KLÜBER LUBRICATION

your global specialist

Make bearings live longer.

Plain bearing lubrication: product selection and tips

Plain bearings and lubricants: our solutions to meet your application requirements

Breathtakingly high speeds, extreme temperatures from –180 to +450 degrees Celsius and the effects of aggressive media – these are the stressful conditions under which plain bearings are expected to function reliably. Correct lubrication contributes to more reliable operation by improving wear resistance, corrosion protection and importantly by providing enhanced bearing service lifetime.

Klüber Lubrication has developed a wide range of high-quality special lubrication products to cover all aspects of plain bearing lubrication. This range encompasses high-performance greases for extreme load conditions, food-grade lubricants for the food-processing and pharmaceutical industries, rapidly biodegradable lubricants for applications in agriculture, forestry and the water resources industry as well as EAL* bio-lubricants for marine applications.

The bearing lubricant – a design element in its own right!

By selecting a lubricant specifically for your application, you can already start making a positive effect on the bearing life in the design phase. A carefully selected lubricant can provide, among other things, low-wear operation under mixed-friction operating conditions, low friction torque at high speeds or improved start-up behaviour under stop-start conditions.

HINT:
The more information we have on your application the better we can determine which lubricant is the optimum choice in your case. In this context, please request our Technical Questionnaire “Plain bearings” for entry of all relevant application data. We look forward to hearing from you!

The heartbeat of industry

We optimise our plain bearing lubricants in close cooperation with plain bearing manufacturers and scientific institutions. We use plain bearing test rigs to develop our lubricants and to assess their performance capabilities. The result is a multitude of customised product solutions for special plain bearing applications as well as recommendations for customers provided by both Klüber Lubrication and plain bearing OEMs for their customers in various industrial sectors such as cement, marine, energy, food-processing and pharmaceuticals.

Think about tomorrow today!

With low friction values and low-wear operation, high-performance lubricants contribute to energy saving reducing CO_2 emissions. Longer relubrication intervals or even lifetime lubrication can help to reduce lubricant consumption with reduced oil disposal effects decreasing the strain on natural resources with both maintenance and disposal costs reduced. An example of savings can be found on page 10.

Klüber Lubrication – the right choice for you!

Within this brochure we would like to provide you with valuable information on the lubrication of bearings. You have your own specific design requirements – we can offer you the most appropriate value-added lubrication solution for a wide range of applications. See the following range of lubricants for plain bearings divided into five sections:

- Oils for hydrodynamic plain bearings
- Oils for plain bearings in the food-processing industry
- Eco-compatible oils
- Greases for plain bearings operating under mixed friction conditions
- Bonded coatings enabling optimised running-in as well as for “dry-running” plain bearings

*Environmentally Acceptable Lubricants

Plain bearings as tribo-systems

The German Society for Tribology states that the damage caused to the national economy by friction and wear is at approximately 5 % of the annual gross domestic product. Extrapolated to the world's four largest economic regions, this would amount to a figure in the region of two billion US dollars.

When the bearing's operating "tribological system" is considered and adequately taken into account, considerable savings can be achieved. After all, lower friction leads to lower wear, which in turn extends component life and increases energy efficiency.

The friction condition within the plain bearing, ranging from boundary to fluid friction and lastly hydrodynamic friction, can be easily discerned in the Stribeck curve, see diagram a).

Diagram b) shows the Stribeck curve effect for oils of different viscosity.

The diagram shows that the higher the viscosity, the quicker the transition point in which fluid friction is reached. Fluid friction is the ultimate speed-related safe state where the plain bearing and the shaft are reliably protected against wear by a full fluid film. At high rotational speeds, however, internal friction may rise significantly should an excessively high-viscosity oil be employed.

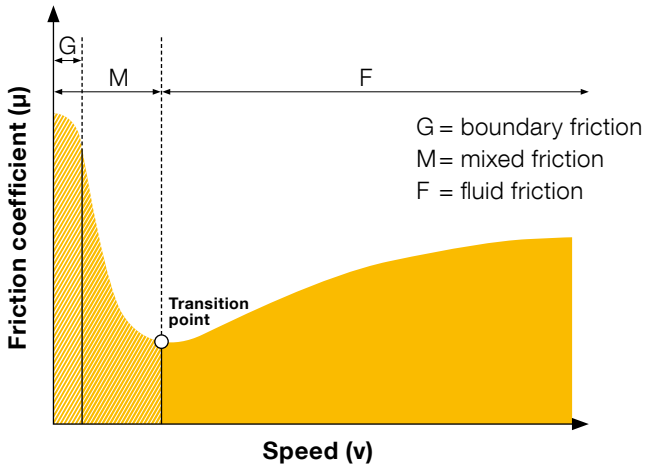
Important: High internal friction can result in high temperature generation, which in turn will negatively affect the oil's ageing behaviour and operational lifetime.

Conclusion: For plain bearings operating mainly in the hydrodynamic friction range, it is better to use a lubricant incorporating a lower viscosity oil. For plain bearings running at lower speeds, by contrast, a lubricant incorporating a higher viscosity oil should be used.

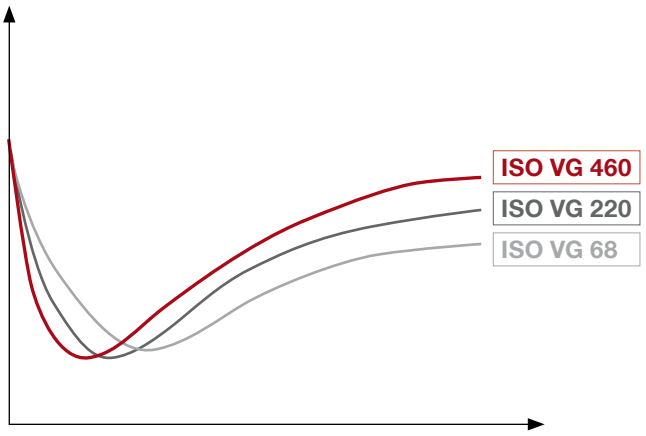
Question: What should you do if bearings operate under continuous start-stop conditions?

