Choosing the Right Grease

This technical article was written by Freddi Stafford

You may ask yourself why the selection of a grease is so important to your application and the operating conditions in which the grease will function. It comes down to the fact that different greases will provide different characteristics and getting the most from a grease lubricated component requires a solid understanding of its composition, properties and applications.

A Little History

Grease was probably the first lubricant ever used. Animal fats were thought to have been used by the ancient Egyptians to lubricate the hubs of the wooden wheels of their chariots. That was some 3500 to 5000 years ago. Those early forms of grease, based on animal fats, were able to handle the moderate loads and speeds of earlier times. The basic nature of a grease hasn’t changed much since that time. However, animal fats would not be capable of meeting the demands of today’s automotive and industrial requirements. High loads, high speeds and high temperatures, along with other special requirements, all place far higher demands on modern greases.

Nonetheless, grease is still made up of an oil thickened by some means, usually by what is called a “soap”. For the budding chemists out there, 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, therefore, is the process used to produce a soap-based thickener as follows: Acid + Base = Soap + Water

A Useful Definition for Grease would be:

Grease, a solid or semi-solid lubricant, starts out as a liquid lubricant (in other words – oil or another liquid) to which a thickening agent is added, usually a soap (like lithium). Most multipurpose/extreme pressure (EP) greases are lithium (soap) based and contain an SAE 90 viscosity oil, like gear oil (the oil).

Greases are affected by viscosity, temperature and oxidation resistance, just as oils are. All greases are made up of different components, including the base oil type, base oil viscosity and thickener type.

Base Oil Type

Oil itself is the basic lubricant, and is the most important component because it has the greatest influence on the behaviour of the grease. The amount of oil included in a grease may be anywhere from 70% - 95%. The oil content of a grease can be any of a wide variety of oils including mineral (paraffinic & naphthenic), natural (vegetable oils), high performance (silicones & fluorinated fluids) and synthetic (PAO, Ester, PAG & Alkylbenzenes). The base oil type is determined by the operating conditions in which the grease will be expected to perform. These include high and/or low temperatures, loads and pressures. The load and pressure will not only influence the choice of base oil type but also the additive package which can comprise up to 10% of the grease.

Additives in the Base Oil

Additives such as extreme pressure, anti-wear, anti-oxidant all enhance desirable properties, suppress undesirable properties and add new properties to the grease. EP additives may also be used in conjunction with the solid additivtes like molybdenum disulphide (moly), graphite or
PTFE (Polytetrafluoroethylene) or they may be used on their own. The additive package of the oil is therefore, also an element which may be added to a grease in some form to provide certain performance characteristics. While a grease made just from oil and a thickening agent is suitable for many light industrial uses, the useful range of greases is considerably increased by additives. These additives include antioxidants, antifoam agents, anti-wear/EP, rust inhibitors, demulsibility, VI improvers, corrosion inhibitors, tackifiers and polymers. In addition to these additives, as mentioned earlier, boundary lubricants such as moly for use in CV joints, PTFE or graphite may be suspended in the grease to reduce friction and wear without causing adverse chemical reactions to the metal surfaces during heavy loading and slow speeds. “Tackiness” additives are utilised in greases for “open” or exposed applications (open gears) especially where high centrifugal forces are expected. While synthetic oils will perform better over a wider range of temperatures and conditions, mineral base oils can be used if you have a more constant running temperature. The base oil will also differ in viscosity, based on the application.

**Base Oil Viscosity**

Oils used in greases range from light spindle oils to very heavy oils having a high viscosity. Base oil viscosity is one of the most important properties of any lubricant and is often overlooked and misunderstood when it comes to grease. In general, medium to high viscosity oils are used in making a grease for high-temperature or low-speed applications. Lower viscosity oils are used in grease intended for lower temperatures and higher speeds.

