Spectro Scientific

AMETEK

GREASE ANALYSIS GUIDE

Contents

1. Introduction

1. Introduction

Extending lubricant condition monitoring programs to include grease analysis

Onsite oil analysis is an effective tool to quickly analyze samples and optimize maintenance activities. As part of a comprehensive condition based maintenance program (CBM), oil analysis proves to be an effective tool to compliment other diagnostic technologies like vibration analysis, infrared thermography and ultrasound technology. However, when the equipment is grease lubricated, this important lubrication monitoring step is often overlooked. SKF states that 80% of the world's bearings are grease lubricated, leaving a vast opportunity to incorporate grease analysis techniques into the overall CBM strategy. The Electric Power Research Institute (EPRI), suggests nearly 50% of bearing failures are related to poor lubrication and contamination (1). The development of grease condition monitoring standards, ASTM D7718 and ASTM D7918, have laid the foundation for a consistent methodology to sample and test grease to implement condition monitoring strategies. By monitoring a few key data points, such as wear, oxidation and additive health, the asset manager has the ability to transition from calendar-based to condition-based change outs. This has the potential to save hundreds of thousands of dollars per year for an owner of a large fleet. The wind, rail and automotive robotics industries are currently implementing these strategies into their programs and potentially avoiding thousands in maintenance costs by predicting failures and extending greasing intervals. Historically, incorporating any kind of CBM strategy into grease lubricated components has been a challenge. The small quantity of grease typically available on an in-service component and the limited amount of testing available for small quantities of grease, often presents barriers for routine grease sampling and analysis as part of a comprehensive CBM Program. To address these challenges, grease sampling tools are available to capture a representative sample from a bearings and gears requiring as little as one gram of grease. Onsite analysis tools are available to assess wear and physical properties of the grease.

This simple sampling technique can be used in a variety of industries including but not limited to wind, rail, robotics, mining and nuclear to sample a large number of grease lubricated components and evaluate next actions based on criticality of the data. Periodic sampling and analysis of the grease from these components can provide asset owners a clearer picture of equipment health, determine grease condition for optimal change-out periods and pinpoint latent issues that can be addressed prior to failure. This application note will discuss grease sampling and analysis as a solution to optimize grease life, identify emerging problems and intervene to correct potential problems before significant damage or failure occurs.

Grease sampling

In most circumstances, procedures for obtaining grease samples from bearing housings and gears are not consistent and likely do not represent the true condition of the "active" grease near the lubricated surface. Therefore the challenge in optimizing a grease analysis program is developing test methodologies that measure in-service grease conditions utilizing a small amount of grease and a sampling process that enables representative grease samples be taken without disassembly of the component (2). To sample the grease, Spectro Scientific offers a scoop that is an additional accessory available with the Ferrocheck. While it is a reality that the user may need to scoop and scrap to the best of his/her ability to get a sample, there is a standard method that exists for taking in-service grease samples: ASTM D7718 Standard Practice for Obtaining In-Service Samples of Lubricating Grease. This standard shows several methods to take a representative grease sample and utilizes the Grease Thief® sampling device to sample the grease from a bearing, valve or gearbox. Spectro Scientific recommends users refer to this standard to learn how to take a representative grease sample.

Grease analysis as a screening tool for fleet analysis

Routine grease analysis is common in high value fleet applications such as locomotive, automotive robotics and wind turbines where a relatively striaghtforward set of screening tests for wear and oxidation can provide guidance on grease relubrication frequency, cases of mixup, and monitoring wear levels. Bearing or joint failures could result in millions of dollars in lost product or power, or even worse could threatened the safety of employees and users. Asset owners need to be able to look at a large quantity of data and pinpoint issues where they can focus their resources and prioritize accordingly. When compared to other diagnostic technologies, grease analysis has the ability to detect issues earlier on the P-F interval than vibration analysis, allowing asset owners more time to address the issues and avoid potential downtime. Once a representative sample is taken, onsite monitoring of the grease sample can be done using the Ferrocheck, FluidScan and Spectroil M or 100 to measure ferrous debris, physical properties and contaminants present in the grease. These onsite tools allow for quick monitoring of a large number of samples so immediate action can be taken.

Ferrous debris monitoring with the FerroCheck

Ferrous debris monitoring is the most common and cost-effective way to trend issues on bearings, gearboxes or valves.
The FerroCheck is a magnetometer that senses the disruption of the magnetic field due to the presence of magnetic particles in the grease. The amount of disruption of the particles can be directly correlated to the amount of ferrous debris in the grease.

