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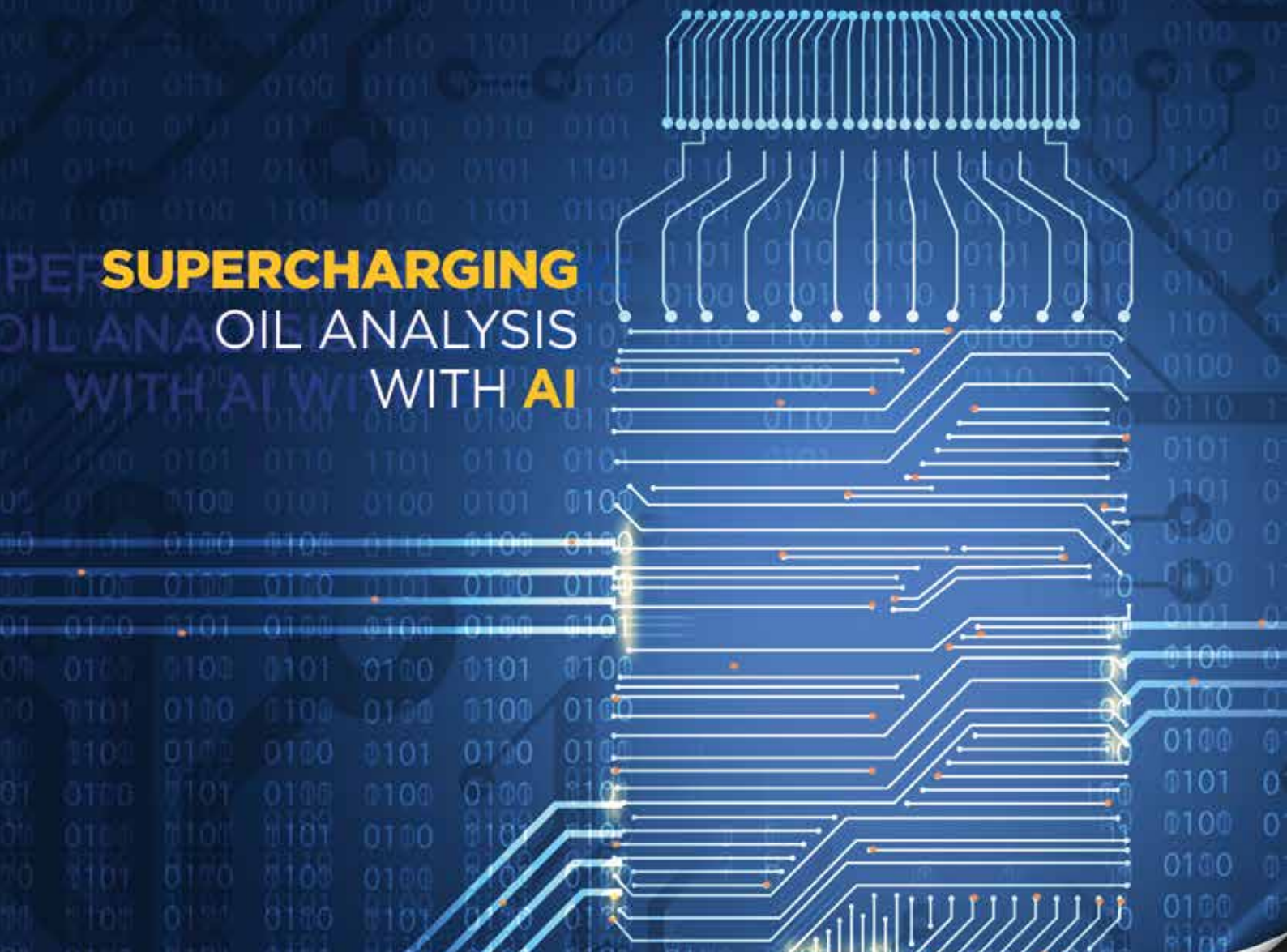
SUPERCHARGING OIL ANALYSIS WITH AI



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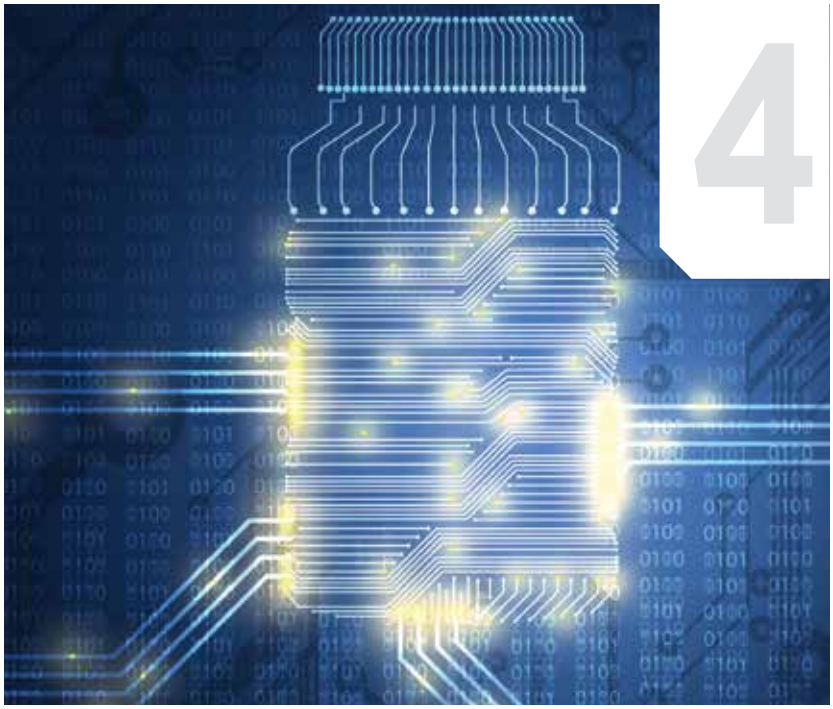
COVER STORY

Supercharging Oil Analysis with AI

The rise of artificial intelligence (AI) and machine learning is allowing the aggregation of oil analysis data into a single platform and the ability to look at assets in a more granular way.



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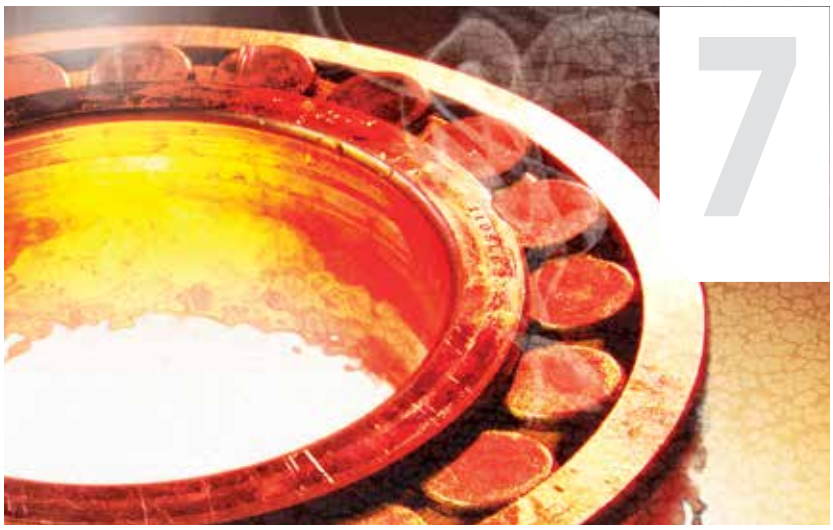
AS I SEE IT

Be Alert to Heat as Both a Contaminant and a Symptom

The first and most pronounced symptom of misalignment and impaired lubrication is excessive heat.



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EDITORIAL FEATURES

Publisher's Note

A good oil analysis program is an integral part of successful lubricant reliability program. With consistent and accurate monitoring of oil, the oil analysis program can help improving bottom line with many benefits like fewer disposals of used lubricants, less labour and less downtime. Developing an effective oil analysis program requires careful planning.

When plant personnel decide to invest in oil analysis, they choose a lab and start sending samples without thinking about what they are trying to achieve. Instead, the program should be developed with a careful plan in place based on a stated series of reliability goals. The overall structure and foundation of an oil analysis program should be based on sound reliability engineering goals. These goals should guide the end user through the process of designing and implementing the program. Of all the factors involved in developing an effective program, sampling strategy has perhaps the single largest impact on success or failure.

With oil analysis, the proverb "garbage in, garbage out" definitely applies. While most oil analysis labs can provide advice on where and how to sample different components, the ultimate responsibility for sampling strategy must rest on the end user's shoulders. Assuming the sampling strategy is correct and the program has been designed based on sound reliability engineering goals; it is up to the lab to ensure the sample provides the necessary information.

The first stage is to make sure the sample and subsequent data is logged in the correct location so that trend analysis and rate-of-change limits can be applied. Diagnostic and prognostic interpretation of the data is perhaps the step where the most antagonistic relationship can develop between the lab and its customers.

Evaluating data and making meaningful condition-based monitoring (CBM) decisions is a symbiotic process. The end user needs the lab diagnosticians' expertise to make sense of the data, while the lab needs the in-plant expertise of the end user who is intimately familiar with each component, its functionality, and what maintenance or process changes may have occurred recently that could impact the oil analysis data. Oil analysis is most effective when it is used to track metrics or benchmarks set forth in the planning stage.

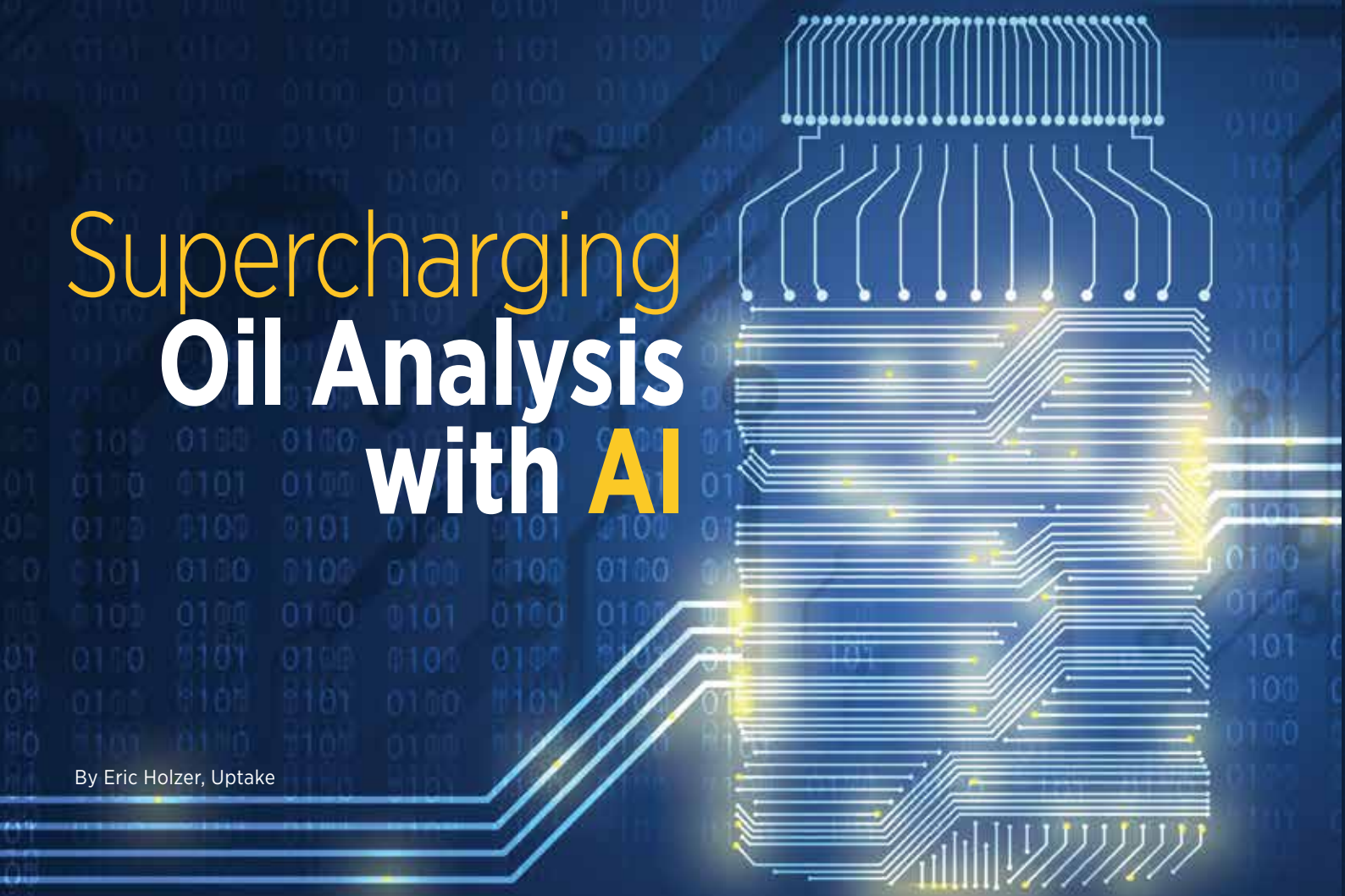
A laboratory likely will not excel in every aspect of oil analysis as one might hope. In order to be competitive, the lab may concentrate its efforts on those areas which are most valued in the market. The problem is many people are often too focused on price and may unknowingly fall short of their end goal by overlooking some of the most important oil analysis principles. Choosing a lab that is located close enough to where samples can be delivered within 24 hours is a must. Most oil analysis test methods are not straightforward but will necessitate having regulations to carefully follow. The regulations may come from standards provided by ASTM, ISO or other comparable standardization organizations. To achieve the end goal of oil analysis, there must be a comprehensive interpretation of the data. The interpretation stage can be challenging to summarize. After the interpretation has been performed, one should expect from the lab to communicate the results in a quality and user-friendly report. The necessary levels of service and quality should not be sacrificed for price. The attainment of the end goal depends on it.

