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LUBRICANT SELECTION

Multipurpose Does Not Mean All-Purpose



COVER STORY

Oil Analysis Interpretation for Gearboxes



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Publisher's Note



Just as with other mechanical components, oil analysis can help drive reliability and uptime in gear systems. This predictive maintenance technology is one of several available tools that can aid in identifying when failure-related symptoms begin to occur. When you monitor the condition of gear-related lubricants, it will be imperative to ensure they maintain the proper viscosity, sufficient film strength, corrosion control, demulsibility and chemical stability characteristics.

While it may seem overwhelming to identify which oil analysis tests to perform, information on this subject can often be obtained by contacting the OEM supplier, oil analysis lab, reviewing online reference sources and participating in technology-specific training.

For gearboxes, the standard test slate should include viscosity, moisture, elemental analysis, particle count, ferrous density, oxidation and/or acid number. Exception tests to perform when an oil or machine failure progression is suspected would involve analytical ferrography, extreme-pressure tests and oil characterization by Fourier-transform infrared (FTIR) spectroscopy. The exact

tests may vary based on the type of gear drive and lubrication method, but most applications will be closely related.

Mechanical seals are often integral parts of a component or system. If they are not considered when changes are made to the system, leaks, failure or downtime may occur.

Contamination, both from external and internal sources, is a significant issue with seals. Among the parameters associated with contamination to trend in your oil analysis reports would be the particle count number and the ISO cleanliness code. If your sample results return with continual increases in the particle count and low levels of ferrous material, this may lead to seal damage.

Although compatibility typically is only an issue when switching lubricants, it is another concern for seal life. Changing the base oil from mineral to synthetic while altering the additive packages that make up the lubricant can have a dramatic effect on the seals. When changing lubricants, consider not only the compatibility between the two lubricants but also how the new lubricant will react with the seal material. Swelling, erosion, blistering,

depolymerization and excessive wear are all possible failure mechanisms when seals and lubricants do not function in a cohesive environment.

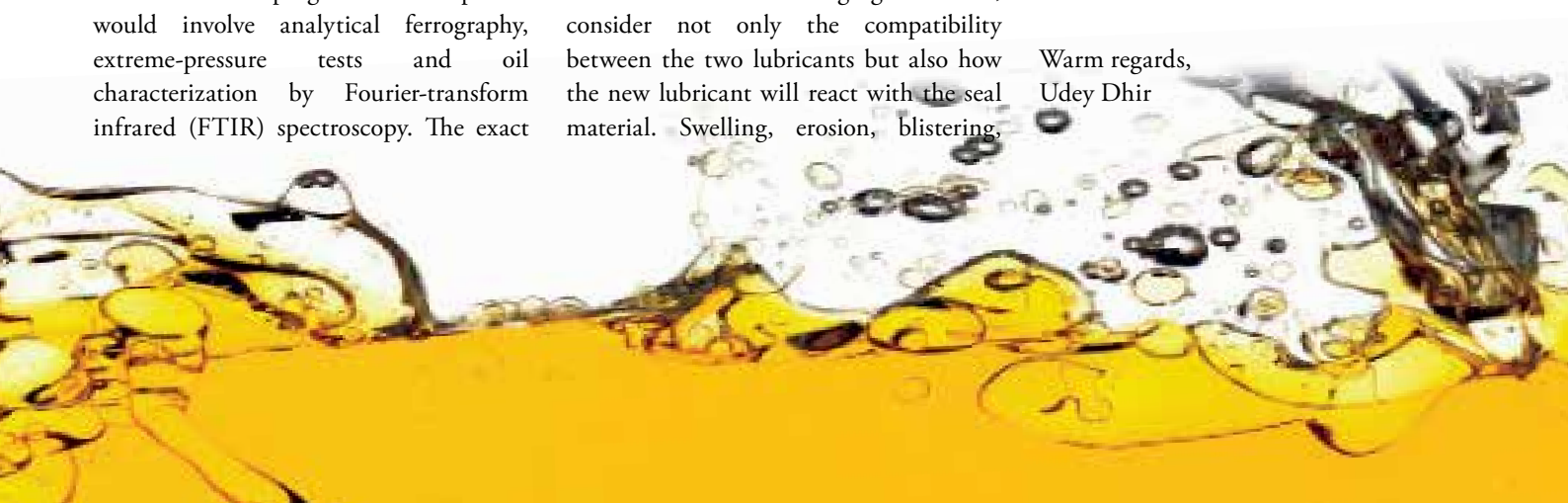
Finally, while not technically an oil analysis test parameter, temperature is another key aspect to account for with seals. As an oil's temperature begins to rise, it not only drastically affects the life of the oil but also impacts seal aging. Although temperature is a factor with almost all components, it is not quite as critical in low-speed gearboxes due to the minimized internal friction and churning

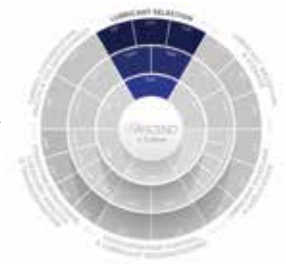
We propose to publish periodic articles on automotive lubricants from our next issue. We request the readers to contribute articles / case studies, which would benefit the readers.

As always, we welcome your feedback on how to further improve the content and presentation of our publication,

Stay safe and healthy,

Warm regards,
Udey Dhir





Multipurpose Does Not Mean All-Purpose

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The term “consolidation” is very popular — especially when it comes to reducing the number of lubricants in an industrial facility. The thought is we can mitigate risks of accidentally using the wrong fluid by reducing the total number in storage. It’s also possible to enhance our purchasing power by purchasing more of a specific lubricant than many obscure ones. Even more appealing is reducing the inventory levels of unique, one-off lubricants that may only be used in a very specific application. This process is underway at countless plants across the planet at any moment, some headed by a task force of plant personnel, others with the aid of outside consultants and lubricant suppliers. While consolidation efforts are necessary to save money and reduce accidents, grease is often the focus of overzealous consolidation.

Most facilities look intimately



at each oil-filled component to ensure the selected lubricant can meet the demands of the equipment and still be properly lubricated. Meanwhile, greased components are rarely scrutinized, and grease consolidation is done heavy-handedly, often resulting in sub-optimum lubrication for many critical components. While a plant may be satisfied with an overall oil product reduction from 25 down to 15, we often find the

same plant is not satisfied with grease consolidation until only two to five greases remain. Oils are uniquely formulated to handle certain stresses in operation from either the machine or the environment, so too are greases. It is generally understood that a machine operating in harsh environments may get a more premium formulated oil or even a synthetic option. We take that same machine and look at greases

in use, and they are often a mismatch for those situations.

Some of this issue comes from grease's dubious reputation as many do not know what it is made of or even how it operates. We know that greases are formulated with specific applications in mind and are made from the same base oil and additives as lubricating oils, but many purchasers fall prey to the allure of the "multipurpose" grease. Once that label is applied to a grease product, some take it as a seal of approval for the grease to be used virtually everywhere.

This could not be further from the truth.

To understand how the term "multipurpose" was introduced and why it is so prevalent in grease nomenclature, we need to understand how greases are specified and tested. The de facto authority in grease is the National Lubricating Grease Institute (NLGI), a membership group comprised of lubricant manufacturers, researchers, consultants and end-users. This group is a working group that helps create standards as well as share technical information among its members. As such, the NLGI was instrumental in the creation of a grease standard for automotive greases known as ASTM D 4950, which outlined the performance characteristics and specifications for greases used for chassis and wheel bearing applications.

These greases were denoted by a series of letters that corresponded with their degree of service. The prefix "L" was chosen for chassis applications, while "G" was chosen for wheel bearings. These were further characterized by a second letter that coincides with the severity of service. For chassis, LA means light-duty, LB for severe duty and then a similar scale for wheel bearings of GA through GC. There are a series of performance criteria that must be

met by the grease in order to achieve these ratings, but early on, it became apparent that a single grease might be able to perform well in both applications and thus pass the specification and testing for both chassis and wheel bearings. Hence these greases became marketed and known as "multipurpose" grease and bore the dual certification GC-LB. This nomenclature stuck, and now if you simply do an internet search for multipurpose grease, you will be awash in results from multiple outlets wanting you to purchase their product. It's important to note that the term "multipurpose" does not have a formalized definition, so this is largely marketing and a common term used to define a grease that may work in multiple applications.

We think back to our consolidation task force that is sitting in a conference room pouring over lubricant technical data sheets and machine manuals to determine the best lubricant to use in their machine, and they come across a grease that is listed as multipurpose. This is viewed as a godsend as it falls in line with what we are hoping to do — find a lubricant that will perform well in multiple applications without sacrificing the health of the machine. Looking at the equipment manuals, all they recommend is to use an NLGI 2 Lithium grease, so surely this multipurpose grease will work fine. Unfortunately, without an industry standard, these greases can vary widely in their performance as well as their chemical and physical properties.

"Multipurpose" has become such a normal descriptor for grease that it has further confounded the issue of over-consolidation. Looking through just three different lubricant manufacturers' product catalogs yielded over a dozen products using the term "multipurpose" in the description of the grease. When compared to each

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other, there were a variety of different thickeners used, a wide range of base oils and varying additive loads. Many were lithium or lithium complex thickened greases, but some were aluminum complex and even polyurea. The base oil viscosity ranged from the low end of an ISO 100 all the way up to an ISO 460. Some had solid additives such as molybdenum, while others were more formulated to resist water-washing. So, selecting a grease based solely on a marketing term could have disastrous effects on our equipment.

Simply looking at the viscosities of the greases is enough to be concerned about. What is typical in an industrial plant is for the same lubricant to be used in most greased bearings regardless of load, speed or environment. This means the overhung fan operating at over 1,000 RPM will be getting the same grease as the conveyor bearing operating at 100 RPM. Selecting a multipurpose grease will undoubtedly lead to a less-than-optimum lubricating film in many cases. So, we need to become more diligent in specifying what grease to use in each application. While this may require the use of more greases onsite, the equipment will be more reliable and operate with a higher degree of efficiency. Often, greases are over-consolidated because of a people problem, not a lubricant problem. There are ways to avoid the cross-contamination of greases, and most of them center around the training of your lubrication team. We also need to have a more technical specification for the greases we are going to use, rather than generic terms that allow purchasing to drift away from our original product.

Writing a grease specification should consider all the unique aspects of the grease to ensure if our supplier changes, we can still get the same level of performance

from the next lubricant. Some items to consider in your grease spec for each piece of equipment are:

- NLGI Grade
- Thickener Type
- Base Oil Type
- Base Oil Viscosity
- Dropping Point
- Water-Wash Resistance
- EP Characteristics
- Oxidation Stability
- Pumpability
- Rust Protection

Other properties unique to the application should be considered in addition to this list.

The NLGI is also working on expanding the specification and getting a standard in place that can begin to address the deficiencies in this area. The new standard will attempt to break down this category into more distinct grease formulations to handle more stressful applications such as high water, load, saltwater and prolonged life. These future classifications will be more granular and allow for a tighter tolerance than what is currently the market norm.

While there are options available to reduce the number of greases in use, careful thought and consideration should be employed to avoid the over-consolidation and subsequent sub-optimum lubrication for these grease-lubricated components. After all, not all greases are the same, regardless of what the description may lead you to believe. **ML**



About the Author

Wes Cash is the Vice President of Services for Noria Corporation. He serves as a senior technical consultant for Lubrication Program Development projects and as a senior instructor for Noria's Oil Analysis

New NLGI Certifications Eliminate Confusion

The NLGI (National Lubricating Grease Institute) has seen the need for updated grease specifications and are currently building these specifications, complete with performance testing criteria. While the traditional wheel bearing and chasis certifications will persist, new certifications will be created in order to further segment greases, breaking down the "one-size-fits-all" approach.

High-Performance Multiuse Grease (HPM) is the first of these new certifications. It serves as a core specification and has additional performance tags to further designate a specific grease application. These tags include water resistance (HPM+WR), salt-water corrosion resistance (HPM+CR), high load (HPM+HL), and low temperature (HPM+LT). There is no limit to the tags a grease may have, so it is possible for a formulation to achieve multiple tags based upon its performance in testing.

