Machinery Lubrication

INDIA September-October 2017

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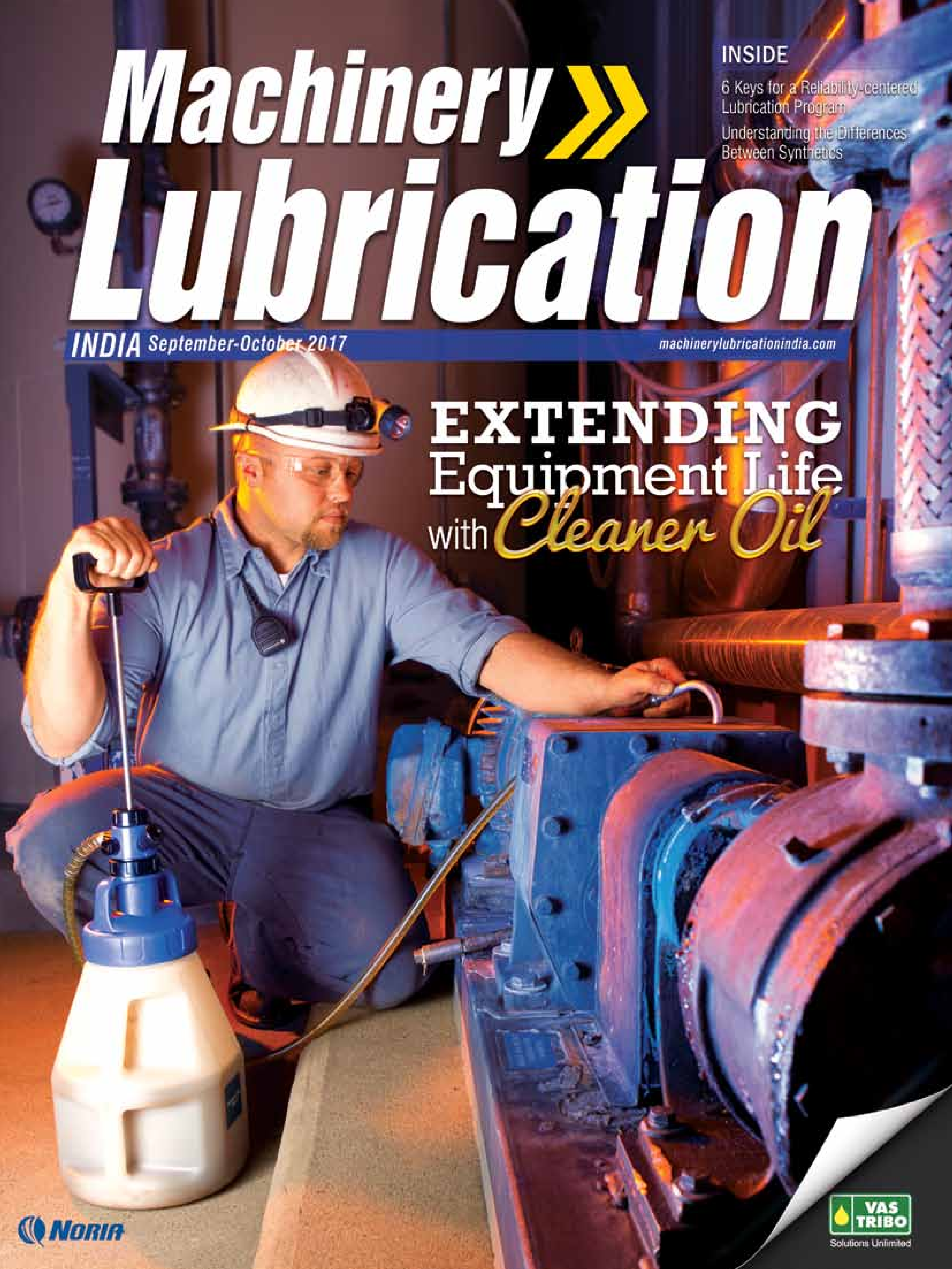
EXTENDING Equipment Life with Cleaner Oil



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Over the past few decades, the world has started looking at technologies that can reduce dependence on oil. India is amongst one of the first movers in the developing countries with a clear road map for introduction of electric vehicles (EVs) by 2030. Two-wheelers are set to outpace four-wheelers in India's ambitious drive towards all-electric mobility, as all top scooter and motorcycle manufacturers have lined up their clean-energy products for launch initiating next year. Hero MotoCorp, Honda Motorcycle & Scooter India, TVS Motor Company, Mahindra, Yamaha and Bajaj Auto are scheduling launches starting 2018. Hero MotoCorp invested Rs. 205 crore in Ather Energy last year and scheduled to launch India's first indigenously designed and developed electric scooter next year.

Electric vehicles (EVs) are already a reality in the international market. 50% of all Dubai taxis will be electric by 2021. According to a recent study, Dubai could see the sale of EVs 42000 by 2030. TESLA plans to begin Model 3 volume production this year. GM plans to produce 500000 EVs by the year end. Also companies like PSA, Volvo, Ford, Jaguar, Nissan, are planning to electrify their models.

In general, about 60% of the total lubricant demand for transportation sector is for engine oils; which are exposed to high temperature in the engine and oxidise or lost in evaporation with combustion products, in exhaust. Electric autos will not have engine or combustion chamber; hence, demand for the engine oil will disappear, that is major chunk of low and medium viscosity oils. Automotive lubricants will be reduced to those for bearings, gearbox, clutches, breaks, hydraulic systems etc. Demand for engine lubricants will continue for marine engines, power generators, special purpose vehicles, mobile pumping machinery etc. Engine oil demand is expected go down by about 90%. Demand for lubrication of large static diesel engines will increase. In large plants, besides condition monitoring and more efficient use of lubricant, waste oil recovery for re-refining and recycle will be better. Waste oil recovery may go well over 70 % from the present 30 %. Demand for high temperature, high load oils will increase because of increase in power generation capacities. This may boost the demand for synthetic and vegetable oil based lubricants.

More electric vehicles on the road will increase the consumption of electricity, which, in turn, increases the consumption of industrial lubricants. An electric car doesn't have the internal combustion engine, which is the major component that requires lubrication. However, these vehicles will continue to have gearboxes, axles, wheel hubs and other lubricant and grease points, although with slightly different lubrication challenges.

Fortunately, these changes will not be rapid as the existing system is too big involving more than thousand million vehicles, connecting infrastructure, and complexity of transportation system, that affects common man's life in many ways. It is not possible to dismantle it suddenly.

Thank you for the encouraging response to our last edition's cover story – "How to manage Hot Bearings in your plant". Our current cover story on "Extending Equipment Life with Cleaner Oil" will help you discover how an improved oil storage and handling practices saves costs and decrease machine failures. We welcome your suggestions and feedback. With this I want to convey my good wishes for Navratri and Diwali. Signing off for now! Wish you a happy and helpful read.

Season's greetings!

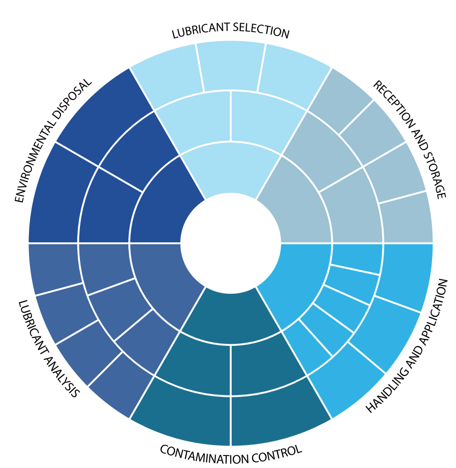
Warm regards,
Udey Dhir

BY ALEJANDRO MEZA | NORIA CORPORATION

6 KEYS for a Reliability-centered Lubrication PROGRAM

When implementing a formal lubrication program to improve reliability and reduce operating costs, it is necessary to have a holistic and systemic vision of the project. This will require taking into account several elements collectively in order to achieve the desired results.

Whether the program is for a fixed plant or a mobile fleet, the lubrication-related factors to consider can be described according to the lubricant's life cycle. These include lubricant selection, lubricant reception and storage, lubricant handling and application, contamination control, lubricant analysis, and lubricant disposal. Following is a brief explanation of each element.



Lubricant Selection

When a new machine is put into operation, one of the first questions that arises is about the lubricant to select for proper operation and warranty protection. The equipment manufacturer's operating manual and technical service representatives are commonly consulted for recommendations. The lubricant supplier may also be involved in this process. In the end, the decision often rests with the reliability or engineering department. Several factors should be considered, such as the required specifications and performance, possible lubricant consolidation, product packaging, the needed stock for proper handling and application, lubricant identification across the plant, purchasing procedures, and product delivery. The technical specifications should also be defined for the necessary consumables and lubrication-related hardware.

Lubricant Reception and Storage

When the purchased lubricant is received, it should be inspected to ensure it meets certain quality standards and comes in the correct amount, package size and time required. Routine tests should be performed on the new lubricant, and a sampling plan established with the appropriate test slates and limits.

Once the lubricant is accepted, it should be stored in a convenient area that maximizes the lubricant's storage life and integrity. All involved personnel must be sure to follow the safety procedures and environmental awareness practices. These requirements will continue for the rest of the product's life cycle. Proper lubricant identification also begins at this point.

Lubricant Handling and Application

Careful handling will help safeguard lubricant integrity, safety and environmental protection while preparing the lubricant for application. An excellent proactive practice is to filter the new lubricant before it is used. Quality filtration and dehydration systems will likely be required to reach the cleanliness targets established for each product. It is also important to have a clean lube room along with sealed containers, appropriate tools, adequate training and detailed procedures.

Lubricant application activities encompass all tasks that facilitate the correct product application, administration and inspection while

40%

of lubrication professionals say training of personnel is the most important factor for continuous improvement of a lubrication program, based on a recent survey at MachineryLubrication.com.

the lubricant is in service. These activities include oil change-outs, top-ups, filtering, regreasing, oil condition inspections and machine condition inspections. Each activity should be executed according to a scheduled plan with documentation detailing the machine's status, safety procedures, tasks to be completed, etc. All activities should also be supported by appropriate training and awareness.

Contamination Control

This strategic element is perhaps the most important part of a proactive lubrication program. It doesn't work independently of the other factors mentioned here, but it is a requirement in most of the lubricant's life cycle. Contamination control refers to all practices related to lubricant cleanliness. There are three important steps to consistently maintain clean lubricants:

1. Set a specific and verifiable target cleanliness level for each machine based on criticality and machine contaminant sensitivity.
2. In order to achieve the selected target, first modify machine and maintenance practices to restrict contaminant ingression. Next, select filtration to remove and control contaminant levels within the target.
3. Frequently monitor contaminant levels to confirm that cleanliness is stable and well within the target.

In addition, do not forget about grease. Although you may not be able to filter or dry it, you can prevent grease from becoming contaminated. Some grease contamination can also be monitored through lab analysis.

Lubricant Analysis

How can a process be controlled if it is not measured or monitored? Oil analysis is an excellent tool for monitoring the oil and machine condition. Its purpose is to confirm the lubricant's quality and type, measure the lubricant's health/condition, estimate the lubricant's remaining useful life, identify and measure contaminants and abnormal wear, find root causes of failures, and support the optimization of lubrication intervals and other maintenance practices.

