

# TRIBO JOURNAL

**KLÜBER**  
LUBRICATION

EDITION 1/2008

Proper function of  
car doors and windows

New certification for  
food-processing and  
pharmaceutical industries

Questions and answers on  
REACH

Preventing bearing damage  
due to electric discharge

Repair lubrication for large  
girth gear drives

Lubrication of heavily loaded  
gears in wind turbines

## Contents

<b>AUTOMOTIVE</b>	<b>Convenient, energy-saving and reliable</b> Speciality lubricants ensure proper door module function	<b>4</b>
<b>FOOD PHARMA</b>	<b>International standard for lubricants in the food-processing and pharmaceutical industries</b> Klüber Lubrication ready for ISO 21469 certification process	<b>8</b>
<b>REACH</b>	<b>Klüber and REACH</b> Answers to frequently asked questions	<b>10</b>
<b>BEARINGS</b>	<b>Preventing discharge damage</b> Conductive rolling bearing grease provides inexpensive and efficient solution	<b>11</b>
<b>OPEN GEARS</b>	<b>Repairing large girth gear drives in full operation</b> Opportunities and limitations of repair and correction lubrication on tooth flanks	<b>14</b>
<b>WIND ENERGY</b>	<b>A fresh breeze for gears</b> High-performance oils for heavily loaded gears in wind power stations	<b>19</b>
<b>NEWS, SERVICE</b>	<b>Making effective use of Klüber brochures</b>	<b>18</b>
	<b>White grease for green vehicles</b> New low-friction grease compatible with plastics extends automotive component life	<b>22</b>
	<b>Uncompromising purity</b> Special oil for pharmaceutical tablet presses	<b>22</b>



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## Dear reader

Paying maximum attention to the customer has always been Klüber's approach to business. Our customers expect top quality of all our products and services as a matter of course. They also appreciate the added benefits offered by our speciality lubricants – for example a lower consumption of energy and raw materials. Quite often, they turn to us with a problem in the field of friction and wear at an early stage. This allows us to develop a solution together with them.

However, this does not mean we are ready to lean back contentedly, rather the opposite. We are constantly looking for new ways of further sharpening our customer focus. For example, we pay particular attention to our supply chain processes worldwide, aiming at a further optimisation of the relevant functional areas Strategy, Purchasing, IT, Production, Logistics and Sales so that our customers get their lubricants exactly in the quantity, at the place and time they wish. We are not happy with

just delivering on time. We want to act with a view to the future so that our customers are thoroughly satisfied when receiving their goods, making us their natural address to turn to with any future needs.

Our sales team plays a major role in this context. For a better forecast of customers' demand and consistent planning, which is one of the goals of our supply chain management, our staff have a close look at the previous as well as the future demand of each individual customer. What did he order in the past, and how much, and when? What will he need, and how much, in the near as well as in the distant future? Will his future orders be influenced by new machines, different applications or new Klüber lubricants? How can we respond to such changes in a customer-oriented way? The answers to these questions help us to improve our internal processes with the goal of increasing customer satisfaction.

Anticipating the future needs of customers is therefore fully in line with our improvements in supply chain management. Another focal point remains to respond to current trends and requirements of our customers by offering new solutions. You will find a number of examples of how we do that in the fields of automotive building, pharmaceuticals, wind energy, bearing technology and open gear drives, as well as in context with REACH, in this issue of Tribojournal.

We wish you interesting reading!

# Convenient, energy-saving and reliable

*Specialty lubricants ensure proper door module function*

*As electro-mechanical and hydraulic actuators are increasingly used for opening and closing car doors and windows, the requirements made on the lubricant become tougher as well. In addition, aspects of convenience and safety are gaining in importance. The lubricant can solve many problems provided it is given due consideration as an intermediate agent early in the design stage. Taking the example of locks, window regulators and Bowden cables, this paper illustrates how the "design element lubricant" contributes to improving the function, reducing energy consumption and increasing the driving comfort. Moreover, relevant test rigs and results are described and discussed.*



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Car doors contain a great variety of (electro-) mechanical and hydraulic components for opening and closing and a number of comfort and safety functions. Such components are, for example, the side door lock mechanism, the lock cylinder (often in combination with electromechanical power closure), door hinges and door stoppers - which often form a single component and are electromechanically or hydraulically controlled - or window lifters, which can also be clustered with the door lock. All these components make new, taxing demands on special lubricants. In addition, new materials and composites generate new requirements, also in terms of material compatibility.

## **Requirements made on lubricants for car doors**

A closer look at the tribo-system and the requirements profile reveals that a distinction can be made according to the materials used for the opposing bodies, the operating temperature, the

ambient media and other OEM-specific requirements on the design element. Some of these parameters are:

- The lubricant has to be compatible with different plastics like PA, POM, ABS, PBT and PP, as well as with elastomers like NBR, EPDM and various lacquers.
- The lubricant has to display excellent friction characteristics at low temperatures and offer lubricity over a wide service temperature range from  $-40\text{ °C}$  to  $+90\text{ °C}$ .
- It should be resistant to water (rain and condensation), cleaning and de-icing agents and offer good corrosion protection (SKF EMCOR 0/1).
- Good wetting and flow characteristics at temperatures as low as  $-40\text{ °C}$  are of major importance.
- Additional requirements are good noise dampening, the possibility of thin-film lubrication (monitored by means of a UV indicator), no odour emission, no fogging as defined in DIN 75201 A and, of course, lifetime lubrication.

## **Problems ... solved by special Klüber lubricants for side door locks:**

**Higher actuating torques at low temperatures:** When temperatures fall below  $0\text{ °C}$ , the actuating forces in side door locks increase over-proportionally. A leading German

OEM experienced a considerable increase of the release torques of the door catch bolts and locking pawls at temperatures between  $-20\text{ }^{\circ}\text{C}$  and  $-40\text{ }^{\circ}\text{C}$ .

Starting and running torques of different lubricants can be compared on the IP 186 low-temperature test rig. In these tests, fully synthetic products of low viscosity show much lower release torques than semi-synthetic or mineral oil based lubricants with a higher viscosity.

Due to the good test results achieved on the IP 186, a fully synthetic and low-viscous lubricating grease was validated for series application on side door locks. Field tests performed with the component show consistently lower actuating torques than a semi-synthetic or mineral oil based product in a wide operating temperature range from  $-40\text{ }^{\circ}\text{C}$  to  $+90\text{ }^{\circ}\text{C}$ .

**Creaking noises in the side door lock:** Relative movements in the mechanism of side door locks generated considerable creaking noise in the full-vehicle test. Therefore, more than 36 locks from series applications were examined on a special lock test rig. A linear drive generated wobbling between the striker/catch bolt, striker/buffer and the striker/safety bearing in order to simulate the vertical impact of the vehicle in motion. 40,000 load alternations were performed – 1 opening and 1 closing is 1 load alternation.

Side door locks made by various manufacturers were tested. These side door locks were taken from the series application on a single platform and tested with different consistent lubricants as well as with bonded coatings. The results show that squeaking noises can only be generated when applying SAE J726 specified Arizona dust.

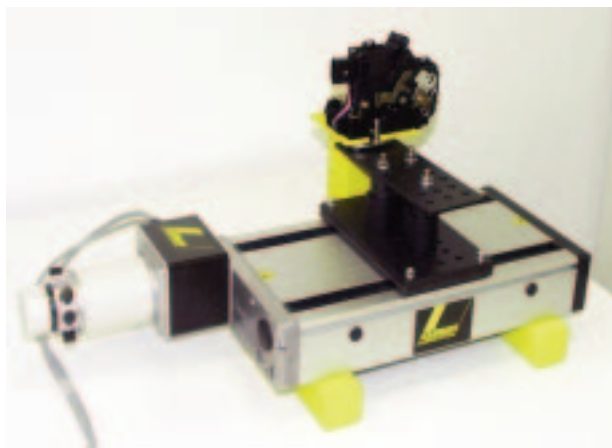
Without this dust, no squeaking can be generated on the test rig. The squeaking noises occur at the contact points of the striker. A special lubricant is able to prevent this type of noise. A lubricant of this type was specified by a car manufacturer for these friction points and prescribed by his component supplier for series application.

