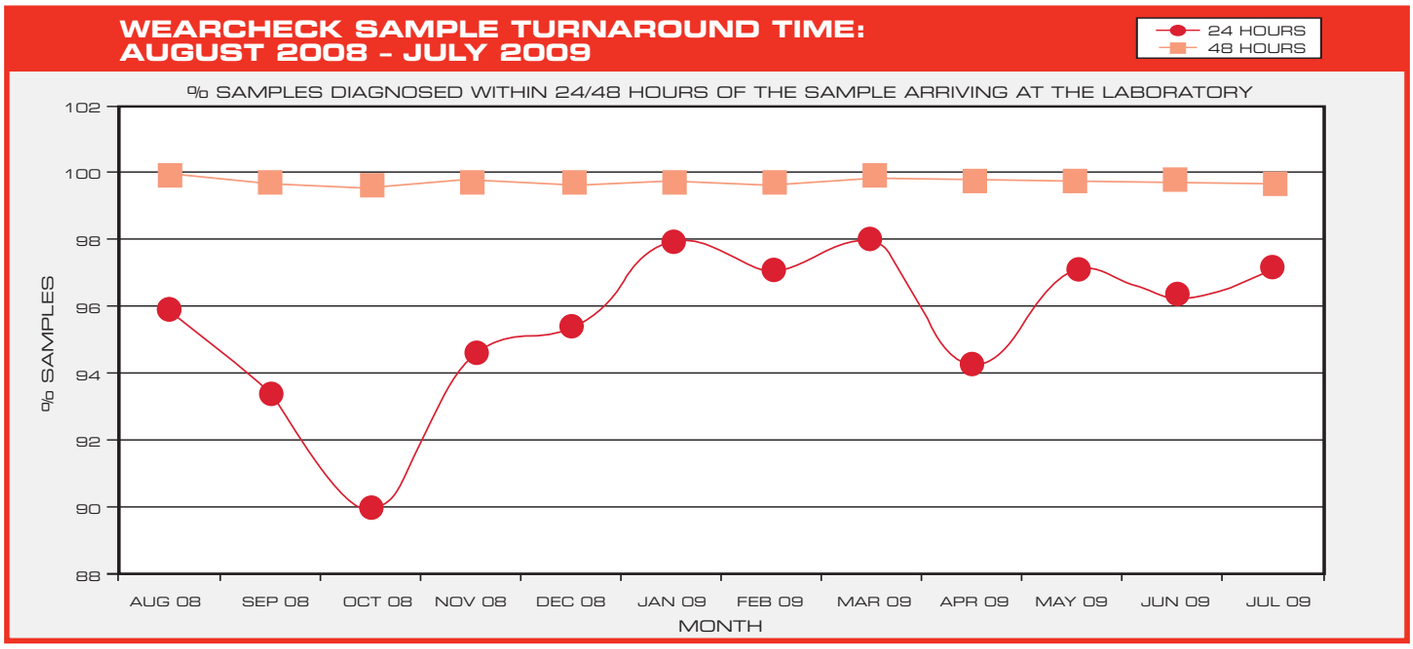
Through all these valuable members, the diagnostics department can be seen to have a varied and extensive amount of experience which it pools, through the use of an open plan office and informal technical meetings, to ensure the best possible service to its customers. Its members have a total of more than 100 years of experience and have diagnosed in excess of 4,5 million samples. But, unlike a real engine, this engine gets better with age and is constantly improving by updating its knowledge and gaining experience from every sample diagnosed like a Formula 1 engine always being modified and tuned to give top performance.

HOW DIAGNOSTICS WORKS

So how does diagnostics do what it does? The best way to get an overall picture is with the help of a flow diagram (below). This helps explain the flow of samples and their results to the diagnostics department.

DIAGNOSTICS FLOW DIAGRAM





WearCheck analyses coolant, oil, grease and filter samples. Many different types of filter samples are analysed namely aircraft, automotive, industrial and marine filters. All except aircraft samples are analysed and diagnosed by any of the diagnosticians in the department for wear debris and contamination levels. Aircraft filters are analysed and diagnosed by the three diagnosticians who have been trained and accredited to do this, i.e. Ravi Chetty, Michelle Allis and Daan Burger. The aircraft section is run as a separate, specialised section of diagnostics with Daan Burger in the pilot seat.

