
LGHP 2/1
High performance polyurea
SKF Bearing grease
Graisse Fett Grasa
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SKF

Lubrication

7

Introduction

To optimize the service life of a bearing arrangement, the correct amount of an appropriate lubricant must be delivered at the proper time. Just as an insufficient amount of lubricant will affect bearing performance negatively, so will an excessive amount of lubricant. Either way, the result can be the same: premature bearing failure and costly machine downtime.

Inadequate lubrication accounts for approximately 36% of all bearing failures. This includes failures caused by the following:

- improper lubricant selection
- insufficient lubricant
- excessive lubricant
- inappropriate relubrication intervals
- lubricant not reaching the bearing due to poor bearing arrangement design, incorrect machine assembly or blocked piping

Add to this the bearing failures caused by a contaminated lubricant supply and the percentage of lubrication-related bearing failures can jump as high as 50%.

Effective lubrication and good lubrication practices can help to significantly reduce premature bearing failures and machine downtime. To meet that goal, SKF offers a comprehensive assortment of lubricants and lubrication systems as well as programs to help with lubricant selection and determine relubrication intervals.

Only lubrication for rolling bearings is presented in this chapter. For information about lubricating other types of bearings, refer to the *SKF Interactive Engineering Catalogue*, available online at www.skf.com, or contact the SKF application engineering service.

For additional information about SKF maintenance and lubrication products and tools, visit www.skf.com/lubrication and www.mapro.skf.com.

For information about the SKF programs LuBase, DialSet and the SKF Lubrication Planner, visit www.skf.com/lubrication or www.aptitudexchange.com.

The SKF Reliability Maintenance Institute (RMI) offers a comprehensive range of training courses in lubrication (→ *Training*, starting on **page 326**). Contact your local SKF representative for additional information, or visit www. skf.com/services.

Lubrication management

In a facility where there can be hundreds and maybe thousands of lubrication points, things can get confusing. But even when only a few lubrication points are involved, it is important to organize and document all lubrication-related information and implement a detailed lubrication management programme. Factors to take into consideration include:

- supply and storage of lubricants
- resources: equipment and manpower
- lubrication schedules and routes
- lubricant analysis and monitoring
- automatic versus manual lubrication

The SKF Lubrication Planner, available at www.skf.com/lubrication, is a user-friendly software that provides all basic features required to properly design and manage a lubrication plan.

Inspection, handling and disposal of lubricants

Inspection of lubricants

Regardless of the date of manufacture, greases and oils should be checked visually prior to use.

For grease, check for abnormal oil separation and any signs of mildew, water or discolouration.

For oil, check for any water or discolouration. If the oil looks cloudy, it usually means it is contaminated with water.

NOTE: When visually inspecting grease, keep in mind that some oil separation is normal.

Recommended lubricant handling practices

Proper lubricant handling procedures are very important. SKF recommends that you do the following:

- Wipe the edges of lubricant containers before opening them to prevent the entry of contaminants.
- Use clean containers when dispensing lubricants.
- Use professional tools.

CAUTION: Direct contact with petroleum products may cause allergic reactions! Read the material safety datasheets before handling lubricants and use protective gloves at all times.

Material safety datasheets

Material safety datasheets (MSDS) provide essential information about the physical and chemical properties of a lubricant. They also present recommended precautions and exposure control procedures.

NOTE: Material safety datasheets for SKF bearing greases are available online at www.mapro.skf.com.

Lubricant disposal

Improper disposal of lubricants can be hazardous to the community and the environment. Dispose of all lubricants in accordance with national and local laws and regulations and good environmental safety practices.

Grease versus oil

Grease is the most widely used lubricant for rolling bearings because it has many advantages over oil and is normally more cost-effective. Less than 20% of rolling bearings are lubricated with oil.

It is essential to match the lubricant to the application and operating conditions, but it is also important to consider the lubricant delivery method, installation and maintenance. When choosing between grease and oil lubrication, many factors should be taken into consideration (→ **table 1**).

Alternative lubricants

In some applications, solid oil can provide benefits that grease or oil alone cannot provide. Solid Oil is a polymer matrix saturated with lubricating oil, which completely fills the free space in a bearing. Solid oil has been developed specifically for applications where conventional lubrication has been previously unsuccessful or cannot be implemented, e.g. in bearing arrangements with limited accessibility.

Many SKF rolling bearings as well as bearing units can be supplied with Solid Oil. The bearings are identified by the designation suffix W64.

In extreme temperature applications, such as reheat furnaces and kilns, the high temperatures can cause normal lubricants to melt or

Table 1

Selection comparison between grease and oil

Selection criteria		**Advantages/disadvantages** Grease	Oil
Application and operating conditions	Associated components	Bearings and associated components need to be kept separate	Bearings and associated components can be lubricated with the same oil (where appropriate)
	Sealing solution	Improves sealing efficiency of enclosures	No sealing advantage
	Operating temperature	No cooling advantage Operating temperature limitations	Assists with cooling Suitable for high operating temperatures
	Speed factor	Speed limitations	Suitable for high operating speeds
	Shaft orientation	Suitable for vertical shafts	Typically not suitable for radial bearings on vertical shafts
	Food compatibility	Low risk of contamination from leakage	Only food grade oils should be used, due to the risk of leakage
Installation and maintenance	Installation	Quick Relatively inexpensive	Time consuming Expensive (pumps, baths etc. required)
	Lubricant retention and leakage	Retained easily in bearing housings	Amount of lubricant controlled easily Leakage likely
	Inspection	Difficult to inspect during operation	Must maintain oil level
	Applying the lubricant	Normally easy to apply	Time consuming
	Lubricant change	Difficult to remove all grease, but not a problem if greases are compatible	Easy to drain completely and refill reservoirs
	Contamination control	Difficult to control contamination	Can be filtered and reconditioned
	Quality control	Difficult to monitor	Easy to monitor

evaporate. For these challenging environments, SKF provides two dry lubricant alternatives:

- bearings with a solid, graphite-based lubricant compound, designation suffixes VA201, VA210 or VA2101
- bearings with a self-sacrificing graphite cage, designation suffixes VA208 or VA228

NOTE: Bearings filled with Solid Oil, solid graphite or graphite paste do not require relubrication.

Grease lubrication

What is in a grease?

Grease can be described as "thickened oil". Rolling bearing grease is usually a suspension of base oil in a thickener, plus additives. By varying these ingredients, it is possible to produce several different greases for a wide variety of applications.

Base oil

The base oil makes up 70 to 95% of the grease and can be classified into one of three categories:

- mineral
- synthetic
- natural

Mineral base oils are refined crude petroleum products. The base oils in grease are normally mineral oils as these are appropriate for most applications.

Under special operating conditions, e.g. extremely low or high operating temperatures, synthetic base oils are preferred. Synthetic base oils are non-petroleum based products.

Natural base oils, i.e. animal and vegetable oils, are not normally used for rolling bearings because there is a risk of quality impairment and acid formation after a short time.

Thickener

The thickener constitutes 30 to 5% of the grease. It is the ingredient that retains the oil and additives, enabling the grease to function. The thickener also gives the grease "body", enabling it to stay in place.

There are various thickeners, each having specific benefits directed at certain application conditions. The broadest category of thickeners can be divided into soaps and non-soaps.

Soaps

The most common greases have metallic soap thickeners based on lithium (Li), calcium (Ca), sodium (Na), barium (Ba) or aluminium (Al). Lithium soap is the most commonly used soap for bearing greases.

Complex soap greases are the result of a chemical reaction between a base metal and two dissimilar acids. These greases typically have increased performance capabilities and can withstand higher operating temperatures than the corresponding conventional soap greases.

Non-soaps

Non-soap thickeners are occasionally based on inorganic ingredients. Inorganic thickeners such as bentonite, clay and silica gel resist leakage at high operating temperatures and are water resistant. Polyurea is an example of a non-soap thickener.

Additives

Chemicals, known as additives, are added to grease to achieve or enhance certain performance characteristics. Some of the more common additives are listed in **table 2**.

Extreme pressure, anti-wear and solid additives

Extreme pressure (EP) additives can consist of many different compounds; examples include sulphur and phosphorous compounds. EP additives increase the load carrying capacity of the lubricant film under heavy loads.

Anti-wear (AW) additives form a protective layer on metal surfaces, similar to EP additives.

Solid additives, such as molybdenum disulphide (MoS_2) and graphite, are beneficial in grease, under low speed conditions, when the base oil may become ineffective.

Table 2

Grease additives

Additive	Function
Anti-rust	Improves the protection of the bearing surfaces offered by grease
Anti-oxidant	Delays the breakdown of the base oil at high temperatures, extending grease life
Extreme pressure (EP)	Reduces the damaging effects of metal-to-metal contact
Anti-wear (AW)	Prevents metal-to-metal contact by the formation of a protective layer
Solid additive	Provides lubrication when the base oil becomes ineffective

How grease functions in bearings

The thickener in grease functions as a container for the base oil and behaves like a water-filled sponge. When a wet sponge is squeezed lightly, a small amount of water is released. When heavy pressure is applied to the sponge, more water is forced out.

Similarly, when a load is applied to grease, the thickener releases the base oil. This is known as oil bleeding or oil separation. When the load is released, the thickener normally absorbs the base oil again.

Interpreting grease datasheets

Grease datasheets provide information in three general categories:

- the properties of the grease
- the bearing operating conditions for which the grease is suitable
- the results of grease performance tests

Interpreting and understanding grease datasheets is essential for successful grease selection as well as for lubrication maintenance.

Grease properties

Grease datasheets typically provide information about important grease properties, including:

- NLGI consistency grade
- soap type
- dropping point
- base oil viscosity/type
- operating temperature range

NLGI consistency grade

Greases are divided into various consistency grades according to a scale developed by the US National Lubricating Grease Institute (NLGI). Greases with a high consistency, i.e. stiff greases, are assigned high NLGI grades, while those
with a low consistency, i.e. soft greases, are given low NLGI grades.

