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The Law of Least Resistance

The FUCHS Lubricants book regarding greases


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FUCHS

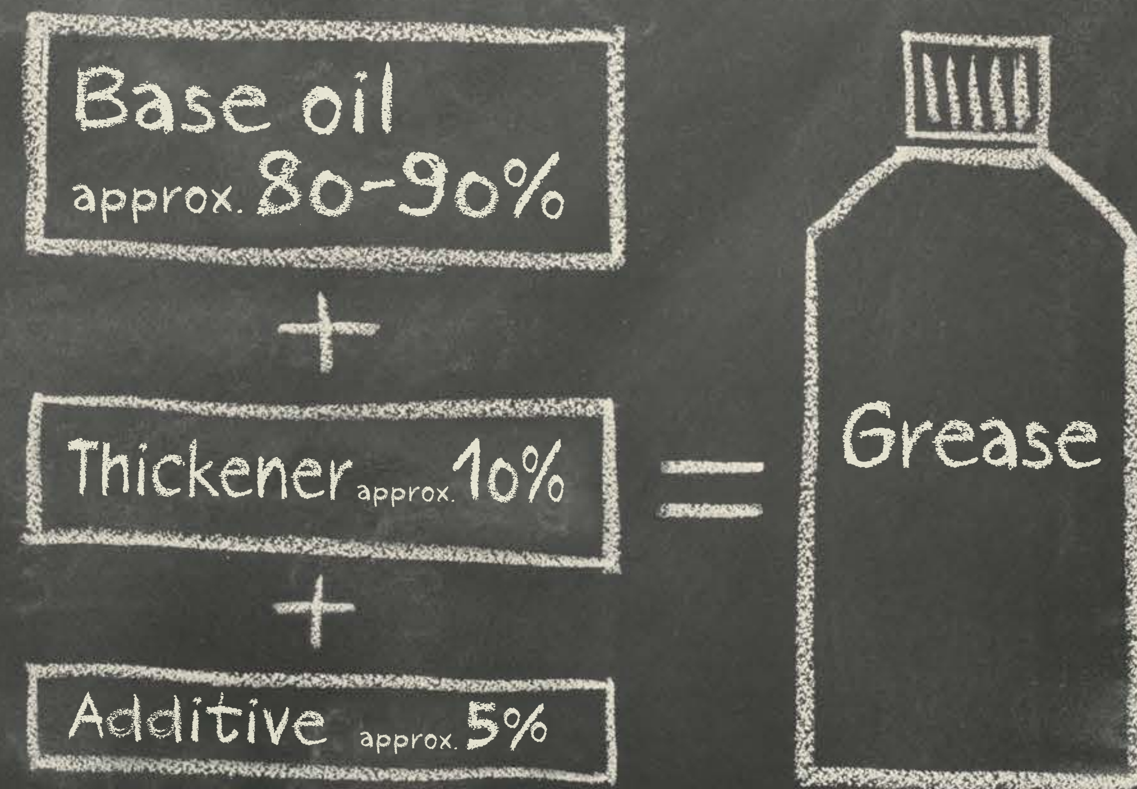
"Greases are high-tech"

"In many ways successful lubrication is more about knowledge than the actual lubricant. Machines are becoming increasingly complex, and they need to work smoothly without causing expensive downtime. Inadequate lubrication is the cause of most bearing damages. Our extensive work with varying applications has brought us in-depth knowledge, knowledge we are happy to share to prevent damage from arising. Recommending the right grease in demanding environments, varying temperatures and varying operating speed under heavy loads is all based on knowledge. At FUCHS Lubricants, we have the knowledge and of course the products to get the job done."

