Summer 2021

OELCHECKER

INSIDER INFO PARTNER FORUM TECHNOLOGY FOCUS

CONTENT

Orcan Energy – efficiency PACKs turn waste heat into clean electricity

Four Orcan efficiency PACKs connected to the Nordenhamer Zinkhütte GmbH roasting plant, where they produce over 5,000 MWh of electricity per year from surplus heat.

Using heat instead of wasting it unused – according to this motto, Orcan Energy's efficiency PACKs convert waste heat from engines, industrial and cooling processes into clean, CO_2-free electricity. They operate efficiently, in close proximity to heat sources and produce electricity at an extremely low cost of less than 5 ct/kWh. In the last five years, more than 500 plants have been put on the market, saving around 48,000 t of CO_2 emissions in over 3 million operating hours in Europe alone. Since 2015, oil analyses from OELCHECK have been used in the efficiency PACKs to safeguard the high demands placed on the refrigeration compressors.

Rethinking a well-established principle

Based on the ORC principle, the Orcan efficiency PACKs function similarly to a steam power plant. ORC stands for Organic Rankine Cycle, whose mode of operation was developed by the Scottish physicist Rankine. However, an organic liquid with a much lower evaporation temperature than that of water vapor is used as the working medium. In a closed ORC system, this working medium is evaporated in a cycle and then condensed. The high pressures that build up in the process drive a generator to produce electricity. The special feature of the ORC process is that it can make heat usable for electricity generation even at a relatively low temperature level. However, previous plants based on the ORC principle could only be operated with relatively large amounts of waste heat and were sized accordingly. Orcan Energy rethought the proven technology and developed second generation ORC solutions with a high number of pieces at low cost. The patented efficiency PACKs are much smaller, require little maintenance and can be used flexibly.

With the help of the efficiency PACKs, clean electricity can be generated from waste heat, regardless of whether it is exhaust gases, exhaust air, exhaust steam, cooling or process water, or water from geothermal energy. They are suitable for any waste heat from 80 to 800 °C, and their components are accommodated in compact housings in a small space. Only elements, that have proven themselves many times over in industry, such as screw compressors used as compressors for refrigeration systems, are used.

Orcan Energy generally uses pentafluoropropane (R245fa) as the working fluid. It is neither flamma-

Check-up

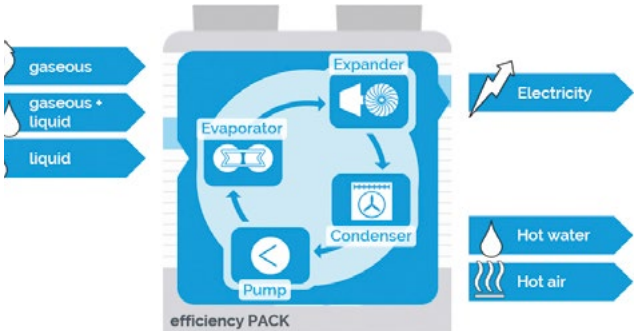
A major special edition of the OELCHECKER will be published in December 2021, as our company turns a young 30 this year. Numerous customers and suppliers have already congratulated us on this round anniversary.

Thank you to everyone who has remembered our company's birthday! This is proof of how strongly our long-time business partners are connected with OELCHECK and how much they appreciate the cooperation.

In the year of our foundation, our company concept was still smiled at by many, but soon more and more customers recognized the unique added value that our lubricant and fuel analyses offer them. In 1991, we started with two employees, and now our team includes more than 100 employees. At the same time, we have remained a family business that is customer-oriented, competent and human.

OELCHECK is still being continuously developed by us. This requires thinking about the future and always being courageous enough to change. Two qualities that are also crucial for our upcoming activities. On the one hand, the go-ahead for our company's climate neutrality was initiated months ago. On the other hand, in the future we will support our customers even more intensively in how they can operate much more sustainably and reduce their CO_2 emissions with lubricant and fuel analyses from OELCHECK. In the upcoming special issue of OELCHECKER in winter 2021, we will present our new projects to you!

Sincerely, Barbara Weismann



Operating principle of Orcan efficiency PACKs

ble nor toxic and is also particularly efficient. In the evaporator, it is converted from its liquid to its vapor state. Evaporation takes place using thermal energy, which in the case of efficiency PACKs is basically waste heat that would otherwise flow unused into the environment. After the working medium has passed through the evaporator, it is fed as superheated steam to an expansion machine. The pressurized steam is used to rotate the screw expansion machine, which drives a generator that produces the electricity. The working medium flowing out of the expander at lower pressure is in turn liquefied in the condenser, brought to high pressure in the downstream pump and fed to the evaporator again. This closes the cycle and the process starts again. The electricity generated is consumed directly on site or fed into the power grid.