### Central locking systems and small gear motors

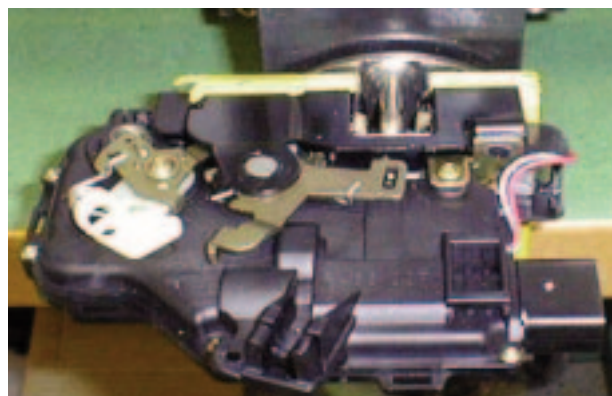
The worm gears of a series window lifter suffered repeated backlash because friction was too low. The same phenomenon was observed in central locking systems. The obvious thing to do was to increase the self-locking of the gear. The locking of a worm gear can be influenced by the flank lead of the worm, the number of teeth of the gear, the choice of gear- and bearing materials, their surface roughness, the electric motor torque as well as by the lubricant used. A suitable test rig for examining the locking effect of lubricants is



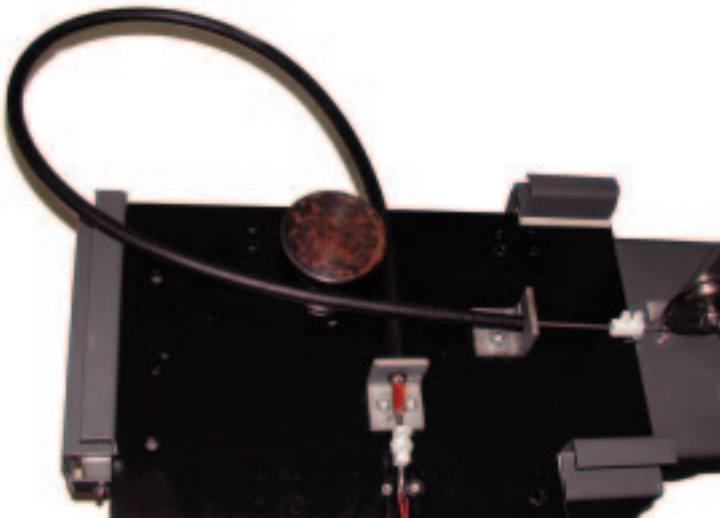
Source: Fotalia



Test rig for determination of a lubricant's influence on squeaking noises in the side door lock. A linear drive causes a wobbling motion between the striker and the catch bolt, the striker and the buffer as well as the striker and the safety bearing, reflecting the vertical motion of the vehicle on the road.



Test rig for determination of a lubricant's influence on squeaking noises in the side door lock due to horizontal movement.



*Test rig for Bowden cables for determination of the operating forces at a laying angle of 270°*

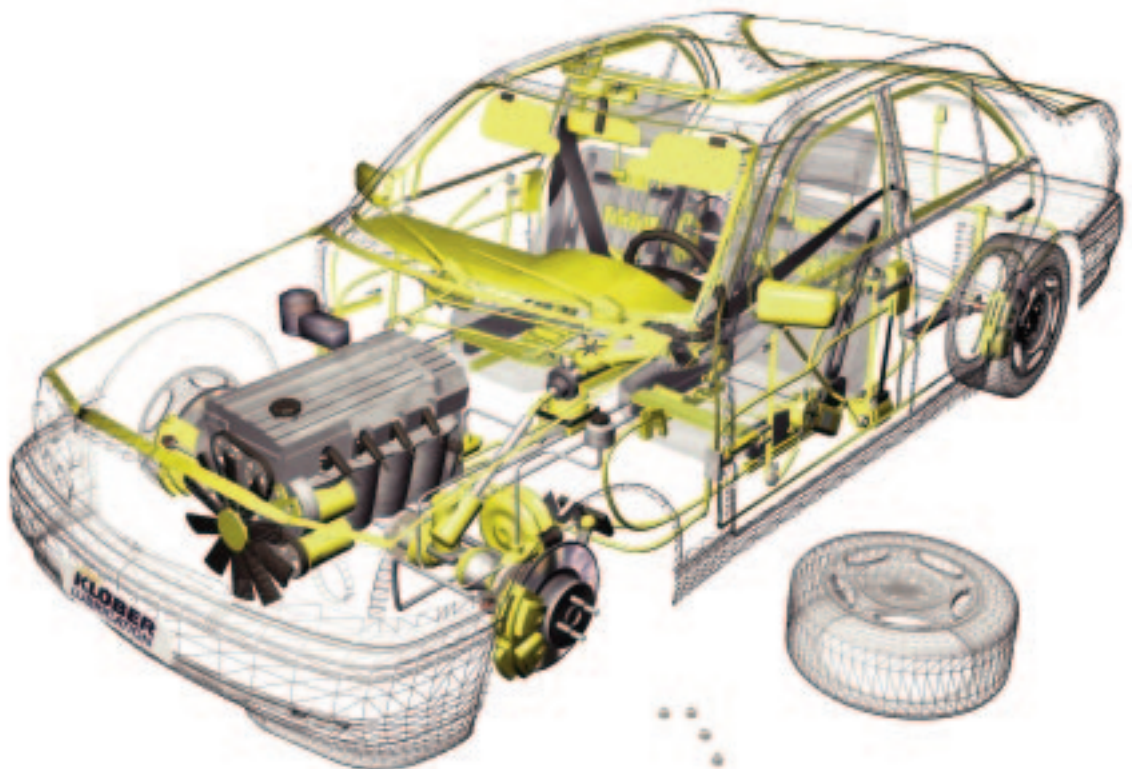
the Tannert sliding indicator. On the Tannert sliding indicator two sliding surfaces are subjected to an oscillating movement (testing with line- or point contact is possible as well) and the load is increased continuously. The Tannert sliding indicator allows determination of sliding and stick-slip behaviour of various lubricants at low sliding speeds. The friction coefficient is recorded over a certain period of time with increasing or constant load.

For a mineral oil based lubricant, for example, the Tannert test rig shows an increase in the friction value with increasing load. A fully synthetic lubricant, however, gives a constantly low friction value. The test allows also conclusions on the breakaway torque.

Therefore, in many gears of window regulator systems and car door modules requiring additional self-locking, special lubricants based on a mineral oil mixture are used.

### **Inside door handle and Bowden cable**

Besides the inside door handle bearing, the type of connection between the handle and the door lock, for example a Bowden cable, determine the operating forces required. The ambient temperature and the laying of the Bowden cable have a particularly decisive influence. With the Bowden cable laid in the side door at an angle of 90°, the operating force is much lower than with Bowden cables laid at an angle of 270°. A German car manufacturer established that at temperatures below - 10 °C the operating forces at the inside door handle increase considerably.



A test rig was built for Bowden cables in order to simulate the influence of the lubricant on the operating forces at an angle of 270°, and to reduce the coefficient of friction. Several test runs were performed with different lubricants based on synthetic hydrocarbons and silicone. The difference between the fluid (oils) and consistent lubricants of medium and high consistency and the fluid greases was considerable. Owing to the good results achieved at low temperatures a special silicone lubricant was chosen for Bowden cables laid at an angle of 270°. For other applications with a laying angle of just 90°, the OEM decided – based on the test results achieved at – 20 °C to + 23 °C – to use a lubricant based on synthetic hydrocarbons.