There are nine NLGI grades in total. In rolling bearing applications, three grades from the scale are generally used: NLGI 1, 2 and 3.

NOTE: It is important to remember that the stiffness of grease has nothing to do with the base oil viscosity. Stiff grease can have a high or low base oil viscosity.

Soap type

The most common greases have lithium, calcium or sodium soaps as thickeners. Lithium and sodium soaps have a wide operating temperature range, typically up to 120 °C *(250 °F)*. Calcium soaps only have an operating temperature range up to 80 °C *(175 °F)*, but provide excellent protection against water, including salt water.

Complex soaps typically exhibit improved properties.

Dropping point

The dropping point of grease is the temperature at which the grease loses its consistency and becomes a fluid. This temperature does not represent the operating temperature limit of the grease.

Base oil viscosity/type

Viscosity is the resistance to the flow of a fluid. Different fluids have different viscosities. Water has a low viscosity because it has a low resistance to flow; honey has a high viscosity, because it does not flow easily.

Viscosity is temperature and pressure dependent. The viscosity of the base oil in grease decreases with rising temperature and increases with falling temperature. Conversely, the viscosity of the base oil in grease increases with increasing pressure.

CAUTION: With every 10 to 15 °C *(18 to 27 °F)* increase in temperature, the viscosity of a mineral base oil drops by a factor of two!

The base oil viscosity in grease is specified at two temperatures:

- the internationally standardized reference temperature, i.e. 40 °C *(105 °F)*
- a high temperature, typically 100 °C *(210 °F)*

With this information, it is possible to calculate the base oil viscosity at operating temperature. For information about viscosity calculations, refer to the section *How to select a suitable oil* starting on **page 204**.

Operating temperature range – The SKF traffic light concept

The temperature range for greases is divided by four temperature limits into five zones:

- low temperature limit (LTL)
- low temperature performance limit (LTPL)
- high temperature performance limit (HTPL)
- high temperature limit (HTL)

SKF illustrates this schematically in the form of a "double traffic light" (→ **fig. 1**).

The low temperature limit (LTL) is the lowest temperature at which grease will enable a bearing to start operating without difficulty. The LTL is largely determined by the type of base oil and its viscosity.

The high temperature limit (HTL) is established by the grease's dropping point, i.e. the temperature when grease becomes a fluid.

SKF does not recommend start-up above the HTL or below the LTL. In fact, SKF recommends performance limits well within the manufacturer's recommended temperature limits. These are referred to as the high and low temperature performance limits. It is within these two limits, the green zone in **fig. 1**, where the grease functions reliably and grease life can be determined.

Since the definition of the high temperature performance limit (HTPL) is not standardized internationally, care must be taken when interpreting manufacturers' data.

At temperatures above the HTPL, grease will age and oxidize with increasing rapidity and the by-products of the oxidation can have a detri-

Fig. 1

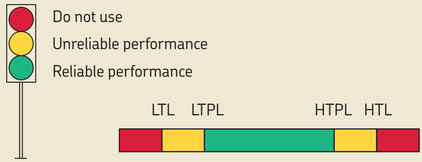

Table 3

Bearing operating temperatures (grease datasheets)

Temperature description	Definition
Low (L)	< 50 °C (*120 °F*)
Medium (M)	50 to 100 °C (*120 to 210 °F*)
High (H)	> 100 °C (*210 °F*)
Extremely high (EH)	> 150 °C (*300 °F*)

Table 4

Bearing speeds for standard bearings (grease datasheets)

Speed description	Bearing speed factor A for Radial ball bearings	Cylindrical roller bearings	Tapered roller bearings, Spherical roller bearings, CARB toroidal roller bearings
–	mm/min		
Very low (VL)	–	< 30 000	< 30 000
Low (L)	< 100 000	< 75 000	< 75 000
Moderate (M)	< 300 000	< 270 000	< 210 000
High (H)	< 500 000	≥ 270 000	≥ 210 000
Very high (VH)	< 700 000	–	–
Extremely high (EH)	≥ 700 000	–	–

mental effect on lubrication. Therefore, operating temperatures in the amber zone between the HTPL and the HTL, should occur only for very short periods.

An amber zone also exists for low temperatures. With decreasing temperature, the tendency of grease to bleed oil decreases and the stiffness (consistency) of the grease increases. This will ultimately lead to an insufficient supply of lubricant to the contact surfaces of the rolling elements and raceways. In **fig. 1**, this temperature limit is indicated by the low temperature performance limit (LTPL). Short periods in the amber zone, e.g. during a cold start, in general are not harmful since the heat caused by friction will bring the bearing operating temperature into the green zone.

Greases and bearing operating conditions

Grease datasheets provide information about suitable bearing operating conditions with regard to:

- temperature
- speed
- load

These descriptions, however, are expressed using general terms such as “low” or “very high” and require interpretation.

Temperature

The operating temperature of a bearing is measured as close to the bearing outside diameter as possible, and is influenced by the ambient temperature. A measured operating temperature of 100 °C *(210 °F)* or above is generally considered “high”.

Information about bearing operating temperatures in grease datasheets can be interpreted using the guidelines in **table 3**.

Speed

The operating speed reference in grease datasheets is based on the speed factor of the bearing. The speed factor compares the speed capability of bearings and is expressed as

$$A = n\, d_m$$

where

A = speed factor [mm/min]
n = rotational speed [r/min]
d_m = bearing mean diameter = 0,5 (D + d) [mm]

Information about bearing operating speeds in grease datasheets can be interpreted using the guidelines in **table 4**.

Load

Reference made to bearing load in grease datasheets is based on the ratio between the dynamic load rating C of the bearing and the equivalent load P on the bearing (the load to which the bearing is subjected). Therefore:

- The smaller the equivalent load P, the bigger the ratio C/P is and the more lightly loaded the bearing becomes.
- The bigger the equivalent load P, the smaller the ratio C/P is and the more heavily loaded the bearing becomes.

Information about bearing loads in grease datasheets can be interpreted using the guidelines in **table 5**.

Table 5

Bearing loads (grease datasheets)

Load description	Load ratio
Light (L)	$P \leq 0{,}05\ C$
Moderate (M)	$0{,}05\ C < P \leq 0{,}1\ C$
Heavy (H)	$0{,}1\ C < P \leq 0{,}15\ C$
Very heavy (VH)	$P > 0{,}15\ C$

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Grease performance tests

The remaining part of a grease datasheet typically contains results of laboratory tests performed on samples of the grease.

The test results can be interpreted using the guidelines in **table 6**.

Table 6

Grease performance tests

Test	What this means	Measurement [unit]	Interpretation of results
Dropping point	The temperature at which the grease begins to flow	Temperature [°C]	–
Penetration	Consistency, the stiffness of the grease (NLGI grade)	Depth of cone penetration Value between 85 and 475 [10^{-1} mm] (60 or 100 000 strokes)	High number = soft grease Low number = stiff grease
Roll stability	How easily the grease softens or hardens	Change in cone penetration depth [10^{-1} mm]	High number = less stable Low number = more stable
Mechanical stability	The mechanical stability of the grease when subjected to vibration	Rating, dependent on the mass of the leaked grease (SKF V2F rating)	M = very little grease leakage m = some grease leakage Fail = a lot of grease leakage
Corrosion protection	The degree of corrosion of the grease when mixed with water	Value between 0 and 5 (SKF EMCOR rating[1)])	0 = no corrosion 5 = very severe corrosion
Oil separation	The amount of oil that leaks through a sieve during storage	Percentage weight loss [%] (DIN 51817)	0% = no oil separation 100% = complete oil separation
Water resistance	The change in grease after water immersion	Value between 0 and 3 (based on visual inspection) (DIN 51807/1)	0 = no change 3 = major change
Lubricating ability	The lubricating ability of the grease under operating conditions typical of large bearings (d ≥ 200 mm)	Rating, dependent on the ability of the grease to lubricate large bearings under normal or high temperature conditions (SKF R2F grease test machine)	Unheated test (normal temperature conditions) Pass = grease is suitable Fail = grease is not suitable Heated test (high temperature conditions) Pass = grease is suitable Fail = grease is not suitable
Copper corrosion	The degree of protection of copper alloys offered by the grease	Value between 1 and 4 (based on visual inspection) (DIN 51811)	1 = good protection 4 = very bad protection
Rolling bearing grease life	The grease life	Time to bearing failure [hours] (SKF R0F grease test machine)	–
EP performance (VKA test)	The ability to classify the grease as an EP grease	Extreme pressure limit of the grease [N] (DIN 51350/4)	–
Fretting corrosion	The ability of the grease to protect against fretting corrosion	Bearing wear [mg] (ASTM D4170)	–

1) Standardized in accordance with ISO 11007.

Selecting a suitable grease

All precautions taken to prevent premature bearing failure count for little if the wrong grease is selected. Therefore, grease selection is critical to the operational success of any machine. Grease based on a mineral oil and lithium thickener with an NLGI 2 grade is sufficient for most applications. However, consider all contributing factors as discussed below.

Gather all relevant information before starting the selection process:

- application
- bearing type and overall dimensions
- bearing load
- operating and ambient temperatures
- rotational speed
- shaft orientation
- external influences e.g. vibration, oscillation
- contamination details

CAUTION: Before selecting the initial grease or switching to a different grease, be sure to check the machine manufacturer's documentation. Not all greases are compatible with each other and there could be components within the machine that are not compatible with some lubricant additives.

Grease selection tools

The SKF grease selection program, LubeSelect, can be used to select an appropriate SKF grease. Another SKF program, LuBase, contains details about more than 2 000 lubricants provided by more than 100 lubricant suppliers. Both programs are available online at www.aptitudexchange.com.

An SKF bearing grease selection chart is provided in **Appendix M**, on **pages 430** to **431**. For additional information about how to select a suitable grease, refer to the *SKF Interactive Engineering Catalogue*, available online at www.skf.com.