An effective oil analysis program includes three primary stages: program design, program setup and field implementation/continuous improvement.

Program Design

The oil analysis program should be designed according to specific targets or goals. Machines to be sampled, laboratory selection, test slates, limits, sampling frequencies, interpretation of results and corrective/proactive actions are the leading factors to define at this stage.

Program Setup

This stage involves making the necessary machine modifications for appropriate sampling procedures, setting up the oil analysis program with the selected laboratory, and providing the required training and tools for those responsible for oil sampling and interpreting lab reports.

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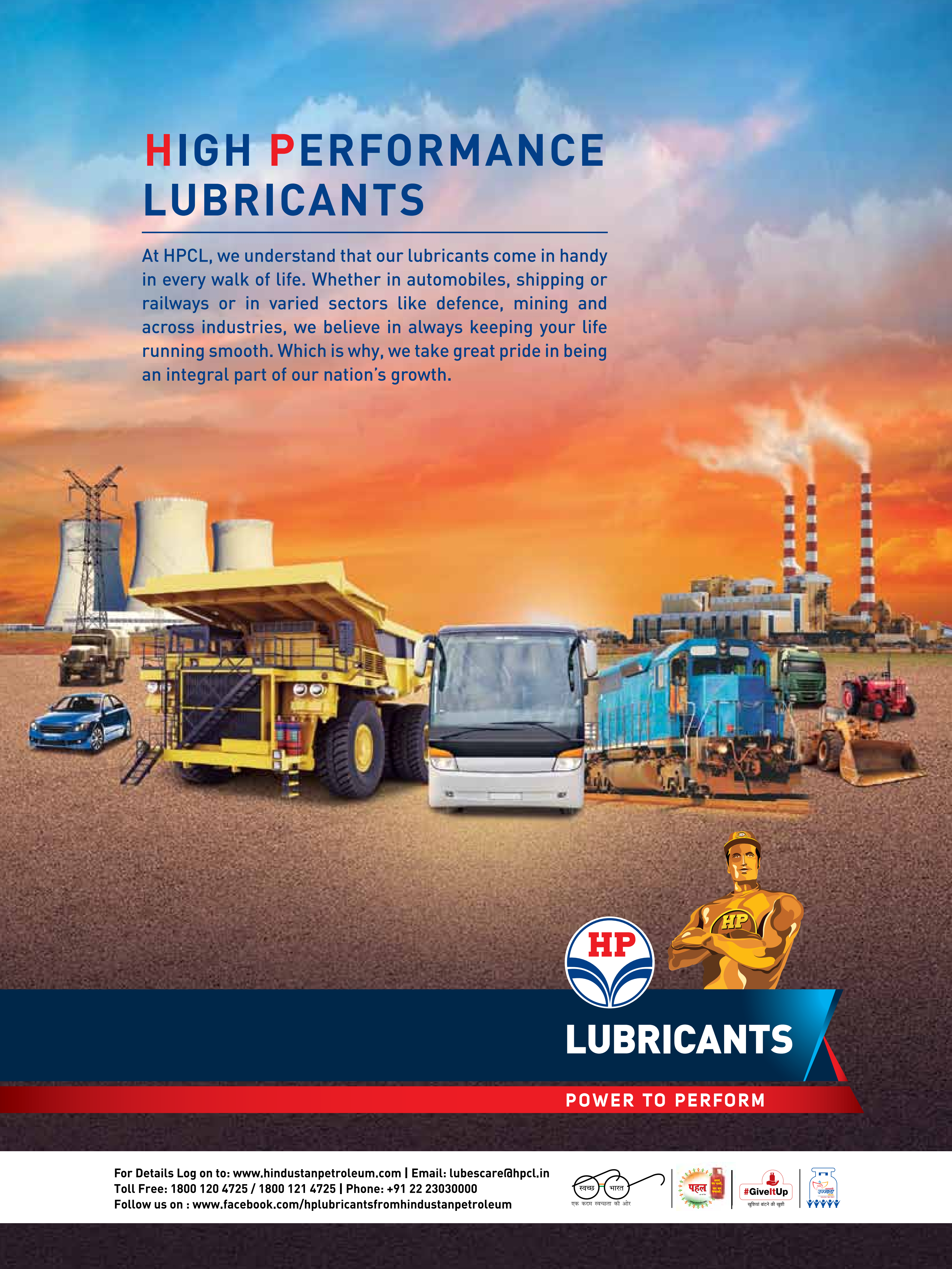
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Field Implementation and Continuous Improvement

Once the resources have been provided, it is time to implement the program. This includes taking oil samples properly, documenting the process and sending samples out for analysis. When the results are received, they must be interpreted so that proactive/corrective actions can be taken. A periodic analysis of the program is also needed to verify its adequacy and opportunities for improvement.

Lubricant Disposal

Once the lubricants and contaminated materials (like oil filters) have reached the end of their useful life, they must be disposed of in a proper manner according to local regulations and corporate policies. The goal is to protect the environment from potential contamination while maintaining safety at your facility.

Controlling lubricant leaks is also important for operating machinery as well as for safety and environmental protection. An effective program for leak detection and control should be in place. This type of program offers many benefits, such as decreasing lubricant consumption, minimizing safety risks, reducing the risk of lubricant starvation in the machine, controlling environmental contamination, achieving higher productivity levels and lowering costs.

Program Implementation Management

A lubrication program consists of different elements that interact with a common purpose. It is necessary to manage all of these factors to keep them working efficiently. Among the essential elements for a reliability-centered lubrication program include:

- Top management support, teamwork and communication
- A motivation and rewards program
- Involvement of affected areas within the organization such as human resources, purchasing and production
- Appropriate training for all involved personnel
- Clear, detailed procedures and work instructions
- Effective records and proper handling of information
- Product identification
- Safety procedures
- Environmental awareness
- Applicable regulations, standards and corporate policies
- Metrics and key performance indicators (KPIs)

Properly combining these elements will allow you to achieve an effective and rewarding program implementation.

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.

JEREMY WRIGHT

TRACKING the Life Cycle of YOUR LUBRICANTS

What do you do with your oil analysis data? Do you thumb through the results looking for outliers and act upon those? Do you look at histories and gauge expectations against current analysis? There are many ways to set up and run an oil analysis program. In this article, I'd like to suggest another way of utilizing the data to help achieve your reliability and lubrication goals.

The evolution of an oil analysis program is easy to understand. The first iteration consists of taking a sample, sending it off to the lab and receiving results. These results are looked at on a case-by-case basis and are acted upon. In this scenario, even if the "rights of oil analysis" are followed perfectly, there is still a lot of value being left on the table. The rights of oil analysis include the following:

The Right Lab

Some organizations use an in-house laboratory for basic tests like viscosity, particle counts and moisture content but utilize an outside lab for exception testing. Knowing the quality of your outside lab is extremely important. Even though the reports from many labs look similar, the data and results contained within these reports can be very different.

The Right Test Slate

Frequently, companies enter into a relationship with a laboratory without really knowing what they want. They rely on the lab to steer them in the right direction regarding the tests to run. In some cases, the "standard" test slate may not capture the information needed to make the best maintenance decisions. Therefore, it is imperative to work with your laboratory to determine your individual needs and develop the proper test slate.

28%

of lubrication professionals do not set cleanliness targets for machine reliability, according to a recent survey at MachineryLubrication.com

The Right Sampling Location

It is critical that samples are taken from the proper location within a system that maximizes data density and minimizes data disturbance.

The Right Frequency

Several factors should be considered when determining the sampling frequency, such as the age of the equipment, the age of the lubricant, the machine's criticality, etc.

The Right Procedure

You must ensure that each sample is representative of the fluid in the reservoir and not affected by outside contaminants. The right procedure must be documented so no matter who takes the sample, it comes from the same place in the same way every time. This is what makes the results repeatable and allows for data trending.

The Right Equipment

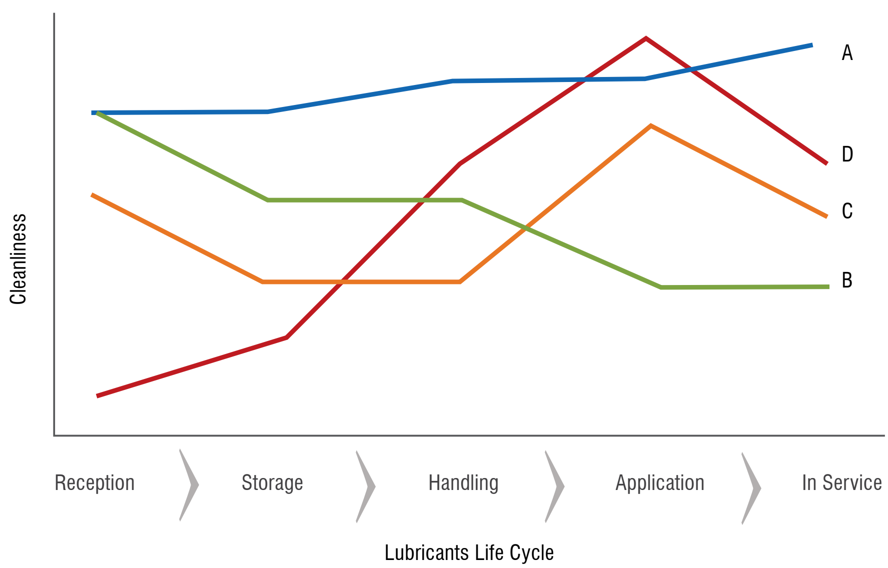
Sampling equipment should be kept in a clean environment and cleaned after each use and prior to storage.

The Right Alarms and Limits

The primary purpose for alarms or limits is to filter data so that the technologist spends his or her time managing and correcting exceptional situations instead of laboriously perusing the data trying to find the exceptions.

The Right Data Interpretation Strategy

Having someone onsite who knows how to read an oil analysis report and the operating conditions of the equipment is extremely important. With this skill set and the right strategy, the real value of oil analysis can begin to be realized.



Keep in mind that the rights of oil analysis are all equally important. No one specific right takes precedence over another. Each of these rights must be addressed and applied correctly. Otherwise, your time, effort and money will be wasted.

Trending Data

In the next iteration of the oil analysis program's evolution, trending becomes a part of the analysis. No longer are you only looking at the report sitting in front of you, but now you are taking into consideration the history of the data. The best way to trend oil analysis data is to follow its movement visually using a standard trend plot. Trending can quickly reveal the rate of change over time (slope on the plot) associated with a series of monotonic data points that might reveal a reportable condition. It can sometimes be concluded that if the rate of change is normal and constant (linear trend slope), the lubricant and machine conditions are equally normal and acceptable. However, abnormal or unhealthy conditions do not always produce steep trend lines.

Trending is a valuable tool to add to your oil analysis program. It is often overlooked in favor of a quick glance for abnormal results on a single, current report, but in doing so, much of the value of oil analysis is lost.

I'd like to propose a different type of trending. Instead of trending oil analysis reports from the same oil and same in-service machine, I'd like to see trending with a focus on the life cycle of the lubricant while onsite. This would require the first sample being taken when the drum arrives onsite. There are multiple reasons for this, including the example I'll use going forward: contamination.