A tailor-made special oil – checked by OELCHECK

The efficiency PACKs are basically low-maintenance. Consequently, the working fluid, together with the oil for lubricating and sealing the expander, also remains in the system throughout its service life. In operation, the flow of the working medium is loaded with a small quantity of oil. The working fluid and oil do not operate separately and accordingly must be in tune with each other. The bearings and the paired worm shafts of the expansion machine are supplied with oil droplets, which are separated from the oil mist in the vapor of the working medium and thus return to the expander in oil form.

For use in the efficiency PACKs, a polyol ester-based oil was developed that can be nebulized very well and then separates easily from the oil again at the pressure difference in the expansion machine. As a lubricant, it is exposed to comparatively low temperatures, which is why hardly any temperature-related oxidation occurs. Oxygen, which could accelerate the aging of the oil, is also not present in R245fa. The oil can therefore remain in service for well over 50,000 operating hours.

Once an efficiency PACK is opened as part of quality control, Orcan Energy's service technicians also replace the oil and send a sample to OELCHECK. However, a proportion of the volatile working medium inevitably enters the sample bottle with the oil. Therefore, only a gas-tight 80 ml aluminum sample bottle from OELCHECK is used. It is resistant to oils as well as refrigerants and withstands the internal pressure that can be built up by working or refrigerant residues in the sample.

Even if the oil in an efficiency PACK is not subjected to high thermal loads, analyses are important as part of quality control. After all, the performance of the oil and its interaction with the working fluid have a decisive impact on the service life of the compressor. The OELCHECK tribologists therefore look at, among other things, the values of any wear metals that may come from bearing points or the worm shafts. Since polyol esters react very sensitively to water, a determination of the water content according to Karl Fischer and a critical assessment of water contents above 50 ppm is an essential criterion.

Saving costs and reducing CO_2

Well-known companies such as BASF, Bertelsmann or the Portland cement plant Wittekind, reduce their electricity costs with Orcan efficiency PACKs and at the same time achieve a significant improvement in their eco-balance. A more recent, typical example is Nordenhamer Zinkhütte GmbH. It is part of the Glencore Group and produces about 175,000 tons of fine zinc and zinc alloys per year. Instead of "blowing" the unused heat into the environment, it uses Orcan's compact plants to generate more than 5,000 MWh of electricity per year and reduce the company's carbon footprint by 2,800 tons annually.

The efficiency PACKs are not only used in a wide range of industries, but increasingly also on ships around the world. The energy generated from the waste heat of the ship's engines is fed to the drive train or fed into the power grid on board. With the intelligent use of the waste heat from the engines, which often have over 100,000 hp, fuel savings of 7-9 % can be achieved. The "Green Jade" from Taiwan, one of the largest offshore installation ships for wind turbines, will soon also benefit from this. Eight efficiency PACKs will recycle its waste heat from engine exhaust and cooling water into electricity in such a way that a net output of more than 500 kW is generated on board.

More info: orcan-energy.com

DIN EN ISO 9001
DIN EN ISO 14001

OELCHECK passes surveillance audits according to DIN EN ISO 9001 and 14001

In July this year we passed the important surveillance audits of our quality and environmental management system. The final evaluation showed that the requirements of the standards continue to be met.
Our quality management system according to DIN EN ISO 9001 has been in place since 1996. With its help, we work absolutely customer-oriented and continuously improve our services. Legal and statutory requirements are consistently met by us. We involve our employees and make decisions based on facts and risk-conscious thinking In this way we operate more efficiently, develop new markets, identify possible risks and are able to manage them. With our environmental management system in accordance with DIN EN ISO 14001, we have been ensuring since 2001 that we regularly monitor any environmental impact of our activities. Among other things, this enables us to consistently monitor our corporate targets for reducing our environmental impact and thus continuously improve the defined key performance indicators. Our employees, customers and partners have a guarantee regarding our responsibility in environmental matters through the strict implementation of our environmental management system.

Re-certifications and surveillance audits

The quality management system according to DIN EN ISO 9001 and the environmental management system according to DIN EN ISO 14001 are recertified every three years. In between, surveillance audits are mandatory, which were last carried out at OELCHECK in July 2021 by the auditors of All-Cert GmbH. Their assessment showed that we meet all the requirements. However, they also revealed further potential for improvement. We were happy to take on board some of the auditors' suggestions and will implement them in the coming months. In this way, we are equipped to improve and expand our performance even further and demonstrate a high level of service quality.

In August 2023, OELCHECK will again be put to the test by the auditors. Then the re-certification according to DIN EN ISO 9001 and the environmental management system according to DIN EN ISO 14001 will take place.

Storyteller with magic carpet in Brannenburg ...

