Machinery Lubrication

India September-October 2015

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OIL ANALYSIS TRAINING
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MACHINERY LUBRICATION

Oil Analysis

Condition-based Oil Changes:
An Easy Way to Save Big Money

- How to Select Machines for Oil Analysis
- Used Oil Analysis a Reliability centered approach
- Benefits of FTIR Oil Analysis
- How to prevent foaming and Air Dispersions in industrial Gear Oils
- Why You Should Reclaim and Recycle Used Oil

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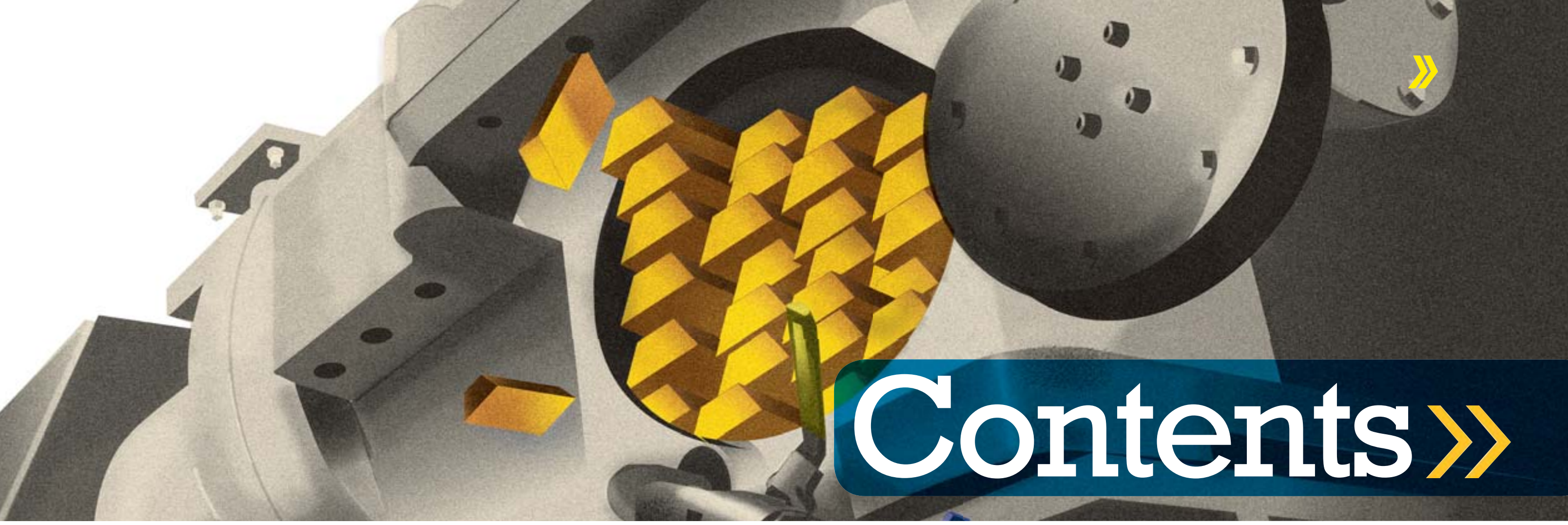

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September-October 2015

Publisher's Note

In September Tata Motors signed a deal with French Lubricants major Total Lubricants for supply of lubricants. It will lead to Tata Motors' service network and its commercial vehicle customer support across global markets. It would be the French company's first partnership with an Indian OEM.

Total also intends to help to enhance skill levels of Tata Motors' networks across the globe and will lead to Indian manufacturers taking a closer look at high performance lubricants and of ways of maintaining their performance. The objective, as always, is to keep an eye on the bottom line. It could be that without a thorough assessment, unnecessary oil changes are being carried out and leads to taking a fine decision on when to change the oil.

That, in turn, leads to oil analysis factors through sampling frequency and machinery required for such analysis. Contaminant dispersion and outside temperatures are accountable in any system, small or large, as in the case of mining equipment. The essentials of most lubrication systems are the grease pump, a motor to drive that pump and some sort of injector or valve to control or measure lubricant volume, as with a programmable logic controller (PLC) to program the frequency of the lubrication replenishment cycle in large or complex systems.

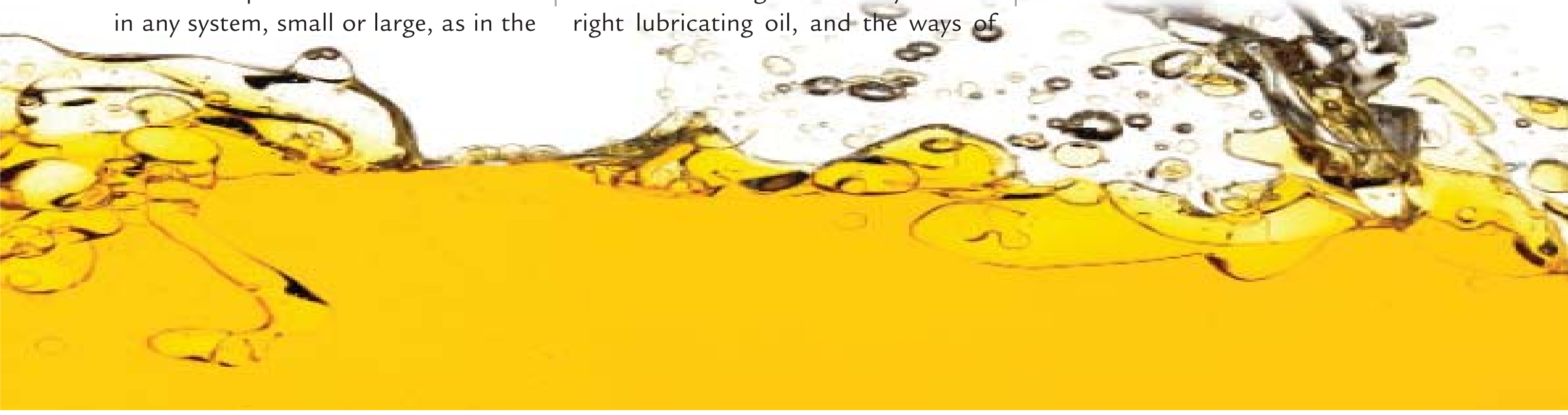
An article in this issue deals with prevention of foaming and air dispersion in Industrial Gear Oils which call for the three types of products - heavy duty lubricating oils, circulating and hydraulic oils and general purpose grease. As used for industrial purposes, walking draglines may require lubricants for large bearings that support the frame as it moves through the process.

