THE GREASE DOCUMENT

WI_Hedgehog

Contents

NLGI Number

(https://www.thedrive.com/guides-and-gear/how-and-where-to-use-lithium-grease-on-your-car)

NGLI stands for National Lubricating Grease Institute, and it has a scale to rate and certify greases. According to the NLGI, the scale is for, "classifying the consistency of lubricating greases, based on the ASTM D217 worked penetration at 25°C (77°F)." NLGI Grades are in order of increasing consistency (hardness) as follows:

[Consistency number: Worked penetration range]

000 : 445-475 (very fluid)

00: 400-430 (semi-fluid)

0: 355-385 (fluid)

1: 310-340 (soft)

2: 265-295 (medium)

3: 220-250 (medium-hard)

4: 175-205 (hard)

5: 130-160 (very hard)

6: 85-115 (block)

TYPES OF GREASE AND THEIR USES

(https://www.valvolineglobal.com/en-eur/grease-101-different-grease-types-and-when-to-use-them/)

CALCIUM GREASE

Calcium grease is one of the first greases that was manufactured for general use. Some of the key features of this multipurpose grease are great water resistance, good corrosion protection, and great mechanical stability. However, this lubricant is best used at lower temperatures, as high temperatures may cause changes in its structure. Today, calcium grease and calcium complex grease are mainly used in marine, industrial, automotive, and agricultural applications.

LITHIUM GREASE

The primary use is **roller bearings** and **high-speed bearings**.

Lithium grease is a multipurpose grease known for its durability, high viscosity, and stability. It is designed to provide long-lasting protection against oxidation, corrosion, extreme temperatures, and wear and tear. Lithium and lithium complex greases are also characterized by their excellent lubrication, good water resistance, and the ability to withstand high pressure and shock loads. They are suitable for a variety of applications, including automotive, gardening, industrial, household, and demanding metal-to-metal applications.

Never use grease on rubber, because the petroleum will eventually degrade the rubber and destroy it. This applies to plastic, as well, though it might take much longer to break down.

Lithium grease will typically be rated NLGI 2. Although lithium grease can be a multi-purpose product, it is designed to operate under specific performance loads, temperature ranges, and environmental conditions for which certain types of regular grease could not be used due to the differing ingredient makeups of the greases.

Lithium grease is common due to its numerous advantageous properties. These include:

- Water resistance
- Corrosion resistance
- Viscous and lightly sticky, so it stays in place
- Works in wide range of temperatures

Not every lithium grease is capable of handling bearing lubrication, so it's best to get a heavy-duty high-pressure grease designed for the job. The NLGI also makes this easy to find. Look for the certification tag, "NLGI GC-LB." The GC means it is certified for disc brake wheel bearings. The LB means it is certified for chassis lubrication. The NLGI has a list of certified products on its website.

LUCAS OIL PRODUCTS, INC.	LUCAS HD MINING & CONSTRUCTION GREASE NLGI #2	GC-LB
LUCAS OIL PRODUCTS, INC.	LUCAS RED "N" TACKY NLGI #2	GC-LB
LUCAS OIL PRODUCTS, INC.	LUCAS X-TRA HEAVY DUTY GREASE	GC-LB

ALUMINIUM COMPLEX GREASE

Aluminium complex grease has many advantages - it can withstand extremely high temperatures, has impressive water-resisting properties, prevents rust, corrosion, and oxidation, and has good shear stability. Aluminium complex greases are best used in the food industry, but are also known to offer excellent results when used in the automotive, steel milling, construction, and farming industry.

BARIUM COMPLEX GREASE

Barium complex grease is a high-performance grease widely known for its mechanical stability, high-temperature resistance, ability to withstand heavy loads and high speeds, excellent water tolerance, great oxidation stability, as well as resistance to various chemicals. Barium complex grease is mostly used in demanding, heavy-load applications, such as industrial, aeronautical, marine, and manufacturing applications.

BENTONE (CLAY) GREASE

Bentone grease is a clay-based lubricant developed with the help of bentonite clay. This grease type is often called non-melt lubricant because it has no known dropping point. Its main properties are temperature change resistance, great wear and tear protection, exceptional water tolerance, good mechanical or shear stability, and impressive adhesiveness. Bentone grease is ideal for highly-demanding applications and it's typically used in the steel, manufacturing, construction, mining, and ceramic industry.

POLYUREA GREASE

The primary use is **roller bearings** and **high-speed bearings**.

Polyurea grease has become very popular due to its amazing characteristics, such as outstanding water resistance, great oxidation stability, rust and corrosion prevention, durability, versatility, good mechanical stability, as well as high-temperature performance. Due to these features, polyurea grease is recommended for long-life applications and used across various industries. It is considered vital for the proper lubrication of steel plants and electric motors.
(See: Advantages of Using Polyurea Grease)

SODIUM GREASE

Sodium grease is formulated by mixing soda soap with additives and base oils. Such mixture provides solid shear stability, high dropping point, excellent rust protection, and good lubrication, but has poor water resistance and oxidation stability. Due to its drawbacks, sodium grease is now mostly used for the lubrication of rolling contact bearings. Moreover, it is commonly mixed with other greases in an effort to produce grease of higher quality and value.

All these seven types of grease can be referred to as multipurpose (MP) greases, extreme pressure (EP) greases, marine greases, heavy-duty greases, specialty greases, automotive greases, industry greases, and so on, depending on the unique properties of base oils, additives, and thickeners used in the process of manufacture.