The storyteller Oliver Machander was a guest at the Wendelsteinhalle in Brannenburg. In a total of 12 performances, he captivated more than 600 children with his NANU fairy tales, animated them to join in and took them into the fabulous world of fantasy and magic.

OELCHECK has engaged the storyteller with a donation of 2,500 € for the Brannenburg Fairy Tale and Children's Theater Days.
Before the first performance, Matthias Jokisch, the mayor of Brannenburg, and Barbara and Paul Weismann, the managing directors of OELCHECK GmbH, opened the Theater Days and welcomed the children.

Oliver Machander is a trained and experienced storyteller - since 2000, he has delighted children and adults with fairy tales and theater plays at over 1,000 performances. In addition, he has written numerous fairy tale books and has also published a book of fairy tales for adults in 2020.

The children from the Brannenburg kindergartens as well as the pupils from the Brannenburg schools could dive into the NANU fairy tale world. Fairy tales of the Brothers Grimm as well as an American Indian fairy tale were performed. The play "The Sultan with the Donkey Ears" formed the conclusion of a wonderful fairy tale week.

Oliver Machander donates part of his proceeds to those affected by the flood disaster in Germany in July.

72 % of our employees are vaccinated!

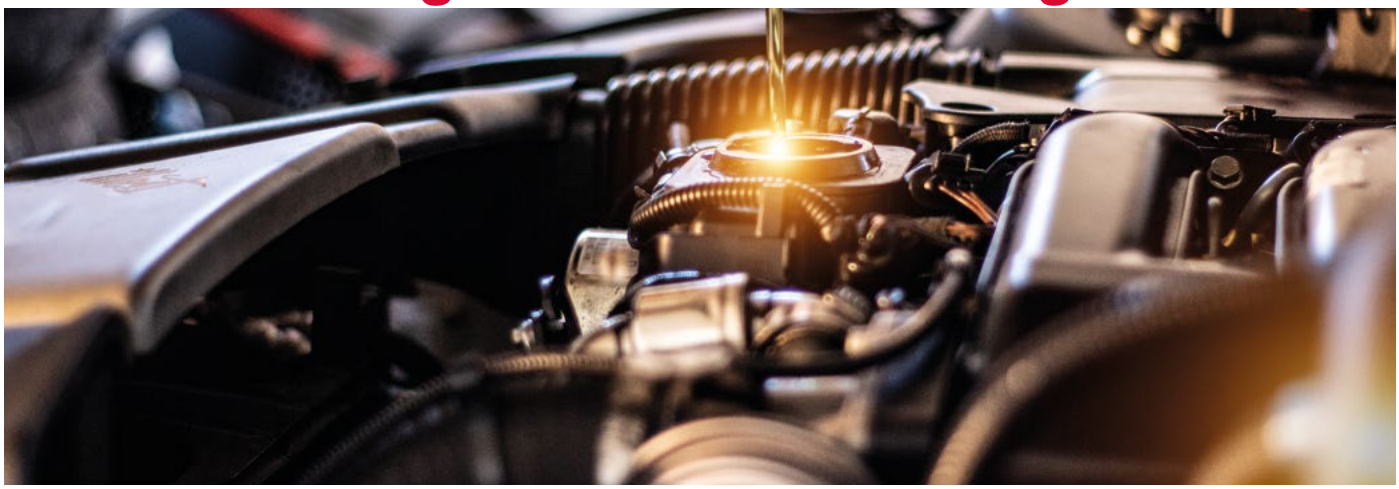
As early as April, we had asked the responsible health office, our district administrator and the Bavarian Minister of Health whether a pilot project for company vaccinations could be started at OELCHECK. Unfortunately, our idea of a pilot project did not work out.
However, thanks to the support of our company physician, after the vaccination prioritization for AstraZeneca was discontinued, it was possible to offer our employees a vaccination with this vaccine as early as the beginning of May. In the weeks that followed, the other employees in our company who were willing to be vaccinated even had the opportunity to select the vaccine they wanted in advance. The vaccination offer was extremely well received by our employees:

With a current vaccination rate of 72%, the rate at OELCHECK is now above the Germany-wide average.

OELCHECK website shines in new splendor!

A company's website should be appealing, modern and user-friendly. For this reason, the OELCHECK website has been redesigned in recent months: Navigation, home page and the layout of the knowledge platform were redesigned and optimized for mobile use. It is the first major relaunch in five years.
You can find the revised OELCHECK website at: www.oelcheck.com
We look forward to your feedback!

