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From Dietenhofen to all over the world – the triumph of PLAYMOBIL

While more than 50 per cent of the toys available in Germany come from the Far East, geobra Brandstätter GmbH & Co. KG, better known as the manufacturer of PLAYMOBIL, has its own production sites in Germany and Europe. The first toy Indians, builders and knights marched their way into children's bedrooms all over the world in 1974. There have been over 3,700 different toy figures produced since then and the PLAYMOBIL figurine population has reached 2.5 billion. Joined together hand-in-hand they would stretch around the Earth 3.1 times.

The beating heart of the company's production is in the Franconian village of Dietenhofen in the district of Ansbach. 1,200 employees work here. Every day, 443 injection moulding machines spray up to 10 million individual components, 250,000 pieces are pressed and an average of 65,000 PLAYMOBIL sets are packaged. In 2011, geobra dispatched a record number of 55 million finished items. To achieve these impressive production figures, shift workers operate the moulding machines around the clock. The seven spraying halls are equipped with first-class machines from Arburg, Babyplast, Battenfeld, Boy, Ferromatik, Sumitomo Demag, Engel and Krauss Maffei. Even the smallest pieces of equipment have a clamping force of six tons; the biggest have a force of between 250 and 2,000 tons. Soon even larger machines used by Brandstätter to make high-quality planters bearing the brand name LECHUZA will become operational.

The hydraulics systems in the modern injection moulding machines are compact and particularly high-performance. Reduced gap tolerances and improved quality of surfaces enable extremely high working pressures with high clamping force and incredibly precise working system components. In Dietenhofen, a specialist hydraulics department maintains the hydraulic systems of the 443 injection moulding machines. Eight engineers and five electricians carry out routine checks based on the guidelines provided by the individual manufacturers at 500-hour intervals. Additionally, extensive annual maintenance work is carried out after 5,000 operating hours, sometimes more frequently. Depending on their make, the hydraulic systems operate with between 12 and 3,000 litres of hydraulic oils, type HLP 46, in accordance with DIN 51524 T-2. These are predominantly conventional mineral-oil based hydraulic oils with ZnDTP-based additives. Zinc-free HLP 46 is only used if specified by the machine manufacturer. On the whole, geobra keeps the range of lubricants and hydraulic oils it uses to an absolute minimum to avoid mixing up oils, e.g. during additional bypass filtration.

Maintaining and monitoring hydraulic oils is vital to the running of the machines. It is not uncommon for

Check-up

There cannot be many people who were not enthralled by Felix Baumgartner‘s space jump. Even though the project had been planned down to the smallest detail it could still have gone wrong. When he went into a tailspin shortly after jumping, disaster did not seem far off. What drives someone to embark on such risky adventures? Courage, an iron will and a daredevil streak are all reasons why he jumped from a height of 39 kilometres. Felix Baumgartner will be provided for financially until his old age. But money alone was certainly not the driving force behind his jump. What probably decided it for him was the unique thrill of pushing the boundaries of human experience.

But do we really need to push ourselves to the limit like that? Aren‘t people who can live without such experiences better off? What does an extreme sportsman feel afterwards, and after his greatest triumph? Does an emptiness spread through him which can only be filled by the next challenge? What will happen at the end of his career? Does he still live for that day and live on his fame from days past? Or has he already found a new fulfilling task?

Everyone deserves a fulfilling life with a job that they love. Not everyone can have a life in the fast lane. However, not everyone can get used to the humdrum regularity of everyday life. We at OELCHECK manage both. We are constantly looking to expand and are devoting all our energies to this. We never give up – again and again we take on big and small challenges alike. It has been a pleasure to work for you for over 20 years now.

Yours, Barbara Weismann

In Dietenhofen, 443 injection moulding machines produce up to 10 million single parts daily.

a machine to operate for over 35,000 hours without oil changes. Fresh oil, which does not always meet the required purity levels because it has been transported and stored, only enters the machine after it has passed through an upstream fine filter. Many machines are also equipped with a bypass filter. The hydraulic oils in machines which use very large quantities of oil undergo bypass filtration through supplementary filters. The inspection of used oils to check for mixing or pollution is carried out according to the manufacturer specifications and includes on-site testing and OELCHECK analyses.

Before each major hydraulic oil change, standard procedure is to carry out a large-scale analysis of the oil in the OELCHECK laboratory. Only by doing this can the need to change the oil be confirmed. Among other things, the process closely examines oil ageing. High temperatures, long service lives, high pressure and in some cases even wear particles all accelerate the inevitable ageing process. If the hydraulic oil is not performing at a satisfactory level and the oil‘s viscosity has changed as well, this will have a direct effect on the efficiency of the pump first and foremost. The build-up of pressure required to operate the injection moulding machine is no longer present and the tendency for cavitation of the oil increases. The air output capability deteriorates. The hydraulic fluid must then be changed.

