Advancements in Grease Sampling and Analysis Using Simple Screening Techniques

MRG Navigator^{TM} and ASTM Standards Provide High-Value Grease Analysis at Low-Cost

Gretchen Kowalik, LLA II
MRG Labs, York, Pennsylvania, USA
gkowalik@mrgcorp.com

Richard Janosky, LLA II
MRG Labs, York, Pennsylvania, USA
rjanosky@mrgcorp.com

Summary

Oil analysis is well established as a routine tool to optimize maintenance activities, improve reliability and equipment life and prevent component failures. As part of a comprehensive Condition Based Maintenance program, lubricant analysis is an effective complement to other diagnostic technologies such as vibration analysis, infrared thermography, ultrasonic detection and motor circuit evaluation. However, when the equipment is grease lubricated rather than oil lubricated, the important lubricant analysis piece is often ignored. The reasons for this include challenges in obtaining samples that can be trended, as well as the large sample volumes required for most current standardized tests for greases. Unlike oil, grease does not typically flow uniformly or circulate in the machine, so particulate and contaminants are present in varying concentrations in the grease. When a grease sample is obtained, it cannot be simply agitated to suspend and distribute particulate, as is the case with oil. These fundamental differences present barriers to acceptance of grease analysis as a routine aspect of diagnostic monitoring programs.

ASTM standardized tools and lab tests have been developed providing improved sampling techniques and lab tests to allow the inclusion of lubricant analysis for grease lubricated equipment. ASTM D7718 and ASTM D7918 are available to optimize grease sample trending as well as accommodate small sample sizes typically available in grease lubricated components. Utlizing the Grease Thief® sampling device outlined in ASTM D7718,a variety of grease analysis tests can be performed per ASTM D7918, Standard Test Method for Measurement of Flow Properties and Evaluation of Wear, Contaminants and Oxidative Properties of Lubricating Grease by Die Extrusion Method and Preparation. The unique design of the Grease Thief® allows the laboratory to perform up to 10 different lab tests with just one gram of grease. The one gram sample is extruded on to a thin film substrate where it can be distributed around the laboratory to perform a variety of different tests including: FTIR, RDE Metals Spectroscopy, RULER, fdM, analytical ferrography, rheology, colorimetry, moisture, microbial content and particle counting. While a full test slate is desirable to maximize information gathered from the grease sample, for large populations with uniform operating conditions, a reduced test slate measuring a few key factors can be utilized to “screen out” samples that do not require the advanced testing. This can provide a low cost solution while still obtaining valuable data looking at wear and contamination.

This paper will discuss how these new technologies can produce improvements in reliability and reductions in lubrication costs through condition-based greasing and trending of wear levels, with samples as small as one gram. A low cost screening test slate, which looks at wear and contamination for evaluating characteristics of used greases will be discussed. Additionally, a case study will be shared that demonstrates how the screening test slate may be used for routine grease sampling and in making maintenance decisions.

1. Obtaining Samples

In most circumstances, procedures for obtaining grease samples from bearing housing and gears are not consistent and likely do not represent the true condition of the “active” grease near the lubricated surface. It may also contain particulate and other contamination picked up during the sampling process. Historically, in-service grease samples from motors, valves, and various bearing housings, typically have required the equipment to be out of service and disassembled. A key factor is that a large volume of sample is needed to perform current analytical testing methodologies and along with this issue is it is extremely difficult to obtain that representative sample from near the bearing while the component is still in service.

Therefore, the challenge in optimising a grease analysis program is the development of test methodologies to measure in-service grease conditions utilizing a smaller amount of grease and a sampling process that enables representative grease samples to be taken without disassembling of the component (ASTM D7718). For motors and certain other components with grease drain paths, new design components are available that allow a replaceable fitting to be installed at the drain port (**Figure 1**). This fitting serves two purposes. First, it takes the place of a drain plug, allowing displaced grease to drain from the cavity without building up pressure--compromising the bearing shield/seal. Secondly, it provides a protected pathway for representative grease which drains from the cavity to be captured and submitted for analysis.

