

## Grease Basics

Written by Ray Thibault, CLS, OMA I & II, Contributing Editor  
Wednesday, 01 July 2009 00:00

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**Getting the most from this lubrication workhorse requires a solid understanding of its composition, properties and applications.**

Grease was first used by the Egyptians on their chariot axles more than 3000 years ago. Today, over 80% of the world's bearings are lubricated with grease. Lithium soap greases— *the most common worldwide*—were introduced in the early 1940s. Lithium complex greases, which are becoming the most popular in North America, were introduced in the early 1960s. The National Lubricating Grease Institute (NLGI), defines grease as:

"A solid to semi-solid product of dispersion of a thickening agent in a liquid lubricant. Additives imparting special properties may be included."

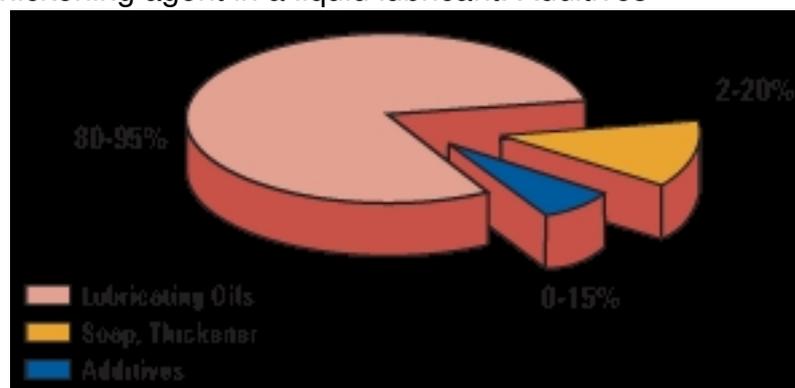


Fig. 1. Contrary to popular belief, grease is mostly oil, which is what does the lubricating. Some people describe grease as a sponge. This is not entirely a correct analogy, but liquid lubricant is dispersed in a fibrous thickener network resembling the pores in a sponge.

Most people think grease is primarily thickener but, in actuality, it is mostly oil—*which is what does the lubricating*

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. This is illustrated in Fig. 1.

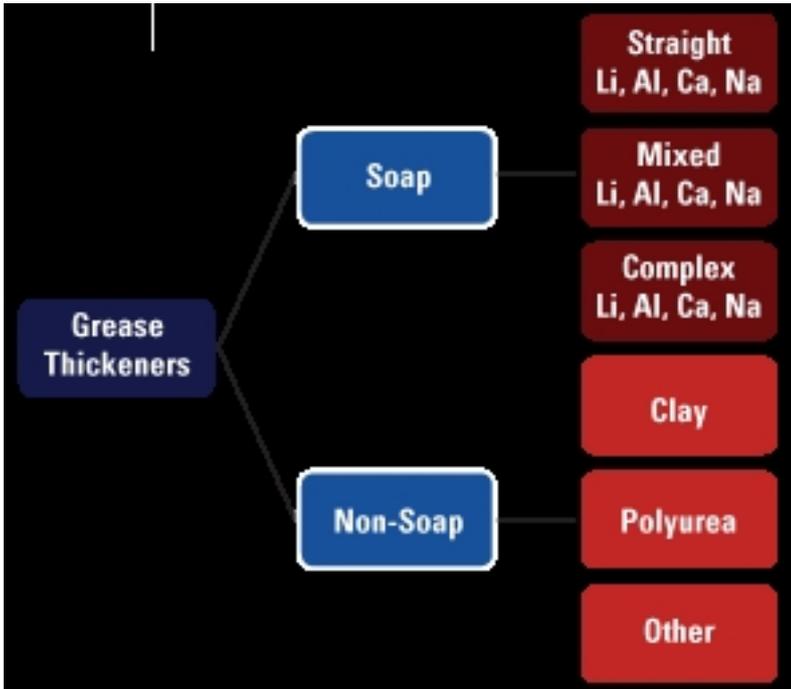


Fig. 2. Thickeners define grease types.

### Composition

As previously illustrated, grease consists of three components: thickener, base oil and additives.

