

Whitepaper

Outstanding riding experience thanks to lubrication.

Tribological solutions for e-bikes



Brief summary

E-bikes are becoming more and more relevant as part of new mobility concepts. Eco- and health-conscious end customers can now enjoy an ever-growing range of models across all product categories, with attractive designs and innovative drive train and

battery technology. Customers choose a specific e-bike primarily for its drive unit, the performance of which can vary greatly depending on the choice of lubricant used.

Specialty lubricants to meet end customer requirements

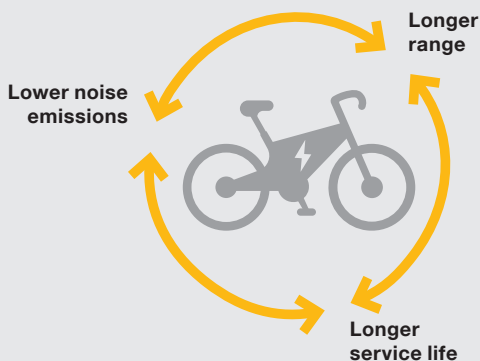
A customer's decision to buy an e-bike is largely driven by the bike's riding range combined with the desire for a high motor power. The bike's service life and the noise level of its drive train also play an important role. Besides, customers are looking for low-weight bikes, ensuring individual riding comfort as well as the bike's suitability for everyday use. All of these requirements represent enormous challenges for e-bike manufacturers and

component producers, pushing them to create extremely power-dense drive trains that are becoming more and more efficient. Growing competitive pressure from newly emerging market players and growing safety requirements are also creating a new market dynamic. Innovative lubricant solutions can help developers and technical designers to meet these requirements and win over future customers.

The gear motor: the heart of the e-bike

The gear motor is the heart of an e-bike and its drive train, and it heavily influences the bike's service life. However, its gear teeth are also responsible for much of the noise perceived by the customer. A suitable high-performance lubricant can be crucial in helping to optimise the function of various gearbox versions.

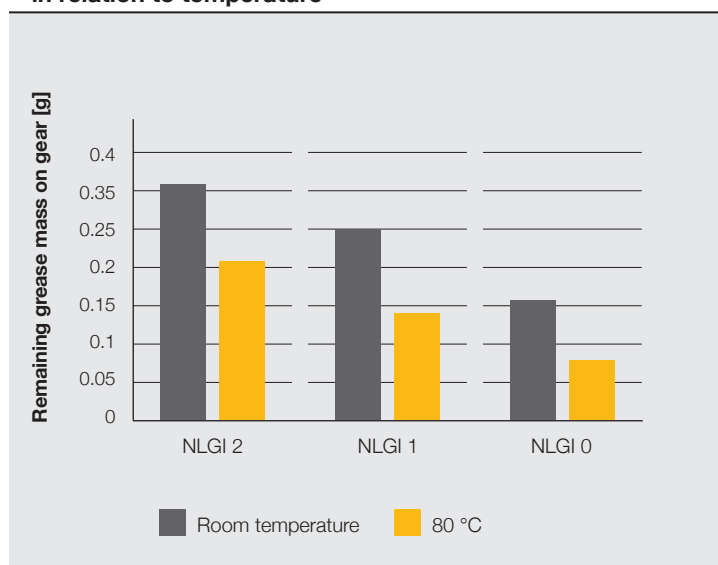
Important requirements for an e-bike drive system