This is certainly a great step forward and helps to ensure that the lubricant selected is correct for the application, bringing grease certifications into the modern age. For more information on these certifications, specifications, and testing you can visit the NLGI website here:

<https://www.nlgi.org/about-us/high-performance-multiuse-grease/>

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Oil Analysis Interpretation for Gearboxes

Jesus Teran Dagnino | Sumitomo Drive Technologies

“ In order to prevent costly downtime or catastrophic failure of a gearbox, the industry has evolved to adopt condition monitoring as a mechanism for predictive maintenance. ”



Speed reducers, commonly referred to as “gearboxes”, are used in a variety of applications. Each application exposes the gearboxes to an array of loading and ambient conditions that directly affect the usable life. In order to prevent costly downtime or catastrophic failure of a gearbox, the industry has evolved to adopt condition monitoring as a mechanism for predictive maintenance.

Condition monitoring provides both historical and current performance data on the gearbox condition, thus providing a likely inference regarding the gearbox’s remaining useful life (RUL). Condition monitoring can guide predictive maintenance activities.

There are several techniques that can provide a status of how the gearbox is performing. These techniques include temperature, vibration, noise and used oil analysis. While all techniques can be considered useful when checking the condition of a gearbox, one thing is certain for all techniques: it is all about trending.



This article will explain how used oil analysis can help determine the condition of a gearbox by learning the most important factors for used oil analysis, how to interpret the results of a used oil analysis report and how trending can help determine the schedule for preventive maintenance actions.

Considerations before Oil Analysis

Used oil analysis is a broad subject that includes several factors that affect the success of both interpretation and trending of used oil analysis results. While

each factor can be broadly described when analyzed in depth, a summary is provided to emphasize the importance of each factor.

1. Baseline oil sample

The first step to successfully trend the oil condition is to take a sample of the oil in an unused condition. This step is usually overlooked, and its significance comes from the fact that the user is able to establish a baseline of all the elements present in the oil in an unused condition. It can also help the user identify



Figure 1: Oil sampling on in-line gearbox.

poor oil storage practices by checking if contaminants such as water are present.

Certain elements can either be additives, contaminants or wear debris. Having a sample of new oil helps differentiate between additives and contaminants. It aids in trending the depletion of additives, oxidation and changes in oil viscosity as the oil ages.

Oil manufacturers can be consulted to clarify if the elements present are part of a lubricating oil formulation or if they are a result of contamination or debris.

2. Sampling location

Critical to the analysis of oil condition is the consistency in both time and location that the data is collected (Figure 1). Due to economic and resource variables, it is also important to focus on assets that are considered critical to the user's operation. Location of oil sampling, e.g., the gearbox's sump, will yield statistically significant gauge that is repeatable and reproducible. Deviating from consistently sampling oil from the same point and operating conditions may result in discrepant data, and/or the data will be more difficult to trend.

3. Oil sample intervals

It is imperative that the oil is sampled at regularly scheduled intervals. This will



Figure 2: Sampling by the reduction component's oil level ensures a turbulent flow for a representative oil sample.

allow consistent trending of the used oil sample results among multiple similar gearboxes, leading to more effective corrective actions.

Oil change intervals are usually established by OEMs. It may be possible to extend both used oil samples and oil change intervals depending on the application. However, care should be taken when doing so since the equipment may be damaged and/or machinery warranties may be voided. Maintenance professionals should be familiar with both gearbox condition and application before making this decision.

4. Representative used oil sample

It is best to take a used oil sample while the unit is running during normal operating conditions after the unit has reached thermal stability where the oil has turbulent flow (Figure 2). Strict adherence to all safety guidelines should be followed when taking oil samples from any equipment in operation. Should it not be safe to do so, the oil sample should be taken immediately after the gearbox is shut down. Taking a used oil sample once the unit has cooled down or has been shut down for an extended period of time will not provide a representative sample, as contaminants will collect at the bottom of the sump. Also, when taking samples on sections where oil has a laminar (smooth) flow, the contaminants or wear particles shown in the oil analysis result may not be representative.

Recommended oil tests for gearboxes and interpretation

The following tests are useful to determine the condition of a gearbox, as well as understanding how the oil is affected by both the operation of the unit and application, including environmental conditions.

Viscosity

Description: Viscosity tests "indicate fluid's resistance to flow at a given temperature," usually measured and reported at 104°F (40°C). The units of measurement are reported in centistokes (cSt).

Interpretation: The viscosity of the oil is prone to change due to wear and chemical reactions. The results of other tests can be helpful to determine what happened with the oil during operation. As an example, an increase in oxidation trending levels could serve as a symptom that explains how the oil viscosity increased in the system. The possible causes of changes in oil viscosity are the following:

- **Increased Viscosity:** Oxidation, thermal failure, water contamination and wrong oil.
- **Decreased Viscosity:** VI improver (additive) shear-down, base oil shear-down, base oil cracking and wrong oil.

ISO VG	MID-POINT VISCOSITY cSt @ 40°C	KINEMATIC VISCOSITY LIMIT cSt @ 40°C	
		Lower	Upper
100	100	90	110
150	150	135	165
220	220	198	242
320	320	288	352
460	460	414	506

Table 1: Viscosity Grades based on ISO 3448.

The Viscosity Analysis can help to determine if both the baseline and used oil are within specifications. For example, assuming that we have a gearbox that uses a lubricating oil with a viscosity of 220 cSt, the expectation is that the viscosity test result for that particular oil is within a 5% range of 220 cSt. As a reference, the most common designations according to ISO Standard 3448 are listed in Table 1. They are a good reference to compare the oil viscosity with the product we should be using for a particular gearbox, even though this reference applies to new oil only.

Oxidation

Description: “Signals the deterioration of the oil due to thermal breakdown and aging causing a physical change in the oil.” Reported in absorbance per centimeter (Abs/cm), oxidation prevents additives from performing properly, promotes the formation of acids and increases viscosity.

Interpretation: While oxidation is a slow process that gradually degrades lubricating oils, it is known that the following factors influence the acceleration of oxidation:

- Temperature.
- The amount of oxygen in the environment.
- Water contamination.
- Metals (particularly copper and iron, which are usually wear metals) and organic and mineral acids that promote oxidation.³

Water content and wear metals directly affect oxidation, and can also be tested during used oil analysis, so it is helpful to relate these three tests while analyzing used oil results.

In general, “for each 10 °C (18 °F) rise in temperature, the oxidation rate will double.” That being said, for high ambient temperature applications, applications that involve corrosive gases and high humidity and dusty environments, it is important to look at the rate at which oil oxidizes — these applications can be considered aggressive for lubricating oils.

Category	Element	Class	Comments
Wear Metals	Iron	W,C	Usually found on reduction components and bearings.
	Chromium	W	Mostly found in bearings but can also be found on gearboxes with Cycloidal reduction components. Care should be taken when iron increases at a similar ratio as Chromium.
	Nickel	W	Found in reduction components in very small quantities.
	Aluminum	W,C	Found in greases as a thickener. Mostly considered a contaminant.
	Copper	W,C,A	Usually found on bearing cages. Contact Oil Manufacturer to ask if it's part of the additive package and/or compare with virgin oil analysis.
	Lead	W	Considered a hazardous material. Not commonly found on gearboxes or lubricants.
	Tin	W	Unlikely to be found gearboxes.
	Cadmium	W	Unlikely to be found gearboxes.
	Silver	W	Unlikely to be found gearboxes.
	Vanadium	W	Unlikely to be found gearboxes.
Contaminant Metals	Silicon	C,A	Considered mostly as a contaminant. Even if found in very small quantities in reduction components, it is not considered as wear metal. Contact Oil Manufacturer to ask if it's part of the additive package and/or compare with virgin oil analysis.
	Sodium	C,A	Found in greases as thickener. Contact Oil Manufacturer to ask if it's part of additive package and/or compare with virgin oil analysis.
	Potassium	C	-
Multi-source Metals	Lithium	C	Found in greases as a thickener.
	Boron	C, A	Contact Oil Manufacturer to ask if it's part of the additive package and/or compare with virgin oil analysis.
	Titanium	W	Unlikely to be found in gearboxes.
	Molybdenum	A	Not considered as wear metal even if it can be found in reduction components in very small quantities. Contact Oil Manufacturer to ask if it's part of the additive package and/or compare with virgin oil analysis.
	Antimony	W	Unlikely to be found in gearboxes.
	Manganese	W	Found in reduction components in very small quantities.
Additive Metals	Magnesium	A	-
	Calcium	C,A	Found in greases as a thickener. Contact Oil Manufacturer to ask if it's part of the additive package and/or compare with virgin oil analysis.
	Barium	A	-
	Phosphorus	A	Considered mostly as additive. Found in reduction components in very small quantities.
	Zinc	A	-

Classification: **W** = Wear, **C** = Contaminant, **A** = Additive

Table 2: Common elements reported during used oil analysis.

This would help schedule oil changes in predictive maintenance.

Acid Number (AN)

Description: “Measures the oil’s acidity representing a change in the oil. Indicates degradation of the oil in service leading to deposit formation.” “Reported in milligrams of potassium hydroxide per gram of test oil neutralized (mg KOH/g).”

Interpretation: In the baseline oil analysis result, it is likely to have a high initial AN value due to additives being slightly acidic. The AN will decline during operation as the additives are being depleted. But once the AN of used oil is higher than the baseline oil value, oil degradation has occurred. An AN above 4.0 means that the oil is “highly corrosive, risking an attack on metal surfaces.”

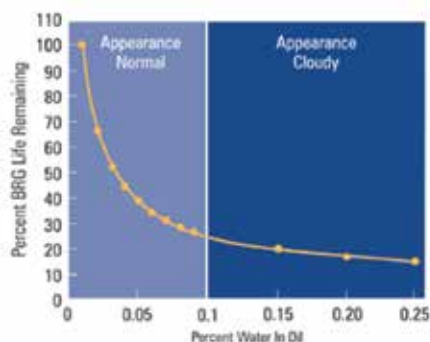


Figure 3: Percentage of Bearing Life Remaining VS Percentage of Water in Oil

Also, testing for oxidation may be difficult for some synthetic lubricants because of infrared band interferences in some components; in these cases, Acid Number (AN) may be a more appropriate test.

Water Content

Description: “Determines the amount of water contamination — reported in percentage (%) or parts per million (ppm).” One percent of water equals 10,000 ppm.

Interpretation: Minimizing water contamination is critical to the life of the gearbox. AGMA recommends having a maximum limit of 300 ppm (0.03%) of water contamination. If this value is compared to the remaining useful life of a bearing, as shown in Figure 3, this would mean that the life of a bearing is reduced to half of its useful life. Therefore, it is important to keep track of water contamination, especially in applications with high humidity or wide ambient temperature ranges that may result in water condensation.

Particle Quantifier Index (PQ)

Description: “Measures the mass of ferromagnetic wear particles/debris in the oil irrespective of the size of the ferrous particles.” “Particle Quantifier (Ferrous Density) exposes a lubricant to a magnetic field. The presence of any ferrous metal causes a distortion in the field, that is represented as the PQ Index.”

Interpretation: “Although PQ does not provide a ratio of small to large ferrous



Figure 4: Gearbox on chain conveyor application.

particles, if the PQ Index is smaller than iron parts per million (ppm) by Inductively Coupled Plasma (ICP), it is unlikely there are any particles larger than 10 microns present. If the PQ Index increases dramatically while the iron ppm remains consistent or goes down, larger ferrous particles are being generated.” This means that there is a possible internal failure for the unit, such as broken reduction components.

Elemental Analysis by ICP

Description: Provides elemental metal analysis of up to 24 metals in the oil representing wear metals, additive metals and contaminant metals. Measures metals less than 10 μm in size and results are reported in ppm. The most common elements to be found on an oil analysis report are listed in Table 2.

Interpretation during trending: When compared to the baseline oil analysis, this can provide insight into either wear particles or contaminants in the oil. For example, during the break-in of a gearbox, the reduction components start to wear by removing asperities that are the result of a machining and heat treatment processes. These worn asperities will affect the oil analysis result by increasing the iron particle count. This is common for most reduction components. When it comes to cycloidal reduction components, both iron and chrome ppm increase at a similar

ratio since the material used on cycloidal reduction components differs from conventional gearing.

It is important to be familiar with the elements present in both gearboxes and lubricants; doing so can help identify elements present in the oil in an unused state and which components are being worn out during the operation of the gearbox, allowing the necessary action to stop wear or replace potentially damaged components to be taken.