How to grease bearings and associated components on initial installation

Most open rolling bearings are supplied ungreased. They are, however, protected with a rust inhibiting preservative. The rust inhibitor on SKF bearings is compatible with most lubricants and additives (except for example SKF LGET 2) and does not need to be washed off before initial greasing. Bearings with a shield or seal fitted on both sides are greased at the factory and do not require additional grease when mounting.

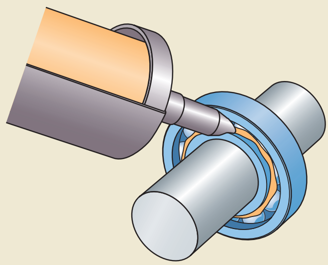
CAUTION: Never wash a bearing that has a seal or shield fitted on both sides.

The best time to apply grease

Generally, open bearings are lubricated after mounting (→ **fig. 2**). The most important reason for this is cleanliness. The later the grease is applied, the less chance there is that contaminants will enter into the bearing.

Bearings should be lubricated prior to mounting when there is no other way to get grease into the bearing.

Fig. 2



WARNING

SKF LGET 2, a fluorinated grease, is not compatible with other greases, oils and preservatives. Therefore, a very thorough washing of the bearings and cleaning of the systems is essential before applying fresh grease.

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The right quantity

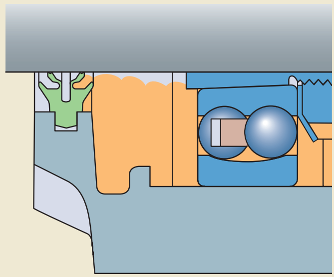
As a general rule, for bearings mounted in housings, the bearings should be completely filled (100%) with grease prior to start-up.

The free space in the housing should be partially filled (30 to 50%) with grease (→ **fig. 3**). In non-vibrating applications, where bearings are to operate at very low speeds and good protection against contamination is required, SKF recommends filling up to 90% of the free space in the housing with grease.

An alternative for highly contaminated environments is to fill the housing completely and use a sealed SKF bearing. This triple layer of protection uses the housing seal, grease in the housing, and bearing seal to protect the bearing and lubricant inside the bearing from even the very smallest contaminants.

CAUTION: Always leave free space in the housing so that grease, ejected from the bearing during start-up, has somewhere to go. If the housing is completely filled, churning can result, which can increase the operating temperature by as much as 50 °C *(90 °F)*. The grease might also be burnt leading to lubricant starvation. If running-in cannot be done, the initial grease fill should be reduced to a maximum of 30% of the free volume in the bearing.

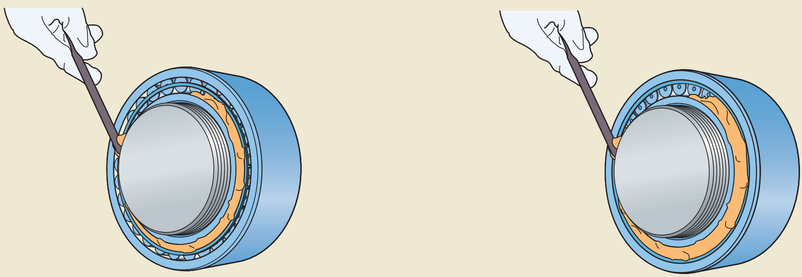
Fig. 3



When labyrinth seals are fitted, the radial or axial gaps in the labyrinth arrangement should be fully packed with grease.

Double-lip seals and seals with a contacting auxiliary lip should also be fully packed with grease because the grease not only acts as a seal but it also decreases underlip temperatures.

Fig. 4



a) Greasing CARB toroidal roller bearings with a cage (high-speed operation)

b) Greasing full complement CARB toroidal roller bearings

CARB toroidal roller bearings

CARB toroidal roller bearings have a relatively large free space available for grease (→ **fig. 4**). If these bearings are fully greased and run at relatively high speeds (> 75% of the reference speed), elevated operating temperatures can be expected. Therefore, SKF recommends filling only the space between the inner ring and the cage of the bearing with grease (**a**).

For full complement CARB bearings or CARB bearings operating at low or moderate speeds, the bearings should be completely filled with grease (**b**).

High- and super-precision bearings

High- and super-precision bearings should generally be lubricated with small quantities of grease. In machine tool applications, which mostly run at high to very high speeds, less than 30% of the free space in the bearings should be filled with grease. From experience in the field, the most common grease fill is about 10 to 15% of the free space in the bearing.

For additional information about greasing high- and super-precision bearings, refer to the *SKF Interactive Engineering Catalogue*, available online at www.skf.com.

Greasing techniques when mounting

Greasing techniques vary according to the design of the bearings and their housings. Bearings can be either separable or non-separable; housings either split or one-piece. A few guidelines for greasing bearings are presented here.

For information about mounting bearings, refer to the chapter *Mounting rolling bearings*, starting on **page 44**.

Separable bearings

Separable bearings include cylindrical roller and tapered roller bearings, four-point contact ball bearings, and all types of thrust bearings. These bearings should be greased while separated in the order determined by the mounting sequence. Make sure the free space between the rolling elements and cage is filled completely with grease. If the rolling element and cage assembly is separable from both rings, grease the raceway of one of the rings lightly to avoid damaging the surface when the rolling element and cage assembly is pushed back onto the ring.

Non-separable bearings

Non-separable bearings, such as deep groove and angular contact ball bearings, can be filled preferably with grease from both sides during the mounting process.

For self-aligning ball bearings, spherical roller bearings and CARB toroidal roller bearings, one bearing ring can be swivelled to facilitate greasing. The bearings should then be turned a few times to distribute the grease evenly.

CAUTION: When swivelling the ring of a CARB toroidal roller bearing or self-aligning bearing, the lower rolling elements can drop slightly. This can cause the rolling elements to jam against the outer ring when swivelling it back into position and damage the bearing. To avoid this, guide the rolling elements smoothly back into place.

Greasing bearings prior to mounting

Open bearings that cannot be greased after mounting should be greased as follows before mounting:

1. Place the bearing on a clean plastic sheet.
2. Chock larger bearings or use a v-block to keep the bearing in place.
3. Fill the free space, from both sides, between the rolling elements and cage with grease, using a grease packer. For self-aligning bearings, swivel one of the bearing rings, exposing the rolling elements, and then apply the grease.
4. If the bearing cannot be mounted immediately, wrap it in plastic.

Running-in of grease lubricated bearings

During initial start-up, the temperature in a newly greased bearing will rise. Therefore, if possible, SKF recommends running-in bearings before operating at full speed. This is particularly important for high-speed applications. Without a running-in period, the temperature rise can be considerable.

Running-in a bearing involves operating the bearing at increasing speeds from a low initial speed. At the end of the running-in period, the grease will be distributed throughout the bearing arrangement and the operating temperature will have stabilized.

Relubrication

Grease does not last forever. Under the influence of time, temperature, mechanical working, ageing and the ingress of contaminants, grease in a bearing arrangement deteriorates and gradually loses its lubricating properties. Relubrication is the addition of fresh grease into a bearing arrangement after a certain period of operation.

There are three critical factors to proper relubrication: the type of grease, the quantity of grease and the relubrication interval. The quantity of grease and relubrication interval depend greatly on whether the grease is applied manually or automatically.

Sealed bearings are normally lubricated for life and typically do not require relubrication. However, when operating conditions are arduous, relubrication might be necessary. Therefore, a number of sealed bearing types have relubrication features.

Relubrication intervals

Relubrication intervals depend on many related factors. Be sure to check the machinery manufacturer's recommendations prior to developing a relubrication programme. If that is not possible, gather all relevant information before calculating relubrication intervals:

- application
- bearing type and boundary dimensions
- bearing load
- operating and ambient temperatures
- rotational speed
- shaft orientation
- external influences, e.g. vibration, oscillation
- contamination details

The relubrication interval t_f can be obtained from **diagram 1** as a function of:

- the speed factor A
- the bearing factor b_f
- the load ratio C/P

where
A = n d_m [mm/min]
n = rotational speed [r/min]
d_m = bearing mean diameter
= 0,5 (d + D) [mm]
b_f = bearing factor depending on the bearing type, and load conditions (for axially loaded spherical roller bearings) (→ **table 7**, **page 194**)

If a bearing failure analysis indicates that there has been a problem with heat and/or lubrication, first check that the appropriate grease was used. If so, check the recommended limits for the speed factor A in **table 7**, **page 194**. If the speed factor of the application is greater than those listed, switching to an oil bath or circulating oil system may substantially increase bearing service life.