Extend service life by using the right gear lubricant

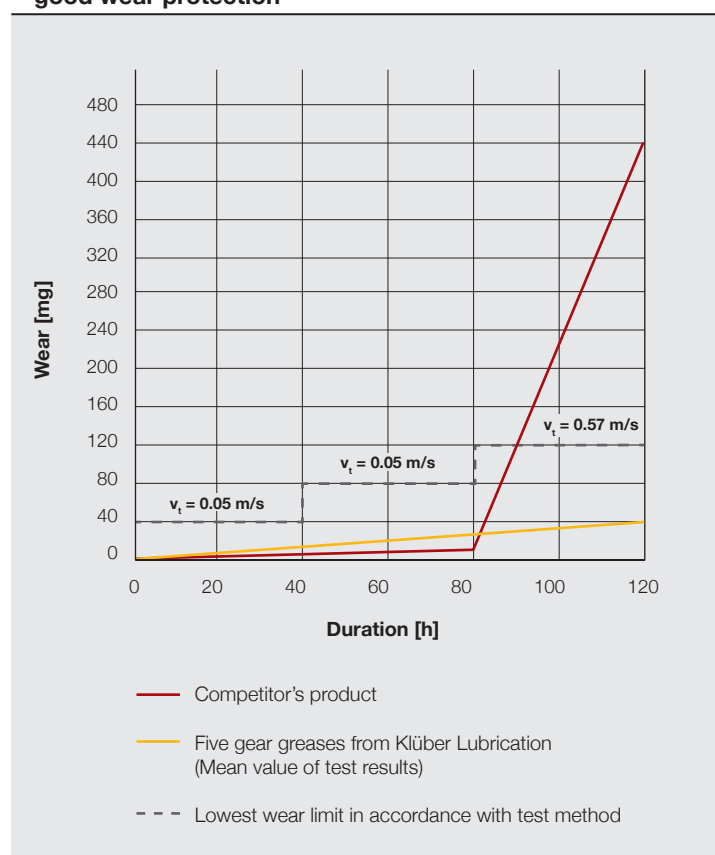
The service life of an e-bike's drive train can be significantly increased by using a suitable lubricant. The right lubricant can increase the drive unit's efficiency and reduce wear without affecting the electronic systems. The best results are achieved by using a grease that adheres to the gear teeth and is not flung off, even in critical operating conditions. A straightforward approach to determine a grease's adhesive strength is to grease the tooth flanks of a gear. After tempering the greased gear, it is rotated at a constant speed for a defined duration. The grease mass remaining on the gear will be an indicator of the grease's adhesion. Speed, temperature and grease consistency all have a significant impact on a grease's adhesive strength. The following graphic shows that lubricating greases with consistency grade (NLGI) 2 show the best results. Too low an adhesive strength or a tendency for the base oil to separate from the lubricating grease can have drastic effects if the grease comes into contact with the bike's power electronics.

Effect of grease consistency (NLGI) on adhesive strength in relation to temperature



High-performance e-bike drive trains have a very high power density. Wear protection by lubricating greases plays an even bigger role for gears made of steel than for those made of plastic. Wear protection can be tested on the FZG test bench using the slow-speed wear test in accordance with DGMK 377-01. This test examines the grease's boundary friction behaviour at slow speeds and high loads. The first 80 hours are tested at a peripheral speed of just 0.05 m/s, with the loss in weight of the gears being measured every 20 hours. For the last 40 hours, the gears run without stop at an increased speed of 0.57 m/s. The following figure shows that high-performance greases from Klüber Lubrication offer very good wear protection, even under critical conditions.

Selected gear greases from Klüber Lubrication offer very good wear protection



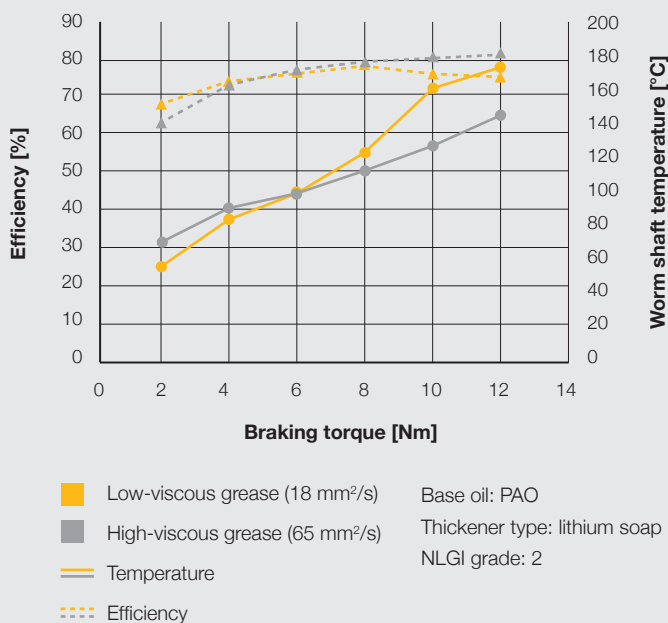
Longer range thanks to improved efficiency

The range of an e-bike enabled by its drive train is an important criterion in the end customer's buying decision. Again, the grease used for gear lubrication can be decisive here since optimised lubrication can significantly improve efficiency. Using its own test benches, Klüber Lubrication examined the efficiency and temperature development of adhesive PAO lithium-based greases on worm gearboxes. Even though most gears used in e-bike drive trains are spur gears, the effects of lubrication can still be clearly identified with this test.

