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OELCHECKER

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IMO slewing rings – making everything run smoothly

High precision on an impressive scale – IMO three-row main bearing for a 5 MW wind turbine

Construction machinery, wind turbines, amusement park rides, tidal power plants, cranes, trams and underground trains, bottling plants for the beverage industry and precision medical devices – many of these share one thing in common: They are fitted with slewing rings made by IMO, one of the world‘s leading manufacturers of large rolling-contact bearings and installation-ready self-contained slew drives.

IMO GmbH & Co. KG, a specialist developer and manufacturer of slewing rings, recommends that operators check the lubricating greases used in their machinery on a regular basis using OELCHECK grease analyses. These analyses, which offer their customers genuine added value, have been greatly valued by IMO for a number of years.

Customers on all five continents know that IMO slewing rings can be relied on everywhere and at all times. Among other things, this makes IMO one of the world‘s leading suppliers of tower-head, blade flange, and main bearings for wind turbines, as well as blade bearings for tidal power stations. IMO‘s ball and roller slewing rings with diameters up to 6,000 mm are available for all manner of industrial applications.

Creative and extraordinary

As components often have to withstand extreme conditions, IMO‘s design engineers are constantly confronted with new challenges. The result: extraordinary ideas and creative solutions.
Even under water, IMO slewing rings work reliably to harness energy. A novel rotor blade adjustment bearing supports and adjusts the rotors of a unique tidal power plant positioned 15 m below the water. As it does so, the three-row roller bearing withstands extraordinary loads – this is despite the fact that the pressure in action on an underwater turbine is three times stronger than the pressure on a wind turbine. IMO supplies efficient solutions to problems of all kinds, and these specially designed solutions even provide some operators with unique selling points which help keep them ahead of the competition.

Lubricating greases in accordance with recommendations

IMO slewing rings are in use worldwide, and their operators are active in a wide range of sectors. Al-

Check-up

Many companies try, but few have genuinely succeeded in finding one: a unique selling proposition that makes them stand out from the competition. OELCHECK is one of the few companies to meet several of these sought-after criteria at the same time.

A **USP, or unique selling proposition**, is something exceptional – but in our case it isn't just a single superficial attribute that sets us apart from the rest. At OELCHECK, a unique selling proposition is always something associated with a direct benefit for the customer; this has been a core value of ours since our company was founded in 1991.

- **USP 1** With its **pre-paid all-inclusive analysis kits**, OELCHECK meets its customers' needs like no other lab in the world. These provide our customers with multiple advantages at a stroke: no need for multiple employees to handle ordering, invoicing or payment. Everything is ready for professional sample extraction and dispatch, with no need to locate a clean container, delivery box, address label or courier service. There's no additional covering letter required; the Sample Information Form says it all. There are virtually no administrative overheads, and the costs are transparent.
- **USP 2** OELCHECK customers are actively involved in protecting the environment. They change their lubricants according to their condition, **saving resources** and significantly reducing the amount of waste oil generated.
- **USP 3** OELCHECK customers benefit from a large number of **free additional services**, including sample entry by QR-Code and App and the online customer portal for sample entry and management, which offers translation of diagnoses into 15 different languages.
- **USP 4** OELCHECK is constantly offering **unique new developments**. A current example is an NFMIC process that we describe in this edition. We also use an HPLC method – unique worldwide – to determine the breakdown of oil additives that prevent non-ferrous metal corrosion.

With the help of our analyses and services, many of our customers have themselves developed unique service propositions that set them apart from the competition. This is something that makes us extremely happy. We invite you to be unique too – just as unique as OELCHECK!

Yours, Barbara Weismann

though this means that IMO doesn't prescribe any specific lubricating greases for ring maintenance, the experts know which lubricants deliver the right performance and which are available in each country. They pass their experience on to the operators and recommend the products that are best suited to them. Lithium and lithium complex greases with a synthetic or mineral base oil and an NLGI class of 1 to 2 are often used. Very large slewing rings need to be re-lubricated with between 50 and 100 kilograms of lubricating grease every year. In many cases, the grease is supplied by a central lubricating system.

Lubricating grease analyses with added value

IMO recommends that slewing ring operators have an OELCHECK lubricating grease analysis performed every six months. The company has held these analyses in high esteem for many years due to the added value that they offer.

OELCHECK lubricating grease analyses:

- provide reliable information on the condition of the grease and other components
- accompany all new IMO developments at the field test stage
- can detect impending damage at an early stage
- provide warnings of lubricant ageing
- identify contaminants and their origins
- detect mixing with other greases
- assist with the optimisation of lubricant amounts and re-lubrication intervals
- contribute to operational reliability and have a positive influence on maintenance costs.