Then, there is the development of multipurpose products designed to meet several different applications from a single lubrication system, along with the challenge to identify the the right lubricating oil, and the ways of keeping it going. Appropriately, the end page basics enumerate reasons why reclamation and recycling lubricants is practical for high volume users. Again, that bottom line has facilitated the need for such search and research.

All in all, the Prime Minister's 'Make in India' initiative gathers momentum in the industrial sector – and the industrial oils segment as small startups strive to emulate the path taken by world leaders such as Tata Motors and Total Lubricants. It is heartening to note the number of small to mid sized lubricant manufacturers and distributors in India who follow the growth model by offersing a range of lubricants and oils as well as assistance, oil analysis, training, and workshop services. The auto sector remains the most visible, but there is also client service of diverse industries throughout the region.

Warm Regards,

Udey Dhir



JIM FITCH | NORIA CORPORATION

HOW TO SELECT MACHINES FOR OIL ANALYSIS

A few years ago, someone mentioned to me that many of his machines were not good candidates for oil analysis because they used little oil that wasn't worth saving. He added that by the time you flushed the sampling port and pulled a proper oil sample, you've almost done an oil change. Why bother with oil analysis?

I'm sure you recognize the misguided purpose of oil analysis in the mind of this individual. While oil analysis can certainly aid in better timed oil changes, it has so much more to offer. In fact, for machines that are mission-critical, the cost of changing the oil is small potatoes in comparison to the value gained from averting a catastrophic machine failure. If oil analysis was only about tracking the remaining useful life of the lubricant, only a fraction of the oil samples analyzed every year could be economically justified.

Think of the oil more as an information messenger of numerous failure modes and root causes of failure. As I've said many times, it's hard for a machine to be in trouble without the oil knowing about it first. For most labs, the number of non-conforming samples from oil analysis will generally exceed 20 percent. In other words, more than one out of every five samples has a reportable condition that requires a corrective response. For this reason, you must be prudent about which machines are selected for oil analysis as well as the sampling frequency.

Like most reliability decisions, being wise in selecting machines to include in an oil analysis program requires a strategy of precision and optimization. This selection is a critical attribute of the Optimum Reference State (ORS) and demands careful consideration. Included in this is an assessment of machine and lubricant criticality, as described below.

The Importance of Saving the Machine

So many reliability and maintenance decisions hang on the assessment of Overall Machine Criticality (OMC). This includes oil analysis and all other machine condition monitoring methods. Critical equipment should be checked more frequently than less critical equipment. Based on the definition of "critical," this refers to the machines with the highest importance to you, your company and your process.

Of course, it is essential to know how to define an asset as critical. There are many approaches to determine an asset's criticality. Some plants employ a simple 1 to 10 grading scale and subjectively assign numbers.

The OMC assesses criticality in the context of lubrication. It is calculated at the multiplied product of the Machine Criticality Factor (MCF), which relates to the consequences of machine failure, and the Failure Occurrence Factor (FOF), which corresponds to the probability of failure. For a more detailed discussion of these factors and the OMC, see www.machinerylubrication.com/Read/29346/machinery-criticality-analysis.

Using the OMC, a machine's candidacy for oil analysis is known by influencing factors such as:

- whether the machine is exposed to failure-inducing conditions (loads, speeds, shock, contamination, etc.);
- whether the machine is a bad actor (chronic problems);

What's in the Bottle?

$$OLC = OMC + (LCF \times DOF)$$

Overall Machine Criticality (OMC): Defines the overall importance of machine reliability, combining mission criticality, machine repair cost and the probability of failure.

OMC — Scaled 1-100

Lubricant Criticality Factor (LCF): Defines the economic consequences of lubricant failure. The LCF is influenced by the cost of the lubricant, cost of the downtime to change the lubricant, flushing costs, system disturbance costs, etc.

LCF — Scaled 1-10

Degradation Occurrence Factor (DOF): Defines the probability of lubricant failure. Influencing sub-factors include lubricant robustness (synthetics, etc.), operating temperature, contaminants and other exposures, lubricant makeup rate, etc.

DOF — Scaled 1-10

Overall Lubricant Criticality (OLC): Defines the overall importance of lubricant health influenced by both the probability and consequences of lubricant and machine failure.

$$OLC = OMC + (LCF \times DOF)$$

OLC — Scaled 1-100

The proposed method for calculating the Overall Lubricant Criticality

37%

of lubrication professionals say machines at their plant are selected for oil analysis based on the amount of lubricant they hold, according to a recent survey at MachineryLubrication.com

- whether the consequences of failure are high (safety, downtime, repair costs, environmental effects, etc.);
- whether failures can be lubricant-induced (degraded or contaminated oil);
- whether failures can be revealed by the oil (e.g., wear debris from shaft misalignment); and
- whether early detection is important.

The Importance of Saving the Oil

The importance of saving the oil is best assessed by the Overall Lubricant Criticality (OLC). The OLC defines the significance of lubricant health and longevity as influenced by the probability of premature lubricant failure and the likely consequences (for both the lubricant and the machine). The proposed method for calculating the OLC is shown above. Like many such methods, this approach is not an exact science but nevertheless is grounded in solid principles in applied tribology and machine reliability.

The Lubricant Criticality Factor (LCF) defines the specific economic consequences of lubricant failure separate from machine failure consequences. The LCF is influenced by the cost of the lubricant, the cost of downtime to change the lubricant, flushing costs and system disturbance costs (e.g., the fishbowl effect). For instance, machines that use large volumes of expensive, premium lubricants will understandably have high LCF values. Studies have shown the true cost of an oil change can far exceed 10 times the apparent cost (labor and oil costs).

The Degradation Occurrence Factor (DOF) defines the probability of premature lubricant failure. The conditions that influence this probability are shown below.

Lubricant Robustness — Synthetics and other chemically and thermally robust lubricants lower the DOF.

Operating Temperature — Lubricants exposed to high operating temperatures, including hot spots, can experience accelerated oxidation and degradation. The presence of such conditions will raise the DOF.

You must be prudent about which machines are selected for oil analysis as well as the sampling frequency.

Contaminants — Contaminants such as water, dirt, metal particles, glycol, fuel, refrigerants, process gases, etc., can sharply shorten lubricant service life. The presence of such exposures will raise the DOF.

Lubricant Volume and Makeup Rate — Lubricant volume relates to the amount of additives available to fight oil degradation, the estimated runtime to complete additive depletion and the density of contaminants. In normal service, it can take years to burn through the additives in systems containing thousands of gallons of lubricant. The makeup rate refers to the introduction of new additives and base oil. New additives replenish depleted additives, and new base oil dilutes pre-existing contaminants. High oil volume and a high makeup rate will reduce the DOF.