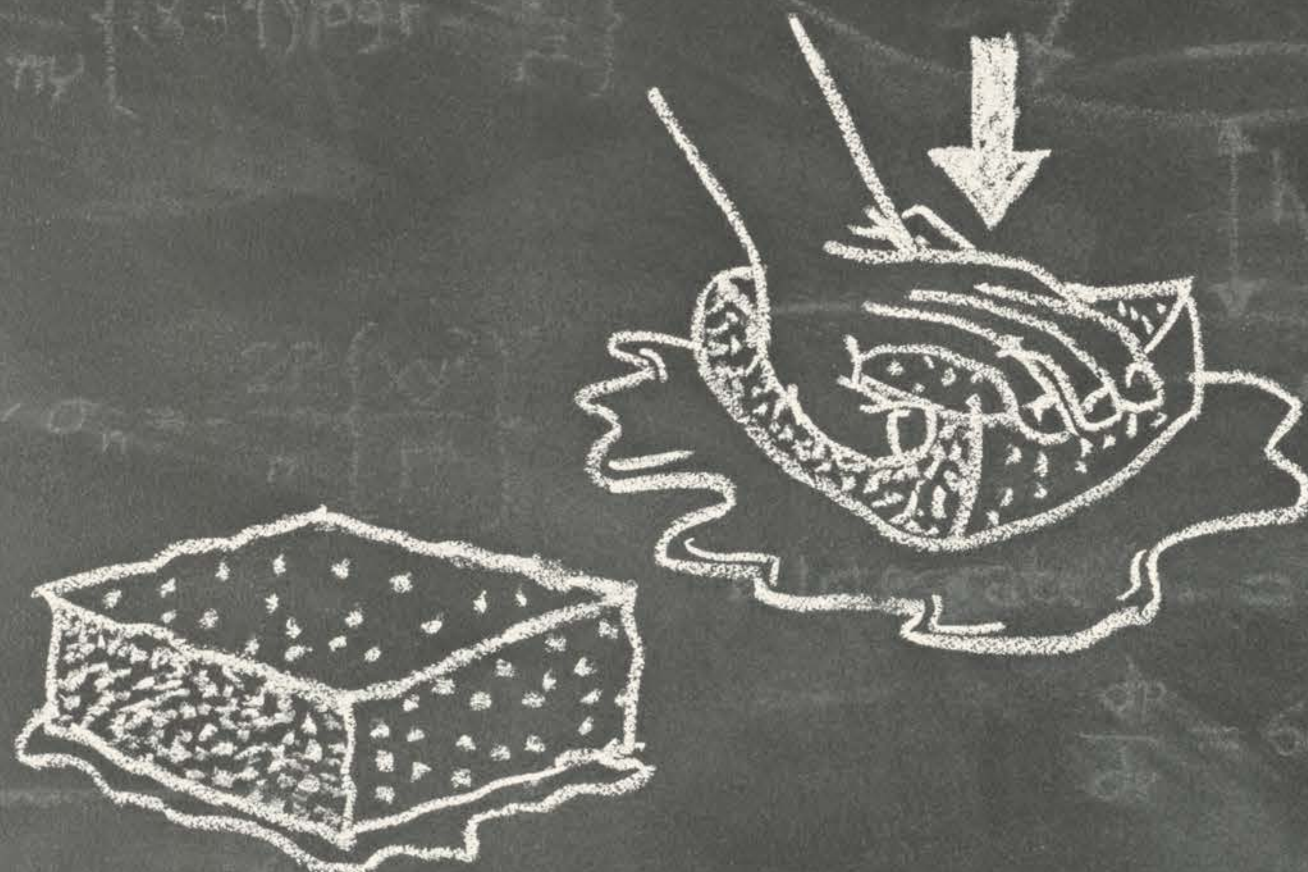
Maria Olanders, Category Manager Industry

What exactly is a grease?

A grease usually consists of three components.
In a carefully controlled process, these components are combined in finely balanced proportions to produce a high-performing end product.



A grease is like a sponge



ASTM, the American Society for Testing and Materials, has defined a grease as: "A solid to semifluid product of dispersion of a thickening agent in liquid lubricant. Other ingredients imparting special properties may be included."

Another, simpler way to describe a grease is to think of it as a sponge. The thickener is the sponge and the base oil is the water. The thickener in the grease creates a matrix that keeps the base oil in place in a solid structure and gives the grease its consistency. When the grease is subjected to different operating conditions such as temperature, loads or shearing, a viscoelastic flow is created in it. The plasticity of the grease, its consistency, is generally given a number according to the NLGI grading system. Semifluid (00) to normal (2) are the most common.

Greases are is primarily used in ball and roller bearings, as well as slide bearings, gearboxes and open gears. Nowadays greases are also increasingly used in forest machines for central lubrication of the cutting bar and chain.

Milan Kopp

Milan Kopp, Development Manager, Grease

A grease should:

- Provide good lubrication, reduce friction and wear
- Seal the lubricated area to prevent dirt, water and pollutants getting in
- Protect against corrosion
- Remain in the lubricated area and not leak, drip or be dashed out
- Be compatible with the sealing material and other component materials it comes into contact with
- Not alter to either solidify or soften when the bearing is repeatedly worked mechanically during the lubrication interval

”A grease stays put.”

A grease should reduce friction in areas where a lubricating oil would simply vanish. However, it should also seal and block, keeping water out and sealing against gas, for instance. Quite simply, it should be in place.

Base oils in greases:

Since a grease is 80-90% base oil, the base oil is an important part of the end product. The choice of base oil has a great impact on the grease's performance. Mineral oils are the most common base oils used in greases. However, synthetic base oils can produce properties that mineral oils simply cannot.

