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GREASE

Lubricating greases are typically applied in areas where a continuous supply of oil cannot be retained, such as open bearings or gears. Factors to be considered when selecting a suitable grease are operating temperatures, water resistance, oxidation stability etc. The second factor, not less important, are the grease's characteristics, including viscosity and consistency.

Grease consists of base oil, performance additives and a thickener which forms a matrix that retains the oil in a semisolid state. Most grease thickeners are soaps, i.e. lithium, calcium, or aluminum soap. Complex soap greases have superior temperature resistance and are commonly usable up to 180°C, at which the mineral oil vaporizes. A smaller number of greases, restricted to very special applications, are manufactured with non-soap thickeners such as organic clays, poly urea or silica compounds.

Grease is the most widely used lubricant for roller bearings and low velocity applications, mainly because grease type lubricants are relatively easy to handle and require only the simplest sealing devices.

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GREASE PROPERTIES									
GREASE TYPE	Calcium	Lithium	Calcium complex	Lithium complex	Aluminum complex	Barium complex	Poly urea	Benton	Sodium
Dropping point	100	160-200	>260	>240	>260	>200	>230	NA	170-190
Max Service Continuous Operating Temp.°C	< 80	125	150	160	150	150	150	150	125
Water resistance	Good	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Poor
High Temp. Use	Very Poor	Good	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Good
Shear Stability	Fair	Good	Good	Excellent	Good	Fair	Good	Fair	Good
Structure	Smooth	Smooth	Smooth & Buttery	Smooth	Smooth & Gel	Fibrous	Opaque	Smooth	Fibrous
Oxidation stability	Poor	Good	Excellent	Good	Excellent	Poor	Excellent	Good	Good
Rust protection	Poor	Good	Poor	Good	Fair	Fair	Good	Fair	Good
Pump ability	Fair	Good To Excellent	Fair	Good To Excellent	Good	Poor	Good	Good	Poor
EP properties	Poor	Poor	Fair To Poor	Poor	Excellent	Good	Good	Poor	Fair

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GREASE COMPATIBILITY CHART

GREASE TYPE	Calcium	Lithium	Calcium complex	Lithium complex	Aluminum complex	Barium complex	Poly urea	Benton	Sodium
Calcium	+	+	+	+	+ -	-	+	-	-
Lithium	+	+	+	+	+ -	+ -	+	-	+ -
Calcium complex	+	+	+	+ -	-	+ -	+ -	-	-
Lithium complex	+	+	+ -	+	+ -	+ -	+	-	+ -
Aluminum complex	-	+ -	-	+ -	+	-	+ -	-	-
Barium complex	-	+ -	+ -	+ -	-	+	+ -	-	-
Poly urea	+	+	+ -	+	+ -	+ -	+	-	-
Benton	-	-	-	-	-	-	-	+	-
Sodium	-	+ -	-	+ -	-	-	-	-	+

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NLGI GREASE CLASSIFICATION
(NATIONAL LUBRICATING GREASE INSTITUTE)

The consistency of industrial greases is classified by the distance in tenths of a millimetre, that a standard cone penetrates a sample of the grease under standard conditions at 25ºC.

NLGI Consistency (Grade no.)	ASTM Worked Penetration at 25ºC (Penetration in 0.1 mm)	Appearance	Consistency food analog	Method Of Application
000	445 - 475	fluid	cooking oil	Central System
00	400 - 430	semi-fluid	applesauce	Central System
0	355 - 385	very soft	mustard	Central System
1	310 - 340	soft	tomato paste	Gun or Central System
2	265 - 295	"normal" grease	peanut butter	Gun or Central System
3	220 - 250	firm	vegetable shortening	Gun
4	175 - 205	very firm	frozen yogurt	Gun
5	130 - 160	hard	smooth pate	Cup
6	85 - 115	very hard	cheddar cheese	Cup

NLGI grades 0, 1 and 2 are applied in highly loaded gear transmissions, grades 1 through 4 are often applied in rolling bearings where grade 2 is the most common.

NLGI GREASE SERVICE CLASSIFICATION

The National Lubricating Grease Institute (NLGI) and the American Society of Testing and Materials (ASTM) have developed a system to identify lubricating grease properties and applications:

CHASSIS SERVICE

LA– Service typical of chassis components and universal joints in passenger cars, trucks, and other vehicles operated with frequent republication in non- critical applications. This grease shall satisfactorily lubricate chassis components and universal joints where frequent republication is practiced (at intervals of 2,000 miles or less for passenger cars). During its service life, the grease shall resist oxidation and consistency degradation while protecting the chassis components and universal joints from corrosion and wear under lightly loaded conditions. NLGI #2 consistency greases are commonly recommended, but other grades may also be recommended.

LB – Service typical of chassis components and universal joints in passenger cars, trucks, and other vehicles under mild to severe duty. Severe duty will be encountered in vehicles operated under conditions which may include prolonged republication intervals, or high loads, severe vibration, exposure to water or other contaminants, etc. This grease shall

resist oxidation and consistency degradation while protecting the chassis components and universal joints from corrosion and wear even when aqueous contamination and heavily loaded conditions occur. NLGI #2 consistency greases are commonly recommended, but other grades may also be recommended.