Solution: Use a lubricant with sufficiently effective anti-wear additives or solid lubricants, taking into account compatibility with bearing materials.

a) Different friction conditions, from boundary friction to fluid friction



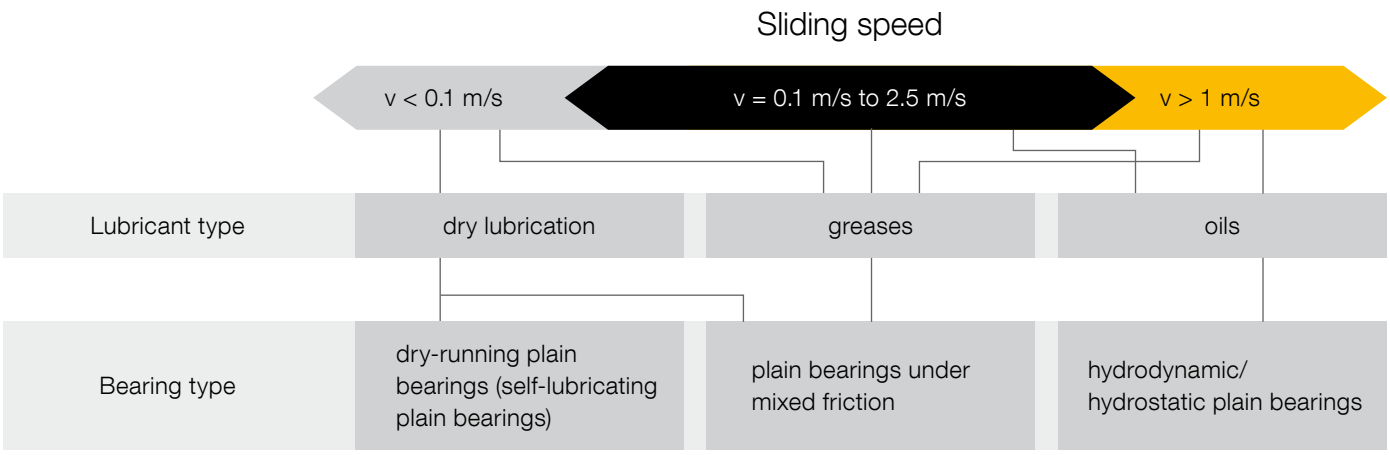
b) Stribeck curve for different oil viscosities



Depending on the plain bearing type and the friction condition, self-lubricating plain bearing materials or coatings may also be used (see bonded coatings, page 20 ff.). Lubricating pastes containing solid lubricants or greases (page 16 ff.) can also provide highly effective lubrication solutions for applications where a centralised lubricating system cannot be used and where continuous relubrication is undesirable.

The following figure indicates the sliding speed above which oils should preferably be selected as lubricants – hydrodynamic conditions occur at speeds of approximately 1 m/s. Where mixed friction prevails, there is a trend to use greases since they ensure good lubricant adhesion to the surface. Purely dry lubrication with solid lubricants may be preferable at very low speeds with limited generation of frictional heat. In other cases, plain bearings exposed to extreme heat conditions may suffer reduced operational lifetime.

Plain bearing lubrication for different speeds



Depending on sliding speed and bearing type, different types of lubricant are used in plain bearings.

Oils for hydrodynamic plain bearings

Continuous operation with low wear and minimum friction during start-up and slow-down are the prerequisites of hydrodynamic plain bearings offering full performance. Oil-lubricated plain bearings will only attain their specified service life if the correct lubricant and required viscosity are used.

To enable selection of the optimum lubricant for a given application, the operational technical requirements should be established as comprehensively as possible.

As sliding speeds, loads and temperatures can vary, a single lubricant may not be the optimum solution for all operating conditions. Different viscosities and possibly different oil types, such as mineral or synthetic oils, are available to obtain the best possible results in each individual application.

A wide variety of possible lubrication options has been outlined within this brochure. You may also use our plain bearing Technical Questionnaire to collect the most important parameters required to select a suitable lubricant. You can obtain this questionnaire from your local Klüber Lubrication representation or contact.

Differentiation is made between dynamic and kinematic viscosity. Dynamic viscosity η and kinematic viscosity ν are directly interrelated via density ρ. Temperature and pressure should also be observed.

$$\eta = \nu \cdot \rho$$

In the system of SI units, the following applies: a substance located between two plates has the viscosity 1 Ns/m² if, for plates the size of 1 m² each, and placed at a distance of 1 m, a force of 1 N is needed to move the plates parallel to one another with a speed of 1 m/s.

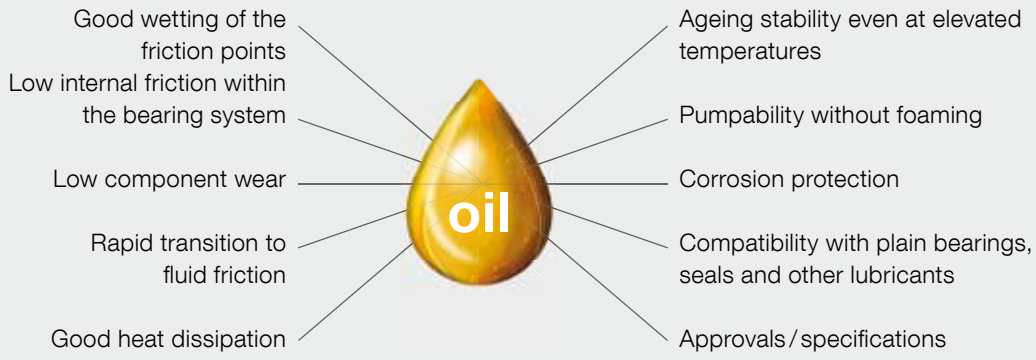
For the SI unit of kinematic viscosity, the following applies:

$$[\nu] = \frac{m^2}{s}$$

Thus, the following applies for the physical unit of dynamic viscosity:

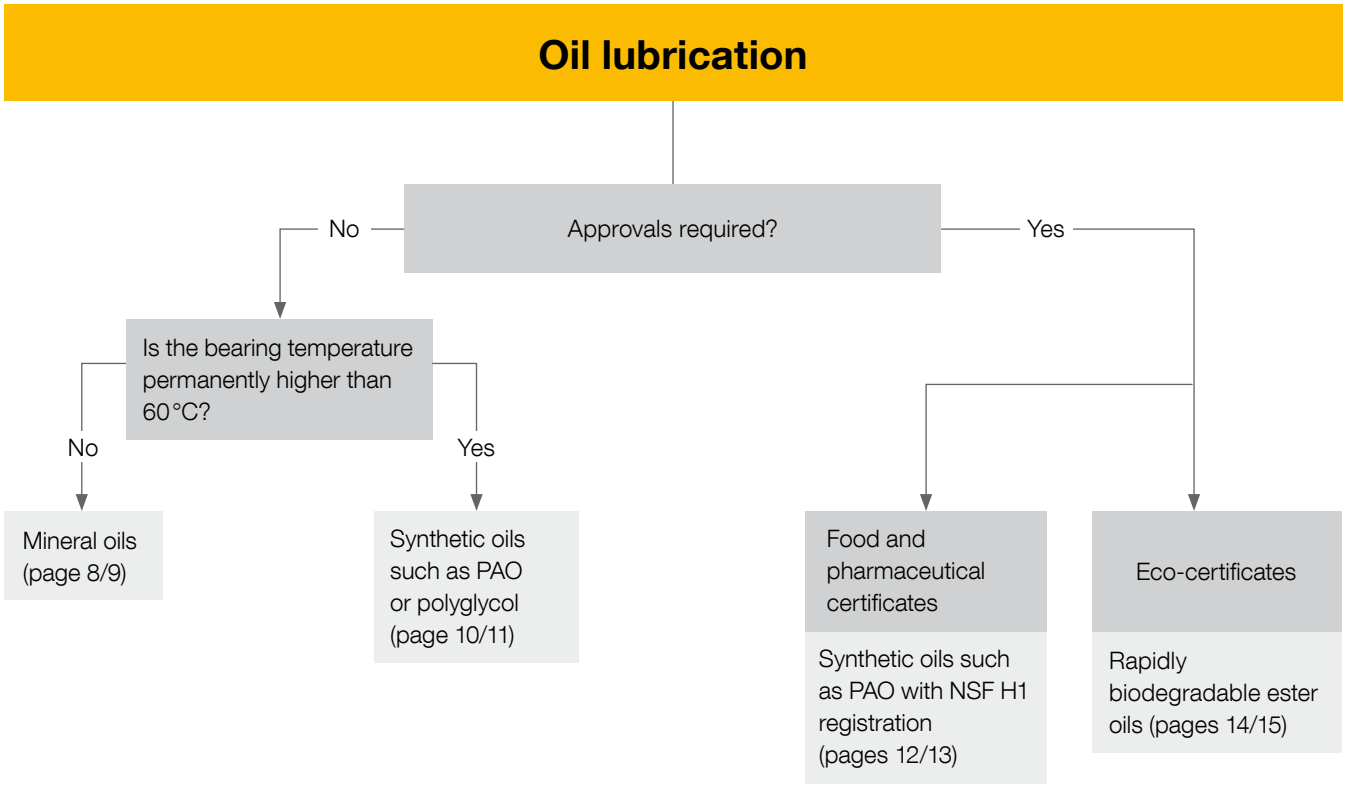
$$1\ N = [\eta] \cdot \left(\frac{m^2 m}{ms}\right) \Rightarrow [\eta] = \frac{N \cdot s}{m^2} = \frac{kg}{m \cdot s} = 1\ Pa \cdot s$$

Requirements to be met by a high-performance oil for hydrodynamic plain bearings



Selecting the ideal operating oil viscosity

The formation of an effective load-bearing lubricant film to fully separate the friction bodies depends greatly on the oil's operating viscosity. Careful bearing dimensioning and accurate calculation of lubricant film thickness are particularly important prior to series application. Most plain bearing manufacturers will do this using computer programs, the plant operator may also provide relevant data.



Oils for hydrodynamic plain bearings

Oils operating under moderate ambient conditions

In hydrodynamic plain bearings where neither easy start-up nor long relubrication intervals at elevated temperatures are major issues, hydraulic and gear oils have been successfully used enabling a single oil to be used for several components. In applications where this is the case plain bearings within the power train are supplied with heavily loaded wear-resistant CLP gear oils. Hydraulic oils contribute to higher efficiency in, for example, turbines, generators or pumps. For centralised oil circulation or oil sump (splash) lubrication, good wetting of the bearing surfaces is particularly important. Pumpability without foam formation and compatibility with the bearing metals are additionally important prerequisites for reliable function and attainment of the longest service lifetime of both the plain bearing and shaft.

Products suggested for different operating conditions

Sliding speed [m/s]	Mean bearing load	Bearing operating temperature [°C]	Suggested product
v = 2 to 4	P < 3 N/mm²	Up to 50	LAMORA HLP 32
		Up to 70	LAMORA HLP 68
		Up to 90	Klüberoil GEM 1-150 N
v = 2 to 4	P = 3 to 7 N/mm²	Up to 50	LAMORA HLP 68
		Up to 70	Klüberoil GEM 1-220 N
		Up to 90	Klüberoil GEM 1-460 N
v > 4		Up to 50	LAMORA HLP 32
		Up to 70	LAMORA HLP 46
		Up to 90	Klüberoil GEM 1-100 N
v > 4		Up to 50	LAMORA HLP 68
		Up to 70	Klüberoil GEM 1-150 N
		Up to 90	Klüberoil GEM 1-320 N

Oils for hydrodynamic plain bearings under moderate ambient conditions

Klüber Lubrication product	Product characteristics	Application notes and benefits
Klüberoil GEM 1 N, ISO VG 46 to 1000*	Tried and tested gear oil series that is compatible with customary plain bearing materials	For ambient temperatures up to 60 °C with oil circulation lubrication, e.g. in energy conversion machinery
LAMORA HLP 32, 46, 68	Mineral oil based hydraulic oils acc. to DIN 51524 pt. 2	For the low-friction and low-wear operation of turbine bearings

* The products can be obtained in various viscosities. The choice of which viscosity to select depends on application parameters such as sliding speed, temperature and OEM equipment approvals.

Where the wind blows

Hydrodynamic plain bearings versus rolling bearings in wind turbine gearboxes

Hydrodynamic oil-lubricated plain bearings have been proven successful in typical fields of application, e.g. turbo-machines and ships' drives, for many decades. A rather new field of application involves the use of plain bearings in wind turbine gearboxes. In wind turbine gearboxes, hydrodynamic plain bearings offer advantages over rolling bearings especially under high-load conditions. Plain bearings are highly resistant to shock loading, dirt particles and vibration.