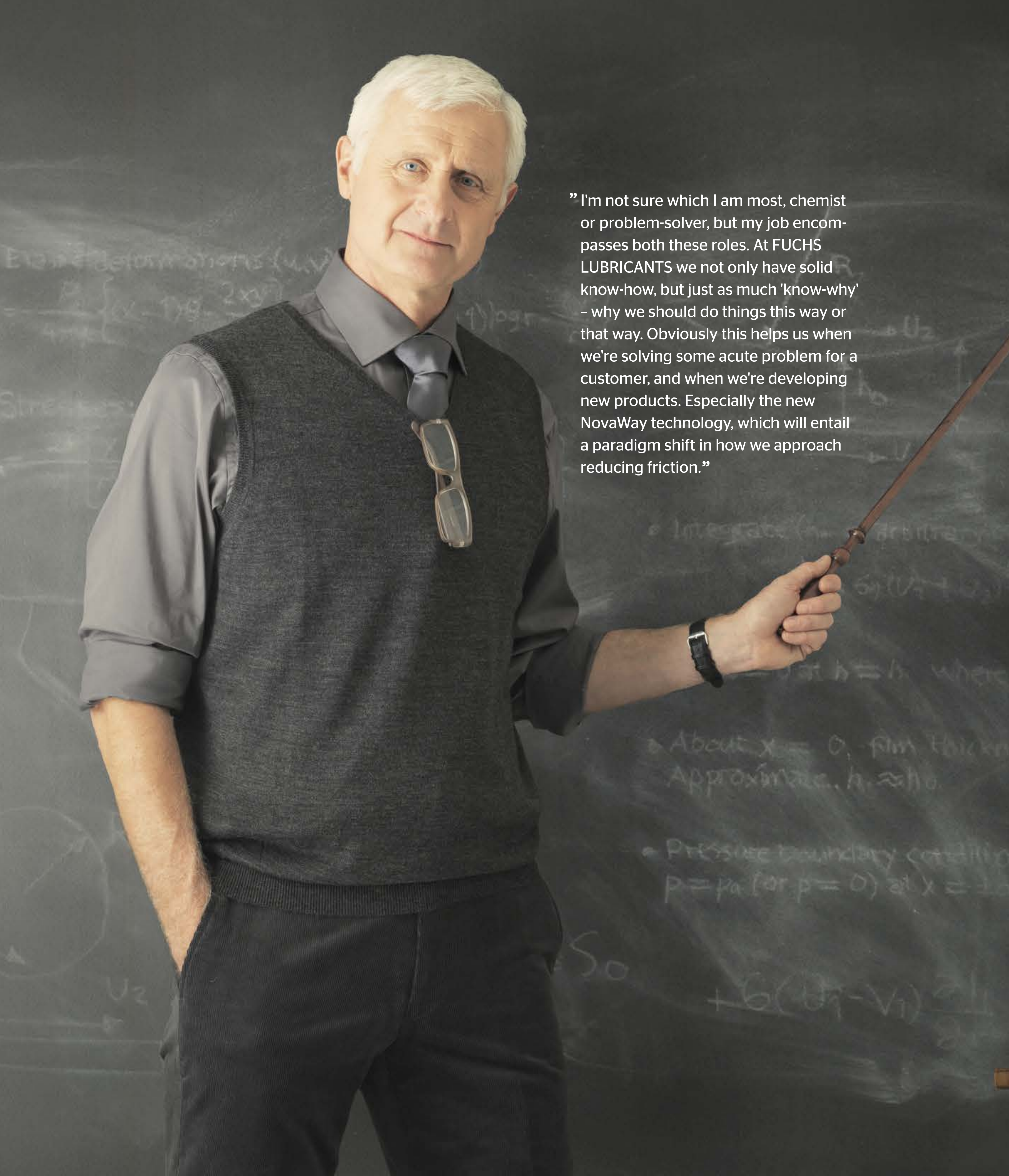
Synthetic base oils are the optimal choice when a product is needed that has a broader temperature interval and greater chemical resistance. Synthetic base oils also have better electrical properties.

The use of greases based on synthetic base oils is increasing, even though they are often slightly more expensive. The higher cost is balanced out by the longer lubrication interval, improved performance and lower maintenance costs.

Some of the more common synthetic base oils are polyalphaolefin (PAO) and esters. Certain types of synthetic ester can be used advantageously in formulating biodegradable greases.

Some of the benefits of synthetic base oils:

- Low volatility
- Improved thermal and oxidative stability
- Higher viscosity index
- Improved fluidity at low temperatures
- Lower internal friction
- Better corrosion protection
- Contain no aromatic hydrocarbons



”I'm not sure which I am most, chemist or problem-solver, but my job encompasses both these roles. At FUCHS LUBRICANTS we not only have solid know-how, but just as much 'know-why' – why we should do things this way or that way. Obviously this helps us when we're solving some acute problem for a customer, and when we're developing new products. Especially the new NovaWay technology, which will entail a paradigm shift in how we approach reducing friction.”

Thickener – The body of a grease

A grease's character is largely determined by the type of thickener used. The thickener is responsible for the structure that keeps the oil in place inside the grease. Properties such as mechanical stability, water resistance, melting point, sealing capacity and re-lubrication interval are all attributable to the thickener.

Grease is usually made by saponifying fatty acids with metal hydroxides. However, there are also soap-free thickeners, such as those based on the NovaWay technology. Thickeners can generally be divided into two main groups: soap-based and non soap-based thickeners, soap-based being the most widely used. Soap-based thickeners in turn can be divided into various subgroups depending on their chemical composition.

The properties of some common thickeners

	Water resistance	Thermal stability	Shearing stability	Load-bearing capacity
Lithium (Li) • The vast majority of greases are based on lithium 12-hydroxystearate	Good	Good	Good	Good
Lithium complex (LiX) • Increasing in popularity compared to traditional Lithium-thickened grease. Broader area of application	Good	Excellent	Excellent	Very good
Water-free calcium (CaH) • Applications in wet environments. E.g. chassis lubrication	Excellent	Good	Very good	Good
Polyurea (PU) • Excellent thermal stability. Lower corrosion-protecting and load-bearing capacity	Good	Excellent	Good	Poor
Calcium sulfonate complex (CaSX) • Excellent load-bearing capacity • Part of the 'functional thickeners' group	Excellent	Very good	Excellent	Excellent
Lithium/Calcium complex (LiCaX) • Excellent properties, e.g. lubrication of open gears • Part of the 'functional thickeners' group	Excellent	Excellent	Very good	Excellent

In addition there are variations and other thickeners. We see great potential for the future and for best performance in the NovaWay technology, as well as in functional soaps.