**Thickener Type**

Most of our customers believe the thickener is the lubricating part of the grease, but this is not the case, except for calcium sulphonate thickeners which provide some tribological performance to grease. The thickener is the component that holds the lubricant in place, like a sponge. The thickener is often referred to as a sponge that holds the lubricant (base oil plus additives). This is not entirely a correct analogy, but liquid lubricant is dispersed in a fibrous thickener network resembling the pores in a sponge. The thickener can comprise between 5% - 30% of the grease. The fibrous material of the sponge holds a relatively large volume of liquid (oil), which it releases when pressure is applied, and then re-absorbs the liquid when the pressure is released. Similarly, the thickener of the grease holds the oil and releases it to provide lubrication when the grease is subjected to high pressure at its point of application in the bearing. When this application of pressure is released, as the bearing rotates (and before the next element of the bearing is subjected to load) the oil is re-absorbed into the grease thickener, ready for the next application of load. In other words, the characteristic feature of grease is that it possesses a high initial viscosity, which upon the application of shear, drops to give the effect of an oil-lubricated bearing of approximately the same viscosity as the base oil used in the grease.

**More on the Thickener**

The thickener itself may have some lubricating value, but the oil determines the lubricating action. A good thickener type will be compatible with the equipment manufacturer recommendations and will be able to withstand the conditions under which it must perform. There are many types of thickeners, but most are not compatible and should not be mixed. The most common thickeners are lithium, lithium complex, aluminum complex and polyurea. A grease thickener can influence your grease’s operating temperature, load, speed, and material compatibility. It is therefore very important to determine which thickener is best suited for use in your specific application as the thickener utilised will determine the success of the grease in service. The thickener type also determines water and salt water resistance thermal stability, thickening efficiency, lubricity, shear stability, load carrying capacity, compatibility, pumpability, oil separation and even noise levels as well as whether or not the grease is food safe. There are organic soaps such as lithium soap (lithium 12-hydroxy stearate and lithium stearate) calcium soaps, sodium soaps, aluminum soaps, mixed soaps and complex soaps. Complex soaps used to manufacture complex greases (lithium complex) typically give you improved temperature resistance and can handle applications where short term high temperature exposure is reached - up to 175°. Lithium, calcium, sodium, aluminium are referred to as “metallic soaps.” More than 90% of the thickeners used worldwide are soap based. Some greases contain mixed soaps such as lithium/calcium. The reason for this is that lithium will improve the high temperature resistance of the grease while the calcium improves the water washout and cost. We also have greases that make use of a thickener called a non-
soap thickener. These include polyurea, calcium sulphonate, standard silica, polytetrafluoroethylene (PTFE), carbon blacks and organo clay (bentonite) based grease. Greases utilising bentonite are generally regarded as high temperature greases and are commonly used in vehicle wheel bearings and where disc brakes are known to generate high temperatures. The bentonite base has no “drop point” and this makes them eminently suitable for this application.

**Drop Point of a Grease**

Drop point should not be confused with continuous operating temperature. Generally, the continuous operating temperature of a grease is two thirds of its drop point. The drop point (upper temperature limit) is the point at which the soap base loses its structure and is a measure of the cohesiveness of the oil and thickener of a grease. When the drop point of a grease is exceeded, the grease will become fluid enough to drip.

**Grease Classification**

Greases are often classified by the type of soap or thickener employed in their manufacture, as this has a significant effect on the overall performance. Some of the more common types of grease and their common uses are as follows:

<table>
<thead>
<tr>
<th>Thickener</th>
<th>Key Characteristics</th>
<th>Applications</th>
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<tbody>
<tr>
<td>Lithium Soaps</td>
<td>Good lubricity, shear stability, thermal resistance, low oil separation, multipurpose with the most advantages</td>
<td>Bearings in automotive and industrial applications</td>
</tr>
<tr>
<td>Calcium Soaps</td>
<td>Improved water resistance over the lithium greases and good shear stability stearate contains water (1%) as structural stabilizer, hydroxystearate contains no water</td>
<td>Used in applications that operate up to 110 °C, bearings of water pump, wheel bearings, and agricultural vehicles</td>
</tr>
<tr>
<td>Sodium Soaps</td>
<td>High dropping points (typically 175 °C), good shear stability and lubricity and emulsifies with water</td>
<td>Bearings in aerospace, wheel bearings, universal joints and axle journal boxes</td>
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<tr>
<td>Aluminum Soaps</td>
<td>Excellent oxidation resistance, good water resistance and excellent adhesive characteristics</td>
<td>Vibrating screens, elevator drive motors and governors where reversing motion occurs, and large electric motors with bearings operating at high linear speeds</td>
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**Grease Consistency**

The consistency of grease is controlled by the thickener concentration, thickener type and the viscosity of the base oil. In much the same way that oils are classed according to viscosity, you can consider that greases can be classified according to their consistency. The consistency of a grease is roughly equivalent to the viscosity of an oil, in its effects. Penetration, a measurement of grease hardness, refers to the consistency or firmness of a grease. Two test methods, namely ASTM D217 and D1403 are used to determine the penetration of unworked and worked greases. In order to measure penetration, a cone of a specific weight is allowed to sink into a grease for five seconds at a standard temperature of 25 °C. The depth, in tenths of a millimetre, to which the cone sinks into the grease is its penetration. A penetration of 100 would represent a solid grease, while a penetration of 450
would be semi-fluid or very soft grease. The NLGI (National Lubricating Grease Institute) has established a scale to indicate grease consistency which ranges from grades 000 (semi-fluid) to 6 (block grease). Therefore, grease consistency can vary from a firm block (similar to cheddar cheese spread) to semi-liquid (similar to tomato sauce). The most common grease is general purpose grease which has a consistency of NLGI 2 which is almost the same in consistency as peanut butter.

**Importance of Consistency**

The consistency of a grease is important because the grease must reach the parts to be lubricated, and do so at all times. Too heavy a grease will “channel.” That is, it will stay in a fixed position as a ridge or hollow (the component being lubricated will cut a channel in the grease) and the grease will therefore not provide adequate lubricating action. If the lubrication is not adequate, this in turn will mean failure of the parts being lubricated.

**Texture and Structure**

The texture or structure of a grease, its “feel,” makes a difference in pumpability, too. It also has an effect in the applications themselves. Some greases are smooth, stringy, or spongy. Others are fibrous (having some stringiness), or feel rubbery.

**Application**

We can see that as with oil, grease displays its own set of characteristics that must be considered when being chosen for an application. These characteristics may be found on the product technical data sheet of a grease. They include pumpability, water resistance and consistency, dropping point (an indicator of the heat resistance of grease) oxidation stability, high-temperature effects and low-temperature effects.

**CV (Constant-Velocity) Joint Grease**

CV joints are degraded as the driving distance increases. Therefore, the measurement of grease degradation is representative of the property and performance of the grease used. When it comes to CV joint greases the correct choice of grease is imperative. This is because the sealed greases of CV joints must provide low friction and wear protection for the lifetime service of the CV joints. The performance of CV joint grease also affects the vibration and noise levels in the vehicle. CV joint grease is usually a heavy duty lithium grease NLGI No. 2 which contains molybdenum disulphide (MoS2) for boundary protection (metal against metal) which will protect against the heaviest sliding, shock or impact loading conditions.