Figure 1 Grease sampler for motor drains

In this design, the sampling fitting is also optimised for the subsequent laboratory analysis. By providing a sealing surface in the fitting cylinder, the entire volume of grease is available for analysis. The full Grease Thief may be used in non-destructive testing for the screening test slate and is then also prepped for further analysis if deemed necessary.

For motor operated valves, gearboxes, and bearings that do not by design deliver grease to a drain point, other sampling tools have been developed. Similar to the principle of a liquid sample "thief", the device must be able to travel from the access hole to the active lubrication location, near the bearing or gear mating area, and bypass the non-representative grease along the way (**Figure 2**). This requires the device to push grease out of the way in the space between the access hole and the lubricated surface, and then capture a small amount of grease close to the gear surface or bearing grease shear area. Such a device has been developed and tested to demonstrate the capability to deliver a representative sample.

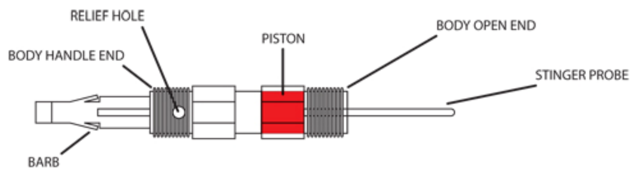

Figure 2 Grease sampler for gearbox testing

The grease sampler is inserted into a t-handle extension (**Figure 3**) to permit remote actuation and capture of the sample at the site of active grease use and wear generation, adjacent to the mating gears or bearing surface.

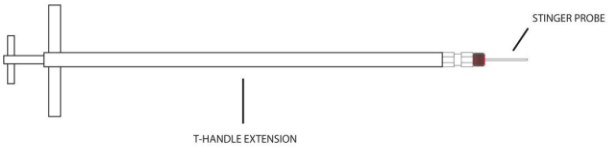

Figure 3 Grease sampler in t-handle extension

2. Grease Screening Analysis

2.1. Navigator

To provide the best results in a screening analysis test slate, the main concerns are to maximize the available data while keeping costs low. In an effort to keep costs down, test must require minimal handling, and still be performed quickly and efficiently. Through discussions with various maintenance professionals, it was determined that wear and contamination are the best risk factors to target. The MRG screening analysis test package looks at wear and contamination through ferrous debris monitoring, FTIR baseline conformation, and colorimetry. Tests are based on analysis described in ASTM D7918. The process starts when the end user takes a sample using the sampling tools and procedures described in Section 1. The sample is then entered into the online Navigator database. The sample is labelled with a pre-printed, prepaid barcode and the equipment identification is entered into the website dialogue (Sample ID, equipment name/information, baseline). The sample is then sent to the lab for analysis.

2.2. Ferrous Debris Monitoring

A difficulty in evaluating wear particulate in grease exists because of the inability to agitate a sample to evenly distribute particulate, as is done with oils. This non-uniformity of distribution can lead to misleading results because the portion of the sample selected for dissolution and analysis may be skewed higher or lower with respect to wear particle content. One way to compensate for that condition is the use of ferrous debris monitor to measure the entire ferrous content of the obtained sample (**Figure 4**). When using the sampling fitting described in Section 1, the entire volume of grease can be measured in a ferrous debris monitoring device that includes a chamber surrounded by the sensing coil. This method minimizes data scatter due to particle distribution issues and improves trending and sensitivity of results (Wurzbach et al 2010). FdM+ values are directly measured in the sampling device and wear content is reported in parts per million (ppm).