The FerroCheck provides a quick and simple non-destructive solution for measuring the ppm of Iron in a grease (7).

Based on criticality of the component, sampling frequency can be determined so wear trend analysis and alarm limits can be determined. It's important to understand that wear particulate in grease is cumulative and, unlike oil, wear particles will remain in the grease until deliberately purged or flushed from the component. With the ability to detect up to 15% ferrous wear, the FerroCheck is an effective tool to use for trend analysis and can clearly identify outliers in a fleet application.

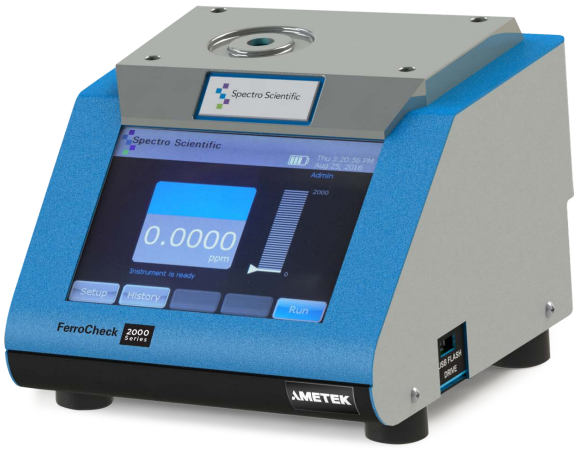


Figure 1: FerroCheck 2100 series

Infrared Spectroscopy with the FluidScan

Utilizing the FluidScan (compliant with ASTM D7889), Infrared Spectroscopy is a powerful tool that can be used onsite to measure oxidation of the grease and identify potential contaminants like moisture or mixtures with other greases. By monitoring these parameters via both trending and direct property analysis it is possible to inform the user when the grease has completed its useful service. Using a comparison library (over 800 oils and greases), the FluidScan can compare the grease sample to the reference to identify potential grease mixing. If at all possible, mixing of greases is a practice that should be avoided. Mixing of greases can lead to changes in the rheological properties of the grease and eventual separation of the oil from thickener. If considering mixing two greases, it is best to perform a compatibility study (ASTM D6185) to determine if mixing is acceptable.

Moisture and oxidation can also be determined on the FluidScan. A typical moisture peak can appear on the IR Spectrum around 3400cm-1. As these greases begin to age and oxidize, the buildup of oxidation products may be monitored by the FluidScan infrared analysis, as illustrated in (Figure 2) for a lithium-based grease. This is translated into an oxidation value and automatically reported

to the customer after each analysis. Oxidation warning and alarm limits for the greases have been built into the system.

Similarly, although greases are designed to reject water intrusion, water may build up in the grease, signaling issues with the health of the grease. This is also reflected in the infrared spectrum as shown in (Figure 3) Both the baseline of the infrared spectrum as well as the water-hydrocarbon bond are monitored to produce a total water reading for greases.

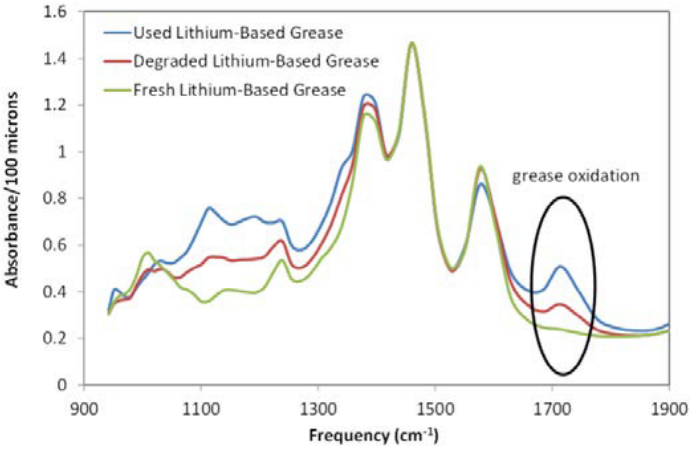


Figure 2: Oxidation of lithium-based grease measured by the FluidScan.

It's important to note that some polyurea thickened greases also have a peak on the IR spectrum in this region and care should be taken not to mistake this peak as moisture. The polyurea peak at 3400cm-1 will be a short, small peak versus a moisture peak which will be a larger broader peak.These same IR masking issues can also occur in greases that are formulated with an ester-based synthetic base oil. These greases will show a peak at 1750cm-1 where oxidation also appears. It's important to understand when these greases are being used and note this could impact the oxidation trend on the spectrum.