Machines to Include in Your Oil Analysis Program

Machines that are good candidates for oil analysis have high OMC or OLC values (say, above 5). Even marginal OMC/OLC machines may be well-suited for a streamlined oil analysis program (fewer samples, fewer tests, etc.). Using this methodology, much of the guesswork is taken out of the first major decision related to any oil analysis program. Once your machines are selected, you can then use the OMC and OLC values to determine the oil sample location, oil sample frequency, test slate, alarms and limits, and data interpretation strategy.

About the Author

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

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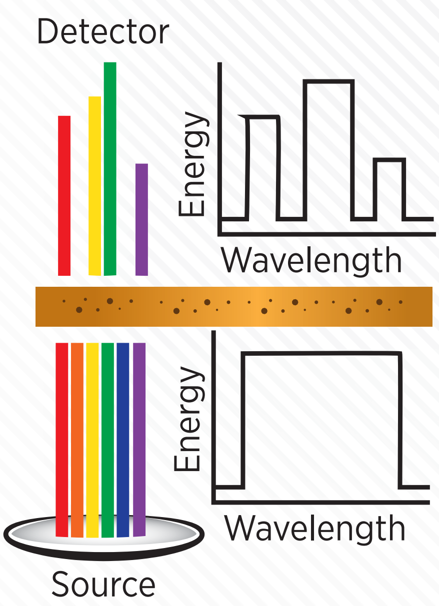
JEREMY WRIGHT | NORIA CORPORATION

BENEFITS of FTIR OIL ANALYSIS

Fourier transform infrared (FTIR) spectroscopy is a versatile tool used to detect common contaminants, lube degradation byproducts and additives within lubricating oils. It has become a widely used technique for quickly assessing multiple lubricant characteristics, and yet many people don't fully understand how it works. When exposed to infrared radiation, molecules absorb radiation at very specific wavelengths. Knowing this, you can pass infrared radiation through a sample and use a detector on the other side of the sample to identify the molecules found in that sample.



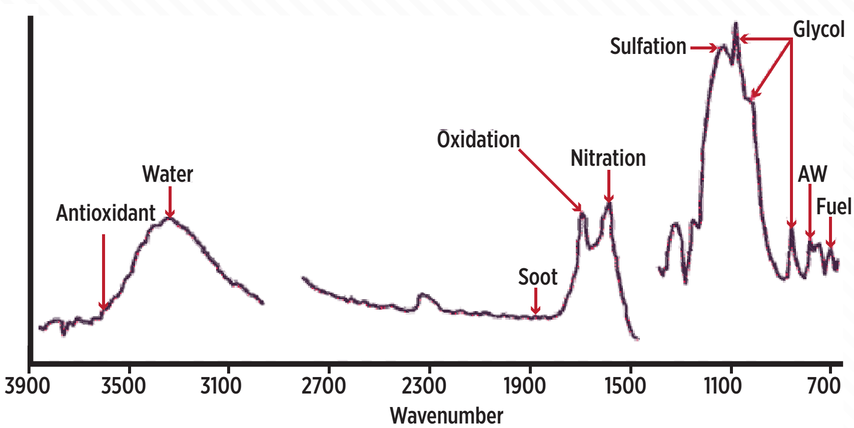
Much like a fingerprint, no two molecules produce the same pattern or wavelength. This is very useful in being able to identify the material composition of a sample. Qualitative analysis becomes easy because of this fact. When a software algorithm is used to plot the resulting spectrum, a visual representation is generated.

This test method is relatively quick to perform and is capable of simultaneously detecting multiple parameters, including antioxidants, water, soot, fuel, glycol, oil oxidation and certain additives. Adding to the power of this qualitative measurement, the size of the peaks is a direct indication of the amount of the specific material found in the sample.

For a better understanding, let's take a more in-depth look at the process and anatomy of analyzing a sample. The first component in the system is the source. The source will emit infrared energy and send it through an aperture to control the amount being presented to the sample.

Next, the beam enters the interferometer where it is "encoded" using a series of stationary and movable mirrors. This encoding is a way to produce a signal that consists of all the important infrared frequencies simultaneously.

The beam then enters the sample, and certain frequencies of the energy are absorbed. The energy that escapes the sample is sent to the detector where it is measured. This measured signal is then sent to a computer where Fourier transformation takes place. Fourier transformation is a mathematical process where a waveform can be broken into an alternate representation for easy viewing. At this point, the results are plotted on the screen, and a simple analysis can be made by the technician.



