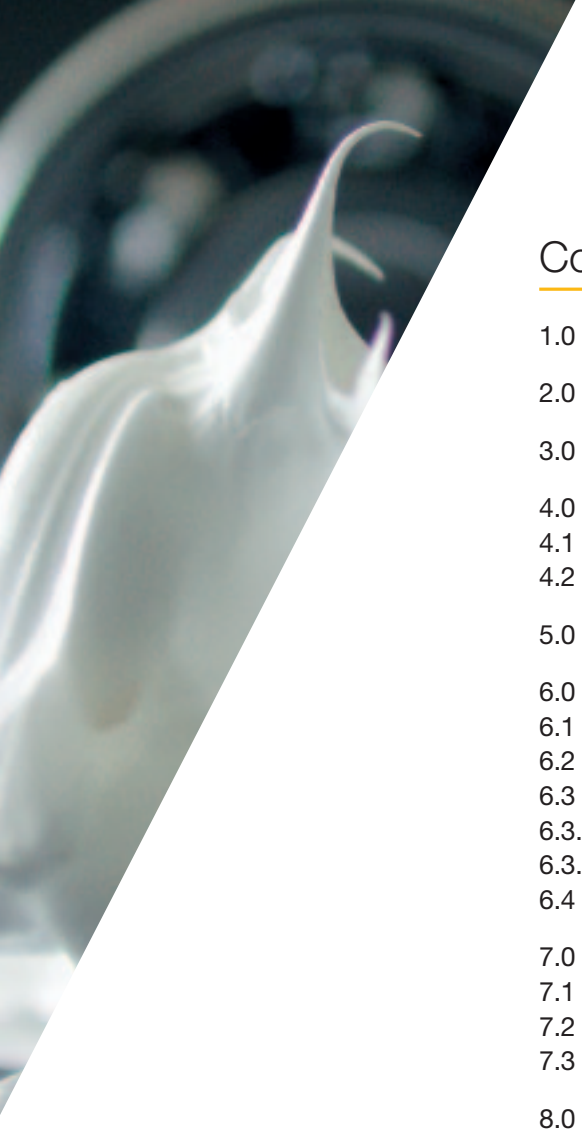
KLÜBER LUBRICATION

The Element That Rolls The Bearing

A bearing is only as good as its grease /
Klüber offers product variety and service

Lubrication is our World



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1.0 Rolling bearing lubricants manufactured by Klüber Lubrication

Rolling bearings are among the most important machine elements.

They may be designed as ball or roller bearings, radial or thrust bearings; what they all have in common is the transmission of load and power via rolling elements located between bearing rings. This is a simple and successful principle, at least as long as the contact surfaces remain separated. However, if the surfaces contact one another, there can be trouble ahead: the resulting damage caused may be anything from light, hardly perceptible surface roughening, pronounced sliding and scratching marks, to extensive material transfer that may promote premature bearing failure - with expensive consequences!
A vital requirement for low-wear or even wear-free operation of rolling bearings is the sustained separation of the friction surfaces by means of a suitable lubricant. Ideally, the lubricant should fill all the free bearing space and completely envelop the cage and rolling elements.

Fit for new challenges

At Klüber Lubrication, several generations of experts have been developing special high-performance lubricants for half a century. The people here are aware that a rolling bearing is only as good as the lubricant it contains. At Klüber, lubricants are considered vital design elements that require constant improvement as operating conditions under which rolling bearings are expected to perform become tougher and tougher for rolling bearings are not without complexity. While a few years ago, for example, 60,000 operating hours was considered a good operational lifetime for bearings in a fan motor, today 110,000 operating hours or more is expected.

Taking care of bearings worldwide

Klüber Lubrication meets these requirements by developing new, innovative speciality lubricants and offering customer-oriented service: we provide immediate solutions to difficult lubrication and application problems plus comprehensive information and reliable supply around the globe. Just call or e-mail – we will be there to assist you.

In close cooperation with customers, Klüber Lubrication develops rolling bearing lubricants – mostly greases – that are specifically tuned to the application at hand. These special lubricant developments are based on the latest know-how in tribology, contain the highest quality raw materials and have been extensively tried and tested.