„Condition monitoring has many tools for keeping track of systems. However, they don't sound the alarm until things become problematic. A typical example are frequency meters in wind turbines. Although they deliver a direct alert in the event that deviating frequencies are registered, by this point the damage is often already done. A lubricating grease analysis allows us to see deep into the fuel and the components, which, in most cases, enables us to intervene before any damage can develop in the first place. And we're right where our customers need us – our service teams are at home anywhere in the world."

As IMO GmbH & Co. KG's Head of Service, Hanjo Hermann knows all about the many possibilities offered by OELCHECK lubricating grease analyses. The analyses are also the method of choice for determining lubricant amounts and relubrication intervals for the application at hand. IMO slewing rings are put to work in a wide range of installations. To begin with, lubricant amounts and re-lubrication intervals are defined based on empirical values and the load involved. A certain safety factor is always included in calculations from the outset. OELCHECK analyses are then conducted on the slewing ring and grease during operation. Based on these results, the lubricant amounts and re-lubrication intervals are adjusted step by step until the ideal state is achieved, while keeping in mind the golden rule: „Too much re-lubrication is expensive, but too little will cost even more!" OELCHECK's all-inclusive analysis kit 5 is the perfect choice for examining IMO slewing ring greases, as it enables OELCHECK's tribologists to derive a precise description of the condition of the grease and the lubricated component. An assessment in the lab determines the following parameters: the components are subdivided according to wear, contaminants & additives, PQ index, IR spectroscopy, water content using the Karl Fischer titration method, and penetration value.

An all-inclusive OELCHECK analysis kit and sampling kit make it simple to take samples. In the case of IMO slewing rings that are over 1,000 mm in diameter, grease samples are taken by spatula from grease outlet boreholes at two to three points as close to possible to the bearing track in the main load-bearing area. Each sample is placed in a separate sample bottle, To allow the OELCHECK lab to make valid statements as to the condition of the grease and the slewing ring.

IMO – innovation belongs to the future

The IMO Group's impressive success story started in 1988. For years now, the group has been among the world's leading producers of large rolling-contact bearings and installation-ready self-contained slew drives. As IMO products often have to withstand extreme conditions, new approaches and extraordinary ideas are continually leading to innovative solutions that are then put into practice.

Both of IMO Group's manufacturing sites are located in Gremsdorf in Southern Germany. Around 500 employees work at the sites in Gremsdorf as well as in the USA and China, and as part of the Group's global sales network.

Further information: www.imo.de

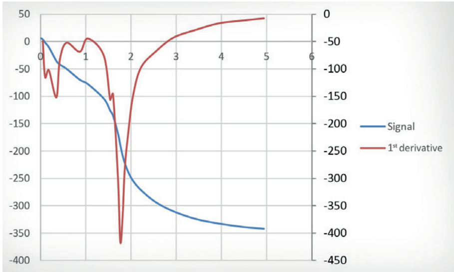
Changing the AN (Acid Number) standard creates confusion

With very few exceptions, mineral oil-based or synthetic base oils are neutral, i.e. they have a pH value which is around 7 on a scale of 0 (extremely acidic) to 14 (extremely alkaline). The pH value is nevertheless influenced by additives that are added to the base oil. Some combinations, such as anti-wear and anti-corrosion additives, have a slightly acidic reaction. The acidic compound content of the oil also continues to increase during practical use, for example as a result of oxidation. The longer an oil is in use, the higher the operating temperatures, while the greater the number of contaminants in the oil, the more the level of acid-forming oil oxidation rises.

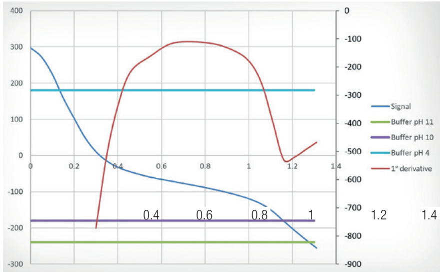
An accumulation of acids in the oil accelerates oxidation and can increase the oil's viscosity. In extreme cases, oil that has become too thick is no longer conveyed in sufficient quantities to the lubrication point. If free acids are present and the corrosion inhibitors are used up, this can lead to the corrosion of all oil-covered surfaces.