Early damage detection is a further invaluable benefit of the analysis. If, for instance, the laboratory report shows increased levels of the wear metals iron, chromium, tin, copper or lead, targeted action can find the components from which the metals originate. Of course, the oils are also analysed for possible cool water leakage because too much water in oil can damage the pumps. With OELCHECK analyses, geobra can rest assured that there will be no delays to production and no children will be deprived of their beloved PLAYMOBIL figures.

OELCHECK China

Getting ready before the new laboratory opens

Intensive training in Brannenburg for our new Chinese employees

Only a few weeks remain before our laboratory in Guangzhou in southeast China is opened. All of the lab equipment for the Chinese laboratory was built in Brannenburg. Nicholas Liu Ke, Andrew Zeng An and William Wang Wei Dong (see photo above with Paul Weismann, from left to right) have got to know how the procedures and equipment work under the tutelage of our scientific director, Dr Thomas Fischer. Laboratory manager William Wang Wei Dong has a Bachelor‘s degree in lubricants and tribology and has already set up and successfully managed a lubricant analysis laboratory in China. Andrew Zeng An, a mechanical engineer, has been writing up Chinese laboratory results for 10 years. With his vast technological know-how, he will be responsible for sales and marketing and will answer inquiries made by Chinese customers. Nicholas Liu Ke has a Bachelor‘s degree in engineering. He will assume responsibility for the intake of specimens, operation of laboratory equipment and communication in English. These three employees will be supported by additional laboratory technicians, other specialised technical staff and an accountancy team.

During the training in Brannenburg, all the testing equipment was set up and linked to the central server in exactly the same way as it will be in Guangzhou. After all, everything must run as smoothly and work as perfectly as in the original laboratory in the spring. However, the results will be assessed and a full diagnosis will take place in Germany. The values recorded in China will be transferred to the Brannenburg database via the internet. There they will be assessed by the diagnostic engineers in the same way as if the specimens came from Germany. Regardless of which country the sample was investigated in and where our customers are from, the following requirement is always applicable: the laboratory reports must be available worldwide on our internet platform www.laborberichte.com within 48 hours. It goes without saying that this is available in 15 different languages, including Chinese!

The OELCHECK laboratory - quicker and more accurate with a new particle counter.

Almost 80% of all hydraulic failure can be traced back to impure oil. In order to lubricate other components, which are produced with an increasing level of precision, the purity and cleanliness of oil is of increasing importance. In order to better predict how much longer oil can be used for, the particle count of over 600 oil samples is carried out in the OELCHECK laboratory on a daily basis. The four counting systems, which are equipped with specimen change-over facilities, often run at full capacity, which is why we have installed an additional innovative particle counter. It has not just made the work of the laboratory technicians easier, but has also sped up work flow.

The innovative particle counter in the OELCHECK laboratory already offers clear-cut advantages.

Impurities in oil can always be a risk. Hard particles such as dust, coloured particles and wear metals can cause abrasive wear. Soft particles can build up from old additive components. Often they are adhesive too and stick to machine parts or filters, which prevent them from functioning smoothly. Particles in oil accelerate the ageing of oil and shorten its lifespan.

Particle counting and optical particle analysis

Particularly when checking hydraulic, turbine and other low-viscosity oils, the pollution level is determined based on ISO 4406 by counting the size and number of particles in the laboratory with help from automatic particle counters (APC). The level of pollution is divided up into purity categories. Here, laser sensors are used to determine the number and size of the particles. After the particles are counted, the oil is classified according to purity. The processes used to determine oil purity and purity categories are defined under ISO 4406 and SAE 4059. ISO 4406 classification is based on particle sizes >4 µm, >6 µm and >14 µm. The ISO particle numbers are cumulative, which means that the stated particle figure for > 6 µm consists of all particles >6 µm plus particles >14 µm.

Detailed information about purity categories can be found at www.oelcheck.de under Downloads, ÖlChecker, Summer 2000, pages 6-7.
Conventional particle counting only distinguishes between the size and number of particles, however. It does not record whether they are soft or hard particles. Water droplets, small air bubbles and soft particles are thus recorded too. OPA, optical particle analysis, provides more precise information on gear oils. It also photographs the outline of particles and divides them into specific categories such as wear fatigue, cutting wear, non-metal impurities (tribopolymers), water droplets and so on. The number and size of particles are recorded during the particle counting process too.