A gearbox plain bearing is expected to perform with the same reliability and low wear rates as the gears providing power transmission. In this context, the compatibility of the selected gear oil with the sliding bearing materials/white metal alloys plays a decisive role. If compatibility is ensured, a single oil can be used without having to compromise on functionality or service life. The gear oils used in wind turbines are subject to exacting operational specifications and have to meet the same requirements as high-performance lubricating oils as shown on page 6 and in the product overview (below) of Klübersynth GEM 4-320 N.

Requirements	**Klübersynth GEM 4-320 N**
Gear oil acc. to DIN 51517-3	CLP HC
Elastomer compatibility 72 NBR 902	passed
Elastomer compatibility 75 FKM 585	passed
Foam behaviour ASTM D 892	passed
Flender foam test (total volume increase)	< 15 %
Fine filtration	possible
FVA 54 IV micropitting resistance, 60 °C	high
FVA 54 IV micropitting resistance, 90 °C	high
FZG scuffing test, DIN ISO 14635-1, A/8.3/90, scuffing load stage	≥ 14
FZG scuffing test based on DIN ISO 14635-1, A/16,6/90, Failure load stage	≥ 14
FZG wear test DGMK 377-01, wear category	low
FAG FE8 wear test DIN 51819-3, roller wear	< 2 mg
FAG 4-stage bearing test	1.0
Klübersynth GEM 4-320 N has proven to meet gear manufacturers' requirements in numerous tests.	

In an effort to overcome operational tribological weaknesses experienced with existing products, Klüber Lubrication has developed a high-performance wind turbine gear oil suitable for high load operation. Compared with standard oils, Klübersynth GEM 4-320 N shows good resistance to ageing, highload carrying capacity, low operational friction effect, excellent micropitting and anti-foaming characteristics. Operational benefits with this product include extended oil change intervals, low power losses and higher plant yield. Across the service life of the wind turbine operational savings of several thousand euros savings per unit can be realised.

Oils for hydrodynamic plain bearings

Lubricating oils with particularly long-term resistance at elevated temperatures

Other than under moderate conditions, mineral oils are subject to much faster ageing at higher temperatures. This undesirable consequence causes not just an increase in oil viscosity but the aggressive residues produced under high-temperature conditions may also attack the bearing metals and sealing materials. Such conditions occur, for example, in electric motors or generators, which also require good start-up behaviour at low temperatures.

In many cases, synthetic oils can attain a much longer service life. Extended oil change intervals contribute to savings in oil consumption and disposal quantities, help cut down on costs for maintenance and loss of production, thus relieving the strain on resources.

Rotary kilns in the cement industry often operate at higher ambient temperatures, which causes a significant increase in bearing temperature. In the following you will see a typical example demonstrating how synthetic oils offer a cost-benefit advantage over mineral oils.

Environmental and economic advantages offered by high-performance lubricants

Plain bearing lubrication in rotary kilns for cement production

	Mineral oil	**Synthetic hydrocarbon oil, e.g. Klübersynth GEM 4-320 N**
Number of bearings per kiln	12	12
Fill quantity (l Ø)	360 l	360 l
Operating hours until oil change (h)	3,500	25,000
Bearing life (10 to 15 years × 7,000 op. hrs.)	≈ 100,000	100,000
Number of oil fills per bearing life	29	4
Lubricant consumption (l)	10,440	1,440
Lubricant price (€*/l)	1.50	7.00
Lubricant cost (€*)	**15,660**	**10,080**
Disposal cost (€*)	**1,566**	**216**
Number of maintenance actions	28	3
Total time needed for maintenance (h)	168	18
Maintenance cost at 40.00 €/h (€*)	**6,720**	**720**
Total cost of bearing lubrication (€*)	**23,946**	**11,016**

* Example. Real-life conclusions may differ depending on operating conditions.

Here you will find a selection of oils that have been successfully used for the lubrication of plain bearings. It should be noted that many of the listed lubricants outlined can also be used to lubricate other components such as gears or compressors.

Products suggested for different operating conditions

Step 1: sliding speed [m/s]	v = 2 to 4		v > 4	
Step 2: mean bearing load [N/mm²]	p < 3	p > 3	p < 3	p > 3
Step 3: bearing operating temperature [°C]	**Special lubricant**	**Special lubricant**	**Special lubricant**	**Special lubricant**
Up to 50	Klüber Summit SH 32	Klüber Summit SH 68	Klüber Summit SH 32	Klüber Summit SH 68
Up to 70	Klüber Summit SH 68	Klübersynth GH 6-100	Klüber Summit SH 46	Klübersynth GH 6-100
Up to 90	Klübersynth GH 6-80	Klübersynth GH 6-150	Klüber Summit SH 100	Klübersynth GH 6-150
Up to 120	Klübersynth GH 6-150	Klübersynth GH 6-320	Klübersynth GH 6-100	Klübersynth GH 6-220
20 to 60	Klüber Summit SH 46	Klübersynth GH 6-80	ISOFLEX PDP 48	Klüber Summit SH 100
20 to 90	Klüber Summit SH 100	Klübersynth GH 6-150	Klüber Summit SH 100	Klübersynth GH 6-100

Lubricating oils with particularly long-term stability at elevated temperatures

Klüber Lubrication product	**Application notes and benefits**
Klüber Summit SH 32, 46, 68, 100*	For ambient temperatures up to 60 °C with oil circulation, e.g. in energy conversion machinery
Klübersynth GEM 4 N, ISO VG 32 to 1000*	May be used as an alternative if the Klüber Summit SH series does not offer the required viscosity, e.g. for heavily loaded plain bearings with oil sump lubrication in cement mills or wind turbine gearboxes.
Klübersynth GH 6, ISO VG 32 to 1500*	With optimised friction behaviour for saving energy, e.g. for heavily loaded plain bearings in coal mills

* The products can be obtained in various viscosities. The choice of viscosity depends on application parameters such as sliding speed and temperature. Viscosity recommendations are often made by the plain bearing manufacturer for a particular application.