	Water resistance	Low temperature properties	Additive response	Compatible with other greases
The NovaWay technology • Read more about this in the final lesson	Very good	Excellent	Excellent	Excellent

= Excellent = Very good = Good = Poor

Additive enhances performance

Additives lend a special character to the grease in the form of targeted performance. The additives used in greases are very similar to those used in liquid lubricants.

Some common additives and their function:

- **Antioxidants** increase resistance to oxidation, lengthening the life of the grease
- **Corrosion inhibitors** protect against corrosion
- **EP additive (Extreme Pressure)** counteracts seizure under high pressure
- **Anti-wear** reduces friction and the risk of wear
- **Paste lubricants,** e.g. molybdenum disulphide and graphite, which protect against wear and reduce friction under heavy load and low speed

Mixing different types of greases

When you start to use a new grease in an application, it is important to know whether the new and the old grease are compatible. This depends on whether the thickener and/or the base oil can mix with each other. A number of things can happen when two different greases are mixed:

- Nothing, i.e. the two greases are miscible
- The grease mix hardens, which can be devastating in, say, a central lubrication system
- The grease mix softens. The soap structure is broken down and the greases are not miscible. This can cause leakage and bearing failure
- FUCHS Lubricants can help with miscibility tests ahead of product changes to avoid problems in advance

Thickeners – miscibility

Thickener	Lithium	Lithium complex	Water-stabilised calcium	Water-free calcium	Calcium complex	Calcium sulfonate complex	Clay	Aluminium complex	Barium complex	Polyurea	Sodium	The NovaWay technology
Lithium		+	O	+	–	+	O	–	O	O	–	+
Lithium complex	+		+	+	+	+	–	+	O	–	O	+
Water-stabilised calcium	O	+		+	–	+	O	–	O	O	O	+
Water-free calcium	+	+	+		O	O	+	+	O	–	–	+
Calcium complex	–	+	–	O		+	O	O	–	+	O	+
Calcium sulfonate complex	+	+	+	O	+		–	–	O	+	–	+
Clay	O	–	O	+	O	–		–	O	O	O	+
Aluminium complex	–	+	–	+	O	–	–		+	O	–	+
Barium complex	O	O	O	O	–	O	O	+		O	+	+
Polyurea	O	–	O	–	O	+	O	O	O		O	+
Sodium	–	O	O	–	O	–	O	–	+	O		+
The NovaWay technology	+	+	+	+	+	+	+	+	+	+	+	

\+ Compatible O Miscibility test required – Not compatible

The above table is based on the type of thickener only.
Please note that different types of additive may affect miscibility.

Grease versus oil

There are many advantages to using grease rather than oil in an application. Because of its consistency, grease remains in place better than oil. Grease also offers excellent sealing capacity, good corrosion protection and can withstand heavy loads. A typical application at the moment is in forestry, where lubricating the cutting bar and chain with oil is being replaced by central lubrication with grease.

However, there are certain performance limitations which readily explain why grease is not used in certain applications. Greases cannot lead heat away as well as oil where cooling is required, such as in an engine. Greases cannot be filtered to increase its purity, and it is hard to separate water from the grease.

How to choose the right type of grease

Each application places specific demands on the grease and its performance. Water, dirt, chemicals, temperature, operating speed and load are all examples of parameters that need to be considered when choosing a product.

Base oil viscosity is an important factor just as it is when using lubricating oils, such as gearbox oils. You don't use an ISO VG 46 where you need an ISO VG 320. One NLGI grade 2 grease is not the same as another NLGI grade 2 grease if the viscosity of the base oils is different. When a machine or bearing manufacturer stipulates an ISO VG 46 grease at 40°C, an ISO VG 150 or ISO VG 220 will not work. The wrong grease could lead to overheating and shorter bearing life.

The base oil in a grease usually has a viscosity of between 20 and 500 mm^2/s at 40°C. The application where the grease is to be used governs what base oil viscosity is required.

Low viscosity oils generally work better at low temperatures, while greases with a higher base oil viscosity are used more for heavier loads and higher working temperatures. It is also important to consider the speed/revs per minute of the application. Low speed calls for a high viscosity base oil, while low viscosity oils are to be preferred in fast-moving applications.

Choosing base oil viscosity

Viscosity	High temperature	High load	Low speed
High viscosity 100-500 mm^2/s	↑	↑	↓
Medium viscosity approx. 100 mm^2/s			
Low viscosity base oil 25-80 mm^2/s			
	Low temperature	Low load	High speed

There are however exceptions when it comes to guidelines for base oil viscosity. Greases based on the NovaWay technology does not follow the common rules and experiences of conventional greases. Read more about this in the final lesson.