We would like to thank our readers for the great response to our previous edition's cover story – "Base Oil-Building block for Lubricants" and other articles. Our current issue's cover story is "Supercharging Oil Analysis with AI" which will help our readers to understand the rise of artificial intelligence and machine learning.
We welcome your feedback & suggestions.

Warm regards,

Udey Dhir

Supercharging Oil Analysis with AI



By Eric Holzer, Uptake

For many years, the process of analyzing lubricants, coolants and fuels to improve the reliability and maintenance of machines has remained relatively unchanged. Fluids typically are sampled from an asset on a regular cadence and sent to a lab to be processed. The results are interpreted by experts or simple rules-based analysis, and a report is returned. The asset owner must then use the report to decide whether to take action or continue normal operation. Although laboratory analysis produces extremely valuable data, the process can become somewhat cumbersome and may not provide a consistent spectrum of deep insights that asset owners need to increase performance and reliability.

Today, the rise of artificial intelligence (AI) and machine learning is allowing the aggregation of all lab data into a single platform as well as the ability to look at assets in a deeper and more granular way. This is resulting in greater insight that can deliver better precision, consistency and lead times than previous methods.

Fluid Analysis History

Fluid analysis was first pioneered by the rail industry in the 1940s. Railroads quickly realized the analysis of fluids could proactively identify potential issues with diesel engines, air compressors and other rail equipment. By the 1960s, the analysis of industrial lubricants, coolants, fuels and other fluids by commercial laboratories had become common. The data delivered to industry by these laboratories facilitated the transition away from time-based maintenance toward condition-based maintenance for critical components.

Oil analysis is now being utilized for a number of benefits, including root cause analysis, preventive maintenance, condition-based oil changes and proactive component change-outs. For new

equipment, it can be used as a supplement to the data generated by sensors and onboard computers. On legacy equipment with no telematics, it serves as one of the only insights operators have for asset health. The practice of oil analysis has become widely utilized and recognized as valuable across all industrial sectors, including agriculture, aviation, energy, transportation, mining, manufacturing, and oil and gas.

Current Data Analysis Options

Laboratories and industrial companies currently utilize oil analysis data in a number of different ways. While each of the following methods has benefits, there are also some important drawbacks.

Manual Analysis

Manual analysis is the process of employing domain experts to review hundreds of lab samples per day and produce recommendations from those results. For large industrial businesses, this method requires a significant number of trained employees to continually monitor laboratory results. As a quarter of the industrial workforce becomes eligible to retire in the next decade, retaining existing experts while training new, younger technicians will become a growing challenge. Analysts tasked with reviewing many samples on a daily basis across several asset types can experience fatigue. At worst, this can yield missed opportunities for alerting on issues that may result in catastrophic machine failures. In addition, human-centered analysis can be inconsistent due to differing views from analyst to analyst. All of these factors can lead to varying levels of value obtained from laboratory analysis.

OEM-provided Alerts

Manufacturers of industrial equipment and lubricants often provide acceptable levels of wear metals, contaminants and fluid quality. Because of a lack of context concerning the usage of each asset, the acceptable ranges from original equipment manufacturers (OEMs) often lean toward the conservative end of the spectrum to protect the asset. In practice, conservative ranges can produce a high number of alerts where no defect is found on the asset or with the lubrication. For example, a 2017 case study involving a Class I railroad found no defects were actually present in 86 percent of the alerts generated. This lack of precision by the OEM alerts has created distrust in oil analysis at many organizations. Moreover, these false alerts ultimately result in thousands of dollars in unnecessary labor and material costs every year.

Statistical-based Alerts

Statistical analysis is used to build acceptable ranges for lab results based on a representative repository of historical sample data. These ranges are then converted to alerts for each customer. In this method, industrial assets must be paired with a dataset with similar assets

so expected normal ranges can be created. Statistical analysis can produce better alerting than previous methods but is difficult to manage and is dependent on the historical dataset used. Over time, the asset's normal acceptable ranges may change based on operating conditions, weather, age and other factors. Operators also may switch lubricant types or top off the fluids in their equipment. With each change, the accuracy of statistical analysis will inevitably deteriorate over the life of the equipment, and the rate of false alerts or missed recommendations will increase. In the end, statistical analysis proves capable in a never-changing application but often falls short in today's highly variable industrial spaces.

Artificial Intelligence

Fortunately, AI is able to resolve many of the drawbacks of these other methods. AI and machine learning techniques utilize both lab analysis data and asset failure data to recognize the difference between normal and alarming lab results. These techniques can be significantly more precise, as they take into account an asset's full dataset over its lifespan as opposed to relying on acceptable high and low set points to produce recommendations.

By utilizing multiple signals at once, AI can provide very specific recommendations, such as alerting on a bearing failure based on tin, lead and copper content changes in the oil. AI and machine learning can also distinguish the difference between the slow, acceptable rise of soot in a normal operating engine and the fast rise of soot in an engine with an injector issue. Through feedback from the end user, AI and machine learning can even adapt with machinery to ensure false alerts or missed alerts don't occur due to changes in the lubricant manufacturer, machinery age or a new operation.

Some organizations have begun using AI on lab data to obtain better insights from the analysis they already perform. In a recent case study conducted for a Class I railroad, 7,683 assets were tracked using conventional laboratory oil analysis as well as AI and machine learning. Over the course of the study, the AI and machine learning analytics proactively identified twice as many failures as compared to the conventional lab alerts. The AI and machine learning alerts also saw an increase in precision by 3.9 times as compared to the conventional alerts. Additionally, the predictive ability of AI and machine learning increased the number of critical alerts with at least 30 or more days of forewarning by 4.5 times.

This increase in alerts, accuracy and lead time offered by AI and machine learning is causing many organizations to take notice. As the reliability and uptime improvements continue across multiple industries, more and more companies are likely to jump on the AI bandwagon. Will yours be one of them? **ML**

About the Author

Eric Holzer is the fluids analysis lead at Uptake. Contact Eric at eric.holzer@uptake.com.

Be Alert to Heat as Both **a Contaminant and a Symptom**

"When a bearing is running hot, the usual suspects are misalignment and impaired lubrication. Likewise, the first and most pronounced symptom of misalignment and impaired lubrication is excessive heat."

Excessive heat is a severe contaminant. It wreaks havoc on oil (chemically and physically) and retards lubricant performance by increasing wear, corrosion and friction. Friction and wear cause more heat, which sends the machine into a cycle of despair.

Heat must be controlled within the machine's operating limits. This varies considerably between machine types and applications. Lubricants have their own unique limits as well. Attempting to solve heat problems by simply adding a cooler or enlarging the cooler just masks the symptom and prolongs

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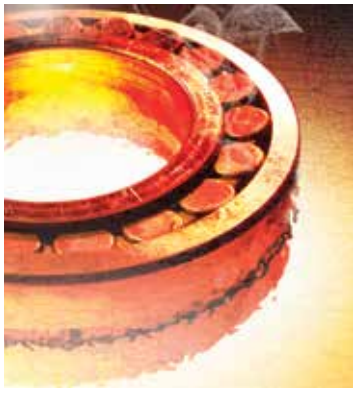

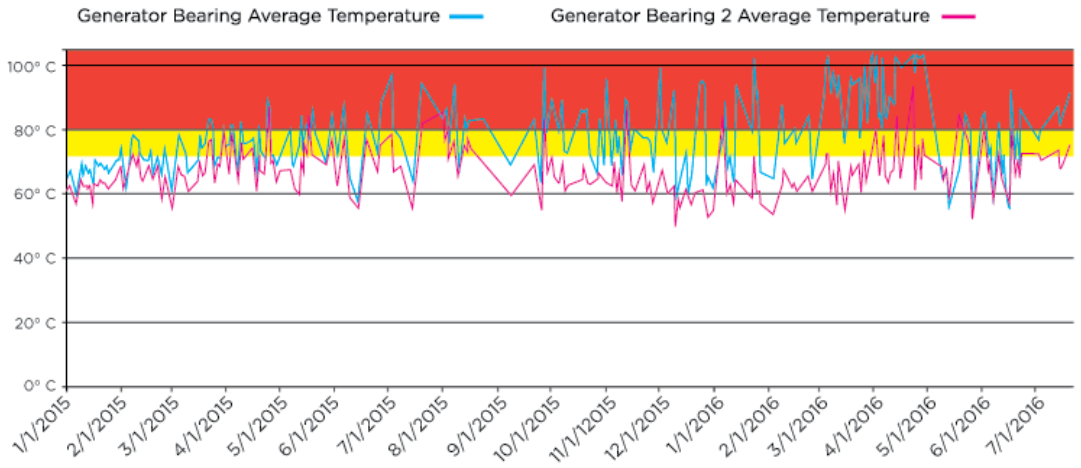

Figure 1. The No. 2 generator bearing experienced lubricant starvation due to grease cake-lock conditions within the housing. The slinger ring failed because of the cake backup, which led to impaired bearing lubrication and tripped the turbine. How was this observed by inspection? Grease was going into the bearing by an auto-luber. However, on the other side of the bearing, only oil was coming out and filling the drip pan. The thickener was logjammed in the bearing, and the oil was pressed through the porous cake (thickener) like a filter press. The bearing temperature rose from 65 degrees C to more than 100 degrees C when it tripped.

Hot-running **Motor Bearings**

An increase in electric-motor temperature of 10 degrees C will cut motor life in half. Motor bearings typically should run less than 160 degrees F (71 degrees C). Often, hot-running motor bearings are associated with overgreasing. Conditions that might be observed include the following:

- Grease leaks onto stator and into rotor windings.
- Grease on windings creates a thermal barrier from the cooling air. This increases the motor temperature.
- Dirt and grime adhere to the grease that enters the windings, causing thermal problems.
- Excess grease in the bearing core results in churning, heat, grease failure and bearing failure.
- High bearing temperature can lead to the inner race slipping on the shaft followed by misalignment. This misalignment causes the stator and rotor winding to make contact and short out.

the solution. Abnormal heat is a telegraphed S.O.S. call that commands attention and remediation.

Critical temperatures on most high-speed and high-value machines are monitored in real time, often at multiple points, such as guide and thrust bearings (typically imbedded thermal couples). A common example of bearing temperature monitoring is shown in Figure 1. Here, a temperature excursion was noticed first before any other symptoms. After inspection, a lubrication issue (cake-lock) was found to be the root cause.

The cake-lock issue was solved by converting to a softer grease and a faster delivery rate. Had the bearing lubrication been more closely monitored by an inspector, i.e., noticing that the drip pan had only oil (not grease), the trip could have been avoided.

Temperature monitoring is a fundamental condition monitoring principle and one of the earliest forms of instrument-based condition monitoring. It is nearly impossible to have a serious or advanced lubrication problem and/or machine component failure without heat being involved as a root cause or symptom. It is often said that when a bearing is running hot, the usual suspects (causes) are misalignment and impaired lubrication. Likewise, the first and most pronounced symptom of misalignment and impaired lubrication is excessive heat.