### Summary

The lubricant makes a decisive contribution to the proper function of door module components. As electromechanical actuators are increasingly used for opening and closing door modules and windows, the requirements made on the lubricant become tougher as well. In addition, aspects of convenience and safety are gaining in importance. Elevated operating forces of door components and noises are no longer accepted. Due to the better dampening of ambient noises, any creaking is heard at once. The lubricant to be used should be given due consideration at an early stage of design. Examples from field tests show which mechano-dynamical model test rigs can help in determining suitable lubricants for side door locks, window lifter motors and Bowden cables.

### References

Test reports from technical Engineering & Mechano-Dynamical Testing of Klüber Lubrication München KG



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## Profit from our experience

Plastic instead of metal – a trend on the rise. No easy task for lubricants. No problem for speciality lubricants made by Klüber.

Due to many years of close cooperation with many manufacturers, we are in a position to reliably solve any task involved in the lubrication of plastics. In fact, we have tailor-made a number of lubricants to specific customer requirements.

Do you wish to profit from our expertise?

Just contact us!

# International standard for lubricants in the food-processing and pharmaceutical industries

*Klüber Lubrication ready for ISO 21469 certification process*

*Today, product safety requirements in the food and pharmaceutical industries are higher than ever before. The pertinent stringent laws and regulations apply to all materials and substances used in the manufacturing processes, for example compressed air, lubricants, disinfectants or mould release agents. As a general rule, manufacturers should proactively identify any hazards and prevent errors. A key factor is the consistent use of tested materials as part of an effective product safety and quality management. Klüber Lubrication supports its customers in the food-processing and pharmaceutical industries with certified speciality lubricants.*



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There is a tangible demand for an international standard for H1 lubricants to be used in the food and pharmaceutical industries. This is why in 2006, the technical ISO committee for lubricants with incidental product contact issued the ISO standard 21469 (ISO EN 21469:2006 – Safety of machinery – Lubricants with incidental product contact – Hygiene requirements).

While the previous standard EN 1672-2:2005 for hygiene requirements to be met by food-processing machinery had only stipulated the use of “food-grade” lubricants, the ISO standard 21469 provides a detailed definition of these lubricants, and its requirements for product contact apply now also to cosmetic products, pharmaceuticals, tobacco and animal feed. The ISO standard 21469 lays down hygiene requirements regarding the formulation, manufacture and use of

lubricants which might have incidental contact with the product. It requires the lubricant manufacturers to develop a hygiene strategy, taking into account chemical (e.g. due to cleaning agents, non-certified lubricants), physical (e.g. due to foreign matter as might come from the machines) and biological (e.g. due to pathogenic or toxic substances, pest) hazards in the intended lubricant application.

Based on the ISO 21469, the National Sanitation Foundation (NSF) – a globally recognised institution offering a comprehensive range of certifications for drinking water and food applications – has developed a certification method. Klüber Lubrication was involved in these activities, contributing the experience it had gained in the development and manufacture of lubricants for the food-processing and pharmaceutical industry over several decades.

The new certification method offered by NSF enables lubricant manufacturers to have themselves certified according to ISO 21469 by an independent and recognised institution. Klüber Lubrication has opted to live up to this international standard and entered an intensive dialogue with NSF for this purpose. “Our goal is to have one of the most comprehensive H1 lubricant portfolios with worldwide availability



# Klüber and REACH

*The highly complex new chemical law REACH is still good for some confusion. Here you will find answers to questions that are frequently asked by our customers.*



*Dr. Luciana Husfeld, Uwe Zimmermann (left) and Johannes Rudhard control Klüber's REACH tasks worldwide*

**Question:** Does Klüber have a centralised approach to REACH, and, if so, does it also cover the individual needs of all Klüber companies, e.g. in Belgium, Sweden, etc.?

**Answer:** The Klüber Group has set up a REACH centre at Klüber Lubrication München KG, which organises REACH matters also for the Klüber companies in the EU.

What is a major advantage is the fact that Klüber created a dedicated department ten years ago that has been dealing with international chemicals law and the approval and registration of raw materials and products since then: Material Compliance Management (MCM). In this group, eleven experts make sure that challenging projects like REACH are handled swiftly and in a competent manner.

You can reach the REACH team at Klüber under the e-mail address [reach@klueber.com](mailto:reach@klueber.com)

**Question:** Are customer-specific uses taken into account for the registration of the phase-in substances?

**Answer:** As soon as the Technical Guidance Document (TGD) "Guidance on preparing the Chemical Safety Report" is published by ECHA, the Klüber Group will inform its raw materials suppliers of their uses. We will also approach our customers and ask them for their uses of our lubricants.

**Question:** Could you give us the registration numbers of certain products?

**Answer:** The speciality lubricants made by Klüber are what is called chemical mixtures, i.e. they consist of a number of different substances. Such preparations/products are not registered under REACH.

What is pre-registered and registered are individual substances or, more precisely, phase-in substances. The phase-in substances include the old substances and the no-longer polymers (NLP). The considerable outlay Klüber has invested during recent years in having newly developed substances registered, e.g. new thickeners for use in greases, is now bringing our the customers the benefit that they don't have to worry about approval problems or additional expenses that might spring up due to REACH: after all, all these substances are already registered.

For the bulk of the substances used in Klüber lubricants, the registration numbers will only be assigned by ECHA in the 2009 to 2018 period.

**Question:** How can Klüber ensure that all substances used are registered and remain therefore available on the market?

**Answer:** In a concerted action for all Klüber companies, we wrote to our raw materials suppliers regarding the availability of raw materials in 2007. We received many positive replies to our request. If any substances that Klüber needs are not pre-registered by our suppliers, Klüber itself can have them pre-registered as of January 2009.

**Question:** Could you please send us automatically an overview of all Klüber products containing substances that are on the candidate list, or a confirmation that no Klüber products are concerned?

**Answer:** Once the candidate list of SVHC substances is published, we will automatically send our customers a product list indicating any SVHC substances for each product individually. We will also issue confirmations for products that do not contain SVHC substances.

**ECHA:** "European Chemicals Agency", based in Helsinki

**SVHC:** "Substances of Very High Concern", referring to human health and/or the environment

# Preventing discharge damage

*Conductive rolling bearing grease provides inexpensive and efficient solution*

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*In machine environments that are susceptible to static charging, rolling bearing damage due to sudden discharge is a frequent occurrence.*

Static charges may have a variety of causes. In film stretchers, for example, plastic material is conveyed on steel rollers, leading to electrostatic charging. In tumble drier drums, the plastic content of the laundry, such as nylon, may be the cause. Rolling bearings operating under high loads have a particularly high risk of damage, since there is frequently partial direct contact between the rolling elements and the raceways, leading to sudden discharge, not unlike an electric arc. As the metal-to-metal contact is restricted to a very small area, even currents well below 1 ampere can cause the contact points to weld or fuse together. Typical discharge damage shows in the form of plates, craters or grooves on the bearing.

Craters result when surface melting takes place on the raceways due to the electric potential. Molten metal particles may also be carried off and deposited on the raceway, where they are rolled down. Grooves form when current flows while the rolling elements and the raceways are under load. This causes the rolling elements to vibrate, and over time the typical grooves form on the inner and/or outer ring. Repairing such damage costs a lot of time and money – in extreme cases the bearing as a whole has to be replaced.