Keeping the ball rolling

Whether your bearings are installed in paper-making or printing machines, household appliances, food-processing plants or even in aerospace applications, rolling bearing greases from Klüber Lubrication will help them do what they’re designed for: rolling.

2.0 Basics of grease lubrication

The most important task of a lubricating grease is to separate parts moving relative to one another in order to minimize friction and prevent wear. A grease that is specifically designed for certain operating conditions will provide a reliable load-bearing wear protective lubricating film. If friction surfaces are separated in this way, one speaks of “physical lubrication”.

However, rolling bearings rarely operate under ideal conditions; they are exposed to the influences of temperature or varying speeds, the lubricating film is therefore changing continuously. Under adverse conditions, the result may be contact between the two friction surfaces. The thinner the load-bearing oil film becomes, the more important is the formation of a lubricating layer on the surfaces of the friction bodies. This happens through the chemical reaction of additives and is therefore referred to as “chemical lubrication”.

So what is lubrication all about?
Basically, we differentiate between three different lubricating conditions:

a) Boundary lubrication

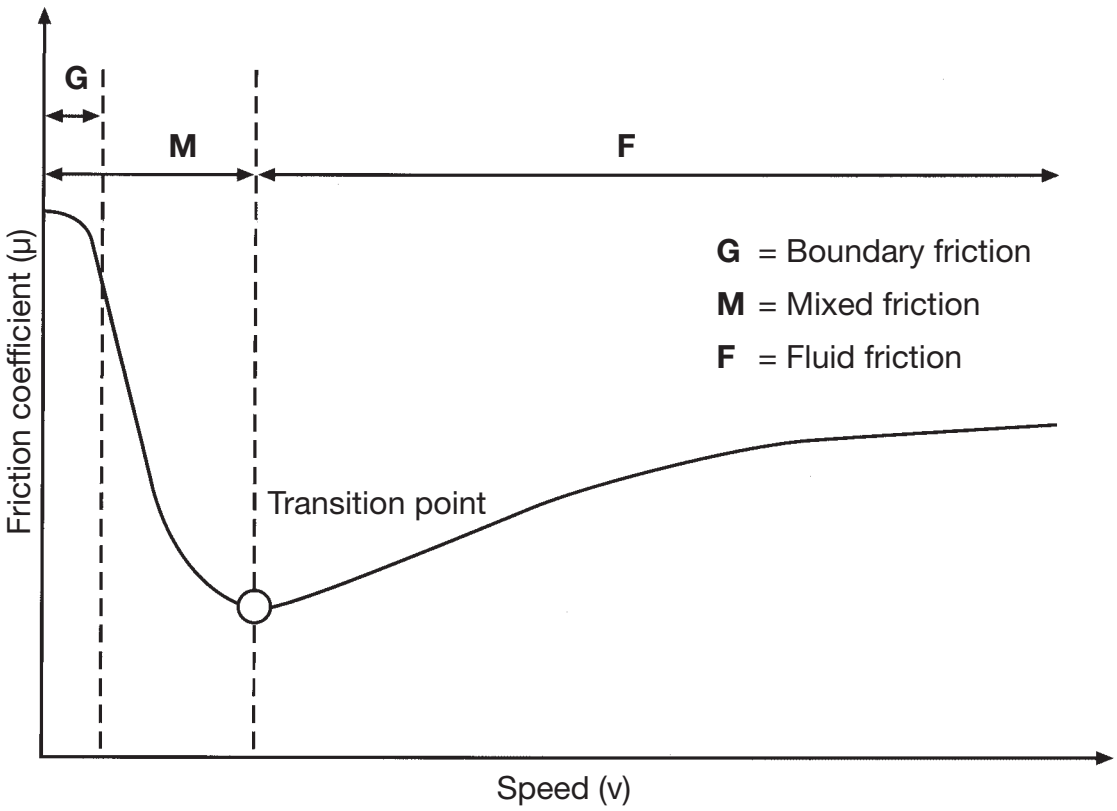
Under boundary lubrication conditions, load is transmitted via continuous surface contact. In combination with poor lubrication this may lead to extreme wear and premature bearing failure. This potentially damaging condition can be prevented by the use of extreme-pressure additives or by the use of solid lubricants. Some heavy-duty greases containing suitable additives for wear protection can also be considered. A special lubricating protective effect can also be attained by means of “sandwich lubrication” consisting of a coated surface in combination with a secondary lubricating grease.