Whether you're using a heat gun, infrared camera or thermal couple/resistance temperature detector (RTD) to monitor heat in real time, you should have a game plan. For lubricants, the use of thermal lubrication charts (TLCs) or something similar makes a lot of sense. There should be a normal working range (green), cautionary zones (yellow and amber), and red (hot and cold) for life-threatening (catastrophic failure) issues. You can read more about TLCs in the sidebar above. ***ML***

About the Author

Jim Fitch has a wealth of "in the trenches" experience in lubrication, oil analysis, tribology and machinery failure investigations. Over the past two decades, he has presented hundreds of courses on these subjects. Jim has also published more than 200 technical articles, papers and publications. He serves as a U.S. delegate to the ISO tribology and oil analysis working group. Since 2002, he has been the director and a board member of the International Council for Machinery Lubrication. He is the CEO and a co-founder of Noria Corporation. Contact Jim at jfitch@noria.com.

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TLC for **Critical Machines**

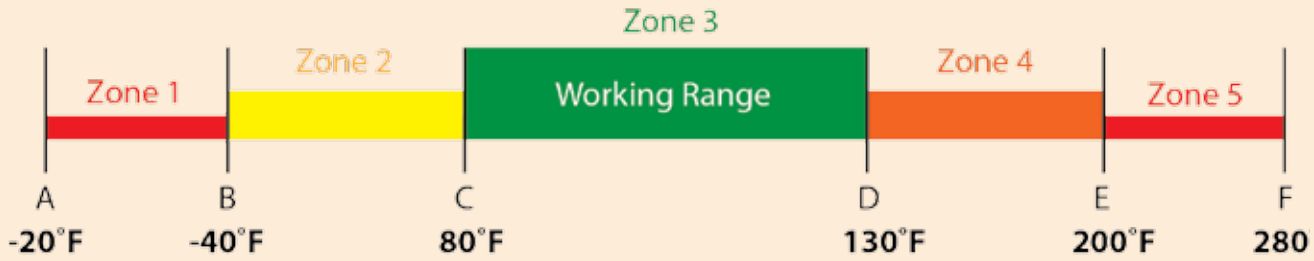
Develop a thermal lubrication chart (TLC) for critical equipment, especially bad actors (as shown below). Define the points (A-F) for a specific location on the machine to be monitored (e.g., a supply line).

The normal working range (zone 3) is banded by temperature points C and D. Temperature excursions below point C are controlled by a heater and alarms. Temperature excursions above point D are controlled by a cooler and alarms.

Sustained operation in zones 2 and/or 4 lowers the service life of the machine and/or lubricant. For instance, operating in zone 2 may retard lubricant flow to the bearings, raise energy consumption and increase the foaming tendency. Operation in zone 4 may accelerate oil oxidation, reduce film strength and increase wear associated with particles.

Operating in zones 1 and/or 5 will threaten machine reliability. Temperature points A and F are sudden-death extremes. Zone 1 is typically a partial lubricant starvation condition, while zone 5 is associated with fire hazards, thermal-oxidative oil degradation, additive depletion, volatilization and high friction/wear conditions.

The use of high viscosity index (VI) lubricants can lower temperature points A through C. The use of high VI and premium-formulated synthetic lubricants helps increase temperature points D and F.

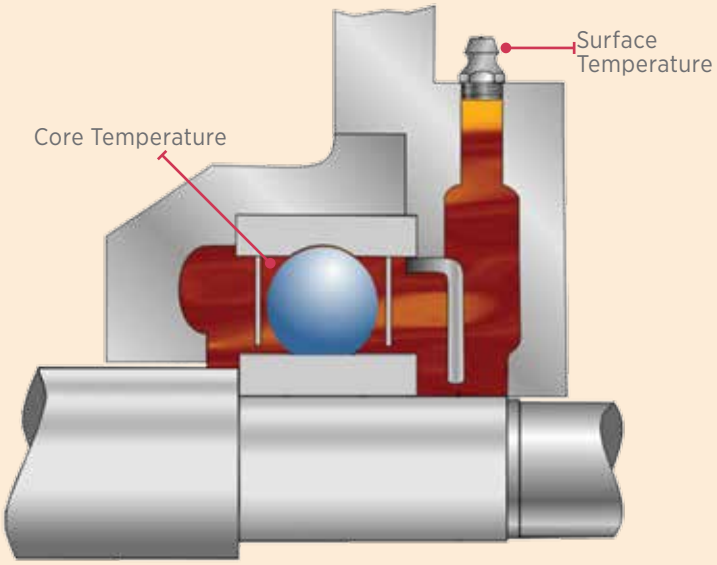


Bearing Temperature **Inspections**

To estimate the rolling-element bearing core temperature, add 15-20 degrees F to the bearing housing or casing temperature from heat gun inspections. However, this internal bearing temperature may be 30-50 degrees F hotter, as influenced by ambient cooling conditions, lubricant circulation, metallurgy, bearing configuration and heat generation factors (such as grease churning and/or high mechanical friction).

For rolling-element bearings running at temperatures higher than 70 degrees C, cut the bearing life by 1.5 (i.e., divide by 1.5) for each increment of 10 degrees C above 70 degrees C.

For circulating oil, there should not be a difference of more than 50 degrees F between the oil going in and coming out of the bearing.



With the vision "To be a leading diversified corporate entity having market leadership in the chosen business segments, consistently delivering value to all stakeholders, with environmental and social responsibility", Balmer Lawrie has been successfully responding to the demands of an ever changing environment and leveraging every change as an opportunity. In a discussion with Machinery Lubrication India, Mr. Sreejit Banerjee- Chief Operating Officer, Balmer Lawrie tells about their journey of emerging leader of the industry.

Sreejit Banerjee is a Petroleum Engineer from IIT-ISM, Dhanbad & a successful Business Leader with cross functional experience in various MNCs for over 25 Years & expertise in Business Development in Indian subcontinent. Currently, he is serving Balmer Lawrie & Co. Ltd. as Chief Operating Officer with P&L responsibility for Grease & Lubricant Business. He is specialised in Management, B2B/ B2C Sales, Acquiring OEM business & Skilled in New Market Entry & Implementing Scale up Strategies & Sustainable Growth. He has Excellent Track record for launching New Brands & making them successful business venture with companies like Shell, Valvoline, Caltex to name a few.

1. How has been the growth in lubricants sales in the last 1-2 years in India? And what do you see the future as?

In terms of volume, the growth is around 2-3% CAGR, however in terms of value many companies particularly the private players have been able to post double digit growth by shifting focus to consumer segment particularly in MCO & PCMO segment, as well as selling more of higher grades including synthetics & largely semi synthetics, lower viscosity grades & being able to grow substantially in Retail/Channel business where margins are higher. The segments that largely affected growth of lubricant business in India are primarily Personal Mobility (MCO/ PCMO), Transport & Fleets & Infrastructure. In our estimates, same trend will continue in next 5 years where we will also see some shift towards higher grades resulting in higher growth rate in value terms.

2. What would be the major challenges that the industry may encounter in the next few years.

The lubricant developer has to achieve the constant scrutiny to improve fuel economy & emission output while also having to raise the performance bar. Transition to lower viscosity oils to improve fuel economy in case of Engine oils / Transmission oils as well as Energy Efficient oils for Industrial application will remain a challenge. Millions of Dollars have to be spent on Engine Tests to make the changes in additive technology / design friction modifiers which ultimately will be passed on to the Oil developer.

The other challenge is what Amin Nasser, CEO, Saudi Aramco describe as "crisis of perception" where multiple stakeholders believe that the in few years entire world will run on anything but oil. But this is factually incorrect. Oil demand is expected to grow with emission standards tightening with more fuel efficient vehicles & this challenge will also impact Lubricants to meet the desired objective.

3. Balmer Lawrie is one of the leading companies in this field.

a) How have you performed and how do you see the next few years as?

"Balmerol " brand owned by Balmer Lawrie is more than 150 years old & we are highly respected by our customers for quality products & services. We are one of the largest Grease sellers in India under Balmerol Brand & in top 10 Grease sellers in Asia. We have been primarily in B2B segment for many years servicing core sector industries like Railways, Defence, Steel Plants and Automobiles (Trucks). We have been growing more than average Industry Standard in last few years both in value & profitability term. The next few years will be quite exciting for us with aggressive double digit growth plan to become one of the significant players in lubricant business in India. Economic Times has recently awarded us Best Brand -2019 in an event in Mumbai based on a study by Nielsen Research which has identified few leading brands in India.

b) What would be your main thrust engines for growth?

We have realized that Balmerol Brand has tremendous potential to grow & to unlock the potential we have made foray into Retail Market with our entire range of Automotive & Industrial Lubricants. Building up a robust distribution network in selected markets will be our thrust area for the next few years backed by strong BTL activities to increase our Brand visibility. We will continue with bringing innovative & high performance products for our customers like Synthplex

Grease which is semi synthetic grease with life of over 2.0 lac KM & entire range of Synthetic Ester based Biodegradable products.

c) What are the major challenges your company may require overcoming in the next few years?

One of the main challenges will be to grow aggressively Pan India basis through building up a robust distribution network & increase brand visibility in a fiercely competitive market. We are going through a transformation process of making it big in Retail Space from being primarily a B2B player where we were well respected for our products & services in Core Sector. Managing these two verticals & continue to grow more than average Industry standard will be a challenge that we need to overcome in next few years.

4. Only a handful of companies have a full-fledged R&D division to support its growth. What are your views on this?

We have the advantage of having our own Application Research Laboratory (fully fledged R&D centre with NABL accreditation) in Kolkata where we have developed high performance specific products like Semi synthetic Grease with life over 2.0 lakh km, Fire Resistance Greases, Synthetic Mould Oils , Biodegradable Products with Synthetic Ester based etc. We are the only lubricant company where we produce synthetic Esters in our in- house Ester plant. We spend around 1.5% of our turnover & 20% of our Profit in our R&D activity.

The biggest advantage of having a set up in India is exposure to our own people, engineers who are working in this R&D centre who can better understand & ability to resolve customer requirement in local condition & atmosphere which may not be matched when someone from USA or UK is visiting the customers once in a while& working at their R&D centre located abroad.

5. The Indian Government is pushing for the growth of the electric vehicles in the country. What impact would that have on the market?

I don't see that this is going to impact us significantly in short term & in another 15-20 years.

However in longer time frame, some business will get definitely affected but the market size & applications where lubricant usage is necessary is big enough & will remain so in next 30-35 years. This is one of the reasons why global companies like Shell, BP & others are still investing heavily in adding capacities & in new Lube blending plants in many countries like China which only indicates growth in overall market size in coming years.

6. Is it true that most multinational lubricant companies focus on speciality lubricants and MWF with (low volume with higher profit margins), PSU's and other mid-sized Indian companies are only looking at basic grades of lubricants (high volume with lower profit margins)? If yes, how do you see the game changing in future?

Every company wants better returns & it is a fact that returns from selling MWF is generally more than selling conventional lubricants where base oils being a commodity today with published Indexes/Pricing anyone has his say on the price of the finished product. However MWF has its own challenges & requires more of After Selling/Maintenance related challenges which are not everyone's cup of Tea. What is slowly happening is companies are trying to get focused on their strength areas where they have competitive advantages over others by which they are trying to shift to better realization. In a country like India with vast geographical area/market, a PSU oil company with Fuel Stations will definitely take their advantage of having a wide distribution network to play on volume while others including MNCs will definitely try to sell with better realization & margin as they will not have the volume advantage to match a player who is into both fuels & lubricants.

7. Government is pushing the "Make in India" concept, but India continues to import lubricants. Would you suggest a higher import duty to encourage local manufacturing?

To excel in any area, we need to be at par with global companies with the ability to manufacture best of products at par with global standard at competitive pricing. I don't think getting protection in any way helps you to be a global leader & be at par with the best in Industries. However it is important for Government to ensure that local manufacturing isn't at any disadvantages with global companies. So local manufacturing need to be encouraged & conditions created to encourage local manufacturing but certainly not by giving protection & restricting others to make local manufacturing an easier option for industries to adopt .Govt's make in India concept should be taken in the right manner & we should be able to produce the best of products in India by creating a business& overall environment to be able to make the Best Products here in India. When Indian people can work in Global companies in other countries & make the best of products in USA, they will be able to do so here as well & it is necessary to create that environment.