As with any effective CBM program, it is important to establish trends and focus on how the grease deviates from the trend. Any significant deviations from the trend would require action. Over time, alarm limits can be established for the particular components based equipment load, runtime and environmental conditions.

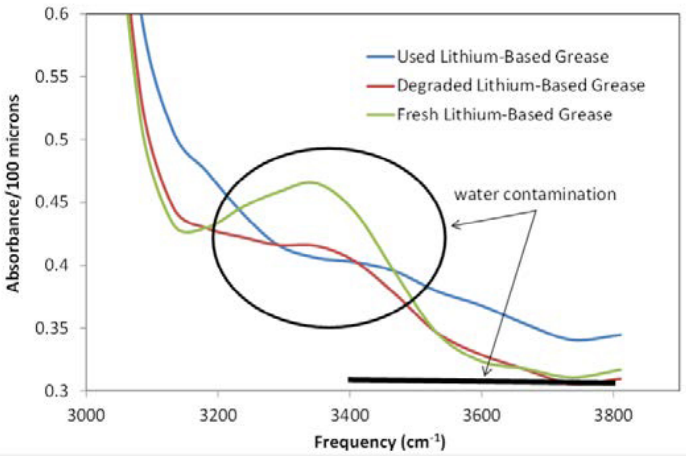


Figure 3: Water in greases is monitored by signature water-hydrocarbon peaks in the range 3300-3500 cm-1, as well as baseline shifts in the grease due to the presence of free and emulsified water in the grease.

Spectroil M and 100 Series Spectrometer

Using a Rotating Disc Electrode (RDE) Spectrometer, the concentration of metals in the grease can be compared to the new grease for the purpose of identifying significant differences in additive metals that could point toward grease mixing. Also, the presence of additional wear metals (Lead, Tin and Copper) can be determined. RDE Spectroscopy has become a common laboratory and field method for quick analysis of grease over the last 15 years. Sample preparation is important, however it differs based on early adopter experiences. The two most common preparation methods are dilution (slurry) and wet smear.

In the case of dilution (slurry) the grease sample is diluted with a solvent to create a low viscosity slurry that may be placed in the sample cup and excited as normal.

A second method is the smear (wet) approach whereby a rotrode is rolled in the grease sample to create a coating on the disk edges, and then it is mounted on the shaft, and a sample cup of base oil is used. Either method relies on consistency of the operator and an understanding of the goals.

2. Running Ferrous Density

(on Ferrocheck 2100 Series/FieldLab 33C)

Testing used grease samples

IMPORTANT: If you have to power up the FerroCheck, you must allow 15 minutes for stabilization time.

1. If this is the first use of a brand new analyzer only, tap Setup -> More -> Autotune. Otherwise, go to Step 2.
2. Make sure the Grease Low Analysis Mode appears in the Main Menu, like this: If it does not, tap the Analysis button, then tap Grease Low to select the row. Tap Done to update the Main Menu:

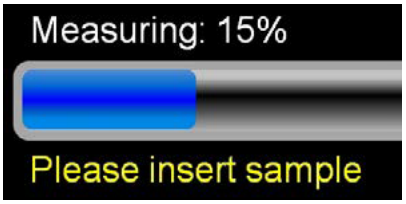
3. Scoop grease directly into the sample boat, like this: Optional: use the included spatula to load the sample.
4. Pack the grease with the spatula. Visually inspect the back of the boat for voids, and rework as necessary to completely fill the boat with grease.

   IMPORTANT: Check the back of the boat and make sure you wipe off any surplus grease.
5. Use the edge of the spatula to scrape the sample smooth and level, like this:

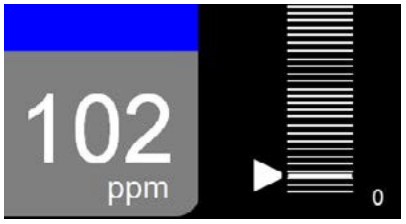
6. Slide the boat inside a standard sample tube making sure that the boat is fully inserted to the bottom of the tube, like this:
7. Hold the sample tube above the hole in the FerroCheck sample table and be ready to insert it at the prompt.

   IMPORTANT: Do not insert the tube until you are prompted in Step 9.
8. From the Main Menu, tap the Run button.