FACTORS TO CONSIDER WHEN CHOOSING THE RIGHT GREASE FOR YOUR NEEDS

When it comes to purchasing the right type of grease for your individual application requirements, it's best to take several factors into consideration prior to making a final decision.

BASE OIL

Base oil represents the foundation of every lubricant and it's worth mentioning that its type determines the overall performance of the grease in question. Three main types of base oils are mineral, synthetic, and vegetable oils. Synthetic oils are considered to offer the best results in terms of protection, performance, temperature and weather resistance, followed by good shear stability.

ADDITIVES

Additives are used to enhance the features and qualities of each grease and boost its performance. The most common additives are extreme pressure additives, oxidation, rust, and corrosion inhibitors, polymers used to increase adhesiveness, insoluble solids, and additives that provide increased wear and tear protection. Also, certain dyes and pigments are added to each grease.

THICKENER

Thickeners are used to enable all grease components to bond better, which increases the overall efficiency of every grease. Types of thickeners that are commonly used are simple and complex soaps, which are based on lithium, calcium, aluminium, sodium, and barium compounds. In addition, certain non-soap thickeners, such as those based on clay and polyurea, can be used to give the grease its consistency.

CONSISTENCY

Consistency is a property defined by the National Lubricating Grease Institute (NLGI) used to determine the level of softness or hardness of every grease. Every grease is assigned a specific NLGI number that goes from 000 to 6. These NLGI grades are then used to express the level of consistency each grease has. So, for instance, NLGI grade 000 grease is completely fluid, NLGI grade 0 grease is described as very soft, NLGI 1 grease is soft, NLGI 2 grease is considered normal, NLGI 3 grease is firm, while NLGI 6 grease is defined as very hard.

VISCOSITY

Grease viscosity determines its ability to remain stable and offer effective protection against friction. Higher viscosity provides greater stability when grease is exposed to heavy, slow loads, while lower viscosity is ideal for high-speed applications.

Grease Compatibility

NSK Bearings Compatibility Chart

(***https://www.machinerylubrication.com/Read/882/mixing-greases***)

NSK Corporation, a manufacturer of rolling element bearings, conducted a compatibility study with 10 greases containing different grease thickeners. For each case, two greases were first tested separately and then blended at three different ratios. The worked penetration test was used on the greases after being blended at room temperature and again after storage at 250°F.

Legend:
○ Compatible
▲ Borderline Compatible
■ Incompatible

	Aluminum Complex	Barium	Calcium	Calcium 12-Hydroxy	Calcium Complex	Clay	Lithium	Lithium 12-Hydroxy	Lithium Complex	Polyurea
Aluminum Complex		■	■	○	■	■	■	■	○	■
Barium	■		■	○	■	■	■	■	■	■
Calcium	■	■		○	■	○	○	▲	○	■
Calcium 12-Hydroxy	○	○	○		▲	○	○	○	○	■
Calcium Complex	■	■	■	▲		■	■	■	○	○
Clay	■	■	○	○	■		■	■	■	■
Lithium	■	■	○	○	■	■		○	○	■
Lithium 12-Hydroxy	■	■	▲	○	■	■	○		○	■
Lithium Complex	○	■	○	○	○	■	○	○		■
Polyurea	■	■	■	■	○	■	■	■	■	

Every grease was incompatible with at least one other grease. The most incompatible were aluminum complex, calcium complex, clay and polyurea-thickened greases.

The most common effect was substantial softening, however lithium grease sometimes hardened. Interestingly, barium grease blends looked like grease on the bottom and oil on the top, which may indicate that the second grease thickener was liquefying upon mixing. It is important to note that even if thickeners are generally compatible, two greases may contain clashing base oil or additive formulations.

Also, not all thickeners of the same group are compatible with each other. Polyurea grease is an example of this as two polyurea grease formulations in specific cases may not be compatible with each other.

Changeover Precautions

Where is it absolutely necessary to change the grease type used, there are some precautions that should be taken to minimize the risk of potential incompatibility. First, the following conditions should be met:

1. Verify that the bearing arrangement allows excess lubricant to be purged from the system. Bearing damage may result in sealed-for-life or shielded bearing arrangements.
2. Verify that the bearing is operating properly before switching products. Improper fits, clearances, bearing configurations or existing bearing damage cannot be corrected by changes in lubrication.
3. Verify that the bearing operating condition can accept a full-fill lubrication condition. This procedure should not be applied to bearings designed to operate with limited grease quantities because excessive bearing operating temperature may occur.

Changeover Procedures

Assuming all conditions have been met, the following procedure may be used to change out greases.

1. Use up as much of the old grease as possible before bringing in the new grease.
2. While the bearing is running, slowly pump in the new grease until the excess grease being purged from the bearing changes in consistency or color. This waste grease should eventually appear similar to the new product.
3. Repeat the previous step after one to two hours of operation or after the bearing has returned to normal, steady-state operating condition.
4. Run the bearing for one week (if the previous relubrication frequency was greater than one week) and relubricate using the normal procedure.
5. Temporarily increase the regrease volume at least during the first two regrease intervals. The increased grease flow will help move out any remaining old grease and will provide sealing while overly soft grease may still be in the bearings.
6. Initiate testing (power consumption, amperage draw, relubrication frequency, vibration, etc.).
7. Prior to reverting to the original regreasing interval, sample the purged grease, test its consistency and check for oil separation.