8. What you have to say about 'Green' manufacturing initiatives?

We need to create an overall environment & infrastructure to adopt Green manufacturing initiatives. It cannot be only restricted within the boundaries of the manufacturing facilities.

The entire supply chain has to be in line with this initiative as well as when it comes to disposals of wastes. It is actually a culture & overall environment to encourage this cultural change that is required. It can't be by bits & pieces that this change can take place & requires quite an Intent & encouragement & support from Government to make this change. Long way to go.

9. What's your personal vision for Balmer Lawrie?

I would like to see Balmer Lawrie, Greases & Lubricant business to grow & acquire 5% market share in next 3 years. We will also make our Retail Channel business to cross 20,000 KL level in next 3 years where we are currently focusing. At the same time we will retain our leadership position in Greases & in some Segments where we still supply products on proprietary basis. We will make continuous investments in our R&D centre, in developing new products & in our people.

4 Things Every Hydraulic Troubleshooter Should Know

"All maintenance personnel should have the knowledge and skills to troubleshoot and maintain in-plant systems."

The philosophy at many plants is that if the hydraulic system is operating the machine, don't mess with it. Frequently, the only hydraulic maintenance ever performed is changing the filters, checking the oil level and performing oil analysis. I recently consulted with a corrugated box plant where the return filter had not been changed since the plant started up 17 years ago.

When a hydraulic issue occurs in a plant, it normally is fixed by a parts-changing process. This is expensive in the cost of the parts and plant downtime. All maintenance personnel should have the knowledge and skills to troubleshoot and maintain in-plant systems. The following are four things every hydraulic troubleshooter needs to know.

1. The Function of the Components

When a hydraulic problem occurs, the machine is visually inspected for busted hoses, pressure on the gauge, low oil level and if the electric motor is tripped out. If nothing obvious is found, a parts-changing process begins. Guess which component is usually changed first? If you said the hydraulic pump, you'd be right. One of the biggest misconceptions is that a pump supplies pressure. Pumps deliver volume or flow. Pressure is only created when there is resistance in the system. Many a good pump has been changed because the gauge showed little or no pressure. This

Valves located in a stack may look alike but perform completely different functions.

is a perfect example of the hydraulic troubleshooter not knowing the function of the pump in the system.

Before any troubleshooting begins, maintenance personnel should understand the function of all the system's components. They can't always be identified simply by looking at them. One valve may look like another but perform an entirely different function. Many valves have a symbol on the housing tag to indicate the type. This is the easiest way to distinguish valves, but it is of no use if the maintenance person isn't familiar with hydraulic symbols.

2. Troubleshooting Procedures

A hydraulic troubleshooter must know the proper procedure for verifying whether a component is good or faulty. In most cases, a quick check or test

Check the oil flow out of the relief valve's tank line to assess whether a fixed-displacement pump is worn.

can be performed. For example, to assess whether a fixed-displacement pump is badly worn, check the oil flow out of the relief valve's tank line. With the pump off and the electric motor locked and tagged out, remove the tank line of the relief valve and port it into a container of a known size. Time the flow for one minute. The pump's rated flow should fill the container in one minute's time. If the pump volume is larger than the container, an alternative method can be used. Fully turn the relief valve adjustment counterclockwise. Next, turn on the pump and observe the oil as it flows into the container. Gradually rotate the relief valve clockwise. If the flow rate drops as the pressure is increased, the pump is bad. If the flow rate does not change, the pump is good. Extreme caution should be used when conducting these tests so as not to expose yourself to high-pressure fluid.

Accumulators are commonly used to supply additional volume, absorb shock and maintain pressure in the system. They typically are pre-charged with dry nitrogen. For the accumulator to perform appropriately, the nitrogen pre-charge must be correct. There are three easy methods to verify whether an accumulator is operating properly.

The first method is to turn off the hydraulic pump and allow the pressure to bleed down to 0 pounds per square inch (psi). Install a charging rig with a gauge on the accumulator's Schrader valve. The nitrogen pre-charge will be indicated on the gauge.

Another method is to watch the pressure gauge as nitrogen forces oil out of the accumulator shell when the pump is turned off. The pressure will gradually fall and then rapidly drop to 0 psi. The pressure at which the needle quickly drops to 0 is the pre-charge pressure.

The final method is to shoot the sides of the accumulator shell with a temperature gun or infrared camera. The shell should be warmer in the lower half or two-thirds when the pre-charge is correct.

I recently consulted with a plant where several accumulators were found to be undercharged. When an accumulator is undercharged, less volume is delivered to the system. Once properly charged, the machine's line speed was increased to reach a higher level of production. These pump and accumulator examples are indicative of the quick tests that can be made to determine whether a component is operating correctly.

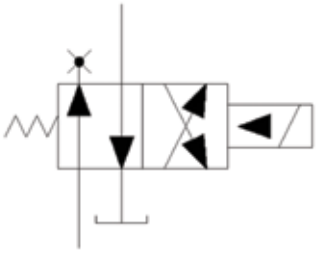
3. How to Adjust the System

One of the main problems, if not the biggest problem, is that random adjustments are made on a system in an attempt to speed up the machine or fix a problem. Often, an adjustment is made, but if no change in machine operation is seen, it is assumed that nothing has changed in the system.

At one plant, the local "knob turner" thought a hydraulic pump was too noisy, so he turned the compensator adjustment clockwise and cracked open a manual valve in the line immediately downstream. The pump's noise level dropped somewhat, so he left, thinking he had solved the problem. Several hours later, the machine shut down because the oil temperature had risen to 160 degrees F. An electrician was called, who promptly jumpered out the high-temperature shutdown switch. Some 24 hours later, the oil temperature rose to 300 degrees F. The machine then had to be shut down and flushed with an expensive solvent to remove varnish and sludge from the system.

By rotating the compensator clockwise, the knob turner set the compensator above the relief valve's setting. This enabled the pump volume to return to the tank at a high

A commonly used directional valve



The hydraulic symbol for a directional valve

pressure, generating heat when not required in the system. Opening the manual valve allowed some of the pump's volume to return to the tank at all times under high pressure, generating even more heat.

All maintenance personnel must be trained to precisely set pump compensators, relief valves, flow controls, pressure-reducing valves and pre-charging accumulators. If this is not done, shock, leakage, overheating, component failure and damage to the machine can result.

4. How to Read Hydraulic Symbols

A schematic should be used to effectively troubleshoot a hydraulic problem. Therefore, maintenance personnel must know how to read hydraulic symbols in order to troubleshoot from the schematic. A commonly used directional valve is shown above along with the symbol for the valve. This symbol indicates five things about the valve: it is normally open (with a pipe plug in the "A" port), has two positions, is four-way, is solenoid-controlled and hydraulic-piloted, and has a spring return.

Without reading the symbol, the only thing that might be identified by looking at the valve is that it is solenoid-controlled. Not knowing the valve's five attributes would make troubleshooting much more difficult.

A valve often is installed on a machine simply because it looks the same as the original valve. If even one letter or number is different, it must be discovered before the valve is changed. When one plant replaced a valve that had a single number difference between the original and the new valve, it resulted in eight hours of downtime at a cost of $12,000 per hour.

If your maintenance crew is not trained on these four things, they likely will do the best they can when an issue occurs, which usually means changing parts until the problem is solved. Frequently, many parts are changed and the machine is fixed, but no one learns anything. By properly training your maintenance personnel, you will spend less on equipment parts, reduce your hydraulic-related downtime and enjoy a safer workforce. ***ML***

About the Author

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7 Steps to Trouble-free **Grease Lubrication**

"Machine greasing must be a systematic and carefully planned process to ensure safe operation of assets and to achieve maximum equipment life."

In January 2000, a tragic event occurred off the coast of California. Alaska Airlines Flight 261 was flying to San Francisco from Puerto Vallarta, Mexico. When the pilots realized the unexpected response from their flight controls, they first attempted to troubleshoot out at sea to minimize the risk to people on the ground. In the terrifying last moments, the pilots tried heroically to fly the plane upside down after the uncontrollable horizontal stabilizer had caused the plane to invert. All aboard were lost.

The investigation began with the recovery of the wreckage, including retrieval of the horizontal stabilizer from the ocean floor. Incredibly, the investigation team was able to recover grease from the stabilizer jackscrew for analysis. The grease analysis, along with inspection of the jackscrew threads, revealed that the stabilizer control had been completely lost as the threads stripped away. The root cause was determined to be inadequate

lubrication of the threads and deferred maintenance inspections, which included measuring wear on the threads.

Among the issues discussed in the investigation was a change in the grease used in the jackscrew. Over the history of operating these planes, the manufacturer presented an alternate product as being approved for use, but there was no documentation of any compatibility testing between the previous grease and the new one. While not a contributing factor in the failure of Flight 261, the investigation suggested that product changeovers could create the condition of mixed lubricants if the previous product was not completely removed, and that this should be a concern for future maintenance activities.

Most lubrication actions are not life-or-death decisions, but the same sort of damage that led to this tragedy is seen on a daily basis in grease-lubricated components around the world. The result of their failure can be unexpected downtime, higher maintenance costs or even personnel safety risks. In the worst cases, human lives may be at stake. It is time to stop treating grease as some simple substance that just needs to be pumped into machines at some random frequency and then hoping for the best. Machine greasing must be a systematic and carefully planned process to ensure safe operation of assets and to achieve maximum equipment life.

Whether your asset mission is critical, or you are just looking to optimize operating costs, the following steps are important for trouble-free grease lubrication:

1. Choose the Right Grease

"Grease is just grease." The death of many machines begins with this statement of ignorance. This perception is not helped by oversimplified instructions from original equipment manufacturers. "Use a good grade of No. 2 grease" is the extent of guidance given for some equipment. However, if long, trouble-free asset life is the goal, then the selection of grease must include the proper base oil viscosity, base oil type, thickener type, NLGI grade and additive package.

2. Determine Where and How to Apply

Some machine locations have a prominent Zerk fitting, and the choice of where and how to apply grease seems obvious. But is there just one fitting? My dad is a farmer, and when he purchases a new implement, his first action is to review the manual or survey all parts of the machine to determine the number of greasing points. He then creates his "lubrication procedure," which consists of writing the total number of fittings and hints on where the tricky ones are hidden with a permanent marker on the machine.

In other cases, the application point may not be obvious or may require special tools for proper application. For threaded applications, like the jackscrew mentioned previously, achieving sufficient coverage of the threads can be challenging. Tools exist to help ensure complete coverage of valve stem threads, for example, which can make a big difference.

3. Select the Optimal Frequency

Unfortunately, many maintenance programs decide on the grease lubrication frequency out of convenience. Rather than consider the conditions of each machine and how quickly a specific grease will degrade or be contaminated, some generic frequency is selected and applied equally to all. Perhaps a route is created to grease all machines once per quarter or once

35%

of lubrication professionals never inspect the grease discharge from bearings and other machine components at their plant, based on a recent survey at MachineryLubrication.com

per month, and a few shots of grease are applied at each point. However, "one size fits all" rarely fits any optimally. Tables and calculations exist for identifying the correct frequency based on speed and temperature, and adjustments can be made according to estimates of contaminant levels and other factors. Taking the time to establish and then follow a proper lubrication interval will improve machine life.

4. Monitor for Lubrication Effectiveness

Once the right grease has been selected and an optimized relubrication schedule developed, it is still necessary to evaluate and adjust as needed due to differences in field conditions. One way to test lubrication effectiveness is with the use of ultrasonic monitoring. By listening for sounds generated by asperity contact in ineffective bearing lubrication and determining the amount of grease required to restore the bearing to the correct lubricated condition, you can make adjustments to the calculated values and achieve precision lubrication.

5. Use the Proper Method for Grease Sampling

In addition to the use of ultrasonic monitoring, feedback on greasing effectiveness can be obtained through grease analysis, but first a representative sample must be taken. New tools and techniques for grease sampling have recently been developed. Although grease analysis doesn't happen as often as oil analysis, it can prove beneficial in monitoring the equipment condition, lubricant condition and lubricant life.

6. Choose the Appropriate Test Slate

Maximum equipment life can be achieved by ensuring grease lubrication is effective. This also results in minimal wear. Detection of wear quantities and modes can help you make adjustments and discover problems earlier. It is important to monitor in-service grease consistency, as grease that softens too much can run out of the machine or fail to stay in place. Grease that hardens can provide inadequate lubrication and increase the load and electrical consumption. Grease mixing with the wrong product is one of the most common causes of failure. Early detection of this condition can allow purging and restoration before significant damage takes place. Tests to measure the quantity of moisture and particle counts in grease have been developed. Utilizing them to identify contaminant ingression, or just plain dirty greases, can present the opportunity for life extension through the use of clean greases and more effective sealing mechanisms.