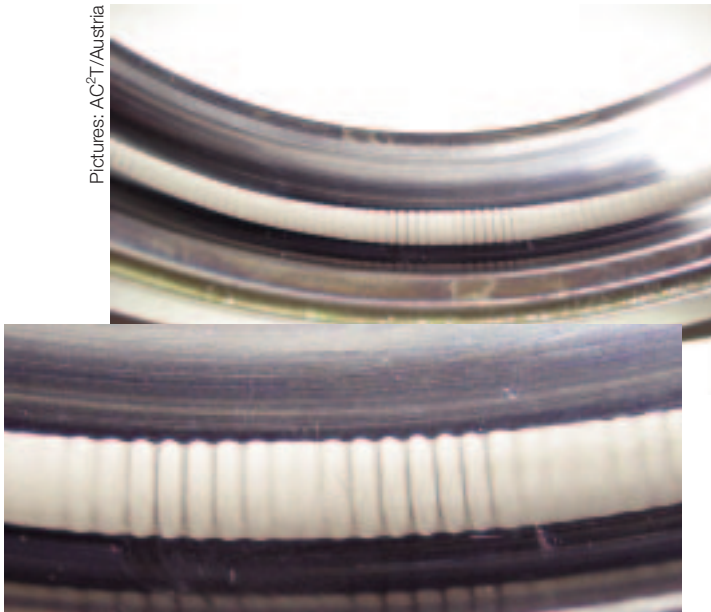
The severity of the damage depends on a number of factors, e.g. the current intensity, the time of exposure, the bearing load, the speed and the lubricant used.

## **Preventing flashover**

This was the starting point of the development of a conductive grease by Klüber Lubrication, enabling the problem to be solved in an efficient and inexpensive way before damage is caused. The conductive rolling bearing grease Klüberlectric BE 44-152 conducts the electric charge continuously through the bearing, thus preventing point-to-point flashover in the first place. At the same time, it is a rolling bearing grease offering a long lubricant life and high reliability.

In order to demonstrate how Klüberlectric BE 44-152 makes a dif-

*Whether in the plastics industry, in paper-making machines or industrial electric motors – the issue of damage caused by electric discharge has been known for a long time, and today it is more acute than ever. It affects primarily rolling bearings in machines that are susceptible to static charging. In many cases, a conductive grease especially made for these applications can provide an inexpensive and efficient solution to this problem – while at the same time ensuring optimum rolling bearing lubrication.*



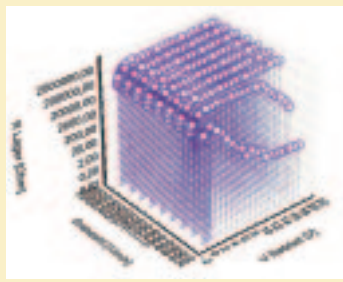
Grooves – typical rolling bearing damage caused by sudden discharge

ference compared with conventional greases, Klüber determined the electrical resistance of greases according to DIN 53482. This standard describes how the electrical resistance of non-metallic materials is measured. It can be done by measuring the resistance between two plates between which the grease is contained in an insulated hollow cylinder. The distance between the electrodes can be anything from one millimetre up to several centimetres. In addition to this standardised test setup, Klüber Lubrication has developed its own dynamic test rig, which was used to develop and optimise the special grease.

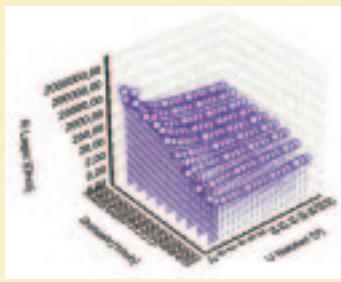
### Resistance reminiscent of semiconductors

While the specific resistance of standard rolling bearing greases ranges from  $10^{11}$  to  $10^{14}$  Ohm x cm, the special grease Klüberlectric BE 44-152 has a specific resistance of a just  $10^4$  Ohm x cm, which is within a range typical of semiconductors.

The higher conductivity of greases like Klüberlectric can also be ascertained under dynamic conditions, i.e. in a rotating bearing. This is done on a purpose-built test rig, where a DC voltage of up to 20 V is fed into running, insulated ball bearings. By determining the voltage drop across the bearings and determining the current intensity, the electrical resistance can be calculated. The bearings can be run at varying speeds, which allows conclusions on how the resistance depends on a bearing's speed.



**Fig. 1:**  
Insulating model grease with a base oil viscosity of  $70 \text{ mm}^2/\text{sec}$  at  $40^\circ\text{C}$ . With a resistance of 2 million Ohm over the whole speed and voltage range applied, this combination of grease and bearing shows an insulating behaviour.



**Fig. 2:**  
Conductive model grease with a base oil viscosity of  $70 \text{ mm}^2/\text{sec}$  at  $40^\circ\text{C}$ . The electrical resistance is considerably lower, it depends on the bearing speed and the applied voltage, making a difference of up to four powers of ten.

### The cause of the damage is a voltage applied to the bearing, which can be of three different types:

- Shaft voltage (AC voltage): the shaft is rotating in an asymmetrical magnetic field and so induction takes place.
- Unipolar voltage (constant or pulsating DC voltage): the shaft is rotating and is itself magnetic giving rise to an inductive effect.
- Extraneous voltage (DC or AC voltage): in this case the shaft is charged from the outside, for example from electric control systems, track currents, welding currents, or electrostatically, e.g. due to process media, lubricants or coolants.

Of course, in all applications of conductive greases in rolling bearings the maximum expected current intensity must be taken into account. If it exceeds 1 ampere, insulating the bearings with ceramic, plastic or other materials might be recommendable. Another possible solution is the use of bearings with ceramic rolling elements. However, such measures entail high costs and may make substantial design changes necessary. At low current intensity, in particular, the use of Klüberlectric BE 44-152 can be an inexpensive alternative to efficiently prevent discharge damage.

Besides its “electrical” performance, a rolling bearing grease is of course also expected to offer good service life and high reliability. So when selecting a lubricant, its suitability for the particular rolling bearing application should also be checked. Reliable information in this regard can be obtained for example through test runs according to DIN 51821, part 2, testing the upper temperature range and the lubricant life. In addition, performance characteristics like corrosion protection or the speed factor should also be taken into account.



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### **Klüberlectric BE 44-152 ...**

... has proven successful in numerous tests as well as in practical use. It can be used over a temperature range\* from – 40 to + 150 °C. On rolling bearing test rigs determining the grease life and speed factor, Klüberlectric BE 44-152 performed “very successfully”. In the FAG-FE9 test (acc. to DIN 51821, part 2,  $F_a$  1500 N,  $n$  = 6000 rpm, at 150 °C), for example, the grease attained an  $L_{50}$  life > 200 hours. Also notable is its very good corrosion protection: in the Emcor test (DIN 51802, 1 week, distilled water), a corrosion degree  $\leq 1$  was attained. Klüberlectric BE 44-152 covers also speed factors\*\* up to 1 000 000 mm x min<sup>-1</sup>, which are encountered in many applications. Klüberlectric BE 44-152 is a fully synthetic grease based on a synthetic hydrocarbon oil, lithium soap and dark solid lubricants.