The effect that particle contamination has on machine reliability has been proven over and over in a number of case studies. It only makes sense that you use this knowledge to your advantage and employ cleanliness as a key performance indicator for your program.

Imagine a plot of ISO cleanliness over the life cycle of the lubricant. Usually the lubricant arrives too dirty for use in the equipment straight from a sealed drum, so it must be cleaned. This means your plot would start with a high point and slope down as you cleaned the lubricant while in storage. If your plot levels out from there throughout its lifespan, you have done a good job at contamination control. However, if there is an upward spike when you take an oil sample after the machine component has been filled, you may want to check your handling practices.

If you notice the plot starts high as new oil, dives down after you clean it up, stays there until it is put into service in the component and then gradually climbs, this tells you that you have an ingression point at the point of use. When oil analysis data is used in this way, it makes it very easy to determine where you need to spend your time, money and energy to improve the process and also your machine reliability.

A number of scenarios could exist. The following are some of the most likely (as shown in the graph above):

A. The fluid arrives from the distributor dirty and is cared for in terms of contaminant ingression, but at no point in the process is the fluid ever cleaned. This results in high ISO particle counts in the machine, which ultimately affects reliability.

B. The fluid arrives dirty, and an effort is made to clean the fluid while in storage. It is kept clean during storage and is cleaned further upon application. The machine is modified to exclude particles but not remove them.

C. The fluid arrives moderately dirty and is cleaned. It is kept clean in storage, but the handling practices are lacking. Once the lubricant makes it to the machinery, the machine is modified to be able to remove the solid particles.

D. The fluid arrives clean but through poor storage and handling reaches the machine very dirty. The machine is then modified to be able to remove these newly ingressed particles.

Because of the effect particle contamination has on equipment reliability, you can see how this data can be used to help drive decisions on where in the process you need to focus. This is essentially where oil analysis earns its keep. It is a means by which you can make better informed decisions about your machinery, your practices and ultimately your business.

Photos by Dave Enterkin, InVision Photography

Extending Equipment Life with Cleaner Oil

Improved Oil Storage and Handling Produce Cost Savings at Bunge

By Ken McPheeters, Bunge North America, Dustin Webster, Bunge Oilseed Processing Division

Excellence in every aspect of business is the daily goal at Bunge, a global agribusiness and food ingredient company. Essential to this effort is the organization's asset reliability and reporting optimization program (ARROP). Among the most important components of this program are monitoring and improving how equipment is maintained, including handling and storage of machine lubricants.

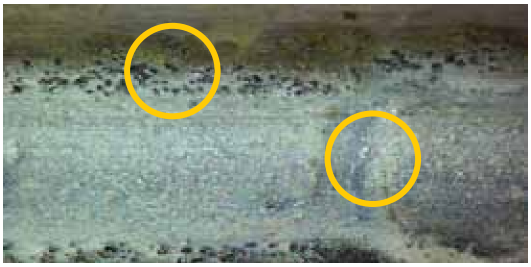
When Bunge started developing a world-class maintenance program, it identified the need to evaluate oil from its arrival at the plant to its placement in a machine. Root cause analysis began indicating bearing failure due to contaminated oil as the cause of breakdowns. The new predictive oil analysis practices also detected poor-quality oil in samples. Bunge's maintenance team researched how to correct these issues and soon discovered that equipment to properly filter and store oil before use was a necessity to keep machines running longer and more efficiently.

Identified Need

Once it was determined that dirty oil was causing breakdowns, the entire oil handling procedure was evaluated. In March 2012, maintenance manager Tony Chavez and maintenance technician Andy Burge received training from Noria and obtained Level I Machine Lubrication Technician certification from the International Council for Machinery Lubrication (ICML). This training revealed that most new oil did not meet the cleanliness specifications necessary for equipment and that contaminants entered the oil through multiple streams. Oil was already dirty in incoming barrels, collected dust and dirt particles during transport from storage to the point of use, was cross-contaminated from using the same container to transport different grades of oil, and collected additional contaminants through equipment ventilation points.

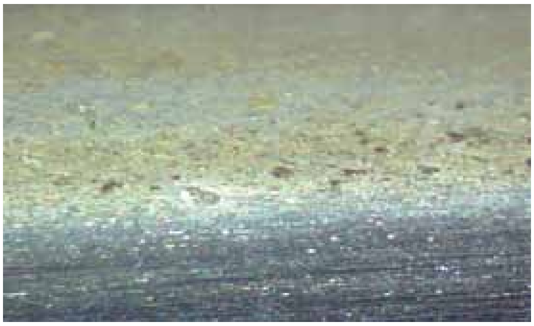
Bunge's ARROP program implemented regular oil analysis, which discovered that oil in the equipment was just as contaminated after an oil change as it was before. The lubricant viscosity after an oil change was also the same as before, indicating the new oil was already out of the acceptable viscosity range. Initially, Bunge didn't want to test oil directly from the barrels as they arrived due to the belief that new oil should be ready for use. However, after the Noria training, the plant tested the new oil and found that it did not meet the cleanliness standards. After sampling the new oil several times, Bunge decided to filter it for two hours, which allowed the oil to cycle about seven times.

The plant's ISO viscosity grade (VG) 220 and 320 oil did not meet the cleanliness standards that were developed with input from Noria. The standard for the ISO VG 320 oil was initially set at an ISO code of 17/15/12, but Bunge was unable to achieve this cleanliness level even after several hours of filtering the oil. The new standard was set at 18/16/13. However, the plant was able to filter the ISO VG 220 oil to 17/15/12 within just a few hours.



Damage to a centrifugal pump's outboard bearing outer race was the result of dirty oil. Contaminants between the race and the rolling element made indentations in both the race and rolling element.

Indentations on the inner race from the same pump (not the outboard bearing). The indentations were more pronounced in the bearing's outer race. This was caused by contaminants in the oil getting caught between the rolling element and the race.



This picture is of an outboard bearing outer race.

These indentations in a gearbox's input shaft inboard bearing inner race weren't entirely caused by putting dirty oil in the gearbox, but they do illustrate the effects of contaminants in lubrication.

This gearbox input shaft inboard bearing outer race shows scratches and indentations from contaminants in the working area of the bearing race.

When oil analysis was first performed, there were several instances when the plant's anti-wear (AW) 68 oil had a viscosity of 71 to 74. This was above the 10-percent allowance for the viscosity tolerance. Even when the oil was changed, the next sample came back with high viscosity.

One sample of new oil that was received had too much water and particulate matter, resulting in the rejection of the drum. The drum was immediately brought inside, where filtration began. The maintenance technician noticed that the fill date was several months old and that water was standing on top of the drum. He also observed that the drum was very dirty compared to the others. The sample came back with excessive particle counts in silicon as well as water. Rather than spending time and money trying to make this oil acceptable, Bunge contacted the supplier and sent copies of the oil analysis along with the drum number and fill date. The supplier took back the drum and sent a new one the next day.

Bunge also recognized the need to improve oil identification and separation. It was recommended that the drums of food-grade and non-food-grade lubricants be separated within the storage area. To assist in separating different oils, it was necessary to properly label each drum based on the type of oil it contained.

This filter cart is air-powered and has quick-connect fittings. The tube and filters have been sized so that enough ISO VG 320 oil can be used to filter the largest gearbox (180 gallons) in about five hours.

Oil Storage Approach

After all of the issues with shipping drums, Bunge needed a way to store oil in other containers. The plant challenged Burge to find storage equipment that would be consistent with his Noria training. In his research, he found several systems that would meet the cleanliness criteria. This equipment included containers for transporting oil, a storage and filtering system, and the proper color-identification system for oils. The transporting containers and bulk storage system matched nicely with the color-coding system. They even adopted the plant's shape coding for labeling the bulk storage tanks.

Bunge also had to consider the size of these storage tanks. The plant reviewed its annual usage of each oil grade to determine how much would need to be kept on hand and which containers would hold the appropriate amount.

The filter size and capacity for each type of oil also had to be researched. Because of the different viscosity levels of each oil being filtered and because only one pump was used for the filtering system, Bunge had to establish the proper beta and micron ratings for the filters to ensure that the plant would be meeting its cleanliness specifications for each grade of oil.

These drum-filtering adapters have a filter draw tube and return sample draw tube so the drum doesn't have to be opened to the atmosphere once the filtering process has begun.

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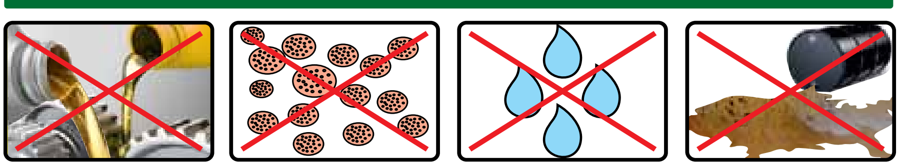

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OIL IN MACHINE IS LIKE BLOOD IN HUMAN BODY

The non-food-grade oil storage units are complete with desiccant breathers, level indicators, pumps and filters for each container. There are no connections between tanks for cross-contamination.

A storage cabinet is used to hold oil sampling supplies.

Pumps and filters are below each storage tank. Every tank has its own pump and filter.

Bunge uses a color and shape-coding system to separate and identify its lubricants. These labels appear in every step of the oil-handling process.

Next, an effective method for filtering oil from the drums into the bulk storage system had to be identified. The plant's filter cart is used in multiple areas, and because there are areas rated for dust and gases in the air, it had to meet certain requirements. Bunge chose an air-powered pump and went through two versions before finding the right size of filters to achieve an acceptable flow rate.

Another storage consideration was having a means of filtering into, out of and through bulk storage. Therefore, the oil would be filtered at every storage or transfer point all the way until it meets the machine.

Aside from filtering contaminants from the oil, Bunge needed a way to eliminate other contaminant streams. One method was to protect oil containers from dust and dirt in the environment as well as from temperature changes. The plant determined a designated clean room would be necessary. This room could be positively pressurized to prevent dirt from entering. This would be achieved by a fan blowing filtered air into the room at a faster rate than it would blow out of the room with the doors open. An open door would allow the positive pressure to escape the room toward the area of lower air pressure.

Within this room, transport containers could be kept clean and organized on a racking system, and oils could be separated by grade using color and shape codes. Shapes would be included to account for color blindness. The combined codes would offer a visual representation of which grade of oil was being used. All points of use could also be labeled with the same color and shape code system.

To ensure the oil remained clean every step of the way, Bunge needed an improved method of transporting oil to its end use. The plant selected top-port containers with closable spouts to prevent contaminants from entering during transportation. A routine schedule for cleaning these containers was also developed.

Completing the Project

To prepare for the possibility of constructing a clean oil storage room, the plant collected quotes from various suppliers. The expenditure would also need to be justified by reviewing the cost of equipment downtime, constantly replacing oil and equipment failure due to lack of proper lubrication.

During this cost evaluation, Bunge had to decide whether this project could fit within the capital budget. It chose to move forward with the clean room because the rate of return was sufficient enough to be absorbed into the maintenance cost. The actual cost of the project would vary depending upon geographic location, building space, equipment need and other factors. Research for the project began in August 2013. Construction started in November 2013, and the project was completed in April 2014.