7. Implement Lessons Learned

While even a single bearing failure is regrettable, it is worse still when the opportunity to learn from it is squandered. I'm often told there is "no time" to save bearings and document as-found conditions following a failure. The focus is on restoring production. Broken parts are thrown away or put in the parts washer where the evidence of the failure is washed away. If a failed part and the grease can be recovered from the ocean floor, you should be able to save these components following a plant failure.

Understanding the reasons a failure occurred doesn't just impact the restoration of the machine but can have a multiplied effect on the reliability and life of other components across the enterprise. Ensure that root cause failure analysis includes inspection of the bearing surfaces, but first start with preservation and then removal of the grease for analysis. Combining results from the lubricant analysis with the bearing analysis will create a more comprehensive picture of the failure and help you determine which corrective actions can be used to prevent it from happening in the future. ***ML***

Mohammad Aatif | VAS Tribology

SUPPLIER SELECTION TIPS

5 Top Things you Should Expect from your Lubricant Supplier

"Apart from the obvious, low cost and high performance lubricants, there are many other important things that users need to seek from their lubricant supplier."

Lubricant suppliers are among the vital stakeholders in your reliability excellence program. When we think about choosing a supplier, there are two things that come in mind, cost and performance. Though these are important, but these are not the only things that users need to focus on. The reason we procure a lubricant is not just to run the machine but also to reduce friction and wear so that asset life can be increased. In order to achieve these goals, emphasis should be given on selection of your lubricant supplier. This article discusses about the top five things that your supplier should consider providing you, apart from the cost and performance benefits.

1. Fresh Inventory

Will you buy a medicine which is about to expire in a month or the one which has longer expiry period? Obviously you will choose the latter one. Same is applicable for lubricants also. Lubricants also have its expiry date, called shelf life. Shelf life is a key consideration in proper inventory-management practices for packaged lubricating oils and greases. It ensures that it is suitable for use and delivering

performance as promised in the intended applications. Like bread, milk and medicine your lubricant also starts degrading over a period of time. Unfortunately, it does not behave like wine .

Old inventory may have several problems. Over a period of time, inappropriate storage may lead to settling of additives, excessive oil bleeding in grease, contaminants might get inside your drum, and extreme temperatures will act as a catalyst for lubricant degradation. Level of degradation will vary based on different storage conditions. Imagine if you put these degraded lubricants in your machine, they are likely to do more harm than good.

To avoid getting old and degraded lubricant from supplier end, it is better to mention in the Purchase Order (PO) that supplied lubricant should be blended within six month from the date of delivery. Interestingly, it has been observed that sometimes old inventory is supplied at a discounted price. Fresh inventory will always have lesser contamination and better chances of performing well. To avoid use of old and degraded lubricant at your end, implement strict First in First out (FIFO) at you facility.

Shelf life can be verified on the top of the pack. Supplier usually mentions the date / week of manufacturing. Some manufacturers also use codification system for blending date and plant information, which the buyer should be able to interpret.

2. Quality Certificate

Quality certificate tells you about the basic properties of the newly blended lubricant. Lubricant deliveries should always be accompanied by quality certificates for each lot. It can be either in the form of a hard copy or a soft copy. There should be no hesitation in asking for quality certificate from the lubricant supplier as it is not an element of distrust but a process of quality verification.

For oils, generally quality parameters like Viscosity, Viscosity Index, Flashpoint, Acid / Base Number, Cleanliness etc, are mentioned in the quality certificate. For grease, Dropping Point, NLGI Class, Base Oil Viscosity etc, are included in the test certificate. The certificate is mostly batch wise.

3. Lubricant Analysis & Interpretation Service

You often get welcome drink once you check into a hotel, so how about getting complimentary oil analysis from your lubricant suppliers?

Some of the lube manufacturers do provide oil analysis and diagnostics to enhance maintenance programs. They offer oil analysis and assist maintenance professionals in the early detection of lubrication problems and in predicting future machine reliability. They will be able to test their brand of lubricant with basic properties like Viscosity, Viscosity Index, Moisture, Elemental Analysis, Acid Number, Base Number etc. The idea of this analysis is not be to replace commercial Oil Analysis (OA) labs but to cross check the test results given by commercial oil analysis labs. However, for less critical machines, OA results provided by the lubricant supplier can be used to take maintenance decisions.

4. Validation of Supplier's Storage Practices

Lubricating oils and greases are formulated to satisfy specific kinds of service. Sometimes suppliers follow inadequate storage practices. Just like a refrigerated medicine loses its properties as it cannot be restored if it gets exposed to high/ abnormal temperature. Similarly, lubricant loses its property as well. Common causes of lubricant contamination, deterioration, and wastages in storage and handling includes— exposure to dust or chemical fumes, poor outdoor storage practices,

moisture, exposure to excessive heat or cold etc. The Idea of validating the supplier's storage practices is to ensure that your lubricants are treated well before they reach you.

5. Technical Expertise

Your lubricant supplier must have competent, preferably certified, Technical Support Engineer (TSE). TSE guides or recommends a particular product for your application and troubleshoots in case you find something abnormal in the lubricant. They should also guide you in creating awareness, providing training and seminars and performing regular lubrication audit. They can also assist you in lubricant consolidation.

Conclusion

Selection of a good lubricant supplier is important, as it is closely linked to your reliability program. Hence price of the lubricant should not be the only guiding principle in the selection of the supplier. The five top parameters discussed in this article should also form the basis of selection. If proper attention is given to the selection of the Lube supplier, then it will pay rich dividends in the long run through bottom line savings.

About the Author

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Understanding the Link Between Lubrication **and Maintenance Strategies**

"WITHOUT A PROACTIVE MINDSET, EQUIPMENT FAILURES WILL **CONTINUE TO PLAGUE MOST MAINTENANCE DEPARTMENTS.**"

Maintenance is frequently regarded as a necessary evil and tends to be delayed or cancelled to meet production demands. Taking equipment out of service to make repairs or improve functionality can be a tough sell, especially if the only maintenance activity is lubrication. As industry has evolved, so have the practices and philosophies for how and when to perform maintenance and lubrication. More options and tools are now available to guide the actions of personnel for nearly all lubrication tasks. However, to truly understand how this evolution has changed the landscape, you must know where maintenance began and where it is today.

Maintenance Philosophies

Most people are familiar with the term "reactive maintenance." This approach involves repairing machines only after a breakdown or failure. Too often, reactive philosophies are adopted by organizations that are short on manpower or stuck in the "that's how we've always done it" mentality. This leads to overblown maintenance budgets, poor operational performance and a staff that is constantly firefighting. As someone who worked in a reactive mode for years, I can attest to the stress it puts on your team. For instance, it was difficult to know when you were going home each day, if at all. Even on weekends or holidays, there was always the risk of being called into work. This maintenance philosophy is not sustainable and has largely been relegated to non-critical or small pieces of equipment.

In an effort to move away from the reactive state and in cases where safety is paramount, planned or scheduled maintenance was implemented. Known as preventive maintenance, this approach entails having a set period or interval when maintenance is scheduled and then performed. The airline industry provides a good example

of this philosophy. Running an airplane engine until failure is not an option because of the safety ramifications. Therefore, maintenance is scheduled based on the number of hours or flights. The same practice was adopted in industry. This included closely following original equipment manufacturer (OEM) recommendations or intervals to prevent a failure. You probably use a similar method with your vehicle's maintenance. By introducing a scheduling component to your maintenance activities, you can add some direction and continuity to a daily process. Although preventive maintenance can help reduce the chaos of failures, it can still result in high maintenance costs when good parts are replaced.

More recently, new tools and accessories have become available to aid in equipment monitoring and catching potential issues earlier. This monitoring of failure symptoms and faults is known as predictive maintenance. The most common forms of this approach include using vibration analysis, ultrasound, thermography, oil analysis and a host of other technologies to provide an early warning of an impending problem. Predictive maintenance works well for machines that run continuously and often results in a reduction of unplanned downtime. However, it usually comes with considerable upfront costs, not just for the necessary tools but also in training the individuals who are expected to capture the pertinent data. Diligence is required to ensure data is collected from the same place and in the same manner each time. Inconsistent practices will skew the data and make it much more difficult to take appropriate action.

Rather than fixing machines, proactive maintenance eliminates what causes them to fail. It can be used to extend equipment life, as opposed to simply improving the process for repairs or identifying when a machine is going to fail. Proactive maintenance focuses on the root causes of failure and addresses them before they lead to an eventual problem. Much of proactive maintenance occurs before a machine is ever turned on, including alignment and balancing. Without a proactive mindset, equipment failures will continue to plague most maintenance departments. Analyzing what went wrong and taking steps to prevent it from happening again are the hallmarks of being proactive.

Lubrication Activities

In a lubrication program, there are tasks for applying lubricants, analyzing their state and eventually disposing of them once they reach the end of their useful lives. Beyond these front-line tasks are management activities to ensure work is completed properly. Perhaps the simplest lubrication task involves the use of a grease gun. However, these devices have been improved in recent years and now incorporate advanced technology. Before utilizing a grease gun, be sure to consider the task in relation to the different maintenance philosophies discussed previously.

Reactive Greasing

You've likely heard the phrase, "the squeaky wheel gets the grease." When performing lubrication in a reactive state, you wait until an issue is experienced before adding grease to a bearing or machine. But greasing in response to a noise or elevated head is very reactive. By the time these symptoms arise, damage has already occurred.

Preventive Greasing

Greasing a machine according

4 Oil Analysis Strategies

Oil analysis falls into the realm of condition monitoring but can be used in various ways to determine what is happening inside a mechanical system. It also can be divided into four different strategies:

REACTIVE – An oil or grease sample is taken only after a potential problem is identified via a sensory inspection.

PREVENTIVE – Routine samples are extracted, but the results are not analyzed.

PREDICTIVE – Good samples are obtained and analyzed, with action taken on results from the lab.

PROACTIVE – New lubricants are sampled prior to service. Samples are taken from the right place, in the right way, using the right tests and with the right interpretation strategy.

to a calendar date or number of operating hours is pervasive in the industry, but adding grease based on time may lead to overgreasing or undergreasing the machine. Although it can help prevent some failures, a lot of manpower will be used to maintain the preventive maintenance (PM) program.

Predictive Greasing

Predictive tools for greasing have gained popularity in recent years due to their ability to identify precise intervals and grease volumes to add. Ultrasound is frequently employed to listen to a bearing and detect if and how much grease is needed. This type of greasing requires an educated staff and the necessary tools, but it can greatly reduce, if not eliminate, the likelihood of overgreasing a machine. Grease sampling and analysis are also becoming more widely used to determine the health of the grease and the machine as well as the optimum relubrication frequency.

Proactive Greasing

By balancing all the best practices, you can be more proactive with your greasing. This begins with selecting the right grease for the application. For critical applications, it may also include sampling the grease prior to use to verify its cleanliness. Also, perform the appropriate bearing calculations to confirm the correct grease volume and to guide your future activities.

This same methodology applies to oil applications. While you may rely on the rotating motion of a machine to apply oil to various internal components, you control many other factors that can provide an indication of success. The workload will vary greatly depending on the mindset of the individual or organization.

Reactive Oiling

Oil is often manually applied from a top-up container or aerosol can based on an abnormal inspection result, such as a sight glass showing a low oil level or a chain that appears dry. Action must be taken immediately in these cases to ensure no lasting damage occurs. With splash-lubricated machines, an oil level that is too low can have catastrophic effects. This also would apply to changing the oil only after it has long exceeded its service life.

43%

of lubrication professionals say their plant uses a proactive maintenance strategy, based on a recent poll at Machinery-Lubrication.com

Preventive Oiling

Changing your oil based on a time period or operational interval is common for most non-critical or small-volume machines, but it can lead to replacing oil that is still good or going far too long between oil changes. This can be wasteful both in terms of manpower and lubricant.

Predictive Oiling

Using oil analysis to identify the proper oil change interval is the best approach for large oil volumes and critical machines. When an oil sample is tested, you can distinguish many of its characteristics and determine whether it should remain in service and how much more life it may have. This greatly improves your decision-making ability and can minimize the impact of a lubricant failure by planning for a shutdown or switching to an auxiliary machine.