Neutralisation number (NN) and acid number (AN)

Determining the acid component is an important parameter in assessing all types of waste oils. Although different analytical methods have been established according to the type of oil involved, the determination procedure is always largely the same. A lubricant oil sample weighing between 2 and 20 g (according to the expected result) is intensively agitated with a solvent mixture containing a very small quantity of water. Acid components from the oil are transferred into the water during this process, which is necessary because the acids cannot be detected directly in the oil itself; it has to be detected in this „aqueous phase“ by means of titration. Used as a strong base, potassium hydroxide (KOH) is added to the sample one drop at a time until the oil becomes „neutral“. When all of the acids have been neutralised by the potassium hydroxide, the next drop of base added causes a sudden increase in the pH value. The acid content of the sample can then be calculated from the KOH consumed up to this „transition point“ and stated in mgKOH/g of oil. NN (Neutralisation Number) and AN (Acid Number) are determined using the same principle. When determining the NN, a colour indicator is added to the water-solvent mixture which changes colour exactly at the transition point - a change that the laboratory technician is trained to recognise.



Titration curve with transition



Titration curve without transition

The AN, which requires more resources to determine, is usually obtained only if a sample is too dark for the transition point to be observed. The sample is agitated with the same solvent used to determine the NN, only minus the indicator. The titrant (KOH) is then added – usually automatically – in small steps with a burette until an electrode that continuously registers the pH value indicates the transition point. The KOH used up to this point is indicated as the AN in mgKOH/g.

Not every titration curve runs in a way that allows an unambiguous transition point to be defined, however. To ensure that the acid component in the oil can still be determined in spite of this, the AN is obtained by titrating the titration up to a potential that has previously been measured in an alkaline buffer.

For many years, under the „old“ AN determination procedure (ASTM D664) this titration was carried out to a pH value of 11 (-240 mV). Under the ASTM D664 standard that applies today, however, titration is only carried out up to a „buffer“, or a pH value of 10 (-180 mV).

This change in the standard means that KOH consumption is lower, with pH 10 having to be achieved instead of the previous 11. It also means that the AN value provided in OELCHECK lab reports has been systematically lower since the entry into force of the new AN standard than it was when pH 11 was the buffer (as trend analyses in particular reveal).

This is because the formula for obtaining the AN is as follows:

$$AN = \frac{V_{KOH} \cdot 5.61}{SW} \quad \text{SW=Sample weight}$$

Why the switch from pH 10 to pH 11?

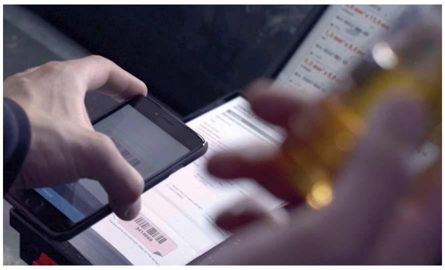
When the ASTM standard was first formulated, the buffer solutions used were organic. At the time the change to aqueous buffers was made, pH 11 was chosen as the buffer because the results obtained with pH 11 were the closest to the initial standard. With the latest automatic analysers, however, it turned out that using pH 11 as the buffer systematically resulted in the value measured being too high. Based on the results of the comparative tests, the standards committee – of which OELCHECK is a member – therefore decided to reduce the buffer to pH 10, as this was found to deliver significantly more stable and comparable results.

In addition to this buffer, another buffer is defined at pH 4 (180 mV). Measurement of the KOH consumed to this pH 4 point enables the SAN (Strong Acid Number) to be calculated and given in mgKOH/g. The SAN only reveals the highly aggressive acids that exist at a pH value below 4. The discovery in used gas engine oil of acids of this kind, which are usually found in landfill gas and the like, means that an immediate oil change is required.

The comparability of AN values

When observing trend analyses, it is noticeable that from 2019, lower AN values are reported in your laboratory reports. This is not a mistake on the part of the lab. As the „old“ AN values were determined using the pH 11 buffer, they cannot be compared with the values calculated since the introduction of the „new“ standard that uses the pH 10 buffer. Unfortunately, there is no conversion factor that could provide clarification in this regard, either. OELCHECK does, however, offer its customers the option of requesting the „old“ value on demand, which we continue to determine together with the „new“ one. In this way, we can – in spite of the new standard – still refer back to these „old“ values if in doubt.

To bauma with a brand-new app



In January 2019, we began working on a **new OELCHECK-App** together with our IT department and an external company of App developers. Plans include new functions, including a login function that gives you access to an overview of your most recent lab reports and your submitted samples, including the status of each sample. The new App will also work offline, allowing you to use it without the need for network reception and send images. You'll have the chance to get an exclusive look at

the first test version of our new OELCHECK-App at **bauma 2019**. **Visit us at stand 539 in Hall A4!**

First-class occupational health care

The health of our employees is an issue that matters to us a great deal; after all, only healthy and content employees are able to do their best every day. That's why **occupational health care** has a special significance at our company. In addition to a modern gym and a spa area with a sauna and swimming pool, we hold regular **health days**, which focus on specific issues such as exercise and mental well-being in collaboration with German health insurance fund KKH (Kaufmännische Krankenkasse).