Oils for hydrodynamic plain bearings

Lubricating oils for the food-processing and pharmaceutical industries

Lubricating oils for hydrodynamic plain bearings with registration for the food-processing and pharmaceutical industries

Klüber Lubrication product	Product characteristics	Application notes and benefits
Klüber Summit HySyn FG 32, 46, 68, 100*	Synthetic compressor oil series that is compatible with customary plain bearing materials	Solution with long-term stability for high and low service temperatures with NSF-H1 registration
Klüberoil 4 UH1 N series, ISO VG 32 to 1500*	Synthetic gear oils and multipurpose oils available in a wide range of viscosities	May be used as an alternative if the Klüber Summit HySyn FG series does not offer the required viscosity.

* The products can be obtained in various viscosities. The choice of which viscosity to select depends on application parameters such as sliding speed and temperature.

Products suggested for different operating conditions

Step 1: sliding speed [m/s]	v = 2 to 4		v > 4	
Step 2: mean bearing load [N/mm²]	p < 3	p = 3 to 7	p < 3	p = 3 to 7
Step 3: bearing operating temperature [°C]	**Special lubricant**	**Special lubricant**	**Special lubricant**	**Special lubricant**
Up to 50	Klüber Summit Hysyn FG 32	Klüber Summit HySyn FG 68	Klüber Summit HySyn FG 32	Klüber Summit HySyn FG 68
Up to 70	Klüber Summit HySyn FG 68	Klüberoil 4 UH1-150 N	Klüber Summit HySyn FG 46	Klüber Summit HySyn FG 100
Up to 90	Klüber Summit HySyn FG 100	Klüberoil 4 UH1-220 N	Klüber Summit HySyn FG 100	Klüberoil 4 UH1-220 N
–45 to 50	Klüber Summit Hysyn FG 32	–	Klüber Summit HySyn FG 32	–
–40 to 40	–	Klüber Summit HySyn FG 46	–	–
–40 to 45	–	–	–	Klüber Summit HySyn FG 46

Selection example: lubricating oils

In a tabletting machine producing fondant sweets the screw conveying the heated sugar mass is supported on two oil-lubricated plain bearings.

Since it is technically unavoidable that small quantities of lubricant may occasionally leak past the seals and into the sugar mass, an H1 lubricant is required for lubricating these bearings.

Bearing data / operating conditions	
Inner Ø of split bearings:	D = 40 mm
Width of split bearings:	B_1 = 38 mm
Split bearing material:	red brass (CuSnZn)
Speed of worm:	n = 4,000 min^{-1} = 66.6 s^{-1}
Load force:	F = 500 N
Measured operating temperature of bearing:	ϑ = approx. 70 °C, constant

Selection of the required oil

1a. Calculation of mean bearing load p_m

$$p_m = \frac{F}{D \cdot B} \text{ (N/mm}^2\text{)}$$

$$p_m = \frac{500}{40 \cdot 38} \text{ (N/mm}^2\text{)}$$

1b. Calculation of sliding speed v

$v = d \cdot \pi \cdot n$ (m/s)
$v = 0.04 \cdot 3.14 \cdot 66.6$
$v = 8.4$ m/s

2. Determination of additional requirements
(overview page 7)
For this application, a physiologically safe oil (food-grade lubricant) is required.

3. Selection based on additional requirements
Corresponding selection chart: page 12

4. Selection of the required oil
The chart on page 12 consists of four selection options. The section in which to look is determined by the calculated sliding speed v and the mean bearing load p_m.

Sliding speed v:	8.4 m/s: this value belongs to section v > 4 m/s
Bearing load :	p_m = 0.33 N/mm²; this value belongs to section p < 3 N/mm²

Result: For a constant operating temperature of approx. 70 °C, the appropriate lubricating oil would be Klüber Summit HySyn FG 46. The recommended oil has a kinematic viscosity of approx. 50 mm²/s at 40 °C. When making an accurate calculation for this bearing application, one will find that the ISO VG 32 of Klüber Summit HySyn FG 32 is also sufficient. This is due in particular to the sliding speed being above 8 m/s. This calculation is based on the viscosity data given in the product information leaflet.

Please verify your product selection by checking the product data in the product information leaflet, which you can obtain from Klüber Lubrication on request.

Oils for hydrodynamic plain bearings

Eco-compatible lubricants for the marine industry

Eco-compatible lubricants are more and more in demand, for example in hydroelectric power stations and marine applications. It is not just your company's image that will benefit from such lubricants.

There are in fact legal provisions that require the use of such products. Klüber Lubrication offers you the following product families with corresponding approvals and registrations.

Fully biodegradable oils for hydrodynamic plain bearings

Klüber Lubrication product	Product characteristics	Application notes and benefits
Klüberbio RM 2-100, 150	Non-toxic synthetic ester oils with good oxidation stability and compatibility with seals, carrying the EU Ecolabel*	Developed for lubrication of stern tube bushes found in propeller bearings in marine applications
Klüberbio EG 2-68, 100, 150	Non-toxic synthetic ester oils offering good anti-wear effect, oxidation stability and compatibility with seals, carrying the EU Ecolabel*	Gear oil series that is compatible with customary plain bearing metals, e.g. those found in hydroelectric power plants
Klübersynth GEM 2- 220, 320	Synthetic ester oils of higher viscosity with biodegradability according to the CEC-L-33-A-93 test > 70 % after 21 days	Tried and tested gear oil series, compatible with customary plain bearing materials, offering excellent wear protection under high pressure conditions
Klüberbio C 2-46	Biodegradable ester oil with good low-temperature behaviour	Developed for lubrication of escalator chains, can also be used in agriculture and forestry applications, chainsaws, etc.

The products can be obtained in various viscosities. The choice of which viscosity depends on application parameters such as sliding speed and temperature.

* Biodegradability according to OECD 301 B is ≥ 60 % after 28 days, also contain > 90 % of renewable raw materials and bear the EU Ecolabel.

Klüberbio RM 2-100 and Klüberbio RM 2-150 are stern tube oils based on synthetic ester oils offering good resistance to ageing. They were developed for lubrication of propeller bushes made of white metal tested for compatibility and approved accordingly by leading propeller shaft seal manufacturers.

Klüberbio RM oils contain more than 90 % of renewable raw materials and bear the EU Ecolabel.