For the the lubrication of plastic gears, compatibility between the grease and plastic type also plays a crucial role. If the two are incompatible, this may lead to premature ageing of the plastic, resulting in the gear becoming brittle. The subsequently altered gear dimensions and increased roughness reduce gearbox efficiency, which, in turn, leads to a reduced e-bike range. In the worst-case scenario, stress cracking on the gear combined with a high load will cause tooth breakage, bringing the e-bike drive train to an immediate standstill. Base oil polarity adjusted to plastic gears and the choice of compatible additives are essential here to ensure a long, maintenance-free service life for the e-bike's drive train. For example, the following graphic shows that new polyamide gears show a significantly higher efficiency and operate at lower temperature than an already aged gear.

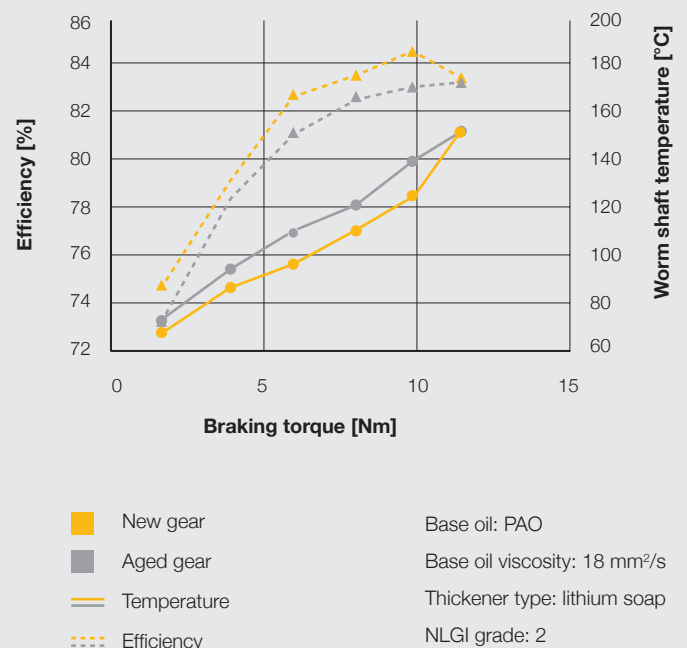
Load conditions determine grease selection

- ▶ At low loads, low-viscous greases reduce loss and temperature.
- ▶ Under high loads, high-viscous greases increase efficiency and keep temperatures lower.



These results clearly show that the choice of lubricating grease must be adjusted to the type of load. For multi-stage e-bike gearboxes, the critical gear stages must be protected under the premise that the whole system is as fine-tuned as possible.

Suitable greases help maintain high efficiency



Taking into consideration the effect of the gear grease on the bike's range, it is also clear that a balance must be found with the lubricating grease's adhesive strength mentioned above. If the adhesive strength is too high, the drive unit will sacrifice efficiency and the temperature will increase. If it is too low, there won't be enough lubricant available for a long service life.

Effect of lubricants on gearbox noise

Noises generated by the e-bike's drive train can be unpleasant to human ears, which can lead to complaints or even deter end customers from buying an e-bike in the first place. Meshing gears in particular generate noises, determined primarily by the tooth geometry and choice of material (see graphic). These noises are then transported through shafts, bearings and the housing acting as soundboxes. They pass through the pedals, frame and chain, finally reaching the rider via airborne and solid-borne sound. Some noises are acceptable, others can be disturbing. Spur gears made of steel generate the most noise. Changing to helical gears, even while using the same material, already reduces this tendency. Switching to helical gears with a mix of steel and plastic, or even pure plastic contacts, can reduce the noise even further. Gear design, including the materials and tolerances used, is therefore one of the main factors when it comes to noise reduction. It's not the only factor, however. As a medium between the gears, lubricating greases can smoothen surfaces and act as a damper to reduce noise or shift it to a more pleasant frequency. To start with, the