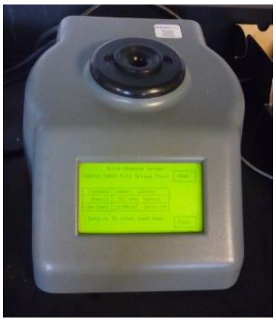

Figure 4 Grease Thief being analyzed in a ferrous debris monitor

2.3. Comparative FTIR Spectroscopy

Fourier Transform Infrared (FTIR) spectra are created from new grease samples for all greases in a facility's program. A thin film of grease is applied across a ZnSe crystal, and the auto-gain function is used to maximize signal and get a representative spectrum. Then the sampled in-service greases are tested and compared to the spectra of new grease. In particular, for different families of greases, the FTIR spectra are quite different and can be compared to see if significant mixing has occurred. In other cases, similar greases (two different polyurea greases) might not have significant differences in their spectra, but there is less likelihood of compatibility issues in that case. Still, many greases within the same family from different manufacturers can be differentiated with FTIR analysis. Results are reported as a baseline conformation index. Results which are closer to a value of 1.000 are more similar to the referenced baseline. Because the grease may be spread onto the ZnSe crystal directly from the Grease Thief, this results in decreased handling and a further reduction of costs associated with analysis.

2.4. Grease Colorimetry

Visual observations of grease appearance are a common assessment tool for field evaluation of lubricated components. Appearance changes including darkening, unexpected color or mixed colors are often the first condition noted that may indicate unusual lubrication conditions or mixing. A desire to empirically evaluate and substantiate such observations led to the development of an optical cell, used to present a grease sample in a uniform manner for subsequent visible light spectral analysis (**Figure 5**). This grease colorimetry optical cell is designed to create an optical path for the i-Lab visible light spectrometer, and includes a sliding drawer that holds the full Grease Thief. The controlled dimensions of the cell allow testing of the grease in a uniform manner without interference from ambient light and without contacting the grease sample.

The analytical result is a representation of the color, in chromaticity and brightness. A full spectral response of the grease in the 400-700 nm range is represented. Sample spectra are compared to the baseline spectra and reported as a differential spectral sum value.

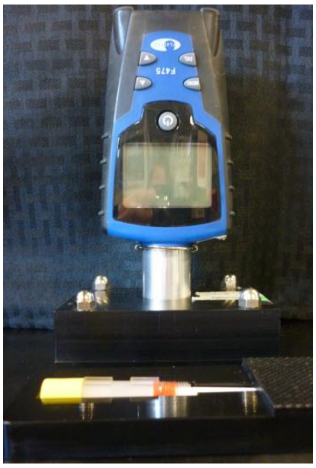

Figure 5 Grease colorimeter with cell and drawer for Full Grease Thief

3. Case Study

Together, these tests can be used to give an overview of the status of the equipment. Due to the low cost of the test set, many sample locations may be tested and analysed to determine where action should be taken first or if any further action is required. Recently, a wind farm sampled and tested the generator bearings, main bearings, and pitch bearings of their turbines to determine the "health" of the fleet. Overall, wear levels were satisfactory for most of the samples collected. **Figure 6** shows the wear levels for all of the pitch bearing samples. Of the 129 pitch bearing samples, only a few of the samples are in the "caution/watch" category while only two samples were at alert levels. Further analysis was recommended on the samples which were above alert levels to determine the type of wear or if any other issues were observed with the turbine.

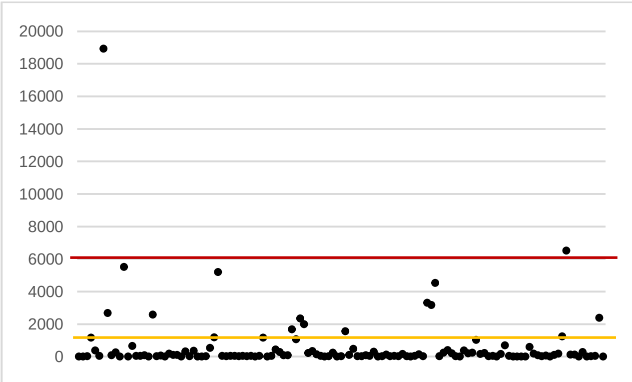

Figure 6 Pitch Bearing ferrous debris levels from a Wind Farm. Results are shown in ppm iron.

Similar to wear, the differential spec sum values were graphed. All 86 of the generator bearing samples (**Figure 7**) were similar in color to the referenced baseline. Some darkening of the samples was present, but some darkening is expected as the grease is in use.

