On-site Lubricant Monitoring: Bringing Lab Insights to the Field

Copyright © 2023 Filtertechnik • Do Not Reproduce

In years past (and still today in many cases), oil monitoring has been used predominantly to determine when oil has reached the end of its useful life and an oil change is required. But lubricants can tell us much more than that about themselves and the machines they protect if we have the tools and knowledge to understand them.

Oil condition monitoring can provide important information about the lubricant's performance and even the condition of the machine asset itself. Just as a blood test can help a doctor uncover or diagnose an illness or inform a treatment plan, an oil analysis test has proven to be an effective way to uncover incipient failure modes and inform maintenance decisions.

But often the key details of oil analysis are poorly understood, or lab results are seen as "too slow" to be useful for quick maintenance decisions in the field. This paper will introduce you to key features of oil condition monitoring, covering particle contamination, wear debris, methods for monitoring lubricants, and how to begin using collected data to inform preventive maintenance activities in the plant.

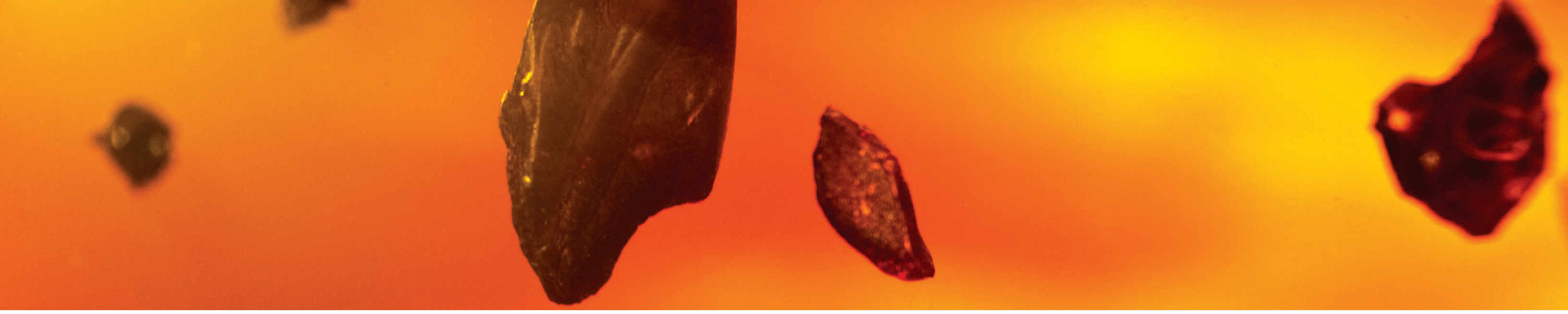
Oil Analysis

Oil analysis is a routine activity used to analyse oil health, oil contamination, particle counts, and machine wear. Its main purpose is to verify that a lubricated machine is operating according to the expectations and standards set for your facility.

This set of standards helps form a quality lubrication program, which focuses on maintaining proper lubrication and avoiding unnecessary wear. As abnormal conditions or parameters are identified through oil analysis, lubrication experts can immediately take action to correct the root cause and mitigate any developing failures that would result if left untreated.

While the purpose of establishing a program is ultimately to gain insights for improving equipment reliability and efficiency, the foremost goal of an oil analysis system is early detection of oil degradation, contamination, and machine wear. Early detection has several inherent benefits that ensure a healthier environment for the employees and the machinery, such as improved safety, early detection and warning of machine degradation, and increased equipment availability and effectiveness.

Copyright © 2023 Filtertechnik • Do Not Reproduce



Smart Technology for Oil Analysis

Oil analyses have become commonplace in many commercial and military applications, and efforts have been made to bring traditional oil analysis procedures into the future with smart technology. Defined by the Applied Research Labouratory (ARL) and sponsored by the United States Department of Energy (U.S. DOE), smart technology "embodies elemental components [such as sensors and data transmission devices] that continuously monitor the state of health of the equipment in terms of failure modes and remaining useful life, to predict degradation and potential failure and inform end-users of the need for maintenance or system-level operational adjustments."