### Thickener...

The thickener defines the type of grease (see Fig. 2).

Greases are classified into two major families: soap and non-soap thickeners. More than 90% of the thickeners used worldwide are soap based.

Soap-based thickeners are produced from an acid base reaction. The acid is a fatty, along with, in some cases, a short-chain organic complexing acid.

Saponification, the process for producing a soap-based thickener, is as follows:

Acid + Base = Soap + Water  
- **Common acids**

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High molecular weight fatty acids: Stearic and 12 Hydroxy Stearic Acid; Short chain complexing acids: Tallow, Azelaic and Sebacic Acid

- **Common bases**

Lithium Hydroxide, Calcium Hydroxide, Sodium Hydroxide, Barium Hydroxide and Aluminum Hydroxide

There are three types of soap-based thickeners:

- **Simple soap**

Simple soap results from the reaction of one fatty acid, such as 12 hydroxy stearic acid (12 HSA), and a metallic hydroxide, such as lithium hydroxide. This produces a simple lithium soap that is the most common worldwide. The metallic hydroxide used defines the thickener type. If calcium hydroxide were used with a fatty acid, the grease would be called simple calcium soap.

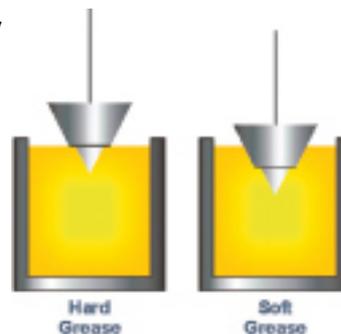
- **Mixed soap**

The mixed soap grease type is not very common. It is produced by reaction of a fatty acid with two metallic hydroxides. For example, if 12 HSA reacted with lithium and calcium hydroxide, it would produce a mixed Ca/Li soap.

- **Complex soap**

Reaction of a fatty acid, such as 12 HSA, with a short chain complexing acid, such azelaic, produces a complex soap. If lithium hydroxide were used, the result would be a lithium complex grease-the most popular grease type in North America. The advantage of this thickener type over a simple soap type comes from it having much better high-temperature properties.

Table I. NLGI Grease Classification by Consistency



**NGLI Grade**  
**Worked Penetration**  
**Range @ 77 F, mm/10**

000	445 to 475
00	400 to 430
0	355 to 385
1	310 to 340

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2	265 to 295
3	220 to 250
4	175 to 205
5	130 to 160
6	85 to 115

The consistency of grease is determined by placing a funnel called a penetrometer (shown in the accompanying diagram) on a smooth cup of grease that has a temperature of 77 F and measuring the penetration in tenths of a millimeter after five seconds. The greater the penetration the softer the grease and the lower the NLGI Grade number. Most grease used today falls under the classification of NLGI 1, 2 and 3, with the most common being NLGI 2 grade. High penetration greases, such as 00 and 0, are used in centralized lubrication systems in colder temperatures.

### ***Thickener classification...***

Greases are classified according to their thickener composition, as previously discussed, as well as on their consistency, according to the NLGI system shown above in Table I.

### ***Base stock and additives...***

Most of our discussion up until now has focused on the thickener. The base oil and additives are also key components of grease formulations. For example, a high-temperature thickener grease will not be effective if the base stock does not have good oxidative stability. Table II illustrates base stock types found in greases; Table III details the types of additives and their functions.

Table II. Base Stocks of Greases	Category	Type
Mineral Oils	Paraffinic & Naphthenic	
Synthetic	PAO, Ester, PAG & Alkylbenzenes	
Natural	Vegetable Oils	
High Performance	Silicones & Fluorinated Fluids	

Table III. Grease Additives and Functions	Additive	Function
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- Antioxidant                      Retard oxidation of base stock for longer lubricant life
- Rust Inhibitor
- Protect ferrous surfaces from rusting
- Antiwear                        Provide wear protection during boundary lubrication
- Extreme Pressure
- Provide protection during high load and shock loading conditions
- Tackifiers/Polymers
- Enhance water resistance and metal adhesiveness
- Molybdenum Disulfide/Graphite
- Solid lubricants providing protection and friction reduction under high load/sliding conditions at low speeds

### Key grease properties

The basic properties of greases are noted below in Table IV.