The new particle counter offers distinct advantages

In principle, the new generation particle counter in the OELCHECK laboratory works like existing devices with a laser sensor, but the samples are now homogenised and prepared better. The entire process has been simplified and optimised. In the conventional particle counting process, air bubbles and water droplets can influence the results. The new device rules out this possibility in the majority of cases.
Particle counting is one of the first stages of analysis an oil sample undergoes. Previous machines analysed the sample directly from the original container. As counting can take up to 5 minutes, this may lead to delays further along the testing process, because too many samples get backed up as they wait to be counted. Now laboratory assistants pour only 20 ml approximately of the homogenised sample into a plastic beaker, which goes into the new counter. Afterwards the sample container is immediately transferred to the next examination stage, which of course reduces processing times. Instead of only 20 samples, the new device can be loaded with 80 sample containers. Before the actual counting, an innovative ultrasound sensor determines the exact size of the sample so that an exact solvent mixture of 75% toluene and 25% propanol at a ratio of 2:1 (based on ASTM D7647-10) can be used and this can be taken into account to determine a blind value. Immediately before the measurement, the sample is homogenised and degassed. Air bubbles escape quickly from the diluted sample and can therefore no longer be counted in the analysis. The effect of the propanol in the solvent mixture is that possible water droplets dissolve and become „invisible". In addition, the toluene dissolves any soft reaction products which may be present and ensures that only the hard particles which are actually present in the oil are counted.
The entire diluted sample of around 30 ml is then counted three times in a row, from which a mean average is extrapolated. If the individual values differ from each other greatly, the particle counter rejects the whole analysis and requests a new specimen. It doesn't get much more precise than that!

A Canadian company is behind our new particle counter. The core of the machine, the particle sensor, comes from Markus Klotz GmbH. In the OELCHECK laboratory, the innovative particle counter has already proven itself to be highly effective. Each day it looks at some 250 samples and is set to be joined by a second device of the same make soon.

HOT TOPICS:

The analysis of lubricating greases

What lubricates more efficiently, oil or grease? Over 95% of all components are lubricated with oil, not because it lubricates better but because it has a wider variety of characteristics. Grease is generally only used if oils cannot be used because sealing the lubrication point is problematic or expensive. Typical cases of where lubricating greases are applied are rolling bearings, around 80% of which are lubricated with grease. During the analysis of used lubricant, oils and grease behave similarly. Both contain important information; however, it is more difficult to decode the results for greases. OELCHECK carries out over 5,000 lubricating grease analyses per year and is thus the world‘s leading lubricating grease laboratory. Our laboratory does not just have specific testing measures and testing devices – experienced engineers are also on hand to interpret the values. The analysis is done with low-cost analysis kits which can be complemented by special additional studies.

Greases contain lubricating oils with additives, which are integrated in a sponge-like structure of „soap“ or „thickener“ so that there is no run-off. According to DIN 51 825, „lubricating greases [are] consistent lubricants which consist of mineral oils and/or synthetic oils as well as a thickener.“ The thickeners predominantly used are metallic soaps such as lithium, calcium, aluminium, barium and sodium soaps as well as their complex soaps. Gels, polyurethanes and bentonite are also used. The sponge-like structure arises when the original material, which is mostly in powder form, is brought to the boil with water. The water which evaporates during the boiling process is continuously replaced with oil. Additives are added during the cooling phase. Before filling the grease is ground and homogenised. Air which has entered the grease is also removed at this point. A multi-purpose grease consists of up to 92% oil. The lubrication is mostly carried out with base oil and its additives. The thickener on the other hand does not just prevent oil run-off, but constantly provides oil to the lubrication points.

Correct sampling

With lubricating greases in particular, correctly drawing off a representative sample is a pre-condition for qualified analysis and reliable diagnosis. OELCHECK offers a professional tool, the „Grease Sampling Kit“, to collect used grease samples.

OELCHECK - Grease Sampling Kit

An OELCHECK Grease Sampling Kit includes:

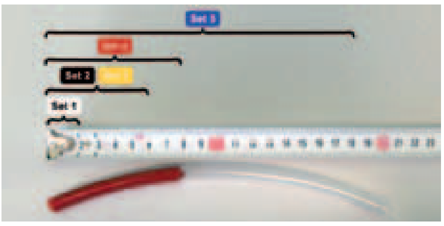
A A large-volume, reusable syringe. In this way the grease sample can be drawn from a lubricating hole using transparent tubing, which is included in every Grease Sampling Kit.