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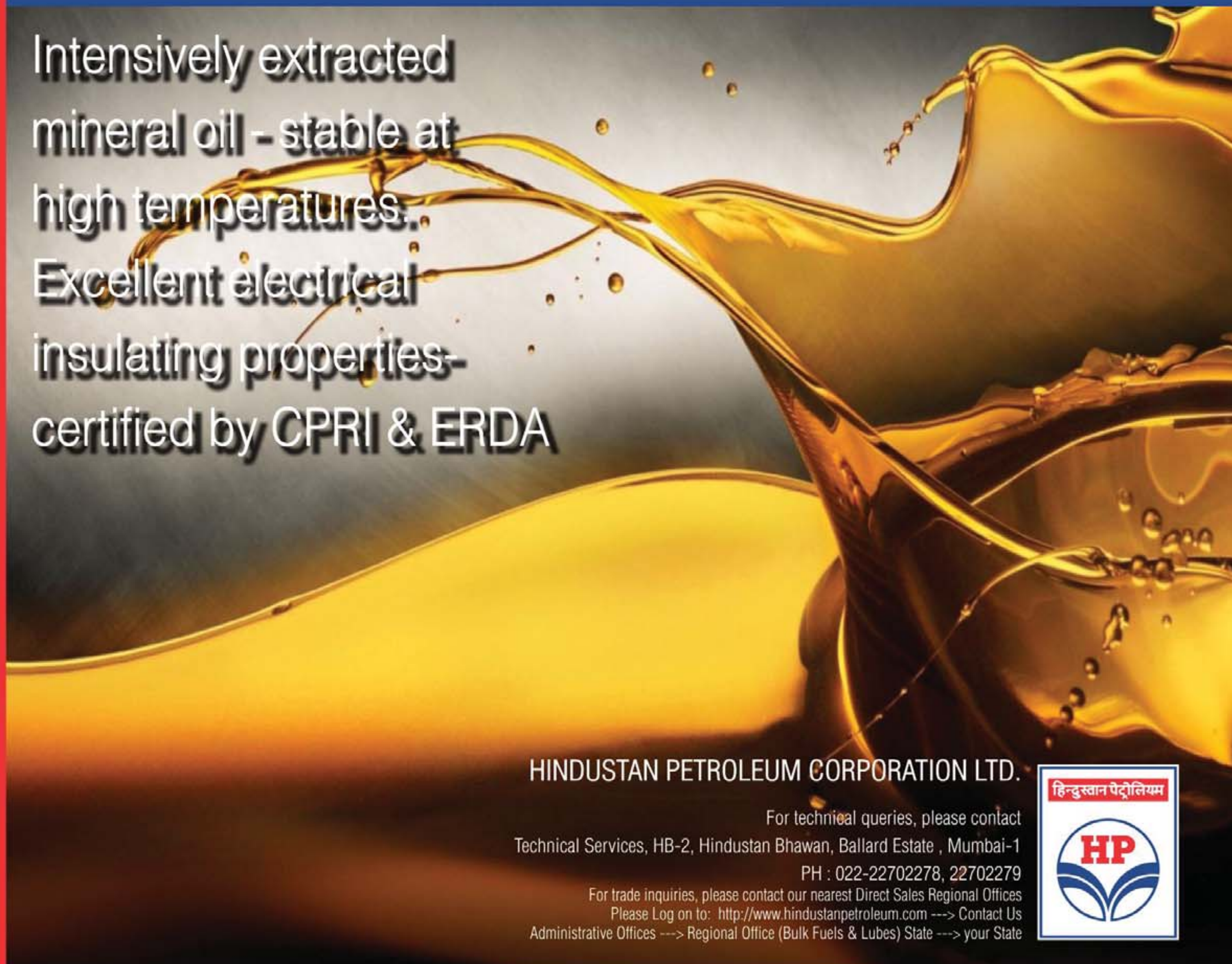
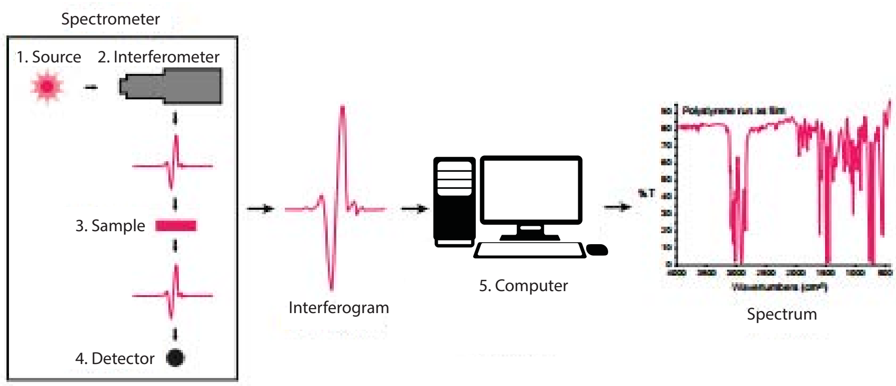


COMPONENT	SPECTRAL LOCATION	MEASUREMENT	TRADITIONAL MEASUREMENT	SENSITIVITY
Soot	2000	Carbon Load	Total Insolubles	Insensitive
Oxidation	1750	Oil Degradation	BN, AN, Viscosity	Partially
Nitration	1630	Oil Degradation	BN, AN, Viscosity	Partially
Sulfation	1150	Oil Degradation	BN, AN, Viscosity	Partially
Water	3400	Contaminant	Karl Fischer	Partially
Glycol	880	Contaminant	Gas Chromatography (GC)	Very
Diesel	800	Contaminant	Flash Point, Viscosity, GC	Extremely
Gasoline	750	Contaminant	Flash Point, Viscosity, GC	Extremely
ZDDP (AW)	980	Additive	Elemental Spectroscopy	Extremely