Now, not only does Bunge have a clean, organized storage area and proper ways of handling its oil, but it also saves a considerable amount of time and money not changing oil and replacing equipment that fails due to poor-quality oil. The plant can also foresee the approximate amount of oil that will be needed ahead of time. Routine predictive oil analysis indicates oil quality in the equipment and determines if and when the oil should be changed to prevent damage to machinery. Cleaner oil keeps the plant running better and longer.

Bunge's maintenance team is constantly moving toward best practices and knows that without a means to protect the oil, it could never achieve world-class status.

An open shelf holds the non-food-grade containers. The shelves are labeled to denote where each of the containers belongs. Different-sized containers are used depending on the amount required and accessibility of each fill point.

This is the outside of the clean room.

WES CASH | NORIA CORPORATION

UNDERSTANDING the Differences Between SYNTHETICS

"Synthetic" is an all-encompassing term used to describe manmade base fluids utilized in the formulation of lubricants. Synthetics can have sharply different performance attributes and can at times be mutually incompatible. The differences between these base fluids must be understood in order to accommodate the needs of the machine application as well as the properties of the lubricant.

What Makes a Synthetic?

Synthetic lubricants do not originate from crude oil like conventional mineral oil. Instead, synthetic lubricants are formulated from derivates of natural gas and other base materials. For instance, polyalphaolefins (PAOs), which are among the most common synthetic base oils, are formulated from ethylene and decene (largely derived from natural gas). Through the process of polymerization, these molecules are built from the ground up and offer a number of benefits. Unlike mineral oils, in which a single batch of oil may contain millions of different molecular structures, the molecular sizes and shapes within a single synthetic oil are much more consistent. This leads to more consistent fluid properties and predictable life cycles.

Synthetic Benefits

Perhaps the most common advantage associated with synthetic fluids is that they last longer in service. This is due in large part to the consistency of their molecules and the lack of aromatic structures. These molecules are much more robust and better able to handle the rigors of operation without oxidizing or thermally degrading rapidly.

Another benefit is the increased viscosity index. Viscosity index is the relationship between a change in viscosity and a change in temperature. The higher the viscosity index, the smaller the relative change in viscosity with temperature. This allows for a single fluid to maintain its viscosity at all in-service temperatures without having to change viscosity grades between seasons. Synthetics also have improved low-temperature performance characterized by a low pour point.

Fire resistance is a common requirement for most turbine hydraulic systems. The majority of these systems use a synthetic fluid to achieve this fire resistance. One of the properties that helps with a fluid's fire resistance is its flash point, which is the temperature at which a flame propagates across the surface of the oil. Synthetics generally have higher flash points than their mineral oil equivalents.

Synthetic lubricants not only have high-performance basestock but usually also benefit from premium additive systems. In fact, many of the benefits that are commonly attributed to synthetic lubricants actually come from the additives with which they are formulated.

Synthetic Drawbacks

The biggest drawback to using synthetic base oils is the additional cost associated with them. They may be anywhere from three to 15 times more expensive than mineral oil. If you are considering making a switch from mineral to synthetic oils, you must be

Synthetic oils can be tremendous assets to any **lubrication program,** but they must be matched to the machinery's needs to get the optimum **benefit** from them.

sure that the benefits to be realized will make up for the additional front-end cost. There are several ways in which this cost can be recouped, such as extending oil change intervals, employing product consolidation or decreasing machine failures.

Another risk with synthetic fluids is the compatibility issues that come with using these lubricants. Some synthetics have been known to cause seals to swell and reduce lubricant flow, while others can dissolve seal materials, allowing leaks and possibly severely damaging the machine.

Not only do some synthetics have compatibility issues with seals, but most have compatibility issues with other fluids. Polyalkylene glycol (PAG) base oils are notorious for their incompatibility with mineral oils, although oil-soluble PAGs (usually called OSPs) largely remedy this drawback. In the event that mineral oils and PAG oils form an incompatible mix, the result is a gelatinous mass that clogs lines and can lead to lubricant starvation and ultimately machine failure. Other incompatibilities for synthetics include paints, hose materials and some additives.

Synthetic esters such as phosphate esters, polyol esters and di-esters are also at risk for hydrolysis. Hydrolysis is a water-induced chemical reaction that can cause a rise in acid number, loss of viscosity and an increase in varnish potential.

Synthetic Types

Polyalphaolefins have been identified as the most common synthetic base oils. They are used in nearly every type of equipment with the exception of compressors that have high discharge pressures, where they have been known to leave deposits. PAOs are miscible with mineral oils and have good demulsibility characteristics.

Polyalkylene glycol oils are used in some refrigeration compressor systems as well as brake fluids, worm gear oils and gas turbine oils. They are unique in that they don't form deposits as the oil breaks down. PAGs also have a natural detergency and clean up varnish left behind by other fluids. If the base fluid is made by the polymerization of ethylene oxide, the resulting fluid is water soluble and is often used in water-emulsion hydraulic fluids.

Di-esters are frequently used in compressor applications and are often paired with PAOs to help with additive solubility. Di-esters also tend to be hygroscopic in nature, which means they absorb moisture readily. They have a high viscosity index as well as a low pour point, so these oils will remain fluid at low temperatures.

Silicone base oils have the highest viscosity indexes and some of the highest levels of thermal and oxidative stability. These bases are used primarily in high heat applications and some brake fluids. They are typically very costly. In addition, the oxidation byproducts are abrasive and can lead to added machine wear. Silicones are also chemically inert, which makes it difficult to blend additives into them and still have them remain in solution.

Overall, synthetic oils can be tremendous assets to any lubrication program, but they must be matched to the machinery's needs to get the optimum benefit from them. When making the transition from mineral base fluids to a synthetic base, be sure to flush the system to minimize any residual compatibility issues that may remain. By understanding the strengths and weaknesses of the synthetic base you are using, you will be well on your way to achieving all of the advantages associated with these fluids. ■

About the Author

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BY CRAIG WINTERFIELD, FLUID LIFE, FREDERIK VAN DE VOORT, MCGILL UNIVERSITY

A New Approach for Determining the Acid and Base Number of Used Oils

The acid number and base number of in-service oils are considered key indicators of oil quality and are used to monitor the accumulation of acid and the depletion of the base additive package. A significant rise in acid number or decrease in base number may reflect a deterioration in oil quality either due to chemical reactions, oxidation, incorrect oils, additive depletion and contamination. Tables 1 and 2 summarize common acid number and base number methods.

ASTM methods, including D664, D974, D2896 and D4739, are the current industry standard methods for measuring the acid and base number. These titration-based methods are slow and expensive to execute, require significant volumes of sample and solvent, and are prone to interferences. As a result, these methods have relatively wide repeatability and reproducibility limits, accounting for their significant inter-laboratory variability. The high cost and poor accuracy of these methods limit their usefulness and application to routine oil monitoring.

The acid number and base number are also sometimes reported using a variety of partial least squares (PLS) direct-read Fourier transform infrared (FTIR) methods, which estimate the acid and base number of used oils by directly measuring the spectrum of undiluted oil.

Quantitative FTIR Spectroscopy

FTIR spectroscopy has been touted as a potential alternative means of obtaining quantitative acid number and base number data. However, there previously had been no solid evidence that FTIR was viable or reliable in commercial practice. FTIR has predominantly been utilized as an automated fingerprint-based survey technique, as per ASTM D7418-07 or the Joint Oil Analysis Program, which is typically used for screening and trending changes in lubricant parameters such as moisture, glycol, soot, oxidation, antioxidants and wear additives. As such, FTIR condition monitoring analysis provides a rapid, automated means of screening a large

ACID NUMBER METHOD	TYPE	REAGENT	CALIBRATION	NOTES
ASTM D664	Titration	Potassium hydroxide	Stoichiometric	Slow, high uncertainty
ASTM D974	Titration	Potassium hydroxide	Stoichiometric	Dark oils interfere with measurement
PLS-FTIR	FTIR direct read	None	PLS calibration	Subject to interferences
Stoichiometric-FTIR	FTIR acid/base reaction based	IR active base	PLS and stoichiometric	Improved precision over ASTM D664

Table 1. Common Acid Number Test Methods

BASE NUMBER METHOD	TYPE	REAGENT	CALIBRATION	NOTES
ASTM D2896	Titration	Perchloric acid in glacial acetic acid	Stoichiometric	Slow, labor-intensive, used for new oil quality control
ASTM D4739	Titration	Hydrochloric acid	Stoichiometric	Slow, high uncertainty
PLS-FTIR	FTIR direct read	None	PLS calibration	Subject to interferences
Stoichiometric-FTIR	FTIR acid/base reaction based	IR active acid	PLS and stoichiometric	Improved precision over ASTM D4739

Table 2. Common Base Number Test Methods

FTIR CALIBRATION TYPE	CALIBRATION SAMPLES	NOTES
PLS (partial least squares)	In-service oil samples with corresponding ASTM acid number or base number data	• Fast analysis • Easy-to-set-up calibration • Subject to interferences • Estimate ASTM D664 and D4739
Stoichiometric – linear fit	Gravimetrically prepared standards of organic acid/base diluted in mineral oil	• Accurate and precise • Calibration is anchored to stoichiometric chemical reactions • Results cannot be directly compared to ASTM D664 or D4739
Mixed mode = PLS + stoichiometric	Gravimetrically prepared standards and samples of used oil with corresponding ASTM D664 or D4739 data	• Results are a direct match to ASTM D664 and D4739/D2896 • Accurate and precise • High initial development cost

Table 3. Summary of Calibration Types for FTIR Acid Number and Base Number Methods

number of oil samples, in part to determine if additional quantitative analyses, such as acid or base number determinations, are required.

Types of FTIR Calibrations

Currently, there are three distinct quantitative approaches available for acid number or base number analysis by FTIR. One is based on direct neat-oil analysis solely using partial least squares (PLS) chemometrics. Another is based on the use of ASTM-like acid/base stoichiometric reactions. A third approach, called a mixed-mode calibration, combines the advantages of both the PLS and stoichiometric calibrations.

PLS-only Calibrations

A PLS-only calibration is created by comparing ASTM D664 and D4739 data to the undiluted FTIR spectra of a representative set of in-service oils. Partial least squares are then used to correlate variations in these spectra to the acid number and base number results measured by titration. The spectrum of unknown samples can then be used to predict or estimate the acid number or base number result.

PLS-based spectral methods rely solely on non-specific spectral changes that can become problematic when dealing with used oil samples because they have significant and tricky interferences that can be difficult to model adequately. These older direct-read methods have trouble accounting for real-life variables such as soot, water, incorrect lubricant or mixtures of lube and oil degradation products.

Stoichiometric Calibrations

The stoichiometric calibration relies on acid/base reactions that are directly measured using the absorbance of infrared light. This is made possible through the use of weaker but "IR active" organic acids and bases rather than stronger inorganic potassium hydroxide (KOH) or hydrochloric acid (HCl), as per ASTM methods. With this approach, the analytical principles are similar to the ASTM methods, e.g., acid/base reactions, but instead of titrating to determine the end point, the acid/base reaction is monitored and measured spectrally.