B Different plastic spatulas.
An alternative method to collect lubricant grease from relief wells, difficult-to-reach storage areas and unusual components, or from the seal lip area.

C Cleaning cloth – used to clean the surroundings of the extraction site, to remove the excessive grease and if need be to wash your hands.

D Sample containers, lubrication sample information form and a pre-addressed envelope. The sample container has room for the tube with the sample inside or the spatula with the grease that has been extracted. The sample information form should be filled out completely and sent to OELCHECK laboratory in the pre-addressed envelope.

Sample amounts and basic rules



- Depending on the questions you need answered and the scope of the analysis, analysis can take place once there is 1g of fat available (2 cm of fat in the tubing) With a full tube (8-10 g), almost all the analyses which are summarised in the Grease Sampling Kit can take place.
- Always take the specimens for trend analyses from the same place!
- Ideally, you should provide us with a fresh grease sample for reference purposes.
- The sample will be more representative if the grease has been mixed again using a slow turning movement before the sampling.
- Ensure via visual inspection (dark colouration in the tubing) that you extract used grease only.

You can download practical tips and detailed instructions on how to take grease samples correctly at the download section of www.oelcheck.de.

Grease analyses in the OELCHECK laboratory

We offer different kits to analyse grease. Further complementary tests are also available. The engineers at OELCHECK can advise you on the selection of the analyses you require and the most suitable analysis kits. This does not just take the kind of lubricant grease and its use into account; the reasons for the analysis are also discussed.

OELCHECK grease analyses can among other things contribute to:

- Optimisation of lubricant amounts and re-lubrication intervals
- Detection of impurities and mixing with other types of grease
- Prove bearing wear and identify its causes
- Distinguish between corrosion and mechanical wear
- Provide early warning against ageing and grease alterations

Analysis kits for lubricating grease

Any kit with a higher number will include the range of analyses found in the preceding kit. Kit 1, for example, provides information about wear, additive decomposition and stubborn impurities based on approximately 30 values. If the sample amount is sufficient we recommend the range of analyses included in kit 5.

Kit 1	**Wear metals:** Iron, chrome, tin, aluminium, nickel, copper, lead and molybdenum **Additives**: Calcium, magnesium, zinc, phosphorus, barium, boron **Impurities:** Silicon, potassium, sodium
Kit 2	Kit 1 + PQ Index, basic oil state (FT-IR)
Kit 3	Kit 1 + KF water
Kit 4	Kit 1 + residual oil content
Kit 5	Kit 1 + Penetration

Preparation for AES analysis

PQ index analysis

FT-IR analysis

Karl Fischer water analysis

The most important analysis methods

AES – the base analysis for all

After homogenisation, OELCHECK looks at 27 elements from each grease sample that is sent in using the atomic emission spectroscopy (AES) by the Rotrode method. These provide information in mg/kg about wear, impurities, thickeners and additive levels in the sample.

Wear metals: Iron, chromium, tin, copper, lead, nickel, aluminium, molybdenum and zinc as well as possible levels of vanadium, titanium, silver, antimony, manganese and tungsten.

Impurities: Silicon, calcium, sodium, potassium, aluminium, cadmium, bismuth.

Additives, thickener or soap levels: Lithium, magnesium, calcium, phosphorus, zinc, barium, silicon, aluminium, molybdenum and boron.

AES information:

- Increased iron and chromium values indicate that a rolling bearing has been subject to wear; copper, lead and tin show corrosion or abrasive wear from bearing cages.
- Possible impurities, such as silicon (dust), calcium (lime) or hard water deposits help to identify the causes of wear.
- Deviations between fresh and used grease in terms of the content and composition of the additive package or the thickener show that another grease is being used.

PQ Index – searching for iron

The PQ Index (Particle Quantifier Index) is specialised in determining magnetisable iron particles. Unlike AES, which cannot easily detect iron particles >5 µm, it records all the wear particles which are magnetisable, regardless of their size. The height of the PQ Index is then measured in conjunction with the AES iron content. As an index the PQ value is dimensionless.

PQ Index information

- An extreme PQ index (e.g. over 500) indicates, regardless of the AES iron values, that acute wear has taken place. Often there has been pitting or material fatigue.
- If there is a high PQ level (e.g. over 200) and at the same time the AES indicates a low iron value (e.g. under 100), acute wear is occurring and causing relatively big wear particles.
- An increased PQ index (e.g. over 100) in combination with a correspondingly high AES iron value is a sign of typical material fatigue, during which „normal" wear occurs.
- A low PQ index (under 50 or O.K.) accompanied by a high AES iron value (e.g. over 100 mg/kg) is always a sign of corrosion and rust formation. Rust is barely magnetisable so produces a low PQ index.