Proactive Oiling

To be proactive when oiling a machine, you must eliminate the root causes of failure. This is accomplished by ensuring the proper oil is applied and that it is clean and defect-free. Your storage and handling practices should be examined and improved to make certain that lubricants are as clean as possible when they reach the machine. This includes filtering the oil prior to service and using transfer containers that can be hermetically sealed. These practices will reduce the number of failures experienced at your plant.

Don't Overlook Inspections

Inspections are often overlooked as the foundation of a world-class lubrication program. Personnel who walk by machines every day are the greatest source of information to drive your program forward. While I've outlined various ways to use the results of inspections to make better lubrication decisions, greater emphasis must be placed on the inspections themselves. Just having a checklist or making simple rounds is not enough. Dig deeper into what you notice about the machine, sight glass or breather. This will be an extremely valuable activity that will bear fruit in all aspects of maintenance, regardless of the philosophy employed. ***ML***

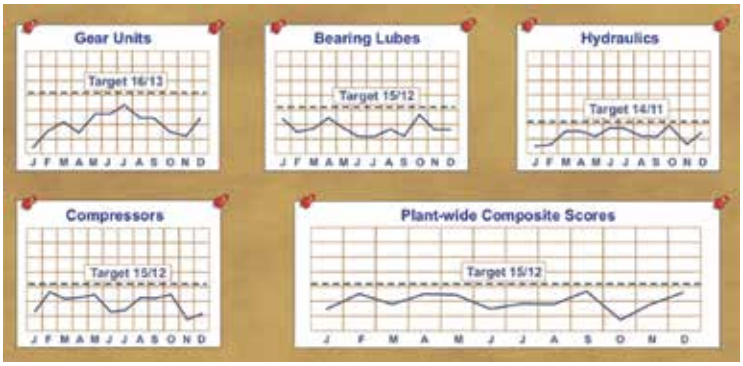
About the Author

Wes Cash is the director of technical 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 II and Machinery Lubrication I and II training courses. Wes holds a Machine Lubrication Technician (MLT) Level II certification and a Machine Lubricant Analyst (MLA) Level III certification through the International Council for Machinery Lubrication (ICML). Contact Wes at wcash@noria.com to learn how Noria can help you transition from reactive maintenance to proactive maintenance practices.

KPIs for Measuring **Lubrication Program Success**

"Consider using KPIs to help you make better decisions that can lead to a more successful lubrication program."

"What gets measured gets managed" is a popular quote from business guru Peter Drucker. While it may seem obvious that key performance indicators (KPIs) or metrics play an important role in the success of a lubrication program, what is not as apparent is defining the best metrics for assessing the program's current status and guiding it to the desired level. This article will explain how to select the right KPIs and implement them effectively.



General KPIs

One approach for developing a system of metrics is to visualize the program from a high-level perspective. What are the program's goals? They should be stated as specifically as possible and include a time frame for completion. Examples would be to improve the lubrication assessment score by 30 points within two years, to reduce bearing failure rates by "X" percent in three years, to implement oil analysis for 100 percent of the critical machines by the end of the year, or to install a new lube room in 12 months.

	GOAL	EXAMPLE OF KPI
1	Retrofit all critical equipment with proper accessories to improve lubricant contamination control, machine inspections and oil sampling within six months	**Report the percentage of machines that were retrofitted monthly**
2	Install a new lube room in 12 months	**Bi-monthly record showing the percentage of the project completed**
3	Complete lubricant changeover and consolidation in the second half of the year	**A. Report the number of machines in which the changeover has been completed during the month B. Report the cumulated percentage of retrofitted machines**

Temporary Goals and KPIs

Some of these examples are more specific than others, but they all refer to relevant program initiatives. General objectives typically will be complemented with more explicit targets. Setting a time frame will be essential to

ensure program accountability. The time should be realistic based on the available resources but also challenging in order to achieve the expected results in a reasonable period.

An effective system of metrics will monitor whether the program's goals are attained (implementation KPIs) and maintained (continuous KPIs). These types of metrics can identify areas that are performing well, others that require attention and those that will be helpful for estimating the benefits of the chosen strategy.

Temporary vs. Permanent KPIs

Temporary KPIs refer to transition or implementation periods. They should be used while the project or any changes relating to the transitory goals are ongoing. Examples of these types of goals and KPIs are shown in the table on page 38.

The chart on the right highlights an implementation metric used as an indicator for monitoring and reporting the success of a lubrication program.

Permanent KPIs report or monitor processes, tasks, routines or conditions that have already been implemented and are expected to be in place for a long time. Most of the metrics discussed in this article would be considered permanent KPIs.

General vs. Specific KPIs

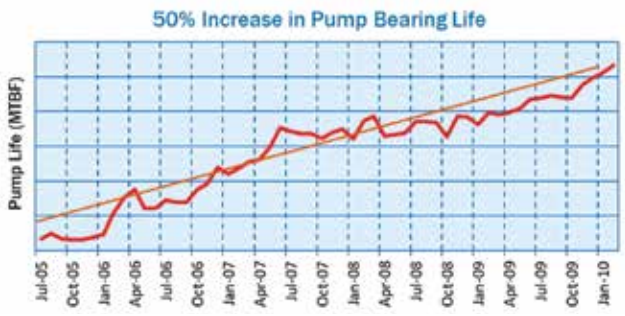
It is possible to have more than one KPI for each goal. In addition, just as specific goals may be part of a more general goal, general KPIs can be a combination of more specific metrics. See the examples in the table on the right.

Macro vs. Micro KPIs

Macro and micro KPIs are a variation of general and specific KPIs. A micro KPI may be categorized by machine, individual, task, etc. On the other hand, a macro KPI could be a summary of various micro indicators condensed into a general metric. An example of a micro indicator would be to determine if the contamination level of particles in a hydraulic system is within the target range. The answer or indicator is simply "yes" or "no." The macro indicator would be the total percentage of hydraulic systems with a cleanliness level compliant with the target. An even more general KPI would be the overall percentage of machines, including compressors, gearboxes, etc., that complied with the cleanliness level. See the illustration on page 38 for how general KPIs can be represented.

Leading vs. Lagging KPIs

Lagging indicators monitor events that happen as a result of a process or sequence of actions. They may trigger a corrective action or reactive maintenance. Examples of these types of KPIs would be the number of oil analysis reports with abnormal conditions, the number of individuals requiring specific training, the percentage of machines with abnormal vibration, etc.



Leading indicators are focused to anticipate potential failures or "non-conformities" and alert when action should be taken. These KPIs may report oil analysis results of the incoming lubricant, failure modes and effects analysis (FMEA) of new machines to be

	GOAL	KPI
GENERAL	Retrofit all critical equipment with proper accessories to improve lubricant contamination control, machine inspections and oil sampling within 12 months for the organization's three plants	Report the percentage of machines that were retrofitted monthly in the three plants: Total % = (1/3) (Plant A% + Plant B% + Plant C%)
SPECIFIC	Retrofit all critical equipment with proper accessories to improve lubricant contamination control, machine inspections and oil sampling within 12 months	Plant A% Plant B% Plant C%

General vs. Specific KPIs

	MICRO (TREES)	MACRO (FOREST)
LEADING (What will happen)	• Particle count • Viscosity • Elemental analysis • Varnish potential • Moisture analysis • Oxidation stability	• Contamination control compliance • Fluid properties compliance • PM compliance
LAGGING (What just happened)	• Wear debris analysis • Thermography • Vibration analysis • Acoustics	• Percent planned maintenance • Uptime/downtime • Overtime hours • Scheduled/unscheduled downtime

Macro/Micro and Leading/Lagging Indicators

installed, oil analysis information on an oil's varnish potential, etc. The table on page 40 includes a combination of macro/micro and leading/lagging indicators.

Lubricant Life Cycle Metrics

For a complete report on the lubrication program's status or progress, a comprehensive system of KPIs will be necessary to monitor the different elements. A good approach is to consider the lubricant life cycle within the facility, including lubricant selection, reception and storage, handling and application, contamination control, lubricant analysis, disposal and safety requirements.

Lubricant Selection

This comprises the strategy and actions performed for the selection of the lubricant, the definition of its specifications and performance, identification and purchase processes, as well as the supplier assessment. Examples of these metrics would include lubricant quality compliance at reception, implementation of the lubricant identification system (LIS) and lubricant specifications, compliance of the technical services versus the goals, and measuring the number of individuals with a Level II Machine Lubrication Technician (MLT) certification who participate in the product decisions.

Reception and Storage

These involve the procedures and tasks related to lubricant reception control, stock rotation and storage conditions. Reception and storage KPIs should focus on compliance of the quality-control program and training plan for personnel, as well as supplier performance in regard to work plans, timely delivery of lubricants and LIS code implementation. Examples of these metrics would include the lubricant's quality-control results at reception, completion of lube room improvements and the number of safety incidents (misses and near misses) resulting from lubrication practices. Performance indicators will enable periodic measurement to identify areas of improvement and help achieve the key elements of lubricant reception and storage.

Handling and Application

Lubricant handling and application may be the most extensive elements in the system, since they encompass all planning activities, such as routes and PMs, as well as lubricant transfer and administration tasks within the in-service machines. These KPIs should be centered on the lubrication program's effectiveness. Some examples would include compliance of the lubrication and inspection routes in a timely manner, unavailability and lost production hours related to lubrication tasks, compliance of the lube technicians and operators with the training and certification plans, overall filter consumption by type, and the number of abnormal conditions detected by lubrication inspections.

Contamination Control

KPIs for contamination control are among the most important metrics for lubrication excellence. They should be focused on the strategy implemented to keep contaminants away from the in-service lubricant. Examples of these KPIs would be the cleanliness target compliance by machine type, the humidity limit compliance by machine type, the temperature limit compliance by machine type, the compliance of varnish potential limits by machine type, and the progress in the implementation of machine modifications and other actions to control contamination levels in the in-service oil.

Lubricant Analysis

Lubricant analysis KPIs help to identify the effectiveness of condition monitoring tasks. These metrics are related to the management of the oil analysis program and the lab's delivery time. Indicators associated with the program's implementation must also be employed, such as measuring the progress in the installation of sampling ports.

These types of temporary KPIs can be removed once the implementation stage is completed. Other examples would include the laboratory turnaround time, sample-to-report cycle time, percentage of abnormal results in the oil analysis program, and the ratio of certified engineers and technicians versus the total number of engineers and technicians.

Lubricant Disposal, Leaks and Spill Management

These metrics refer to all the procedures used to ensure proper disposal of lubricants and contaminated materials. They may also focus on lubricant spill and leak management. Examples would include the percentage of lubricants disposed of relative to the number of lubricants purchased, the amount of lubricant-contaminated materials disposed of, the consumption of spill-containment material, the volume or cost of lubricant leaks, and compliance with the ecological disposal training plan.

Implementation Tips

When implementing KPIs, be sure to set goals according to your program's current conditions. Do not wait until you have a world-class lubrication program to begin monitoring. The goals may be permanent or temporary, but they should be relevant to your program. Start with a few indicators that you can measure with reasonable confidence and consistency, and then expand as the program progresses. Set responsibilities for the KPIs across your organization and consistently communicate these metrics to your team to create credibility and confidence. All indicators should also be reviewed periodically. When a metric is not adding value or the results are inconsistent, it may be necessary to redefine or replace it.

KPIs are critical for monitoring the status of your lubrication program. They will enable you to take corrective actions and define improvement strategies. Consider using them to help you make better decisions that can lead to a more successful program. ***ML***

About the Author

Alejandro Meza is a senior technical consultant with Noria Corporation. He has more than 20 years of experience in the lubricant industry, technical services, quality assurance, training, consulting and development in the United States, Brazil, Mexico and the Americas region. Contact Alejandro at ameza@noria.com to learn how Noria can help you develop KPIs to measure your lubrication program.

Devin Jarrett | Noria Corporation

Getting Started on the Path to **Lubrication Excellence**

"All paths to excellence, regardless of the destination, follow a similar path: assess, plan, implement and reassess."

The pursuit of excellence is a natural endeavor of humankind, whether it involves a personal hobby, professional occupation or common destination of a group of individuals. Not everyone is blessed with the opportunities to achieve excellence in all aspects of life, but I firmly believe that every person has a chance to attain excellence at some point or another.