Table IV. Grease Properties	<b>Consistency</b>	NLGI grade is based on amount of thickener
<b>Dropping Point</b>	This is the temperature of grease where the first drop of oil separates from the grease	
<b>Water Resistance</b>	Water washout test measures ability of a thickener to remain intact in bearing	
<b>Base Oil Viscosity</b>	Because oil does the lubricating in a grease, and viscosity is the most important property of oil	
<b>Load Carrying Ability</b>	Under high-load conditions, high-viscosity base stock is required and usually is the most important property	
<b>Shear Stability</b>	Grease needs to maintain its consistency under high shear conditions. The most important property	
<b>Compatibility</b>	This is one of the most important grease properties. Whenever two incompatible greases are used, the result is usually a poor quality grease	
<b>Pumpability</b>	This is an important property when pumping grease in centralized systems and in applications where the grease is applied by hand	
<b>Oil Separation</b>	For a grease to be effective, a small amount of oil must separate from the thickener	

Product data sheets are available for purchased greases—and they should be consulted to determine the correct grease for the application

. Table V, on page 14, lists typical properties reported. This table is fairly complete; note that many suppliers do not report all this test data.

Table V. Typical Grease Properties for Purchased Greases from Test Data Reported by Suppliers

Test Method	Expressed Value	ASTM #
Cone Penetration Unworked & 60 double strokes		
Millimeters/10	D 217	
Worked Penetration 10,000 Millimeter, 600 double strokes	D 217	
Dropping Point		
Temperature in C & F	D 566	
Corrosion Prevention	Pass/Fail	
D 1743		
Oil Separation	Percentage of oil separated	D 1742
Water Washout	% grease washed out	D 1264
Water Spray-Off Resistance	% grease sprayed off	

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D 4049		
Timken OK Load	Maximum weight in Kg or lbs	D 2509
Four Ball EP	Weld point in kilograms & load wear index as a number	
D 2783		
Four Ball Wear	Scar diameter wear reading in millimeters	D 2106

Table VI summarizes key grease properties based on thickener types.

Table VI. Key Grease Properties by Thickener Types      **Grease Thickener**      **Appearance**

Calcium	Buttery	Good	Fair
Sodium	Fibrous	Fair	Poor
Barium	Fibrous	Good	Poor
Lithium 12 OH Stearate	Buttery	Excellent	Good to Excellent
Lithium Complex	Buttery	Excellent	Good to Excellent
Calcium Complex	Buttery to Grainy	Good	Fair
Aluminum Complex	Buttery to Grainy	Good to Excellent	Good
Clay (Bentonite)	Buttery	Good	Good

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Polyurea	Buttery	Good	Good
Calcium Sulfonate	Buttery to Grainy	Good	Good

## Applications

Based on the properties of grease, the following list describes situations where grease is the lubricant of choice:

- Where leakage and drippage is present
- In hard-to-reach places where lubricant circulation is impractical
- Where sealing is required in a high-contaminant environment (i.e. water and particles)
- To protect metal surfaces from rust and corrosion
- To lubricate machines that are operated intermittently
- To suspend solid additives such as moly during slow-speed, high-load sliding conditions
- For use in sealed-for-life applications such as electric motors
- To lubricate under extreme or special operating conditions
- To lubricate badly worn machines
- Where noise reduction is important

## Conclusion

While grease is a very important part of every lubrication program, many people use it without fully recognizing the differences among various types and/or the guidelines for their proper selection and application. This article focused primarily on various greases and their compositions, and only touched on their key properties. Those properties, however, need to be understood so that the correct selection can be optimized. These issues will be discussed in more detail in a future article on the proper selection and application based on equipment type and environment. **LMT**

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*Contributing Editor Ray Thibault is based in Cypress (Houston), TX. An STLE-Certified Lubrication Specialist and Oil Monitoring Analyst, he conducts extensive training in a number of industries. Telephone: (281) 257-1526.*

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