February was devoted to the important topic of nutrition. Our employees learned about healthy and balanced eating during a lecture in which they were encouraged to take an active part, and had the opportunity to find out their body weight, skeletal muscle mass, and water and body fat ratio via an InBody analysis. Following this, they even received an individual assessment of their values and a personal consultation complete with a recommended courses of action.

Our employees also used all of their senses to discover different foods at a nutrition challenge course, where they built on the theoretical knowledge gained from the lecture with practical experience.

Even our popular **special courses**, which have already become a firm part of our health promotion activities, are being relaunched. Following „Yoga“ and „A Healthy Back“, a new course devoted to back care will start in May.

We are now planning new measures to promote healthy living for the future, including a **varied range of menu options** in the cafeteria of our new building.

Only through such measures can we make sure our employees feel good as they go about their day.

One step ahead with continuous training

Alongside modern office and lab equipment, continuous training is an indispensable part of long-term quality assurance. That's why we invest in further training for our employees on a regular basis.

Our preparations for the TOEIC (Test of English for International Communication) began in February. We've been offering our employees **English courses** for over 10 years, and these courses are now being relaunched with a new design: based on an initial TOEIC placement test, we've divided our employees into groups with similar competence levels.

They now sit down every week during working hours to learn together for the TOEIC.

All of the costs of the preparatory course, the accompanying textbook and the exam are covered by OELCHECK. The TOEIC is an internationally recognized language test that we have adopted with the intention of improving the service we provide. Our employees will also receive a certificate that they can use at any time to verify their knowledge of English in accordance with the Common European Framework of Reference for Languages (A1-C1); this ensures we are as ready as possible when it comes to dealing with the ever-growing world of international business.

We also hold regular **Machinery Lubrication Analyst** (MLA) and **Laboratory Lubricant Analysis** (LLA) advanced training courses for our employees' benefit. In March, we launched another MLA II advanced training course, which is designed to provide 13 employees from the lab, sample capture, sales, and technical assistance divisions with specialist knowledge to help them as they go about their work. This enables us to optimise both our lab processes and the way in which we interact with our customers. The course is led by the Head of our Tribology Team, Carsten Heine, and the training and exam costs are again covered by OELCHECK.

We're giving our tribologists the opportunity to obtain practical knowledge with regular **study trips**, which are also helping us to establish a closer connection with our customers and further optimise our services. In February, our tribologists visited **Gunvor refinery in Ingolstadt**, where they were able to see the individual stages that crude oil passes through during processing and gain special insights into how the machine operators on site go about their work. We are placing a great deal of importance on continuous training as a key component of our efforts to expand our position as Europe's leading lubricant and fuel analysis lab. With their experience and knowledge, our employees are guaranteeing our success right now – and promise great things in the future.

No cure without an integrated approach

Just as the blood circulating in a human organism is vital to its survival, so the oil circulating in a machine is essential for ensuring it functions properly. As relevant as it is valid, this comparison ultimately leads us to the question of whether the blood that flows through machines might be deserving of more appreciation than it has previously been given.

fotolia © Production Perig

When humans or animals feel unwell or are showing symptoms of illness, no doctor thinks about swapping out their patient's blood – and that's even if such a thing happened to be straightforward from a medical/technical point of view. Any doctor proposing such a thing would likely have their medical licence revoked. Instead, the correct procedure is to subject the blood to a thorough analysis – which is exactly what the doctor does. This gives them an insight into why their patient is sick, enabling them to better understand the symptoms and recommend measures for treatment.

In the case of our complex machines, the process is a very different one. Oil changes are often carried out as a preventative measure, and they are always exchanged if any damage occurs. The result is that important information about the causes of the damage contained within is thrown away with the waste oil, meaning that the factors responsible for the damage remain in place unchecked. It is not uncommon for a (usually unnecessary) oil change to be the instigator for the next breakdown. The whole process simply starts all over again.

Supposedly cost effective, but with expensive consequences

Another frequently made mistake in this respect is to judge oils predominantly by their sale price. There is a saying that cheap oil is good oil. Although employees in purchasing departments – most of whom are strongly influenced by commercial factors – go on to compare the standards and licenses as a precaution, they overlook the fact that these standards only concern minimum requirements. In other words, they fail in many cases to consider the fact that total oil costs generally comprise far less than 1% of machine operation costs. Attempting to further reduce this minimal amount is illogical, as even a cursory consideration will reveal. However, this is often precisely what is done due to sweeping declarations of the need to save money. The urge to save often ends up being an expensive solution in the overall analysis, because it intentionally overlooks the fact that up to 50% of the total operating costs of a machine depend on the quality of the oil used. This applies to general wear as well as system disruptions and failures, overall machine service life, and energy consumption.