The relubrication intervals in **diagram 1** are estimates, based on the following operating conditions:

- an operating temperature of 70 °C *(160 °F)*
- lubrication with good quality lithium based grease
- a horizontal shaft
- a rotating inner ring
- a clean environment

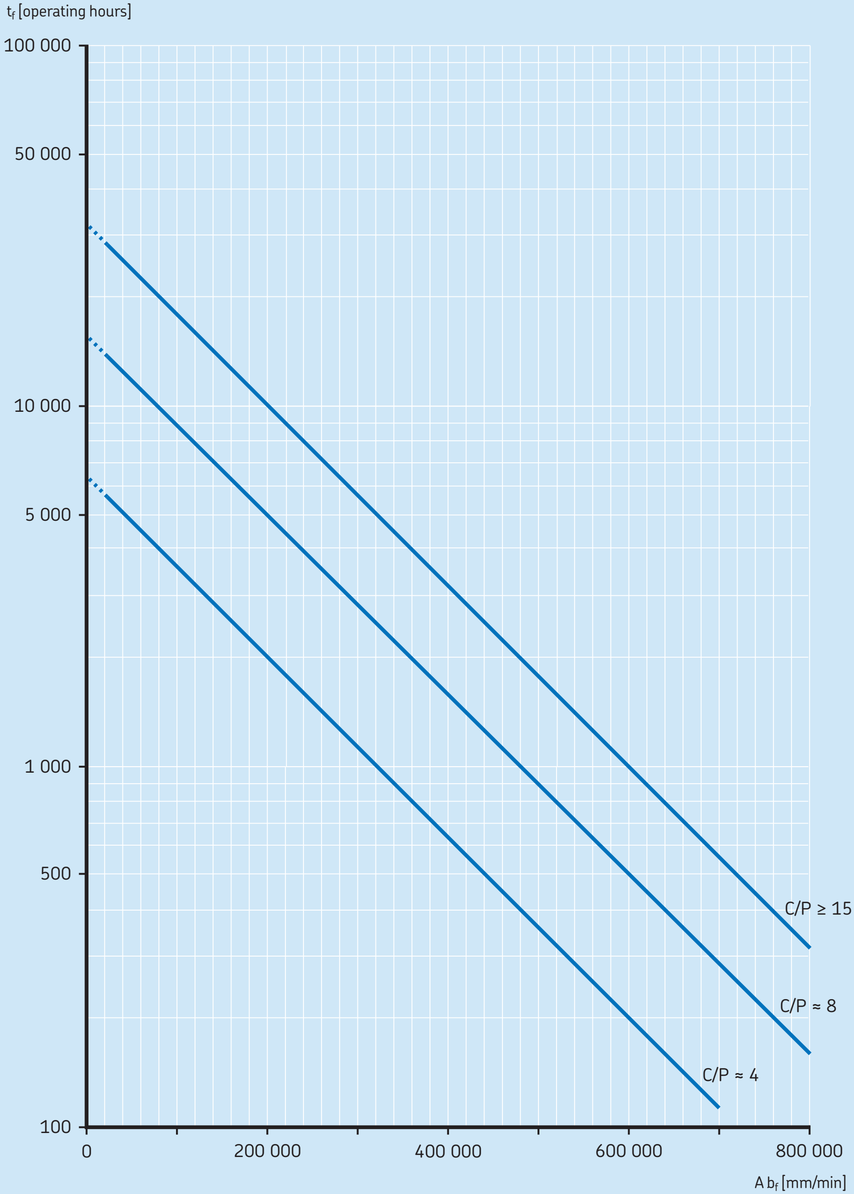
When bearing operating conditions differ, adjust the relubrication intervals according to the information provided in **table 8**, **page 195**.

NOTE: When using different bearings in an assembly, apply the shortest calculated relubrication interval to all bearings.

The SKF grease selection program, LubeSelect, available online at www.aptitudexchange.com, can also be used to calculate relubrication intervals.

Diagram 1

Relubrication intervals at 70 °C (*160 °F*)



Relubrication procedures

The choice of a relubrication procedure generally depends on the application, the operating conditions and the relubrication interval t_f. There are two primary relubrication procedures: replenishment and continuous relubrication (→ **table 9**).

Table 7

Bearing factors and recommended limits for the speed factor A

Bearing type[1)]	Bearing factor b_f	Recommended limits for the speed factor A, for load ratio		
		C/P ≥ 15	C/P ≈ 8	C/P ≈ 4
–	–	mm/min		
Deep groove ball bearings	1	500 000	400 000	300 000
Angular contact ball bearings	1	500 000	400 000	300 000
Self-aligning ball bearings	1	500 000	400 000	300 000
Cylindrical roller bearings				
• non-locating bearing	1,5	450 000	300 000	150 000
• locating bearing, without external axial loads or with light but alternating axial loads	2	300 000	200 000	100 000
• locating bearing, with constantly acting light axial load	4	200 000	120 000	60 000
• without a cage, full complement[2)]	4	NA[3)]	NA[3)]	20 000
Tapered roller bearings	2	350 000	300 000	200 000
Spherical roller bearings				
• when $F_a/F_r \leq e$ and $d_m \leq 800$ mm				
– series 213, 222, 238, 239	2	350 000	200 000	100 000
– series 223, 230, 231, 232, 240, 248, 249	2	250 000	150 000	80 000
– series 241	2	150 000	80 000[4)]	50 000[4)]
• when $F_a/F_r \leq e$ and $d_m > 800$ mm				
– series 238, 239	2	230 000	130 000	65 000
– series 230, 231, 240, 248, 249	2	170 000	100 000	50 000
– series 241	2	100 000	50 000[4)]	30 000[4)]
• when $F_a/F_r > e$				
– all series	6	150 000	50 000[4)]	30 000[4)]
CARB toroidal roller bearings				
• with a cage	2	350 000	200 000	100 000
• without a cage, full complement[2)]	4	NA[3)]	NA[3)]	20 000
Thrust ball bearings	2	200 000	150 000	100 000
Cylindrical roller thrust bearings	10	100 000	60 000	30 000
Spherical roller thrust bearings				
• rotating shaft washer	4	200 000	120 000	60 000

1) The bearing factors and recommended practical limits for the speed factor A apply to bearings with standard internal geometry and standard cages. For alternative internal bearing designs and special cages, contact the SKF application engineering service.
2) The t_f value obtained from **diagram 1**, **page 193** needs to be divided by a factor of 10.
3) Not applicable. For these C/P values, SKF does not recommend a full complement bearing, but a bearing with a cage instead.
4) For higher speeds, oil lubrication is recommended.

Table 8

Relubrication interval adjustments

Operating condition / bearing type	Description	Recommended adjustment of t_f	Reason for adjustment
Operating temperature	For every 15 °C (*27 °F*) above 70 °C (*160 °F*), up to the high temperature limit (HTL)	Halve the interval	To account for the accelerated ageing of grease at higher temperatures
	For every 15 °C (*27 °F*) under 70 °C (*160 °F*)	Double the interval (maximum two times)[1]	To account for the reduced risk of ageing of grease at lower temperatures
Shaft orientation	Bearings mounted on a vertical shaft	Halve the interval	The grease tends to leak out due to gravity
Vibration	High vibration levels and shock loads	Reduce the interval[2]	The grease tends to "slump" in vibratory applications, resulting in churning
Outer ring rotation	Outer ring rotation or eccentric shaft weight	Calculate the speed factor A using D, not d_m	The grease has a shorter grease life under these conditions
Contamination	Heavy contamination or the presence of fluid contaminants	Reduce the interval[2] [3]	To reduce the damaging effects caused by contaminants
Load	Very heavy loads i.e. P > 0,15 C	Reduce the interval[2]	The grease has a shorter grease life under these conditions
Bearing size	Bearings with a bore diameter d > 300 mm	Reduce the interval[2]	These are typically critical arrangements, which require strict, frequent relubrication programmes
Cylindrical roller bearings	Bearings fitted with J, JA, JB, MA, MB, ML, MP and PHA cages[4]	Halve the interval	Oil bleeding is limited with these cage designs

[1] For full complement and thrust bearings, do not extend the interval.
[2] Contact the SKF application engineering service.
[3] For severely contaminated conditions, consider sealed SKF bearings or continuous relubrication.
[4] For P, PH, M and MR cages, there is no need for adjustment.

Table 9

Relubrication procedures

Relubrication procedure	Suitable relubrication interval t_f	Advantages	Disadvantages	Requirements
Replenishment	t_f < 6 months	Uninterrupted operation	Lubrication ducts in the bearing housing required Labour intensive Easy access to the bearing housing required High risk of contamination	Bearing housings equipped with grease fittings Grease gun
Continuous relubrication	t_f is very short	Ideal for difficult access points Low risk of contamination Not labour intensive Continuous monitoring of lubrication possible Uninterrupted operation	Good pumpability of grease required (especially at low ambient temperatures)	Automatic lubricators or centralized lubrication systems

Replenishment

Since only the grease in the bearing should be replaced, the quantity needed for replenishment depends purely on the size of the bearing.

Some bearings are provided with relubrication features in the inner or outer ring to facilitate efficient relubrication through the centre of the bearing (→ **fig. 5**). The suitable quantity of grease for replenishment is then

$$G_p = 0{,}002\ D\ B$$

Other bearings can only be relubricated from the side (→ **fig. 6**). The suitable quantity of grease for replenishment is then

$$G_p = 0{,}005\ D\ B$$

where

G_p = grease quantity to be added when replenishing [g]

D = bearing outside diameter [mm]

B = total bearing width (for thrust bearings, use height H) [mm]

Bearing arrangements in housings that have contact seals, i.e. double-lip or four-lip seals, should be equipped with a grease escape hole to enable used and excess grease to purge from the arrangement. The escape hole should be positioned on the same side as the lock nut and therefore, on the side opposite the grease fitting (→ **fig. 7**).

Bearing arrangements with non-contact seals such as labyrinth seals do not require a grease escape hole as the used and excess grease is pressed out between the gaps of the labyrinth when fresh grease is introduced (→ **fig. 8**).

Grease should be replenished in the early stages of lubricant deterioration. For grease replenishment, SKF recommends the following:

1 If a different grease is being introduced, check that the greases are compatible (→ *Grease compatibility*, starting on **page 200**).
2 Clean the grease fitting.
3 Replenish the grease while the machine is operating. If this is not possible, rotate the shaft by hand.
4 Where long lubrication ducts and low ambient temperatures exist, check that the grease is pumping adequately by checking that there is no excessive oil separation as a result of the pumping action.
5 After three to five replenishments, if possible, renew the grease fill (→ *Renewal*, starting on **page 198**).

CAUTION: Do not apply more grease than is appropriate. If grease leaks out of the contact seals from overfilling, this could damage the seals and cause overheating and premature bearing failure.

Fig. 5

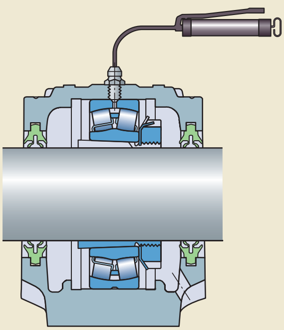
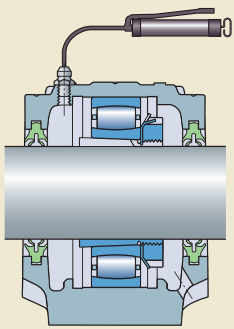


Fig. 6



Continuous relubrication

Continuous relubrication is used, for example, for high-speed applications where a small quantity of lubricant is continuously required. It is also used in highly contaminated environments where continuous lubrication is necessary to keep contaminants out.