A simple way of determining oil condition in low-alloy polyalphaolefin oil types

The Klüber Summit T.A.N. Kit has been especially designed for the simple and rapid determination of the neutralisation number required to assess the ageing condition of low-alloy mineral oils or polyalphaolefin oils. An oil sample size of 1 ml is sufficient for a typical T.A.N. test to immediately indicate the condition of the oil by a change of colour. The Total Acid Number (TAN) indicates the alkaline quantity in mg of KOH (potassium hydroxide) per g of oil that is required to neutralise the acids contained in the oil.

The T.A.N. kit measures the neutralisation number in the range of 0 to 2 mg KOH/g. However, it should not be used for oils with a neutralisation number above 2.0 mg KOH/g (of fresh oil) since other factors might distort the result in these oils.

EU Ecolabel

The EU Ecolabel is a label of environmental excellence that is awarded to products and services meeting high environmental standards throughout their life cycle: from raw material extraction, to production, distribution and disposal.

Oil analysis programme

Klüber Lubrication's commitment to service support continues beyond the original lubricant purchase by means of an oil analysis programme. You can take advantage of this oil analysis programme to obtain a general overview of the physical and chemical characteristics of the lubricant in use.

This analysis allows the detection of any significant lubricant deterioration as well as discovering machinery problems before they become serious thus avoiding expensive equipment repair costs.

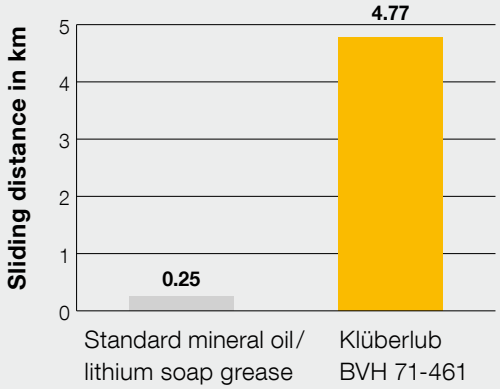
Greases for plain bearings operating under mixed friction conditions

Klüber Lubrication offers a comprehensive range of lubrication products for grease-lubricated metal and plastic plain bearings with products tested for suitability. The focus here is on low-wear operation over long operating periods.

Grease-lubricated bronze plain bearings were tested on the plain bearing test rig at Fachhochschule Zwickau.

Under typical mixed friction conditions, the special grease **Klüberlub BVH 71-461** enabled a runtime 10 times longer than a conventional plain bearing grease based on mineral oil/lithium soap. The measured benefits being improved wear protection, optimum lubricant film formation and excellent compatibility with bearing materials due to the special additivation package incorporated within this special development.

Result obtained on plain bearing test rig, Klüber Lubrication in cooperation with Fachhochschule Zwickau



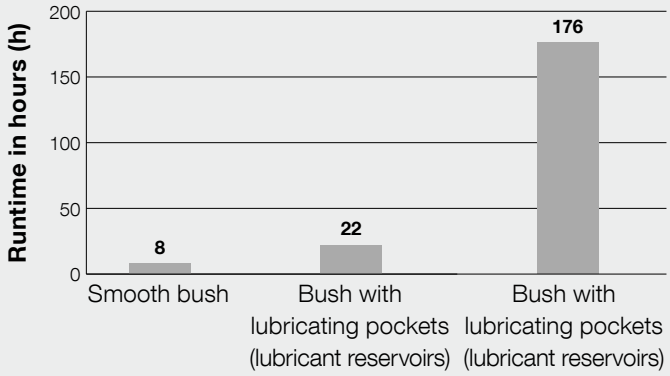
Temperature: ambient
Bearing temperature: 40 to 60 °C
p = 50 N/mm²
v = 0.01 m/s
Plain bearing: CAROBRONZE
Shaft: rotating, steel 1.3349, hardness 46HRC, roughness Rz 2.5
Test is terminated when the friction value μ > 0.2

Symbiosis of the plain bearing and lubricant

For Wieland bronze plain bearings Klüber Lubrication developed the special grease **Klüberplex SK 12**. Many years of experience have shown that Klüberplex SK 12 can provide extended performance capacity in Wieland bushes incorporating bore hole lubricant reservoirs. Its long operating times reduce the need for maintenance. Sometimes relubrication is not necessary at all.

Conclusion:
Combining a suitable grease within adequate grease reservoirs incorporating sealing proves to be the best solution for attainment of long-term lubrication or long relubrication intervals.

Result plain bearing test rig



p = 23 N/mm²
Oscillating angle = 60 °C
v_m = 0.05 m/s
Ambient temperature
Steel shaft
Bronze plain bearing made by Wieland Werke Ulm, preferably lubricated with Klüberplex SK 12

Selection example

The grease required is to lubricate the plain bearings of calender rollers used in a rubber manufacturing plant. Operating conditions: very slow roller speed combined with high bearing radial loading and elevated bearing temperatures.

Bearing data / operating conditions:

Bearing bore:	D = 295 mm
Bearing width:	B = 320 mm
Bearing running surface:	smooth
Bearing material:	bronze
Operating speed:	n = 4 min^{-1}
Bearing load, radial:	F = 685.7 kN
Bearing temperature:	T = 145 °C
Environmental media resistance of the lubricant:	sodium hydroxide in solution
Lubrication dispensing:	continuous lubrication by means of automatic lubrication dispenser

Selection of lubricating grease:
The calender rollers are pieces of general machinery.

See relevant grease table, page 18/19, column Applications, section: sliding speed < 1 m/s, maximum surface pressure approx. 100 N/mm², service temperature range –20 to 160 °C

Result:
Suitable grease in this example:
Klüberlub BVH 71-461

Please note: all plain bearing greases listed in the table on pages 18/19 are high-performance lubricants. Friction measurements derived from test bearings at room temperature (25 °C) have shown that a low friction coefficient and low operating temperatures can be obtained even under difficult operating conditions, e.g. v = 0.01 m/s, p = 50 N/mm². The correctly selected lubricating grease contributes to long component life.

Greases for plain bearings operating under mixed friction conditions

The process of lubricant selection for plain bearings is simplified when using the selection table provided. Please observe the following criteria to enable maximum performance of the bearings throughout their service lifetimes:

Permissible bearing load: depends on bearing material and bearing geometry.