One of the consequences of using weaker organic acids and bases is that the predicted analytical FTIR acid number/base number values obtained will be significantly lower than those obtained using the titration methods. Until recently, this divergence of FTIR acid number and base number values from those obtained using titration procedures was a major impediment to laboratories wishing to make use of the stoichiometric approach. Oil analysis and reliability clients are naturally reluctant to change their familiar analytical frame of reference, and a shift in expected acid number and base number values could lead to confusion. This problem was solved by the development of a "mixed-mode" stoichiometric calibration with the concurrent implementation of PLS.

Mixed-mode Calibrations

The mixed-mode method combines the

Figure 1. An example of a system used for the FTIR determination of ASTM-identical acid number and base number results for in-service mineral oils

advantages of both types of FTIR calibration. This calibration is anchored using gravimetrically prepared ideal standards to define the fundamental acid/base relationship. Hundreds of in-service oil samples are then used to further account for the spectral variability induced by real samples and to align the data with the corresponding ASTM method. PLS serves only to refine the measurement and to ensure that the results match the ASTM reference method used in its development.

A variety of mixed-mode PLS calibrations were recently developed and assessed. The bulk of the samples analyzed for the PLS component of the base number calibration were in-service engine oils covering most major lubricant suppliers and representing a wide range of equipment applications (mining, transport, generators, marine, etc.), with nearly 70 percent using diesel fuel and the balance natural gas. In the case of acid number, a mix of new and in-service oils covering a wide range of suppliers and grades was considered, including oils from engines, compressors, hydraulic systems, turbines, transmissions and gearboxes.

Figures 2 and 3 illustrate the typical cross-validated FTIR calibrations obtained for acid number and base number, respectively.

The performance of the mixed-mode calibrations was monitored over a six-month period. Some 177 acid number samples and 284 base number samples were analyzed using both the FTIR method and the corresponding ASTM titration methods (D664 and D4739). Samples included a mixture of new and used oils from a wide variety of components, including hydraulic systems, gearboxes, transmissions,

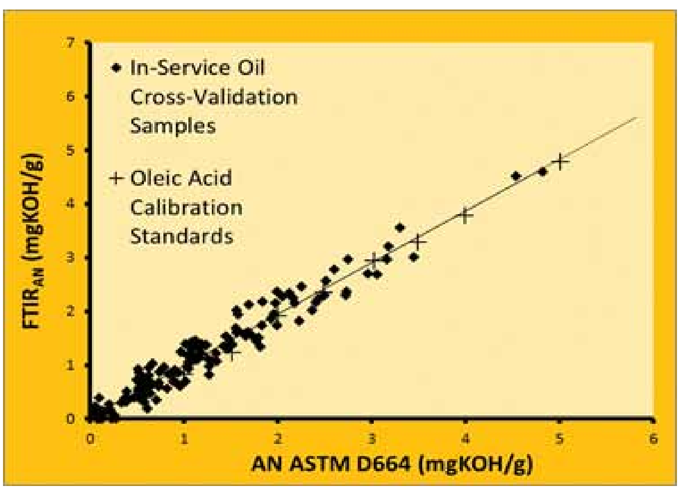

Figure 2. A cross-validation chart of the mixed-mode calibration comparing acid number data for in-service oil samples analyzed by ASTM D664 and the FTIR acid number method

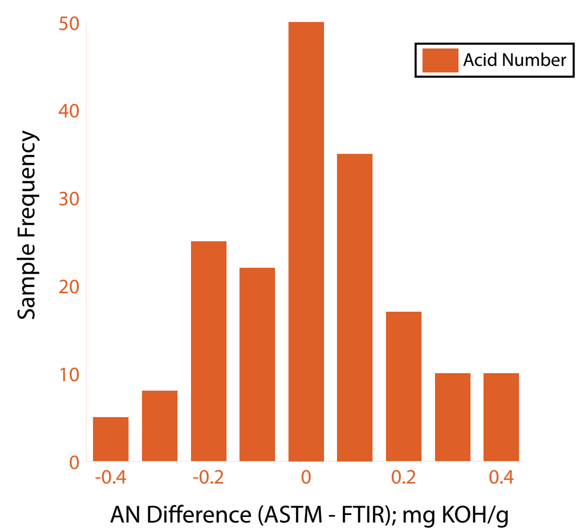

Figure 4. Comparing the differences between ASTM and FTIR acid number results obtained for random operational samples

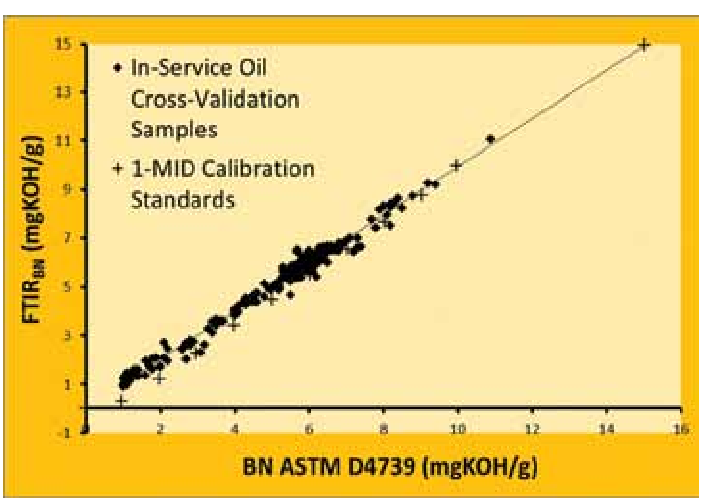

Figure 3. A cross-validation chart of the mixed-mode calibration comparing base number data for in-service oil samples analyzed by ASTM D4739 and the FTIR base number method

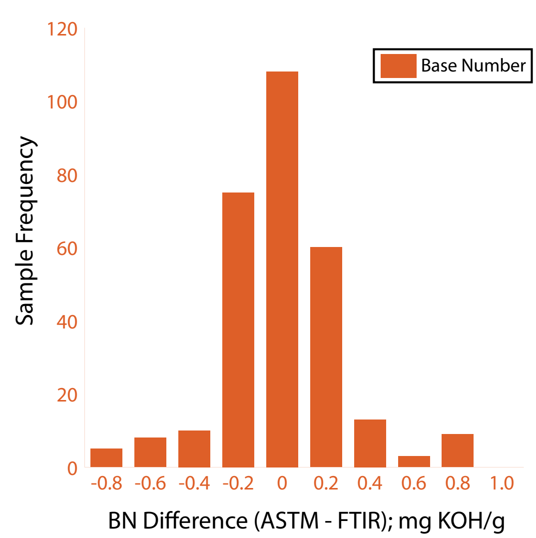

Figure 5. Comparing the differences between ASTM and FTIR base number results obtained for random operational samples

	ASTM D664	FTIR ACID NUMBER
Sample preparation time	120 seconds per sample	60 seconds per sample
Samples per hour	4-6	60
Daily startup and preventative maintenance time	Variable (up to 1 hour)	< 15 minutes
Waste disposal volume	~130 ml	~25 ml

	ASTM D4739	FTIR BASE NUMBER
Sample preparation time	120 seconds per sample	60 seconds per sample
Samples per hour	4-6	60
Daily startup and preventative maintenance time	Variable (up to 1 hour)	< 15 minutes
Waste disposal volume	~90 ml	~25 ml

Table 4. Comparison of Key Performance Characteristics Between the ASTM and FTIR Methods

BASE NUMBER	MIXED-MODE BASE NUMBER FTIR REPRODUCIBILITY	ASTM D4739 REPRODUCIBILITY
6	1.3	3.55
10	1.3	4.52
15	1.3	5.46

ACID NUMBER	MIXED-MODE ACID NUMBER FTIR REPRODUCIBILITY	ASTM D664 REPRODUCIBILITY
1	0.20	0.44
2	0.20	0.88
3	0.20	1.32

Table 5. Reproducibility Comparison of Acid and Base Number Results

engines, turbines and compressors.

Figures 4 and 5 show the differences between the individual ASTM and FTIR results for acid number and base number, respectively. The analytical differences between the two methods are normally distributed in both cases, with each having an overall mean difference of almost zero. This indicates on-average similarity in their results, with the variability around the mean difference reflecting the reproducibility of the ASTM reference methods. These extended production results clearly demonstrated that the FTIR acid number/base number methods are capable of delivering ASTM-identical results.

FTIR Calibration Pros and Cons

Based on the recent two-year assessment, the mixed-mode calibration can deliver statistically ASTM-identical data at rates roughly equivalent to operating nine to 10 dedicated titrators for each analysis type. Tables 4 and 5 summarize and compare the key variables of the two analytical approaches (ASTM and FTIR). With one analyst capable of analyzing nearly 500 samples by FTIR per 8-hour shift, the advantage is clearly in favor of the FTIR system.

Although the mixed-mode calibration was developed to produce results statistically identical to ASTM D664 and D4739, accuracy is intrinsically limited by the uncertainty of these reference methods. The uncertainty and bias in the FTIR methods can be minimized by using a large set of in-service oil samples (more than 200). The FTIR methods also benefit from excellent precision in contrast to the more complicated indirect titration-based methods.

While the stoichiometric approach was found to be superior in accuracy relative to the neat-oil PLS-only approach, this does not mean the PLS-only method should be completely discounted as a potentially useful procedure. It is possible that this method may serve to provide adequate tracking estimates of ASTM parameters in more limited situations. Unfortunately, there is no published information or performance data available for the chemometric PLS-only approach. The advantage of this method is that it can make use of FTIR instrumentation that many laboratories already have in place.

Neither the FTIR PLS-only nor the stoichiometric acid number/base number approaches are sanctioned by any governing bodies, ASTM or otherwise. Therefore, any laboratory using either of these methods can only present the results to their clients as an accurate, precise and cost-effective means of obtaining acid and base number data.

PILOT Course at JK CEMENT

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, efficiently and safely.

The content of the course includes-

- Basic of lubrication
- Contamination control
- Hands on training for handling lubricants
- Sampling
- Field inspection of lubricants
- And much more....

PILOT (Practical Industrial Lubrication Orientation Training) Course at JK Cement Nimbahera, Rajasthan

PILOT course was recently organized at the Regional Training Centre (RTC), J.K. Cement, Nimbahera Rajasthan. The two day training program on 20th and 21st

September was successfully conducted by Lubrication Institute (an associate of VAS Tribology Solutions), in which training was imparted to the technicians by demonstrating various lubrication activities and best practices using standard hardware. There were 34 participants including lube technicians, charge hands, fitters, mechanics and GETs. The candidates who were a part of this program got an opportunity to undergo training with the help of graphics, animations and videos along with the activity based practical training modules. Entire training module (including manuals and videos) was delivered in regional language (Hindi). Training concluded with the certificate distribution to the participants.

ExxonMobil and Primetals Technologies sign global lubrication agreement

- Partnership introduces a joint lubricants and technical services offering
- Available to Primetals Technologies long rolling and Morgoil flat rolling equipment owners

"To meet their demanding productivity goals, operators want suppliers who can deliver end-to-end support to optimize mill reliability and performance," said Gabriel Royo, Vice President and Head of Metallurgical Services at Primetals Technologies USA LLC. "As a leading lubricants supplier for the metals industry, ExxonMobil is the ideal partner to help us deliver a complete solution – providing world-class products and technical support for our advanced equipment designs – so our customers can focus on achieving their business goals."