Extremely thin – yet fit in practice?
The 0W-X generation of car engine oils



Engine oils for passenger cars, almost as thin as diesel fuel! It was unimaginable just a few years ago, but today almost every lubricant manufacturer offers them. Engine oils of the SAE classes 0W-16, 0W-12 or 0W-8 are very popular. It is only with their help that many of the modern internal combustion engines and hybridized drive concepts can comply with the increasingly stringent emissions regulations. The low-viscosity oils ensure reduced internal friction in the engines, increase their efficiency, reduce fuel consumption and thus CO_2 emissions. However, they must also reliably lubricate the engines permanently and protect them from wear. Given the large number of tasks to be performed, however, conflicts of objectives are unavoidable. OELCHECK knows what is of importance and sheds light on the critical parameters.

Road traffic is responsible for about 25% of total CO_2 emissions in Europe. In order to turn the ambitious targets for CO_2 reduction in the transport sector into reality, only cars with electric drives are to roll off the production line in Europe from 2035. But this alone is not enough. The efficiency of the latest generation of internal combustion engines must be further increased as well, also with regard to their use in hybrid vehicles.

For vehicles (classic internal combustion engines and hybrids), a maximum of 95 grams of carbon dioxide (CO_2) per kilometer has applied since 2021 in accordance with the EU's exhaust emissions regulations. In addition, manufacturers are working hard to increase the overall efficiency of their vehicles.

In internal combustion engines, internal friction plays a decisive role. After all, in partial power operation, up to 25 % of the energy contained in the fuel cannot be converted into kinetic energy due to losses via internal friction in the engine. In order to minimize these losses, engine development not only takes into account the materials, loads and design geometry, but also always the engine oil as a design element. In this respect, the extremely thin-bodied, low-viscosity oils at many friction points in the engine can reduce its power loss even more significantly than, for example, multigrade oils of the SAE classes 10W-40 or 5W-30. However, in order for the oils of Generation 0W-X to be fully effective, many components in the engine, such as plain bearings and their design, piston rings, oil control rings and the transmission ratio of the oil pumps, are adapted to the properties of the low-viscosity lubricants.

High expectations of a multi-talent

The engine oils of the new 0W-X generation are supposed to minimize friction in the engine, reliably lubricate its moving parts and protect them from wear, be economical and remain fully efficient over many kilometers even at extreme temperatures. But this is easier said than done! After all, these lubricants work under particularly difficult conditions. The downsizing of engines with fewer displacements and cylinders, direct injection and the simultaneous turbocharging of engines lead to higher temperature loads in addition to the lower oil volumes. All this means that the combustion process in gasoline engines is becoming increasingly similar to that in diesel engines.

Unprecedented expectations are being placed on the low-viscosity engine oils of the 0W-X generation. Formulating these lubricants is a balancing act, and conflicts of objectives are inevitable!

Time for new oil specifications

The European ACEA, the American API and the Japanese JAMA, as well as ILSAC, as a merger of API and JAMA, are the associations that publish internationally valid specifications for car engine oils. The limit values defined in their specifications are based, among other things, on extensive lubricant tests on engine test benches. These were carried out over many years on unchanged test benches. Because of dynamic developments in engine design, it was high time to replace some units with types at the cutting edge of engine development and use them to determine the values for the updated oil specifications. The trend towards ever thinner engine oils was also taken into account.

For use in petrol engines, ILSAC now distinguishes for the first time between engine oils of different viscosities with the new GF-6A and GF-6B specifications. The ILSAC GF-6A applies to engine oils SAE 0W-20 and higher, the GF-6B to engine oils SAE 0W-16 and below. This distinction is particularly important in practice, since extremely low-viscosity engine oils build up much thinner lubricating films than their viscous counterparts. However, this means that they cannot adequately protect older engines against wear and may well cause capital engine damage. To avoid confusion between GF-6A and GF-6B oils, ILSAC and API have developed the

ACEA	API	ILSAC
Association des Constructeurs Européens d'Automobiles	American Petroleum Institute	International Lubricant Standardization and Approval Committee
Publisher		
Association of European car, truck and bus manufacturers with production in Europe	Association of about 600 companies in the oil and gas industry	Representatives of the American and Japanese vehicle manufacturer associations in close cooperation with API
System		
Distinguishes between 4 lubricant classes: A = Passenger car gasoline engines, gasoline engines B = Diesel engines for passenger cars, vans, transporters C = Passenger car gasoline and passenger car diesel engines with exhaust aftertreatment E = Truck diesel engines	First letter stands for the engine type: S (Service Station) = Gasoline engines C (Commercial) = Diesel engines commercial vehicles	Specifications closely based on those of the API with emphasis on gasoline engines
Current specifications		
A3/B4 - A5/B5 - A7/B7 C2, C3, C4, C5, C 6 (C8 in preparation) E6, E7, E9 (E11 in preparation)	SJ, SL, SM, SN SP CH-4, CI-4, CJ-4, CK-4 / FA-4	GF-6A, GF-6B

The current engine oil specifications at a glance

"Starburst" and "Shield" symbols. The "Shield symbol" on the container of an engine oil complying with ILSAC GF-6B warns against use in unsuitable older engines. "Starburst" signals that the product in the container meets the ILSAC GF-6A specification for SAE 0W-16 and thinner engine oils.