One example of this currently being applied in the industry is real-time lubricant monitoring technology. Real-time technology, like the Filtertechnik Particle Pal Plus' FS9V4 lubricant monitoring system, analyses and delivers accurate and detailed oil analysis results almost instantaneously. The data is collected by a plant employee, who then enters the information into the lubrication monitoring system. From here, the information is put through different algorithms where it is evaluated and transcribed into easy-to-read reports that immediately get sent to a user-friendly dashboard. The whole process takes minutes to complete, all with minimal effort from the employee.

By allowing lubrication specialists to discover the state of their lubricants at a moment's notice without having to wait for results from a traditional lab gives the team more control of the health and productivity of their machines by allowing the lubricants to be used to their fullest potential while minimising machinery downtime, resulting in increased savings and productivity.

Particles

With the importance of having an effective oil analysis program solidified, it's important to evaluate what an oil analysis is examining – particle contamination.

Particle contamination is one of the most destructive and dangerous types of machine degradation that can end in severe consequences. A particle of the right size, shape, and hardness has the potential to wreak havoc on systems by coming into contact with other surfaces. In fact, the total amount of surface material damage can be four to ten times the weight of the original offending particle. Not only do particles cause contamination by damaging surfaces, but they also have their own reproductive cycle. Controlling particle population growth in all its forms is a fundamental and effective strategy for stabilising machine reliability.

The Domino Effect

When the machinery and the lubricants protecting them are exposed to particle contamination, it creates a domino effect of catastrophe. The lubricant should be focused on protecting vital equipment, but when particles are introduced, it is forced to also fight against contamination, hindering its ability to perform its main functions properly.

Not only will the machinery suffer critical damage, but so will the lubricant – more specifically the additives. These additives, originally designed for a specific duty under normal conditions such as water emulsification and particle envelopment, are now being forced into overdrive to compensate for the additional harm being caused, pushing the limits of what the additives were designed to do. Over time, these additives will deplete at an alarming rate and the effectiveness of the lubricant will suffer greatly, losing any beneficial characteristics.

82% of wear-related failures are the direct result of particle contamination.

Copyright © 2023 Filtertechnik • Do Not Reproduce

When the effectiveness of the lubricant begins to fail, machine parts will begin exhibiting premature wear at an alarming rate. This increased wear expedites the failure process for that part, and as one part begins to fail, it can become the catalyst for other equipment to fail down the line. Eventually, all the dominoes will topple.

With the potential for so much destruction from just one particle, it's important to continually monitor and react quickly and appropriately. Two of the most common ways particles enter lubricants are through contamination and wear debris.

Contaminants

When contemplating contaminants, many naturally default to only thinking of solid particulates. But in reality, contaminants include any foreign or unwanted substance that can have a negative effect on a system's operation, life, and reliability. This also includes pollutants such as water, air, glycol, soot, and fuel. Even the wrong lubricant mixed into the current selection can cause a type of contamination known as cross-contamination.

Over the past decades, numerous industry studies have been conducted, both by Original Equipment Manufacturers (OEMs) and end-users, positively identifying contamination as the number one cause of wear on the majority of lubricated components. They were also able to establish that the cost of controlling contamination through predictive maintenance (PdM) and optimised best practices dramatically reduced lubrication and maintenance spending.

By performing an oil analysis, plants can begin detecting the presence of destructive contaminants and narrow down their probable sources, both internal and external. Oil analyses answer questions such as:

- Is the oil clean?
- What types of contaminants are in the oil?
- Where are the contaminants originating from?
- Are there signs of lubrication cross-contamination?
- Are there signs of internal leakage?

Ferrous vs. Non-ferrous

While monitoring for ferrous particles can be helpful, the materials with which modern bearings and other hard components are made create a large amount of non-ferrous debris, so utilizing a technology that can identify all wear particles, regardless of the metal type, provides the most valuable insight.

The lubricant is like the machine's blood, and just like blood, you can test and learn something. When a blood test is performed, doctors don't just count blood cells; no, they analyse different substances and the levels at which they exist in the blood. Similarly, oil analysis should not simply focus on the number of particles but instead on the types of particles, their size, and in what volume they are present. An optical laser counter only gives you a total count, while digital optical technology helps you identify more of the "problem particles," so it can tell you more about the health of your machine.