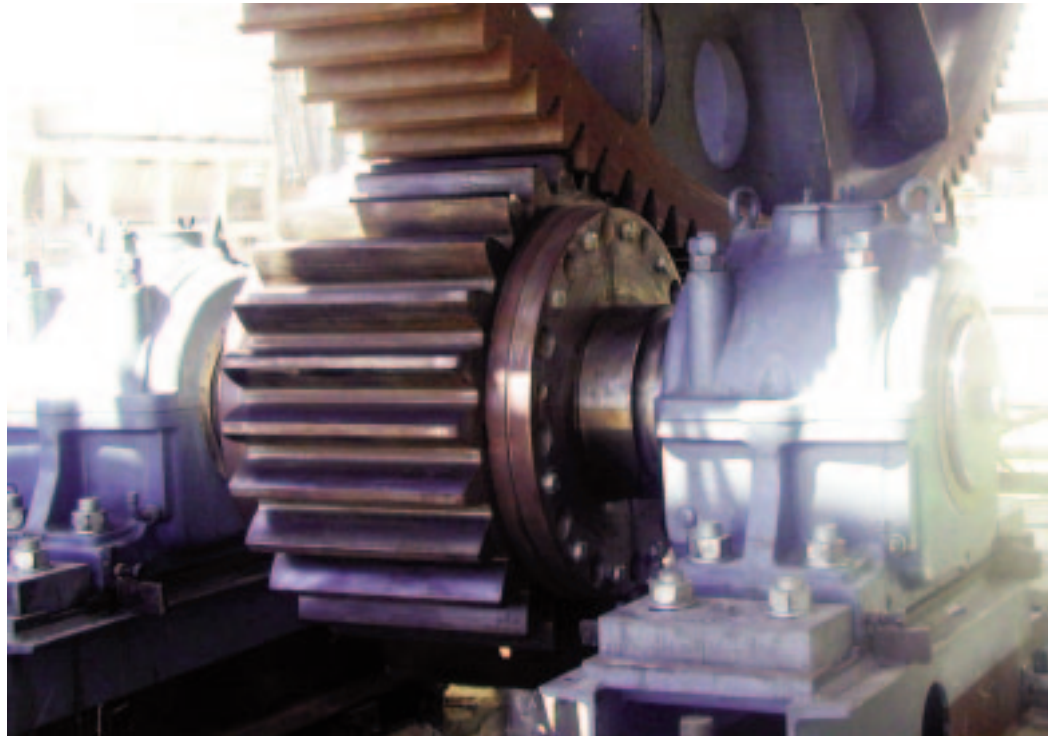
\* Service temperatures are guide values which depend on the lubricant's composition, the intended use and the application method. Lubricants change their consistency, apparent dynamic viscosity or viscosity depending on the mechano-dynamical loads, time, pressure and temperature. These changes in product characteristics may affect the function of a component.

\*\* Speed factors are guide values which depend on the type and size of the rolling bearing and the local operating conditions, which is why they have to be confirmed in tests carried out by the user in each individual case.

# Repairing large girth gear drives in full operation

## *Opportunities and limitations of repair and correction lubrication on tooth flanks*

*When it comes to repairing tooth flanks of large girth gear drives, repair lubrication provides a number of advantages over mechanical processing. Even the operation of seriously damaged gear drives can be improved through repair lubrication so that replacement can often be postponed for several years. Further advantages are: life span extension of girth gear drive components and the possibility to repair the girth gear drives in operation. To the operator, this means that the girth gear drive can remain in operation and production can continue. No costs for gear outage arise. As the procedure is complex, it is recommended to consult experts before undertaking it.*



Not too long ago, tooth flank damage in large girth gear drives was repaired exclusively by applying mechanical treatments and costly repair procedures. High tooth flank qualities could not be obtained as demands regarding the life span and operation of a girth gear drive prevailed. In turn, costs arising through the loss of production and through the human resources needed to repair the damage caused were very high. Nowadays, repair lubricants are widely used to repair tooth flank damage. Repair lubricants make it possible to restore damaged tooth flank surfaces in a way that the gear can remain in use with improved operating performance. Moreover, repair lubrication prevents renewed breakage of restored surfaces and new tooth damage.

The decisive advantage of repair lubrication over mechanical processing

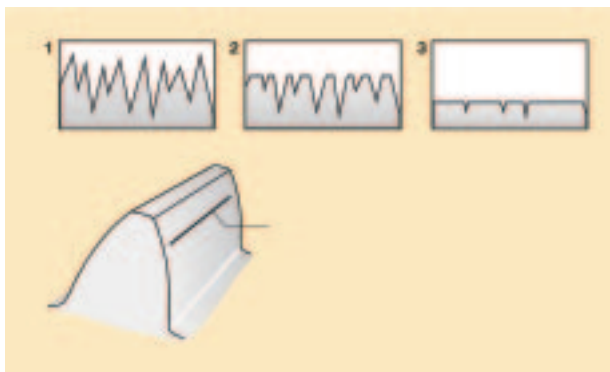
is that the girth gear drive remains fully operable and that high loads even increase the success of repair lubrication.

Compared to several days of standstill as in case of mechanical processing, short girth gear drive downtimes for control and documentation purposes during the repair lubrication process are all but negligible.

### **Principle and effect**

Repair lubricants wear off material. They contain specially developed compounds that are highly active and effective. These compounds subject metallic surfaces to mechanical, chemical and corrosive wear. Thus a small amount of lubricant can remove just the right amount of flank material – corresponding to the customer's repair needs and technical feasibility – in a short period of time.

The material is worn off evenly at the contact points. The ability to repair through material removal is limited by the thickness of the hardened tooth flank surface layer.\* There is only minor influence on the hardened surface layer itself. Surface wear and hence damage repair can be controlled by the amount, application duration and reaction time of the



**Smoothing flanks during damage repair**

lubricant in each application cycle, and by the repair time as a whole. By applying controlled wear, the tooth flank profile is evened across the entire tooth width and height so that it matches its mating gear.

Scuffing, scratches and scoring are very easy to repair with this technique. Plastic material deformation can be repaired up to a certain extent.

When pittings are encountered, the progress of damage and the formation of new pitting are prevented by eroding material at the overloaded flank parts, which leads to a more even load distribution over the tooth flanks and hence a reduction of specific tooth flank peak loads and a higher rolling endurance.

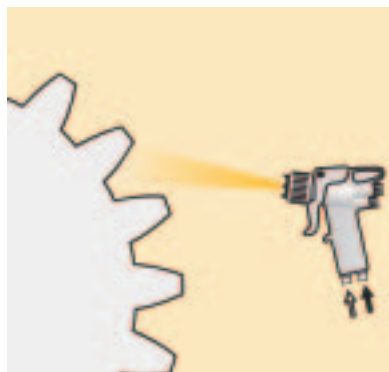
In mill drives, successful repair lubrication can be achieved in a relatively short time.

Compared to kiln drives, the speed of rotation is higher and thus tooth contacts are more frequent. The repair procedure is also accelerated by higher sliding speeds. Depending on the damage, repair lubrication takes one to two working days for mill drives. Kiln drives require higher amounts of repair lubricants due to lower rotation and less frequent tooth contacts. In this case, the process of repair lubrication takes about two to three working days.

### Limitations of repair lubrication

Repair by controlled wear is limited by the degree and type of damage. Depending on the drive's base material, removal of a few hundredths to several tenths of millimetres can be achieved. Generally, "only" a few hundredths millimetres are removed, but this can lead to significant operational improvement.

It is not recommended to use repair lubrication for the repair of burrs at the tip and the side of the teeth, material elevation, wear steps at the tooth root, sharp edges and deep pitting. These types of damage have to be repaired



**Applying the repair lubricant using a manual spray equipment**

mechanically by milling (end-milling cutter, spherical cutter) or grinding (cutting-off wheel for material steps or abrasive buffs for flank treatment).

### How the operator is involved

To start with, please note: during the warranty period of a large gear drive, the manufacturer's and the operator's permission must be obtained prior to repair lubrication.

For the preparation of repair lubrication, it is vital to identify the causes of the damage and to eliminate them. Depending on the type and degree of the tooth flank damage, mechanical treatment (grinding, milling) might be required prior to repair lubrication.

To document the condition of the tooth flanks and the contact ratio unambiguously before and after repair lubrication, photographs are taken and silicone impressions of some representative tooth flanks are made. It is important to always document the changes of the same tooth flanks. In doing so, the operator obtains an illustration of the actual condition of the flanks and how it has changed.

Repair lubrication is effected under operating conditions, thus permanent operation is normally ensured, although short interruptions needed for inspection by the service engineer have to be allowed for. Despite the damage, a contact ratio of 60 per cent or more should be achieved prior to the repair lubrication process because otherwise the gear drive will have to be readjusted.