"Metals producers today want a lubrication program that boosts machine efficiency and reduces costs," said Tim Hinchman, Director of Strategic Global Alliances at ExxonMobil. "This partnership enables us to combine our lubrication expertise with Primetals Technologies' equipment expertise to achieve one shared goal – help our customers improve their operational reliability, productivity and profitability."

Training on "Essentials of Machinery Lubrication" at NTPC Power Management Institute (PMI), Noida

NTPC Ltd. organised a 3 day In-House training program on "Essentials of Machinery Lubrication" for its plant maintenance team at their Power Management Institute (PMI), Noida from 25-27th Sep 2017. Engineers from NTPC's 18 locations were nominated for this program which focused on Lubricants, Lubrication & Reliability. The training also gives inputs on how to build and operate a safe and effective lubricant storage and handling program. During the training various lubrication related issues with corrective actions were also discussed. The program had a pre and post assessment exam.

Training concluded with the certificate distribution to the participants.

BENNETT FITCH | NORIA CORPORATION

Understanding the DIFFERENCES Between BASE OIL FORMULATIONS

All lubricants contain a base oil. It serves as the foundation of the lubricant before it is blended with additives or a thickener in the case of a grease. But how do you know which base oil is best? Trying to choose between mineral oils and synthetics can be confusing. This article will break down the complexity between base oil formulations so you can make the right decision for each application.

When you are choosing a base oil, there will be tradeoffs in the lubricant properties required for the application.

Base Oil Categories

Lubricants can be categorized in many different ways. One of the most common classifications is by the constituent base oil: mineral, synthetic or vegetable. Mineral oil, which is derived from crude oil, can be produced to a range of qualities associated with the oil's refining process. Synthetics are man-made through a synthesizing process and come in a number of formulations with unique properties for their intended purpose. Vegetable base oils, which are derived from plant oils, represent a very small percentage of lubricants and are used primarily for renewable and environmental interests.

Base Oil Characteristics

All base oils have characteristics that determine how they will hold up against a variety of lubrication challenges. For a mineral oil, the goal of the refining process is to optimize the resulting properties to produce a superior lubricant. For synthetically generated oils, the objective of the various formulations is to create a lubricant with properties that may not be

SYNTHETIC	STRENGTHS	WEAKNESSES
Polyalphaolefins (PAOs) Maximum Operating Temperature: 270°F/132°C	High VI, high thermal oxidative stability, low volatility, good flow properties at low temperatures, nontoxic and compatible with mineral oils	Limited biodegradability, limited additive solubility, seal shrinkage risk
Diesters and Polyolesters Maximum Operating Temperature: 360°F/182°C	Nontoxic, biodegradable, high VI, good low-temperature properties, miscible with mineral oils	Low viscosities only, bad hydrolytic stability, limited seal and paint compatibility
Phosphate Esters Maximum Operating Temperature: 240°F/116°C	Fire resistant, biodegrades quickly, excellent wear resistance and scuffing protection	Low VI, limited seal compatibility, not miscible with mineral oils, moderate hydrolytic stability
Polyalkylene Glycols (PAGs) Maximum Operating Temperature: 300°F/149°C	Excellent lubricity, nontoxic, good thermal and oxidative stability, high VI	Additives marginally miscible, not miscible with mineral oils, limited seal and paint compatibility
Silicones Maximum Operating Temperature: 450°F/232°C	Highest VI, high chemical stability, excellent seal compatibility, very good thermal and oxidative stability	Worst mixed and boundary film lubrication properties, not miscible with mineral oils or additives

achievable in a mineral oil. Whether mineral-based or synthetic-based, each base oil is designed to have a specific application.

Some of the most important base oil properties include the viscosity limitations and viscosity index, pour point, volatility, oxidation and thermal stability, aniline point (a measure of the base oil's solvency toward other materials including additives), and hydrolytic stability (the lubricant's resistance to chemical decomposition in the presence of water).

Base Oil Groups

The 20th century saw a number of improvements in the refining process used for mineral oils along with the introduction of a variety of synthetics. By the early 1990s, the American Petroleum Institute (API) had categorized all base oils into five groups, with the first three groups dedicated to mineral oils and the remaining two groups predominantly synthetic base oils.

Groups I, II and III are all mineral oils with an increasing severity of the refining process. Group I base oils are created using the solvent-extraction or solvent-refining technology. This technology, which has been employed since the early days of mineral oil refining, aims to extract the undesirable components within the oil such as ring structures and aromatics.

Group II base oils are produced using hydrogen gas in a process called hydrogenation or hydrotreating. The

goal of this process is the same as for solvent-refining, but it is more effective in converting undesirable components like aromatics into desirable hydrocarbon structures.

Group III base oils are made in much the same way as Group II mineral oils, except the hydrogenation process is coupled with high temperatures and

	MINERAL OIL	PHOSPHATE ESTER	POLYGLYCOL	POLYOLESTER	DIESTER	PERFLUOROPOLYETHER	SILICONE	POLYALPHAOLEFIN
Cost	L	VH	M	M	M	VH	H	M
Seal compatibility	AA	BA	A	BA	BA	AA	AA	AA
Compatible with mineral oil	-	BA	BA	A	A	BA	BA	E
Corrosion stability	E	AA	A	BA	BA	BA	A	E
Oxidation stability	BA	AA	AA	AA	A	E	E	AA
Viscosity range	AA	BA	A	BA	BA	A	A	A
Flash point	M	E	A	AA	A	E	E	AA
Pour point	A	AA	M	L	L	L	VL	L
Temperature range	BA	A	A	AA	A	E	E	AA

KEY

E	EXCEPTIONAL
AA	ABOVE AVERAGE OR VERY GOOD
A	AVERAGE OR GOOD
BA	BELOW AVERAGE OR LESS THAN IDEAL
VL	VERY LOW
L	LOW
M	MEDIUM
H	HIGH
VH	VERY HIGH
NA	NOT AVAILABLE

Comparison of essential properties for base oils high pressures. As a result, nearly all undesirable components within the oil are converted into desirable hydrocarbon structures.

When comparing properties among the mineral base oil groups, you typically will see greater benefits with those that are more highly refined, including those with enhanced oxidation stability, thermal stability, viscosity index, pour point and higher operating temperatures. Of course, as the oil becomes more refined, some key weaknesses also occur, which can affect additive solubility and biodegradability.

Group IV is dedicated to a single type of synthetic called polyalphaolefin (PAO). It is the most widely used synthetic base oil. PAOs are synthetically generated hydrocarbons with an olefinic tail formed through a polymerization process involving ethylene gas. The result is a structure that looks very much like the purest form of the mineral oils described in Group III. The advantages of PAOs over mineral oil include a higher viscosity index, excellent low- and high-temperature performance, superior oxidation stability, and lower volatility. However, these synthetic lubricants can also have deficiencies when it comes to additive solubility, lubricity, seal shrinkage and film strength. Much like mineral oils, PAOs are widely employed for lubricating applications and are often the preferred option when higher temperatures are expected.

Group V is assigned to all other base oils, particularly synthetics. Some of the most common oils in this group include diesters, polyolesters, polyalkylene glycols, phosphate esters and silicones.

Diester (dibasic acid ester) is manufactured through a reaction of dibasic acid with alcohol. The resulting properties can be adjusted based on the types of dibasic acid and alcohol used.

Polyolester is made through a reaction of monobasic acid with a polyhydric alcohol. Much like diesters, the resulting properties will depend on these two constituent types.

Polyalkylene glycol (PAG) is produced through a reaction involving ethylene or propylene oxides and alcohol to form various polymers. A number of PAG products are developed based on the oxide used, which will ultimately influence the base oil's water solubility.

Phosphate ester is created through a reaction of phosphoric acid and alcohol, while silicones are formulated to have a silicon-oxygen structure with organic chains attached. Each of these synthetics has specific strengths and weaknesses, as shown in the table on page 34.

55%

of lubrication professionals use both synthetic and mineral-based lubricants at their plant, according to a recent survey at MachineryLubrication.com

Applications

In general, synthetics can provide greater benefits when it comes to properties influenced by extreme temperatures, such as oxidative and thermal stability, which can contribute to an extended service life. In situations where the lubricant will encounter cold startups or high operating temperatures, synthetics like PAOs typically will perform better than mineral oils. PAOs also exhibit improved characteristics in relation to demulsibility and hydrolytic stability, which influence the lubricant's ability to handle water contamination.

While PAOs are ideal for applications like engine oils, gear oils, bearing oils and other applications, mineral oil remains the predominant oil of choice due to its lower cost and reasonable service capabilities. With more than 90 percent usage in the industrial and automotive markets, mineral oil has solidified its place as the most common base oil in the majority of applications.

Paraffinic mineral oil, which is represented in Groups I, II and III, can offer a higher viscosity index and a higher flash point in comparison to naphthenic mineral oils, which have lower pour points and better additive solvency. Even though naphthenic oil is mineral-based, it is considered a Group V oil because it does not satisfy the API's qualifications for Group I, II and III. The unique characteristics of naphthenic mineral oils have often made them good lubricants for locomotive engine oils, refrigerant oils, compressor oils, transformer oils and process oils. Nevertheless, paraffinic oils continue to be the preferred option for high-temperature applications and when longer lubricant life is required.

Ester-based synthetics, such as diesters and polyolesters, have advantages when it comes to biodegradability and miscibility with other oils. In fact, it is common for diesters and polyolesters to be mixed with PAOs during additive blending to help accept more significant additive packages. Diesters and polyolesters are often deployed as the base oil for compressor fluids, high-temperature grease applications and even bearing or gear oils. Because they are known to perform well at higher temperatures, polyolesters have also been widely used for jet engine oils.

Compared to other oils, polyalkylene glycols (PAGs) have a much higher viscosity index and good detergency, lubricity, and oxidative and thermal stability characteristics. PAGs can be formulated to be water soluble or insoluble and do not form deposits or residue during extreme operating conditions. PAGs can be employed in a number of applications, such as compressor oil, brake fluid, high-temperature chain oil, worm gear oil and metalworking fluid, as well as for applications with food-grade, biodegradability or fire-resistant requirements.

Phosphate esters are primarily beneficial for fire-resistant applications. They are often utilized in hydraulic turbines and compressors due to their unique properties, including high ignition temperatures, oxidation stability and low vapor pressures.

Silicone-based synthetics are infrequently used in industrial applications, but they can be advantageous in extremely high temperatures, when the lubricant will contact chemicals, or when exposed to radiation or oxygen. These synthetics have a very high viscosity index and are among the best options for oxidation and thermal stability because they are chemically inert.

Selecting a Base Oil

When you are choosing a base oil, there will be tradeoffs in the lubricant properties required for the application. A common example is viscosity. Higher viscosity provides adequate film strength, while lower viscosity offers low-temperature fluidity and lower energy consumption. In some cases, you may prefer to have a balance between the two so there isn't too much of a compromise on either side. The chart on page 33 shows a comparison of the most essential properties for each base oil.