Did you know?

Approximately 30% of all turbine engine failures are caused by metal particle contamination in the lubricating oil systems

**According to a US Department of Defense study.*

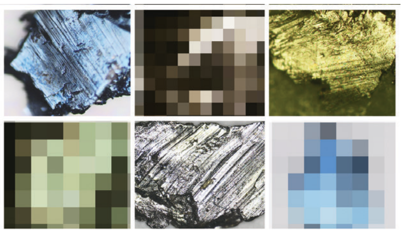
Copyright © 2023 Filtertechnik • Do Not Reproduce

Wear Debris

Wear debris consists of particles that are produced as a result of mechanical wear and other machine surface degradations. All mechanical equipment deteriorates over time, but depending on the type of work and environmental conditions it endures, the mechanical wear can take on many forms. This includes:

1. Abrasion
2. Adhesion
3. Fatigue
4. Corrosion
5. Cavitation
6. Erosion
7. Fretting

Out of these seven common wear mechanisms, the first four are the most likely to cause extremely high or abnormal wear rates.



From a macroscopic level, the wear debris produced by these mechanisms can appear as insignificant specks of mass that mostly act and look the same. But, by taking a look at the microscopic level, it can be seen that the wear particles all have a unique morphology (shape and size) and surface topography (roughness, texture, and surface pattern) based on the wear mode they were produced by.

Wear debris can be broken down into two simple groups – mild and severe. Mild wear is typically unavoidable. Instead of viewing it as a problem, it should be seen as a condition to be expected and to prepare for. Most machines have a limited lifespan, and all will wear at some rate. Luckily, these particles are easily detectable, allowing for action to be taken quickly.

Severe wear, although manageable, should be considered a very serious issue. These particles are larger in size – at least 5 microns – and result from continuous surface interaction or lubricant degradation. While this type of wear can be difficult to predict, it can and should be prevented through appropriate maintenance practices.

Observations	Root Causes	Maintenance Activities
Abrasion	Dust-in-oil	Contamination control program
Adhesion	Low viscosity	Lubrication program
	High loads	Vibration analysis program
	Slow speeds	Lubrication program
Fatigue	High loads	Vibration analysis program
Corrosion	Fluid contamination	Contamination control program

By performing appropriate maintenance and oil analysis practices, facilities can begin to understand and identify the signs of wear particles in their systems, preventing severe damage and costly repairs before they can occur. Oil analysis attempts to answer questions surrounding wear debris, such as:

- Is the machine degrading abnormally?
- Is wear debris being produced?
- From which internal component is the wear likely originating?
- What is the wear mode and cause?
- How severe is the wear condition?

Particle Counting

One crucial component of any quality oil analysis program is particle counting, and there are several methods to accomplish this. While each method is effective in some form, there are pros and cons to each option, and as technology has advanced, many of these options are quickly becoming outdated. But, it is important to understand the differences to help properly identify the right solution for each facility and their unique challenges.

Ferrogram

With a ferrogram, wear particles are captured on a glass surface. These samples are then placed in a magnetic field to separate the wear debris from the lubricating oil, and further washed to remove any remaining lubricants. From here, the sample is ready for examination.

Although ferrogram testing does capture non-ferrous particles, because the sample is placed into a magnetic field, it can have a bias towards ferromagnetic particles, such as iron and steel. The wear particles also have a tendency to pile up, and it's not uncommon for the preparation equipment to generally be more expensive than other alternatives.

Filtergram

During a filtergram, an oil sample is forced through a filter membrane where the particles are randomly trapped on the membrane surface. The sample is then evaluated using a bottom light. Despite having more affordable hardware and no apparent bias towards ferrous particles, it can be extremely difficult to distinguish between metal types or have the bottom light be effective enough to clearly see through the opaque membrane.