Note: high surface pressure at low speed – e.g. during start-up and slow-down will induce a mixed friction service condition involving partial metal-to-metal contact. The use of special lubricants will enable lowest wear and longest lubricant and bearing life under this condition.

Application	Sliding speed [m/s]	Max. surface pressure [N/mm²]	Service temperature [°C][5]	Product
General machinery, installations, equipment and vehicle applications	< 1	approx. 100	–20 to 160	Klüberlub BVH 71-461
			–40 to 140	Klüberplex SK 12
			–20 to 160	Klüberlub BE 71-501
			–30 to 140	Klüberlub BEM 41-122
			–20 to 140	Klüberlub BE 41-542
			–30 to 180	PETAMO GHY 441
			–40 to 150	POLYLUB GLY 501
			–40 to 260	Klüberalfa BHR 53-402
	≥ 1	approx. 10	–50 to 150	POLYLUB GLY 151
	≥ 2	approx. 1	–50 to 130	Klübersynth LR 44-21
Machines and installations in the food-processing and pharmaceutical industries	< 1	approx. 100	–35 to 120	Klüberfood NH 94-301
			–5 to 140	Klübersynth UH1 64-1302
	≥ 1	approx. 10	–40 to 120	Klübersynth UH1 14-151
Machines, installations, equipment and vehicles where the lubricant may come into contact with the environment (for example hydroelectric power plants, agriculture, mining, marine bearings)	< 1	approx. 100	–30 to 100	Klüberbio LG 39-701N
	≥ 1	approx. 10	–40 to 120	Klüberbio BM 32-142

[1] NSF H1-registered lubricant, complies with FDA 21 CFR § 178.3570. The lubricant was developed for incidental contact with products and packaging materials in the food-processing, cosmetics, pharmaceutical or animal feed industries. The use of this lubricant can contribute to increasing the reliability of your production processes. We nevertheless recommend conducting an additional risk analysis, e.g. HACCP.

[2] Owing to the many different compositions of elastomers and plastics, we recommend checking their compatibility prior to series application.

Hint:
To compare the resistance and media sealing effects of different lubricating greases, the water resistance tests according to DIN 51807 pt. 1, 3 h/90 °C are used. The lower the test result, the better the grease's resistance to water (i.e. 0 = best value).

	Product characteristics (composition and purpose)	**Application notes and benefits**
	The preferred plain bearing lubricant for long service life and long relubrication intervals	Universal use and suitability for plain bearings operating under mixed friction conditions
	Special lubricant for long service life and long relubrication intervals, offering excellent resistance to media	Especially developed for slow-running and oscillating bronze plain bearings (CuSn8) with lubricant reservoir for use in civil engineering and agricultural machinery
	Special grease offering optimised friction behaviour and excellent wear protection, especially when subject to shock loads	Especially developed for heavily loaded bronze plain bearings in forging presses, good pumpability in centralised lubricating systems[4]
	Preferred for steel/steel pivoting bearings	Better functionality and long-term lubrication due to formation of a tribological protection layer that is resistant to wear
	Slightly stiffer (NLGI 2) alternative to Klüberlub BVH 71-461	Corresponds to the frequently requested standard for bearing lubricants DIN 51825 as a KP2N 20 grease
	Alternative to Klüberlub BVH 71-461 for higher ambient temperatures	Long-term stability enabling longer relubrication intervals also at elevated temperatures
	Especially for plain bearings made of plastic[2], also available in other base oil viscosities	Good compatibility with many plastic materials facilitates product selection
	High-temperature long-term grease that is widely neutral towards many materials (metals, plastics)[2]	Considerable reduction of lubricant quantities to enable lifetime lubrication
	Preferred for plastic plain bearings[2] because of good compatibility	Universal use for standard and automotive applications
	Preferred for plastic plain bearings[2] because of good compatibility	Universal use for standard and automotive applications
	Registered as NSF H1 for food-processing and pharmaceuticals industry[1]	Good corrosion and wear protection also under micro-movement; pumpability in centralised lubricating systems[4]
	Registered as NSF H1 for food-processing and pharmaceuticals industry[1]	Good resistance to water and strong wear protection ensure long service life
	Registered as NSF H1 for food-processing and pharmaceuticals industry[1]	Good water resistance reduces risk of bearing failure
	Biodegradable[3] high-performance grease, lower environmental impact in the event of leakage, base oil from renewable raw materials	Selected additives and good adhesion ensure longer component life and reduced wear
	Biodegradable[3] high-performance grease (EAL), especially eco-friendly, bearing the EU Ecolabel	Versatile use due to good wear protection and water resistance

[3] Biodegradability acc. to CEC-L-33-A-93. When handling biodegradable products, the same care should be exercised as with conventional greases. Any avoidance of contamination is to the benefit of the environment.
[4] The product can normally be applied by means of centralised lubricating systems. Please note, however, that due to different system configurations and application conditions, the pumpability of the products has to be confirmed. We would be happy to provide assistance in this matter.
[5] Service temperature range: the service temperatures given in the tables are guideline values assuming the grease is used in a plain bearing; they depend on the individual operating conditions.

Bonded coatings

Dry lubrication can prove advantageous in applications where, due to low sliding speed, no load-bearing lubricant film can form so the friction bodies are not sufficiently separated. A layer capable of separating the two sliding surfaces can therefore only be achieved by the use of a bonded coating or a self-lubricating layer – in such cases, there is a protective "lubricating film" present immediately at the commencement of motion.

Even under extreme operating conditions, e.g. at very high temperatures, under vacuum or when exposed to chemical media, dry lubricants help to reduce wear significantly and protect the various friction bodies.

Bonded coatings are frequently used as lifetime lubrication solutions – which may require special testing. They may also be used complete with a secondary lubricant film (oil or grease layer), a combination termed "sandwich lubrication" in which special running-in or damage prevention benefits are achievable.

As an additional advantage the emergency lubricating properties of dry lubricants protect the bearings from the effects of starved lubrication and reduce the risk of surface damage.