FT-IR – basic oil type and state

The principle of FT-IR (Fourier Transform Infrared) spectroscopy is based on there being different molecules present in a lubricant which, because of their typical chemical structures, absorb infrared light to different degrees with certain wavelengths. Changes to the used lubricant can be compared to the fresh grease reference spectrum and depicted, calculated and interpreted as typical „peaks" for certain „wave numbers". In addition to identity controls, oxidation can also be proven with FR-IT spectroscopy, for instance. As they age, molecular compounds alter and absorb more infrared light than fresh grease. Through the process of Fourier transformation, these values can be read and the molecular vibrations represented in an FT-IR diagram. Depending on the molecular compounds, the peaks develop as corresponding wave numbers. Synthetic lubricants frequently contain ester-based components. Because of the oxygen molecules contained within them, they absorb infrared light in almost the same wavelength range as the double oxygen bonds which arise through oxidation. That is why oxidative changes to a synthetic oil cannot be calculated accurately using IR alone. The RULER test is needed to do this.

FT-IR spectrum information

- Through comparison with the deposited fresh grease spectra, the process provides quick and reliable information on whether greases have been mixed together or whether a completely different type of grease has been used.
- The process can also determine whether the grease that has been examined contains mineral-oil-based base oil or synthetic base oil.
- For mineral-oil-based base oil, the FT-IR determines whether oxidation has taken place because of a lack of re-lubrication or because of damage caused by high temperatures.
- If a grease contains high-pressure additives, e.g. zinc phosphorus base, additive deterioration may be detected.
- A fresh grease comparison can also prove whether there is too much water.

Water analysis, Karl-Fischer titration

Too much water in grease may cause corrosion and bearing damage. In places with high relative movement, cavitation can occur. If too much water is present or water penetrates continuously, re-lubrication must be done more frequently. If the grease cannot withstand the water it may become soft or watery and the quality will drop.

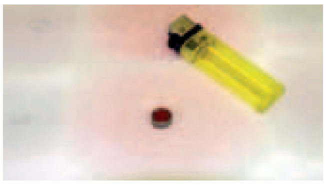
The amount of water in a grease sample is calculated exactly using the Karl-Fischer method in ppm (mg/kg), the same method as for oil. To do this, water must be „driven out" of the sample. With oil, the water from the sealed sample is steamed away by heating it to temperatures of up to 140 °C, but it is much harder to boil the water out of grease. In this case, the water must be extracted slowly at a temperature of 120 °C. The water is channelled into a titration vessel using a hollow needle and nitrogen. Here, an electrochemical reaction takes place with a special KF solution. Once the transition point of the titration curve has been reached, the exact water content can be stated.

K.F. information Water analysis

- If a grease contains too much water, it is important to track down the origin and to eliminate it. The Karl Fischer method provides quantitative information about water content. The elements investigated by the Atom Emissions Spectroscopy process help to distinguish between condensate and tap water.
- If unlike the fresh grease sample the used grease sample is polluted with sodium, calcium, potassium or magnesium this points to „hard" water. It may have penetrated the grease during high-pressure cleaning. If these minerals are not present it may be „soft" rain or condensed water.
- If water has not been satisfactorily removed during the production of the grease, it may be found in fresh grease. An analysis of fresh and used grease clarifies this matter.

Bleeding test - lubricating effectiveness of residual oil content

The sponge-like structure of the thickener or soap used in grease holds the base oil firm and allows it to transfer slowly to the lubrication point. But if the oil flows too quickly and uncontrollably from the thickener structure, the grease „bleeds" away. If the remaining thickener contains too little oil for the lubrication tasks, the remaining grease dries out. If the residual oil content of a grease falls too quickly, either the grease at hand is unsuitable or it must be reapplied more frequently or in larger quantities. Determining the residual oil content provides the necessary information to decide which. The test shows the percentage of base oil that the soap structure has lost over the course of six hours, at a temperature of 60 °C. The residual oil content of used grease should then be compared with the fresh grease sample.