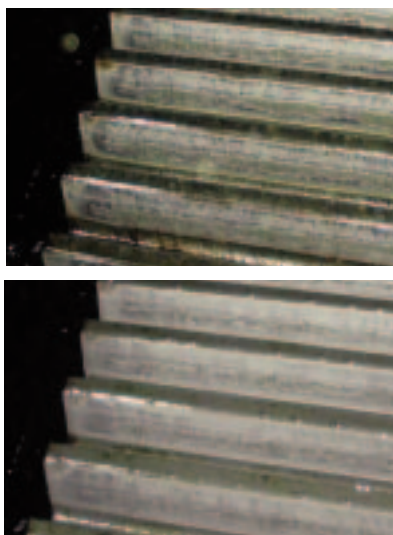
While the lubrication system runs on "continuous operation" with a running-in lubricant, the repair lubricant is applied by the use of a manual spray equipment (e.g. Klübermatic LB) which is connected to a pneumatic system.

The manual spray equipment is used to apply the repair lubricant in larger quantities to the bearing pinion flanks

\* For case-hardened materials with a hardening depth (R<sub>h</sub>t) of approx. 2 mm, as well as for surface-hardened materials (R<sub>h</sub>t up to 10 mm attained with induction hardening and approx. 2 to 4 mm attained with flame hardening), repair lubrication is a highly suitable technique. For nitride-hardened materials, whose nitriding depth (white layer + diffusion layer) is approx. 1.5 mm, repair lubrication with its special compounds is not suitable since it would also remove the extremely thin (5 to 30 µm) white layer, which shows the greatest hardness.

and the gear rim so that the lubricant is distributed evenly over the tooth flanks. The process of material removal begins.

Afterwards, the repair lubricant is applied in smaller quantities to correct elevations and edges on the tooth flank profile.



*Damage repair through the use of repair lubrication: The effect of the repair lubricant is clearly visible in the lower photo*

## Measuring success

There are the following means to measure the effectiveness of repair lubrication:

- Visual inspection of rotating girth gear drive by means of a stroboscope (applies to mill drives only)
- Measuring the temperature distribution across the tooth's width and around the circumference by means of an infrared thermometer
- Measuring vibrations at the pinion bearings (applies to mill drives only)
- Taking photographs of the tooth flanks under stroboscope light in regular intervals

All measured values enter the statistics.

If necessary, low lubricant quantities will be used for fine tuning in spots where slight material elevations still occur on the flanks. These spots are light, bright metal areas that experts can easily make out. If there are no such areas, the repair lubricant will be sprayed evenly across the entire flank.

Repair lubrication is completed when the temperature curve is even across the entire tooth flank's width and around its circumference. This means that the estimated contact ratio is above 80 per cent, that surface roughness, minor scuffing damage, scoring, scratches and minor plastic deformations have been smoothed and that there are no more significant vibrations.

On the termination of the repair process it is recommended to use running-in lubricants for a short while, as these help to smooth minor roughness caused by the repair process.

## Repair lubrication – what's in it for you?

- *No costs arising from production downtimes as repair lubrication is effected during operation*
- *Excellent results within a very short time frame*
- *Improved operation even if tooth flanks are severely damaged*
- *Prevention of new flank damage*
- *Extended life span of girth gear drive components*
- *Replacements can often be postponed*

**Experienced Klüber specialists will be pleased to assist you worldwide with:**

- *Damage inspection and evaluation*
- *Investigation of damage causes*
- *Implementation of repair lubrication*
- *Documentation*

**All in all ...**

Due to the complexity of the repair process, and to avoid unintended damage, repair lubrication should only be carried out by a trained and experienced application engineer.

Nevertheless, if implemented correctly, repair lubrication is a very interesting alternative to mechanical treatment. When it comes to repair issues, repair lubrication should always be the first choice.

Operators of large girth gear drives can avoid costly production downtimes as the repairing process can be implemented in full operation. In addition, the repair lubricant on tooth flank surfaces improves the girth gear's operational performance and prevents new flank damage. Replacements can often be postponed for years.



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**HUSUM**  
WindEnergy  
The Leading  
WindEnergy Exhibition  
9-11 September  
Husum Convention  
Hall 3, Stand C01

**Gear oils for extreme conditions  
save real money**

Gears in wind power plants make substantial demands on the lubricant used. It should, for instance, be thoroughly reliable and at the same time extend maintenance intervals as much as possible. No problem with speciality lubricants made by Klüber.

The benefit gained can be expressed in solid figures: compared with traditional mineral oils, special lubricants may enable savings of more than 50000 € calculated over the lifetime of a wind turbine. Why not make use of Klüber's many years of expertise in the wind energy sector and save real money?

Contact us!

# Making effective use of Klüber brochures

## Which lubricant should I take for ...?

For a first answer to this question from engineering practice, have a look at Klüber's new **product selection** brochures, categorised as "Detailed Information". In the overview charts, you will always at first find a machine, a component or a particular lube point. This will then take you to our recommendation for a lubricant and some notes on the benefits it offers.

Of course, brochures have their limits and cannot exhaustively answer more complex questions regarding lubrication. Whether the lubricant recommended for your application is in fact the right one in your particular case should always be verified by a specialist. So please contact our experts to find out if there are any aspects to your application that might require a different lubricant.

Our engineers will be pleased to consult you so that you can be sure to make the right selection.



*Know-how and interesting background information can be found in the Special Knowledge brochures*



*Your machine or component is the starting point for any lubricant recommendation*

## How does the lubrication of ... actually work?

Those wishing for a more profound insight are best advised to refer to a "**Special Knowledge**" brochure offering information, hints and advice on various aspects of lubrication – written by experts for experts.

Our expertise comes from a variety of sources, e.g. in-house tests during the development phase of a lubricant, joint research projects with universities and other institutions and, of course, many years of experience in the field.

### New Klüber brochures:

- **Product Selection**  
White Goods – Special Lubricants for Household Machines and Appliances
- **Special Knowledge**  
Klüber Lubricants for Electrical Switches and Contacts

### Coming soon:

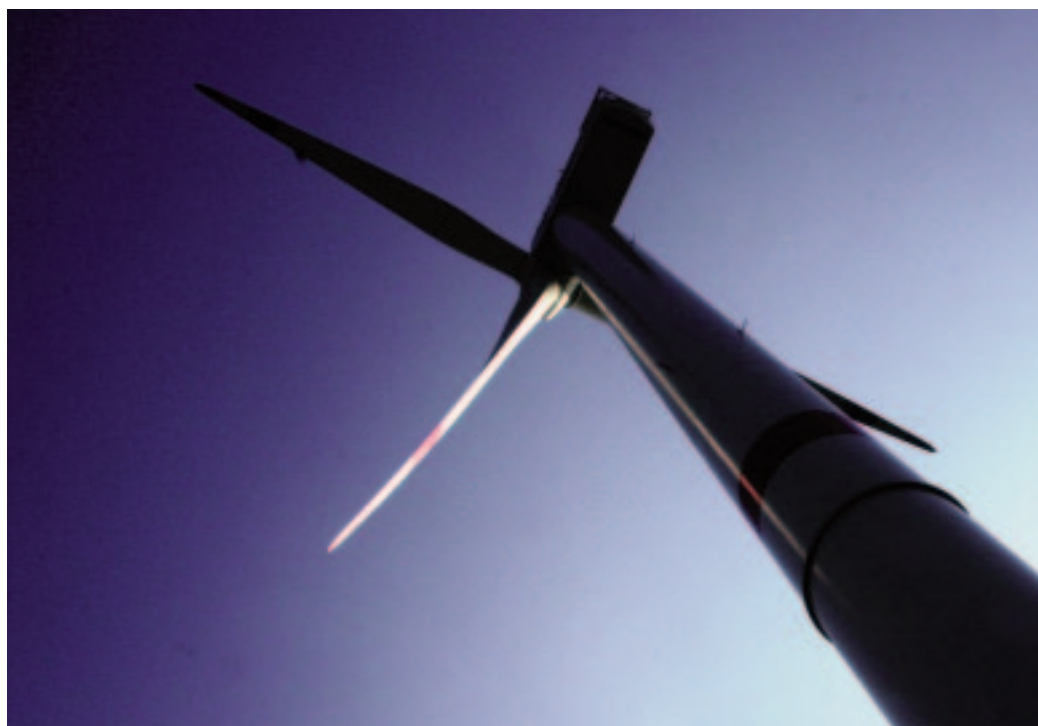
- **Product Selection**  
Speciality Lubricants for Rolling Bearings

The company      Industrial sector      Special knowledge      **Detailed information**

The front page tells you what kind of brochure you're holding in your hands: just watch out which term is highlighted in the bottom line.