Any buyer choosing oil primarily due to price considerations is unlikely to want to spend more money on oil care. One follows from the other, and the argument appears to be conclusive: if the oil is cheap, then oil care must also be uneconomical. But this overlooks the fact that oil care is not only about extending the service life of the oil – it is primarily about removing contaminants present in the oil in order to counteract increased wear, system disruptions and machine failures, and to reduce maintenance costs. Besides this, oil and energy consumption are also reduced in this way; it is well known that due to wear, the contaminants in the oil lead to losses in performance and, as a result, to increased energy consumption.

From disposable products to system components

Ideally, oils – primarily hydraulic oils, but also gear and/or engine oils – should be seen less as disposable products and far more as valuable components. Regular oil analyses can provide valuable indications about the condition of a particular machine. Most modern oils are partly or fully synthetic, and contain high-performance additives. Avoiding increased contamination enables them to remain in the machines for much longer than advised by standard machine recommendations. Moreover, carefully planned offline filtration makes it possible to filter most abrasive and catalytic contaminants out of the oil.

Spectrochemical element analyses make it possible to successfully „read" the wear status of the respective machine from the oil over a long period of time - information which, as previously mentioned, is lost for good when the oil is changed regularly, as a preventative measure and/or prematurely.

Any company seeking to become a true oil expert should use the virtually ideal combination of offline filtration with oil analysis sensors, which is also known as „the integrated fluid concept". Oil sensors make it possible – at very little financial cost and using straightforward hardware and software – to compare the condition of the machine at very short intervals (mostly within the space of a few minutes). In the event that major deviations are identified and indicated, the risk status as well as the cause can be determined by means of a complete oil analysis, after which the necessary countermeasures can be taken for the situation required.

NOx and CO_2 are also influenced by machine oils.

Lubricating oils and fuels are being subjected to more intense scrutiny due to stricter emission regulations and the discussion surrounding NOx, CO_2 and fine particulates. Oils with smooth-running attributes can sometimes save a great deal of energy. This quality, combined with longer oil change intervals, translates automatically into a lower CO_2 load and/or more favourable CO_2 balance. The Panolin GreenMachine concept has been devised especially to enable meaningful certification to be issued here. Even so, all of the advantages mentioned above can only be put into practice and deliver their benefits if oil is removed from the category of ‚disposable products' and instead treated as a valuable component of the machines in which it is used.

A guest article by Milorad Krstić
Executive Director, Kleenoil Panolin AG – www.kleenoilpanolin.com

New! Non-ferrous metal inhibitor content (NF-MIC) provides earlier warnings of impending wear

New, improved lubricants arrive on the market at regular intervals, and the formulation of these high-tech products, in most cases based on synthetic base oils and additives, also has direct consequences for lubricant analysis. That's why OELCHECK continually invests in innovative testing procedures and develops new analysis methods based primarily on test procedures that have become standard. A brand-new development is to inspect the remaining non-ferrous metal inhibitor content in waste oils using high-performance liquid chromatography (HPLC). Previously used by OELCHECK for coolant analysis, the HPLC method can now be applied for early detection of the breakdown of non-ferrous metal inhibitors used in gear oils to prevent non-ferrous metal wear.

Our new analysis method of non-ferrous metal inhibitor (NFMI) content developed from an exciting case that initially had OELCHECK tribologists scratching their heads. Oil from the mean gear of a wind turbine filled with 600 litres of synthetic gear oil was inspected three times over a period of six years. The analysis values obtained showed that no oil change was necessary, as all of them were normal. However, a closer look at a sample of the oil that had been in use the longest revealed changes that were completely outside what was expected.

Discolouration of the synthetic gear oil

The oil samples were taken at irregular intervals of 12,600, 43,800 and 52,700 operating hours, respectively. They revealed a change in the colour of the oil that was documented photographically in the lab report. Although there is no standardised evaluation for oil colour, this enables specialists to make an initial appraisal of oil changes in comparison with a fresh or previous sample. In this case, the first sample was still light and clear, but after that the oil had discoloured to a dark brown within the relatively short space of time up to 52,700 operating hours. As the remaining analysis values (with the exception of copper content) showed nothing unusual, the darkened oil alone revealed no clues to suggest that an oil change was needed. Nevertheless, the tribologists at OELCHECK were alarmed. Due in part to the copper content, they first examined the visual change since the last sample more closely under the microscope and compared it with the previous samples and with fresh oil.

