6 Critical Grease Characteristics

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6 Critical Characteristics of Bearing Grease: Testing for The Optimal Blend

Whether you design, build or maintain industrial equipment, it is likely you have encountered many types of bearing grease over the years. Lubrication plays a crucial role in virtually all operations, and certain key characteristics allow grease to perform its job better in demanding applications.

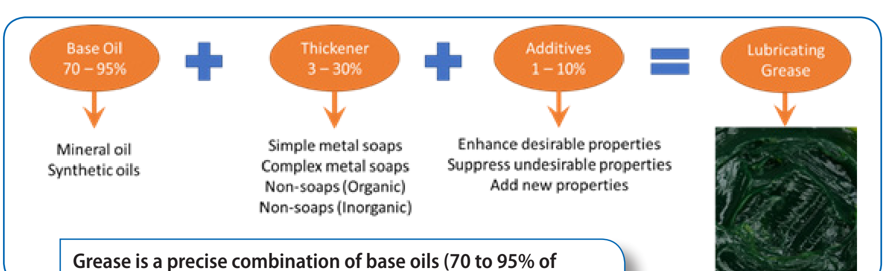
Bearing greases are expected to meet an array of functional requirements including oxidation and corrosion resistance, wear resistance, water resistance, mechanical stability and low friction torque. Greases must also handle a wide range of operating temperatures. And while the right grease can significantly extend bearing life, protect your equipment and reduce costs, it can be difficult to know if your grease formulation is the optimal mix for the environment it is exposed to.

At its headquarters facility in North Canton, Ohio, The Timken Company operates a tribology and lubrication laboratory for conducting research on interacting bearing surfaces and the behavior of various greases and oils. By studying how lubrication and the design of bearings influence friction and wear, Timken can identify specific grease formulations that can maximize component life in everything from rolling mills to race cars.

Gaining a stronger appreciation for grease starts with understanding the criteria that govern its effectiveness. This article looks at primary grease characteristics and how testing can reveal which blends will outperform others without bringing busy plants and factories to a grinding halt.

Film Thickness Formation

Film thickness formation is a vital property for any grease or lubricant as it keeps bearing surfaces separate to minimize wear. In bearings where the correct film thickness is achieved, it becomes much more likely the bearing will reach its expected service life. Increasing film thickness, however, increases friction and drag inside the bearing, thereby reducing its efficiency. Meanwhile, an insufficient film will cause metal surfaces to rub together, leading to severe damage modes and early bearing replacement.



Grease is a precise combination of base oils (70 to 95% of composition; most are petroleum-based mineral oils, others are synthetic oils), thickening agents (3 to 30% of composition; agents include soaps, complexes, mixed soaps and non-soaps) and additives (1 to 10% of composition; there are many types from oxidation inhibitors to anti-wear additives).

While grease selection can be a dirty job, choosing the ideal lubricant can mean a clean bill of health for hardworking bearings.

Viscosity—the measure of the flowability of a lubricant—is a major factor in film thickness formation. A high viscosity index—meaning the viscosity of the lubricant does not change radically when subjected to temperature changes—is generally preferred to get machines running at low-temp start-up conditions and keep them running at high-temp conditions. By knowing the load, speed and temperature requirements for your application, it becomes a practical matter to select a grease having the right viscosity to essentially control film thickness formation.

While there is no industry standard test to determine film thickness formation, there are many specially designed measuring devices used by bearing manufacturers to define operational values. In many cases, a purpose-built bearing test rig can predict the film thickness for a specific grease with extreme accuracy.

Consistency and Mechanical/Shear Stability

Consistency (hardness) is the degree to which grease resists deformation when force is applied. Consistency characterizes the plasticity of a solid in much the same way that viscosity characterizes a fluid. The measure of consistency is called penetration.

Penetration is expressed by the National Lubricating Grease Institute (NLGI) number system that categorizes greases by their hardness. Greases are assigned a "grade" based on ASTM D217 testing, a standard measure of consistency. The harder the consistency of the grease, the higher the NLGI grade. The NLGI scale ranges from 000 (semi-fluid) to 6 (solid).

Penetration is a critical grease characteristic because lubricants must remain at the bearing contact surfaces (where rolling elements contact the raceway), especially in applications where extreme loads and speeds work to push grease out of the bearing. What no equipment owner wants is a scenario where grease must be constantly pumped into the bearing to prevent early damage onset. Depending on the mounting orientation of the bearing, gravity can also cause grease to move away from contact areas, making it even more important to achieve the ideal consistency.

Grease consistency is usually measured by cone penetration according to ASTM D217 or ASTM D1403. ASTM defines penetration as the depth that a standard cone penetrates a sample of lubricating grease under prescribed conditions of cone weight, time and temperature. Penetration is measured in tenths of a millimeter, sometimes abbreviated dmm. Tests can be conducted for unworked, worked and prolonged worked penetration, with worked penetration (where grease is first subjected to 60 double strokes in a standard grease worker) being the most common test.