Some additional tips to keep in mind:

- Always clean grease fittings before relubrication.
- Always pump in grease slowly.
- Always apply new grease to a bearing while in normal operating conditions.

To avoid lost downtime and serious equipment failure from potential grease incompatibility, it is imperative to proceed cautiously when changing lubricants. Follow the recommendations discussed in addition to those provided by the OEM and lubricant supplier.

References

1. Kusnier, Walter. NSK Bearings. “Mixing Incompatible Greases.” Plant Services magazine, June 1997.

2. Kluber Lubrication North America. “Grease Changeover Procedure.”

Machinery Lubrication Compatibility Chart

(*https://www.machinerylubrication.com/Read/1865/grease-compatibility*)

Grease Compatibility Chart

	Aluminum Complex	Barium Complex	Calcium Stearate	Calcium 12-Hydroxystearate	Calcium Complex	Calcium Sulfonate	Bentonite Clay	Lithium Stearate	Lithium 12-Hydroxystearate	Lithium Complex	Polyurea (Conventional)	Polyurea (Shear Stable)
Aluminum Complex	-	I	I	C	I	B	I	I	I	C	I	C
Barium Complex	I	-	I	C	I	C	I	I	I	I	I	B
Calcium Stearate	I	I	-	C	I	C	C	C	B	C	I	C
Calcium 12-Hydroxystearate	C	C	C	-	B	B	C	C	C	C	I	C
Calcium Complex	I	I	I	B	-	I	I	I	I	C	C	C
Calcium Sulfonate	B	C	C	B	I	-	I	B	B	C	I	C
Bentonite Clay	I	I	C	C	I	I	-	I	I	I	I	B
Lithium Stearate	I	I	C	C	I	B	I	-	C	C	I	C
Lithium 12-Hydroxystearate	I	I	B	C	I	B	I	C	-	C	I	C
Lithium Complex	C	I	C	C	C	C	I	C	C	-	I	C
Polyurea (Conventional)	I	I	I	I	C	I	I	I	I	I	-	C
Polyurea (Shear Stable)	C	B	C	C	C	C	C	C	C	C	C	-

B = Borderline C = Compatible I = Incompatible

SKF Bearings Compatibility Chart

(***https://www.skf.com/us/products/lubrication-management/lubricants/grease-compatibility***)

In order to declare two greases as “compatible“ they are mixed in different proportions and the mechanical stability of the different mixtures is evaluated. An excess of hardening or softening would lead to a lubrication failure and therefore it is the first parameter to be assessed. Additional parameters as dropping point are included in the standard method ASTM D6185.

Although two greases might not suffer drastic consistency changes when mixed, no assessment is done on the performance of the mixture since in general the process of replacing a grease by another one is considered as a transition that is to be executed as fast as possible, meaning that as much as possible of the old grease is expected to be removed and the relubrication periods are expected to be reduced in order to smooth the process. It is virtually impossible to assess the performance of a mixture that will be continuously changing while new relubrication tasks are executed, so as general rule try always to remove as much as possible the old grease.

SKF Thickener compatibility chart

	Lithium	Calcium	Sodium	Lithium complex	Calcium complex	Sodium complex	Barium complex	Aluminium complex	Clay (Bentonite)	Common polyurea 1)	Calcium sulphonate complex
Lithium	+	•	-	+	-	•	•	-	•	•	+
Calcium	•	+	•	+	-	•	•	-	•	•	+
Sodium	-	•	+	•	•	+	+	-	•	•	-
Lithium complex	+	+	•	+	+	•	•	+	-	-	+
Calcium complex	-	-	•	+	+	•	-	•	•	+	+
Sodium complex	•	•	+	•	•	+	+	-	-	•	•
Barium complex	•	•	+	•	-	+	+	+	•	•	•
Aluminium complex	-	-	-	+	•	-	+	+	-	•	-
Clay (Bentonite)	•	•	•	-	•	-	•	-	+	•	-
Common polyurea 1)	•	•	•	-	+	•	•	•	•	+	+
Calcium sulphonate complex	+	+	-	+	+	•	•	-	-	+	+

+ = Compatible

• = Test required

- = Incompatible

1) SKF high performance, high temperature bearing grease LGHP 2 is not a common polyurea type grease. It is a di-urea bearing grease, which has successfully been tested for compatibility with lithium and lithium complex thickened greases i.e. LGHP 2 is compatible with such greases.

SKF Base oil compatibility chart

	Mineral/PAO	Ester	Polyglycol	Silicone: Methyl	Silicone: Phenyl	Polyphenylether	PFPE
Mineral/ PAO	+	+	-	-	+	•	-
Ester	+	+	+	-	+	•	-
Polyglycol	-	+	+	-	-	-	-
Silicone: Methyl	-	-	-	+	+	-	-
Silicone: Phenyl	+	+	-	+	+	+	-
Polyphenyl- ether	•	•	-	-	+	+	-
PFPE	-	-	-	-	-	-	+

+ = Compatible

• = Test required

- = Incompatible

Advantages of Using Polyurea Grease

(https://www.machinerylubrication.com/Read/31367/using-polyurea-grease)

When comparing a polyurea grease to a lithium-complex grease, the biggest drawback is that polyurea thickeners are quite incompatible. This incompatibility can cause hardening or softening of the grease.

Grease softening can lead to several issues, such as not allowing for proper lubrication of rollers. Additional grease must then be supplemented to maintain the appropriate lubrication until the incompatible mixture is displaced.