Although it's not necessarily important to understand the way in which the oil was manufactured, it is critical to know the available base oil options and the advantages and disadvantages they provide. Optimizing your lubricant selection can help minimize the opportunities for machine failure. While synthetics are justifiably more expensive than mineral oil, the cost of equipment failure is typically much higher. If cost is a key factor in your decision, be sure to choose wisely. ■

4 Things to Know About Base Oils

1. All oils from each base oil type are not the same, as the formulations can produce unique distinctions. Therefore, the properties described for each base oil type are generalized for the category as a whole.
2. Group III oils are sometimes advertised as synthetics. There is an understanding that the refining process has severely modified the original hydrocarbon, thus synthesizing the more highly pure product.
3. Water-based fluids are an alternative when fire resistance is imperative and typical lubricant properties like viscosity or lubricity are less important.
4. Be cautious when switching lubricants, particularly when they have different base oils, as they may be incompatible with each other.

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Lube-Tips™

THE "LUBE-TIPS" SECTION OF *MACHINERY LUBRICATION* MAGAZINE FEATURES INNOVATIVE ideas submitted by our readers. Additional tips can be found in our Lube-Tips email newsletter. If you have a tip to share, email it to admin@machinerylubricationindia.com. To receive the Lube-Tips newsletter, subscribe now at www.MachineryLubricationIndia.com/page/subscriptions.

Tip for Pulling Representative Oil Samples

When working in an industrial plant where some or all of the equipment is open to the atmosphere (rain, mist, snow, etc.), wipe the moisture off your hard hat before taking or handling your sample. This is important even if the lube oil system is housed in an enclosed building. Walking from building to building, you can accumulate contaminant and moisture on your hard hat. All it takes is one unseen drop of moisture to contaminate your sample.

Avoid Overfilling Gearboxes

Overfilling a gearbox sump can be just as damaging as underfilling. Overfilling may cause air entrainment and foam, overheated oil and leakage due to overflow. Over time, oxidation may occur due to increased temperatures and exposure to air.

Extend the Life of Your Machine

Have you had a blood test lately? It is important to be aware of your physical condition, and a blood test can provide crucial information about your health. In a similar manner, oil analysis is just as important to equipment, because it analyzes not only the oil but the machine itself. This provides vital information to help determine the root cause of mechanical problems that threaten your machine. Utilizing oil analysis helps you get the most information, which can lead to success in asset management.

Advice for Summer Cooling System Maintenance

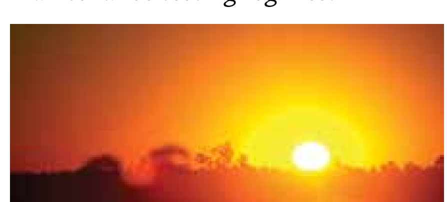
Summertime heat can take its toll on cooling systems already taxed with engine operating temperatures at 225 to 250 degrees F. Today's engines have a much tighter cooling margin than previous models. As a result, proper coolant and cooling system maintenance becomes increasingly important to maximizing system life and maintaining efficiency.

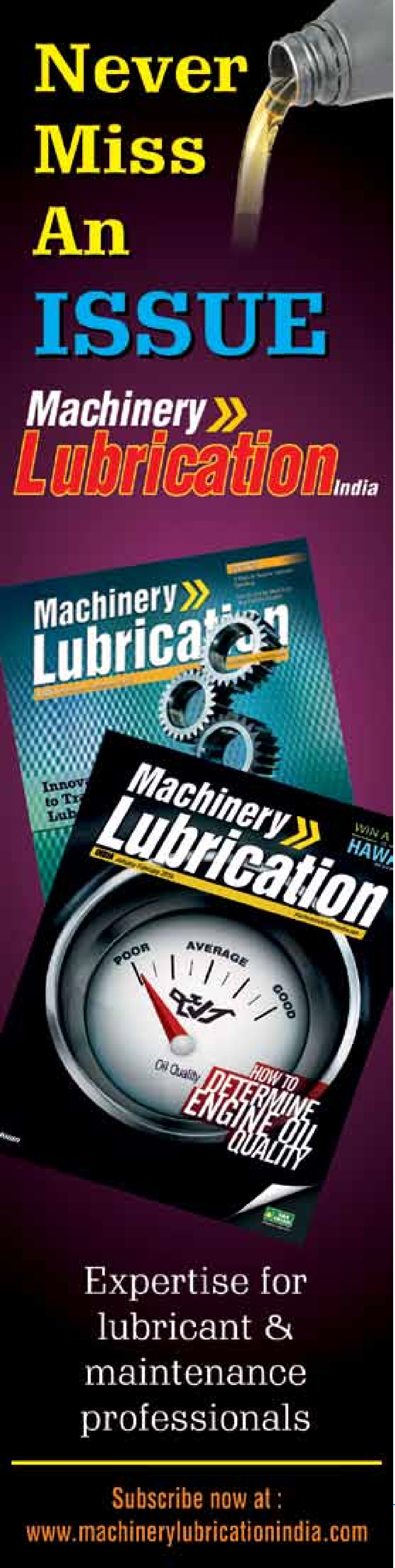
Field testing performed with preventive maintenance (PM) is vital to maintaining an efficient cooling system and a coolant formulation that protects and prolongs system life. It ensures that system components are functioning properly, glycol levels are maintained at 50 to 60 percent for boiling-point control, inhibitor levels are maintained for proper metal protection, and the pH level is within the OEM's and the coolant manufacturer's specifications for adequate corrosion control.

Just how important is coolant formulation and system efficiency? A 50/50 coolant mix — 50 percent concentrate to 50 percent water — brings the coolant's boiling point to 225 degrees F at sea level. That's the low end for an engine today that operates at 225 to 250 degrees F. But every added pound of pressure raises that boiling point another 2.7 degrees F. So a 14-pound pressure cap raises the boiling point of a 50/50 formulation to about 263 degrees F. If a pressure cap or relief valve is defective or glycol levels are inadequate, the boiling point is right back down to the engine operating temperature.

A 40-degree buffer provides adequate protection against boiling. When conventional coolants are allowed to boil, glycol decomposition can cause several problems. The chemical reaction results in oxalic acid. This "burnt" coolant has a very distinctive dark brown/gold color and an even more distinctive odor. It creates a "varnish" that covers internal system components, prevents the system from operating properly and is extremely difficult to correct. This varnish must be flushed, the system thoroughly cleaned and any hot spots corrected before new coolant can be introduced. Monitoring the system's condition and strip-testing the coolant at every PM can keep operations running smoothly and without unexpected interruptions.

Further laboratory testing on a quarterly schedule can identify many issues caused by excessive heat before catastrophic failure occurs and assist maintenance management in determining appropriate preventive maintenance testing regimes. ■





TEST your KNOWLEDGE

This month, *Machinery Lubrication India* 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.

1. A downward base number trend indicates:

A) The type of base stock used in the finished oil
B) The build-up of alkalinity in the used oil
C) The neutralization of the acids in turbine oils
D) The depletion of the alkaline detergent additive in engine oils
E) The base oil density

2. Single-point grease lubricators:

A) Are able to pump grease to a large number of grease points
B) Are a reliable "set it and forget it" grease-dispensing system
C) Are useful for hard-to-reach lube points
D) Are capable of producing pressures similar to centralized systems
E) All of the above

3. Vacuum dehydration is a good option for drying oil because:

A) The method also vacuums up small particles
B) The method maintains a vacuum that prevents buildup of moisture in the future
C) The method boils the water off at high temperatures
D) The method removes all three forms of water
E) All of the above

Answers

1. D
Base number is an important parameter to monitor, especially for engine oils. Engine oil is alkaline (basic) because it is fortified with detergent additives to control deposits and neutralized acids generated during combustion. As the oil ages, these types of additives are used up, leading to a decrease in the base number.

2. C
A single-point grease lubricator is used to pump grease to a limited number of grease points (normally one). It should be inspected regularly to ensure it is functioning properly. These types of lubricators are very useful for hard-to-reach lube points, enhancing safety and reliability. The pressure produced by single-point lubricators is much less than centralized greasing systems, so the correct answer is „C."

3. D
Vacuum dehydration is a good option because it removes dissolved, emulsified and free water. Most of the other techniques are not capable of removing all forms of water, especially dissolved water.

"Are there any **warning signs** of when a **bearing** is about to **fail**?"

Think of a bearing failure as happening in four stages. During the first stage (or earliest detectable point using vibration analysis), the signals will appear in frequency bands around 250 to 350 kilohertz (KHz). In the second stage, a signal around 500 to 2,000 hertz (its natural frequency) will begin to ring.

At the onset of the third stage, the harmonics of the fundamental frequency will start to be very apparent. Defects in the races are now obvious and will be visible on vibration analysis of the noise signal. At this point, there will also be a significant temperature increase.

During the fourth stage, there will be very high vibration. The fundamental frequency and harmonics begin to decrease as the random ultrasonic noise is boosted. Temperatures will start to skyrocket as the bearing self-destructs.

So, the short answer is yes. There are definitely warning signs of a bearing about to fail. The real question is, "Do you know what to look for?" The most popular technologies today for bearing monitoring are vibration analysis, oil analysis, ultrasonics and thermography. You can use these tools to compare current states to historical data and accurately assess the remaining life of the bearing.

Vibration analysis and oil analysis are considered the best at predicting a failure but are not always the most cost-effective. Bearing manufacturers have long known of the relationship between bearing life and temperature. They even have formulas that work very well at calculating safe operating temperatures. These formulas and calculators show that once a bearing starts operating outside its ideal temperature range, its life will begin to degrade at an accelerated rate. Keep in mind that for every 15 degrees C above 70 degrees C that the base oil operates, its life is more than halved.

Considering this, why is thermography not a more popular method for bearing life prediction? The monitoring of temperatures is not always considered reliable because of the sheer amount of variables that contribute to the heat generation. Ambient temperature, friction, speed variability, load and runtime all have an effect on the temperature that will be measured.

Friction is the variable you should be the most concerned with if trying to predict a failure, but how do you separate it from all the others? If you could account for all the variables accurately, the increases you would get in operating temperature could be a great indicator of an impending failure. Perhaps the cheapest and easiest way to spot a bearing failure is to use a non-contact infrared thermometer. The caveat is that you must always account for the other variables as well.

"How **important** is the **kinematic viscosity** at 100 degrees C for a **vacuum pump oil**?"

Viscosity is the most important physical property of a lubricant. Whether you are looking at the viscosity at the standard 40 degrees C or at 100 degrees C, it is the viscosity at the machine's operating temperature that is critical to understand. Most bearing temperatures are hotter than 40 degrees C (104 degrees F) at the core, which is where the temperature should be analyzed to match the correct viscosity for the application.

Vacuum pumps stress oil in a variety of different ways. Aside from the operating temperature, contamination is prevalent if these machines are not properly set up to exclude the ingress of contaminants. Also, the gas being processed has a huge impact not only on the viscosity but also on the lifespan of the oil in service. Process gases can reduce the oil's viscosity, raise the acid number, increase the moisture level and lead to short lubricant life and low oxidative stability.

Most lubricant manufacturers will provide the viscosity for their products at 40 degrees C and 100 degrees C. The amount of change in the viscosity in relation to the temperature is known as the viscosity index of the lubricant. The viscosity index is most often reported in the technical data sheet of the candidate oil. The higher the viscosity index value, the less the viscosity changes with a change in temperature. This is a crucial factor to consider when looking to switch to a different type or brand of oil.