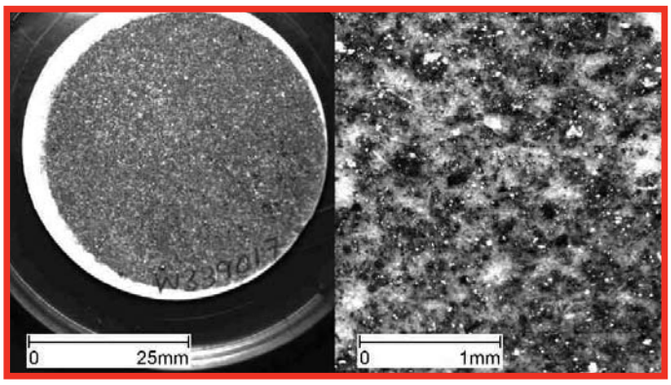
Oil, coolant and grease samples all go into the laboratory and receive various laboratory results depending on the component the sample is from. Each sample is given a test class, e.g. coolant, grease or oil. The oil test class can be broadly broken down into engines, clean oil systems (such as hydraulics) or drivetrains (such as gearboxes). This test class determines what tests are carried out on the sample. These sample results are then married to the information provided by the customer and with any prior history held on the database. Then they go through to the diagnostics department for their expert opinion and to be given a diagnosis, which is inserted into the final customer report.

The diagnostics department divides the samples into what it calls “batches” for easy to handle chunks of work. There are three types of batches: normal batches, pad batches and coolant batches. Each diagnostician can then diagnose a smaller batch. The samples are arranged in these smaller batches in alphabetical order using first the customer name, then the vehicle name, keeping customer and vehicle samples together for diagnosis consistency. Samples that have been in the laboratory the longest are diagnosed first as quick turnaround time is crucial. Over 90% of all samples are diagnosed within four hours of the results being made available to the department.

Normal batches are samples that have gone through the laboratory with no flagged “out of limit” or “abnormal” results that require them to have a debris pad done on them. They are diagnosed by any of the diagnosticians as and when they are ready and the results appear on the computer system. As they do not have debris pads done on them, they are normally the quickest and easiest samples to diagnose with the most normal results.

Pad batches (samples with debris or filtergram analysis) consist of all samples that have had debris filter pads performed on them. Each test class has a cut-off limit for PQ (Particle Quantifier Index) and particle count. Once the test result exceeds this limit the sample is sent for a filter debris pad to be carried out on it so that the diagnostician can look at the debris pad and ascertain the cause of the higher than normal PQ or particle count. All grease samples have two debris pads, one for magnetic wear debris and one for non-magnetic contaminants. Every debris pad done in the laboratory has a number of images taken of it: one of the entire pad, and a whole range of magnified images at 20 times magnification, of which the diagnostician can choose up to three to send to the customer.

All samples with debris pads carried out on them will accumulate in a large batch in the computer system until the diagnostics department splits them into smaller batches according to the number of diagnosticians available to diagnose them. It is important to note that diagnosticians do not spend all day, every day, diagnosing samples; there are many other tasks that the department carries out. Once this is done the pad batches are assembled and the laboratory staff bring the debris pads through to the diagnostics department, with each diagnostician receiving one pad batch of anywhere from 5 to 50 samples depending on the amount of pad samples requiring diagnosis at the time.