Hardening of the grease can result in even worse problems, since the grease can no longer flow into the bearing cavity, leaving the bearing starved for lubrication.

However, polyurea thickeners do offer some advantages over lithium thickeners. For instance, polyurea greases are often the preferred choice for sealed-for-life applications. These greases tend to have high operating temperatures, inherent antioxidative properties, high thermal stability and low bleed characteristics.

They also have a dropping point of approximately 270 degrees C (518 degrees F). In addition, since their formulation is not based on metal soap thickeners like lithium greases, which can leave behind wetter sediment when used up, they typically are the preferred choice of lubrication for electric motors. On average, polyurea greases can have a three to five times better life expectancy than lithium-based greases.

On the other hand, lithium complex is the most common thickener on the market, making up nearly 60 percent of the greases available in North America. Compatibility statistics show there is a vast array of thickeners with which lithium-complex thickeners have proven to be compatible.

They are also the main choice of thickener for most equipment manufacturers. Lithium-complex greases generally offer good stability, high-temperature characteristics and some water-resistance properties.

Both polyurea and lithium-complex greases have their advantages and disadvantages, so be sure to check the compatibility and viscosity of each product first.

Polyurea thickeners can be beneficial in wetter environments and in applications where a longer grease life is expected. Extreme-pressure (EP) and antioxidant additives may be blended in to help achieve longer life and equipment reliability.

Of course, the application and the desired characteristics of the grease will influence which base thickener should be used.

Moly (molybdenum) Grease

(https://bobistheoilguy.com/forums/threads/when-should-you-use-grease-with-moly.252908/)

From a Tundra thread, by a lubrication engineer:

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Moly additized greases are excellent lubricants, however, should only be used in limited applications as the moly can actually cause early failures in most uses. Never, ever use a moly additized grease in a wheel bearing or universal joint application. Moly additized greases are primarily indicated only where extreme pressure sliding action occurs. When Moly is used in non-friction bearings the moly causes accelerated surface degradation (frosted mug appearance) of the rolling surfaces and premature bearing/race failure. The moly is actually harder than the hardened bearing surface and does not crush when the bearing rolls over it. In universal joints, in addition to surface failure, the moly centrifuges to the extremes of the bearing, blocking oil flow, causing accelerated bearing end wear.

If a single grease is being considered a non-moly grease is the safest primary recommendation. The use of both moly/non-moly specific for sliding/bearings application is ideal.

I currently have 5 failed universal joints sitting on my lab table with very low time; all were regularly greased with a moly additized grease and each failed due to the use of the moly grease.

George Morrison

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I know what the manual says with respect to U-Joint grease. My statements are from a lube engineer's perspective (along with 6 inches of scar tissue on derrier from having used Moly in U-joints before this was known!). CV joints, however, are another story.

Purging the U-joint will work fine; it is continued use of the moly grease over time which causes the problems..

One can never go wrong using a high quality non-moly grease in every applilcation (except CV joints), however the same is not true of moly greases. There are so few real applications and need for moly additized greases and so many potential problems as a result, moly greases are like a curse for us lube engineers..

George Morrison, STLE CLS

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We should never, ever use a Moly additized grease for wheel bearings or any non-friction type bearing. Moly is superb for plain bearings (anything without ball or roller bearings) such as are used in back-hoes, bulldozers, etc. In these cases, severe impact loading can exceed the film strength of the base oil and the moly can act as a fail-safe lubricant and work superbly. However, in non-friction bearings we are relying on the oil film to do the lubrication. Grease is composed of 80 to 90% oil; we are lubricating with oil, just as tho you were oiling the bearing with an oil can. The remainder 10% is sponge which holds the oil in suspension for use when pressure calls for its need.

Color has no bearing on grease performance EXCEPT for one area: never use a black grease in a non friction bearing/wheel bearing/universal joint. Period.. Use yellow, purple, pink, red, whatever, just no moly. Moly will give a steel grey appearance to a grease. There are black greases which contain no moly and they are fine, of course.

George Morrison, STLE CLS

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NLGI GREASE GLOSSARY

Definitions of Terms Relating to the Lubricating Grease Industry

(Developed by: Mary Moon, David Turner & Bill Tuszynski)

Additive: Any substance added to a lubricant to modify its properties. Typical examples are antioxidants, corrosion inhibitors, anti-wear, and extreme pressure (EP) additives.

Adhesion: The force or forces between two materials in contact, such as lubricating grease and a metal substrate, that causes them to stick together.

Age Hardening: Increase in consistency (hardness) of a lubricating grease during storage.

Anhydrous: Without water, for example, a lubricating grease in which no water is detected by ASTM D128.

Antioxidant (Oxidation inhibitor): An additive used to slow the degradation of lubricants by oxidation. Oxidation is degradation caused by chemical reactions with oxygen. These reactions change the chemical composition and properties of a lubricant.

Anti-Wear Additive: An additive used to protect lubricated surfaces from contacting one another under moderate to high loads, as in the elastohydrodynamic lubrication regime. Antiwear additives function by forming an adsorbed molecular layer on metal parts, thus keeping the surfaces separated. For more highly loaded applications, extreme pressure (EP) additives are required.

Apparent Viscosity: The apparent viscosity of grease refers to flow under applied shear measured according to ASTM D1092. Apparent viscosity versus shear can be useful in predicting pressure drops in a grease distribution system under steady-state flow conditions at constant temperature.