In the first half of 2021, ACEA also revised its engine oil specifications for light duty vehicles (including passenger cars). New specifications A7/B7 were published for oils used in passenger car gasoline engines and diesel engines in passenger cars, vans and transporters, respectively. These ACEA specifications and the API SP specification also take into account the long-known problem of LSPI (low-speed pre-ignition), i.e. premature ignition at low engine speeds.

left: Shield symbol, right: Starburst

This affects highly supercharged, high-compression gasoline engines with direct injection, as in a diesel engine. The injection nozzles deliver fuel under high pressure directly into the combustion chamber. If the engine has not yet reached its operating temperature, fuel components can condense on the still cold cylinder walls. The high supercharging and compression result in high combustion chamber pressures, which ignite the condensed fuel droplets early and in an uncontrolled manner, similar to the diesel engine. This is often exacerbated by situations where high loads are called for at low engine speeds. Ash-like deposits on the piston, influenced by engine oil additivation, for example, can glow when the engine is hot and intensify these premature ignitions. This results in strong knocking combustion ("super knocking"). In extreme cases, the resulting pressure surges can destroy the piston and connecting rod. Many lubricant manufacturers are changing the additive composition of their engine oils to counteract these effects, mainly by reducing the tendency to deposit.

The number of internationally valid specifications for car engine oils is definitely not decreasing. In addition, explicit approvals from some car manufacturers for individual lubricants are being added. It is becoming increasingly difficult for car repair shops to keep track of which product may be used for which vehicle. Even if the extremely low-viscosity engine oils are currently still predominantly used for Asian and American vehicles as well as cars with hybrid drives, the original aim of reducing the number of grades is increasingly giving way to a variety of grades in the lubricant warehouse.

Fit for practice?

The specifications of ACEA, API, JAMA and ILSAC only specify the minimum requirements, even for engine oils of the 0W-X generation. However, the real performance of an engine oil must be evaluated on a case-by-case basis. Some parameters must be considered particularly critically.

Viscosity

Viscosity is of decisive importance for the ability of a lubricant to form a stable lubricating film. However, it is strongly dependent on temperature. In order to assess this temperature behavior, the viscosity index "VI" is calculated from the viscosities measured at 40 °C and 100 °C. The higher the viscosity index, the less its viscosity changes at different temperatures. For any multigrade engine oil, and thus also for the engine oils of Generation 0W-X, a high VI is therefore an absolute must. This is achieved through the targeted use of base oils based on esters and PAOs (polyalphaolefins). Selected additives make a further contribution. For example, an SAE 0W-16 engine oil has a typical viscosity index between 160 and 168.

With a low-viscosity oil, an engine generally runs with less friction and is more economical. The HTHS viscosity (High Temperature High Shear) of an engine oil must inevitably also be considered under this aspect. It indicates the dynamic viscosity, which is measured in millipascal seconds (mPas) at 150 °C under the influence of high shear forces. By lowering the HTHS viscosity, a further reduction in power loss and thus fuel savings can be achieved by means of lower "internal friction" of the oil.

However, the HTHS viscosity must not be lowered too much. This is because the thinner an oil is, the harder it is to build up a hydrodynamic, stable oil film. With a thickness of about 2 µm, the lubricating film of a Generation 0W-X engine oil is only about half as strong as that of a classic 10W-40 multigrade oil. Nevertheless, the oil must prevent mechanical contact between moving components as far as possible and protect their contact surfaces from wear. If the HTHS viscosity is reduced too much and the oil film becomes too thin, wear resistance is compromised. Therefore, lower limits of HTHS are defined in some engine oil specifications. According to ACEA A7/B7, for example, the

HTHS viscosity must be between 2.9 and 3.5 mPas at 150 °C, and that according to ACEA C6 between 2.6 and 2.9 mPas. This is to ensure that the engine oils provide the necessary lubrication reliability even in connecting rod bearings with their large shear forces and high oil temperatures.

The additives

Engine oils contain a wide range of additives. These can change the characteristics of the base oil, optimize the positive properties of a lubricant and reduce or even eliminate its undesirable ones.

Even the low-viscosity engine oils of the 0W-X generation are only possible at all through the targeted use of additives. Some of the active ingredients contained play a special role in this.