Hint:
The adhesion and service life of a bonded coating is heavily dependent primarily on the pre-treatment of the parts to be coated, the application method used for the coatings and the care dedicated to hardening and the subsequent use of the parts. Before using a bonded coating, please observe the information in the product information leaflet which we would be happy to send you on request. You are of course welcome to draw on the experience of our R&D engineers developing bonded coatings and our application engineers. Alternatively, you can contact the competent staff of one of our contract coating companies near you.

Bonded coatings for tribologically optimised plain bearings

When selecting a bonded coating for a plain bearing application the following operating conditions should be considered:

- Operating temperature, sliding speed, applied load
- Vacuum requirements, friction coefficient, etc. For plastic plain bearings, the bonding agents in the coating are adjusted to the bearing material to ensure the required compatibility, elasticity and adhesion effects.

We recommend checking the compatibility of the materials to be coated prior to series application (Klüber Lubrication results were obtained based on tests made on random samples and do not release the customer from the obligation to perform his own tests).

The following optimised recommendations are made for plastic and metal plain bearings. For further information, please also see the brief product descriptions in the bonded coatings table.

Application	Product	Product characteristics	Application notes and benefits
Bushes and split plain bearings in internal combustion engines e.g. main bearings, connecting rod bearings and crosshead bearings as well as camshaft and crankshaft bearings	Klübertop TG 05 N	Good adhesion and wear protection on metal sliding surfaces due to a heat-hardening binder system	Enables reliable component function, especially for emergency and running-in lubrication in combination with oil lubrication
Sliding material combinations consisting of metal/metal and metal/plastic, e.g. in automotive and power transmission engineering	Gleitpan HN	Good adhesion and wear protection on metal sliding surfaces due to PTFE particles and a heat-hardening binder system	Enables lifetime lubrication under low loads and speeds, even without additional lubrication. Used for coating magnet armatures and air conditioning compressor pistons
Sliding material combinations consisting of metal/metal, e.g. in automotive and power transmission engineering	Klübertop TM 06-111	No stick-slip and very good wear protection, especially on zinc-phosphated surfaces	Enables long-term protection at high loads
Metal sliding surfaces and guideways for the aerospace industry	UNIMOLY C 220	Hygrosetting bonded coating, also available as spray for ease of application	High-performance dry lubrication under high vacuum and an extremely wide service temperature range

Selecting a bonded coating depends on the component geometry, the material used as well as the application, the operating conditions and the desired application processes. Further products can be named on request and found in our bonded coating brochure on our website klueber.com.

Selection example: running-in of a truck engine bearing with bonded coating and operational lubricant

For the camshaft bearing in a truck diesel engine, a bonded coating is needed which

1. together with the operational lubricant (engine oil) improves the bearing running-in process and prevents initial damage to the sliding surfaces.

2. supports lubrication during the start-up phase until the engine oil has reached the friction points to form a protective hydrodynamic lubricating film.

Bearing data / operating conditions:

Split journal bearing, inner Ø	50 mm
Width:	32 mm
Material pairing:	steel / steel
Operating temperature:	–40 to 120 °C
Load p:	oscillating to impact load, 6...8 N/mm²

Result:
For split steel bearing shells, Klübertop TG 05 N proves to be an excellent bonded coating. It offers a long service life, wear resistance, resistance to lubricating oil and contains graphite as a solid anti-wear emergency lubrication component.

Cost-benefit calculation

Application: Camshaft plain bearing in diesel engines, 4 cylinders, 3,000 cm³
Requirement: Running-in without wear on plain bearings

	Plain bearings without coating	Plain bearings coated with Klübertop TG 05 N
Number of camshaft bearings per engine	5	5
Number of diesel engines p. a.	60,000	60,000
Coating costs per bearing (€)	–	0.80
Coating costs for total quantity (€)	–	240,000.–
Running-in time per engine (min)	60	10
Running-in time for annual lot (h)	60,000	10,000
Costs for running-in at approx. 100.– p. h. (€)	6,000,000.–	1,000,000.–
Costs for running-in (€)	6,000,000.–	1,240,000.–
Savings (€)		**4,760,000.-**

Hint:
To ensure a perfect surface finish, we recommend running in bearings at reduced load (approx. one third of the rated load and one third of the rated speed).

Utilise your potential for higher efficiency

KlüberEfficiencySupport

EfficiencyManager

KlüberEnergy
Energy Efficiency

Consultant services for optimisation of the energy efficiency of your lubricant application; verification through energy measurements and reporting of cost saving.

KlüberMaintain
Maintenance Efficiency

Support for your lubricant management and maintenance programmes such as TPM[1] with regard to lubricants and the associated maintenance activities.

Service Online Portal

KlüberMonitor
Production Efficiency

Increased productivity through used lubricant analyses. Recommendations for optimisation based on trend analyses and test rig results.

KlüberRenew
Working part Efficiency

Services to increase the lifetime of your cost-intensive components such as large gear drives and chains including appropriate training.

KlüberCollege – Increasing people efficiency

The methodology was developed by Klüber Lubrication, is tried-and-tested and consists of a multi-stage, systematic approach. We identify your requirements together with you at an early stage to discover potential for optimisation. The results can be displayed by means of our maintenance software EfficiencyManager, which is used by our specialists to efficiently handle the processes relevant for production. The EfficiencyManager is an online portal combining all services offered by Klüber Lubrication and ensuring transparency among the ever more complex requirements in a smart factory.

[1] TPM: Total Productive Maintenance

The data in this document is based on our general experience and knowledge at the time of publication and is intended to give information of possible applications to a reader with technical experience. It constitutes neither an assurance of product properties nor does it release the user from the obligation of performing preliminary field tests with the product selected for a specific application. All data are guide values which depend on the lubricant's composition, the intended use and the application method. The technical values of lubricants change depending on the mechanical, dynamical, chemical and thermal loads, time and pressure. These changes may affect the function of a component. We recommend contacting us to discuss your specific application. If possible we will be pleased to provide a sample for testing on request. Products from Klüber Lubrication are continually improved. Therefore, Klüber Lubrication reserves the right to change all the technical data in this document at any time without notice.

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Klüber Lubrication – your global specialist

Innovative tribological solutions are our passion. Through personal contact and consultation, we help our customers to be successful worldwide, in all industries and markets. With our ambitious technical concepts and experienced, competent staff we have been fulfilling increasingly demanding requirements by manufacturing efficient high-performance lubricants for more than 85 years.

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