Patch Test

With a patch test, an oil sample is diluted in a solvent and pushed through a membrane where particles are captured for later inspection. This method also has no inherent bias towards either ferromagnetic elements or other metallic debris. The patch test also separates itself by being one of the lowest-costing, easy-to-operate options that allows technicians to quickly identify abnormal levels of contamination. Unfortunately, this simplicity can also be its downfall. While it can help take a read on the levels of contamination present in a lubricant, it is difficult to identify and categorise different types of particles, which can withhold important information necessary to the success of an oil analysis program.

Lubricant Monitoring Technology

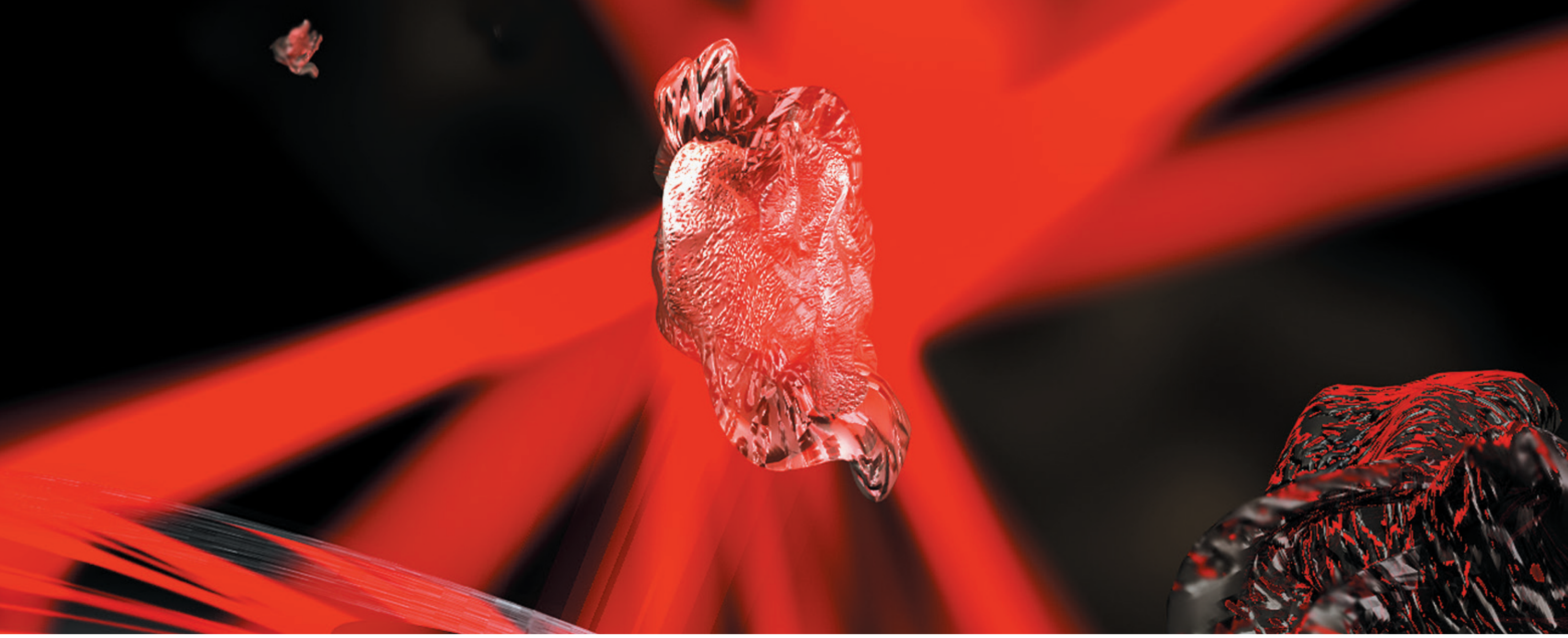
Predictive Maintenance

While these traditional particle counting options are effective to a certain extent, their modest nature presents challenges when it comes to developing a quality oil analysis program. When it comes to developing a quality oil analysis program. The ferrogram, filtergram, and patch test all promote increasingly outdated operations methods, such as reactive and time-based maintenance. While these still produce results, for those looking to take proactive measures to ensure the safety and health of their critical equipment, they should turn to systems that promote predictive maintenance (PdM).