Bleeding test

Penetration

Sulphate ash

Shearing burden

Bleeding test information

- If the values are between 5 and 25% and the difference between the used and fresh grease is +/- 15% or less, the grease can still be used without changing the re-lubrication intervals.
- If the used grease loses considerably more oil than the fresh oil, the thickener is no longer able to maintain the base oil in its sponge-like structure.
- If considerably less oil is released from the used grease, it has already begun to dry out. The bearing surface is „hungry" for lubrication. It must be lubricated again.
- Residual oil content levels which are too low may be caused by the following:
  - too much usage time and lack of or insufficient re-lubrication
  - strong vibrations, load or rotation speeds
  - mixing of greases which have been saponified differently
  - impurities caused by water, acids or lyes
  - insufficient temperature resistance
  - oxidation and ageing (acetifying) of the base oil

Penetration – consistency

While viscosity describes the ability of a lubricating oil or a hydraulic fluid to flow, consistency refers to the extent to which a lubricating oil is stiff. However, the consistency of a grease is not directly linked to the viscosity of its base oil or the kind of thickener used. The National Lubricating Grease Institute (NLGI) in the USA divides lubricating greases into classification groups based on their consistency.

NLGI classes	Penetration number	Consistency at room temperature
000	445–475	Very liquid
00	400–430	Liquid
0	355–385	Semi-liquid
1	310–340	Very soft
2	265–295	Soft
3	220–250	Semi-solid
4	175–205	Solid
5	130–160	Very solid
6	85–115	Extremely solid

Alongside the variety and viscosity of the base oil, the consistency category it belongs to is another important value to classify the firmness of the grease. The consistency shows whether the grease is feedable or whether it has become too firm, e.g. as a result of bleeding.

The consistency is measured using a standardised cone. The grease is spread into a small pot. The tip of the cone touches the grease. The penetration depth is reached in 5 seconds, measured in 0.1 mms and produces the grease penetration number used to determine the NLGI class. The softer the grease, the deeper the cone penetrates. This indicates a high penetration number and a low NLGI class.

Information about grease penetration

The comparison of fresh and used grease penetration allows certain conclusions to be drawn:

If the used grease has become softer and therefore has a higher penetration number than fresh grease:

- a grease may have mixed with another grease. In particular, greases with different thickener types become softer when they are mixed.
- If a grease has been contaminated by water or another liquid.
- If the grease has been mechanically sheared and loaded (tapered roller bearing).

A strong drop in the penetration number, which causes a lower penetration depth of the measuring cone, indicates that:

- The grease may have been bled by excessively strong vibrations.
- Too high temperatures may have resulted in oil separation.
- High levels of pressure in the central lubrication system have disturbed the balance between base oil and thickener.

Sulphate ash – wear and impurities

Investigating sulphate ash is a process used to determine inorganic (firm) levels in organic samples. This is determined by heating the sample to temperatures of 775 °C. At this temperature the organic elements in the samples „combust" (e.g. the oil). All that remains are ashes, which consist of metallic oxides (soap, additives) and impurities. By smoking this with concentrated sulphuric acid, the oxides in the ashes are transformed into sulphates. The weight of the remains is then recorded.

Information about sulphate ash

- If the proportion of sulphate ashes in the used grease has increased compared to the fresh grease, this is a clear indication of impurities and/or wear.
- If the metal values determined by the AES process are also consulted at this stage, the cause of the weight increase can be clarified. High levels of iron and chromium point to wear, while increased proportions of silicon and calcium hint at impurities.
- The weight of the sulphate ash is affected by:
  - metallic abrasion from bearing wear
  - hard impurities such as silicon (dust), which often indicates that too much time has passed between re-lubrication intervals
  - levels of solid lubricants such as MoS_2
  - metal organic EP additives
  - other metal soaps and inorganic thickeners, recorded with another grease they have been mixed with

Shear stress, visible viscosity – rotation speed suitability

A rheometer is used to measure the visible viscosity of a grease at different temperatures. For this purpose a small amount of grease is placed on a temperature-controlled plate. The plate-based testing cone, which develops a gap between the upper and the lower plates, moves on to the film of grease. The force between the plates and the cone is measured as dynamic viscosity, which for grease is also called „shear viscosity". The stability after the shearing, which, for instance, assesses characteristics such as deformability of a lubricating grease, can be described in apparent viscosity terms. The rheometer gives the shear viscosity at the beginning and the end of the testing procedure and displays the shear viscosity decrease in percentage terms.

Information about apparent viscosity

Using the index, particularly when compared with different fresh greases or through trend analyses, the following can be determined:

- whether the grease is suitable for high rotation speeds.
- the lower temperature limit at which the grease can be used.
- whether the grease is suitable for specific types of bearing (spherical roller bearings).