Mechanical stresses can reduce lubricant viscosity as grease is worked between bearing surfaces, making shear stability another vital grease characteristic. ASTM D1831 offers a test method to determine changes in the consistency of greases (as measured by ASTM D1403) when worked in a roll stability test apparatus. Test results can reveal a directional change in the consistency of the lubricant that could occur in actual service, helping equipment owners avoid costly problems caused by thinning grease.

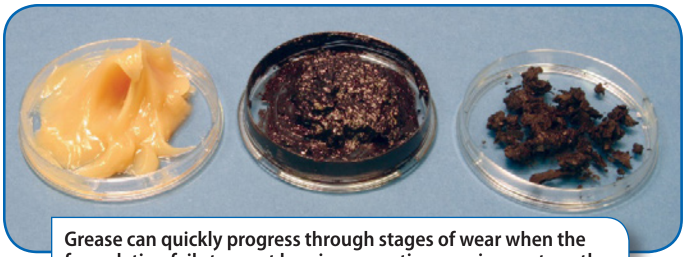
Oxidation Stability

Grease oxidation, which is a time- and temperature-dependent phenomenon, directly affects grease life by diminishing its ability to form an effective lubricant film on bearing contact surfaces. A grease consequently requires significant oxidation stability to operate in applications with high operating temperatures and long service period requirements.

A reliable method of measuring grease oxidation stability is ASTM D5483 testing using pressure differential scanning calorimetry or PDSC (a calorimeter measures the heat involved in a chemical reaction or physical process — a pressure differential scanning calorimeter measures the effects of surrounding gas pressure on these measurements). This method is commonly used to compare grease oxidation resistance and predict the relative life of the lubricant. ASTM D5483 evaluates the oxidation induction time of lubricating greases using PDSC, where the induction time is used as a measure of oxidation stability.

In this test, a grease sample is placed in a cell that is heated to a specified temperature (commonly 150°C or above) under pressurized conditions (e.g., 500 psi) until an exothermic reaction occurs in the presence of oxygen. The oxidation onset time is then measured, with a longer induction time indicating longer grease life.

To prevent oxidation from becoming a problem, it is advisable to keep your bearing seals in good condition and to avoid unexpected temperature spikes by taking correct steps such as proper bearing installation, grease selection and grease-fill. Air can easily infiltrate through defective seals, enabling oxygen and hydrocarbons to react and form oxidation products that degrade the bearing grease.



Grease can quickly progress through stages of wear when the formulation fails to meet bearing operating requirements — the result being an expensive repair in many cases.

Rust and Corrosion Resistance

Moisture and water ingress can lead to corrosion or water etching on the contact surfaces of bearings and typically occurs when the bearing is stationary for prolonged periods. Severe corrosion can cause pitting of metal surfaces, thereby increasing the risk of surface or subsurface fatigue damage. Thus, the degree of rust and corrosion protection provided by bearing grease is a major consideration.

ASTM D1743 and ASTM D6138 are two standard rust and corrosion tests. ASTM D1743 is a static test of a grease-packed roller bearing for 48 hours under 100% humidity at 52°C. Conversely, ASTM D6138 is a dynamic test of the grease's corrosion preventive properties. This test, also known as EMCOR, involves testing the grease packed in a double row of self-aligning ball bearings at a speed of 80 rpm (cycled) under no load, without heat and in the presence of water. In both ASTM D1743 and ASTM D6138, the outer rings are respectively examined for corrosion.

Timken has developed special tooling with some alteration to conduct ASTM 6138 testing on roller bearings using distilled water, synthetic seawater and sodium chloride to determine how different levels of aggressive fluids impact grease corrosion resistance. The results of this analysis have helped many customers avoid the cost of purchasing new bearings that would have continued to fail due to inadequate corrosion protection of the grease.

Extreme Pressure Performance and Wear Evaluation

Some greases use extreme pressure (EP) additives to create a tribochemical film between contact surfaces (tribochemistry being concerned with chemical reactions triggered by mechanical forces). Greases that break down under extreme pressure increase the likelihood for scuffing (abnormal wear due to localized fracturing) and spot welding to occur, which can abruptly end a bearing's effective life.

ASTM D2596 is commonly used to determine the load-carrying capability of greases under pure sliding contact. Using a four-ball extreme pressure tester, grease samples are subjected to a series of 10-second tests at increasing loads until welding occurs. The weld point is then recorded. The higher the weld load, the better the grease for extreme pressure protection.