# A fresh breeze for gears

*High-performance oils for heavily loaded gears in wind power stations*



In wind power stations both fluid (lubricating oils) and consistent (lubricating greases) lubricants are used. The main task of the lubricant is to ensure reliable operation of the machine elements. Important lubrication points in wind turbines are in the main gear drive, the yaw system gear, the main and generator bearing, the pitch adjustment unit and the nacelle slewing ring. High demands are made on service life, load-carrying capacity and thermal resistance. All these characteristics should be maintained over an extended period of time.

Therefore, plant operators require prolonged oil service life and grease relubrication intervals. While the engine oil of a car is changed after 15,000 to 30,000 km, which corresponds to an oil service life of 300 to 600 hours at an average speed of 50 km/h, the gear oil in a wind turbine is changed after as many as 25,000 to 50,000 service hours. Commodity lubricants as defined by various standards cannot meet the expectations of today's wind industry.

## **Gear oils especially designed for wind power stations**

The ever increasing performance requirements made on wind turbine gears have led to higher loads and temperatures in a smaller space. Therefore, nowadays the main gearboxes of wind turbines are generally lubricated with synthetic oils. In this context it needs to be observed that different base oils (polyalphaolefin, polyglycol or rapidly biodegradable ester) are used to formulate these gear oils. Experience gained with usual synthetic lubricants has shown, however, that even these products cannot always meet the high requirements made in terms of wear protection of rolling bearings, micro-pitting resistance, foam and residue formation.

The global lubricant specialist Klüber Lubrication has made it its job to develop a series of gear oils which ful-

*Following a decision of the European Union, about 21% of the European energy demand has to be covered by renewable energy sources by 2010. Wind energy is bound to play a major role in this development. The performance of today's wind power stations ranges from 2 to 5 MW while prototypes generating up to 10 MW are already under development. Due to this increase in performance the lubricant assumes an ever-greater importance, i.e. it has become a major element in the tribological system to be taken into account in the design of wind power stations. Only special lubricants are able to cope with the operating conditions of highly loaded components like gears and enhance their reliability.*

Requirements	Klübersynth GEM 4-320 N Polyalphaolefin	Klübersynth GH 6-320 Polyglycol	Klübersynth GEM 2-320 Ester
Gear oil acc. to DIN 51 517 - 03	CLP HC	CLP PG	CLP E
Flender approval	x	x	x
Elastomer compatibility 72 NBR 902	passed	passed	passed
Elastomer compatibility 75 FKM 585	passed	passed	passed
Foaming characteristics, DIN 51 566	passed	passed	passed
Flender foam test	< 15%	< 15%	< 15%
Fine filtration	possible	possible	possible
FVA 54 IV micro-pitting load capacity, 60 °C	high	high	high
FVA 54 IV micro-pitting load capacity, 90 °C	high	high	high
FZG scuffing test A/8.3/90	> 13	> 13	> 13
FZG scuffing test A/16,6/90	> 12	> 12	> 12
FZG wear test	low	low	low
rapidly biodegradable	no	no	yes

Fig. 1: Performance data of the new Klüber gear oils for wind power stations

fill the operators' demands for synthetic products with different base oils and eliminate the weak points of existing lubricants. After having gone through numerous development stages and extensive performance tests, three synthetic high-performance gear oil series are now available:

- Klübersynth GEM 4 N – polyalphaolefin
- Klübersynth GH 6 – polyglycol
- Klübersynth GEM 2 – rapidly biodegradable ester.

These synthetic lubricants offer higher ageing resistance, improved load-carrying capacity and lower friction than mineral oils, and thus enable extended service life and very economical operation.

## Performance range of the high-performance gear oils

In Germany, industrial gear oils are classified in accordance with DIN 51517. Part 3 of this standard defines the requirements gear oils exposed to high loads need to fulfill. In addition to the usual tests on viscosity, pour point, foaming characteristics, steel and copper corrosion, the scuffing load characteristics of the oils are determined in the FZG (Gear Research Center) scuffing load test. DIN 51517, part 3, stipulates a scuffing load stage  $\geq 12$  for gear oils. The task of a gear oil is not just limited to gear lubrication. The oil should also be suitable for the lubrication of the rolling bearings incorporated in the gearbox. Therefore, the revised standard DIN 51517, part 3, also contains the FE 8 rolling bearing test rig developed by the rolling bearing manufacturer FAG.

The FAG FE 8 test rig can be used to assess the anti-wear properties of an oil and its effect on the rolling bearing service life. In this test the wear of the rolling elements should not exceed 30 mg. With the high-performance gear oils of Klüber Lubrication wear is just one third of the maximum permissible value. Klübersynth GEM 4-230 N, Klübersynth GH 6-320 and Klübersynth GEM 2-320 comply with the performance parameters stipulated in the standard without problems.

## Wide scope of requirements

These results, however, are insufficient for assessing the gear oil performance for wind turbines. Further tests should be performed. In addition to an improved scuffing load resistance at higher circumferential speed, the Klüber special oils achieve the load stage  $\geq 10$  in the micro-pitting test, classified as "high". This high micro-pitting resistance is not only achieved at 90 °C but also at an injection tempera-

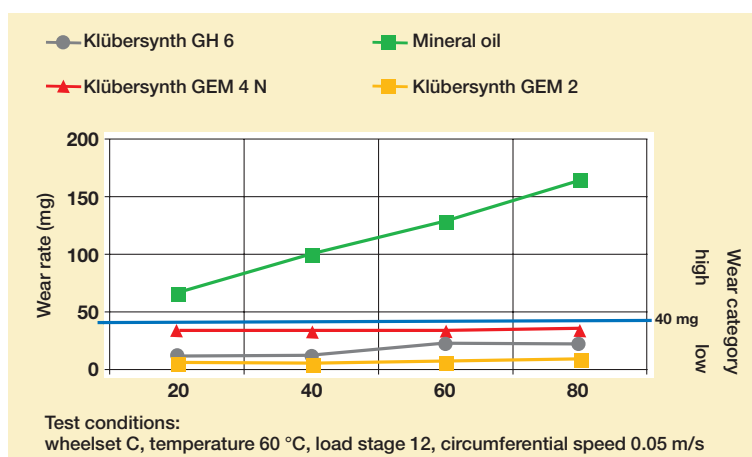


Fig. 2: Influence of low speeds on the wear rate – FZG wear test results of high-performance gear oils of Klüber Lubrication versus a mineral oil