Case study: Chain Conveyor

The gearbox in Figure 4 has been operating on a chain conveyor for around 10 years. The load depends on the type of product that is being handled (moderate to high shock load) and operates continuously for 24 hours, six days a week, with no starts and stops during operation.

The oil analysis results are shown in Figure 5. The following characteristics were monitored during oil analysis:

- Viscosity.
- Oxidation.
- Water content.
- Particle Quantifier Index.
- Elemental Analysis.

This case study excludes baseline data, and a target of 100ppm of iron was set by the end-user.

Regarding oil viscosity, it can be observed that the viscosity increased from around 150 cSt to 220 cSt. The trend can be observed in Figure 6. The reason is that the manufacturer’s recommendation is to use an approved oil with a 150 cSt viscosity. However, an unapproved 150 cSt viscosity oil was being used. After consulting with a lubricant specialist, it was decided to schedule an oil change and replace it with a 220 cSt viscosity oil, even though the oil used was not approved by the manufacturer.

It is important to point out that in this case, there is historical data in both oil analysis and application that backed the use of an unapproved oil, and with the help of a lubrication specialist, it was possible to find the right oil properties and viscosity to properly lubricate the gearbox. Even though a solution was found, it is a best practice to follow the manufacturer’s recommendation.

While using an unapproved 150 cSt oil, it can be observed that ferrous wear increased while having a low count on contaminants. This can be shown in both elemental analysis wear trend (Figure 7), contaminants trend (Figure 8) and particle quantifier index.

An increase in the iron count can be considered normal. It is the nature of a gearbox to transmit torque by the interaction between reduction components and variable loads can increase the possibility of

	Sampled	08 Feb 2011	17 Sep 2012	21 Sep 2015	28 Sep 2016	21 Aug 2017
	Reported	12 Feb 2011	20 Sep 2012	06 Oct 2015	07 Oct 2016	30 Aug 2017
	Contamination Rating	Normal	Normal	Normal	Normal	Normal
	Equipment Rating	Normal	Normal	Normal	Normal	Normal
	Oil Rating	ALERT	ALERT	Normal	Normal	Normal
Lubricant	Diluted ISO Code (4/6/14)					24/24/20
	Particle Count (Diluted) >4um					159411
	Particle Count (Diluted) >6um					117932
	Particle Count (Diluted) >14um					6415
	ISO Code (4/6/14)	21/19/16	22/20/15	22/21/19	22/21/18	
	Particle Count >4um	13296	22003	25845	28641	
	Particle Count >6um	3807	6649	18136	18317	
	Particle Count >14um	537	276	3164	1487	
	PQ Index	0	40	11	22	77
	Visc @40C (cSt)	136.7	158.6	205.8	210.6	219.3
	Oxidation (Ab/cm)	2	4	1	0	
	TAN (mg KOH/g)					0.83
	Water (Vol%)	0.013	0.018	0.007	<0.003	<0.003
ICP Wear Debris (ppm)	Al (Aluminum)	0	0	0	0	0
	Cr (Chromium)	0	1	0	0	0
	Cu (Copper)	6	0	0	0	0
	Fe (Iron)	35	135	45	57	96
	Mo (Molybdenum)	0	0	0	0	0
	Ni (Nickel)	0	0	0	0	0
	Pb (Lead)	0	0	0	0	0
	Sn (Tin)	0	0	2	0	1
ICP Contaminants (ppm)	K (Potassium)	0	1	0	0	0
	Na (Sodium)	3	6	1	0	0
	Si (Silicon)	1	4	8	6	17
ICP Additives (ppm)	B (Boron)	2	3	2	3	1
	Ba (Barium)	6	17	0	0	0
	Ca (Calcium)	39	23	0	0	1
	Mg (Magnesium)	2	0	0	0	0
	P (Phosphorus)	362	229	316	317	403
	Zn (Zinc)	344	8	2	1	1

Figure 5: Used oil analysis results for chain conveyor gearbox.

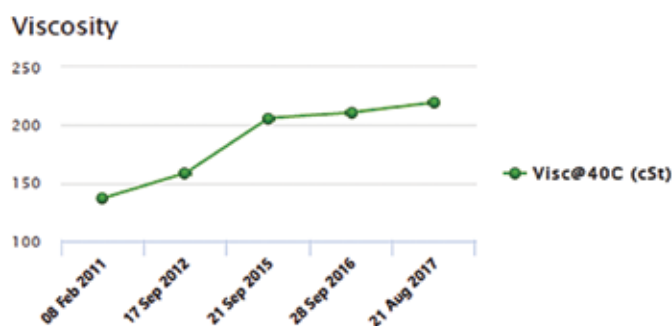


Figure 6: Viscosity trend from used oil analysis results.

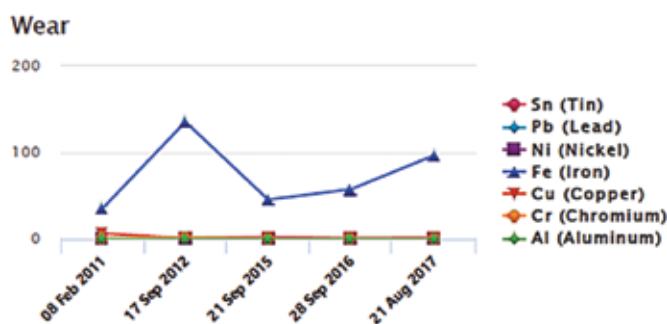


Figure 7: Wear trend from used oil analysis results.

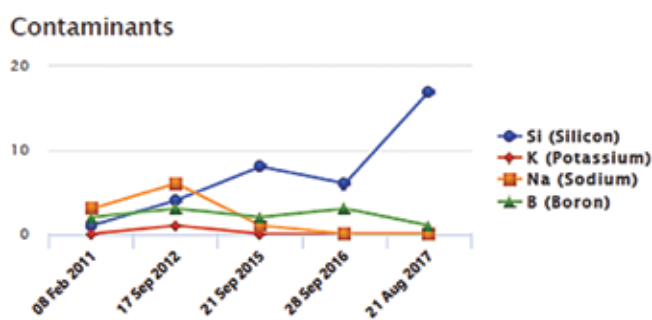


Figure 8: Contaminants trend from used oil analysis results.

having metal-to-metal contact, resulting in wear. However, in this case, the ferrous wear exceeded the wear limit set by end-user in one year, which can be considered as an abnormal increase of wear and resulted in scheduling oil change.

As both iron count and particle quantifier had increased, it is likely that reduction components are being worn out. Once the viscosity was increased to 220 cSt, the rate at which ferrous wear was generated was reduced by more than half, or in other words, the ferrous wear limit did not exceed the limit of 100 ppm in two years.

If both wear and contaminant trends are analyzed, it can be concluded that once the viscosity changed, the wear was generated as a result of contamination and less likely to be due to poor lubrication.

Both water content and oxidation affect the performance of the lubricant. Once these two characteristics are analyzed, it makes sense that ferrous wear was increased while using the unapproved 150 cSt oil.

As a conclusion, poor lubricant performance affected by oxidation and water and use of an unapproved 150 cSt oil resulted in increased ferrous wear, even when the

contaminant count was considered low compared to the rest of the trend. After consulting with a lubrication specialist and analyzing the data collected from condition monitoring and the application, the viscosity was increased, which resulted in cutting the ferrous wear rate by more than half and ensured proper lubrication for the gearbox.

Conclusion

It is important to always compare the latest used oil analysis result with the new oil and previous used oil analysis results. The key to trending is knowledge of the gearbox, lubricant, application and environmental conditions, and how these interactions affect the condition of the lubricant and gearbox.

Unexpected downtime and gearbox replacement can be both costly and affect the operation of the facility. As a countermeasure, knowing and understanding used oil analysis for condition monitoring can be cost-effective, as this practice can help extend the useful life of both lubricant and gearbox through predictive maintenance. Note that the value of used oil analysis comes from taking action. It is important to take action every time an issue is identified during used oil analysis, whether that action involves changing the oil or overhauling a gearbox.

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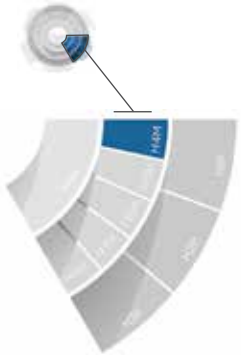
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How to Streamline Lubrication Tasks

The phrase “lubrication tasks” is a broad term encompassing a vast array of tasks, including inspections, monitoring and relubrication. The number of steps required for each task will vary, and some tasks will take longer than others. This article discusses some common lubrication program inefficiencies and ways to correct them. Additionally, we’ll look at some helpful tips you can use to organize and implement tasks, allowing you to schedule and complete them in an efficient, streamlined manner.

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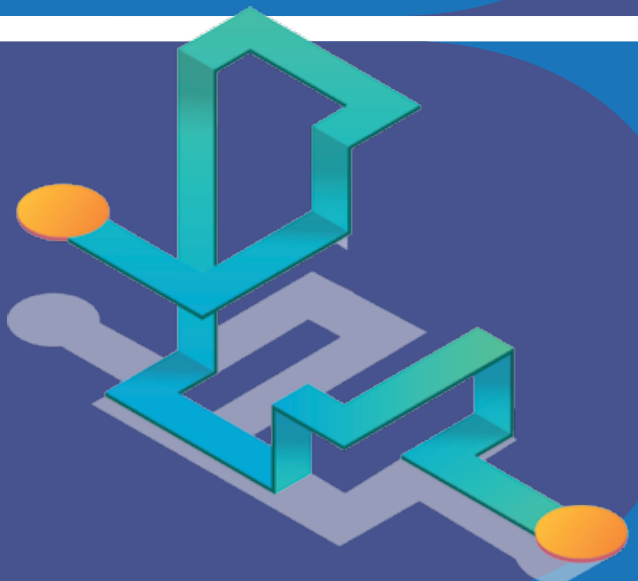
INVEST IN THE RIGHT SOFTWARE

Your operations may implement Computerized Maintenance Management Systems (CMMS). While these systems track man-hours and system maintenance, they don't accurately track lubrication tasks, typically omitting factors such as the time needed to travel between the lube room and equipment and the time required to gather supplies. Routing software like LubePM does account for this time and adapts lubrication tasks accordingly. Once the necessary data, including task times, are entered into LubePM, the software accurately estimates the number of man-hours required. Understanding the time requirements for each task helps you better plan your approach to lubrication.



SIMPLIFY YOUR ROUTING

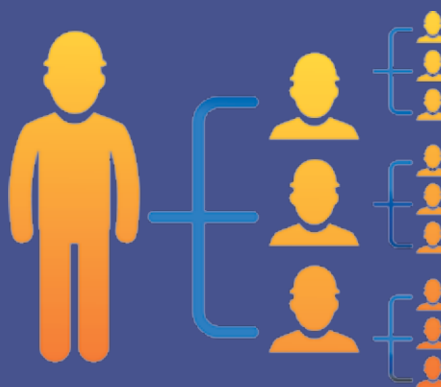
Before you go about tackling the work of lubrication tasks, you should determine the most efficient order in which to complete them. Routing should be approached like a game of baseball: you must go from first base to second; you wouldn't run directly to third base. Similarly, you shouldn't grab your lube cart and go to the machines furthest from the lube room, back to the machines closest to the lube room, and then to the machines in the middle. Developing and optimizing a lube route saves time and increases efficiency.



Once your lubrication tasks are organized and streamlined, things get a lot smoother for everyone involved. Implementing best practices increases machine efficiency and service life and ensures that your maintenance staff members have the tools they need to handle the tasks presented to them.

RAMP UP YOUR TRAINING PROGRAM

Operators and maintenance personnel who know what they're doing (and why they're doing it) are able to perform tasks efficiently and quickly. Untrained personnel, when tasked with a new or complex procedure, can be intimidated by their lack of understanding. They may be hesitant to approach the procedure, and when they do get to it, they will likely spend a good chunk of time trying to make sure they're doing things correctly. Properly trained staff, on the other hand, can approach procedures with confidence. Even when tasked with new procedures, the base knowledge possessed by properly trained staff can likely be applied.