Debris image

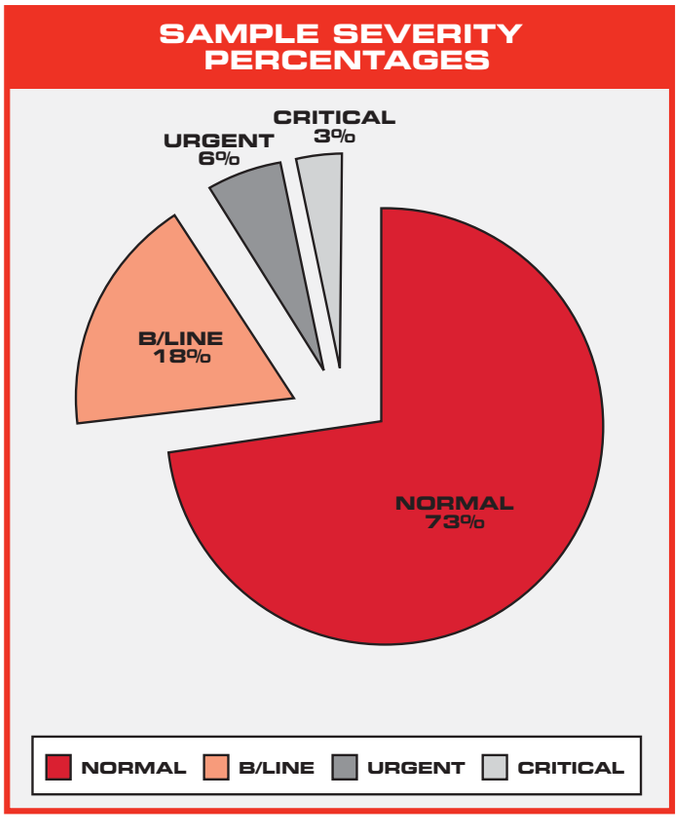
The diagnostician calls up each sample's laboratory results and images on his or her monitor, while studying the debris pad under a microscope. He or she captures the appropriate images on the computer for attachment to the report and enters the diagnosis into the computer system. Each pad sample diagnosed is given an MPE (Microscopic Particle Examination) rating. This is a subjective rating that describes numerically what is seen on the pad by giving a rating from 1 to 4 for each specific type of particle or contamination seen on the pad, e.g. dirt, wear, grease or rust, with 1 being nothing detected and 4 being a heavy concentration of the specific contamination. The images captured for each pad are also saved on the system for any future referencing and a full description of each debris pad is given in the diagnosis.

Coolant samples are split into their own coolant batch and are diagnosed by the diagnostician on that duty for that day. The coolant samples never get debris pads but the diagnostician diagnoses them with the coolant sample bottle present so that the sample may be visually assessed. Each day there is also a "duty" diagnostician whose task it is to answer customer phone calls, deal with customers arriving at the front door and diagnose special request samples and coolant samples. Also every day, a diagnostician works an early shift, starting work at 07h00 in order to deal with any phone calls before opening time. There is also a diagnostician on duty to deal with any filter samples arriving each day and one to analyse and diagnose aircraft samples each day. All this is done in order to streamline workflow.

The diagnosing task of the department is the "combustion process" of "the engine". Just as a four stroke engine has four parts to the combustion process (suck, compress, power, exhaust), so does the diagnostic process (sample results from the laboratory, analysis of the results, diagnosis, reporting). It is a holistic process that takes into account all information and results as well as diagnostician experience and knowledge.

The diagnosis is made using a large set of diagnostic codes to ensure uniformity of language and correct grammar. These are short sentences or statements saved into the system as numeric codes. They are created with the equipment and machinery in mind and can be specific to makes or types of components. The diagnosis is entered into the system as numeric codes and these are immediately decoded into a paragraph of statements including recommendations if necessary. Each sample is given a problem category and severity at the time of diagnosis. These are generated by the numeric diagnostic codes used and can be changed by the diagnostician if need be. Typical problem categories are ones that describe fuel dilution, dirt entry, overheating or poor combustion. The severity is either 0 (normal), 1 (borderline), 2 (urgent) or 3 (critical) and is an indication of the severity of the problem. The severity status "borderline" will shortly be changing to "monitor" as part of an initiative to make the report more user-friendly. Read more about this in the next issue of WearCheck Monitor.

All these problem categories and severities are triggered by the type of diagnostic codes employed and statistically analysed on a monthly basis in order to produce a month end report. The whole system is automated and driven by the diagnosis. The final result with the diagnosis attached is then saved in the report driver ready for sending to the customer at the time of the next print. The print is a process that collates all the reports and information processed since the previous print and sends the reports out to the customer. This process takes place three times a day on a weekday, once on a Saturday and most public holidays.



At any time a diagnostician can send any result back to the laboratory for retesting. This might slow down the sending of the report to the customer but is imperative in order to maintain a quality service and is part of the quality control present at WearCheck. All and any test results present for any sample are recorded in the

system and can be seen at any time by using the sample number to call them up on the computer screen. This allows the diagnosticians to view all the raw laboratory data before it is processed for display on the report. The diagnostician is also able, through sophisticated software, to see infrared spectra and chromatographic traces on the screen. If further testing is required then the diagnostician can request this of the laboratory at any time and this is usually a service that is not charged for. The laboratory has a management philosophy that its only customer is the diagnostics department. This is at the discretion of the diagnostician and utilises the many sophisticated instruments in the laboratory to aid the diagnostician in making a meaningful diagnosis. Tests such as analytical ferrography are an example of this.