b) Mixed lubrication

Under mixed-friction lubrication conditions, variable load is transmitted partly between the surface asperities across the roughness peaks in contact with one another, and partly via a lubricant film. Wear protection additives should be used under these conditions to prevent excessive wear.

c) Full-film lubrication

Full-film lubrication is the optimum lubrication condition characterized by complete separation of the surfaces by a load-bearing lubricant film. Depending on the internal friction of the lubricant, extremely low friction coefficients can be attained.



Stribeck curve

Friction

Theoretically, the resistance met by the rolling elements when contacting the bearing raceways is assumed to be of a purely rolling nature. In practice, however, partial sliding may occur between the rolling elements and the raceways. Sliding between the cage and the rolling elements can also occur resulting in churning or displacement of the lubricant.

The frictional moments, and hence the friction coefficient μ, are dependent on the load, the lubricating condition and the bearing speed. The Stribeck diagram (see Fig.) shows the friction coefficient μ relative to the speed v. In the diagram, we can discern the three different lubricating conditions:

- ❑ boundary lubrication
- ❑ mixed lubrication
- ❑ full-film lubrication

The curve of the friction coefficient μ indicates the increase and decrease of the frictional moments that occur in line with a temperature increase and decrease in the bearing.

3.0 Overview of rolling bearing greases

There are a large variety of grease options to be considered by the manufacturers and users of rolling bearings. In the following overview you will find a selection of available types along with their relevant characteristics such as service temperature range, drop point, water resistance, corrosion protection, extreme-pressure

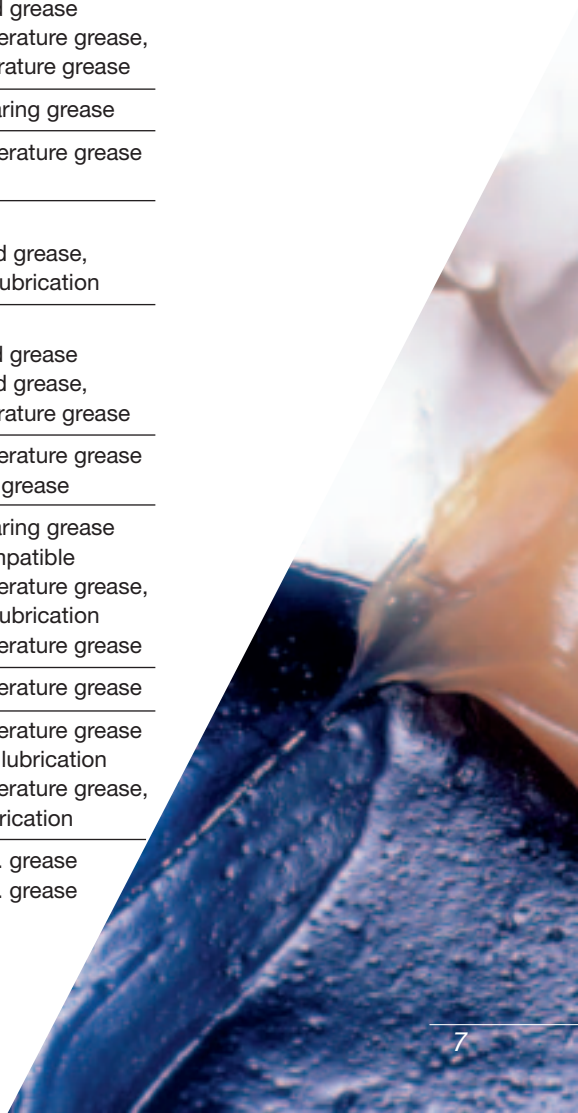
Greases	Indications		
Thickener	**Base oil**	**Service temperature range**[1] [°C]	**Drop point** [°C]
Calcium soap	Mineral oil	-20 to 50	< 100 some < 130
Lithium soap	Mineral oil PAO Ester oil Silicone oil	-35 to 130 -50 to 150 -65 to 150 -60 to 170	< 200 < 200 < 200 < 200
Sodium soap	Mineral oil	-20 to 100	< 130
Aluminium complex soap	Mineral oil	-30 to 160	> 230
Barium complex soap	Mineral oil PAO	-30 to 140 -50 to 150	> 220 > 220
Sodium complex soap	Mineral oil Silicone oil	-30 to 160 -50 to 200	> 220 > 220
Calcium complex soap	Mineral oil Ester oil	-30 to 130 -40 to 120	> 220 > 220
Lithium complex soap	Mineral oil PG Ester oil Silicone oil	-30 to 140 -30 to 150 -40 to 180 -40 to 180	> 230 > 230 > 230 > 230
Bentonite	Mineral oil	-20 to 160	–
Polyurea	Mineral oil PAO Ester oil	-20 to 160 -40 to 160 -40 to 180	> 250 > 230 > 230
Synthetic (PE, PTFE, FEP)	Silicone oil Alkoxy fluorine oil	-50 to 200 -40 to 250	> 230 not measurable