About the Author

Paul Farless is an industrial service technician for Noria Corporation. His duties include collecting data and preparing reports for the engineering team. Prior to joining Noria, Paul worked as an automotive maintenance technician for an auto-repair service company. He also served four years in the U.S. Navy as a gunner's mate third-class petty officer and as a seaman deckhand, where he was responsible for the troubleshooting and maintenance of electromechanical and hydraulic systems. A detail-oriented team player, Paul works well in fast-paced environments and uses his military background to excel and maximize efficiency.

DESIGNATE A LUBRICATION CHAMPION

Clearly defining one person as the lubrication champion significantly reduces the likelihood of a project failure. The lubrication champion is responsible for overseeing all the aspects of lubrication procedures, including tasks and people. A good lubrication champion adroitly streamlines lubrication tasks by identifying objectives, prioritizing project phases, implementing best practices, identifying and eliminating obstacles, allocating resources and communicating with other departments. Your lubrication champion should be properly trained and have a strong knowledge of tribology and lubrication. Additionally, they should be highly motivated individuals with a knack for problem-solving and the ability to communicate well with others.





Complete Guide to Lubricant Deposit Characterization

“ One tends to look at the color of a deposit and assume that, since it is brown, it must be the same as the brown sample previously observed.”



The current practice for the users of industrial lubricants has been to assume that all deposits or varnishes are created equal. One tends to look at the color of a deposit and assume that, since it is brown, it must be the same as the brown sample previously observed. This assumption can be far from correct and can lead to taking the wrong corrective actions. There are many chemistry types in varnish materials.

When one thinks of sludge or varnish, the concept needs to be broadened. This material is not simply the oxidation or degradation products from the lubricant — more generally, it is the material coming out of the fluid with the potential to cause operational issues. Equipment reliability issues are not only caused by fluid degradation and varnish deposits but by any material that is not a homogenous single phase with the lubricant. Therefore, any foreign material causing deposits in the lubricant can potentially be defined in this



category.

Deposit Characterization Process

The characterization of deposits becomes the path toward the root cause of its formation. There are a wide variety of testing technologies available for determining the chemistry of the deposits. However, it is sometimes challenging for operational plants to obtain samples of deposits to allow for these analyses. It is

much easier to get a sample of the in-service lubricant. In this case, the first step is separating the oil degradation products believed to be responsible for generating the deposits from in-service oil samples. The separation step developed can be accomplished physically, mechanically or chemically.

The next step is to determine the organic and inorganic composition of the deposit. Two useful tests for analyzing the

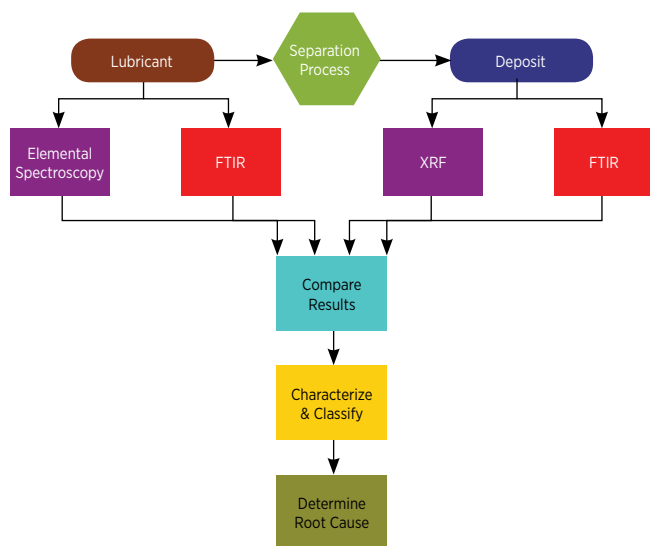


Figure 1: Root Cause Determination Process

lubricant are elemental spectroscopy and Fourier Transform Infrared spectroscopy (FTIR). Common deposit characterization tests used in these studies are FTIR and X-ray Florescence spectroscopy (XRF). These results are then compared to provide a chemical characterization of the deposit, as well as allow for a possible root cause, to be determined. These steps are presented in Fig. 1.

Lubricant Degradation & Deposit Formation

There are many sources of lubricant degradation that often lead to deposits. Some of these include:

- Oxidation
- Thermal Degradation
- Micro-Dieseling
- Spark Discharge
- Extreme Temperature Zones
- Combustion
- Ultraviolet Degradation
- Contamination
- Incompatible Lube Or Other Liquid
- Dirt And Hard Particles
- Water
- Gas
- Additive Reaction By-Products

Once a fluid has undergone degradation or been exposed to contamination or initiation

failure, there are several factors to determine the lubricant's propensity to develop deposits. The formulation can play a large role in this. Engine crankcase formulations contain dispersants to suspend or solubilize soot and other degradation products in the fluid. The base stock of the lubricant also contributes to its solvency and the fluid's deposit control abilities. Mineral oils have lower solvency, and synthetic API Group V fluids have higher solvency.

In addition to lubricant formulation, two other variables that determine deposit formation are temperature and pressure. These factors are particularly relevant when the degradation products are soluble and easily transition in and out of a solution. Lower temperatures will decrease a fluid's solvency, causing some types of degradation by-products to precipitate, forming deposits. Pressure can also drive these contaminants out of solution, explaining one of the reasons why it is common to see deposits in journal and thrust bearings.

Deposit Classification Bins

There are many mechanisms that degrade lubricants and an even higher number of different chemistries found in lubricant deposits. The virtually limitless number of deposit chemistries can, however, be

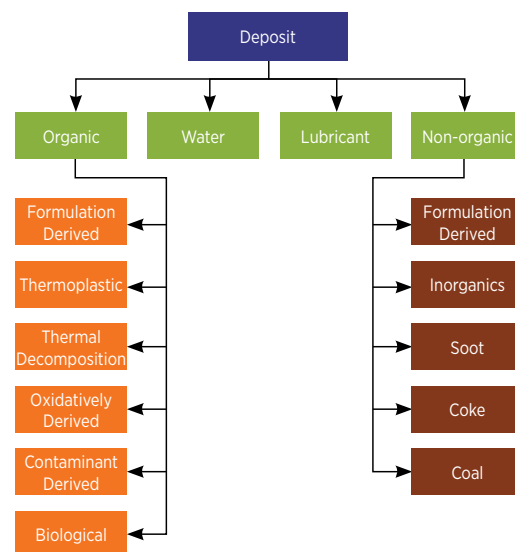


Figure 2: Deposits Classifications

classified by their physical characteristics and the source of their formation. Sorting deposits into classification bins is beneficial to better understand the source of the deposits and determine appropriate remediation efforts. This article suggests some nomenclature and definitions for these Deposit Classification Bins, as shown in Fig 2.

These bins can first be defined as Level 1 in broad terms based on their chemistry, as illustrated in Fig. 3.

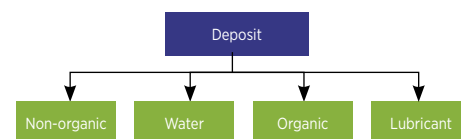


Figure 3: Level 1 Deposit Classification Bins

Better understanding the composition of the deposit allows further classifications based on the deposit formation source. The most basic chemistry difference is whether the deposit is organic or non-organic.

Non-organic deposits can be defined as those deposits that are insoluble in highly polar organic solvents and contain no carbon-hydrogen spectral features.

Organic deposits can be defined as material

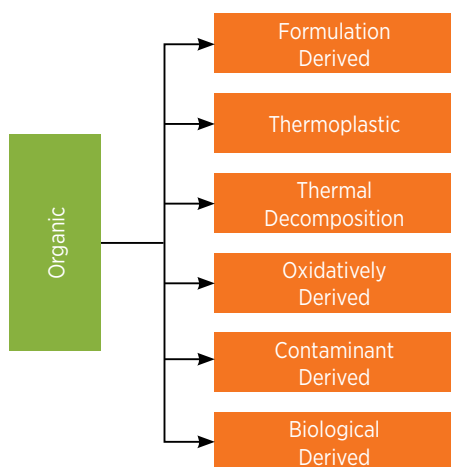


Figure 4: Level 2 - Organic Deposit Classifications

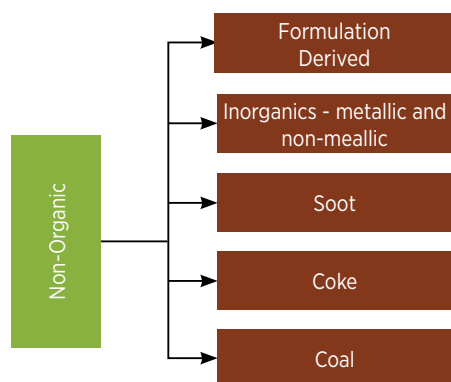


Figure 5: Level 2 - Classifications of Non-Organic Deposits

that contains carbon-hydrogen bonds (CH₂ and CH₃), is primarily insoluble in hydrocarbon solvents (which makes it a deposit) and is often soluble in polar organic solvents.

Water content is also found in many deposits. Although water is potential sediment itself, more often it is part of the deposit. It often determines the consistency and tenacity of a deposit. It is common to find moisture in deposits when they are first generated, allowing the deposits to be easily wiped off. These types of deposits are often referred to as sludge; however, they don't necessarily contain the chemistry to make them actual sludge. Over time, these deposits may dehydrate and cure onto metal surfaces, becoming difficult to remove mechanically. These deposits are

often referred to as varnish.

In contrast, sludge deposits have been shown to be those containing metal salts of carboxylic acids.

When these deposits are dried, they become powders. They physically differ from varnish in that they are always soft deposits. These deposits are classified as oxidatively derived-organic deposits with inorganic parts.

Deposits that fall into the Lubricant Bin are those components that are part of the oil formulation. Occasionally, one may find an additive component that has come out of a solution from the lubricant and deposited itself in the system. Improper blending or additive incompatibility is a prime cause of this type of deposit. Incompatibilities between two lubricant formulations can also cause one or more of the additive formulations to come out of the solution to form a deposit.

Further categorization of the deposits into Level 2 Classification set of Bins is also possible, allowing one to group by the sources of deposit formation.

Organic Deposits

Organic deposits are often soluble in the in-service lubricant, allowing them to transition in and out of the solution depending upon the environment. These deposits are often referred to as "soft contaminants." Organic deposits can be further divided into formulation derived, thermoplastic, thermal decomposition, oxidatively derived and contaminant derived sub-categories. This Level 2 Classification is illustrated in Fig. 4.

Formulation Derived

Many additive components may contribute to deposits either after they have reacted or due to dropping out of the solution in an unreacted state. It is common to see reaction products from sacrificial additive

components in deposits. In Rust and Oxidation lubricants, it is common to find reacted primary antioxidant species in deposits, which produce organic deposits.

Thermoplastic

Some high-temperature degradation processes produce high molecular weight molecules that create deposits which act like thermoplastics. These deposits are typically solid at room temperature, however, they become liquid and flow at elevated temperatures (typically at or below fluid operating temperatures). It is common to see this type of deposit from fluids that have failed due to spark discharge.

Thermal Decomposition

Hydrocarbon molecules will typically crack at temperatures above 300°C. There are two actions that can happen. The first is when small, cleaved-off molecules volatilize from the fluid. This portion of the reaction is not a deposit former. The second is molecular condensation. As the small molecules are split off, the remaining portion of the molecule will condense. This condensation is in the absence of air, so dehydrogenation will be part of its decomposition. As a final product, the formation of coke will be observed, however, there are numerous deposit chemistries observed before the coke is formed.

Oxidatively Derived

Oxidatively derived deposits are among the most common classification found in lubricant deposits because oxidation is one of the primary lubricant failure modes. These deposits usually have a higher molecular weight than the lubricant, which contributes to their inability to stay in solution. Many incorrectly assume that most deposits fit into this category.