In spite of this, neither the values obtained nor the FT-IR spectroscopy indicated a significant change in the oil or oil mixing. The viscosity and viscosity index had remained stable, the Neutralisation Number had barely risen, and the oil purity was within tolerable limits. Phosphorous and sulphur content – a typical part of the additive component – had only fallen slightly in the darkened sample. With the exception of copper, the wear metals showed no signs of significantly increased wear. Although the high copper value quite clearly indicated corrosive wear of components containing copper, such as roller bearing cages, copper alone is not a cause of oil discolouration.

		Fresh oil	Sample A	Sample B	Sample C
Date		11.12.2017	29.08.2013	02.05.2017	06.04.2018
Operating time		0h	12.600h	43.800h	52.700h
PQ index		<25	<25	<25	<25
Iron (Fe)	mg/kg	0	10	21	23
Chromium (Cr)	mg/kg	0	0	0	0
Aluminium (Al)	mg/kg	0	0	0	0
Copper (Cu)	mg/kg	0	0	3	30
Manganese (Mn)	mg/kg	0	0	0	0
Lead (Pb)	mg/kg	0	0	0	0
Water	mg/kg	91	110	72	91
Kin. Viscosity 40°C	mm²/s	328,66	323,18	322,63	321,04
Kin. Viscosity 100°C	mm²/s	36,24	37,82	36,41	36,34
Viscosity index		158	167	160	161
Cleanliness class	ISO 4406		16/14/11	16/14/10	19/17/12
Neutralization number	mgKOH/g	1,02	0,98	1,05	1,02
Calcium (Ca)	mg/kg	0	0	0	0
Magnesium (Mg)	mg/kg	0	0	0	0
Boron (B)	mg/kg	0	0	0	0
Zinc (Zn)	mg/kg	0	10	16	30
Phosphorus (P)	mg/kg	431	372	376	335
Barium (Ba)	mg/kg	0	0	0	0
Molybdenum (Mo)	mg/kg	0	0	0	0
Sulfur (S)	mg/kg	3841	3290	3472	3168

Oil ageing and its traditional parameters

When inspecting wear values, OELCHECK uses an internal database where permissible boundary and warning values are defined for every system type on the basis of several hundreds of thousands of analysed samples. A comparison against the limit for copper levels resulted in the gear condition being assessed as „critical"; however, no clear cause for the unusually elevated copper content could be found, even with the more than 30 analysed values available. OELCHECK's tribologists consulted with lab management to find a method that could provide clarification.

It was striking that both the high increase in copper levels and the dark discolouration of the oil had taken place within the relatively short period of fewer than 10,000 operating hours. Additives break down or lose some of their effectiveness, while synthetic base oils also deteriorate. Contaminants or lubricating grease often find their way into the oil as well. Most processes interact with one another. In addition, the various base oils or additives of individual production batches, other operating temperatures or conditions, altered operating times, or stop-and-go operation can often have their own influence on oil ageing. These alternations are all summarised in the lab report under the heading of „Oil Ageing".

Just as varied as these factors are the traditional parameters of lubricant analysis, most of which yield values through standardised methods. It is with the help of these factors that the oil's condition or degree of ageing is assessed. It is only possible to make a reliable diagnosis when the various informational elements acquired are linked together. When it comes to the ageing of gear oils, appearance and colour are assessed subjectively in addition to comparing a change in viscosity and viscosity index, acid content and still-present additives with the values of a fresh oil sample. Oxidation is also revealed within a spectrum made visible using FT-IR (Fourier-transform infrared) spectroscopy.

The proven FT-IR method and its limits

The FT-IR spectrum of a used oil sample provides information about changes to the oil or oil mixtures (albeit mostly only in comparison with the spectrum of a corresponding fresh or reference oil). For example, oxygen bonds that change within a sample can deliver a diagnosis of oil oxidation.

Although this standardised process has now become established for classic mineral oils, FT-IR spectroscopy can no longer be used to reliably quantify oxidation for synthetic oils, the base oils of which are based on PAO (poly-alpha olefin) or PAO with an ester base, or the additives of which contain synthetic components like these. Spectrum comparison can only be used to determine oil ageing if the molecules present in the lubricant absorb the infrared light differently at specific wavelengths. In accordance with the applicable standard, the oxidation of a used oil is determined from the differential spectrum of the used and fresh oil at a wave number of 1710 cm^{-1} and given as a numerical value in A/cm (absorption per cm of oil layer thickness).

In the case of a lubricant with a mineral oil-based base oil, a relatively small „peak“ that rises continuously in the used oil spectrum is indicative of increasing oil oxidation.