PdM actively determines the condition of in-service machinery and equipment in order to analyse their condition and determine when maintenance should be performed while taking active steps to promote the overall health and wellness of these critical machines. In many ways, this is similar to how humans monitor and take care of their own health. For instance, it isn't the monitoring of someone's cholesterol that saves them from heart disease, it's the actions they do daily that matter. But, the tests are great ways to trend data and recognise health patterns in order to make better and more informed decisions.

Unlike its reactive counterparts, with the use of real-time sensors, facilities no longer run the risk of performing too little or too much maintenance. By reducing the human-error element, technicians can see marked improvements in asset uptime and facility safety, as well as a healthy reduction in unexpected failures and labour, equipment, and inventory costs.

Copyright © 2023 Filtertechnik • Do Not Reproduce



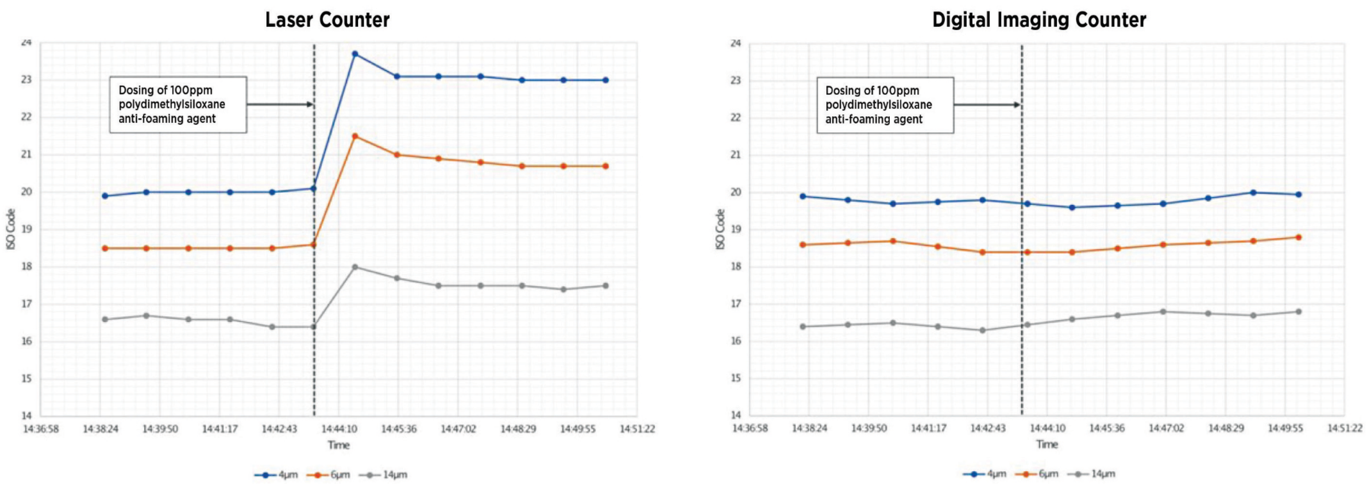
Optical Particle Counters using Lasers

One form of lubricant monitoring technology focused on this goal is laser-based particle counters. This light-blocking method allows fluid to flow through a measurement cell where a light source detects the particles as they pass through. The light source becomes partially blocked by the particles, creating a shadow that directly corresponds to their size.

While this system has helped the industry make great strides in its PdM efforts, there are significant drawbacks to the laser particle counter. Although the machine can count and record the size of the particles, it is unable to distinguish between different types of contaminant particles, such as water, air bubbles, and phantom particles (sometimes caused by certain additives). As these shortcomings have become more widely recognised, it has created the demand for systems that can accurately record and distinguish bubbles from particles and identify particles by shape without waiting to receive lab results.