Contaminant Derived

Organic contaminants can ingress into the lubricant system, initiating a reaction. This reaction can be with the current formulation or it can be incompatible with the fluid,



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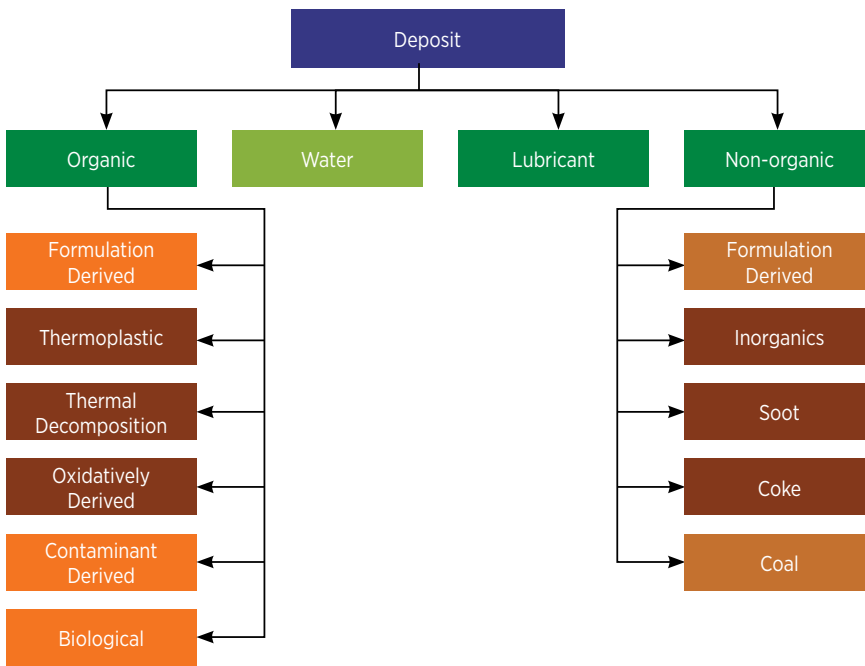


Figure 6: An example of various deposit components found in a compressor lube oil system

resulting in an organic contaminant deposit. This has been observed with some types of gas contaminants that may react with the in-service lubricant to create unique, organic deposits. Ammonia gas ingress, for example, has been found to react with Oxidation Derived degradation products to create deposits consisting of primary amides. Other gases have been known to produce their own signature deposits.

Biologically Derived

Deposits that are derived from biological growth include plant materials such as sugar, cotton and proteins are considered biologically derived. These are often from fermentation processes. Microbial growth can also cause deposits classified in this bin. Although these deposits are organic in nature, they are typically found with the non-organic deposits during isolation.

Non-Organic Deposits

Non-Organic deposits are also defined as a Level 2 Deposit Classification Bin. The Non-Organic Bin includes wear metals and dirt. In the non-organic classification,

one finds the categories of coal and plant life. These two do contain some carbon-hydrogen functionality; however, they behave more similarly to the non-organic than the organic. In addition, coal is often misidentified as coke or soot and thus should be placed near these materials in the classification tree. When Coke is formed as a deposit, there is often a corresponding Thermal Decomposition deposit observed in the Organic Deposit Classification Bin. The synergism between these two allows improved identification of the source and thus the root cause determination.

The choice of the analytical tools being employed can also be defined by the sample classification. If one observes organic chemistry, the testing methodologies should be tailored toward organic characterization. Similarly, non-organic constituents have a different set of tools for their characterization.

Below are definitions of the different bins included in non-organic contaminants:

Formulation Derived

Many additive components may contribute

to deposits either after they have reacted or due to dropping out of solution in an unreacted state. Non-organic formulation-derived deposits typically come from inorganic additive chemistries that have depleted, such as ZDDP.

Inorganics

Inorganic deposits can be defined as those that are free of carbon and are the bin where one includes hard contaminants in the lube, such as dirt, debris and wear metals. It is also common to find inorganic deposits derived from degraded additive components. Depleted ZDDP, for example, can produce inorganic deposits such as phosphates and sulfates.

Soot

High-temperature events may cause the formation of soot particles. Soot deposits consist of black body carbonaceous particles less than 1-micron in size and are typically generated from a dieseling event such as in a diesel engine or in micro- dieseling (the implosion of air bubbles).

Coke

High-temperature events may also produce coke. These are black body carbonaceous materials larger than 1-micron in size. These deposits are typically generated from severe overheating (above 572°F or 300°C) of an organic material until it has released all of its hydrogen and oxygen.

Coal

Coal deposits are also black body carbonaceous materials larger than 1-microns in size, however, they exhibit solubility in some polar organic solvents such as Tetrahydrofuran or Pyridine.

Root Cause Determination

To perform a proper root cause analysis, one should start with a collection of the deposits, the in-service fluid and any known materials that come in contact with

the system. Often, but not all the time, the deposit components can also be identified within the in-service fluid. In addition, the overall condition of the fluid tells volumes about the formation direction. For example, if the antioxidant level is in good condition, one should look at something other than simple oxidation as the cause.

After gathering as much data as possible about the fluid condition, we characterize the deposit. A proper analysis of the deposit is often the root cause determination itself. Defining the deposit source classification will help establish the actions to take when fixing the cause. Many times, the deposit contains more than one deposit classification. That information can assist in this root cause determination.

A deposit from a centrifugal compressor used at a petro-chemical site in Scandinavia was recently analyzed. The following deposit types were identified

in our analysis: inorganic, soot, coke, thermoplastic, thermal degradation, oxidation and lubricant. The deposit types are highlighted in the classification chart in Fig. 6.

Characterizing the different types of chemistries found in the deposit allowed us to understand the various fluid degradation mechanisms in this application. It was also critical in putting together a strategy to address these root causes.

With a root cause and deposit classification assigned, one can direct efforts toward the elimination and the removal of the tar-ball deposits. The chemistry of the deposit defines the mitigation strategy since any one deposit removal technology is not capable of removing all deposits. In addition, it is often beneficial to stop the deposit formation before attempting to remove it.

Conclusion

Lubricant deposits can have a significant impact on a plant's reliability program. Deposits may have a similar look, leading some to believe that they are all the same in chemistry, originating from the same source. In fact, lube deposits come in a wide range of chemical flavors. Understanding their constituents allows one to better understand why the deposits formed and what remediation strategy to pursue.

This article presented nomenclature and definitions to categorize lube deposits by chemistry and source. In some applications, we find deposits that have components with a wide range of different categories. In other cases, the deposit neatly fits into one categorization bin. In all cases, however, properly characterizing the deposit provides information to allow one to determine the root cause of the problem: the first step to a deposit-free system. **ML**

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When it comes to managing the headspace of a machine or machine component, many different breathers can be used, such as desiccant breathers, particle breathers, dry instrument air and expansion chambers. In this article, we will discuss the difference between the first two methods mentioned: the particle breather and the desiccant breather. However, before we dive into the differences between these two types of breathers, it is important to understand headspace management and the purpose of breathers.

The headspace of a lubricated sump is the area between the top of a lubricant and the top of the sump itself. The size of this space can fluctuate as a machine exhales and inhales. There is not much emphasis put on the air that is leaving the machine. However, when a machine breathes in, there is a chance that harmful contaminants such as water and dirt can ingress and potentially



cause harm to the lubricant and the machine. For this reason, it's important that we control what comes in with the air as it enters the machine.

Particle Breathers

Simply put, a particle breather is similar to the filters used to make coffee. Just like a coffee filter is used to keep the coffee grains out of the coffee pot, particle breathers are used to keep particles out of lubricated sumps. One downside of particle breathers is that they

can allow water to easily find its way inside our machines, just like the coffee filter. These filters usually come threaded and spun into the top of machines such as gearboxes, hydraulic units and pumps.

Generally, the particle breathers that come on most OEM equipment are not sufficient to properly protect a machine's headspace. Think of the typical breather that comes on a hydraulic unit — they will usually have a

PARTICLE BREATHERS

1 oz. - Multiple Pounds	WEIGHT:	1 oz. - Multiple Pounds
Generally 3"-12"	HEIGHT:	4" to 40" Based on Application
Generally Around 40 Micron	REACH:	3 Micron Particles

twist-on lid with what looks like steel wool inside. While these will help keep rocks out, they are not able to trap the small particles that cause harm to machine surfaces. You will not often find a micron rating on the side of a particle filter; this rating would show the particle size that the filters are targeting.

Desiccant Breathers

The most important characteristic of a desiccant breather is the ability to desiccate, meaning it can remove moisture. Incoming air is cleaned and dehydrated through an initial solid particle filter, a container of silica gel and then another solid particle filter. Typically, this desiccant material has a limited lifespan — once it becomes saturated or spent, either the desiccant or the entire breather will need to be replaced.

There are many different types of desiccant breathers, ensuring that the headspace will be protected no matter the application. The

DESICCANT BREATHERS

most basic of these breathers is set up so that both incoming and outgoing air from the machine will go through the desiccant material. If this type of unit is set in a high-moisture area, it will become spent very quickly because it constantly pulls moisture from both the machine and the atmosphere. Very humid environments, like those found in Louisiana and South Texas, can be detrimental to this specific type of breather unless the proper add-ons are implemented.

Other types of desiccant breathers, like those with check valves that only allow air to flow through the desiccant when the machine is inhaling or exhaling, are better suited for humid or wet environments. A few add-ons, depending on the environmental conditions, are wash-down caps, isolation check valves, high-capacity air filters and even manual indicator vacuum gauges.

Summary

Particle breathers will suffice for a short amount of time in perfect conditions, but we're here to inform you of best practices while assuming the worst conditions. Simply put, particle breathers can't do half of what desiccant breathers can. In the end, it all comes down to dollars and cents. You can be proactive and protect your equipment by paying to install and utilize desiccants, or you can be reactive and spend thousands of dollars and many man-hours replacing components and lubricants. In comparison to particle breathers, desiccant breathers are the most efficient way of proactively keeping your oil clean and dry, and a proactive step is a step towards lubrication excellence.



About the Author

Travis Richardson is a technical consultant for Noria Corporation. He holds a Level II Machine Lubrication Technician (MLT) certification and a Level III Machine Lubricant Analyst (MLA) certification through the International Council for Machinery Lubrication (ICML). Contact Travis at trichardson@noria.com.

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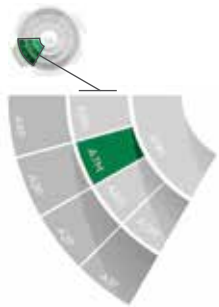
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Scanning Electron Microscopy for Wear Debris Analysis

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Oil analysis deploys various types of instruments, technologies, standards and techniques, all of which help provide a perspective on the health of the lubricant and the machine. The oil analysis data either targets specific properties of the lubricant, quantifies the level of various contaminants or directly measures any evidence of mechanical wear through wear debris analysis. Many concerns arise anytime solid debris (particulates) of any kind accumulate in the lubricant within a machine.

On the one hand, if the solid debris is contamination-related, such as dirt or product debris entering the oil, this is a proactive (pre-failure) indicator that machine wear could occur as the debris becomes abrasive and disrupts the film thickness. While some amount of contaminant is expected, keeping this controlled is critical. On the other hand, if it's wear debris related, composed of metals such as iron or copper, this



Placing the Prepared Debris Specimen into the SEM

is a predictive (progressive failure) indicator that machine wear is already occurring, and action should be strongly considered if a functional failure is to be avoided.

Monitoring for debris can be done in many ways. For example, daily visual inspection of the machine sight glasses or IIoT sensors can be the first indicator of abnormal

conditions. Routine oil analysis can include tests to quantitatively look for particles in different ways, such as total particle size distribution (ISO particle counts), specific elements (ppm) or just ferrous debris (wear particle concentration), amongst others. All of these debris monitoring methods are great for initial detection and trending data. However, they each have their limitations and may not provide much investigative evidence on where the particles came from and how they were produced.

When abnormal trends arise during routine debris monitoring, it's often necessary to prompt additional analysis (called exception testing) to answer some of these questions:

What is the root cause? How threatening is the condition? What is the failure mode? How far has the wear mode progressed?

Even if a failure has already occurred, the remaining debris can shed light on what caused the failure and if it could have been avoided. These questions often require techniques with microscopic debris analysis to provide the answers. Crucial evidence to answer million-dollar questions about machine failure modes lies within the hidden depths of the particles.

What is Scanning Electron Microscopy?