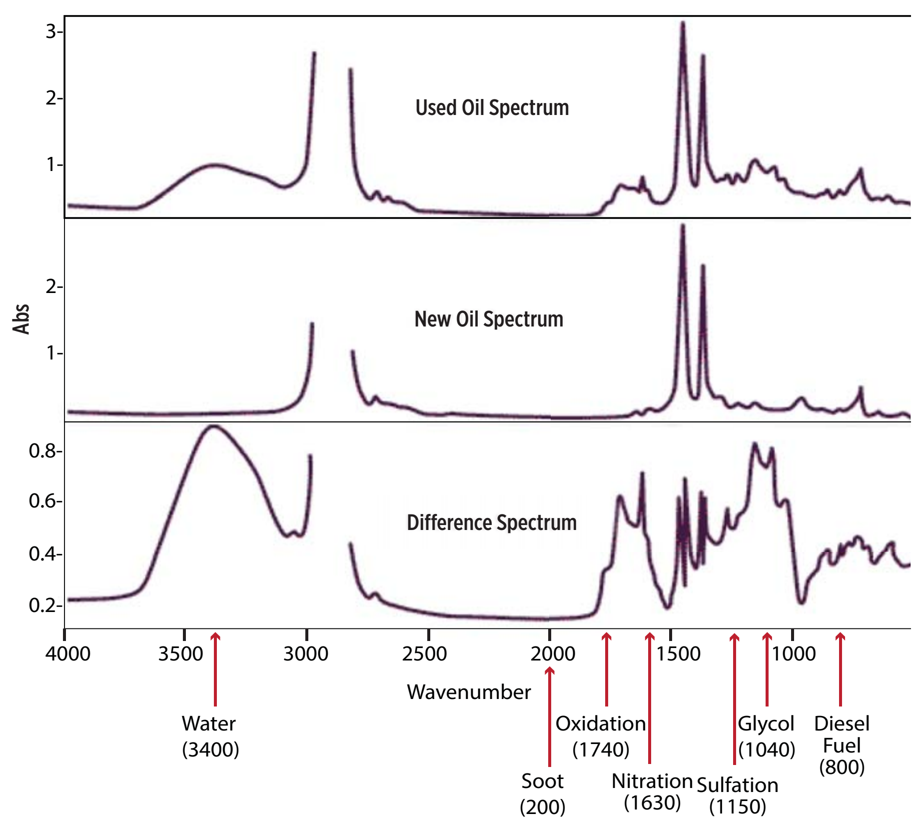


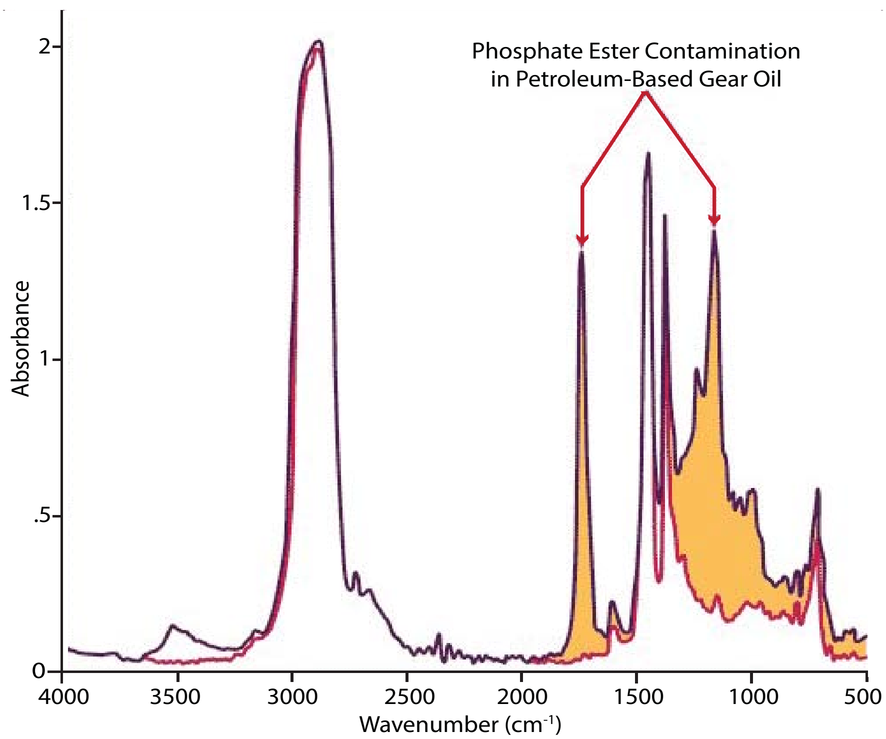
Since most used oil samples are complex mixtures of thousands of different molecules, including base oil molecules, additives, oil degradation byproducts, wear debris and contaminants, the infrared spectrum of the sample is typically complex and can be difficult to interpret with any degree of certainty, as some wavenumbers may overlap. Despite these drawbacks, FTIR still has great value in used oil analysis and is employed by the majority of oil analysis labs as a screening tool.

To minimize the effects of the base oil and additive molecular resonances, FTIR analysis of used oil samples is a three-stage process. The first stage is to record the FTIR spectrum of a new oil sample to obtain a baseline FTIR trace. The second stage is to record the same FTIR spectrum of the used oil sample. The third and final stage is to subtract the new oil baseline, often referred to as the new oil reference, from the used oil spectrum to obtain the difference spectrum. In theory, the difference spectrum allows the changes in both the chemical composition of the oil, such as oil oxidation (represented by an increase in a peak centered around 1740 cm-1), and any contaminants to be measured without interference from the new oil molecular resonances.

The one major limitation of this difference spectrum procedure is that it is often not practical to send a

> "FTIR is a valuable addition to any oil analysis program."





sample of new oil with the used oil sample each time analysis is required. In order for the procedure to be accurate, the new oil reference for this purpose should not only be the same type, brand and grade as the used oil, but also from the same manufactured batch of oil.

Another area where FTIR can prove extremely valuable is in determining significant changes in oil chemistry, such as what might be expected when two oils with different chemical compositions are added together because of cross-contamination. The figure below shows the FTIR spectrum of a blend of a polyalphaolefin-based synthetic oil and a phosphate ester electro-hydraulic control (EHC) fluid. By recording the FTIR spectrum of the suspected blend along with the known new oil reference spectra of the pure polyalphaolefin and pure EHC fluid, this accidental mixing can be confirmed. In fact, when an unknown contamination issue is suspected, it often is advisable to immediately run an FTIR spectrum in conjunction with a fresh new oil reference whenever possible.

50%
of lubrication professionals use FTIR testing in their oil analysis program, according to a recent survey at MachineryLubrication.com

FTIR is a valuable addition to any oil analysis program. By understanding how the technique works as well as its strengths and limitations, oil analysts and end users can obtain a vast amount of information when utilizing it alongside other standard test methods and strategies.

About the Author

Jeremy Wright is the vice president of technical services for Noria Corporation. He serves as a senior technical consultant for Lubrication Program Development projects and as a senior instructor for Noria's Machinery Lubrication I and II training courses. He is a certified maintenance reliability professional through the Society for Maintenance and Reliability Professionals, and holds Machine Lubricant Analyst Level III and Machine Lubrication Technician Level II certifications through the International Council for Machinery Lubrication. Contact Jeremy at jwright@noria.com.

FEATURE STORY

Condition-based Oil Changes: An Easy Way to Save Big Money

By Brian Thorp, Seminole Electric

Perhaps your facility has a well-established oil analysis program that is providing great results, but are you utilizing all of the information available in the reports? If everything in a report is correct and within the specifications, do you do anything else with the information? Do you still allow the time-based preventive maintenance work order to change the oil and filter? If you answered “yes” to this question, you could be wasting thousands if not hundreds of thousands of dollars per year on unnecessary oil changes. You could also be introducing human error and creating more problems through this needless maintenance.

What are Condition-based Oil Changes?

There are three types of oil changes: reactive, preventive and proactive or predictive. So which of these is a condition-based oil change? It is a proactive or predictive oil change performed at the right time and for the right reason.

In the "old days" before oil analysis was common in most larger facilities, the original equipment manufacturer (OEM) set up guidelines for recommended oil change frequencies. They usually erred on the safe side, which left nearly 50 percent of the useful life in the lubricant. Sometimes even the warranty was involved, requiring that the lube be changed at specific time intervals to maintain the warranty. In recent years, most OEMs will recognize a good oil analysis program and allow extended oil drain intervals without compromising the warranty. Of course, this is something that must be discussed and agreed upon before establishing extended drain intervals.

After switching to condition-based oil changes, the Seminole Electric plant was able to achieve a cost avoidance of $1.27 million over a five-year period.

Condition-based oil changes are not to be taken lightly. You can reap the benefits of major cost avoidance or experience the wrath of catastrophic failures if not done correctly. You must also have a champion over your oil analysis program.

Not all equipment is a candidate for extended drain intervals. You need to have an understanding of the equipment, material makeup of internal components and the operating parameters. You must also incorporate proper oil sampling techniques, the right slate of analysis tests and special tests performed periodically to ensure you are not missing any valuable information when making decisions on extending drain intervals.

With a well-established oil analysis program, you will have trend information on the equipment, which will help you decide what pieces are eligible for extended drain intervals. It is true that the larger the reservoir, the bigger the potential savings. However, if you are performing oil analysis on smaller reservoirs due to criticality, why not take advantage of that information as well? Other factors that should be considered for extended oil drains include reservoir volume, the amount of makeup oil, operating temperatures and the quality of filtration and breather systems.

In addition, you should have a good understanding of how different oil analysis tests are performed and the strengths and weaknesses of each test. This is why it is important to have good communication with your oil analysis laboratory and discuss concerns as well as which special tests may need to be performed to obtain all the information to help make your decisions on the drain intervals. The more you let your lab know about your program and what you are trying to accomplish, the better your results will be.