9. At the Insert Sample prompt (at 15% elapsed time, as in this example) immediately insert the tube crisply and firmly through the hole in the sample table:
10. At the Remove Sample prompt (at 60% elapsed time) immediately remove the tube quickly and cleanly.



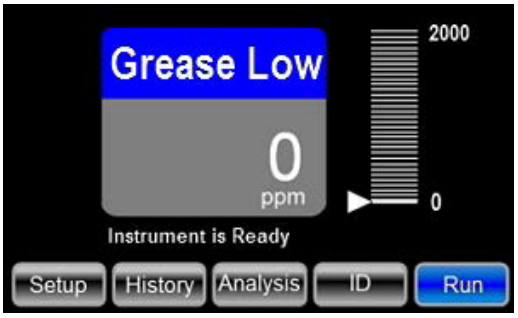
11. A valid result displays in white as in this example: If you do not get a valid measurement but instead get an error message, refer to the troubleshooting section of the FerroCheck User's Guide for an explanation. The most common mistake is not inserting or removing the sample at exactly the right time when prompted.



Testing used grease samples

If you have to power up the FerroCheck, you must wait for 15 minutes so the device can warm up and stabilize.

For this example, assume the sample comes from a centrifuge and so you you would expect your grease samples will test at less than 2,000 ppm. You can test used grease using any grease Analysis Mode, but for the greatest accuracy with this sample the Grease Low Analysis Mode (or a customized Grease Analysis Mode) needs to be selected in the Main Menu, like this:

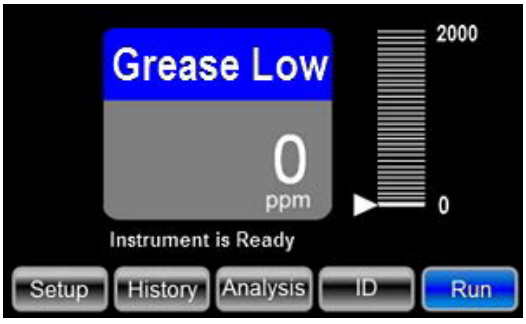


If it is not the current Analysis Mode, follow these steps to switch to the Grease Low Analysis Mode:

1. From the Main Menu, tap the Analysis button. The Analysis Menu opens similar to this example:

Analysis	Min	Max	Units
High PPM Oil	2000	10000	ppm
Low PPM Oil	0	2000	ppm
Grease High	0.2	15	%
Grease Low	0	2000	ppm

2. Tap Grease Low to select the Analysis Mode.
3. Press Done to update the Main Menu:



4. Scoop used grease directly into the sample boat or use the provided spatula to load up the sample:

5. Pack the grease with the spatula. Visually inspect the back of the sample boat for voids, and rework as necessary to completely fill the boat with grease.
6. Wipe any excess grease from the back of the boat.
7. Use the edge of the spatula provided to scrape the sample smooth and level:

5. Pack the grease with the spatula. Visually inspect the back of the sample boat for voids, and rework as necessary to completely fill the boat with grease.
6. Wipe any excess grease from the back of the boat.
7. Use the edge of the spatula provided to scrape the sample smooth and level:

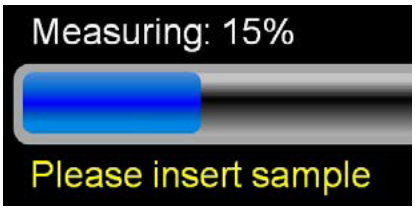
9. Hold the tube ready to insert through the hole in the analyzer sample table.

DO NOT insert the tube until you are prompted in Step 12.

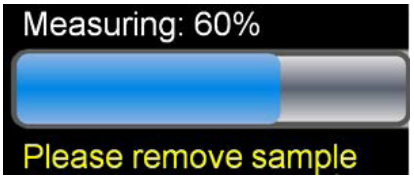
10. From the Main Menu, tap the Run button:

11. The sample timer starts counting up from 0 percent.

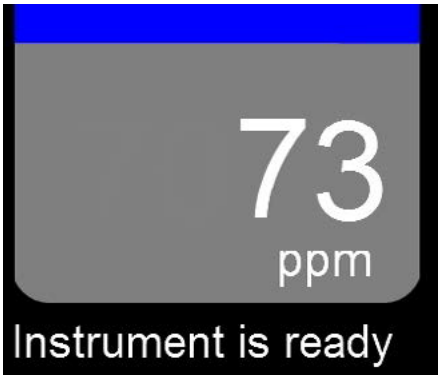
12. At the Insert Sample prompt (which will occur at 15% elapsed time) immediately insert the tube crisply and firmly through the hole in the sample table:



13. At the Remove Sample prompt (which will occur at 60% elapsed time) immediately remove the tube quickly and smoothly:



14. When the test is over, you should see a result of less than 2,000 ppm similar to this example:



3. Monitoring Chemistry Condition

(using FluidScan/FieldLab chemistry module)

Measuring a grease sample

1. Select Measure Fluid
2. Under Select Fluid Category, Select Grease.

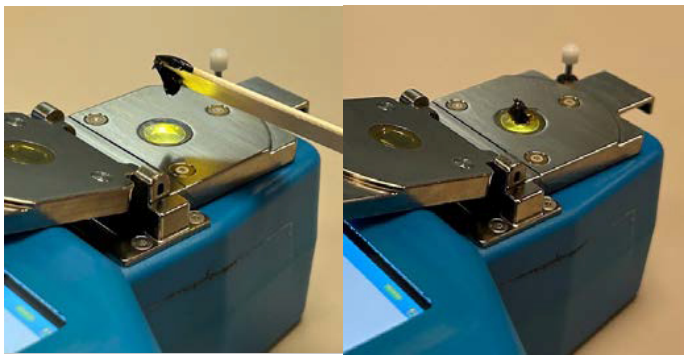


Figure 4: Placing grease onto the the cell of the FluidScan. The process of placing grease on the cell is the same for Fluidscan and FieldLab.

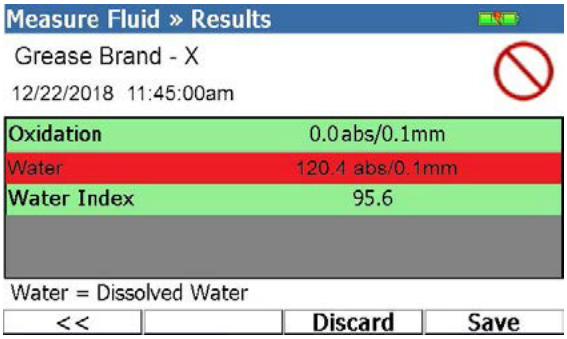
3. Then you can select a grease from the library or select Generic Grease if the exact grease type to be tested is not listed.

Note: In order to run greases on the FluidScan device, user must have the "All Libraries" license on the FluidScan. If not, please contact customer support.

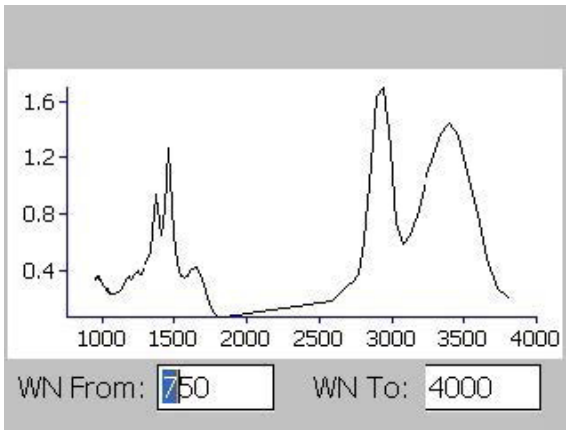
FL360 is the pn for All Libraries.

Water measurements for grease samples are reported as Dissolved Water measured in Absorbance Units/0.1 mm and the Water Index.

Water Index is a unitless measurement intended to trend results over time as the grease degrades. Water Index does not have alarms associated with it, but the Water measurements will indicate when water alarm thresholds have been exceeded.



OPTIONAL: Press << to view a graph of the spectrum similar to this example:



Spectral displays are primarily used by expert users to 'eyeball' different fluid signatures and confirm fluid identities look similar or not. The graph displays are low resolution and therefore not provided for further analysis.

In the above example, the graph starts at ~950 and measures out to ~4000 cm-1. This is the default spread for all spectral graphs, but users can zoom in on areas of particular interest. For example, follow these steps to zoom in on the peak in the region ~1200 - 1600 cm-1:

1. Press the Tab button to place the cursor in the WN From field, then use the direction pad on the FluidScan to change the WN From value to 1200.
2. Press Tab again to place the cursor in the WN To field, then use the direction pad on the FluidScan and change the WN To value to 1600.
3. Press Refresh to display the adjusted plot.
4. Press Back to return to the output screen.
5. Optional: the test result can be saved, but - as you are only interested in the condition of this particular sample at this particular point in time - there is little reason to do so.
6. Press Discard to return to the Main Menu.