WHEEL BEARING SERVICE

GA – Service typical of wheel bearings operating in passenger cars, trucks, and other vehicles under mild duty. Mild duty will be encountered in vehicles operated with frequent republication in noncritical areas. The grease shall satisfactorily lubricate wheel bearings over a limited temperature range. Many products of this type are limited to bearing temperatures of -4 – 158°F. No additional performance requirements are specified for these greases.

GB – Service typical of wheel bearings operating in passenger cars, trucks, and other vehicles under mild to moderate duty. Moderate duty will be encountered in most vehicles operated under normal urban, highway, and off-highway service. The grease shall satisfactorily lubricate wheel bearings over a wide temperature range. The bearing temperature may range down to -40°F, with frequent excursions to 320°F. During its service life, the grease shall resist oxidation, evaporation, and consistency degradation while protecting the bearings from corrosion and wear. NLGI #2 consistency greases are commonly recommended, but NLGI #1 or #3 grades may also be recommended.

GC – Service typical of wheel bearings operating in passenger cars, trucks, and other vehicles under mild to severe duty. Severe duty will be encountered in certain vehicles operated under conditions resulting in high bearing temperatures. This includes vehicles operated under frequent stop-and-go service (buses, taxis, urban police cars, etc.), or under severe braking service (trailer towing, heavy loading, mountain driving, etc.). The grease shall satisfactorily lubricate wheel bearings over a wide temperature range. The bearing temperatures may range down to -40°F, with frequent excursions to 320°F and occasional excursions to 392°F. During its service life, the grease shall resist oxidation, evaporation, and consistency degradation while protecting the bearings from corrosion and wear. NLGI #2 consistency greases are commonly recommended, but NLGI #1 or #3 grades may also be recommended.

CATEGORY	SERVICE	PERFORMANCE
LA Chassis	Frequent republication intervals (<3200 km). Mild duty (non-critical applications).	Oxidation resistant, shear stable, and corrosion and wear protective.
LB Chassis	Prolonged republication intervals (>3200 km). Mild to severe duty (high loads, vibration, exposure to water).	Oxidation resistant shear stable, and corrosion and wear protective even under heavy loads and in presence of aqueous contamination. Temperature range: -40°C to 120°C
GA Wheel Bearings	Frequent lubrication Intervals. Mild duty (noncritical applications).	Temperature range: -20°C to 70°C
GB Wheel Bearings	Mild to moderate duty (cars, trucks in urban and highway service).	Oxidation and evaporation resistant, shear stable and corrosion and wear protective. Temperature range: -40°C to 120°C occasional excursions to 160°C
GC Wheel Bearings	Mild to heavy duty (vehicles in frequent stop-and-go service, trailer hauling, mountain driving, etc)	Oxidation and evaporation resistant, shear stable, and corrosion and wear protective. Temperature range: -40°C to 120°C with frequent excursions to120°C

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SELECTING GREASE

Selecting the correct lubricant is a critical factor in ensuring the functional reliability and optimum operating life of a rolling bearing. Failure statistics (see Fig 1) show that a significant proportion of premature rolling bearing failures are directly or indirectly related to the lubricant used. The main causes of failure here are unsuitable lubricants (20%), aged lubricants (20%) and insufficient lubrication (15%).

Although lubricating oils (e.g. mineral oils and synthetic oils) are sometimes recommended for use with rolling bearings in extreme operating conditions (e.g. high temperatures or radiation), most bearing manufacturers recommend the use of greases. This article will therefore focus on selecting suitable greases for rolling bearings.

When selecting suitable grease for a rolling bearing, a number of application-related factors need to be considered.

An appropriate grease selection process comprises below steps.

1. SELECT THE CONSISTENCY GRADE

Greases are divided into various consistency grades in accordance with the National Lubricating Grease Institute (NLGI). Greases with a high consistency, i.e. stiff greases, are assigned high NLGI grades, while those with low consistency, i.e. soft greases, are assigned low NLGI grades. In rolling bearing applications, three consistency grades are recommended:

•The most common greases, used in normal bearing applications, have an NLGI grade of 2.

• Low consistency rolling bearing greases, classified as NLGI 1 greases, are preferred for low ambient temperatures and oscillating applications.

• NLGI 3 greases are recommended for large bearings, vertical shaft arrangements, high ambient temperatures or the presence of vibration.

2. DETERMINE THE REQUIRED BASE OIL VISCOSITY

For detailed information about calculating the required base oil viscosity, refer to Lubrication conditions - the viscosity ratio κ. The graphs are based on the elasto-hydrodynamic theory of lubrication (EHL) with full-film conditions.