As a young boy, I dreamed of becoming a professional football player. My sports heroes were guys like Derrick Thomas, Neil Smith, Marcus Allen and Barry Sanders. While I missed out on being one of the best football players in the world, I have become one of the top football officials in my local association. In this pursuit, I have found that all paths to excellence, regardless of the destination, follow a similar course: assess, plan, implement and reassess.

Before going any further, I would like to define what excellence means. Excellence is superior, very good for its kind or first class. It does not mean perfect, faultless or without defects. Therefore, lubrication excellence does not imply having a perfect program but rather one that is first class.

Assess

The first step toward a superior lubrication program is to determine where you are on the spectrum of excellence. This can be accomplished by performing an assessment of your current state, preferably by an unbiased source. This step is never easy. Many organizations would like to skip this step, as it is often viewed as an outside authority telling them what they already know — that they are bad. While you may realize that you are nowhere near excellence, you still need this

reference point. This is where you can begin tracking how impactful future changes will be to your lubrication program and maintenance budget.

A good assessment can reveal a multitude of things, including what you are doing well, what you need to improve, how to measure your effectiveness and how to maintain the program in the future. This also can help change any misconceived perceptions about lubrication, such as "grease is grease," "new oil is clean oil," "if a little grease is good, more is better," etc. The assessment is the first step in learning what you didn't know. How can you expect to change or improve if you don't have a knowledgeable person or organization to show you where you are and teach you what you didn't know you needed to know?

Plan

After you have established where you are on the spectrum of excellence, it is time to begin planning your journey for where you want to go. If you don't take the time and effort to invest properly in this step, all future steps will be impacted, and you will run the risk of failure. During the planning stage, try to account for all obstacles that may be encountered. You likely will not be able to identify all of them, but the more you can address early, the better you can handle them in the future.

Planning as it relates to excellence in a lubrication program involves a point-by-point review of the current practices along with the recommended practices. Every lube point in your facility must be evaluated to ensure you are performing the "rights" of lubrication – the right lubricant in the right amount at the right frequency and right place using the right procedure with the right tools and hardware.

One of the biggest pitfalls during this step is over-consolidating lubricants or using a blanket approach across the facility. There is no such thing as a universal grease or oil that can provide the proper protection for every type of machine. You must consider the environment, operating conditions and application, and then perform calculations to discover which lubricant would work best. Once you know which types of lubricants you need, you can begin consolidating to the optimum number of lubricants for your facility.

Keep in mind that you cannot achieve lubrication excellence without lubricant analysis. Until recently, lubricant analysis was thought to only apply to oils. However, significant advances have been made in analyzing in-service grease. All applications must be evaluated to determine which ones should be included in the lubricant analysis program. Among the factors to take into account are the reservoir size, machine type, lubricant cost, machine criticality, lubricant age and machine age.

Once you know which machines and lubricants will be analyzed, you must choose the appropriate test slates and alarm limits. After all the tests have been selected, you will need to decide if it is more cost-effective to use an in-house lab or an outside vendor. An in-house lab can conduct simple tests and offer many advantages, but it should be climate-controlled with limited access.

All procedures for how lubricants will be maintained while in service must be documented so everyone on the lubrication team can perform each task the same way. A good procedure will include the machine name, which tools are required, which lubricant to use, how much lubricant to apply, how to perform the task with step-by-step details, and how to clean up after the task is completed.

69%

of lubrication professionals say their plant has not achieved lubrication excellence, based on a recent survey at MachineryLubrication.com

Finally, you must decide how you will receive, store and transfer lubricants throughout the plant. Find a central location that has sufficient room, is climate-controlled and offers a means to control access. This area can set the stage for lubrication excellence. It is where you will clean and store incoming lubricants as well as the tools for lubricant application, sampling and filtration. This is your first line of defense for protecting your lubricants and machines from contamination and ultimately failure. If you don't get things right in this area, it will be impossible to achieve lubrication excellence.

Implement

Next comes the real challenge of the journey — putting your plan into action. Up until this point, you have not actually made any changes to your program. You now must find a suitable computerized maintenance management system (CMMS) to manage the program, including all the lube points and procedures. You might need to purchase equipment to better maintain your machines and lubricants, as well as tools to provide better feedback of what is happening inside the machines. This may include particle counters, vibration measurement instruments, thermal imaging cameras or temperature sensors. In addition, equipment for obtaining lubricant samples and testing for the desired properties may be necessary.

The days of passing down tribal knowledge

from one generation to the next are no more. All lube points and tasks should be documented so you no longer just guess at how much or how often to apply the lubricant.

Another area that tends to be overlooked is how you will inspect and maintain your equipment. Once again, a blanket approach will not work. You should not just install a desiccant breather on every machine. In certain cases, this type of breather will be required, but in other areas you may need a particle breather or an expansion chamber.

When selecting a level indicator, take into consideration where the oil level should be and the accessible port locations. In some instances, a columnar level gauge may be preferred. Other modifications might include bottom sediment and water bowls, quick connects, offline filters, sample ports and heat exchangers. Depending on if air entrainment issues exist, you may also need baffles, diffusers or other alternatives to increase the oil's residence time inside the reservoir.

For grease applications, the two most common recommendations are line extensions and single-point lubricators. Again, employ these modifications wisely. Remember, the best place to regrease a lube point is as close to the rolling element as possible. If you can safely access and apply grease at the Zerk fitting on the housing, you should not be applying grease as a matter of convenience for the lube tech. Install an extension line only when these parameters cannot be met. If an extension line is needed, it should not be longer than 4 feet. As a rule of thumb, if a lube point must be regreased 12 or more times a year and requires 10 ounces or more, a single-point lubricator may be the best option.

Of course, all the greatest tools and widgets in the world will not achieve lubrication excellence. You must also train your team members on how to use these tools and on the importance of lubrication. They will need the knowledge and ability to develop the necessary skills to make the correct decisions. If trained properly, they will be able to identify problems long before a catastrophic failure occurs.

Next, you must measure how you are doing by establishing and tracking key performance indicators (KPIs). Hopefully, you were utilizing some KPIs before you started. Generally, plants measure things like unscheduled downtime, lost production, etc., to show how efficient they are. However, you should track metrics such as lubricant cleanliness, mean time between failures, route compliance, lubricant consumption, etc. This is a good way to gauge how effective your changes have been.

The last step in implementation is to change your culture. Without transforming the mindset and practices of what has always been done, you will never cross over to the other side of the excellence spectrum. This process of changing your business as usual may consume more time and effort than anything else you are implementing, but without a positive culture change, all of your other efforts will be futile.

Reassess

After you have assessed where you were, planned how to achieve excellence and implemented your plan, you must reassess where you are in the spectrum of excellence. Did you accomplish all that you set out to attain? Do you have more to do? While you might have achieved everything that you set out to do, there may be other things you need to address or additional areas of improvement.

Once you have reached excellence, periodically reassess how you are doing. Like all things in life, excellence is not a lifetime achievement award that you receive and then always maintain without doing anything else. The definition of excellence is continuously changing. There are always new or better ways of doing things that redefine excellence. You must keep up with the latest developments in the industry and continue to find ways to improve your program.

Finally, don't hesitate to seek help from outside experts. In my pursuit of excellence in officiating, I have had to rely on someone else to guide me through the pitfalls. While it is not impossible to get there on your own, it is much easier and enjoyable going through the journey with someone by your side. ***ML***

About the Author

Devin Jarrett is an associate technical consultant with 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 Devin at djarrett@noria.com to learn how Noria can help you achieve lubrication excellence.

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

Quick Filter Check

When checking differential filter clogging indicators, be sure that the pilot holes in the filter body (the ones that feed the indicator with oil pressure) are clear of debris. This will help ensure you are receiving the correct signal.

Unusual Breather Treatment

Washing down machinery with water often results in desiccant breathers becoming saturated with water. One solution is to put pantyhose over the breather. Though it may look silly, it repels the water yet allows air to move through it and is easier than training personnel over time.

Oil Sampling Pointer

For reservoirs, drop-tube oil sampling is rarely the ideal method. However, if it cannot be avoided, it is important to consistently sample as close to the active fluid zone as possible. Measure the stand-off distance desired from the bottom of the sump and attach the drop tube with wire ties (or other suitable method) that distance from the end of a rod. Consistency in the sample location will help make the analysis results more suitable for trending.

Use Lube ID Tags

Consider using equipment lube tags to avoid adding the wrong oil to a machine. These identification tags decrease the possibility of error by inexperienced lube techs, facilitate training of new technicians and reduce confusion associated with switching suppliers. Use color- and/or shape-coding wherever possible. Whether plastic, stainless steel, aluminum or coated paperboard, these tags can indicate the lubricant's name and viscosity, and can be affixed to each reservoir. ***ML***

Did You Know?

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

Have Some Tips?

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

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. High soot loading is managed by what additive?

A) ZDDP
B) Dispersant
C) Over-base detergent
D) AW/EP
E) Demulsifier

2. The blotter spot test is primarily used to detect:

A) Silicone sealant
B) Viscosity increase
C) Particles, soot and organic insolubles
D) Air entrainment
E) Spent additives

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

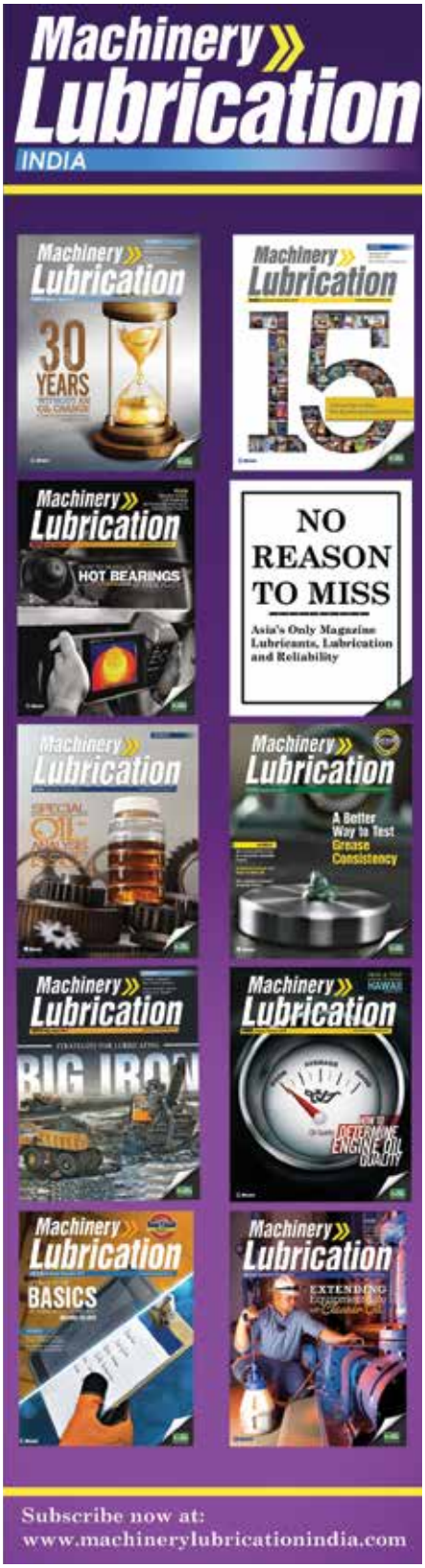
A) 50 percent
B) 75 percent
C) 90 percent
D) 100 percent
E) It doesn't matter

ANSWERS

1. B
High soot loading is controlled by dispersant additives. This type of additive is polar and is used to disperse soot particles in order to prevent agglomeration. Dispersant additives envelop particles and keep them divided.

2. C
This test is extremely simple and inexpensive. It involves placing two drops of used oil on chromatography paper. When the oil makes contact with the absorbent blotter paper, it will wick out into the paper. Once all the oil has moved into the pores of the paper, the blotter is ready to be examined. This test is primarily used to detect the accumulation of particles, soot and organic insolubles such as sludge and other oxidation byproducts. It is also a good tool to assess the condition of oil dispersants.

3. B
A sample bottle should be filled to enable enough agitation by lab personnel to assess the contaminants and wear metal contents. Otherwise, contaminants and wear metal will stay in the bottom of the sample bottle and will not be measured, making the sample unrepresentative. In addition, a sample bottle that is filled less than 75 percent may be insufficient to perform all the required tests.