- Viscosity index improvers (VI improvers) increase the viscosity index of the oils. This makes the viscosity behavior much more temperature-stable. Especially at high temperatures, the engine oils do not become even thinner.
- Friction modifiers are friction-reducing additives, mostly based on molybdenum. Thin-bodied engine oils build up less powerful lubricating films. At high engine temperatures in particular, there is therefore a risk of a disruption of the lubricating film. Friction modifiers themselves form a fine protective layer on the friction surfaces. This ensures reliable lubrication throughout. Even during stop-and-go and frequent use of the automatic start-stop system in city traffic, the protective lubricating film is not disrupted.
- Detergents and dispersants are contained to varying degrees in every engine oil. In connection with the engine oils of the 0W-X generation and the LSPI problem in gasoline engines, they are currently of particular interest to lubricant manufacturers.

  Detergents break down contaminants into fine particles. These contaminants are mainly caused by the aging process of the oil, during the combustion process in the engine or, in gasoline engines with direct injection, by unburned fuel. Dispersants are the indispensable counterpart to detergents. They keep the detached contaminants in suspension and ensure that they cannot form new deposits. In doing so, they literally envelop the dirt particles and enable them to be transported to the oil filter.

However, some detergents reach their limits in their task of rendering deposits of unburned fuel harmless in a gasoline engine with direct injection and thus counteracting premature ignition. High-quality or even completely newly formulated active ingredients are needed here.

The sulphate ash

Compliance with stricter emission standards can only be achieved by installing catalytic converters or particulate filters. However, these components require engine oils with a low tendency to form ash deposits in order to function properly. Thus, a so-called "low-SAPS engine oil" (sulphated ash, phosphorus, sulphur) must hardly tend to form ash and contain only comparatively low levels of phosphorus and sulfur. These values are influenced by the additives, which are usually based on compounds containing calcium, zinc, phosphorus and sulfur. However, these pose a danger to catalytic converters and particulate filters (DPF and OPF).

If an engine oil contains too much "ash-forming compounds", which are mainly based on calcium, magnesium, zinc, phosphorus, sulfur, and in some cases also molybdenum and barium, fine particles form from these when the oil burns. These quickly clog the fine pores of the particulate filters and deactivate the catalytic converters, whose service life then rapidly decreases. For this reason, the international specifications and the requirements of the vehicle manufacturers stipulate significantly reduced proportions of ash-forming substances in the engine oil. ACEA A7/B7 requires: Sulfate ash < 1.6 % m/m; ACEA C6: Sulfur < 0.3 % m/m, phosphorus between 0.07 and 0.09 % m/m and a maximum of 0.8 % m/m sulfate ash.

Whether an engine oil really contains only small amounts of ash-forming substances is determined in the OELCHECK laboratory by determining the sulfate ash. To do this, an oil sample is annealed at 775 °C. At this temperature, all organic substances of the sample burn. Only ash remains, consisting of metal oxides and contaminants. By fuming with concentrated sulfuric acid, the oxides of the ash are converted into corresponding sulfates. The difference in weight of the amount left behind is then determined, which is the fraction "potentially" available for deposit formation in the oil.

The evaporation loss

The low-viscosity engine oils of Generation 0W-X counteract friction losses in the engine and help reduce emissions. They work at very high temperatures. Some components of the oils are more volatile than others and evaporate more quickly at high temperatures. This can not only increase oil consumption, but also cause a deterioration in multigrade characteristics and low-temperature properties.

Therefore, evaporation loss is an important criterion for the viscosity stability of an engine oil. The lower the evaporation loss of an oil, the more stable its viscosity properties. The evaporation loss, which is determined by the Noack test in 60 minutes at 250 °C, is limited to a value of ≤ 13 % in the current ACEA A7/B7 and C6 specifications. This value is even undercut by some high-quality multigrade oils, such as some of the SAE classes 5W-30 or 10W-40. This is not as easy for engine oils of the 0W-X generation. The trend toward further lowered viscosities tends to lead to slightly increasing evaporation losses with these oils, since individual components of the engine oils already come very close to the boiling range of diesel fuel. As a result, the LSPI phenomenon can also occur to a greater extent. In the formulation of Generation 0W-X engine oils, there is also a conflict of objectives between extremely low viscosity, evaporation loss and boiling range.

Conclusion The EU has de facto set an end date of 2035 for classic internal combustion engines in passenger cars. By then at the latest, only e-mobiles are to be registered. The near future will show whether this is feasible. In any case, combustion engines for cars and trucks will be with us for some years to come, and in other areas, such as shipping, for much longer.

But regardless of whether internal combustion engines are then powered by gasoline, diesel or synthetic fuels such as hydrogen, e-fuels, methanol or ammonia: They will always need engine oils - and their development is and will remain exciting.