Meanwhile, ASTM D2266 is used to evaluate the wear-preventive characteristics of greases. This test mirrors ASTM D2596, except that it measures wear resistance at a lower load over a longer time, and welding does not occur. As an example, a grease under 4-ball sliding contact (where a steel ball is rotated against three stationary steel balls having a lubricant film) will be tested for 60 minutes at 1,200 rpm under a 40-kg load. Wear scars on the stationary balls are then measured, with smaller-size wear scars indicating that the grease offers superior protection.

Note that more EP additives do not always equate to a better performing bearing grease. In fact, greases having too high an additive concentration can increase the potential for aggressive chemical reactions, to the point that damage modes like micropitting (seen as small craters on contact surfaces) become a concern. This unintended consequence of grease selection can be the difference between a bearing that performs for 100 million cycles and one that lasts 200 million cycles more. Like most aspects of grease formulation, the need for EP additives must be carefully balanced against other operational requirements.

Extreme Temperature Performance

Many industrial machines must endure extreme low temperatures, making some synthetic greases a strong choice for achieving good flow properties even at -50°C.

ASTM 1478 is a grease low temperature torque test that investigates the ability of a grease to lubricate a slow rotating ball bearing. The test records starting and running torques at temperatures below -18°C and provides an accurate data point for selecting grease for a wide range of applications. At -18°C, many standard greases approach their pour point, where the grease can no longer flow. When greases congeal and bearings seize up, companies can lose days of production time, and the problem is not uncommon.

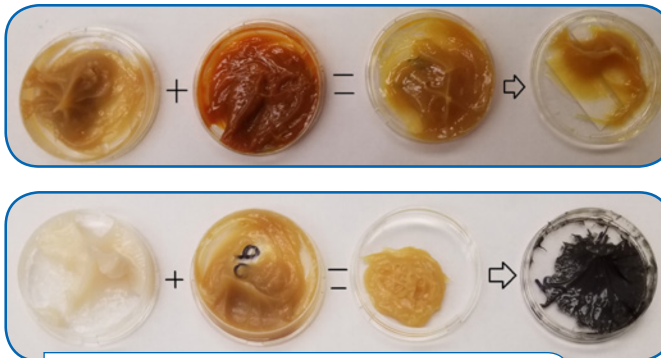
Meanwhile, the dropping point of a grease — the temperature at which it transitions from a semisolid to a liquid state (where the base oil leaves the grease thickener) — gives good insight into high temperature performance.

ASTM D2265 is a standard method for measuring the dropping point of grease. In this test, grease samples are gradually heated until the thickener can no longer hold the base oil and drips start to occur. The market offers many ultrahigh temperature greases that can withstand temperature spikes over 400°C; however, a consideration of overall grease performance is key.

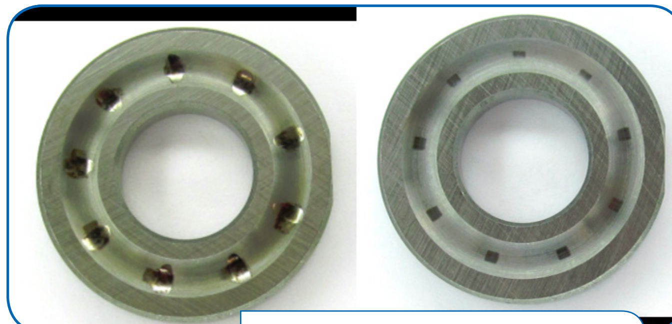
Additional Considerations

There are many more tests to determine other grease characteristics such as water washout (the ability of a lubricant to resist being removed from a bearing when acted on by a stream of water, governed by ASTM D1264); grease compatibility (where the properties of different mixtures can be incompatible, leading to an assortment of problems, see ASTM D6185); seal compatibility (measuring the changes in the volume and hardness of an elastomer immersed in grease to evaluate its relative compatibility, see ASTM D4289); and fretting performance (how well grease can tolerate the effects of sliding and vibration where bearings oscillate, see ASTM D4170).

Turning to a knowledgeable lubrication resource can help you overcome issues you may be experiencing with bearings. Oftentimes, bearing failures are the result of poor lubrication practices or improper grease selection — situations that can be remedied with the help of an expert professional who understands your unique operational requirements or production demands. Most greases look the same, but no two formulations are perfectly identical. Dialing in the optimal blend for your application is possible with grease testing that is available from many lubricant makers and bearing manufacturers. **PTE**



Compatible greases (top) will appear similar after several hours of operation whereas incompatible blends (bottom) can result in darkening of the grease due to mechanical degradation, oxidative degradation, starvation and/or wear debris, thus leading to bearing damage.



Anti-fretting grease can result in less false-brinelling wear compared to a typical EP grease when tested under ASTM D4170.

Grease Glossary

There's a lot to know about grease — the Lubricants Glossary (*autoam.timken.com/techseries/lubricant_pages/lubricant_glossary.htm*) is part of the free Timken Tech Series (*www2.timken.com/testing/index.asp*) and explains common terminology.

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