Just like an engine can perform with better fuel, so a diagnosis is only as good as the fuel (laboratory results) it receives. If the lab results are the fuel for the engine then the information attached to each sample is the coolant. It is what keeps the diagnostician cool, calm and collected and helps to ensure an ideal environment for the process to take place. The less information received with a sample, the more difficult it is to make a holistic diagnosis. It is important that the department receives as much information on the component being sampled and the sample itself as possible. The most crucial piece of information when making a diagnosis is the period that the oil has been in use. The same value might be normal for 250 hours (or 10 000 km) but highly abnormal for 50 hours (or 1000 km).

MAKING A DIAGNOSIS

Let us take a closer look at the actual diagnosis and how it is put together. When sample results appear on the diagnostician's computer monitor there are a number of things displayed, e.g. customer name, vehicle ID, vehicle make and model, component, component make and model, and all information present on the submission form. The sample is not viewed on its own but with the history of samples available for that component, up to a maximum of five at one time (though more may be called up if required). This is to enable the diagnostician to trend the results. It is important to note that, when diagnosing, WearCheck believes in trending the results rather than diagnosing to limits. This is due to the fact that each machine operates under its own set of circumstances and in its own environment. What may be normal for one machine, might be highly abnormal for another in a different environment. It has to be remembered that the type of job, the environment, the skill of the operator, make, model and age of machine, the period the oil has been in use, oil consumption, application, fuel or oil used, and maintenance practices all have an effect on the results received on the oil sample. Each sample is treated on its own merits.

There are three things to take into account when making a diagnosis:

- the health of the machine
- the health of the oil
- the contamination level.

When looking at the sample results, each point is looked at separately, the results are trended, and the diagnosis is then assembled using a four stage process:

- the wear present
- a possible cause for this wear
- any action that may need to be taken to correct a problem
- the lubricant condition.

If a sample is assigned a severity rating of anything other than normal (0), i.e. borderline (1), urgent (2) or critical (3), then a feedback card must be attached to the report and a problem category given describing the problem found. This feedback card is to allow the customer to return any information on the action taken due to the recommendation received in the diagnosis. It is read by the diagnostician on the subsequent sample as a part of the holistic diagnostic process. It is imperative to realise that the important thing is not that the feedback card is only returned, but that it is returned and **meaningful**. So many feedback cards are returned with the words "No action taken". This removes it from the responsible person's desk but adds no value to the customer's maintenance programme. Only about 30% of all feedback cards are ever returned to WearCheck.

To ensure that all the diagnosticians are on the same page and are all up to scratch, WearCheck carries out regular "round robin" sample diagnoses, whereby the diagnostics manager gives the same samples to each of the diagnosticians and compares their diagnoses. This means that each diagnostician is tested on a regular basis.

There is also a new oil library available on the database. This is an accumulation of results from any new oils received for comparison with used samples received with the same oil description. These come both from the oil companies and customers who submit new oil samples on a regular basis. With new oils being formulated regularly, this helps to accumulate as much information as possible. There are also what are known as "named batches". These are customer's samples that for some reason need special attention at a particular time and are thus flagged against a particular diagnostician's name for diagnosis. This is done to ensure a certain request or suspected problem can be investigated by a specific diagnostician who has dealt with the customer before and so is aware of the request or problem.