Automatic lubrication solutions are designed for continuous lubrication or when lubrication points are difficult or dangerous to access, or when the reliability on the relubrication tasks needs to be improved. The main advantage of automatic lubrication is that it provides more accurate control over what lubricant and how much of it is supplied to each lubrication point. In addition, the risk of contamination associated with manual greasing using grease guns is reduced.

The quantity of grease required for continuous relubrication can be calculated approximately by

$$G_k = (0{,}3 \ldots 0{,}5)\ D\ B \times 10^{-4}$$

where

G_k = grease quantity to be continuously supplied [g/h]

D = bearing outside diameter [mm]

B = total bearing width (for thrust bearing use total height H) [mm]

Alternatively, the calculated replenishment quantity G_p (→ *Replenishment*, **page 196**) can be spread over the relubrication interval.

SKF manufactures single point and multi-point automatic lubricators such as the SKF SYSTEM 24 lubricators. Centralized lubrication systems provide another option for automatic lubrication (→ *Centralized lubrication systems*, starting on **page 213**).

Fig. 7

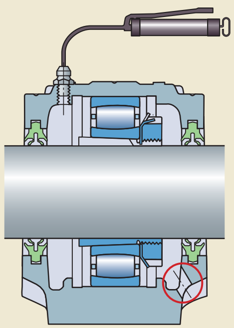
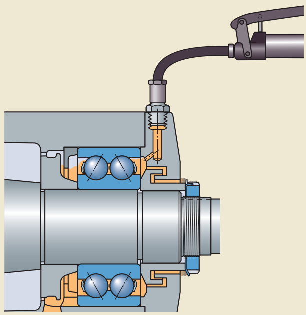


Fig. 8



SKF SYSTEM 24

SKF SYSTEM 24 lubricators in the LAGD series (→ **fig. 9**) consist of a transparent container, filled with a specified lubricant, and a gas producing cell. The values on the time set dial are an indication of the real emptying time. The lubricators can be deactivated temporarily by resetting the time set dial to zero.

SKF SYSTEM 24 lubricators in the LAGE series (→ **fig. 10**) consist of a transparent container, filled with a specified lubricant, and an electromechanical lubricator system. Refill sets with battery packs are available. The dispense rate is temperature independent.

Both series of lubricators have a maximum operating pressure of 5 bar and a G 1/4 connection thread. Additional technical data is provided in **table 10**.

CAUTION: Check that the new lubricator contains the same grease as the old one. If new grease is being introduced, check that the greases are compatible.

WARNING
To minimize the chance of serious injuries, prior to starting any work, perform required lockout/tagout procedures.

Renewal

Renewal is the process of stopping a machine, removing the existing grease inside the bearing arrangement and replacing it with fresh grease. Renewing the grease fill is generally recommended after several replenishments or when the relubrication interval is longer than six months.

When renewing the grease fill in a bearing arrangement with a split housing, SKF recommends the following:

1 Clean the work area.
2 Open the housing.
3 Remove the used grease in the housing cavity completely, using a palette knife, and clean the housing cavity with a solvent.
4 Clean the bearing with solvent and allow it to dry. Remaining traces of the solvent will evaporate.
5 Fill the free space between the rolling elements and cage with grease from the accessible side, using a grease packer.

Fig. 9

Fig. 10

6 Fill 30 to 50% of the housing with grease (typical quantity for normal applications).
7 Put the housing cap back in position.
8 Run-in the bearing.

When housings are not easily accessible but are provided with grease fittings and a grease escape hole, SKF recommends the following:

CAUTION: If a different grease is being introduced, check that the greases are compatible (→ *Grease compatibility*, starting on **page 200**).

1 Make sure the grease escape hole is open.
2 Clean the grease fitting.
3 Introduce fresh grease steadily (not too fast) via the grease fitting, while the machine is operating.
4 Capture the old grease expelled from the escape hole in a container.
5 Continue to add fresh grease until fresh grease is expelled from the escape hole.

CAUTION: Adding too much grease or too quickly without the ability to purge will result in churning and high operating temperatures.

Table 10

SKF SYSTEM 24 lubricators

Property	**Lubricator** LAGD 60	LAGD 125	LAGE 125	LAGE 250
Grease capacity	60 ml	125 ml	122 ml	250 ml
Nominal emptying time	1 to 12 months (adjustable)	1 to 12 months (adjustable)	1, 3, 6, 9 or 12 months (adjustable)	1, 3, 6, 9 or 12 months (adjustable)
Ambient temperature range	–20 to +60 °C *(–5 to +140 °F)*	–20 to +60 °C *(–5 to +140 °F)*	0 to +55 °C *(30 to 130 °F)*	0 to +55 °C *(30 to 130 °F)*
Ordering designation for pre-filled lubricators	LAGD 60/lubricant	LAGD 125/ lubricant	LAGE 125/ lubricant	LAGE 250/ lubricant
Suitable SKF greases	LGWA 2	LGWA 2, LGEM 2, LGFP 2, LGHB 2, LGHP 2, LGGB 2, LGWM 2	LGWA 2, LGEM 2, LGFP 2, LGHB2, LGHP 2, LGWM 2	LGWA 2, LGEM 2, LGFP 2, LGHB 2, LGHP 2, LGWM 2
Suitable SKF chain oils [1]	–	LHMT 68, LHHT 265, LHFP 150	LHMT 68, LHHT 265, LHFP 150	LHMT 68, LHHT 265, LHFP 150

[1] For additional information about SKF chain oils, refer to **table 16** on **page 209**.

Grease compatibility

Before changing from one grease type to another, check that the two greases are compatible. Also, since grease in a bearing arrangement makes contact with the entire bearing, the grease should be compatible with all bearing materials and any bearing preservatives or coatings.

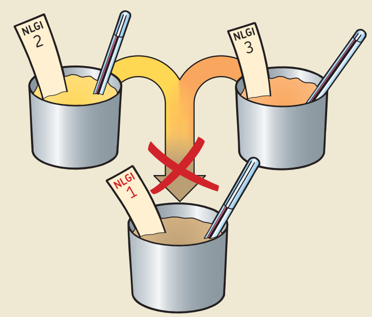
Compatibility between greases

Greases with the same thickener and similar base oils can generally be mixed without any problems. However, if two incompatible greases are mixed, the resulting mixture usually has a softer consistency (→ **fig. 11**) and can cause premature bearing failure through grease leakage from the bearing. The mixture also has a lower maximum operating temperature and the lubricant film (in operation) has a lower load carrying capacity than that of the individual greases.

CAUTION: It is generally good practice not to mix greases. If the original grease type is unknown, first completely remove the old grease and then refill (→ *Renewal*, starting on **page 198**).

To determine if two greases are compatible, compare the base oils (→ **table 11**) and thickeners (→ **table 12**).

Fig. 11



WARNING
SKF LGET 2, a fluorinated grease, is not compatible with other greases, oils and preservatives. Therefore, a very thorough washing of the bearings and cleaning of the systems is essential before applying fresh grease.

Table 11

Base oil compatibility

	Mineral/PAO	Ester	Polyglycol	Silicone: methyl	Silicone: phenyl	Polyphenyl-ether	PFPE
Mineral/PAO	+	+	–	–	+	o	–
Ester	+	+	+	–	+	o	–
Polyglycol	–	+	+	–	–	–	–
Silicone: methyl	–	–	–	+	+	–	–
Silicone: phenyl	+	+	–	+	+	+	–
Polyphenylether	o	o	–	–	+	+	–
PFPE	–	–	–	–	–	–	+

+ = Compatible o = Test required – = Incompatible

Table 12

Thickener compatibility

	Lithium	Calcium	Sodium	Lithium complex	Calcium complex	Sodium complex	Barium complex	Aluminium complex	Clay	Common polyurea [1)]	Calcium sulphonate complex
Lithium	+	o	–	+	–	o	o	–	o	o	+
Calcium	o	+	o	+	–	o	o	–	o	o	+
Sodium	–	o	+	o	o	+	+	–	o	o	–
Lithium complex	+	+	o	+	+	o	o	+	–	–	+
Calcium complex	–	–	o	+	+	o	–	o	o	+	+
Sodium complex	o	o	+	o	o	+	+	–	–	o	o
Barium complex	o	o	+	o	–	+	+	+	o	o	o
Aluminium complex	–	–	–	+	o	–	+	+	–	o	–
Clay	o	o	o	–	o	–	o	–	+	o	–
Common polyurea[1)]	o	o	o	–	+	o	o	o	o	+	+
Calcium sulphonate complex	+	+	–	+	+	o	o	–	–	+	+

+ = Compatible o = Test required – = Incompatible

[1)] SKF LGHP 2 has been tested successfully for compatibility with lithium and lithium complex thickened greases.

Symptoms of grease incompatibility

The following symptoms, observed during operation, are typical of grease incompatibility:

- lubricant leakage
- lubricant hardening
- lubricant colour change
- increased operating temperature

Quick compatibility test

A quick test, based on thickener compatibility (mechanical stability) and base oil compatibility (surface wetting) can be performed as follows:

1 Put equal amounts of each grease type into a container.
2 Stir the mixture with a rod.
3 Pour the mixture into another container.

If the mixture hardens, or becomes much softer and pours more easily from the container than either of the original greases, the greases are probably incompatible.

CAUTION: This quick compatibility test is only a guideline! SKF recommends actual laboratory tests to determine compatibility.

Compatibility between greases and bearing materials

SKF bearing greases are compatible with most bearing materials. However, keep the following in mind:

- Grease containing EP additives may react adversely with polyamide 66 cages above 100 °C *(210 °F)*.
- Grease containing sulphur EP additives may attack brass cages above 100 °C *(210 °F)*.
- Grease based on an ester oil is not compatible with seals made from acrylic rubber (ACM).