Masterclass in Lubricants Blending and Quality Assurance

Two day training program on Lubricants Blending and Quality Assurance was conducted for Indian Oil Corporation Limited in Mumbai recently. The training was a great success as the participants enhanced their knowledge on Lubricant blending, Troubleshooting, Quality Assurance, Efficient operation of Lube blending plant. This two day training course provides an in-depth understanding of the principles, economics and flexibility of lubricant blending plants. It also covers how to operate a lubricants blending plant efficiently and economically.

For additional details on this training and similar trainings, visit- http://lubrication-institute.com/

8th Annual Base Oil and Lubes Middle East Conference (BLM 2019)

BLM 2019 organized by Conference Connection in Dubai, UAE from 10-11 April 2019 at Intercontinental Dubai Festival City. Hosted and Sponsored by Emirates National Oil Company (ENOC), the event continues to build on last year's success and strong performance – the agenda provided a good spread of topics, high calibre speakers, quality presentations, premium networking opportunities and was a platform for the exchange of ideas, information and discussion for the base oil and lubricant industry.

The eminent speakers like Mr. Mohammed El Sadek, Director- Lubricants Marketing, ENOC Lubricants, ENOC Marketing LLC, UAE, Mr. Burhan Al Hashemi, Managing Director, ENOC Marketing, Emirates National Oil Company Limited (ENOC) LLC, UAE, Dr. Matar Hamed Al Neyadi, Undersecretary of Ministry of Energy and Industry, UAE, Mr. Daniel Colover, Market Engagement Manager, S&P Global Platts, UAE, Ms. Geeta Agashe, President, Geeta Agashe & Associates, LLC, USA, Mr. Benoît Mahe, Senior Consultant,Energy & Environment Practice, Sia Partners, Europe, Mr. Milind Phadke, Director, Energy Practice, Kline & Company, USA, Mr. Abudi Zein, CEO, ClipperData, USA, Mr. Jean-Pierre Corniou, Deputy CEO, Sia Partners, Mr. Patrice Estoueig, Product Line Manager, IEO-Specialties Additives Europe, Africa, Middle-East, Chevron Oronite, France, Mr. Kerem Tercan, Division Manager, Ekin Kimya, Turkey, Mr. Sanjiv Wazir, Technical Manager, LUKOIL Marine Lubricants, UAE, Mr. Kailash Sawant, Regional Business Manager, Engine Oil-India/Middle East, Lubrizol India Pvt. Ltd., India, Mr. Eduard Gracia, Principal, A.T. Kearney, UAE and others delivered their presentation on various aspects of Base oils, additives and technology.

Continuing its focus on the global base oil business, BLM provides both knowledge sharing and networking opportunities, with participation from leading producers, suppliers, manufacturers, re-refiners, traders and end-users from twenty-five countries.

3rd AMEA Bitumen, Base Oil, Lubes and Wax Conference

The 3rd AMEA Bitumen, Base Oil, Lubes and Wax Conference jointly organized by Petrosil and Rex Fuels on February 6-7, 2019 at The Oberoi Hotel in Dubai. Building on the success of the 2nd AMEA Bitumen and Base Oil Conference in India last year, the organizers were delighted to welcome more than 200 attendees from 20 countries. Given the diverse geographic attendance and wide cross-section of disciplines represented, excellent opportunities were provided for profile building and premium networking. This event is expected to grow in participation and importance to the industry in the future. The conference was very well received by the participants with an

overall assessment. Delegates commented favourably on the major topics being covered, premium networking and deal making opportunities and the quality of presentations. The opportunity to network and the program content are the two key reasons cited for attendance. Feedback also showed that participants were interested in learning more about OEM approvals, marine lubes, additives, GTL, fate of Group I base oils and bright stock, future trends for base oil and lubricants in the Middle East & Africa, logistics & shipping of base oils; raw material pricing and emerging technologies. Majority of the participants also indicated that they would like the conference be held twice a year in different locations in the Asia, Middle East and Africa (AMEA) Region.

Cricket and **Lubricants**

Cricket is more than a sport in India, it's a religion. A religion where cricketers are more than just players, they are Gods and every victory is a festival. The lubricants market is a largely fragmented space with more than 2,000 players, including national as well as multi-national oil companies.

It is obvious that the top lubricant brands would strive to rope the cricketers in for grand-scale product endorsements and huge mass reach. The passion of cricket has a long lasting impact on customers. Keeping this in mind lubricant brands like Valvoline, Gulf Oil, GS Caltex, IPOL Lubricants and many more brands leverage this passion to their products.

IPL has been the most celebrated sport event in India ever since it started back in 2008. The tournament involves domestic Indian teams which include players from all over the world. Over the years, Indians have been satisfying their entertainment quotient through the IPL every summer.

The 2019 IPL season began with excitement at its peak and ended up with Mumbai Indians holding the trophy of this season. Being the champions of the last season, Chennai Super Kings (CSK) continued leading the IPL chart with their consistent and outstanding performance this season as well. To keep the momentum going, Gulf Oil Lubricants India Ltd, part of the Hinduja Group and one of the oldest partners of CSK, have launched 'Dum Andar' campaign. 'Dum Andar' is a first digital campaign, which revolves around the idea of inner strength. Gulf Oil approached Bravo to create a peppy rap song that articulated the spirit of Dum Andar along with his team-mates Ravindra Jadeja, Shane Watson, Harbhajan Singh and M S Dhoni, who is also Gulf Oil India's brand ambassador and represented Gulf Oil since 2011. Cricketer Hardik Pandya also signed an endorsement deal with Gulf Oil Lubricants India Ltd.

Gulf Oil recently launched an exciting contest for the cricket fans. Participants are asked to share a slogan for cheering Team India. The slogan must contain word "pride". The participant with best slogan will get a ticket to England to witness the ICC World Cup 2019 featuring the Men in Blue. The lubricant brand has also released a commercial video with its brand ambassadors MS Dhoni and Hardik Pandya to promote the contest.

‘Castrol Activ Champions’ on Cricbuzz features a champion cricketer every week with parallels being drawn with the brand benefit.

GS Caltex India, a 100% owned subsidiary of GS Caltex Corporation, South Korea had signed cricketer Shikhar Dhawan as a brand ambassador in a strategic move to establish itself as a major player in the premium lubricants category in the country. As part of the association, Shikhar Dhawan became the face of GS Caltex India for the company’s premium lubricants range & new business initiatives.

On the field, Virat Kohli breaks every batting record and on the commercial pitch, he is batting at level where no one ever has. Valvoline Cummins India had signed up Captain Virat Kohli as its ambassador. As part of the association, Kohli became the face of Valvoline engine oils and lubricants range.

An eminent Indian cricketer Suresh Raina was approached by GP Petroleums Ltd, a leading lubricant maker and part of UAE-based Gulf Petrochem Group as the brand ambassador for IPOL Lubricants, the signature brand of the company into the industrial lubricants segment.

Castrol India has two social communities; one of them is Castrol Cricket. They create special contents for these communities. Castrol is also associated with sporting properties.

Indian Cricketer’s endorsement market has vastly evolved. Cricketers have enormous commercial appeal. It is believed that social media influence of cricketers is increasingly becoming a major factor in their selection as brand ambassadors. It will be great to see Cricket and Lubricants exciting innings together in future.

BASE OIL REPORT

Reliance Industries will shut for up to four weeks a 330,000-bpd crude oil processing unit at its 660,000-bpd Jamnagar refinery, beginning in the middle of June for planned maintenance. The refinery predominantly supplies refined oil products to the domestic market. Reliance's Jamnagar site is the world's largest refining hub, in which the refinery in the Special Economic Zone (SEZ) is the sixth largest in the world with a capacity to process 580,000 bpd of crude oil. The first refinery at the Jamnagar site was built in 1999 and has an installed capacity of 660,000 bpd, selling refined oil products on the domestic market. The refinery at the SEZ was added in 2008 and made the Jamnagar complex the world's largest oil processing hub. Last year, Reliance increased the capacity of its export-oriented refinery by 30 percent to 704,000 bpd.

As per reports, Saudi Arabia's oil giant Aramco is in "serious discussions" to buy up to 25 percent of the refining and petrochemicals businesses of Reliance Industries. In recent years, Saudi Arabia has been pursuing downstream deals in Asia—the most prized market for oil exporting nations, aiming to lock in future demand for Saudi crude oil. India, for its part, is a fast-growing demand centre and the world's third-largest oil consumer after the U.S. and China.

India imported 222897 MT of Base Oil in March 2019. Base Oil import of India has gone down by 18% in March 2019, as compared to last month i.e. February 2019. Base Oil import of India has gone down by 8% in March 2019, as compared to same period last year i.e. March 2018.

In the month of March 2019, India imported 222897 MT of Base Oil, India imported the huge quantum in small shipments on different ports like 124435 MT (56%) into Mumbai, 24683 MT (11%) into JNPT, 23560 MT (11%) into Hazira, 19859 MT (9%) into Pipavav, 12110 MT (5%) into Chennai, 10393 MT (5%) into Mundra, 6207 MT (3%) into Kolkata, 1261 MT (1%) into Ennore and 390 MT into Other Ports.

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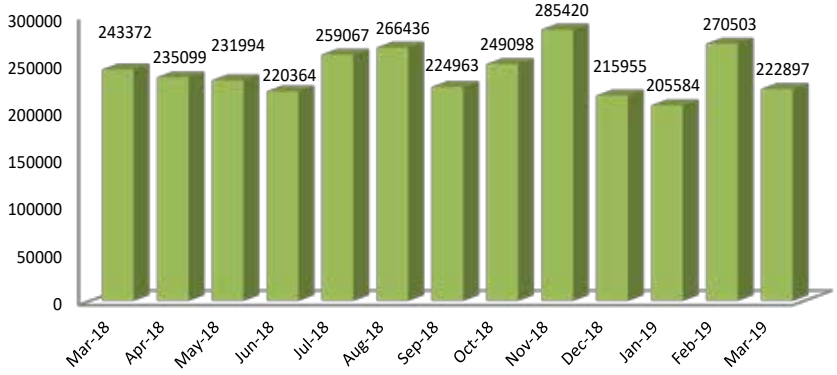
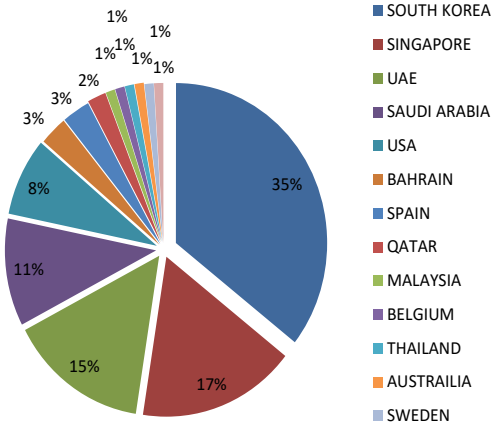
Month wise input of Base Oil in India



Origin wise Base Oil input to India, Country and %- March 2019



Base Oil Group I & Group II CFR India prices:-

Month	Group I - SN 500 Iran Origin Base Oil CFR India Prices	Group II - N-150 Singapore Origin Base Oil CFR India Prices	N- 70 South Korea Origin Base Oil CFR India Prices	Naphthenic HYGOLD L 2000 US Origin Base Oil CFR India Prices
March 2019	USD 620 – 630 PMT	USD 715 – 725 PMT	USD 665 - 675 PMT	USD 740 – 750 PMT
April 2019	USD 630 – 640 PMT	USD 725 – 735 PMT	USD 675 - 685 PMT	USD 750 - 760 PMT
May 2019	USD 635 – 645 PMT	USD 730 - 740 PMT	USD 680 - 690 PMT	USD 755 - 765 PMT
	Since March 2019, prices have increase by USD 15 PMT (2%) in May 2019.	Since March 2019, prices have hike up by USD 15 PMT (2%) in May 2019.	Since March 2019, prices have increase by USD 15 PMT (2%) in May 2019.	Since March 2019, prices have marked by USD 15 PMT (2%) in May 2019.

PILOT (Practical Industrial Lubrication Orientation Training)

An accessory and activity based onsite practical lubrication training

PILOT is a skill based lubrication training program specifically designed for lube technicians, operators and shop floor associates. The objective of this training program is to upgrade the skill of technicians who actually perform the lubrication and inspection tasks. This training program is a combination of classroom as well as onsite practical training (activity and accessory based). The main focus of the training program is to illustrate how to perform various lubrication related tasks effectively, effciently and safely.

Main contents of the course include:

- Basics of lubrication
- Contamination control
- Hands on training for handling lubricants
- Sampling
- Field inspection of lubricants

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