Generally speaking, there are some guidelines based on the NLGI rating:

NLGI 00/0

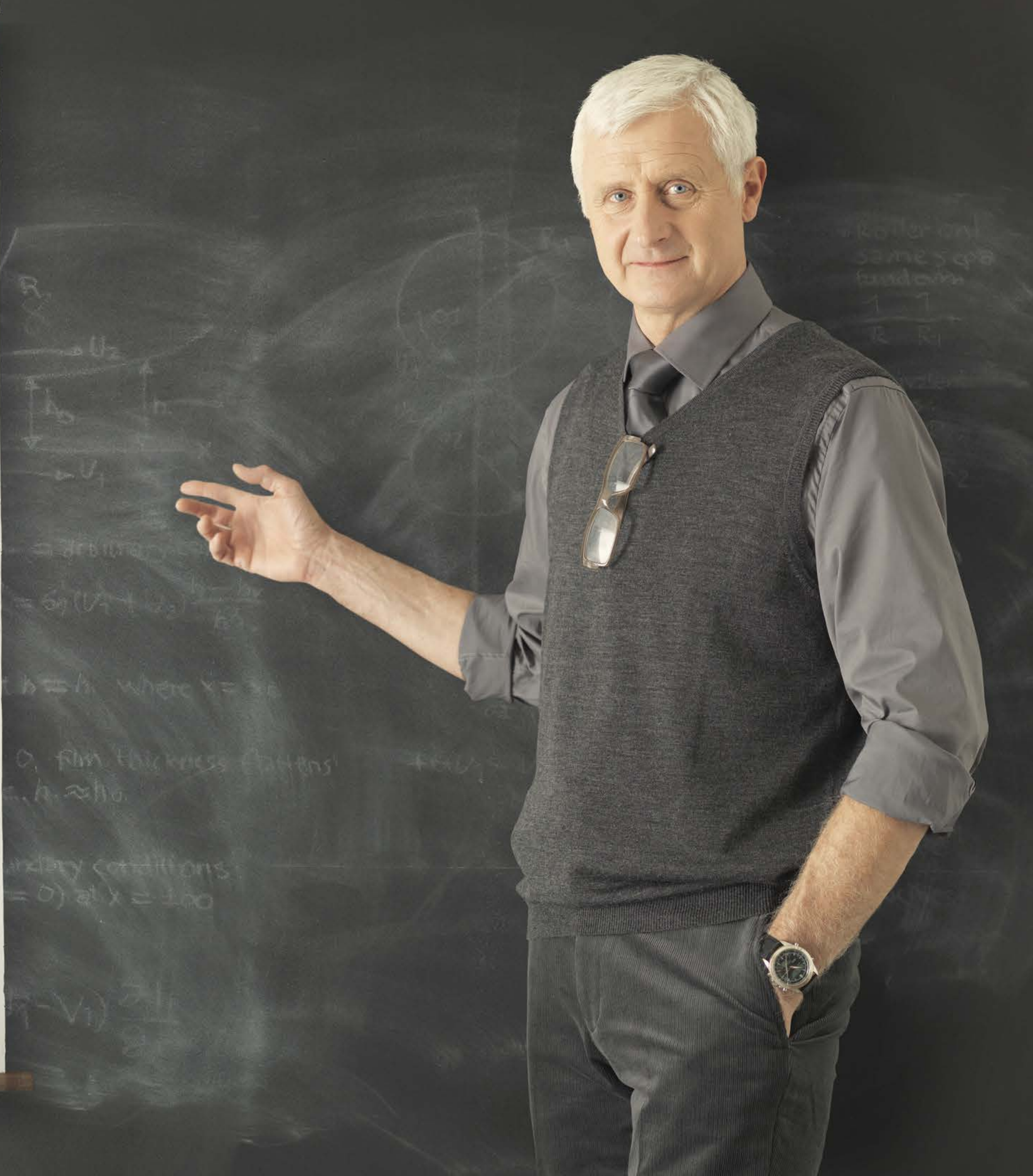
- Lubrication of shafts/axles where good fluidity is required
- Where excellent pumpability is key

NLGI 1

- In low surrounding temperatures
- For oscillating applications
- When good pumpability is required

NLGI 2

- For normal bearing applications



Testing of greases – some common tests

Base oil viscosity

The viscosity of the base oil is perhaps the single most important property in all lubricants, including greases. The thickener and the base oil are what give a grease its lubrication properties, but it is mainly the base oil viscosity that determines the grease's lubrication capacity. Viscosity depends both on temperature and pressure. The temperature is always stated when measuring viscosity, as viscosity decreases as the temperature rises. Viscosity is normally measured in terms of the time it takes for a standard quantity of fluid to flow out through a specific opening at a given temperature. Base oil viscosity is given as 'Kinematic viscosity' in mm²/s at 40°C and also at 100°C.