Appearance: Characteristics of a lubricating grease that are observed by visual inspection: Bloom, Bulk Appearance, Color, Luster and Texture.

ASTM D02.G0: ASTM International (formerly the American Society for Testing and Materials) is an international standards organization. Committee D02 covers petroleum products, liquid fuels, and lubricants. Subcommittee D02.G0 covers lubricating grease.

API Groups I – V: The lubricating fluid in a grease can be mineral oil (derived from petroleum), a synthetic fluid, or a vegetable based fluid. Lubricant base fluids are divided into five groups, defined by the American Petroleum Institute (API) as follows:

• Group I – Paraffinic mineral oil, typically produced by solvent extraction processes, with a sulfur content of >0.03% and/or saturates <90%. The viscosity index is in the range from 80 to 120.

• Group II – Paraffinic mineral oil, typically produced by a combination of solvent extraction and catalytic processes, with a sulfur content of <0.03% and saturates >90%. The viscosity index is in the range from 80 to 120.

Source: NGLI Grease Glossary

https://www.nlgi.org/grease-glossary/

- Group III – Paraffinic oil produced by severe hydrocracking processes, with a sulfur content of <0.03% and saturates >90%. The viscosity index is >120. Group III oils are considered to be synthetic. Gas-to-liquid base oils are classified as Group III materials.
- Group IV – Polyalphaolefins. This group is dedicated only to polyalphaolefin (PAO) fluids. PAO is a synthetic lubricant base stock.
- Group V – This group covers all base stocks not covered elsewhere. It includes all synthetic fluids other than PAO, as well as naphthenic mineral oils.

Applied Shear Stress: The motive force per unit area for fluid flow.

Asperity: An asperity is a microscopic “bump” or “peak” on a surface.

Biodegradable: Biodegradable lubricants are those products that decompose or transform in the environment due to the action of organisms or their enzymes (found in groundwater or soil). A lubricant is defined as biodegradable if it contains <10% by weight oxygen content and undergoes ≥60% biodegradation as theoretical CO_2 in 28 days and ≥67% biodegradation as theoretical O_2 uptake in 28 days in laboratory testing. Biodegradable products should not be confused with food grade.

Bleeding: The separation of liquid from a lubricating grease.

Blending: Blending is the process of mixing components to produce a mixture with desired properties.

Bloom: The surface color (usually blue or green) of a lubricating oil or grease when viewed by reflected daylight at an angle of about 45 degrees from the surface. Bloom is associated with the absorption of ultraviolet light in the oil and may not be visible if the sample is viewed using artificial light.

Boundary Lubrication: See Lubrication.

Bulk Appearance: Visual appearance of grease when the undisturbed surface is viewed in an opaque container. Also see Texture. Bulk Appearance should be described in the following terms-

- Bleeding – Free oil on the surface or in the cracks of grease.
- Cracked – Surface cracks
- Grainy – Small granules or lumps of thickener or additive particles.
- Rough – Many small irregularities.
- Smooth – Relatively free of irregularities

Cavitation: Formation of a void due to reduced pressure in lubricating grease or oil. Cavitation of a lubricating grease in a dispensing system can prevent the grease from flowing.

Certified Lubricating Grease Specialist (CLGS): A standard that certifies that an individual possesses a defined level of expertise in the field of lubricating grease. Certification indicates that NLGI recognizes the individual as a grease expert. Certification is awarded after an individual passes a two-hour exam that consists of 120 questions about lubrication fundamentals and grease types, selection, manufacturing, applications, maintenance, testing, etc.

Source: NGLI Grease Glossary

https://www.nlgi.org/grease-glossary/

Channeling –1) The tendency (usually desirable) of a channel to form when grease is worked in a bearing, leaving shoulders of unworked grease that serve as a seal and a reservoir of oil.

2) The tendency of liquid lubricants and flow-type lubricating greases at low temperatures to form a plastic structure sufficiently strong to resist flow under gravitational forces. Similar to, but not identical to the pour point of liquid lubricants, it is measured with empirical tests such as Method 3456.2 in Federal Test Method Standard No. 791 (D).

Coefficient Of Friction: Consider two relatively flat surfaces that are in contact, such as a block on a tabletop. When there is no relative motion between these two surfaces, the coefficient of initial friction is the ratio of the force applied to initiate relative sliding motion (parallel to the surfaces) to the force due to the load (perpendicular to the surfaces). The coefficient of kinetic friction is the ratio of the applied force to the load in order to maintain sliding motion. The term coefficient of friction usually refers to the coefficient of kinetic friction.

Cohesion: Attractive forces between molecules in a substance. For example, cohesion between molecules in grease contribute to its resistance to flow.

Cold SETT: See Sett.

Colloid: A substance that consists of microscopically dispersed insoluble particles that are suspended throughout another substance, typically in a fluid. Lubricating grease is a colloidal system of thickener particles or fibers in oil. Also see Thickener.

Color (of lubricating grease): The shade and intensity observed when lubricating grease is viewed under conditions that eliminate Bloom. For example, lubricating grease in an opaque container such as a metal package can be observed under reflected light from a position approximately perpendicular to the surface. Grease color can also be observed with transmitted light by placing the sample on a transparent plate. It is important to indicate the method used to determine the color of grease. Colors of lubricating greases are best described in terms of the predominant hue such as amber, brown (or perhaps green, red, or blue for dyed grease) with a qualifying adjective describing intensity in terms of light, medium, or dark.