It is also critical to have an established baseline from new, unused oil samples. If you or your lab does not know what the new oil is supposed to look like, how will you know when something is wrong, since you have nothing against which to compare your current samples?

Limitations of Oil Analysis Tests

One of the weaknesses of oil analysis tests is that they can give you a false sense that everything is fine. For instance, spectroscopic analysis only identifies particles smaller than 7 microns (depends on particle composition and analysis method), so you could have visible metal in the sample but only get results of 100 parts per million (ppm) of iron on the analysis report. A few alternate methods to obtain the necessary information would include acid or microwave digestion. This would break down the larger particles so that a more complete spectral burn can identify and quantify them.

Analytical ferrography is another great method to detect and characterize large ferrous and other particles in your samples. This not only quantifies a particle amount but also can identify shapes, sizes and morphology of the particles, which can help determine the type of wear occurring.

It is also important to keep in mind that a high copper value may not be actual wear but leaching from a cooler. Zinc dialkyldithiophosphate (ZDDP) is an additive that sometimes causes copper leaching and thus high copper results. Silicon is another very common false positive. Unless you are used to seeing silicon in your analysis, a drastic increase is most likely from a repair job that utilized room-temperature vulcanizing (RTV) silicone or a silicone sealer.

Water can be another misleading result in your oil analysis report. Most labs perform a crackle test on all samples, while some rely on Fourier transform infrared (FTIR) spectroscopy to detect water. A crackle test can identify water at around 500 ppm and higher, although a good lab technician can sometimes catch it at a lower ppm in certain oils with low additive levels (e.g., turbine oil). The crackle test is approximate and not considered quantitative. If you need to know the exact amount of water, have a Karl Fischer titration performed, but understand that there can be interferences with this as well. Also, be sure to specify the evaporator or drying method, especially with engine oils (also called co-distillation).

Particle counts are usually obtained with a laser particle counter. While this is an accurate method, darker oils, water and air entrainment can sometimes cause problems. The pore blockage particle count can be performed in place of the laser particle count when the oil condition is extremely dark or contaminated with water. This method is not as accurate as a laser particle count, but it is a viable option in assessing fluid cleanliness to avoid the previously mentioned interferences.

Another less common way to perform a particle count is with a Millipore patch. This can be time-consuming and expensive, but in specific situations, the Millipore patch can be used to help with wear debris analysis in place of analytical ferrography.

Special Tests

Even with an extensive oil analysis test slate, special tests are often needed to provide additional information when extending oil drains. For example, a rotating pressure vessel oxidation test (RPVOT) can be conducted to determine the oxidation stability of the in-service lubricant compared to a new lubricant. The RULER test offers another way of comparing new oil with in-service oil to estimate the remaining useful life. Other tests, such as the varnish potential rating, membrane patch colorimetry (MPC) and quantitative spectro analysis, can help identify the amount of oil degradation byproducts and depleted additives. These soft contaminants can create serious problems if left unattended.

A demulsibility test is used to indicate a lubricant's ability to shed water. Air release or foam tests are also important, as air does not provide a proper oil film to keep machine surfaces separated. Rust and copper strip corrosion tests can help identify a lubricant's remaining anti-corrosive additives, while acid and base number tests measure the rate of change between a new and used lubricant. See Figure 1 for a list of the ASTM test methods.

These are just some of the special tests that can be performed on in-service lubricants to help make decisions about extending drain intervals. Once again, having good communication with your lab will be invaluable when it comes to making sure you are getting all the information needed to achieve cost avoidance and prevent catastrophic failures.

Cost Avoidance

With lubricants, there is the actual cost (what you pay the distributor per gallon, pound, pail or drum) and the real cost. The real cost of a lubricant is the total cradle-to-grave cost once it reaches your facility. This includes receiving, storing, dispensing, installing and disposal. Several years ago this cost was estimated to be an average of four to seven times per gallon. For contaminated special case oil (radioactive), the cost could be as much as 40 times per gallon. The average industry cost per gallon is $9 to $14 for mineral oil and $20 to $30 for synthetic lubricant, with the exception of specialty synthetics being $60 and more. For the purpose of this discussion, let's estimate mineral oils at $10 per gallon and synthetics at $25 per gallon.

At the Seminole Electric facility, which is a two-unit, 1,300-megawatt combined coal-fired power plant, the equipment monitored for condition-based oil changes contains 6,043 gallons of oil (see Figure 2). Prior to condition-based oil changes, some of this equipment received oil changes every six months and some every 12 months. With these oil changes, the total increased to 7,948 gallons of lubricant per year. If you were to use the average of $10 per gallon and the real cost of seven times per gallon, the total would be a real cost of $70 per gallon. In a perfect world, if you could go one year without an oil change on all of the equipment, you would have a cost avoidance of $556,360.

As can be seen in Figure 2, the average meantime between oil changes at the Seminole Electric facility is now closer to 1.5 years, with some equipment reaching five years. On the five-year oil change equipment, the total gallons of oil is 18,145, based on the six- and 12-month change frequencies over five years. Four to seven oil changes are avoided, since the equipment is usually inspected with an oil change at the fifth year of operation or around 40,000 runtime hours. This equals a cost avoidance of $1.27 million for those six groups of equipment over the five-year period.

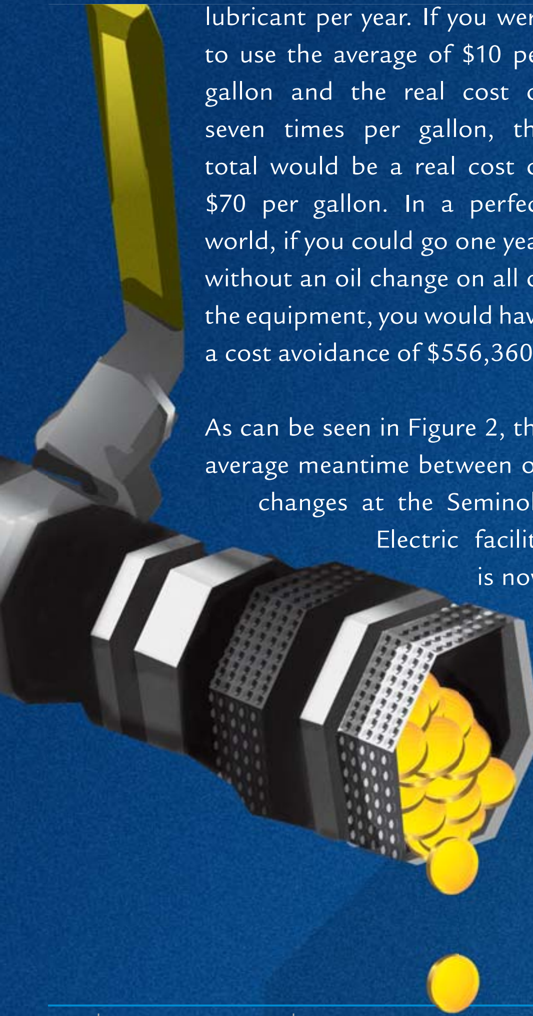


FIGURE 1. ASTM TEST METHODS

Acid Number	D664/D974	MPC	D7843-12
Air Release	D3427	RULER	D6810/D6971
Demulsibility	D1401	Rust	D665
Foam	D892	RPVOT	D2272
Karl Fischer	D6304		

Please note that turbines, turbine control oil and boiler feed pumps are not included in these numbers. Due to their size, these reservoirs, which are more than 25,000 gallons combined, and filtration systems generally receive extended drain intervals.