FT-IR spectroscopy, which works on the basis of oxygen concentrations, provides no clear information in the event that the oils or additives include ester-containing components. The ester-containing components conceal an oxidation peak in the FT-IR spectrum due to the fact that an oversized peak forms in an ester-containing oil in a wave number region of around 1740 cm^{-1}. This is why infrared spectra of synthetic fresh oils mostly display an oversized „peak“ in a wave-number region around 1740 cm^{-1}. If the spectra of fresh and used oil are compared with one other, any „peak alteration“ caused by oil oxidation is no longer visible.

When appearances are deceiving

A statement with respect to oxidation provides information about the general ageing condition of the lubricant. In the case of the synthetic gear oil described here, however, a safe diagnosis was difficult to make.

Synthetic oils often show conspicuous changes over a period of several thousand operating hours in the form of increasing wear or oil ageing. However, some wear values – especially those for non-ferrous metals such as copper and zinc – increase unexpectedly and significantly without prior warning. This is often accompanied by a dark discolouration of the oil. Even so, this colour change alone is no indication of a critical change in the oil. It is only cause for alarm if the darkened oil displays unexpectedly high copper and zinc values.

Faster, more accurate results with HPLC

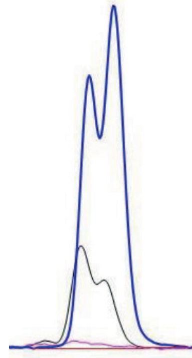
A traditional oil analysis provides valuable indications as to changes in the lubricant and its effects, providing the maintenance engineer with timely information about any change in viscosity, rising water content, acids in the oil, or contaminants. However, the question of why the darkened oil in our example showed such a high copper content could not be answered with the analysis included in a traditional OELCHECK analysis kit.

Instead, the OELCHECK tribologists had to develop an all-new approach. To inspect the gear oil, they employed **high performance liquid chromatography (HPLC)** for the first time.

The HPLC device is normally used to test whether the expected number of inhibitors is still present within a coolant. An inhibitor is added to a coolant to slow down or inhibit chemical or physical changes. The inhibitors used are azoles like tolytriazole and/or benzotriazole, which protect components with non-ferrous metal-containing surfaces from corrosion.

Non-ferrous metal inhibitors are also used to protect surfaces in lubricants. These additives can, however, break down and lose effectiveness as usage time continues. If it is possible to detect the breakdown of these protective ingredients accurately and ahead of time, an impending corrosive attack on the lubricated elements can be identified and documented. Non-ferrous metal inhibitors cannot be identified with an element analysis, FT-IR spectroscopy or other standardised process. With high performance liquid chromatography, however, OELCHECK already has the perfect laboratory device in place.

The two synthetic gear oil samples taken at 43,000 and 52,700 operating hours, respectively, were tested together with a fresh oil sample using the HPLC method. The results confirmed the OELCHECK tribologists‘ hunch.



The HPLC graph for the fresh oil (blue) shows its high tolytriazol content. A significant decline is evident in the graph for the sample taken after 43,800 operating hours (grey). Finally, after 52,700 operating hours (red), the content of the non-ferrous metal inhibitor tends towards zero. In other words, the wear has already begun.

This information about the significant decline in the non-ferrous metal inhibitor at 43,000 operating hours would have made it possible to halt the rising copper wear in time, e.g. by performing an oil change.

Examples in the OELCHECK database, which contains over 3 million data records, shows that increases in non-ferrous metal content can be even more striking. Sample comparisons show that copper and zinc values have risen within the space of fewer than 2,000 operating hours to concentrations of well over 100 mg/kg without a cause being identified.

With the HPLC method, OELCHECK now has a method at its disposal for identifying non-ferrous metal wear at an earlier stage. The process itself is relatively expensive due to the fact that after every analysed sample, the device has to be recalibrated with the oil to be inspected; however, these advance warnings will enable damage and cost-intensive repairs to be avoided.

Non-ferrous metal inhibitor content (NFMIC) available as a special test

A traditional oil analysis accurately determines the oil condition and wear as part of an analysis kit. With the examination of non-ferrous metal inhibitor content, an additional method has been made available with results that enable any corrosive wear procedures at work in non-ferrous metal components to be identified earlier than was previously possible.

OELCHECK recommends the new NFMI procedure for the analysis of gear oils in order to improve operating safety, especially in the event that an elevated non-ferrous metal component (copper, lead, tin) is identified.

With the analysis of NFMI content using the high performance liquid chromatography (HPLC) method, the remaining residual amount of non-ferrous metal inhibitor is given as a percentage in comparison with the value from a fresh oil sample in the „Additional Tests“ section of the OELCHECK lab report.