Molybdenum disulphide or MoS2 is the most common natural form of molybdenum and is extracted from the ore Molybdenite and then purified for direct use in lubricants. Molybdenum disulphide should not be confused with graphite. While moly has a hexagonal lamellar crystal type structure, graphite has a hexagonal layered lattice structure (planes of polycyclic carbon atoms) and due to a weak bonding between layers only delivers superior lubricity in the presence of moisture (high humidity). Molybdenum disulphide solid lubricants, on the other hand, cannot be utilized in wet conditions as moisture increases friction. Moly has the extraordinary affinity to stick to metal, especially if rubbed in. The Moly, solid film friction plating is extremely durable. Probably the only method of removal is to grind it off. Because Moly is an extremely effective lubricant, it is possible for two moly plated parts such as a bearing and a shaft to run for an indefinite period of time without a fluid like oil. MoS2, due to its hexagonal layer lattice crystal structure gives it low friction and excellent adherence to most metals. This has made it the perfect solid lubricant when added to CV joint grease because even when all the grease is forced out of the CV, moly acts as a dry lubricant and provides increased load-carrying capacity thereby protecting components from wear. The grease as a whole passes into the contact zone in a CV, rather than only the oil component of the grease. This is also the reason why MoS2 containing greases are used to lubricate railroad curved railway tracks, also known as curve-rail greases. These greases are normally smooth grey to black (due to the presence of moly – although you do get white moly) and are formulated with extreme pressure additives for maximum loading applications, anti-wear protection and water washout resistance. CV joint greases contain effective rust, oxidation and corrosion inhibitors and will resist “squeeze out” from surfaces requiring lubrication under load conditions. The temperature limitation of MoS2 at 400ºC is restricted only by oxidation. CV joint greases therefore cost more than general purpose greases.
Grease Compatibility

Grease compatibility can be complicated. One common mistake is when grease specifications are interchanged based on performance, without considering the composition (thickener and base oil). This can result in serious consequences if two different greases with the same performance specifications are mixed together and their compositions are incompatible. While the compatibility charts offer an effective way to determine general compatibility between two greases, your grease supplier should always be consulted, especially where the application is critical.

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<tr>
<th>GREASE COMPATIBILITY TABLE</th>
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<tr>
<td>Aluminium Complex</td>
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<tr>
<td>Barium</td>
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<tr>
<td>Calcium</td>
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<tr>
<td>Calcium 12 Hydroxy</td>
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<td>Calcium Complex</td>
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<tr>
<td>Bentonite</td>
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<tr>
<td>Lithium</td>
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<tr>
<td>Lithium 12 Hydroxy</td>
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<tr>
<td>Lithium Complex</td>
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<td>Polyurea</td>
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Advantages of Grease Lubrication

In many automotive and industrial applications, the use of the correct grade and type of grease has numerous advantages over the use of oil as a lubricant, for the same application. Because greases incorporate the use of a thickener, they have “stay put” characteristics and do not readily leak from bearings. Grease can form a “collar” on the outside of bearings, or a type of barrier, thus assisting in the reduction of the ingress of dirt and water. Water-resistant greases can be used in areas where water contamination would normally cause failure. Greases are eminently suitable for high-temperature applications, especially for bearings in difficult locations where periodic replacement and longer service intervals need to be applied. In many cases, by the use of a grease gun or automatic applicator etc. replenishment of the grease is easily accomplished. Also, in general, less complex seals are required to retain the grease in the bearing or housing compared to oil filled units.

The disadvantages of Grease Lubrication:

Greases exhibit little cooling effect as greases are a poor conductor of heat and offer little heat transfer. Difficulties associated with removing old grease in some applications before re-packing with new grease can also present challenges. Application difficulties can exist in some circumstances and a reasonable knowledge of grease specifications is needed in order to make a good decision on which grease to use in a particular application.

Conclusion

Modern greases are an integral part of modern lubrication practices for both automotive and industrial lubrication. Their properties can be tailored to meet the many specific demands that now exist in both automotive lubrication and industry. By careful selection, many lubrication problems can be avoided by the use of grease and they can provide long service life (filled for life bearings) often under extremely difficult and demanding conditions. As you can see, there are many different types of applications and environments and just as many types and brands of grease to go along with these components, machines and conditions.

Therefore, a good grease will be the one that best works for you and your motor vehicle or machinery, based on careful selection, with all of the above in mind, because grease is not just grease!