When observing an object, what we see with our eyes is the light reflected off the

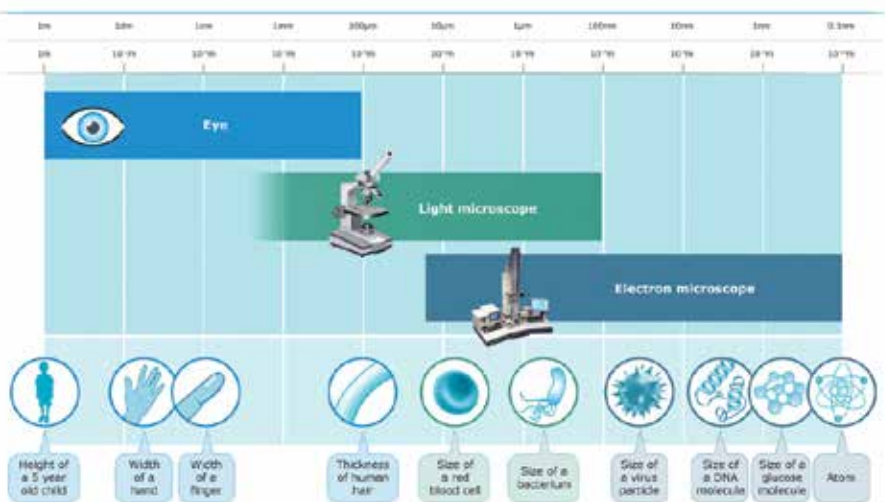
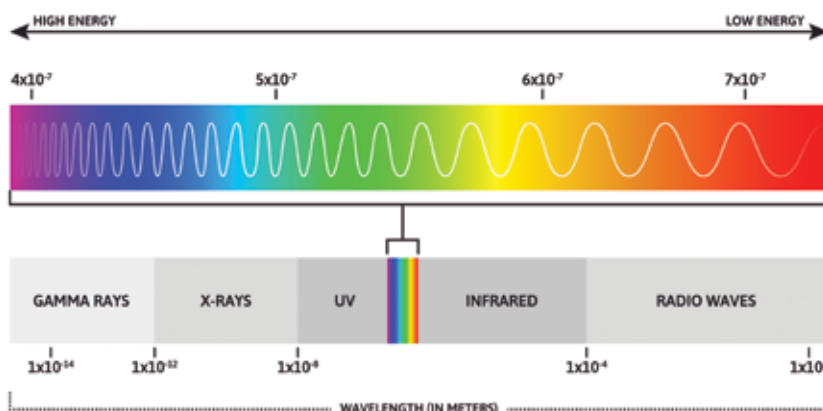
object. Our unaided eyes have a resolution; at about 100 microns (0.1 millimeters), we begin losing the ability to distinguish individual objects. Optical microscopes, which use lenses to focus light, allow us to see smaller features and objects.

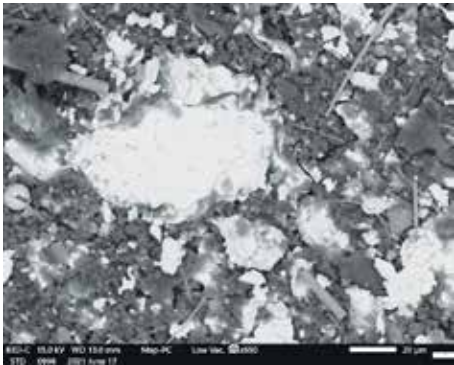
Light travels in waves with a specific wavelength, which is the distance that light takes to complete one oscillation. The wavelength of the visible light spectrum is between 400 and 700 nanometers (or 0.4 and 0.7 microns). As we attempt to magnify objects with an optical microscope, we encounter a resolution problem: the viewing area size of the object we are looking at becomes close to the wavelength of light. In other words, the image does not look clear, and we cannot distinguish individual features.

To visualize objects (or features on an object) smaller than the limits of the visible light spectrum, we must apply a different technology that uses a smaller wavelength, such as the Scanning Electron Microscope (SEM). Instead of light, an SEM uses electrons that travel with a much smaller wavelength (about 0.01 nanometers). An electron column focuses and shoots a beam of electrons at the surface of an object, often in a vacuum-controlled chamber. Detectors measure the electrons that are reflected off the surface or knocked out of the atomic orbitals near the surface of the material; this information is then used to generate an image of the material.

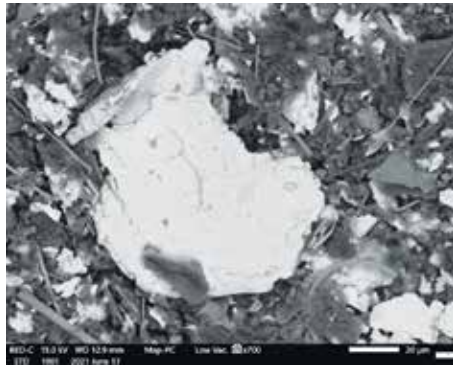
Because the SEM uses electrons to produce an image, the object being observed must be conductive. The electron column and specimen may need to be kept under a high vacuum in order to minimize interference of air molecules and other airborne contaminants during high magnification (greater than about 5000x). However, for analysis purposes that require the magnification of typical wear debris (2500x to 5000x), a low vacuum option (along with specialized laboratory techniques) can be

VISIBLE SPECTRUM

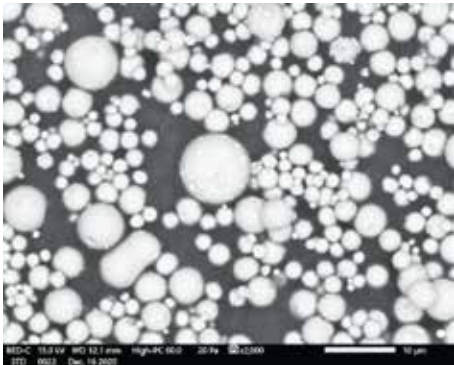




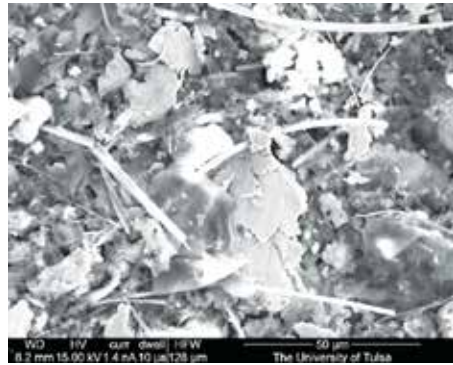
Steel debris (Fe, Si-1-2%)



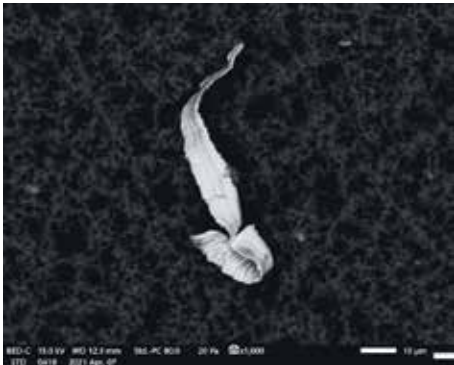
Steel debris (Fe, Si-1-2%)



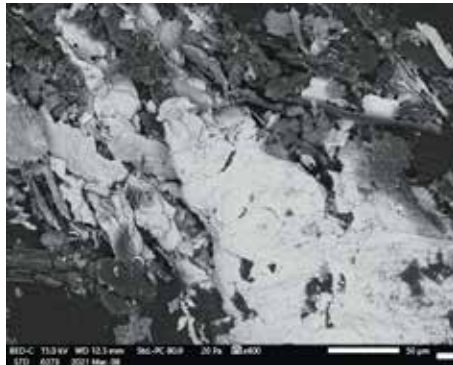
Spherical Wear Particles



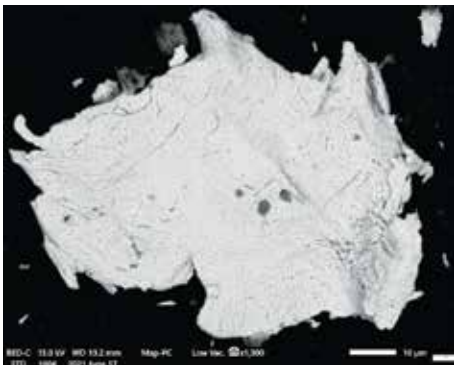
Fibers and Abrasive Wear From Filter Debris



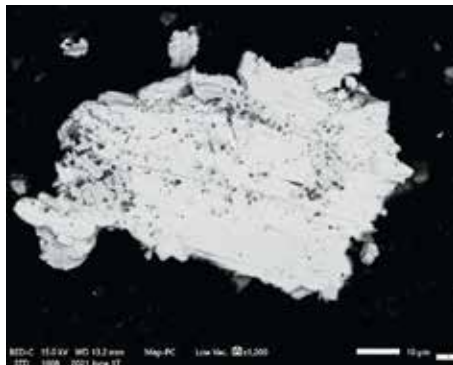
Cutting Wear



Flake-like Surface Fatigue Particles



Iron/Zinc Particle from Engine



Zinc/Aluminum Particle from Engine

used to more easily emphasize the particle's characteristics.

In order to obtain SEM images of the particulate in an oil sample, the solid debris gathered from the oil sample (or elsewhere, such as a used filter) is collected onto a patch and, using a conductive adhesive, is adhered to an aluminum specimen mount. If sputter coating is used, a nanometer-scale layer of ions of a conductive material is deposited onto the surface of the sample, creating a conductive pathway for the electrons. Common materials for sputter coating include carbon, aluminum and gold. Once the sample on the mount is prepared, it can be placed onto the SEM sample holder. The sample holder is on a movable stage which can be manipulated to different positions and rotations to help enhance observations of surface features as needed.

The resulting image will be monochrome (grayscale) since the objects are being observed with electrons, rather than how we observe color within the visible light spectrum. Contrast in an SEM image can be caused by physical features, differences in atomic number between materials or differences in conductivity of the materials.

SEM images of particles can appear differently from optical images of the same particles because the electrons will penetrate the surface of the material during imaging, rather than just reflecting off the surface like light waves. Operating conditions will affect the depth of penetration of the electrons. An electron beam with a lower operating voltage will have less penetration depth but will more clearly show surface features such as oxide layers.

Two major advantages of SEM over a light microscope are greater magnification and an increased depth of focus. Like a light microscope, the beam of electrons is focused more narrowly at higher magnifications, resulting in a clearer image but a reduced depth of focus. With an SEM, however,

FEATURE	AUTOMATIC PARTICLE COUNTER	ANALYTICAL FERROGRAPHY	ICP ELEMENTAL ANALYSIS	RDE ELEMENTAL ANALYSIS	SEM/EDX
Sample Preparation Requirements	Usually	Yes	Yes	No	Yes
Particle Detection Range (microns)	2-100	2-500	<3	<7	0.2-2,000
Individual Particle Size and Shape	Usually	Yes	No	No	Yes
Total Element Chemical Analyses Range	No	No	38	32	98
Particle Classification by Chemistry	No	Limited	No	No	Yes
Particle Classification by Morphology and Chemistry	No	Yes	No	No	Yes
Analyses Time (minutes)	5	10	3	3	10 to 30
Ease of Use (1=easy, 5=moderate, 10=difficult)	5	10	5	3	1
Particle Size Distribution	Yes	No	No	No	Yes
Automated Trending	Yes	Limited	Yes	Yes	Yes

SEM/EDS in Comparison Against other Common Particle Counters and Elemental Analysis Technologies

because the electron beam is narrower and has a smaller wavelength relative to light, it is often possible to get very high magnification and highly focused images of entire particles. Because of the larger depth of focus, we can see tall features and background features simultaneously.

Scanning electron microscopy is commonly used for applications like failure analysis and particle analysis. Because the SEM provides images at high magnifications, we can quantify the sizes and topography of particles in the sample. The higher depth of focus allows us to image large particles and small particles in the same area simultaneously, giving a better understanding of particle size distribution. We can also observe features such as wear patterns or evidence of fatigue which will provide clues to the formation of the features.

Energy-Dispersive X-Ray Spectroscopy

In addition to the high-resolution images of very small surfaces and features with high magnification, the SEM is typically arranged with an additional technology that can determine the particle elemental composition — this is called Energy-Dispersive

X-ray (EDX) or Energy-Dispersive Spectroscopy (EDS).