It has been found, however, that when using greases containing very low or very high viscosity base oils, a thinner oil film than that predicted by EHL theories results. Therefore, when using the graphs to determine the required base oil viscosity for grease

lubricated super-precision bearings, corrections may be necessary. From practical experience, determine the required viscosity ν at reference temperature 40 °C (104 °F) and then adjust as follows:

• $\nu \leq 20$ mm^2/s → multiply the viscosity by a factor of 1 to 2 In this low range, the viscosity of the oil is too thin to form a sufficiently thick oil film.

• 20 mm^2/s < $\nu \leq 250$ mm^2/s → no correction factor is used

• $\nu > 250$ mm^2/s → contact the company application engineering service

High viscosity greases increase friction and heat generated by the bearing but may be necessary, for example, for ball screw support bearings in low-speed applications or in applications where there is a risk of false brine ling.

3. BEARING TYPE

A distinction needs to be made between point contact (ball bearings) and line contact (needle roller bearings and cylindrical roller bearings).

In ball bearings, each overruling motion at the rolling contact places strain on only a relatively small volume of grease. In addition, the rolling kinematics of ball bearings exhibit only relatively small proportions of sliding motion. The specific mechanical strain placed on greases in bearings with point contact is therefore significantly less than in bearings with line contact. Typically, greases with a base oil viscosity ISO VG 68 to 100 are used.

In rolling bearings with line contact, higher requirements are placed on the grease. Not only is a larger grease quantity at the contact subjected to strain, but sliding and rib friction is also to be expected. This prevents the formation of a lubricant film and would therefore lead to wear. As a countermeasure, greases should be selected that exhibit a higher base oil viscosity (ISO VG 150 to 460 or higher). Anti-wear additives may also be required and consistency is normally NLGI 2.

4. LOAD

For a load ratio C/P <10 or P/C > 0.1, greases are recommended that have higher base oil viscosity and anti-wear additives. These additives form a reaction layer on the metal surface that provides protection against wear. These greases are also recommended for bearings with an increased proportion of sliding motion (including slow running) or line contact, as well as under combined radial and axial loads.

Grease with EP additives may be appropriate if super-precision bearings are subjected to any of the following such as very heavy loads, shock loads, low speeds, and periods of static loading, frequent starts and stops during a work cycle.

Lubricants with EP additives should only be used when necessary and always within their operating temperature range. Some EP additives are not compatible with bearing materials particularly at higher temperatures. For additional information, contact the bearing manufacturer engineering service.

5. WATER & MOISTURE

If the application is in a damp environment, moisture can enter the bearing. Water may condense within the bearing if there are rapid temperature fluctuations between warm and cold. This is a particular problem if large cavities exist in the bearing or housing.

Water can cause severe damage to the grease or bearing and is often due to ageing or hydrolysis, interruption of the lubricant film and corrosion. Barium and calcium complex soap greases have proved favourable in these conditions as they provide good water resistance and act to repel water. The anti-corrosion effect of grease is also influenced by additives.

6. OSCILLATIONS, SHOCKS AND VIBRATIONS

Oscillation loads can have a considerable effect on the structure of thickeners in greases. If mechanical stability is not sufficient, changes in consistency may occur. This leads to softening, de-oiling on an isolated basis, but also hardening of the grease with a corresponding reduction in lubrication capability. It is therefore recommended that a grease should be selected whose mechanical stability has been tested accordingly. Options here include the expanded worked penetration, the Shell Roller Test in accordance with ASTM D 1831 and a test run on the FAG AN42 test rig.

7. SEALS

If hard contaminant particles penetrate the bearing, this will not only lead to increased noise but also to wear. Appropriate sealing of the bearing should prevent this. The grease can assist this sealing effect by forming a stable collar on the seal. In this case, more solid type greases are more suitable, as greases that are too soft tend to favour the escape of grease.

8. MOUNTING POSITION & ADJACENT COMPONENTS

Even where an axis of rotation is vertical or inclined, lubricant must remain at the lubrication point. In addition to appropriate seals, flowing away of the grease can be

prevented by using more viscous grease. If several lubrication points are located close together, unintentional contact can occur. Attention must therefore be paid to compatibility of the lubricants with each other. However, where possible, the optimum solution is to use only one grease, which should also be compatible with the cage and seal material.

9. LEGAL & ENVIRONMENTAL

Depending on the application and the industry sector, legal and environmental factors must be considered when selecting a suitable grease. In the food processing industry, for example, the use of greases with appropriate authorisation is specified. A worldwide standard that can be used is approval in accordance with the NSF (National Sanitary Foundation) H1 or H2, listed in the so-called White Book™.

A lubricant with the code H1 (food-grade lubricant) may be used where occasional, technically unavoidable contact with foodstuffs cannot be eliminated. This means that the grease must be non-toxic, rapidly broken down by the organism and neutral in terms of both odour and taste. Such lubricants often comprise aluminum complex soap thickeners and polyalphaolefin or medicinal white oils as base oil.

H2 lubricants are intended for general use within the food processing industry where no contact with foodstuffs occurs.

Greases with biological degradability must be provided where the lubricant can pass directly into the environment.