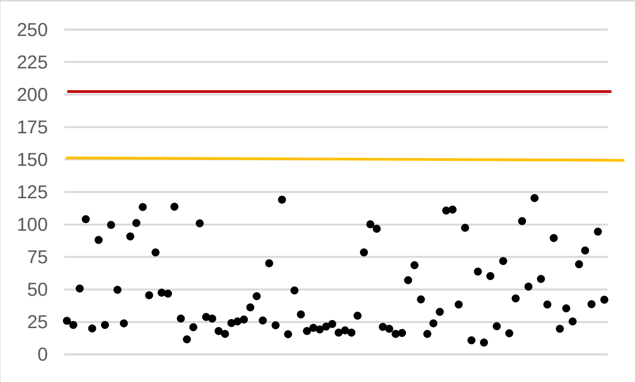

Figure 7 Generator bearing colorimetry analysis. Differential Spectral Sum index values are compared.

Lastly, all of the samples were compared to their respective baselines. **Figure 8** shows the baseline conformation data of all of the samples. Of the 258 samples only seven showed significant deviations from the referenced baseline. Deviations may have been due to high wear levels, mixing or the presence of moisture. Advanced analysis was recommended to determine why deviations were observed.

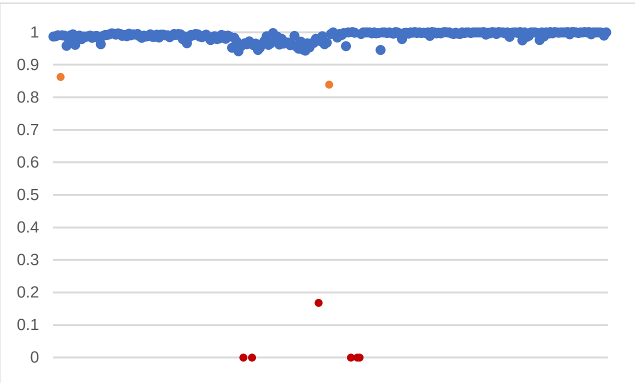

Figure 8 Baseline confirmation values for main bearing, generator bearing and pitch bearing samples.

4. Conclusion

Wherever there is critical machinary, regardless of lubricant type, the demand for reliability drives the development of improved sampling methods and analysis techniques to produce the valuable information present in lubricant analysis. Grease analysis presents a significant opportunity to expand machinery diagnostic capabilities. The historical challenges of obtaining representative and trendable samples are being addressed through technological developments and new approaches. The development of the grease analysis screening test slate includes repeatable analysis methods that utilize smaller quantities of grease at a greater value. This may encourage the sampling of greases from locations where reliability is important. The screening test slate has increased benefits when a large number of samples need to be taken to determine the overall health of a wind fleet (AWEA RP Ch 8), a large number of robots, or pumps and motors throughout a plant. Results are able to pinpoint areas of concern and further analysis may be suggested to further assess the condition of the grease. Because the sample is already in a Grease Thief® and the tests are non-destructive, samples are already prepped for additional analysis, including Die Extrusion, spectrochemical analysis, and moisture analysis if recommended.

For more information regarding grease sampling and analysis pleae contact MRG Labs at 1-717-843-8884 or visit www.mrgcorp.com.

List of References

ASTM D7718-11, Standard Practice for Obtaining In-Service Samples of Lubricating Grease, ASTM International, West Conshohocken, PA, 2011, www.astm.org

ASTM D7918-17, Standard Test Method for Measurement of Flow Properties and Evaluation of Wear, Contaminants, and Oxidative Properties of Lubricating Grease by Die Extrusion Method and Preparation, ASTM International, West Conshohocken, PA, 2017, www.astm.org

AWEA O&M Recommended Practice Chapter Eight: Condition Based Maintenance. Sections 812-815. American Wind Energy Association, Washington, DC, 2017, www.awea.org

Wurzbach, R., Williams, L., Doherty, W., “Methods for Trending Wear Levels in Grease Lubricated Equipment”, Society of Tribologists and lubrication Engineers (STLE) Annual Meeting, Las Vegas, NV, USA, May 2010.