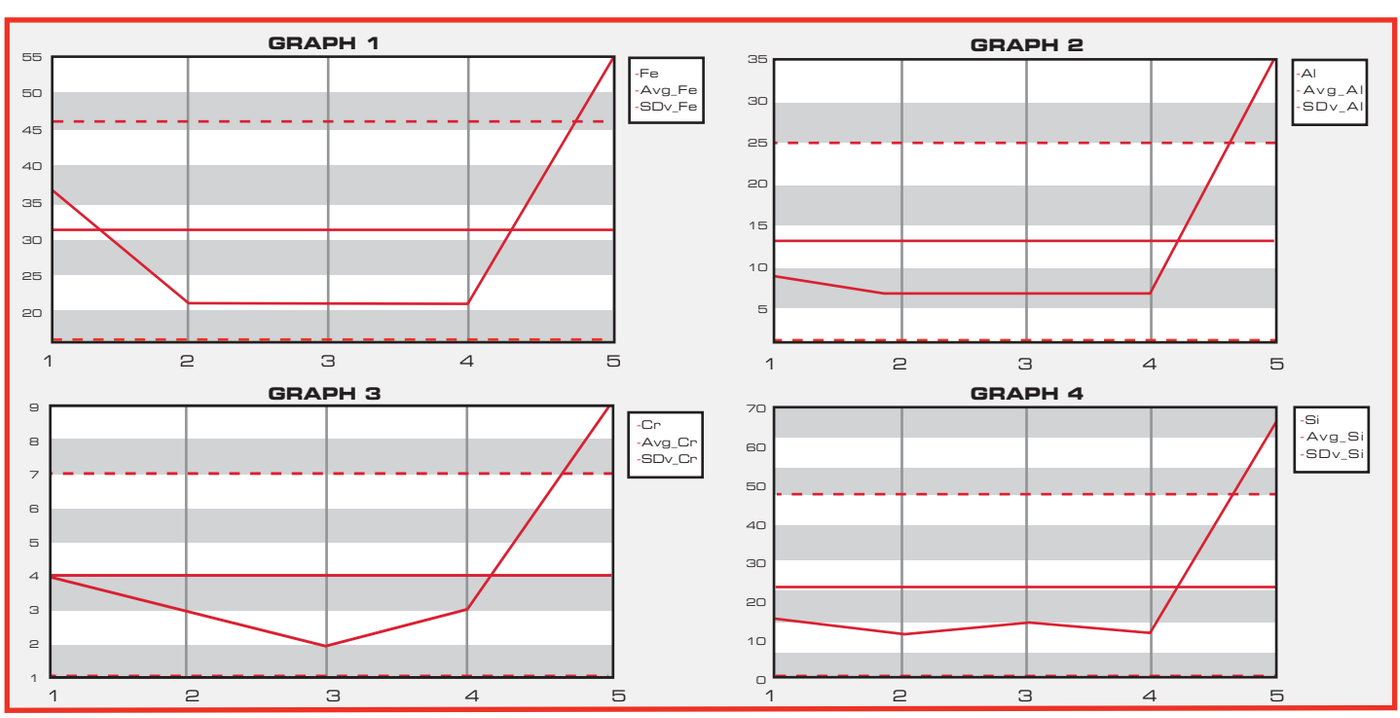
WearCheck's IT department has also written software that highlights any "out of spec" parameters. This is done by using statistics and highlighting any value that is more than the "mean plus one" standard deviation or any reading that is doubled from the history samples. Some customers specify their own limits that are highlighted to align the WearCheck diagnosis with their specific maintenance practices. There is also a programme which can be used by any

diagnostician on any sample with three or more samples on its history, to trend or graph any result with its average, standard deviation and even normalise the results if need be (see examples below). This is an extremely powerful tool once a component has accumulated enough history samples as it assists in wear trending.

With diagnostics acting as an engine, the department drives the customer's maintenance programmes. The power produced is there to help carry the load the customers carry in maintaining their equipment. An efficiently run diagnostic programme should show a return on investment of 10:1. With this in mind diagnostics is like a finely tuned vehicle and, just like a vehicle, needs to be cleaned to shine; we need to "brush up" on our knowledge periodically. This means we need to gain as much experience and knowledge as possible. But to do this we need as much interaction with OEMs and customers as possible in order to enable us to absorb as much information as possible. Through the large customer database and the number of samples diagnosed (about 45 000 a month), we are able to notice trends and pick up similar problems quite quickly. But we are always open to any information available and encourage customers or OEMs to share as much as possible with us to help us supply them with the maximum amount of power to drive their maintenance programmes.

This bulletin has thus shown that diagnosing an oil sample is no easy task but rather takes a lot of effort and input from a number of different sources - number one being the customer. It is only through working as a team within diagnostics and WearCheck, and together with the customer, that WearCheck can achieve the excellence it strives for in providing the most professional service possible to its customers so that they can achieve every success in their maintenance programmes.

Michelle Allis is senior diagnostician at WearCheck Africa



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