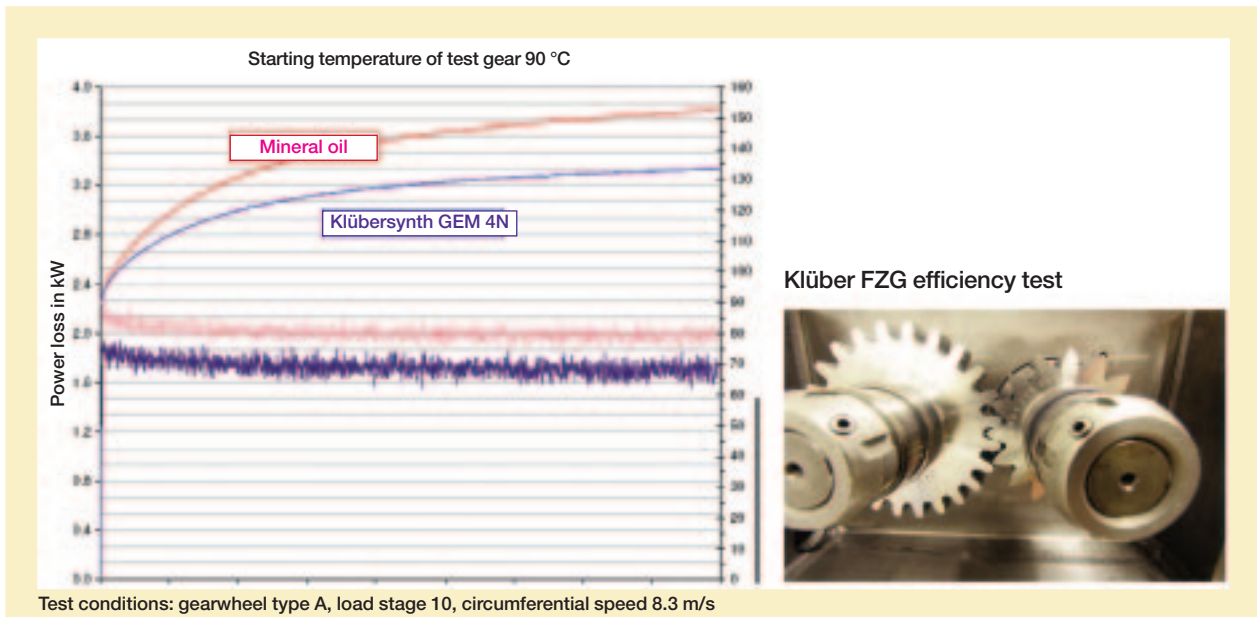


Fig. 3: Compared to a conventional mineral oil Klübersynth GEM 4 N shows reduced wear, temperature and power loss in the FZG test.

ture of 60 °C (common in wind power stations). The Klüber lubricants were subjected to adequate tests at both temperatures.

A trouble-free operation of a wind-power station is also determined by the anti-wear properties of the lubricant at low gear speeds, as the planetary gear stage is run at the lowest speed. Here a test method developed by FAG provides useful information. The Klüber gear oils pass the test run with wear being below 40 mg and therefore fall under the “low” wear category, which is the best possible classification.

Gear efficiency is determined to a large extent by the friction characteristics of the lubricating oil. The friction coefficients of different base oils can be determined on the FZG test rig. The new gear oils reduce temperatures by up to 20 °C and power losses by up to 18% compared with standard gear oils. These advantages contribute considerably to increasing the efficiency and energy output of wind turbines – worth up to several thousand Euro over the operating time of the plant.

long oil change intervals and low friction values lead to cost reductions. The service package consisting of extensive consulting by the Klüber sales team as well as oil analyses ensure that operators will always be provided with the lubricant tailored to suit the individual requirements of wind power stations.

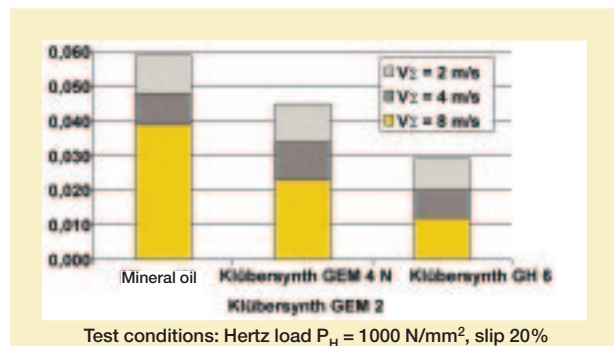


Fig. 4: Friction values of various base oils determined on a double-disc test rig

## Experience

More than 1,000 wind power stations are already lubricated with the high-performance gear oils of Klüber Lubrication and many others are to follow. Operators are convinced of the good wear protection for both the gear and the rolling bearings, the improved micro-pitting resistance as well as the high purity throughout the service life of the gear oils. Also, economic aspects like high operational reliability,



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# White grease for “green” vehicles



*The new low friction lubricant enables high efficiency, e.g. in small gears operating under high loads*

To lower a vehicle's energy consumption, many technologies are being tested in the automotive industry. Weight reduction is of particular concern, which is the reason why in many cases plastics are being used to replace metals. This is a special challenge for lubrication, because the compatibility of plastics and lubricants is not always easy

to achieve. Klüber has developed the special plastics-compatible high-temperature grease Klübersynth HIP 84-401 for the automotive industry. Thanks to clever addition, this special grease is compatible with various plastics and elastomers – even at temperature peaks of up to 180 °C. With Klübersynth HIP 84-401, excellent friction coefficients can be attained enabling small gear drives and constant velocity joints to operate with maximum efficiency, so internally generated heat during the operation of the components is reduced. This leads to increased reliability and a longer lifecycle of the components.

The white, almost non-odorous lubricating grease has a very low fogging value and reduces oscillation and vibration as well as excessive noise. It can also compensate for tolerances. All in all, components lubricated with Klübersynth HIP 84-401 offer a pleasant and high-quality switching feel. This high-temperature grease has been specially designed for components such as joints, small gears operating under high loads, control knobs, sliding rails, guide rails, fan flaps, air conditioning systems as well as for the dampening in car interiors and the gear shifting gate.

## Purity without compromise



*Lubricants make a contribution to the safe and clean manufacture of tablets*

GMP guidelines for the manufacturing processes, highly sensitive products – the manufacture of pharmaceuticals requires production lines operating with a maximum of precision and safety. Consequently, the purity and performance capabilities of all materials and substances used in the process must also meet the highest of standards. They are required to be suitable for use in the pharmaceutical industry (documented according to GMP) as well as compatible with each other. The importance of compatibility becomes apparent, for example, where tablet presses have bronze guideways. Only a lubricant that is compatible with bronze alloys will enable a clean manufacturing process. For highly complex high-performance rotary tablet presses, Klüber

Lubrication has developed a special oil for plunger lubrication that is also compatible with materials like bronze, making sure that the oil-bronze system does not produce any substances that might contaminate or discolour the tablets during the production process. Compared with conventional lubricants, Klüberpharma UH1 4-220 helps to considerably reduce the reject rate and rule out contamination as specified in the GMP guideline for the pharmaceutical industry.

The newly developed speciality oil offers also good wear protection for a more reliable and accurate machine operation. Due to the excellent lubricating effect, the friction coefficient at press start-up is reduced significantly.

Klüberpharma UH1 4-220 was developed with a view to the requirements of the ISO standard 21469 (machine safety: hygienic requirements made on lubricants where contact with the product is technically unavoidable). The product complies with FDA requirements and is registered as NSF-H1, i.e. it is in line with the American requirements of the “Guidelines of sec. 21 CFR § 178.3570 of FDA regulations”. This constitutes also the material documentation required by the Pharma GMP guideline for lubricants.

## Last but not least ...

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**Klüber Lubrication – the world market leader**  
**in specialty lubricants**

- subsidiaries in over 30 countries
- more than 1,700 staff
- products available worldwide

Klüber Lubrication offers expert tribological solutions. Through our worldwide presence, we meet customers' needs reliably and on time. We supply tailor-made specialty lubricants to customers from nearly all branches of industry and around the world – oils, greases, bonded coatings, pastes and many more. Over 75 years of experience, industry-specific know-how, and exceptional test facilities all help to optimize our solutions.



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