This is how precisely OELCHECK detects water

Water is one of the most common contaminants of lubricants and operating fluids and often causes serious operational problems. It can affect not only the lubricating film formation of lubricants, but also hydraulic properties or dielectric strength. Through evaporation processes in the friction point, water can accelerate their aging process and cause corrosion or deposits. For good reason, we therefore devote a considerable amount of attention in the OELCHECK laboratory to any contamination by water.

Visual inspection and crackle test

Before a sample is tested in the high-quality analytical equipment in the OELCHECK laboratory, it is visually inspected and subjected to a crackle test. After the sample has been stored upside down for at least 30 minutes, water droplets may appear on the white lid seal. Streaks or a milky clouding of the oil also indicate contamination with water. However, even if water is not conspicuously visible, it may be present in unacceptably high concentrations.

Therefore, the visual inspection is always followed by a crackle test. Using a pipette, a drop of oil (0.2 ml) is sprayed onto a 150 °C hot plate. If the drop contains more than 5% water, this escapes from the oil with a crackling sound, often in conjunction with steam bubbles. The laboratory technician rates the progress of the test with a numerical value from 0 (no reaction) to 3 (strong reaction). This assessment is based on his subjective observation and does not provide a quantifiable numerical value. Therefore, no "crackle value" is given in the laboratory report.

For the OELCHECK tribologist, however, a "crackle value" of e.g. 3 is just as much a warning sign as visible streaks or turbidity of the oil. They cause him to take a particularly critical look at the water values determined in the further process with IR spectroscopy and, if necessary, with the Karl Fischer method.

Infrared spectroscopy

Infrared spectroscopy is one of the most important tools in lubricant analytics. IR spectroscopy can be used to detect oil aging, detect mixing with other oils, and calculate contamination such as with water.

By comparing a spectrum of the current sample with that of the previous trend sample or fresh oil, conclusions can be drawn about changes in the oil due to oxidation and nitration, additive degradation can be assessed, or any percentages of carbon black and water can be indicated.

However, the detection of water in oil is relatively inaccurate. Values below 0.1% (1,000 ppm) cannot be detected by IR spectroscopy; higher concentrations can be reported in 100 ppm increments (0.11%, 0.12%, etc.).

It is the ideal instrument for detecting water in mineral oil-based engine and transmission oils, or lubricants from applications where there are no problems from relatively low levels of water contamination, such as from condensation of moisture in the air, and/or where moisture that has penetrated the oil can evaporate during operation. In many cases, if more than 0.1% water is detected by IR spectroscopy, it is leakage, water that has entered the system from the outside, or a sample taken from the bottom of a reservoir after extended machine downtime.

The Karl Fischer method

However, for some types of oil, such as glycol- or ester-based synthetic oils, water determination using the IR method reaches its limits, just as it does for lubricating greases. In addition, the water content in hydraulic and transformer oils, for example, usually has to be determined much more precisely.

In these cases, the water content is determined with a titrator using the Karl Fischer method. Titration is a method of quantitative analysis in chemistry. A known substance, such as water, whose concentration in the oil is unknown, is reacted in a specific chemical reaction with a titrating solution whose concentration is precisely specified.

Depending on the type of lubricant, a coulometric or volumetric Karl Fischer titration method is used. The coulometric method can be used to detect extremely low water concentrations in the trace range from 10 ppm (mg/kg) to values of about 10,000 ppm (mg/kg), or 1%.

It is the method of choice for:

- All turbine, gear and hydraulic oils tested with an OELCHECK all-inclusive analysis kit 3 and higher.
- Oils from refrigeration compressors where the limit value for water (according to DIN 51503-2) is max. 60 ppm, depending on the refrigerant and lubricant.
- Mineral oil-based insulating oils for use in electrical equipment (according to DIN IEC 60422). In some cases, they may only contain a maximum of 15 ppm water at high stresses.
- Synthetic lubricants based on polyglycols, such as worm gear oils.
- Ester-based oils, such as rapidly biodegradable products. Water can decompose esters into their components, alcohol and organic acid. This "hydrolysis" can accelerate corrosion, among other things. OELCHECK tribologists therefore advise additional drying or a change already at water contents above 450 ppm.
- Lubricating greases, because their water content is difficult to determine via infrared spectroscopy.
- Diesel fuels according to DIN EN 590 (contains up to 7% biodiesel) as well as heating oils, which may have a maximum water content of 200 ppm, and biodiesel (maximum 500ppm).
- In addition, this method is recommended for:
  - Large oil volumes, such as in oil circulation systems of paper machines.
  - Industrial plants with connected cooling circuits from which water can penetrate into the lubricant.
  - Oils with relatively complex friction- or wear-reducing additive packages.

The volumetric variant of Karl Fischer titration is used to determine extremely high water concentrations of more than 1 % up to 100 %.