Return on Investment

Now let's consider the return on investment (ROI) for condition-based oil changes. The primary cost is the oil analysis. In Figure 2, there are 792 oil samplings per year for the equipment listed, at an average cost of $20 to $40 per sample analysis. A range of $15,840 at $20 per sample to $31,680 at $40 per sample provides an idea of the cost for the oil analysis. While $40 might be slightly high, that should more than make up for the few special tests needed to obtain additional information throughout the year. Even if you include the salary of the person managing the oil analysis program at the facility, you would still be well below the projected cost avoidance of $556,360 per year.

Additional Benefits

Now that you have seen the potential cost avoidance of condition-based oil changes, let's examine some of the other benefits. First and foremost is the freeing up of man-hours to perform proactive work on equipment that really needs it. You may also have a reduction in machine failures or infant mortality, since you are not unnecessarily exposing equipment to human error. Unfortunately, too many times something is left out, left loose or leaks afterward. The system will remain cleaner if you are not opening it up in a dirty industrial environment and stirring up sediment that has settled to the bottom of the reservoir during operation. Filter usage likely will be reduced as well, as filters will not be changed on a time frequency but rather when they need to be changed based on differential pressure. You also will leave less of a footprint on the environment by reducing the number of new lubricants and the waste stream of used oil for disposal.

It is easy to see how you can create substantial cost avoidance by doing nothing more than utilizing all of the information your oil analysis report is providing. It should also be encouraging to know that you are generating enough cost avoidance to exceed the cost of the oil analysis program. If managed correctly, you can start reaping the benefits of condition-based oil changes by doing the right thing at the right time for the right reason.

FIGURE 2. EQUIPMENT MONITORED FOR CONDITION-BASED OIL CHANGES				
EQUIPMENT GROUP	TOTAL GALLONS	PREVIOUS SERVICE FREQUENCY	AVERAGE DRAIN FREQUENCY	SAMPLE FREQUENCY
Large Electric Motors	550	12 Months	5 Years	Quarterly
Large Air Compressors	515	6 Months	5 Years	Quarterly
Large Blowers	1,100	6 Months	5 Years	Quarterly
Ball-mill Gear Reducers	540	6 Months	1.5 - 2 Years	Monthly
Ball-mill Lube Lift Reservoirs	780	6 Months	1-1.5 Years	Monthly
ID Fan Bearing Reservoirs	640	12 Months	5 Years	Quarterly
FD Fan Bearing and Hydraulic Reservoirs	200	12 Months	5 Years	Quarterly
PA Fan Bearing Reservoirs	320	12 Months	5 Years	Quarterly
APH Gear Reducers	100	12 Months	1-2 Years	Quarterly
APH Support Bearings	300	12 Months	1-2 Years	Quarterly
APH Guide Bearings	48	12 Months	1-2 Years	Quarterly
Coal Yard Gear Reducers	425	6 Months	1-2 Years	Quarterly
Coal Yard Hydraulic Reservoirs	525	6 Months	2-3 Years	Quarterly
TOTAL GALLONS	6,043			
Total gallons for six- and 12-month frequencies: 7,948				

RÜDIGER KRETHE | OilDoc

How to Prevent Foaming and Air Dispersions in Industrial Gear Oils

Lubricating oils are not completely free of air. Whether during operation or storage in barrels, oils are constantly in an exchange process with their air-containing environment. Even if the oil is free of air bubbles, it will have a proportion of dissolved air. This depends primarily on the gas solubility, but pressure and temperature also have an effect. Some mineral oils can have air content approaching 9 to 11 percent volume at atmospheric pressure and room temperature. As long as the air remains dissolved in the oil, this generally is not a problem.

However, free air bubbles, which usually are caused by constantly immersing machine parts or through oil returning to the reservoir, can lead to serious disruptions in equipment operation, including impaired cooling effect, increased oxidation tendency, shortened oil life, reduced carrying capacity of the lubricant film, oil spills, decreased oil pump capacity, lack of lubrication, cavitation and microdieseling.

Foam and Air Release

Oil returning to a reservoir has enough time to separate air in the form of air bubbles. The main influences on the speed at which these air bubbles separate from the oil and rise include the size of the bubbles, the oil's viscosity and the oil temperature. The amount of dispersing additives, the oil's density and any impurities also play a role.

DISSOLVED AIR	UNDISSOLVED AIR
Dissolved into molecule structure (mineral-based oils = approximately 9%)	Not dissolved into molecule structure
No "free" air; no bubbles present	"Free" air; air bubbles present (entrained bubbles in the body of the oil or on the oil's surface, i.e., foam)
CAUSES	
Permanent reaction with air from environment by diffusion; air content primarily depends on pressure and temperature	Generated primarily by entrainment of air bubbles, e.g., by immersing machine parts, return of the oil into the reservoir, suction of air bubbles, etc.
CONSEQUENCES	
No problems	Problems
Variations of pressure and temperature can "transform" dissolved air into free air bubbles	Greatly increased compressibility, affected lubrication and cooling capabilities, increased oil oxidation, cavitation, microdieseling, etc.

TABLE 1. Comparison of dissolved and free air

As air bubbles arrive at the surface, surface foam is formed. Therefore, foam consists of a series of air bubbles, which are each surrounded by a skin of oil. As a function of the oil's surface tension, this skin of oil can burst more or less rapidly. The time it takes for the ascended bubbles to burst and achieve complete separation from the oil is mostly dependent on the oil's viscosity and temperature, but the content of polar aging products, impurities and certain additives also have a bearing. The oil property that describes how fast these ascended bubbles burst is called the foaming behavior.