Kinematic viscosity is the measurement of a fluid's resistance to flow due to the effects of gravity. It is the viscosity that most people are accustomed to in terms of how thick a fluid is. This will be one of the most noted changes as the oil is heated, the viscosity drops and the oil flows more readily. For all tribosystems, the oil's ability to flow and support loads is what protects the component from surface degradation and ultimately the loss of usefulness and failure of the machine.

The viscosity at 100 degrees C is critical, not just for vacuum pumps but for all machines. It is important to understand the viscosity requirements of the bearings or gearsets at the operating temperatures and to ensure that they are being met by the lubricant in use. By verifying that the viscosity is appropriate, you will be generating less wear and prolonging the life of your machines.

If you have a question for one of Noria's experts, email it to editor@noria.com.

LOREN GREEN | NORIA CORPORATION

BEST PRACTICES for Waste OIL MANAGEMENT

Proper handling techniques do not end when oil has been put into service. Once the life of the oil has been exceeded, you must ensure the lubricant is captured and disposed of both safely and in an environmentally friendly way. To achieve this goal, it is essential to employ best practices for used oil management.

> "In most cases, the 'waste oil' in a plant is in fact used oil and is not subject to the special handling that is required of true waste oil."

Waste Oil vs. Used Oil

Many people use the terms "waste oil" and "used oil" interchangeably. While both labels may identify the same fluid, from a regulatory standpoint there is a significant difference. Used oil is defined by the U.S. Environmental Protection Agency (EPA) as follows:

"Used oil is any oil that has been refined from crude oil or any synthetic oil that has been used and as a result of such use is contaminated by physical or chemical impurities."

This does not include vegetable or animal-based oils, but any petroleum or synthetic-based oil that has been used previously. In contrast, waste oil has been contaminated and is deemed not usable. For example, if the cap on a new oil drum had been leaking and water had gotten into the drum, this product would be deemed to be unusable and as such would be waste oil. Due to some of the additive chemistries, it is entirely possible that this mixture of finished lubricant and water would exceed the chemical limits and need to be classified as waste oil.

Oils that are off-specification typically contain arsenic (5 ppm), cadmium (2 ppm), chromium (10 ppm) and lead (100 ppm), as well as have a minimum flash point of 100 degrees F and total halogens of more than 4,000 ppm. This would qualify the mixture as hazardous waste. Hazardous materials are defined in various ways under a number of regulatory programs, including the Occupational Safety and Health Administration (OSHA), U.S. Department of Transportation (USDOT), etc.

71% of lubrication professionals say their plant has procedures to dispose of used lubricants in an environmentally friendly way, based on a recent survey at MachineryLubrication.com

Going back to the oil drum example, imagine if the seal on that drum had held and no water was allowed to enter. The lubricant was then put into service, and the seals leaked on the pump in which the lubricant was placed. Due to the leaking seals, water was allowed to enter the lubricant sump and mix with the oil. Once this mixture was drained and placed into a container, it would be classified as "used oil." While the end result of both of these processes was a mixture of oil and water, there is a significant difference in the requirements for each. Several plants have "used oil" being stored in drums, tanks and totes marked as "waste oil."

In addition to the EPA's used oil management standards, your business may be required to comply with federal and state hazardous waste regulations if your used oil becomes contaminated by mixing it with hazardous waste or waste oil. Hazardous waste disposal is a lengthy, costly and strict regulatory process. The only way to be sure your used oil does not become contaminated with hazardous waste is to store it separately from all solvents and chemicals and not to mix it with anything.

State and local regulations are often even more stringent than the EPA guidelines. For this reason, it is important to be familiar with your local laws and regulations regarding waste and used oil. There have been occurrences in which an inspector walked through a plant and assessed severe penalties and fines due to the mislabeling of used oil containers. The easiest way to ensure that you are in compliance and can avoid these fees and headaches is to label containers correctly. Unless it is truly waste oil, it should be labeled as "used oil."

Also, be sure to keep proper records. The EPA uses 12-digit identification (ID) numbers to track used oil.

Facts About Used Oil

- The used oil from one oil change can contaminate 1 million gallons of fresh water.
- It only takes one cup of used motor oil to put an oil sheen on a 1-acre pond.
- The United States produces 1.3 billion gallons of waste oil each year, of which 800 million gallons are recycled. (Almost 40 percent is not being recycled).
- If all the waste oil in the United States was recycled in a single year, it would save half the output of the Alaskan pipeline for the same period.
- Recycled used motor oil can be re-refined into new oil, processed into fuel oils and used as raw materials for the petroleum industry.
- One gallon of used motor oil provides the same 2.5 quarts of lubricating oil as 42 gallons of crude oil.
- If all the oil from American do-it-yourself oil changers was recycled, it would be enough motor oil for more than 50 million cars a year.

Transporters hauling used oil must have a valid EPA ID number, and generators, collection centers and aggregation points must use transporters with EPA ID numbers for shipping used oil offsite. Used oil transporters, processors, marketers and burners are required to keep records of each used oil shipment accepted for transport. These records for shipment must include:

- the name and address of the generator, transporter or processor/re-refiner that provided the used oil for transport;
- the EPA identification number (if applicable) of the generator, transporter or processor/re-refiner who provided the used oil for transport;
- the quantity of used oil accepted; and
- the date of acceptance.

These records are required to be kept for at least three years. It is recommended that you maintain these same records for the same period. As the ISO 55001 certification becomes more prevalent, this recordkeeping will be a positive step toward certification.

It should be noted that any used oil shipments less than 55 gallons do not need an EPA tracking number. However, special permitting may be required by state and local governments.

While re-refiners, processors, transfer facilities and burners must have secondary containment systems (e.g., oil-impervious dikes, berms, retaining walls, etc.) to mitigate oil escaping into the environment in the event of a leak or spill, the EPA encourages generators to use a secondary containment system to prevent used oil from contaminating the environment.

Used Oil and Filters

During a root cause analysis/failure investigation, a post-mortem oil sample can contain a vast amount of information that can be very helpful in establishing the cause of failure. Simply pouring the used oil into a container is essentially just throwing away this potentially useful information.

The same is true of the filter and the oil it contains. The filter has been called the "hard drive" of the lubricant system, storing all the information about the system's contamination. Frequently, once the filter is changed, it is placed on top of a drum to drain the oil and then thrown into a waste container.

A better way is to use a filter cutter. Take some of the filter media, rinse it with kerosene or a very light clean oil and conduct a patch test. You likely will be shocked and amazed at what you see. Based on the particles you find, you can determine if wear is occurring, what specific part of the equipment is wearing, and the type of wear that is taking place.

You can use the same approach for the oil contained in the filter. Both of these are excellent sources of information that are often just thrown away. Collecting data from these sources will help round out your oil analysis program.

In conclusion, it is critical that used and waste oil be identified and handled correctly. This can help to avoid significant costs and fines. In most cases, the "waste oil" in a plant is in fact used oil and is not subject to the special handling that is required of true waste oil, which is considered to be a hazardous material. ■

About the Author

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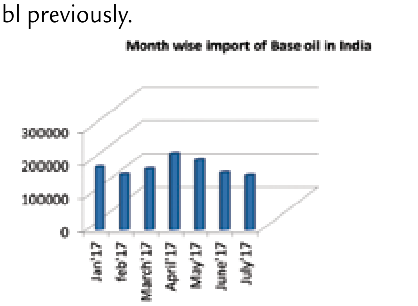
BASE OIL REPORT

The price of International crude oil of Indian Basket was USD 54.56 per barrel (bbl) on mid September this year compared to USD 53.83 per bbl previously on the starting of this month. By considering this on Indian rupees, the price of Indian Basket increased to Rs 3495.38 per bbl on mid of September as compared to Rs 3443.89 per bbl previously.



Import is decreased by 20 % in the month July'17. Also, it fell down by 40% compared to last year in July'16.

Because of the weakening of Global markets, the prices of oil fell following North Korea's latest missile launch, but crude remained close to five-month highs reached this week on bullish demand forecasts and U.S. refineries restarting.

India's Bharat Oman Refineries Ltd (BORL) has bought, via tender, its first crude cargo from the United States, which will be delivered in November. Trafigura will deliver 1 million barrels of Mars crude from the U.S. Gulf of Mexico to BORL. BORL is likely the third Indian oil refiner, after Indian Oil Corp and Bharat Petroleum Corp, to import U.S. crude. Hindustan Petroleum Corp has also said about the plans of buying U.S. in the next few months.

During the period January to July 2017, India imported 1.31 million MT of Base Oil.

India's major imports are from Korea, Singapore, USA, UAE, Iran, Taiwan, France,

Origin-wise Import of Base oil into India (January'17-July'17)

BASE OIL IMPORTED FROM	MT	%
SOUTH KOREA	500428	38%
UAE	297286	23%
SINGAPORE	190771	14%
USA	176429	13%
SPAIN	49576	4%
TAIWAN	31685	2%
SWEDEN	18808	1%
IRAN	7410	1%
OTHER COUNTRIES	47446	4%

Ports-wise Import of Base oil into India (January'17-July'17)

BASE OIL IMPORTED INTO	MT	%
MUMBAI	914525	69%
JNPT	212028	16%
PIPAVAV	51800	4%

UK, Netherlands, Japan, Italy, Belgium, etc. Indian State Oil PSU's IOC/HPCL/BPCL has changed their base oil numbers as reflected in the price chart effective September 01, 2017.

During the period January to July 2017, India imported 1.31 million MT of Base Oil.

Dhiren Shah (Editor – In – Chief of Petrosil Group)

Petrosil Base Oil Report offers solutions to the entire base oil value chain, from refiners, suppliers, buyers, traders, agents, consultants, lubricant companies, professionals and logistic providers as well as any other entity of the base oil value chain.

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

Month	Group I - J 500 Singapore Origin Base Oil CFR India Prices	SN-150 Iran Origin Base Oil CFR India Prices	N- 70 South Korea Origin Base Oil CFR India Prices	Bright Stock-150
April 2017	USD 705 – 720 PMT	USD 640 - 655 PMT	USD 650 - 660 PMT	USD 1060 - 1080 PMT
May 2017	USD 705 – 720 PMT	USD 640 - 655 PMT	USD 650 - 660 PMT	USD 1060 - 1080 PMT
June 2017	USD 705 – 720 PMT	USD 640 - 655 PMT	USD 650 - 660 PMT	USD 1060 - 1080 PMT
July 2017	USD 705 – 720 PMT	USD 640 - 755 PMT	USD 650 - 660 PMT	USD 1060 - 1080 PMT
August 2017	USD 705 – 720 PMT	USD 640 - 655 PMT	USD 650 - 660 PMT	USD 1060 - 1080 PMT
September 2017	USD 710 – 725 PMT	USD 645 - 660 PMT	USD 655 - 665 PMT	USD 1065 - 1085 PMT
	Since April 2017, prices have gone up by USD 5 PMT (1%) in September 2017	Since April 2017, prices have remained same in September 2017.	Since April 2017, prices have gone up by USD 5 PMT (1%) in September 2017	Since April 2017, prices have hike up by USD 5 PMT in September 2017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