Compatibility between greases and SKF bearing preservatives

SKF bearings are treated with a petroleum based preservative that is compatible with the majority of bearing greases. However, the preservative is not compatible with synthetic fluorinated oil based greases with a PTFE thickener such as SKF LGET 2. With such greases, it is important to wash and dry the bearings carefully before applying this grease.

To remove the preservative from a bearing, wear grease resistant gloves and use a suitable detergent. The detergent evaporates quickly and the grease should be applied immediately afterwards to prevent the surfaces rusting.

SKF grease lubrication products

SKF offers a wide assortment of bearing greases and grease lubrication equipment, covering most application requirements (→ **Appendix L,** starting on **page 420**). More details about bearing greases from SKF and a grease selection guide are provided in **Appendix M**, starting on **page 423**. For additional information, visit www.mapro.skf.com and www.skf.com/lubrication.

Oil lubrication

What is in an oil?

Lubricating oil consists of base oil mixed with additives.

Base oil

The base oil makes up approximately 95% of lubricating oil and is classified into three groups:

- mineral
- synthetic
- natural

Mineral base oils are petroleum-based products. These oils are generally preferred for rolling bearing lubrication.

Synthetic base oils are generally considered for bearing lubrication under special operating conditions, e.g. at very low or very high operating temperatures. The term synthetic oil covers a wide range of different base stocks including polyalphaolefins (PAO), polyalkyleneglycols (PAG) and esters.

Natural base oils, i.e. animal and vegetable oils, are not normally used for rolling bearings because there is a risk of quality impairment and acid formation after a short time.

Additives

Chemicals, known as additives, are added to base oils to achieve or enhance certain performance properties. The additives are often grouped according to their function, e.g. performance, lubricant protective or surface protective additives.

Some of the more common additives are listed in **table 13**.

Table 13

Oil additives

Additive	Function
Anti-rust	Improves the protection of the bearing surfaces offered by oil (water or oil soluble)
Anti-oxidant	Delays the breakdown of the base oil at high temperatures, extending lubricant life
Anti-foaming	Prevents bubble formation
Extreme pressure (EP)	Reduces the damaging effects of metal-to-metal contact
Anti-wear (AW)	Prevents metal-to-metal contact
Solid additive	Provides lubrication when the base oil becomes ineffective

Oil viscosity

The most important property of lubricating oil is viscosity. Viscosity is the resistance of a fluid to flow and is dependent on temperature and pressure. Viscosity decreases with rising temperature and increases with falling temperature. High viscosity oil flows less readily than thinner, low viscosity oil.

The viscosity of oil is typically specified at the internationally standardized reference temperature, i.e. 40 °C *(105 °F)*.

Viscosity index (VI)

The viscosity-temperature relationship of oil is characterized by the viscosity index (VI). If oil has a high VI, it means there is minimal change in the viscosity of the oil with changes in temperature. Similarly, oil that is heavily dependent on temperature has a low VI.

For rolling bearing lubrication, SKF recommends using oils with a VI of at least 95.

ISO viscosity grade (VG)

ISO has an established standard about oil viscosity, known as the ISO viscosity grade (VG). It is simply the average oil viscosity at 40 °C *(105 °F)*. As an example, ISO VG 68 oil has an average viscosity of 68 mm^2/s at 40 °C *(105 °F)* (68 cSt).

The minimum and maximum viscosities for each ISO viscosity grade are provided in **Appendix I-2**, on **page 415**. A comparison of the various viscosity classification methods is provided in **Appendix I-1**, on **page 414**.

NOTE: Viscosity is expressed in mm^2/s or cSt (identical units).

How to select a suitable oil

Standard mineral oils provide adequate lubrication for most applications that are oil lubricated. Synthetic oils should only be selected if they can be justified, as they are normally much more expensive.

When selecting an oil, it is best to consider all contributing factors. Always gather the relevant information first, before starting the selection process:

- application
- bearing type and boundary dimensions
- bearing load
- operating and ambient temperatures
- rotational speed
- shaft orientation
- external influences e.g. vibration, oscillation
- contamination details

CAUTION: Be careful not to just substitute oil from one lubricant manufacturer with oil from a different manufacturer. They may not be identical or compatible.

Oil selection process

Accurate oil selection is comprised of three detailed steps. A summary of the selection process is provided below.

1 Select the oil viscosity

Oil is chosen on the basis of the viscosity required to provide sufficient lubrication under the prevailing operating conditions.

NOTE: Low viscosity means low friction, but a thin oil film. High viscosity means a thick oil film, but high friction. There needs to be a balance!

To form an adequate lubricant film between the internal contact surfaces in a bearing, the lubricant must retain a certain minimum viscosity "at normal operating temperature". The minimum kinematic viscosity ν_1 required for adequate lubrication can be determined using the bearing mean diameter d_m and the rotational speed n (→ **diagram 2**). The effectiveness of a particular lubricant is determined by the viscosity ratio κ, which is the ratio of the actual operating viscosity ν to the minimum kinematic viscosity ν_1. Suitable viscosity ratios are typically between 1 and 4.

The minimum kinematic viscosity is the viscosity required "at normal operating temperature". The corresponding viscosity at the internationally standardized reference temperature of 40 °C *(105 °F)* can then be obtained (→ **diagram 3**, **page 206**) or calculated. With this information, the minimum ISO VG can be selected.

To determine the minimum ISO VG, follow these steps:

NOTE: When determining the operating temperature of a bearing, keep in mind that the oil temperature is usually 3 to 11 °C *(5 to 20 °F)* higher than the bearing housing temperature.

1. Determine the bearing mean diameter d_m, rotational speed n and expected bearing operating temperature T.
2. Using **diagram 2,** locate the point where the mean diameter and rotational speed intersect.
3. Read across horizontally to the vertical axis to determine the minimum kinematic viscosity ν_1 at operating temperature.
4. Using **diagram 3**, **page 206**, locate the point where the minimum kinematic viscosity ν_1 at operating temperature, determined in the previous step, intersects the vertical line of the expected bearing operating temperature.
5. Locate the first diagonal curve to the right of this point. This is the minimum ISO VG that can be selected.

If a lubricant with a higher than required viscosity is selected, an improvement in bearing performance can be expected. However, since increased viscosity raises bearing operating temperature, there needs to be a balance.

Example

A bearing having a bore diameter d = 340 mm and outside diameter D = 420 mm is required to operate at a speed n = 500 r/min. Therefore, $d_m = 0,5 (d + D) = 380$ mm. From **diagram 2**, the minimum kinematic viscosity ν_1 required for adequate lubrication at the operating temperature is approximately 11 mm^2/s. From **diagram 3**, **page 206**, assuming that the operating temperature of the bearing is 70 °C *(160 °F)*, it is found that a lubricating oil of ISO VG 32 viscosity class, i.e. a kinematic viscosity ν of at least 32 mm^2/s at the reference temperature of 40 °C *(105 °F)*, will be required.

Diagram 2

Estimation of the minimum kinematic viscosity ν_1 at operating temperature

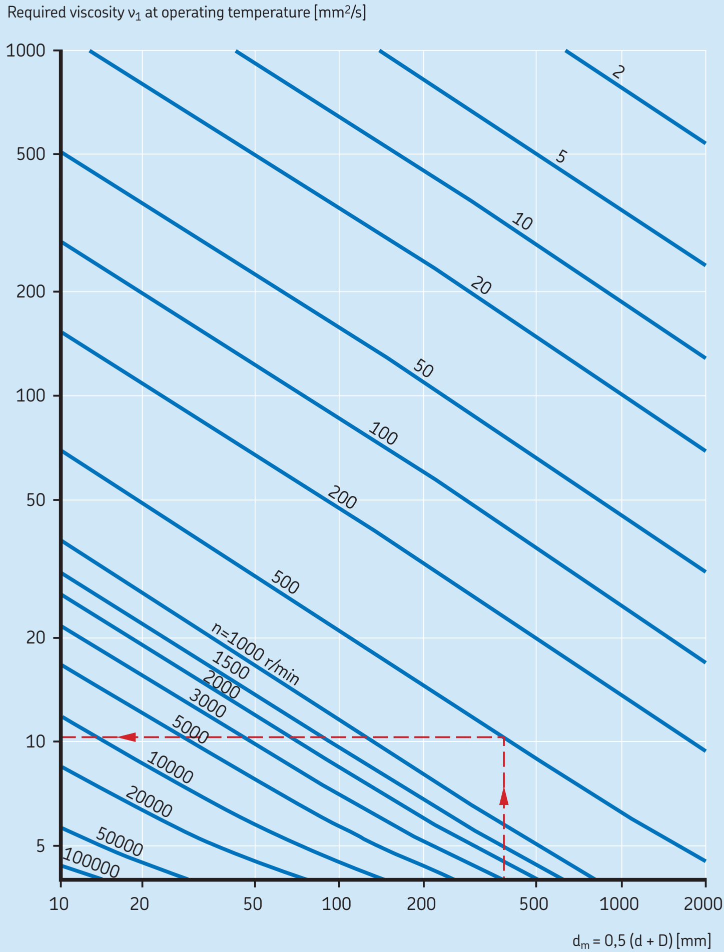
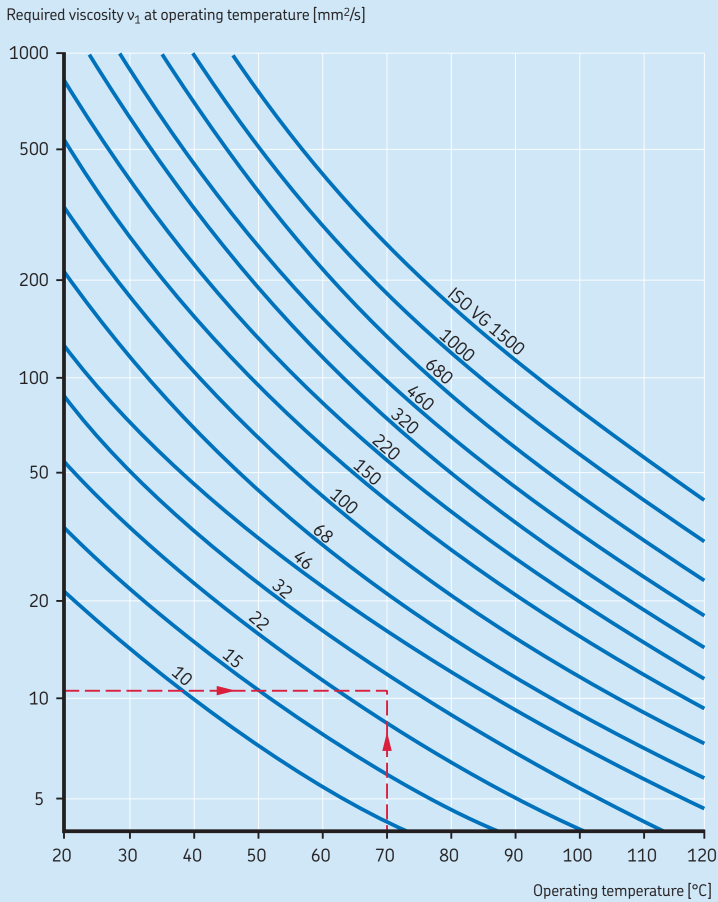