During an EDS analysis, the material of interest is bombarded with electrons. The incoming electrons knock existing electrons out of their orbitals and into higher orbitals. When these electrons fall back to their initial state, x-ray energy is released. Depending on the elements that are present, the energy that is released will have a specific wavelength. The detector quantifies the amount of energy released at each wavelength. EDS software matches the measured energies to specific elements that are likely to be present within the material, giving the user a qualitative list of likely elements and the relative amounts of those elements within the material. Elemental identification with EDS can be performed over the entire area on view in the SEM or on specific particles or areas within the sample. A more detailed analysis can identify the location of each element within the material.

When performing an EDS analysis, it is important to select operating parameters compatible with the material. Higher operating voltages are required for elements with higher atomic numbers. Because EDS functions in a similar way to the SEM, the

specimens must also be conductive. For non-conductive materials, EDS analysis is possible on specimens that have been sputter coated, but the coating material will also be present in the results.

Answering the Questions

With detailed images provided by the SEM and elemental data of specific wear particles provided by the EDS, interpretation can answer the crucial questions. A trained lubricant analysis technician can observe the topographical characteristics of each particle to determine which wear mode produced them and the severity of the wear event. The elemental composition and concentrations provide clues as to their source or formation. Unlike traditional elemental analysis (such as with inductively coupled plasma, ICP), which cannot easily analyze particles greater than about 3 microns, SEM/EDS techniques can easily provide elemental data on surfaces of particles at any size.

With SEM/EDS, particles can be categorized by their shapes, sizes and elemental composition, with minimal limitations to particle detection range and greater chemical and topographical determinations. In a chart published by

Susan Benes in Machinery Lubrication Magazine, the SEM/EDS is compared against the other common particle counter and elemental analysis technologies.

While each technology has different intentions in reporting, the combination of techniques is crucial in creating conclusions on wear debris characteristics. SEM/EDS has been increasingly more available and easier to use in recent years, bringing it more into a standard practice for oil analysis. Many use SEM/EDS, along with other advanced wear debris monitoring techniques, to periodically analyze filter debris or other collected debris oil samples. The cost of failure could be too great for these questions to be left unanswered. Making the decision to use SEM/EDS analysis for your sample may be situational, specifically with problem-solving. A few reasons may include:

- When the originating source (wear

surface) of unique particles exhibiting advanced wear must be known (matching the elemental composition of the particle with the known metallurgy of the machine).

- When the type of harmful contaminants must be known.
- When more precise particle images are needed to better understand the wear mode(s).
- When elemental analysis from ICP or RDE is unable to accurately quantify the elemental concentration of large contaminant and wear debris particles.

ML

To learn more about the SEM/EDS technology and read case studies on the applications with oil analysis, visit machinerylubrication.com

Acknowledgements:

- This work made use of the Nano

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The pandemic has altered business operations across the sector. How is India's manufacturing sector evolving its vision?

The IHS Markit India Manufacturing Purchasing Managers' Index (PMI) settled at 55.9 in October 2021 – maintaining its mark above the consensus of 50. This is good news for the sector, and manufacturers are now keen to maximize productivity and recover revenue foregone in the last year. Alongside, there is a visible shift among manufacturers to opt for cleaner, more efficient solutions that can increase machine performance. Simultaneously, manufacturers today are opting for customized and specialty products that cater to their specific equipment. For us at Mobil™ Lubricants, this is a great opportunity to drive transformation by

introducing technologically superior products.

What difference can the right lubricant make in improving manufacturing output?

Lubricants play a key role in ensuring machine performance and long life. Very often, insufficient information and lack of guided expertise can lead to misuse and consequent breakdowns. Further, lubricant usage is linked closely to factors like environmental conditions, speed, load, and temperature – adopting correct practices, thus, is imperative. For instance, using the appropriate grade and type of lubricant is essential to prevent shortened bearing life. Over the years, our proven lubrication solutions and application expertise have assisted manufacturers in implementing



practices that enhance operations, improve safety, and streamline maintenance. To achieve utmost efficiency, we provide them with a variety of products, ranging from engine oils, slideway oils, bearing oils, greases and more – along with timely servicing and industry insight.

What are some products by Mobil for manufacturing industries?

Our products attempt to solve specific challenges that manufacturers encounter in their everyday operations. For instance, the Mobil DTE™ 20 Ultra Series oils are high performance anti-wear hydraulic oils with extended oil life capabilities and have demonstrated up to 2 times longer oil drain intervals versus similar competitive oils (*). They meet the stringent requirements of hydraulic systems using high pressure, high output pumps as well as other hydraulic system components such as close clearance servo-valves and numerically controlled (NC) machine tools.

Similarly, the Mobil Velocite™ Oil

Numbered Series oils are premium performance products primarily designed for the lubrication of high-speed spindles in machine tools. They are formulated from select high-quality, low viscosity base oils and additives that impart good resistance to oxidation and provide protection from rust and corrosion. They possess very good resistance to foaming and separate readily from water. Additionally, the Mobil Vacutra™ Oil Numbered Series are specifically designed to meet requirements of accuracy, aqueous coolant separability and equipment protection of precision machine tools. The Mobilcut™ Series products, on the other hand, provide dependable performance in a wide array of metal removal processes. These are some examples of a diverse portfolio we have built to deliver to Indian circumstances.

Manufacturing today is gradually moving towards Industry 4.0. How is Mobil catering to manufacturers' demands in this atmosphere of change?

Industry 4.0 is altering manufacturing in

irrevocable ways with a promise for greater efficiency, productivity, and profitability. Duly, to cater to our customers' myriad demands and business goals, we have drawn focus to providing superior service through remote assistance. The Mobil™ Solcare Service application has been a breakthrough in providing digital services with immediacy, accuracy and reliability. We also offer services through the Mobil ServSM Lubricant Analysis (MSLA) programme, which delivers a full-spectrum analysis on the usage and maintenance of Mobil branded lubricants. Now, with the move towards Industry 4.0, we have introduced Mobil ServSM IIoT Insights. It is a critical cloud-based solution that turns insights into action, taking businesses towards improved efficiency and overall productivity. This platform is bringing special benefits with Artificial Intelligence and Machine Learning (AI/ML), automated monitoring and precise analysis that directly benefit machine performance and manufacturing efficiency.



(*) with a viscosity index around 100 and a zinc-based anti-wear system - meeting at least ISO 11158 (L-HM) and/or DIN 51524-2 (HLP type) requirements.

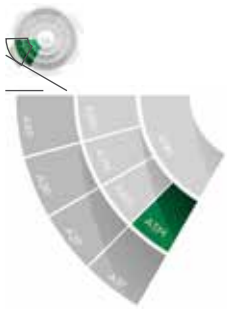
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“Failure is central to engineering. Every single calculation that an engineer makes is a failure calculation. Successful engineering is all about understanding how things break or fail.” — Henry Petroski

All manufacturing facilities are different, and each has its own needs. Most of these facilities do have some common components such as electric motors, gearboxes, pumps and bearings.

Inspections and condition monitoring for each:

When we think about equipment maintenance, what drives the equipment should be a primary concern. It doesn't matter if you are talking about a gearbox, a pump or a chain drive; if it is run by an electric motor (as is often the case) and that motor fails, no amount of gearbox care is going to fix the problem.

Not all electric motors are equal. Some will be carefully maintained and lubricated, while others will



not. Even motors that are not carefully maintained usually make it onto an inspection schedule. In any case, there are a number of things that we can look for on any electric motor during inspections.

Certain aspects should be obvious, like operating temperature, sound, obvious shaking, etc. These are all things that even a layman should be able to spot if they have seen what “normal” operating conditions look like.

But it is often the case that all our other duties get in the way of even the clearest signs of problems. As younger folks enter workplaces where apprenticeship programs are not as prevalent, a lot of the

“old knowledge” that we could assume everyone has is being lost. Of course, not all old knowledge still holds true. We need to address which knowledge is fact and what has become fiction as our understanding of lubrication and maintenance has developed.

Let's start with temperatures. Now, I have to admit that I have been as guilty of this as anyone out there, but just because a motor is too hot to touch doesn't mean that the motor is “running hot.” Don't get me wrong, I would love it if all electric motors could run at 125° F (52°C) all the time while being in an ambient temperature of 77°F (25°C), but we all know that this just isn't the case. More

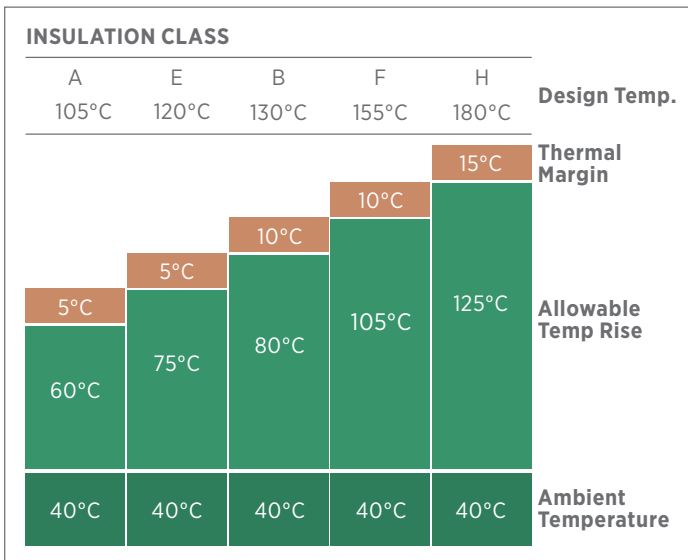


Figure 1 NEMA rating chart for electric motors.

often than not, I see electric motors running upward of 175° F (79°C) and even up to 225°F (107°C). Looking at these issues with lubrication in mind, my focus would be on the grease, and more specifically, the base oil inside of that grease.

Lower operating temperatures for an oil means a much longer life (this can be seen in a drastic way when you look at the oil change frequency difference in hydropower turbines versus steam turbines). For this reason, I had long thought that an electric motor too hot to touch meant that it was automatically degrading the lubricant prematurely, but this isn't necessarily the case.

Too hot to touch?

According to ASTM C1055, 140°F (60°C) is about the temperature where it is unsafe to touch something for more than 5 seconds (any longer and there could be permanent burn damage). Most electric motor greases are going to be rated for an operating temperature of closer to 350°F (177°C), which is much hotter than we should ever touch. Now, this doesn't mean that we should run our motors this hot, but we should understand a few things while we are looking at a motor's temperature, like the difference in temperatures that the bearings might be exposed to versus the temperature of the outside housing. Keep in

mind that there are a number of factors that determine the outside temp of the motor housing, but in relation to the bearings, the housing will typically be about 50°F-77°F (10°C-25°C) cooler than the actual bearing temperature. The range is so large because different designs will dissipate this heat at different rates.

So what are we really looking at, or what should we be looking for? Most electric motors out there have a NEMA rating listed on them. This is where we start. Your electric motors should have a NEMA rating designation of either an A, E, B, F or H. Figure 1 helps explain these ratings a bit better.

The motors that fall into the A category aren't really used in manufacturing anymore, but you may find them in some of your household items. The E category is going to be some of your light-duty applications, but once again, you're probably not going to find these doing a whole lot of work in a large manufacturing facility. The Class B and Class F are where you are going to find most of your motors today. These are designed for higher temperatures, as you can tell from the chart, and continuous duty.

Now that we know what temperatures our motors are rated for, we have an idea of what our grease is tested to, and we know that the bearings and windings are going to be a bit hotter than the housing of the motor, but what do we do with that information?

We can't just focus on one aspect of electric motors or any other piece of equipment.

We have to look at the criticality of the equipment to help determine what inspections we should put in place to keep an eye on it. If you've been to one of Noria's classes or have been a Machinery Lubrication reader, you have probably heard of the Optimum Reference State. This helps us match the reliability needs of a specific piece of equipment with our operating needs, operating conditions and budget.

I would never recommend placing real-time vibration and temperature sensors on every electric motor in a facility, but I would recommend identifying which pieces of equipment might have a higher consequence of failure. Think of it this way: If this specific motor fails, is it going to cause a cascade effect in other equipment? Is it going to shut down production for the entire facility, or maybe a production line? Maybe this motor is in a location where you would have to hire a crane to move it or even have the motor airlifted into position. Replacing a motor in these scenarios is going to cost 50 times more than motor itself.