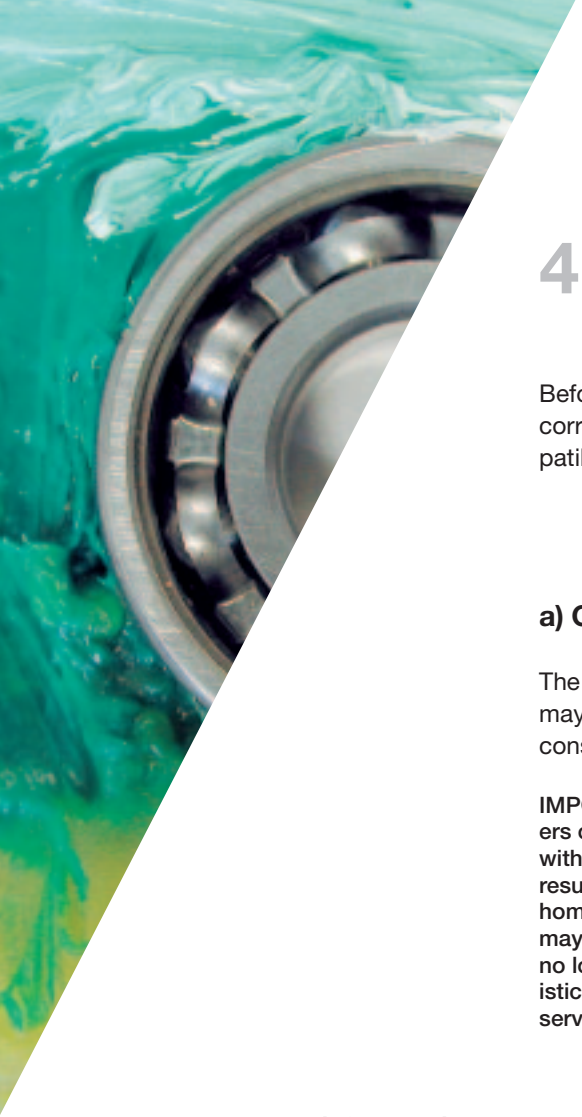
[1] *see page 63*

characteristics and suitability in rolling bearings as well as notes on possible applications.
NLGI consistency classes 2 or 3 are selected for the majority of rolling bearing applications.