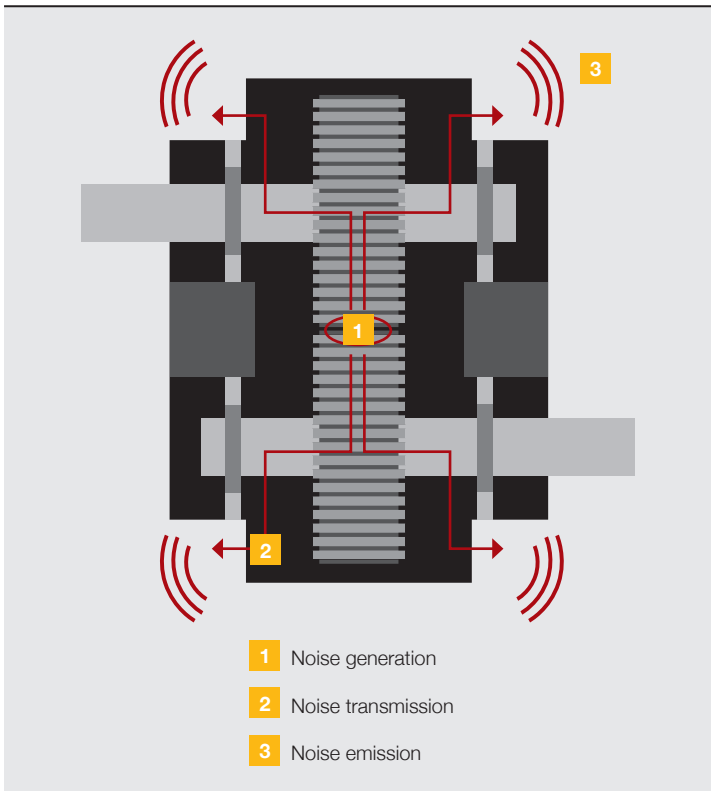
grease must adhere to the teeth. Adhesive strength once again plays a crucial role here. The lubricating film helps to dampen noise between the meshing gear teeth. The interaction of factors such as consistency grade, thickener type and base oil viscosity determine the film's thickness. However, it is important to note that the issue of noise cannot be considered in isolation. For example, high-viscous lubricating greases that reduce noise may also have a negative impact on the gearbox's efficiency.

High-performance lubricating greases from Klüber Lubrication – a complete solution for your e-bike gears

It has been shown that the end user's e-bike drive train requirements must be considered as a complete package to ensure the perfect riding experience by using the right lubricating grease. To extend the service life, the lubricating grease should protect the materials as much as possible, prevent wear and remain in the lubrication point. The adhesive strength required to do so, however, can also affect the efficiency of the gears. A balance must be found here, just as with the example of noise reduction through high-viscous greases. The adhesive strength required to extend the service life is also in line with the goal of noise reduction.

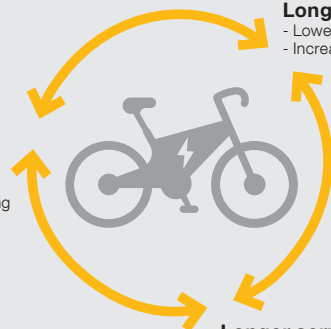
Klüber Lubrication will help you to choose the right lubricating grease to meet your individual requirements and optimise your e-bike drive train.

Noises occur within the gearbox and are transmitted to the outside




Important requirements for an e-bike drive train

Lower noise emissions
- Reduced noise generation
- Improved damping



Longer range
- Lower friction
- Increased efficiency

Longer service life
- Improved adhesive strength
- Reduced wear
- Improved plastic compatibility



Another field of action: electrical contact lubrication

The plug-in contacts of the e-bike's battery system are exposed to various environmental influences that require special protection. Contacts made from copper alloys coated with gold, silver or tin are put under a particularly high amount of strain through ever longer plug/unplug cycles and a wide temperature range. A special surface protection can prevent tribo-corrosion, wear and the increase of resistance throughout the service life. Precise application of the suitable lubricant at the lubrication point also plays an important role. Klüber Lubrication offers a wide selection of tribological solutions for electrical contacts and has extensive experience with the application technologies used in this area. New products are tailored to meet the needs of the customer.

Let's develop the perfect drive train experience with you!

Klüber Lubrication has extensive experience with the application technologies used in this area. Together with various partners from science and industry, we work continuously to develop high-performance lubricating greases for e-bikes and bring new solutions to the market. Contact us and let's find an individual solution for your drive unit and shape a sustainable future.

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Geisenhausenerstraße 7, 81379 München, Germany, HRA 46624

www.klueber.com