4. Wear trending with Spectroil

Procedure for performing grease analysis on the Spectroil

Applicable for Spectroil M and Spectroil 120C

Running grease on the Spectroil is a little more time-intensive when it comes to prep of the sample, but the correct procedure will allow for repeatable results that fit within the normal calibration methods.

1	Start off by calibrating the Spectroil using the 0 ppm, 100ppm and 900 ppm oil standards. Note: Depending on the ppm concentrations of additive levels in the grease (which can be in the 3,000 ppm range or more), some customers may wish to extended their calibration range. That is okay, but the standard calibration range is a good place to start.
2	Just like running an oil sample, set up the rod and disk.
3	Place the grease slurry into a black high-temperature cap designed for the Spectroil.
4	Place the filled cap onto the cap holder and sit it inside the chamber.
5	Place the fuel cover over the disk to shield any flame that will occur due to the volatile solvent being used.
6	Properly gap the rod and disk.
7	Hit start to run the sample.
8	After each run is complete, wipe down the chamber and fuel cover with a Kimwipe and Simple Green, followed by P/N m99915 window cleaner. The chamber will be sootier then running an oil sample and it is very important to clean the chamber and sensors after each run. Due to the larger flame that occurs in the chamber, it is recommended to have a replacement rescue block in storage. The rescue block sits inside the chamber, below the disk and is easily replaced.
9	Solvent dilution prep method: After ensuring you have a representative sample of grease (per ASTM D7718), dilute 0.5 grams gram of grease in 10ml of heptane/toluene (50/50) solution and shake thoroughly. Use a small scintillation vial with a cap. Some thickeners will be tougher than others to completely dissolve, but most will dissolve by shaking vigorously by hand for a minute or two. Smear method: Where solvent is not available or on greases which do not dissolve, the smear method is used. Place a representative sample of grease, (agitated with a non metallic spatula to improve flowability) into a a black temperature cap. Using a rotrode disk holder (P-10688 cotton tipped applicator or spare rotrode axel) dip and rotate the disk manually in the grease filled cap to achieve a uniform coating of grease on the outer circumference. Place the smeared electrode into the chamber, using a kimwipe to help place, and avoid excess grease rubbing off other areas of chamber. Place a filled cap of CS75-500 base oil underneath the smeared disk and properly gap rod and disk as normal. It is not necessary to use a flame cover with this approach. Go to page 8. Note: Whichever method is chosen dilution or smear, it is important to be consistent with sample preparation for trending purposes. Different preparation techniques will yield different results.

Important data analysis notes:

- Applying a dilution factor is recommended. Make sure it is consistently used in the procedure to properly trend and detect abnormal wear modes.
- Fluorinated greases will not give accurate readings in the Spectroil. The numbers end up being much lower than actual. It is recommended to use an XRF for these greases.
- Always use the same preparation method when performing grease analysis. Different preparation methods will result in different results, making it difficult to trend.

Consumables parts needed (in addition to normal parts for Spectroil):

- Fuel Cover - M90204 (reusable)
- P-10688 - Cotton tipped applicator - 1000/box

References: 1) E. (2001, October). EPRI_Lubrication Guide 1003085. Retrieved from https://www.scribd.com/doc/128347108/EPRI-Lubrication-Guide-1003085 2) Williams, L. A., & Wurzbach, R. N. (2016). Managing the Health and High Costs of Robotics Using Grease Sampling and Analysis (Tech.). Hot Springs, VA: NLGI National Meeting. 3) Kowalik, G., & Janosky, R. (2017). Advancements in Grease Sampling and Analysis Using Simple Screening Techniques (Tech.). York, PA: MRG Labs. 4) Williams, L., Wurzbach, R., & Alarcon, J. (2016). Integrating Grease Sampling and Analysis into Wind Turbine Maintenance Programs (Tech.). Bilbao Spain: LUBMAT. 5) https://www.awea.org/wind-energy-facts-at-a-glance 6) McKenna, P., Subramanian, M., Berwyn, B., Kusnetz, N., Jr., J. H., Lavelle, M., . . . Spiegel, J. E. (2017, June 01). U.S. Wind Energy Installations Surge: A New Turbine Rises Every 2.4 Hours. Retrieved from https://insideclimatenews.org/news/03052017/wind-power-rising-clean-energy-jobs 7) Oil Analysis Handbook (3rd ed.). (2017). Chelmsford, MA: Spectro Scientific.

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