Color (of lubricating oil): That shade shown when viewed under transmitted light only. Usually lubricating oil colors are obtained by viewing under specified conditions in test equipment. Several such methods are available, the most widely used being ASTM D1500, which describes the colors in terms of numbers.

Complex Soap: A soap thickener wherein the soap crystal or fiber is formed by co-crystallization of two or more compounds:

1. The primary soap (such as metallic stearate or oleate)
2. Complexing agents such as metallic salts of short chain organic acids or inorganic salts. The complexing agent modifies grease characteristics and usually increases the dropping point.

Cone Penetrometer: A device described in ASTM D217 and D1403 that measures the consistency of lubricating grease. The device consists of a freely moving cone and shaft assembly, a pedestal for placing

Source: NGLI Grease Glossary

https://www.nlgi.org/grease-glossary/

the grease sample below the cone, a locking device to stop the motion of the cone and shaft, and a scale for measuring the depth to which the cone penetrates the grease.

Consistency (Hardness): The degree to which lubricating grease resists deformation under the application of force. Consistency characterizes the plasticity of a solid in much the same way that viscosity characterizes a fluid. Grease consistency is usually measured by cone penetration according to ASTM D217 (IP 50) or ASTM D1403.

Corrosion: The gradual destruction and/or pitting of a metal surface due to chemical reactions with the environment. The most common form of corrosion is caused by oxidation of metal or electrochemical reactions of metal with oxygen or aggressive ions. Also see Fretting.

Corrosion Inhibitor: An additive that is used to enhance the corrosion prevention properties of the grease to which it is added. Test methods for corrosion prevention properties of grease include D1743, D5969, and D6138 for ferrous metals and D4048 for copper. Different types of chemistries are used for the different types of metals to be protected.

Dispensability: The ease with which grease may be transferred from its container to its point of application. Mostly used in discussion of grease dispensing systems, where it includes both the properties of pumpability and feedability.

Dropping Point: The temperature at which a drop of fluid falls from the orifice of the test apparatus under the conditions of ASTM D 2265. The dropping point is not the melting point of lubricating grease.

Dropping point is used in many grease specifications. However, this test has very limited relevance to service performance. Dropping point should not be used to determine the upper operating temperature of a grease. However, certain bearing life tests can show how well lubricating grease performs under applied loads at high temperatures under actual operating conditions.

Dry Film Lubricant: Dry or solid lubricants form films that reduce friction without the need for oil. Dry lubricants are often used in locks, certain bearings, and applications at high temperatures and oxidizing conditions. Examples include graphite, molybdenum disulfide, boron nitride, PTFE (polytetrafluoroethylene) and certain soaps.

Dynamic Viscosity: The ratio between the applied shear stress and rate of shear of a liquid. The dynamic viscosity can be measured by placing the liquid between two parallel plates, and measuring the force required to move one plate while holding the other plate fixed.

Elastohydrodynamic Lubrication: See Lubrication.

Evaporation Loss: That portion of a lubricant that volatilized in use or in storage. Widely used test methods are ASTM D972 and D2595.

Extreme Pressure (EP) Additive: Extreme pressure (EP) additives are additives that provide added load carrying capacity under boundary lubrication conditions. EP additives chemically react with the metal surface under conditions of high load and elevated temperature, forming a chemically bonded lubricating film.

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Extreme Pressure Property (EP): The ability of a lubricant to reduce scuffing, scoring and seizure that can occur when highly-loaded moving surfaces are in contact. High loads are applied to moving surfaces that are in contact. Commonly used laboratory test measurements of EP level are Timken OK Load (ASTM D2509 (grease) and D2782 (oil)) and Four Ball Weld and Load Wear Index (ASTM D2596 (grease) and D2783 (oil)).

False Brinelling: Localized fretting that occurs when the rolling elements of a bearing vibrate or oscillate with small amplitude while pressed against the bearing race. The mechanism proceeds in stages: 1) asperities weld, are torn apart, and form wear particles, which may then be oxidized; 2) the wear particles are abrasive and accelerate wear. The resulting wear depressions appear similar to Brinell depressions obtained with static overloading. Also see Fretting. Note: Asperities are microscopic “bumps” or “peaks” on surfaces.

Feedability: The ability of lubricating grease to flow under suction in a dispensing pump at a rate at least equal to pump delivery capacity. (Some lubricating greases do not feed satisfactorily and cause cavitation at the inlet to a dispensing pump. In such cases, feedability can often be improved by the use of follower plates).

Fiber: Soap thickeners form microscopic fibers in lubricating grease. Some soaps crystallize in the form of threads, which are 20 or more times as long as they are thick. (Most soap fibers are microscopic in size, so that the grease appears smooth to the eye). Some greases have a fibrous appearance when fiber bundles are large enough to be seen by the unaided eye. The most common fibrous lubricating greases contain sodium based thickeners, although not all sodium base greases are fibrous. Also see Appearance and Texture.

Fibril: An extremely small fiber, barely visible even at maximum magnification of an electron microscope. Fibrils may collect in bundles to form larger fibers.

Filler: A material added to a grease to increase bulk or density. Dependent on type and amount, a filler may contribute to, detract from, or have no effect on the lubricating properties of the grease. Examples of fillers are talc, pigments, and carbon black.

Film Strength: The ability of a film of lubricant to resist rupture due to load, speed, and temperature.