Diagram 3

Conversion to kinematic viscosity ν at reference temperature (ISO VG classification)



2 Check anti-wear and extreme pressure additive requirements

Anti-wear (AW) and extreme pressure (EP) additives are required for slow rotating bearings under heavy loads. These additives are also beneficial for shock loads, oscillating applications and when frequent start-ups and shutdowns take place.

CAUTION: Some EP additives may have a detrimental effect on bearing materials and can shorten bearing service life dramatically, particularly above 80 °C *(175 °F)*. Check with the lubricant manufacturer.

3 Assess additional requirements

If specific operating conditions exist, the properties of the oil should complement these conditions accordingly. When bearings have to operate over a wide temperature range, for example, oil with the least changes in temperature variation, i.e. oil with a high VI, should be selected.

Additional oil selection tools

The SKF LubeSelect program can also be used to select an appropriate oil type and viscosity. Another SKF program, LuBase, contains details on more than 2 000 lubricants, provided by more than 100 lubricant suppliers. Both programs are available online at www.aptitudexchange.com. Calculations for minimum oil viscosities can also be made using the formulae in the *SKF Interactive Engineering Catalogue* available online at www.skf.com.

These additional oil selection tools are based on a generalized selection process and should be used as guidelines only.

Oil lubrication systems

Types of oil lubrication systems

The choice of oil lubrication method depends on the application, operating conditions and shaft orientation. The design of the subsequent lubrication system should receive careful consideration. For example, since oils are liquids, suitable sealing solutions must be provided to prevent leakage.

A basic understanding of the design and function of a lubrication system is beneficial for carrying out maintenance activities (→ **table 14, page 208**).

Oil mist lubrication, which is used in very specific applications, is not included in the table.

Maintaining oil lubrication systems

Maintaining an oil lubrication system requires a careful and systematic approach. In addition to the guidelines presented below, SKF recommends taking regular oil samples and trending the results of the analyses.

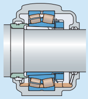
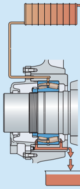
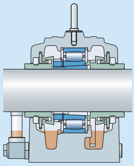
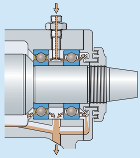
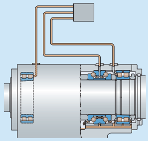
- For new oil lubrication system installations, make sure that the reservoir, sump or collecting trough is filled with oil to prevent the bearings running without lubrication on start-up.
- When starting a machine with an oil pick-up ring that has been at a standstill for a long time, make sure that the oil sump is filled with oil.
- Inspect the oil at regular intervals for contamination, oxidation or foaming. But keep in mind that the smallest particle size seen by the human eye is 40 µm.
- For an oil-air lubrication system, check the air pressure at the oil inlet hole. It should be about 6 bar.

WARNING

Machines that leak oil are dangerous and are a fire hazard. Find the source of the leak and repair it immediately!

Table 14

Oil lubrication systems

	 Oil bath	 Circulating oil	 Oil pick-up ring	 Oil jet	 Oil-air
Description	Oil, which is picked up by the rotating components of the bearing, is distributed within the bearing and then flows back to the sump.	Oil is pumped to a position above the bearing, runs down through the bearing and settles in the reservoir. The oil is filtered and temperature-adjusted before being returned to the bearing.	The pick-up ring, hanging loosely on a distance sleeve, dips into the oil sump and transports oil to a collecting trough. The oil runs down through the bearing and settles back in the sump.	A jet of oil under high pressure is directed at the side of each bearing.	Metered quantities of oil are directed at each bearing by compressed air. Oil, supplied at given intervals, coats the inside surface of the feed lines and “creeps” toward the nozzles, where it is delivered to the bearings.
Suitable operating conditions	Low and moderate speeds	High speeds	High speeds High operating temperatures	Very high speeds	Extremely high speeds Low operating temperatures
Advantages/ disadvantages	Simple Economical	Pump, filters and cooling system required	Suitable for horizontal shafts only	Relatively small amount of oil required	Economical Helps repel contaminants
Design recommendations	Provide a sight glass for visual checks.	Provide suitable drainage ducts – horizontal drains should be avoided. Make sure the outlet hole is larger than the inlet hole. Include efficient seals.	Provide a sight glass for visual checks. Include effective seals.	Make sure the velocity of the oil jet is at least 15 m/s. Provide suitable drainage ducts – horizontal drains should be avoided.	Oil nozzles must be positioned correctly. Feed lines of up to 10 m can be used. A filter is recommended.

Oil change intervals

The interval between oil changes depends mainly on the oil lubrication system, the operating conditions and the quantity of oil used. For all lubrication methods, oil analysis is recommended to help establish an appropriate oil change schedule.

Guidelines for oil change intervals are provided in **table 15**. In general, the more arduous the conditions, the more frequently the oil should be analyzed and changed.

NOTE: Don't forget to change the filter elements regularly.

Chain oils

Chain lubrication requires a proper lubricant film, especially in the internal parts of the chain. Without suitable lubrication, hastened sprocket wear and chain elongation may occur.

SKF manufactures chain lubricators (→ **fig. 12**) supplied with three different chain oils (→ **table 16**).

Fig. 12

Table 16

SKF Chain oil range

Property	**Designation** LHMT 68	LHHT 265	LHFP 150
Description	Medium temperature	High temperature	Food compatible
Base oil type	Mineral	Synthetic ester	Synthetic ester
Viscosity / Viscosity Grade	ISO VG 68	265 mm²/s	ISO VG 150
Operating temperature	–15 to +90 °C *(5 to 195 °F)*	Up to 250 °C *(480 °F)*	–30 to +120 °C *(–20 to +250 °F)*

Table 15

Oil change intervals

Oil lubrication system	**Typical operating conditions**	**Approximate oil change interval**[1]
Oil bath or oil pick-up ring	Operating temperature < 50 °C *(120 °F)* Little risk of contamination	12 months
	Operating temperature 50 to 100 °C *(120 to 210 °F)* Some contamination	3 to 12 months
	Operating temperature > 100 °C *(210 °F)* Contaminated environment	3 months
Circulating oil or oil jet	All	Determined by test runs and regular inspection of the oil condition. Dependent on how frequently the total oil quantity is circulated and whether or not the oil is cooled.

[1] More frequent oil changes are needed if the operating conditions are more demanding.

Oil compatibility

Before changing or mixing different types of oil, check that the two oils are compatible. When incompatible oils are mixed, the base oils may have an adverse chemical reaction. Check base oil compatibility provided in **table 11** on **page 201**.

SKF bearings are treated with a petroleum based preservative that is compatible with the majority of bearing oils.

CAUTION: Keep in mind that even if the base oils are compatible, additives from the old oil may alter the performance of those in the new oil. For additional information, contact the lubricant manufacturer.

Oil analysis

Oil analysis is an important part of lubrication maintenance. Samples should be taken at regular intervals and analyzed carefully as soon as possible after drawing the sample. Trending is also essential for proactive maintenance.

In addition to analyzing used oils, SKF recommends analyzing new oils. Often, there is a high particle count in new oil drums as a result of the different handlers and environmental changes experienced from manufacturer to customer.

NOTE: Keep in mind that new oil affects trending!

Oil sampling

An oil sample should be representative of the true condition of the oil. SKF recommends following these guidelines when taking oil samples:

1. Use a small, clean container that can be properly sealed.
2. Take samples at the pressurized side of a circulating oil system. This can be done via a simple ball valve.
3. Take samples from non-pressurized systems, e.g. oil baths, via the outlet hole, allowing some oil to drain out first.
4. Seal the container immediately after drawing the sample to prevent the ingress of contaminants.

Oil samples are typically analysed for:

- viscosity
- oxidation
- wear particle concentration
- water content
- loss of additive content

The viscosity of an oil should typically be within 10% of the baseline value. Wear particle concentration and water content are measured in parts per million (ppm). Water content should be < 200 ppm.

Crackle test

The crackle test is a simple way to detect the presence of free water in an oil sample:

1. Heat a hot plate to approximately 130 °C *(265 °F)*.
2. Shake the oil sample vigorously.
3. Place a drop of oil in the centre of the hot plate.

If water is present, vapour bubbles will appear. If crackling can be heard, the water content is likely to be in excess of 2 000 ppm.

NOTE: This test does not detect water dissolved in the oil and should be used as a guideline only. SKF recommends sending the samples in for analysis.