By taking the above aspects into consideration when setting inspection tasks, it is possible to minimize catastrophic problems without spending too much time inspecting relatively low-priority or low-maintenance-cost motors. *ML*



About the Author

Jeremie Edwards is an Associate Technical

Consultant at Noria Corporation. He is one of an elite few certified by the International Council for Machinery Lubrication (ICML) as a Machinery Lubrication Engineer (MLE) and did so in order to become the best advisor for clients when it comes to their continuing education needs. Before joining Noria, Jeremie served six years in the U.S. Army as a parachute rigger and was deployed in Afghanistan, Uzbekistan, Turkey and Germany.



TEST YOUR KNOWLEDGE

This month, *Machinery Lubrication* continues its “Test Your Knowledge” section in which we focus on a group of questions from Noria’s Practice Exam for Level I Machine Lubrication Technician and Machine Lubricant Analyst. The answers are located at the bottom of this page. The complete 126-question practice test with expanded answers is available at store.noria.com.

1. Which maintenance strategy employs condition monitoring to detect early-stage failures with the repair or replacement of the asset scheduled based on this condition?

- a) Reactive
- b) Preventive
- c) Predictive
- d) Proactive

2. Slow speeds, high loads, shock loads and machine stops/starts can all cause what form of lubrication?

- a) Boundary Lubrication
- b) Hydrodynamic Lubrication
- c) No Lubrication happens during these conditions
- d) Particle Lubrication

3. What is the term used to define the measure of a fluid’s internal resistance to flow?

- a) Shear
- b) Viscosity
- c) Back Flow
- d) Friction

4. The primary reason that machinery is replaced is due to:

- a) Erosion
- b) Accidents
- c) Obsolescence
- d) Surface Degradation of the Metal
- e) Corrosion

5. For a typical hydraulic fluid, how full should a sample bottle be filled with hydraulic fluid?

- a) 50%
- b) 75%
- c) 90%
- d) 100%
- e) Doesn’t Matter

1. C 2. A 3. B 4. D 5. D
ANSWERS

Machinery Lubrication

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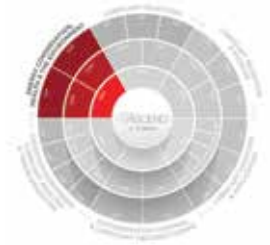
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Rags are one of the most essential items to have for a lubrication technician, mechanic or anyone working on equipment on the plant floor. They're a necessity for cleaning up greasy or oily surfaces on tools, machine components and our own hands once work is done. We can go through quite a few just working on one machine, especially during machine assembly and disassembly. When we drain oil and dispose of any lubricants, there are procedures to follow to ensure we do not accidentally pose any safety, health or environmental risks with the waste oil. There are plenty of regulations established to help workers fully comprehend the importance of these procedures. But what about the materials, like rags, that are soaked with oil and grease? Do we just toss them out?

It's common to find these rags or shop towels tossed into waste bins or left around. Aside from these, there are many other similar materials used for cleaning in



industrial work environments, including lint-free cloths, spill mats, absorbent socks/dikes or loose absorbent. These are particularly necessary when spills occur but may be difficult to handle afterwards. The same holds true for other lubricant-contaminated materials — used

oil filters, oil-soaked breathers and single-shot top-up containers can all contain leftover volumes of lubricant.

When oily rags and other lubricant-contaminated materials are handled properly, it keeps the workplace safe, clean and helps

maintain an organized front. When this occurs, many other efficiencies can result. In addition to equipment operation, it also helps manage a stronger, healthier culture in the workforce.

A Brief History on Related Standards and Regulations

In 1973, under the Clean Water Act, the U.S. Environmental Protection Agency (EPA) implemented the Spill Prevention, Control, and Countermeasure (SPCC) regulation. This regulation aims to prevent oil pollution, and in turn, protect drinking water and natural resources. The SPCC regulation sets standards regarding the prevention of and response to oil discharges. The regulation requires that affected facility owners and operators prepare and implement a spill prevention, control and countermeasure plan unique to their facility. Within these SPCC plans, standards are set for the containment and storage of oil-contaminated materials.

In 1976, Congress enacted the Resource Conservation and Recovery Act (RCRA). The RCRA created standards for identifying and handling hazardous waste and non-hazardous waste materials. A complete list of these standards can be accessed on the EPA's official website, wherein you can find guidelines to determine if the materials that you are dealing with are considered hazardous or non-hazardous. This determination will dictate how you can dispose of your oil-contaminated materials.

EPA regulations require containers and above-ground tanks in which oil-contaminated materials are stored to be clearly labeled as "Used Oil." Some State Environmental Protection Agencies may have additional standards; for example, California's Code of Regulations requires that – in addition to being labeled as "Used Oil" – containers are labeled with the name and address of the oil source, the hazardous

properties of the material being stored, the date that the container began accumulating used oil and the composition of the waste being contained (CCR, Title 22 § 66262).

It is not uncommon for individual companies to provide further regulations or specifications to be followed in combination with the legal regulations. As an example, the internal regulation guide for a particular chemical company dictates that "Oil contaminated material, such as filters, oil pads, etc., shall be disposed of [in] the dedicated environmental dumpsters at each oil storage area where the material can be recycled and disposed of properly by the environmental department."

How to Store Oil-Contaminated Materials

Drums and other industrial containers can be used to collect oil-contaminated materials. These containers should be appropriately labeled and easy to access. Many containers on the market have foot-operated and self-closing lids (Waste Disposal Safety Container). Proper storage containers make it easy to collect absorbents and reduce the risk of fires and oil contamination.

Knowing what containers to use is one thing, but it's up to the plant to make these readily available where necessary and implement proper training for everyone to know how and when to use them. Having documented procedures also helps to ensure there is proper storage of oily rags and other similar materials. As part of the Ascend™ Methodology, one of the Energy Conservation, Health and the Environment factors focuses on the understanding of these disposal practices with Storage and Disposal of Used Oil And Materials (E2P). This should be a staple of safe workplaces.

How to Properly Dispose of your Oil-Contaminated Materials

Once you have implemented proper storage procedures for your oily rags and similar materials, they cannot stay there forever. Next, a decision needs to be made on how to eventually dispose of these properly. Before choosing how to proceed, you will need to determine if your material is considered hazardous. This can be done by referencing the EPA guidelines mentioned previously. Additionally, you must determine if your material contains free liquid oil. Free liquids cannot be disposed of in the same ways as solid waste.



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Materials can be tested to determine if they contain free liquids. One of the EPA-approved tests (Method 9095B) uses a conical paint filter (mesh number 60 +/- 5%). The test guidelines direct that “A predetermined amount of material is placed in a paint filter. If any portion of the material passes through and drops from the filter within the 5-min test period, the material is deemed to contain free liquids.” Exhaustive testing such as this is generally not needed; if your materials drip liquid when squeezed, they likely are considered to contain free liquids and cannot be disposed of with solid waste. This is particularly important to understand when considering the varying waste and disposal procedures between simply just an oily rag and the absorbent pads that may be soaked when handling a sizable oil spill.

Used oil filters can be drained of their contents and disposed of as non-hazardous waste. It is common for filters to first be placed on a grate that can allow dripped oil to collect into a drum. Additionally, oil crushers, will push out most of the remaining oil into a used oil drum, while making the remainder filter more easily recyclable. According to the EPA (40 CFR Part 261), once oil filters are drained and crushed or dismantled, they are no longer considered hazardous waste (provided the filters are non-terne plated and are not mixed with hazardous waste materials).

Beyond this, the EPA doesn't regulate what happens to oil filters, although they encourage recycling.

Recycling programs exist for absorbents, and using these programs is more environmentally friendly than simply disposing of the waste. If used oil is to be recycled and used for energy recovery, the material will be collected and stripped of water and contaminants. The remaining oil is then burned; the heat produced can be used to power different industrial processes. Burning used oil for energy reduces the amount of new material that needs to be burned to create energy.

Additionally, your rags and shop towels may be eligible for industrial laundry services. These programs typically retrieve your absorbents, launder them offsite and then return them clean and ready to use again.

Did you know oily rags can start fires on their own?

As some oily rags sit, the oil in them can age and further oxidize. The oxidation process consumes oxygen and expels heat. Thus, if oily rags are thrown in the trash, placed in a pile or put in an inappropriate storage container, the heat produced by oxidation has nowhere to go. If the heat isn't dispelled, the oxidized oil can reach temperatures hot enough to ignite the rag

material, causing a fire without a spark also known as spontaneous combustion.

Conclusion

Properly storing and managing oil-contaminated materials, like rags and filters, not only creates an organized environment, but also helps protect assets and your fellow workers. Properly labeling and using storage containers ensures that valuable materials are not cross-contaminated and improperly used. And of course, proper storage can help prevent fires and other accidents. So next time you decide to throw out an oily rag, think twice and do it right.

Author's Note: Thanks to Hayden Beeson for his contribution on this article. **ML**



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The “Lube-Tips” section of *Machinery Lubrication* magazine features innovative ideas submitted by our readers.



Don't Rely on Color Alone

Color-coding can be an effective way of setting up a lubricant management program, but don't use color as the only designation for which lubricant goes into what equipment. A significant portion of the population has partial or total color blindness. In labeling lubricants, colors should be supplemented with either shapes or text.

Avoid Recurring Water Contamination Problems

Large hydraulic reservoirs operating outdoors often develop a problem with recurring water contamination. The problem often is related to the humidity in the air. When hydraulic systems operate, the oil heats up and expands. If the system is shut down at night, the oil will contract and fresh humid air from the outdoors will enter the reservoir through the breather. By morning, when the outside air temperature has cooled significantly, the humidity introduced into the reservoir has usually condensed into water droplets in the oil. To correct and avoid this, use water-removal filtration offline to remove any free and dissolved water and add a desiccant breather to filter moisture out of any air entering the reservoir.



Did You Know?

Additional tips can be found in our Lube-Tips email newsletter. To receive the Lube-Tips newsletter, subscribe now at machinerylubricationindia.com

Have Some Tips?

If you have a tip to share, email it to admin@machinerylubricationindia.com

Don't Overlook Barrier Fluids

One often-overlooked lubricant is the barrier fluid used in double mechanical seals. Although it may be topped off when the level in the seal pot is low, how much thought goes into maintaining the high-quality lubricant needed for extended mechanical seal life?

Seal faces are lapped to within two helium light bands of flatness and are every bit as precise as rolling-element bearings. These lubricants are generally added to a seal pot and are expected to perform for the life of the seal. Conditions to consider include temperature, oxidation, coking of the lubricant, cleanliness, PM needs, scheduled changeout or sampling/testing and possible justification for synthetics. **ML**





Golden Jubilee

Of India's No. 1 Homegrown lubricant brand



SERVO, India's most preferred lubricant brand, marked its 50th year since inception on January 12th, 2022.

SERVO, India's No. 1 lubricant brand, was launched by Indian Oil, in 1972. SERVO is testament to India's indigenous efforts in the petroleum sector, having been formulated at Indian Oil's R&D Centre, one of Asia's most advanced facilities, in Faridabad. Over the decades, SERVO has evolved to producing and marketing an extensive range of 1,200 active lubricant grades and has established an international footprint, with presence in 34 countries. SERVO, a Superbrand, is the undisputed leader and caters to core industries including Defence, Railways, Transport, Power, Coal, Mining, Automobiles and Steel. SERVO has been approved as

lubricant of choice by OEMs lubricants. Addressing the need for sustainability, SERVO has developed lubricant solutions suitable for BS-6 vehicles, EVs and the wind energy sectors.

S M Vaidya, Chairman, IndianOil, said, "SERVO has a 50-year-long history of driving the industry forward in innovation, establishing itself as a brand that has withstood storms of competition and surpassed global benchmarks to reach the heights of glory. Keeping pace with the changing demands over the decades, SERVO is a true reflection of the ethos of Indian Oil to stay attuned to the dynamic changes in the market and customer aspirations."

"Expansion of energy-efficient offerings

is essential to enhance the business competitiveness in a market that is driven by energy efficiency while delivering the highest performance.

V. Satish Kumar, Director (Marketing), Indian Oil said, "The name SERVO has become a statement for the confidence that our stakeholders have in us, of a superior lubricant with cutting edge technology that performs the desired functionality, as expected, at all times. The brand positioning was always in line with this promise in mind. Successfully steering from World Class Lubricants, our tagline today – 'Science of Extreme' aptly reflects the innovation in technology and formulation of products to cater to most advanced vehicles, plants, and machinery across industries.

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