Follower Plate: A plate fitted to the top surface of lubricating grease in a container and designed to assist delivery of grease to the inlet of the dispensing system.

Food Grade: A food grade lubricant is one suitable for use when incidental food contact may occur. It is given the H1 designation by a certifying body such as NSF International or InS Services. Food grade lubricants are formulated to minimize risks associated with unplanned trace contamination in food and beverages. Components for H1 lubricants often carry the HX1 designation.

Four-Ball Weld Point: In ASTM D2596, the applied load at which the lubricant can no longer prevent metal-to-metal contact, and the standard steel balls used in the test weld together.

Fretting Wear: A form of wear caused by vibratory or oscillatory motion of limited amplitude and characterized by the removal of fine particles from the rubbing surfaces. Fretting wear is often followed by localized oxidation, hence the term Friction Oxidation. In the case of ferrous metals, the oxidized

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wear particles are abrasive iron oxide (Fe_2O_3) that resemble rust, which has led to the term Fretting Corrosion. Also see False Brinelling. Note: Wear is damage that removes material from a surface.

Fretting Corrosion: Fretting corrosion occurs between a bearing inner ring and shaft or the outer ring and housing. The corrosion occurs at points where the fit is too loose. When the fit is too loose, the metal oxide film can be worn away, allowing oxygen from the air to attack the underlying metal. The build-up of corrosion products can cause severe bearing damage, including cracking of bearing rings.

Friction: The force resisting relative motion between two surfaces that are in contact.

Friction Oxidation: See Fretting Wear.

Gel: An elastic, jelly-like material that resembles a solid but flows like a liquid. Most gels are dispersions of liquids in networks of colloidal particles or polymers.

Grease: See Lubricating Grease.

Grease Worker: A device designed to apply shear to a grease. The full-scale grease worker consists of a metal cup of standard dimensions, and a cover fitted with a handle and shaft attached to a metal plate drilled with 61.x ¼-inch holes. The plate is designed to be pushed through the grease sample to be worked. The device can be manually or mechanically driven. For ½-scale and ¼-scale penetrations, the equipment is progressively smaller. The equipment details can be found in ASTM D217 (full-scale) and ASTM D1403 (small-scale).

Grease Worker Cup: A machined metal cup that holds grease for working. It is also the cup that is used to hold the grease for penetration measurement. A full-scale worker cup holds about one pound (450grams) of grease. See ASTM D217 for the details of the cup dimensions. Smaller scale (½- and ¼-scale) worker cups are detailed in ASTM D1403.

Homogenization: The process of very thoroughly mixing and applying intensive shear to improve the dispersion of components in a mixture. Grease is homogenized to disperse the thickener, improve the bulk appearance, improve the yield, and reduce the cost of the product.

Hydrated Soap: A soap that has water associated with its structure. A typical example is a water-stabilized calcium soap grease, which owes its stability to hydrated calcium soap.

Hydrodynamic Lubrication: See Lubrication.

Hydrophilic: Having an affinity for water; capable of uniting with or dissolving in water.

Hydrostatic Lubrication: See Lubrication.

Incompatibility: Two lubricating greases are incompatible when a mixture of the products has physical or performance properties that are inferior to those of the individual greases. Physical or performance properties inferior to one of the products and superior to the other may be due to simple mixing and would not be considered as evidence of incompatibility.

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Induction Period (Grease Oxidation): A period of time during which oxidation occurs at a relatively slow rate. The point at which a change occurs to a significantly more rapid rate is the end of the induction period. Methods of measurement of induction time include ASTM D942 and D5483.

Inorganic Acid: An acid that does not contain a carbon chain. Inorganic acids, such as boric acid, are sometimes used as complexing agents in complex soap greases. Contrast with Organic Acid.

Inorganic Salt: The reaction product of an alkali with an inorganic acid. Inorganic salts, such as lithium borate, are sometimes found in complex soap greases.

Inorganic Thickener: See Non-Soap Thickener.

Insolubles: Components of a lubricating grease that are insoluble in the prescribed solvents in an analytical procedure such as ASTM D128. The analytical procedure should be indicated when specifying insolubles. Additional identifying analytical tests are required to determine the nature and composition of insolubles, which may consist of fillers, additives, certain types of thickeners, or impurities.

Kinematic Viscosity: The resistance of a liquid to flow under gravity. Kinematic viscosity can be measured directly, as in ASTM D445. It is measured by the time required for a volume of liquid to flow under gravity through a calibrated glass capillary viscometer. Standard temperatures of 40°C and 100°C are typically used. Kinematic viscosity can also be calculated as the ratio of the dynamic viscosity to the density of the liquid.

Load Wear Index: An index of the ability of a lubricant to minimize wear at applied loads. The test consists of four steel balls in a pyramid configuration, with three balls fixed and one ball turning against the other three. The applied load is increased step-wise, until welding (seizure) occurs. The load wear index is calculated based on the wear scars of the 10 highest non-seizure loads. See ASTM D2596 for further details.

Lubricant: Any material that is used or applied to surfaces in order to reduce friction and/or wear that can occur when two surfaces are in contact and undergo relative motion. Lubricants are available in various forms: liquids, greases, dry films, and coatings.

Lubricating Grease: A lubricant that is a solid to semi-fluid dispersion of a thickening agent (thickener) in a liquid. A lubricating grease may be formulated with additives that impart special properties such as resistance to oxidation or wear.