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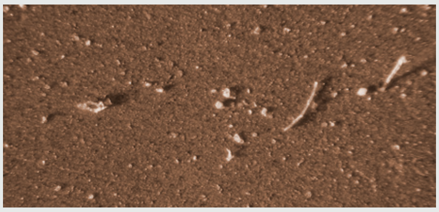
Q & A

We have the hydraulic fluids from our construction machinery analysed on a regular basis with analysis kit 2 for mobile hydraulics. This also includes a particle count in accordance with ISO 4406.
How useful is an analysis of this kind if the hydraulic fluid is sent to the lab in a sample bottle that contains particles itself? Are the results of the analysis influenced by the transportation of the sample in the sample bottle? How clean are your bottles?
Are you able to provide a statement on how many particles are present in a new sample bottle and how large they are?



OELCHECK:
Our sample bottles are manufactured by EME International in China. This manufacturer conducts regular checks to guarantee the purity of our bottles. To provide official evidence of this purity, EME International tested the sample containers for us together with their lids.
To do so, a representative number of bottles were selected, removed from their sealed, transparent protective film and filled to 90% of their volume with a particle-free liquid that is certified „super-clean". The test bottles were then closed using their lids, before being heated together with the samples to 50°C and shaken for 10 minutes. A particle count in accordance with ISO 4406 was then conducted both with the liquid shaken in the sample bottles and with fresh samples of the liquid.

The purity test was conducted using CONOSTAN PartiStan™ SCF – Super Clean Fluid. This fluid has a particle count of 980 per 100 ml at particles > 4 µm (see Table 1).

Table 1: Values before and after the test

	Fresh, super-clean fluid	Fluid after	Purity class
Particles/100 ml > 4 µm	980	1900	11
Particles/100 ml > 6 µm	110	200	8
Particles/100 ml > 14 µm	0	3	3

For comparison purposes: The corresponding particle count in fresh oil is between 4,000 and 8,000 per 100 ml (see table 2).

Table 2: Compared values of the sample bottle and a fresh oil

	Influence of the sample bottle	Fresh, super-clean industrial oil
Particles/100 ml > 4 µm	920	4,000 – 8,000
Purity class	10	13
Particles/100 ml > 6 µm	90	1,000 -2,000
Purity class	7	11
Particles/100 ml > 14 µm	3	250 - 500
Purity class	2	9

Following the test, the particle count obtained for the fluid was 1,900 per 100 ml. In the case of particles > 6 µm, the particle count rose from 110 to 200 per 100 ml, while in the case of particles > 14 µm it rose from 0 to 3 per 100 ml.
As the oils analysed in the OELCHECK lab have a purity class higher than 13/11/9, the influence of the few particles can be ignored. A comparison of tables 2 and 3 shows that the particles in the sample bottle can increase the purity class by a maximum of one class if the value lies in the boundary region between two classes, with it being more probable that they have no effect on the purity class.
We also guarantee the particular purity of our sample bottles by using packaging that is unique worldwide: the lid and container are shrink-wrapped together, and are only unpacked and separated upon reaching the customer and shortly before use.
This is why it is especially important that you use our pre-paid analysis kits, because a meaningful analysis begins with professional sample extraction and storage. Even containers that you wash before using them as sample containers may be contaminated through the very process of cleaning with particles that could influence the results of the analysis.

Our analysis kits provide you with the proper „tool" that allows you to send your sample to us reliably and easily. In addition to the sample bottle, it includes a Sample Information Form with a detachable lab number and an addressed returns envelope with a UPS return delivery form.

Why you should determine the purity class of an oil

Approximately 80% of hydraulic system failures are caused by impurities in the hydraulic oil. That's why OELCHECK examines the purity of hydraulic oils with particular precision when conducting a particle count.
A particle count is also advisable for oils from roller bearings due to the fact that solid contaminants in the oil can influence the bearing's service life. The purity class should also be determined for oils from plants that pose especially stringent requirements in terms of service life and availability. After all, maintenance work on facilities such as wind turbines can end up being extremely expensive. Do keep in mind, however, that we can only provide a meaningful diagnosis from samples that reach us in a clean sample bottle.

Table 3: Purity classes in accordance with ISO 4406

Number of particles per 100 ml		Purity class
over	up to	
8,000,000	16,000,000	24
4,000,000	8,000,000	23
2,000,000	4,000,000	22
1,000,000	2,000,000	21
500,000	1,000,000	20
250,000	500,000	19
130,000	250,000	18
64,000	130,000	17
32,000	64,000	16
16,000	32,000	15
8,000	16,000	14
4,000	8,000	13
2,000	4,000	12
1,000	2,000	11
500	1,000	10
250	500	9
130	250	8
64	130	7
32	64	6
16	32	5
8	16	4
4	8	3
2	4	2
1	2	1

OELCHECK is ready to answer any questions you may have about tribology or lubricant analysis.
Contact us by email (info@oelcheck.de) or by fax (+49 8034 9047 47).