Method: ASTM D445, ISO 3104, DIN 51562, IP 71

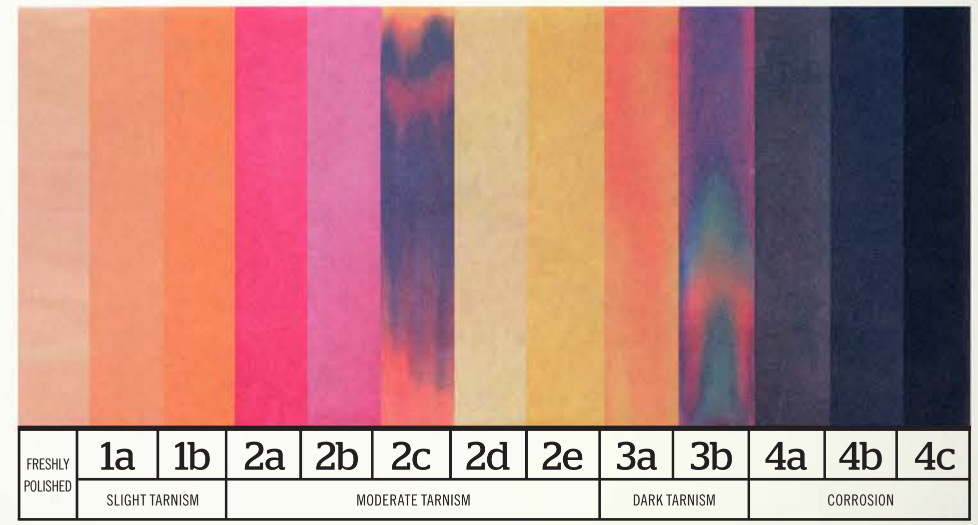
Dropping point

When a grease is heated, it eventually reaches a temperature where the thickener has changed to such an extent that it can no longer keep the oil in place. The dropping point is the temperature at which the grease releases the first drop of oil. The parameter is measured using a standardised method whereby a container of the grease is heated in a furnace until the first drop of oil comes out of the container.

Many people wrongly believe that the dropping point is a measure of the grease's performance at high temperature. In fact the dropping point says nothing about the grease's working properties, nor does it define some kind of upper temperature limit. It is more the fact that at temperatures above the dropping point, the grease is likely to produce more leakage. However, this also depends on whether the higher temperature can be assumed to be constant, or is a temporary peak.

Method: ASTM D566, ISO 2176, DIN 51801, IP 396

ASTM Copper strip corrosion standards



Copper corrosion

Copper corrosion tests are used to determine the grease's ability to protect copper metals/yellow metals and other soft alloys sometimes found in bearings. A polished copper strip is exposed to the grease for a specific time at a specific temperature, usually 24 hours at 100 to 120°C. The strip is then cleaned and the colour is compared to the ASTM standard for grade determination. '1a' is the best rating on the scale.

Method: ASTM D4048, ISO 2160, DIN 51811, IP112/154

Testing of greases

Cone penetration
By far the most common test for greases is cone penetration, which measures the grease's consistency. The grease is heated to 25°C and placed in a container. The grease is subjected to 60 strokes over 60 seconds. A standardised cone is allowed to sink under its own weight into the grease in the container, and the penetration distance is given in tenths of a millimetre. The higher the value, the softer the grease. The resulting value produces an NLGI* rating as per the table to the right. Greases rated NLGI 0 to 000 are often used in central lubrication systems. NLGI 2 is by far the most common consistency, while NLGI grades 3 to 6 are rare.

NLGI rating	Consistency	Penetration mm/10 in 5 secs
000	Fluid	475 – 445
00	Semi-fluid	430 – 400
0	Very soft	385 – 355
1	Soft	340 – 310
2	'Normal' grease	295 – 265
3	Firm	250 – 220
4	Very firm	205 – 175
5	Hard	160 – 130
6	Very hard	115 – 85

Nowadays it is common to add a consistency rating between the various established NLGI ratings. These are designated by half values, such as 1.5 or 2.5.

Method: ASTM D217, ISO 2137 DIN 51580, IP 50

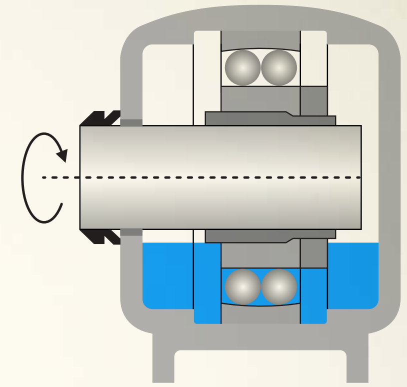
Water resistance
Water resistance according to the water washout test is used to measure the grease's ability to remain in place in the bearing in wet conditions. A water jet is sprayed onto the bearing's housing at a flow of 5 ml/s at 79°C. After the test, the housing is opened and dried at 77°C for 15 hours. The result is the amount of washed-out grease. The higher the percentage of grease remaining in the bearing, the better its resistance to water washout.

Method: ASTM D1264, ISO 11009, DIN 51807/2, IP215
* NLGI = National Lubricating Grease Institute

Corrosion protection
The EMCOR test is a dynamic test for evaluating the grease's corrosion protection capacity in a bearing. The test can be run with distilled water, synthetic salt water or a specific process water. A specially designed bearing is filled with the grease that is to be tested. The bearing is mounted onto a motor-driven shaft and placed in a closed housing which is sealed at one end (water must be able to pass through the bearing).