Dropping point – temperature resistance

As temperatures rise, lubricating greases behave differently to edible fats. They do not melt like butter or coconut oil when warmed. Lubricating greases hardly change at all as the temperature rises because the thickener holds the base oil firm. Only when the thickener's critical temperature has been reached does the soap structure dissolve.

To determine the dropping point, a grease sample is warmed in the testing device until liquid drops fall through the opening of a nipple to the bottom of the test tube. Gel or powder-based lubricant greases which are measured at temperatures of over 300 °C are considered as not having a dropping point.

Information about dropping points

There is not always a correlation between a grease's dropping point and its maximum operating temperature. Of course, the permissible temperature is always less than the dropping point value. Not just the thickener, but most of all the type of oil are what determine a grease's maximum operating temperature.

A lower dropping point of a used grease in comparison to a fresh grease may be caused by the following:


Dropping point analysis


RULER with grease specimen


Soxleth extraction


Analysis of acid values

- Greases with different thickeners which have been mixed together. In general this reduces the dropping point. The used grease does not just become softer. It often reacts like a semi-fluid product when the temperature rises.
- The grease contains water or other foreign fluids.
- Under extreme load the grease shears into extremely small particles. The soap structure has collapsed and can no longer bind the base oil.

Re-lubrication intervals with the RULER

The RULER test, a process based on cyclical voltametry, establishes the amount of amino and phenol oxidation inhibitors in a grease sample.
Like all oil, even lubricating greases are altered by factors such as time and temperature. That is why, in addition to EP and AW additives, they also contain antioxidants. These can break down. The re-lubrication intervals and amounts must be adapted to decreasing additive levels.
IR spectroscopy can be used to accurately determine the development of oxidation in mineral-oil-based greases. No IR oxidation figures can be calculated for synthetic base oils. That is why oxidation cannot be determined for high temperatures grease using the FR-IT spectroscopy. The RULER test is used for such greases in particular.

Information about RULER tests

By comparing the curves of fresh and used greases:

- the remaining lifespan of a grease can be determined.
- the best time for the next re-lubrication due to oil ageing can be calculated.

Base oil viscosity using Soxhlet extraction

As base oil viscosity is one of the decisive factors when trying to calculate bearing life spans, most lubricant grease manufacturers provide information on the viscosity of the base oil that is being used. However, there are no clear regulations regarding this matter. In general, high viscosity is considered better. To be able to indicate high viscosity, all fluid components such as oil, additives, adhesive additives, VI improvers are mixed. The viscosity is stated based on this mixture. However, this viscosity has very little in common with the way that viscosity is calculated for oil used in roller bearings because the grease no longer releases some parts of the thickener on to the bearing track.
The Soxhlet apparatus can separate the liquid grease component from the thickener. The oil which is extracted in this process only contains liquid components. Polymer or adhesive supplements, VI improvers and even solid lubricants remain in the thickener.

Information about base oil viscosity

After the oil-based components have been divided from the soap, information can be provided about the oil and thickener levels in a grease. Separating them into solids and oil makes it possible to carry out a detailed analysis of the base oil that has been used, with respect to:

- its viscosity – whether it is highly viscous or not and what viscosity level is actually available to the bearing surface.
- its base oil composition – mineral or synthetic.
- its proportion of additives, such as EP additives, antioxidants and corrosion inhibitors.

Neutralisation number

Even greases can turn „sour". Oxidation of base oil, the breakdown of wear protection additives or the entry of salted fluids result in the development of acids in the lubricant grease. These can destroy alkaline thickeners so that the grease takes on a soup-like consistency and the base oil and soap residue separate. The grease runs off the bearing surface. Unless it is re-lubricated at regular intervals, bearing failure may occur.

The experience our OELCHECK diagnostic engineers have

Over 100 grease samples arrive at the OELCHECK laboratory in Brannenburg every day. The analysis values provide significant information about the used grease and the element it has lubricated. The OELCHECK diagnostic engineers examine the interaction of analysis values, detect mixings, impurities, wear and suggest causes of bearing failure. They recommend optimised amounts and different intervals for re-lubrication. During their work they benefit from their knowledge of lubricating greases and their practical use, as well as from the largest database of grease analyses from around the world. They investigate wear processes on a daily basis. Their experiences below regarding indications of different kinds of wear are confirmed again and again.

Normal wear process

The elements which are typically involved in wear register only a slight increase.

- The values for iron (Fe) reach around 80 mg/g, for chromium (Cr) 10 mg/kg and for copper (Cu) 50 mg/kg.
- The PQ Index is lower than 60.
- Water content is less than 500 ppm
- The RULER value is clearly over 25%.
- The bleeding test is between 5% and 25%.