Contamination and filtering

Contaminants, which are unwanted substances that negatively impact the performance of the lubricant, can be solid, liquid or gaseous. Contamination can result from an inadequately sealed application or lubrication system, an inadequate or poorly functioning filtration system, contaminated filling points or wear particles generated by the application.

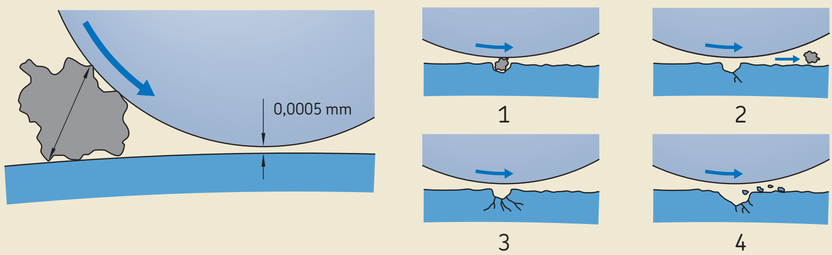
Solid contaminants

Solid contaminants are either created within the application as a result of wear or damage, or they can enter the application through an open port, inadequate or faulty sealing system or, more likely, as a result of poor relubrication practices.

The ingress of solid contaminants into the bearing cavity (→ **fig. 13**) will cause indentations in the raceways as a result of being overrolled by the rolling elements (**1**). Raised edges will form around the indentation due to plastic deformation (**2**). As the rolling elements continue to over-roll the raised edges, and lubrication is impaired, fatigue occurs (**3**). When fatigue reaches a certain level, premature spalling starts at the far end of the indentation (**4**).

NOTE: Lubricant cleanliness and careful handling during mounting are important factors in the prevention of indentations. Keep in mind that even small pieces of paper or threads from cotton rag can be harmful to a bearing.

Fig. 13



The standard method for classifying the contamination level in a lubrication system is described in ISO 4406:1999. In this classification system, the result of a solid particle count is converted into a code using a scale number (→ **table 17**). There are two methods for checking the contamination level:

- The microscope counting method: With this counting method, two scale numbers are used relating to the number of particles ≥ 5 µm and ≥ 15 µm.
- Automatic particle counting method: With this method, three scale numbers are used relating to the number of particles ≥ 4 µm, ≥ 6 µm and ≥ 14 µm.

Using the automatic particle counting method, for example, SKF recommends maintaining particle levels at or below a contamination level classification of 18/15/12. This means that the oil contains between 1 300 and 2 500 particles ≥ 4 µm, between 160 and 320 particles ≥ 6 µm, and between 20 and 40 particles ≥ 14 µm. Higher levels are acceptable for bearings with a bore diameter > 100 mm.

A filter rating is an indication of filter efficiency. The efficiency of filters is related to one specific particle size. Therefore, both the filter rating and the specified particle size have to be considered.

For additional information about contamination classification and filter rating, refer to the *SKF Interactive Engineering Catalogue* available online at www.skf.com.

Liquid contaminants

Liquid contaminants include water, fuel, process by-products and chemicals such as glycol. Water extractors should be utilized where water contamination is expected. The type of water extractor depends on the estimated risk of water entering the lubrication system. Where necessary and when economically viable, continuous water removal is recommended.

Gaseous contaminants

Air or gas contamination reduces oil viscosity and increases foaming. Foaming may lead to a loss of oil.

Table 17

ISO contamination classification

Number of particles per millilitre oil		Scale number
over	incl.	–
10 000	20 000	21
5 000	10 000	20
2 500	5 000	19
1 300	2 500	18
640	1 300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10

SKF oil lubrication products

SKF offers a wide assortment of products for oil management and maintenance of oil lubrication systems (→ **Appendix L**, starting on **page 420**). For additional information, visit www.mapro.skf.com and www.skf.com/lubrication.

Centralized lubrication systems

Centralized lubrication systems feed lubricant from a central reservoir to the points on a machine where friction occurs. The lubricant is supplied as often as necessary and in the correct quantity. Oil and grease with NLGI grades up to 2 can normally be used. Since pumpability is one of the deciding factors, greases with low NLGI grades are often used.

NOTE: Maintenance for centralized lubrication systems is typically limited to refilling the lubricant reservoir and occasionally inspecting the connection points for oil leaks. However, always follow the maintenance instructions supplied with the equipment.

Selecting the appropriate lubricant

Many malfunctions in centralized lubrication systems can be attributed to the wrong choice of lubricant. Lubricants used in centralized lubrication systems should meet the following criteria:

- be free of solid particles capable of passing through a filter with a mesh of 25 µm
- be free of air in the form of bubbles (undissolved gases) to prevent pressure build-up and uncontrolled behaviour of the lubrication system
- be compatible with materials of all components in the bearing arrangements, e.g. seals
- have good oxidation resistance, i.e. good ageing stability
- have a suitable oil bleeding rate, as excessive bleeding leads to pressure losses and blocked systems
- remain homogenous and retain an even consistency at all envisaged operating temperatures
- be free of solid additives that may cause deposit build-up in the pump, valves and distributors

When choosing between a grease and oil lubrication system, technical and economic considerations are decisive. The two types of centralized lubrication systems are compared in **table 18**, **page 214**. SKF recommends using oil, where possible, but especially for applications such as machine tools, wood-processing, printing and plastic processing machines.

Types of centralized lubrication systems

In technical terms, centralized lubrication systems are divided into total loss and circulating lubrication systems, depending on whether the lubricant is reused or not.

Centralized lubrication systems are in turn categorized by how the system works (→ **table 19**, **page 215**). Selecting the appropriate system depends on:

- the operating conditions, e.g. operating temperature, viscosity, presence of salt in the atmosphere
- the accuracy requirement of the lubricant quantity
- the geometry and size of the lubrication system
- the monitoring requirements

SKF offers comprehensive and state-of-the-art lubrication systems and integrated solutions that combine SKF's tribology knowledge – the combination of friction, wear and lubrication sciences – and experience in bearings, seals and condition monitoring.

For additional information about SKF Centralized Lubrication Systems, visit www.skf.com/lubrication. For technical support about specific requirements, contact your local SKF representative.

Total loss lubrication systems

In total loss lubrication systems:

- There is no reuse of lubricant.
- Friction points are supplied with fresh lubricant during the lubrication cycle.
- The quantity of lubricant delivered is the amount needed to build up an adequate lubricant film.
- There is no heat dissipation.

Most applications with centralized lubrication systems deal with the lubrication of moving parts, e.g. bearings and gears.

Minimal quantity lubrication (MQL) is a special form of total loss lubrication. These systems deal with the lubrication of machining processes, spraying or wetting of surfaces. With minimal quantity lubrication, it is possible to achieve effective lubrication with extremely small quantities of oil from an aerosol.

Circulating lubrication systems

In circulating lubrication systems:

- There is reuse of lubricant, i.e. the oil flows back into the lubricant reservoir for reuse after being filtered and temperature-adjusted.
- Friction and process-related heat are dissipated.
- Vibrations are dampened.
- Abrasive particles, condensate and process water are removed.
- Air bubbles are removed and foam is reduced.
- Corrosion is prevented.

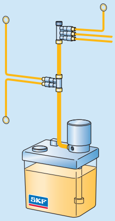
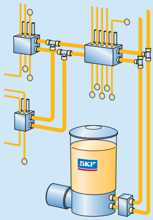
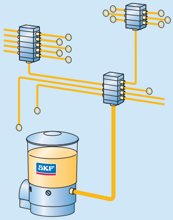
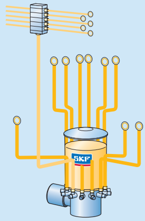
Table 18

Comparison of centralized grease and oil lubrication systems

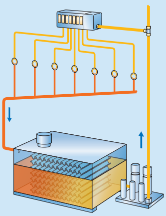
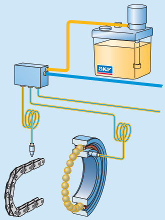
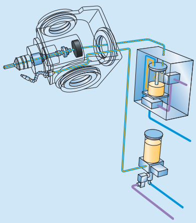
Selection criteria	**Advantages/disadvantages** Grease	 Oil
Operating pressures	50 to 400 bar	14 bar
Tubing and fitting requirements	Large diameter tubing (as a result of excessive pressure loss)	Small diameter tubing
Pump power requirements	Relatively high power	Low power
Contamination	Contaminants remain in suspension and can make their way to the friction area	Contaminants settle at the bottom of the reservoir
Maintenance	Measuring the grease level in the reservoir is complicated Not easy to top up the grease	Easy to measure the oil level in the reservoir Easy to top up the oil
Option for circulating lubricant	Not possible	Relatively easy to achieve
Sealing	Bearings do not need to be sealed Lubricant has a sealing function	Bearing arrangement needs to be sealed to prevent oil leakage and contaminating the surroundings Lubricant offers no protection to contaminants
Cooling and flushing possibilities	None	Yes

Table 19

SKF Centralized Lubrication Systems

	SKF Monoflex	SKF Duoflex	SKF ProFlex	SKF Multiflex
Type	Single-line	Dual-line	Progressive	Multi-line
Suitable lubricants	Oil Grease with NLGI grades from 000 to 2	Oil Grease with NLGI grades from 000 to 3	Oil Grease with NLGI grades from 000 to 2	Oil Grease with NLGI grades from 000 to 3
Application examples	Machine tools, printing, textile and off-highway applications	Metal working machines, pulp and paper industry, mining and cement plants, deck cranes, power plants	Printing and industrial presses machines, off-highway applications, wind turbines	Oil and gas industry, heavy industrial applications

	SKF CircOil	SKF Oil+Air	SKF LubriLean
Type	Circulating oil	Oil and air	Minimal quantity lubrication (MQL)
Suitable lubricants	Oil	Oil	Oil
Application examples	Pulp and paper industry, metal working machines, heavy industrial applications	Machine tools, chain applications, steel industry	Machine tools