Legend	
+++	very good
++	good
+	satisfactory
–	sufficient
– –	poor

Water resistance	Corrosion protection	Pressure resist-ance	Suitability for rolling bearings	Application notes
+++	++	++	–	Rolling bearing grease
++	++	+	+++	Rolling bearing grease
++	++	++	++	Low-temperature grease
+	+	+	+++	Low-temperature grease, high-temperature grease, high-speed grease
++	–	–	++	High-temperature grease, low-temperature grease
–	+++	+	++	Rolling bearing grease
+++	+++	++	+++	High-temperature grease
+++	+++	+++	+++	EP grease
+++	+++	+++	+++	High-speed grease, long-term lubrication
+	+++	++	+++	EP grease, high-speed grease
++	+	–	+++	High-speed grease, low-temperature grease
++	+++	++	+++	High-temperature grease
++	++	++	++	Long-term grease
+	++	++	+++	Rolling bearing grease
+	++	++	++	EPDM-compatible
++	++	++	+++	High-temperature grease, long-term lubrication
++	++	–	+	High-temperature grease
++	–	–	++	High-temperature grease
+++	+	–	++	High-temperature grease
+++	++	+	++	Long-term lubrication
+++	++	+	+++	High-temperature grease, lifetime lubrication
+++	+	–	++	High-temp. grease
+++	+	++	++	High-temp. grease





4.0 Miscibility of greases

Before mixing different greases, or greases and oils (e.g. anti-corrosion oils), both substances should be checked for compatibility to prevent occurrence of the following problems:

a) Grease/grease

The mechanical stability of the mixture may suffer; negative changes to grease consistency may occur!

IMPORTANT: Different types of thickeners or base oils may not prove miscible with one another. When mixed, the resulting substance may not be fully homogeneous (two separate phases may result). The grease "mixture" may no longer maintain its original characteristics becoming extremely unreliable in service!

b) Grease/oil

Anticorrosion oils originally applied to the bearing may not necessarily be as pure as the rolling bearing grease selected. Mixing the two substances may therefore lead to a loss of purity, thereby affecting the low-noise operating characteristics. The upper service temperature limit of high-temperature grease may also suffer from the influence of "standard" mineral-oil-based anticorrosion oil due to its chemical decomposition at elevated temperatures.

IMPORTANT: Optimum adhesion between a grease and metallic surfaces can only be ensured if no other substance (e.g. anticorrosion oil) is present between the two, the only exception being anticorrosion oils that are specifically tuned to the particular grease used. Greases based on PFPE oils require clean surfaces for attainment of maximum adhesion.

The following tables provide an overview regarding miscibility of thickeners and base oils. For this purpose, mixing ratios of 50:50 are assumed.

HINT: Since additives may also have undesirable effects when mixed, we recommend consulting the manufacturer of the particular lubricating grease prior to use.

4.1 Miscibility of thickeners

Legend

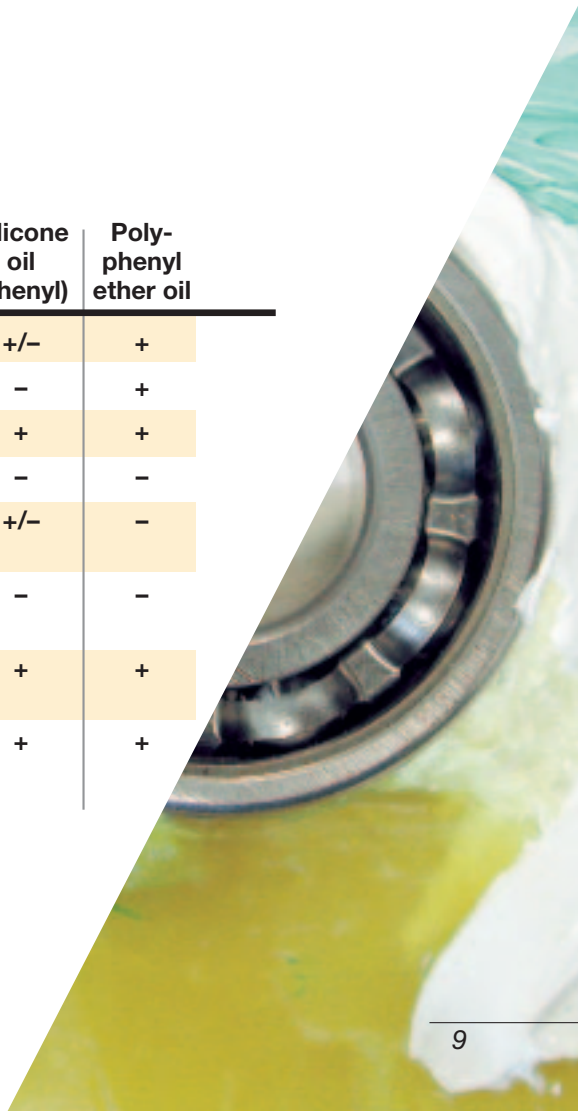
+	miscible
+/–	partially miscible
–	not miscible