Lubricating Grease Structure: The physical arrangement of thickener particles or fibers in a lubricating grease. The nature, form, and stability of this arrangement determine the appearance, texture, and physical properties of the grease.

Lubrication: The use or application of a material (lubricant) to reduce friction and/or wear that can occur when two surfaces undergo relative motion while in contact under an applied load. Friction and lubrication performance depend upon the relative speed of the surfaces, the lubricant viscosity, and the applied load. There are four major lubrication regimes or types of behavior.

• Boundary Lubrication – The lubricant film is too thin to form a fluid layer that completely separates two surfaces. Asperities or microscopic "peaks" on the surfaces collide. Friction and wear depend upon the presence of chemical additives that adsorb and form molecular layers on the surfaces.

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• Elastohydrodynamic Lubrication – Elastohydrodynamic or EHD lubrication is intermediate between boundary and hydrodynamic lubrication. EHD results from two effects. EHD occurs in rolling bearings and certain gears when very high loads are concentrated on small surface areas. Under these conditions, the surfaces can deform elastically or flatten to increase the surface area that bears the load, Lubricant can be trapped between the surfaces, and its viscosity can increase under the pressure. As a result, the lubricant is able to form a hydrodynamic film and separate the surfaces.

• Hydrodynamic Lubrication – Under appropriate conditions, the relative motion of two sliding surfaces causes a continuous fluid film to form and completely separate the surfaces. This requires a balance between the sliding speed, the applied load, and the lubricant viscosity. Fluid Film Lubrication is another name for this type of lubrication.

• Hydrostatic Lubrication – Lubricant is supplied under pressure to a plain bearing. This applied pressure forces the lubricant to form a continuous fluid film that completely separates the surfaces. Hydrostatic lubrication is used typically during start-up of plain bearings. Hydrodynamic lubrication becomes effective when plain bearings are in motion.

Luster: The intensity of light reflected by lubricating grease- its sheen or brilliance. Luster should be described as follows:

• Bright – Reflects light with a relatively strong intensity.

• Dull – Reflects light with a relatively weak intensity. Some greases with a high water content may have a dull luster. Certain thickeners and fillers give a grease a characteristic dull luster.

Macroscopic: Visible to the unaided human eye, not microscopic, where the particles are at least 40 µ or 0.0015 in. in size.

Mechanical Stability: See Shear Stability.

Metallic Soaps: Metallic soaps are the most common thickeners used in lubricating greases. Materials such as NaOH (sodium hydroxide), Leo(lithium hydroxide), Ca(OH)2 (calcium hydroxide), and Al(OH)3 (aluminum hydroxide) contain basic or alkaline hydroxide groups (-OH). These materials are mixed with organic fatty acids in oil and heated to prepare grease. The –OH groups react with acidic –H atoms on fatty acids such as stearic acid. This reaction produces thickener fibers plus water as a by-product, This reaction is known as saponification.

Microscopic: Not visible to the unaided human eye, smaller than 40 µ or 0.0015 in. in size.

Newtonian Behavior: Simple liquids are said to be Newtonian when the applied shear stress is directly proportional to the shear rate. In other words, the viscosity (applied shear stress/shear rate) of a Newtonian fluid is constant and does not depend on shear stress or shear rate at constant temperature.

NLGI Grade: A numerical scale for classifying the consistency of lubricating greases, based on the ASTM D217 worked penetration at 25°C (77°F). NLGI Grades are in order of increasing consistency (hardness) as follows:

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NLGI Consistency Number Worked Penetration Range, 25°C (77°F)

000 445-475

00 400-430

0 355-385

1 310-340

2 265-295

3 220-250

4 175-205

5 130-160

6 185-115

Some grease suppliers use descriptions such as NLGI Number 1.5, which indicates that the grease is between NLGI Numbers 1 and 2.

Non-Newtonian Behavior: Some fluids and many plastic solids, including lubricating grease, exhibit non-Newtonian behavior. In other words, the viscosity (applied shear stress/ shear rate) is not constant, but depends on shear stress and shear rate at a given temperature. Thus, non-Newtonian fluids are described by their apparent viscosity, which may vary widely with the shear rate. Conventional types of viscometers with uncontrolled shear rates are not suitable for measuring Non-Newtonian materials.

Non-Soap Thickener: Any of several specially treated naturally occurring or synthetic materials, excepting the metallic soaps, which can be either thermally or mechanically dispersed in liquid lubricants to form lubricating grease. Sometimes called Synthetic Thickener, Inorganic Thickener, or Organic Thickener.

Oiliness Agent: A material which reduces friction by formation of an adsorbed film.

Organic Thickener: See Non-Soap Thickener.

Oleate: An oleate is a salt or ester of oleic acid. Oleic acid is a fatty acid with chemical formula $C_{18}H_{34}O_2$ or CH_3-$[CH_2]_7$-CH=CH-$[CH_2]_7$-COOH. Oleate greases are made by reacting oleic acid with an inorganic base to form a salt, i.e., soap thickener.

OK Load: The OK load or the Timken OK load describes the load-carrying capacity of a lubricant. The OK load is measured in a standard test (ASTM D 2509). In this test, a bearing ring rotates against a stationary steel block under an applied load. The OK load is the maximum load that can be applied without scoring the steel block. It is used to characterize the extreme pressure performance of greases and lubricants. The name of this test refers to the Timken Company, which developed this machine.