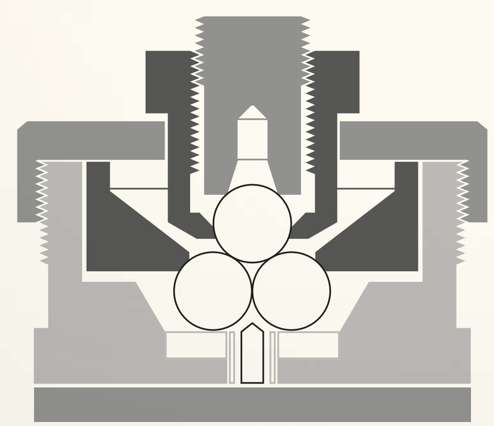
The bearing alternates between operational and stationary over a specific test cycle. The outer ring is then assessed on a scale of 1 to 5, where 0 = no corrosion and 5 = heavy corrosion.

Method: ISO 11007



Load-bearing capacity
The 4-ball weld test is a method for measuring the maximum load-bearing capacity or EP/ extreme pressure properties of a grease. At the weld point, the maximum load the grease can withstand has been exceeded and the grease no longer provides any lubrication. It can be hard to compare results from different test methods.

The test entails filling a container with grease. Three clean steel balls are sunk into the grease and locked into place with a ring and nut. The fourth ball is mounted into the machine above the three others. A given weight burdens the torque arm to produce a specific pressure. The top ball rotates at 1420 rpm for 60 seconds and the test is repeated with increased load until the balls weld together. The result is given in Newtons, N.



Wear-resistance
The 4-ball wear test is used as a method of measuring the grease's ability to prevent wear under demanding conditions. The grease's wear resistance is examined in sliding contacts steel on steel. The test is set up the same as the 4-ball weld test, but with a limited load and more sensitive equipment. Once the test is complete, the size of the wear marks on the three stationary balls is measured. The lower the value, the better the grease's wear resistance under dynamic strain.

Method: ASTM D2266, DIN 51350, IP 239

The risks of over-lubrication

The correct amount and frequency of lubrication are important to the function. More is not always better, in fact with greases overdosing can be very costly.

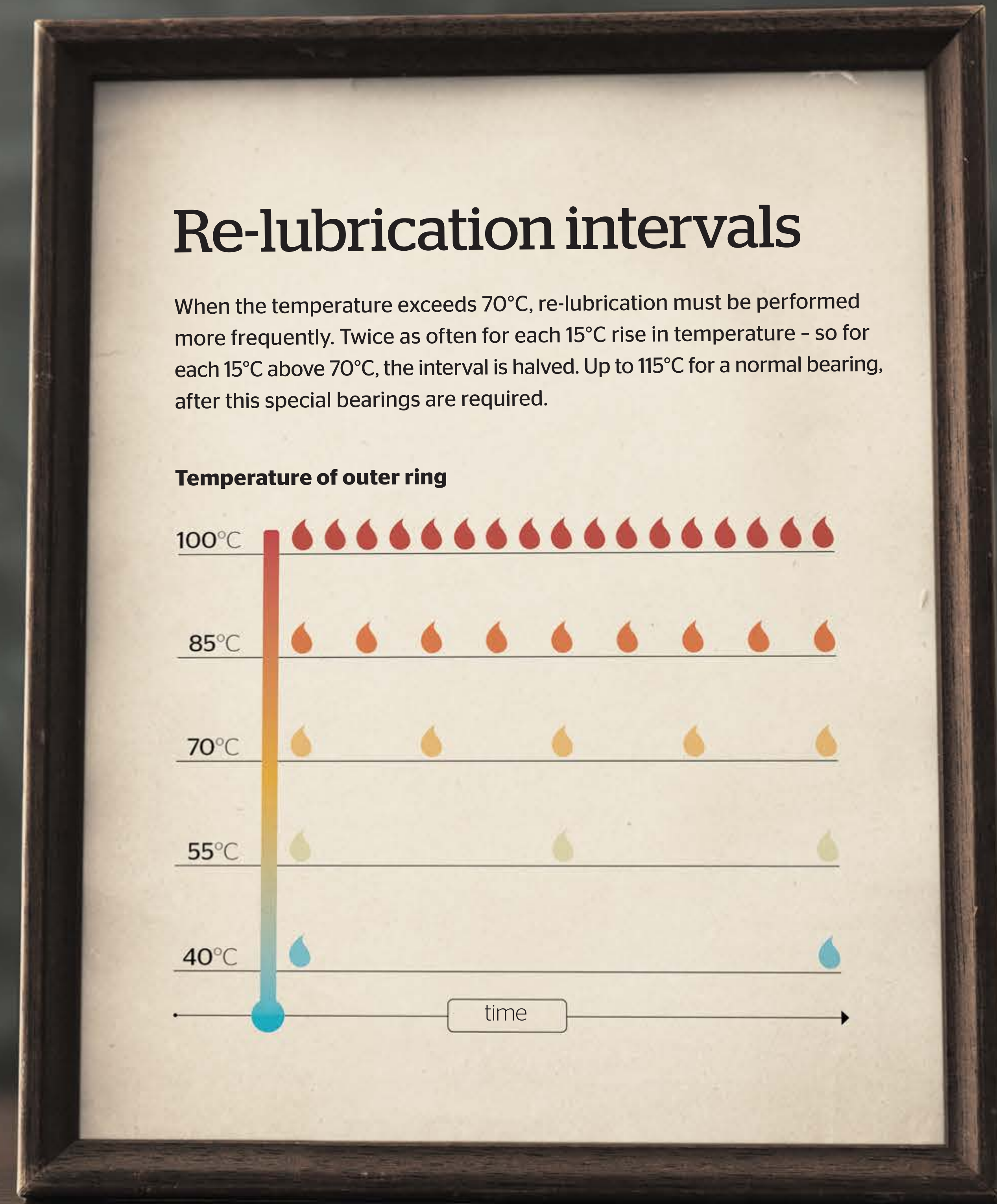
Over-lubrication of bearings can lead to higher temperature and subsequent oxidation of the grease, which degrades and ages far more quickly. Energy loss in the bearing increases, oil can 'bleed' out from the grease, and the thickener solidifies under long-term high temperature. New grease may not reach the lubrication point, and this can lead to higher component wear and eventually bearing failure. Seals can also be damaged by over-lubricated bearings. Excessive pressure from the grease gun when lubricating bearings can also damage the seal, potentially allowing water and pollutants in, which leads to wear and corrosion.