Corrosive wear is present

Waters, acids and/or oxidation caused the formation of rust and corrosion. The elements typical of wear have risen relatively strongly.

- The values for iron (Fe) are over 150 mg/kg, for chromium (Cr) over 15 mg/kg, and/or for copper (Cu) over 50 mg/kg.
- The PQ Index is clearly lower (more than 15%) than the iron value. Since rust particles are only marginally magnetisable, a grease polluted with rust particles will register a low PQ Index.
- With used grease, the value for sulphate ash has increased by more than 2%.
- The RULER value fell below 25%.
- More than 2,000 ppm of water are present; there are increased levels of calcium (Ca), sodium (Na) and potassium (K).

Wear through material fatigue

Bearings and/or grease have reached the end of their lifespan. This has resulted in pittings, chipping, or other damage.

- The wear metals have only increased slightly.
- The PQ Index is more than twice as high as the iron value in mg/kg because the iron particles are so large that they cannot be stimulated by the AES procedure.
- The PQ Index registers values far above 300.
- The value for sulphate ash in used grease has increased by more than 2%.
- The bleeding patterns and the proportion of base oil remaining in the used grease have changed considerably.

Mechanical-abrasive wear

- Wear metals have increased relatively strongly.
- The value for iron (Fe) is over 100 mg/kg and for chromium (Cr) over 10 mg/kg.
- Silicon (Si) and often potassium (K), calcium (Ca) and/or aluminium (Al) reach values of over 50 mg/kg.
- The PQ Index is higher than 150.
- With used grease, the value for sulphate ash has risen by more than 2%.

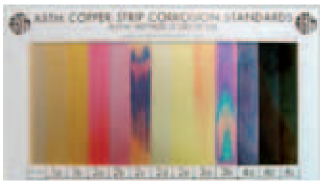
Recommended activity

- If you plan to switch to another variety of grease, or if the individual values have changed so considerably that the laboratory report is labelled with a „?" or „!" symbol, the used grease still present should be removed from the lubrication point. Where possible, this should also be cleaned. If this is not possible, then larger amounts of grease must be used to re-lubricate more frequently.

OEL CHECK

Öl Checker

Water resistance



Comparative scale for copper corrosion

Information about neutralisation numbers

- The fat has become acidic because of various reactions. Re-lubrication should take place at more regular intervals.
- The grease is not suitable for use. Either the base oil or the thickener should be improved.

Water resistance

Although it is easier to seal lubrication points with greases than oils, the grease should be resistant to water. A simple test where a thin strip of grease is placed on a strip of glass using a template tells us whether or not the grease absorbs moisture when stored in water. In this case the layer of grease turns a cloudy or milky colour or dissolves from the glass strip in its entirety. If the water runs off the layer of grease, the grease can be considered water-resistant.

Information about water resistance

- The grease can emulsify water. There is a risk of corrosion and hydrogen embrittlement when this happens.
- The grease is hydrophobic and therefore provides a seal against splash water.

Copper corrosion

A copper strip is covered with grease on all sides and placed in a specimen container with the same grease. The sealed sample container is stored for a certain amount of time in a warming bath. Once the test period has finished, the copper strip is removed, cleaned with solvent and dried carefully. The level of corrosion at the end of the experiment is ascertained by comparing the discolouration of the copper strip on a colour scale.

The technique is used to investigate the corrosive characteristics of greases in the presence of copper. This is because the sulphur level alone does not provide enough information on the corrosion of metallic machine parts that can be expected.

Information about copper corrosion

- How does the grease behave in terms of non-forous metal corrosion when used in bearing cages?
- Do the additives, coloured metal deactivating agents that are supposed to reduce the effect of sulphur compounds, still work?

IMPRINT

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Kerschelweg 28 · 83098 Brannenburg · Germany
info@oelcheck.de · www.oelcheck.de

Concept and text:
Astrid Hackländer, Marketing & PR, A-4600 Thalheim
www.astridhacklaender.com
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Agentur Segel Setzen, Petra Bots, www.segel-setzen.com
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OELCHECK Ltd. · geobra Brandstaetter

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Typical laboratory reports on various grease analyses
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Detailed instructions on how to take a grease sample
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Q & A

OELCHECK lubricant analyses are a major part of our Condition Monitoring. The number of machines we use and the oil samples we analyse are constantly on the rise. Our foreign subsidiaries are now using the service too. However, not all employees speak German or English. The documentation of your laboratory reports and the implementation of your comments is thus becoming increasingly complicated. Do you have a tip for us on how we can remedy this?

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