Base oils must be miscible

		Metal soaps				Complex soaps					Other thickeners		
		Al	Ca	Li	Na	Al	Ba	Ca	Li	Na	Bentonite	Polyurea	PTFE
Metal soaps	Al	+	+/–	+	+/–	+	+/–	+	+	+/–	+	+	+
	Ca	+/–	+	+	+	+	+	+	+/–	+	+	+	+
	Li	+	+	+	–	+	+	+	+	–	+/–	+/–	+
	Na	+/–	+	–	+	+	+	+/–	+/–	+	–	+	+
Complex soaps	Al	+	+	+	+	+	+	+/–	+	+/–	+/–	+/–	+
	Ba	+/–	+	+	+	+	+	+/–	+/–	+	+	+/–	+
	Ca	+	+	+	+/–	+/–	+/–	+	+	+	+/–	+	+
	Li	+	+/–	+	+/–	+	+/–	+	+	+/–	+	+/–	+
	Na	+/–	+	–	+	+/–	+	+	+/–	+	–	+	+
Other thickeners	Bentonite	+	+	+/–	–	+/–	+	+/–	+	–	+	+	+
	Polyurea	+	+	+/–	+	+/–	+/–	+	+/–	+	+	+	+
	PTFE	++	+	+	+	+	+	+	+	+	+	+	+

4.2 Miscibility of base oils

	Mineral oil	Synth. hydro-carbon	Ester oil	Poly-glycol	Silicone oil (methyl)	Perfluoro-alkyl ether	Silicone oil (phenyl)	Poly-phenyl ether oil
Mineral oil	+	+	+	–	–	–	+/–	+
Synthetic hydrocarbon	+	+	+	–	–	–	–	+
Ester oil	+	+	+	+	–	–	+	+
Polyglycol	–	–	+	+	–	–	–	–
Silicone oil (Methyl)	–	–	–	–	+	–	+/–	–
Perfluoro-alkyl ether	–	–	–	–	–	+	–	–
Silicone oil (Phenyl)	+/–	–	+	–	+/–	–	+	+
Poly-phenyl ether oil	+	+	+	–	–	–	+	+



5.0 Compatibility with elastomers and plastics

Besides miscibility with other greases, the compatibility of a lubricant with elastomers and plastics should be tested prior to its use.
Such tests normally consist of immersing materials into the grease at the required operating temperature for several hours or even up to one week. When removed, change in volume, Shore hardness, tensile strength and elongation at tear are measured.
Based on our many years of experience with materials compatibilities, our tables a) elastomers and b) plastics provide some basic hints as to which material combinations should be normally preferred and which avoided. To make sure, however, lubricant and elastomer/plastic compatibility, tests should be performed.

Legend	
+	resistant
+/–	partially resistant
–	not resistant

a) Elastomers

	Mineral oil	Synth. hydro-carbon	Ester oil	Poly-glycol	Silicone oil	PFPE	Poly-phenyl ether
NBR	+	+*	+/–	+/–	+	+	+
HNBR/NEM	+	+	+/–	+/–	+	+	+
FPM/FKM	+	+	+	+	+	+	+
EPDM	–	–	–	+	+	+	-
ACM	+	+	+/–	+/–	+	+	+
AU	+	+/–	+/–	+/–	+	+	+/–

b) Plastics

	Mineral oil	Synth. hydro-carbon	Ester oil	Poly-glycol	Silicone oil	PFPE	Poly-phenyl ether
POM	+	+	+	+	+/–	+	+
PA	+	+	+	+	+	+	+
PE	+/–	+/–	+/–	+	+	+	+/–
PC	+**	+***	–	–	+	+	–
ABS	+**	+***	–	+/–	+	+	–
PTFE	+	+	+	+	+	+	+

* *slight shrinkage in most cases*
** *with white oil*
*** *without additives*