For the best results in industry, for example, all lubrication points should be reviewed and a maintenance schedule established. A meticulous review of the amount of grease and re-lubrication intervals is usually required. Calculation software is available for this, and FUCHS Lubricants's application engineers work in close collaboration with different industrial sectors, setting up lubrication schedules and recommending the best products for optimal performance and reduced maintenance costs.

Read the bearing manufacturer's instructions to ensure the best function, and consult one of our application engineers for professional advice.

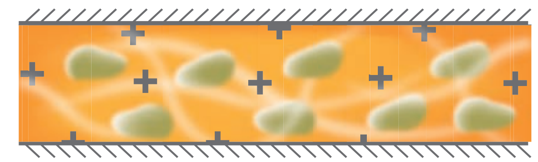
Points to remember for re-lubrication

- Ideally use the same type of grease as in the application. If not – check miscibility
- Re-lubricate at operating temperature and during rotation
- Re-lubricate before any long period of down time
- Do not over-lubricate
- The re-lubrication interval may need to be adjusted depending on temperature, oscillation, load and environment. Consult your contact at FUCHS Lubricants

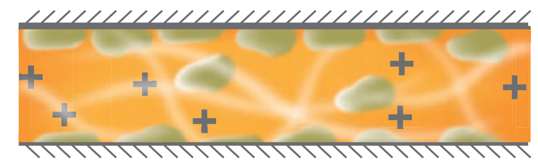


The final lesson: The NovaWay technology

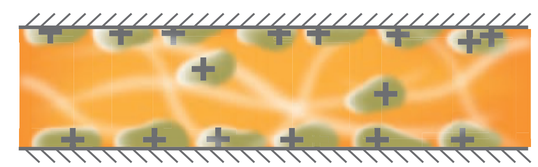
We are heralding in a new era in the world of greases. Turning everything we've learnt so far on its head. Greases based on the NovaWay technology does not adhere to our previously mentioned rules and principles on choosing a product based on base oil viscosity, NLGI ratings and calculations.



Greases based on the NovaWay technology. The additives can reach the metal surfaces and do their job.



Conventional soap-based grease has a higher polarity than the additives. Consequently, a large amount of additive does not reach the metal surfaces.



Grease based on functional soaps. The soap and the additives are intertwined – more additive reaches the surface, but a fair amount gets blocked in the middle.

Soap   Additive   Oil

So what exactly is the difference between NovaWay greases and grease based on conventional thickener?

Part of the performance relates to the additives and their function. The thickener in conventional greases (such as lithium or lithium complex grease) has a higher polarity than the additives, and it is therefore hard for the additives to reach the metal surface.

In 'functional thickeners' (such as calcium sulfonate complex), the additives are more integrated into the thickener. They may work slightly better, but that does not fully resolve the problem of enabling the additives to reach the metal surface.

In NovaWay greases, however, the additives reach the metal surfaces and can do the job more effectively. See the figure, which provides a general overview of this.

A whole new world of opportunities is opening up

When you can use the same NovaWay grease for slow-moving bearings under heavy loads as for fast-moving bearings, all kinds of new opportunities open up. This is a relatively new technology and we are constantly expanding our knowledge in applications for these greases. With the experience we at FUCHS Lubricants have amassed to date, there is great potential for reducing the number of greases needed in an industrial company that has varying requirements on grease performance in different applications.

There are many applications where conventional grease does not work well enough. When it comes to resistance against over-rinsing with aggressive chemicals and water, the adhesion and low solubility of NovaWay greases are why they are good problem-solvers in such cases. A longer re-lubrication interval and reliable operation contribute to lower costs for maintenance, yet another argument in favour of these products' performance.

Where can the NovaWay greases be used?

Some examples are industries where there is contact with process water and/or acids, bases or metalworking fluids. This includes bearing lubrication in rolling mills, and alkaline environments in the paper and pulp industry, where NovaWay offers excellent adhesion, good sealing capacity and excellent corrosion protection.

NovaWay can contribute to a better environment in applications where the lubrication interval can be extended. The products are also suitable in various automotive and marine applications. For instance, the NovaWay greases are good alternatives to lithium based greases, where the price of lithium could increase and access decrease as the use of lithium increases in the electronics industry.

There are far more applications than the examples mentioned above, and we are constantly expanding our experience around the products.

If you would like to know more, please contact us!

Notes