It is used for lubricants that inherently have a high water content, such as:

- Fire-retardant HFC hydraulic fluids whose water content is between 20 and 50 %.
- Water-miscible metalworking fluids.

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Q&A

For years we have had our hydraulic oils regularly tested by OELCHECK. Now one of your tribologists has recommended that we also have the relative humidity measured once in addition to the complete all-inclusive analysis. What are the possible reasons for advising further tests that are not included in the scope of an analysis kit?

OELCHECK:

All-inclusive analysis kits and "additional tests"

We provide all-inclusive analysis kits for every lubricant and machine type as well as for almost every industry. With the test methods contained in them, OELCHECK tribologists can answer almost any question customers may have. But in some cases, our tribologists advise performing one or more additional test methods. In these cases, the additions to an analysis kit allow even more precise statements to be made about the condition of a lubricant. A typical example of this is the determination of relative humidity including the creation of a water saturation curve for your hydraulic oil. The tribologist advised you to do this because you had a question regarding the cloudy appearance of the oil during sampling. Based on the water saturation curve, he can accurately see that the oil is still clear at 70 °C, for example, becomes cloudy at 40 °C, and that corrosive-acting free water will separate out as the temperature drops further below 20 °C.

No individual values without all-inclusive analysis kit

OELCHECK can determine more than 100 individual values of a lubricant. If required, more than 60 different tests are available for special questions in addition to the test methods included in the analysis kits. Generally, these tests only act as supplements to an all-inclusive analysis kit.

As a general rule: Determining a single value hardly makes sense for used oil analytics. With a single value, your questions cannot be answered or the conclusions derived from it are wrong.
Here are some typical examples:

- If, for example, only the viscosity at 40 °C is determined, this may fit the ISO VG class. But it does not determine, among other things, whether the oil is a mineral or synthetic oil, or whether it is incompatible with others.
- Evaporation loss can give an indication of the consumption of oils that are used at temperatures above 100 °C, such as engine oils or chain oils in paint shops. While this provides a better estimate of oil consumption, it is not possible to assess whether components are operating with low wear without specifying the amount of additives that protect against wear.
- The value for iron (Fe) determined with element analysis can be alarmingly high. But what caused the iron wear can only be determined with additional information, such as about oil oxidation, water, dust (Si) or acid content.
- If only a questionably high water content is detected in an engine oil sample, this still does not allow an assessment of where the water came from. The all-inclusive analysis kit provides the clues: A load of glycol in the oil indicates water from the cooling circuit. If the sodium and potassium values are elevated, it is usually "hard" water, as from a high-pressure cleaner. If both values are very low and the water is therefore "soft", it has probably formed as condensate.

One combination - many advantages

Only if the advised additional test is carried out in combination with an all-inclusive analysis kit, you will fully benefit from the time and cost saving advantages of the OELCHECK laboratory analyses.
In the Sample Information Form, which is enclosed with every all-inclusive analysis kit, industry-specific questions are asked about the sample origin. You should also list any questions, observations or notes you have in the Sample Information Form.

Please note: The more precise and comprehensive your information is, the more accurate the commentary of the OELCHECK tribologists will be! When assessing the laboratory results, they take into account the up to 40 individual values of the analysis kit, the values of any additional tests, and the photos and diagrams shown in the laboratory report. The OELCHECK tribologists also know your machines as well as the lubricants used and always consider all values and information in interaction! In this way, OELCHECK customers benefit from truly accurate comments. They receive well-founded answers to specific questions and targeted recommendations for further action.

The additional workload also speaks against the determination of only a single value that has been removed from its context. Frequently, consultations with the customer are necessary because important information is missing. However, if a sample is analyzed as part of an all-inclusive analysis kit and any additional tests, we can work much faster and more efficiently. OELCHECK customers benefit from easier handling of sample bottles and shipping. In addition, our customers incur fewer costs than if two or three special tests are ordered for an oil sample without an all-inclusive analysis kit.

Please note: Comprehensive information regarding the sample

With your complete sample details you also support us in ensuring the fast availability as well as precision of all test methods. Many instruments have to be adjusted to the oil to be analyzed. For example, the sample weight may depend on the viscosity, density or oil type. If the oil brand name is specified precisely, we can immediately find all the information about it in our database and save time as well as costs for time-consuming investigations. If you send us a sample of a silicone oil, a PFPE oil or even an unknown liquid, please be sure to indicate this! After analyzing them, our equipment would have to be cleaned completely and therefore would be blocked. As a result, we analyze silicone oils with their extremely high creeping capacity, PFPE oils or unknown liquids only to a limited extent.

**OELCHECK also answers your questions about tribology and lubricant analysis.
Contact us by e-mail (info@oelcheck.de) or fax +49 8034/9047-47.**