True Optical Digital Particle Counters

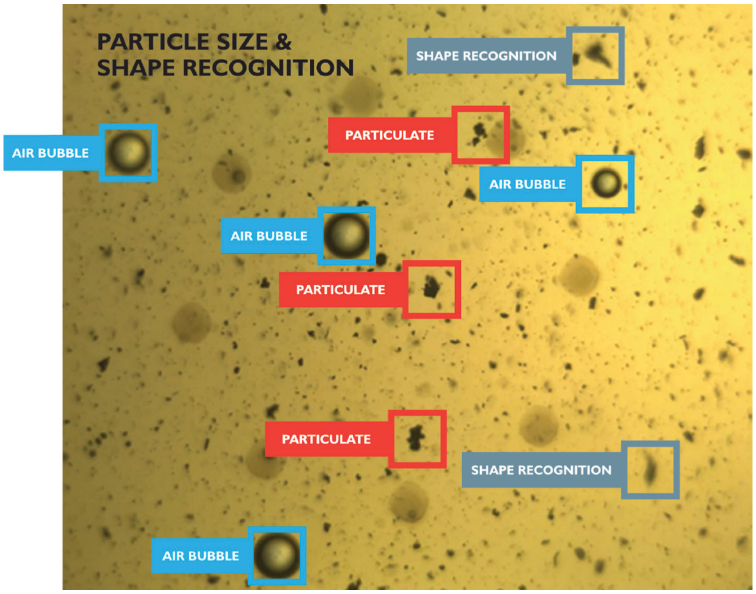
While optical laser particle counter data can be useful in predictive maintenance, deeper insights can be gained with more advanced technology. Particle counters that use a "true optical" digital technology like the Atten2 S120, take out more of the guesswork when analysing, trending and making decisions based on particle data. This system uses high-definition lenses, LED lighting, a camera instead of a traditional laser, and a digital processor to not only count particles, but to identify and report on their size and shape.



Laser counter versus FS9V4 digital imaging counter when registering additive agent.

Copyright © 2023 Filtertechnik • Do Not Reproduce

By replacing the traditional laser, it is possible to improve the accuracy of count readings by excluding bubbles or additive particles from the count. Sensors like this can be part of a standalone solution or can be combined into a more holistic fluid monitoring platform like the Filtertechnik Particle Pal Plus system, which can provide data on relative humidity, density, viscosity, or other readings. Viscosity is a particularly critical lubricant characteristic because it plays a major role in wear protection and efficiency. Monitoring viscosity closely for changes due to oxidation, glycol ingression, thermal stressors, or other issues prevents unnecessary wear and helps catch incipient failures sooner.



Using a continuous or real-time system bring the benefit of data for quicker decisions on the plant floor. It also simplifies the process, so an entry-level technician can accurately run the system and interpret results without extensive training or technical knowledge. Data is displayed in an easy-to-read format automatically and can be shared to other platforms as well.

Onsite systems like this bring useful labouratory-quality data in ten minutes instead of waiting weeks or even months, allowing users to monitor lubricant or machine health and make preventative maintenance decisions immediately.

Conclusion

Even the most comprehensive data is not valuable if it is not accurate or readily accessible. By researching and investing in the progression of its oil analysis program through a particle counting system, a facility can begin to see vast improvements in the continued operation and efficiency of its equipment and lubrication.

It's important to ensure that the particle counting process chosen fits seamlessly into a company's current system while enhancing its lubrication culture as a whole. By evaluating the options and being receptive to newer technologies, facilities can bring the lab to the field and begin building an effective oil analysis program centered around the continued health and success of lubricants and the critical assets they protect.

The S120 digital imaging particle counter at the heart of the PPPlus analysis contamination the fly. Air bubbles and shape recognition are standard features.

Copyright © 2023 Filtertechnik • Do Not Reproduce

Tired of wasting time and money with oil analysis?

- Devices that only give you partial information?

- Devices that don't give TRUE particle data?

- Devices that have to be sent in for expensive calibration every year?

- Having to have multiple devices for each type of contamination type?

- Waiting to take action on an issue due to oil lab sample analysis delays?

Welcome to the Digital Age with instantaneous information regarding ISO, water ppm, density and temperature for any type of oil(gear, lube or hydraulic), synthetic oils and even fuels!

CFI is blown away by the technology so much we have installed it on our own equipment and we have communicated our praise and excitement to our customers regarding this product which has opened their eyes of the possibilities.

Scott Hester
Certified Hydraulic & Lubrication Specialist

CFI
CONTROLLED FLUIDS, INC.

An ISO 9001 Company