As seen in Table 2, air release cannot be improved by additives. However, the foaming behavior of lubricating oils can be improved by anti-foam additives, which reduce the surface tension of the oil, i.e., by the well-proportioned addition of silicone-containing compounds or oil-soluble polyglycols. Too many anti-foam additives can lead to a significant deterioration of the air-release capability.

Operational Causes

The possible causes of foam formation in gears can be divided into two groups: transmission and lubricating oil. If lubricating oil mixes with other lubricants or contaminants such as dust or water, foaming can result along with oil aging, which leads to the formation of polar oil-aging products, an increase in viscosity or filtering out of anti-foam additives by bypass filters.

Transmissions with short residence times of the oil in the reservoir are particularly sensitive to changes. Increased air entry due to a high oil level may cause high flow velocities of oil injection directly into the gear teeth.

In practice, you often see an overlap of several of these factors. While each factor on its own would not be a problem, a combination of these factors can lead to increased foaming. This makes it difficult to identify the actual causes.

Air Release Standards

Several standards exist for the measurement of air-release properties: ASTM D3427, ISO 9120 and IP 313. All of these use the same test procedure (the impinger method). Air is blown into the oil sample through a valve at a precise time and pressure. The release of dispersed air bubbles is recorded until the volume remains unchanged. The air release is defined as the number of minutes needed to release the air dispersed in the oil to 0.2 percent volume.

Air release is an important property for many applications. For example, minimum air-release requirements are included in the standards for new hydraulic fluids and turbine oils. Modern turbine oils and hydraulic fluids often have lower air-release values than the minimum requirements listed in Table 3. Air release is also a key property for the condition monitoring of in-service fluids. For highly viscous lubricating oils, air release is measured at higher temperatures, e.g., 75 degrees C.

Foaming Standards

The measurement of the foaming characteristics of lubricating oil is standardized in ASTM D892 (ISO 6247 and IP 146). Air is pumped into the oil through a spherical, porous stone. Small air bubbles are created, which form an air-in-oil dispersion. These air bubbles rise to the surface where a layer of foam builds up. After five minutes, the air flow is stopped. The volume of foam is measured immediately after switching off the air and after 10 minutes.

After the first test sequence at 24 degrees C, a second oil sample is measured in the same way but at 93.5 degrees C and then at 24 degrees C. The test result for each sequence consists of two numbers, as seen in Table 4. However, DIN 51517/3 includes a footnote that seems to discredit ASTM D892 as a test procedure for foaming characteristics of industrial gear oils:

"A change of the given test procedure for the foaming characteristics will be

AIR RELEASE	FOAMING BEHAVIOR
At what speed do air bubbles rise to the surface?	At what speed do ascended bubbles burst?
Residence time in the tank should be higher than the air release to avoid re-intake of air bubbles.	Ascended bubbles should burst fast to avoid a stable or increasing foam buildup.
Large bubbles ascend faster than small bubbles.	Small bubbles produce big bubbles before bursting.
In higher viscosity oil, air bubbles rise less quickly.	Higher viscosity oils show higher foam stability.
Air release cannot be improved by additives.	Foaming behavior can be improved by additives.
Aspiration of air bubbles promotes pseudo cavitations; dieseling effect reduces the capacity.	Surface foam reduces cooling capacity and promotes oil oxidation.
An air-oil emulsion distributed over the entire volume of oil leads to serious problems in plain bearings or hydraulic systems, including diminished capacity, limited lubrication and cooling, declining oil life, cavitation, microdieseling, etc.	

TABLE 2. Air release and foaming behavior characteristics

ISO VG/Type	32	46	68	100	(150)	(>320)
Turbine Oil DIN 51515, ISO 8068	5	5	6	-	-	-
Hydraulic Fluid (HLP/HM) DIN 51524/2, ISO 11158	5	10	13	21	32	-
Lube Oil (CLP/CKC) DIN 51517/3, ISO 12925/1	-	-	-	-	-	-

TABLE 3. Minimum air-release requirements according to various international standards

<table>
<tr><th>ISO VG/Type</th><th></th><th>32</th><th>46</th><th>68</th><th>100</th><th>(150)</th><th>(>320)</th></tr>
<tr><td>Turbine Oil
DIN 51515,
ISO 8068</td><td>I
II
III</td><td colspan="4">450/0
50/0
450/0</td><td>-</td><td>-</td></tr>
<tr><td>Hydraulic Fluid (HLP/HM)
DIN 51524/2, ISO 11158</td><td>I
II
III</td><td colspan="5">150/0
75/0
150/0</td><td>-</td></tr>
<tr><td>Industrial Gear Oil (CLP/CKC)
DIN 51517/3, ISO 12925/1</td><td>I
II
III</td><td colspan="5">100/0 (100/10)
100/0 (100/10)
100/0 (100/10)</td><td>150/60</td></tr>
</table>

TABLE 4. Foaming characteristics requirements

FIGURE 1. Foaming characteristics test (ASTM D892)

Up to 5%	Good foaming characteristics
Up to 10%	Satisfactory foaming characteristics
Up to 15%	Still acceptable foaming characteristics
Above 15%	Unacceptable foaming characteristics

	1702513	1702514	1702515
	Foam	Reservoir	New Oil
Water (Wt.-%)	<0.1	<0.1	<0.1
Silicon (ppm)	6	2	0
Kin. Viscosity (40°C, mm^2/s)	145.3	115.2	104.0
Kin. Viscosity (100°C, mm^2/s)	15.27	12.3	11.1
Viscosity Index (VI)	107	97	91
Calcium (ppm)	174	55	0
Phosphorus (ppm)	189	73	25
Zinc (ppm)	106	34	0
Barium (ppm)	1	0	0
Sulfur (ppm)	3,588	3,605	3,481
Acid Number (mgKOH/g)	0.25	0.18	0.19

TABLE 5. Test results from a lifting gearbox

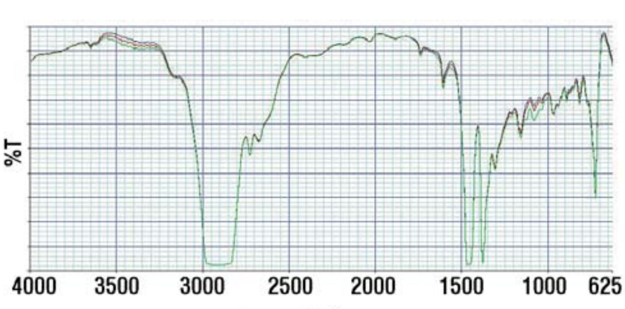


FIGURE 2. Infrared spectra of oil samples from a lifting gearbox

done if a new or modified test procedure is standardized."

Certainly the test equipment does not work as well with highly viscous oils in comparison to turbine oils or hydraulic fluids. One of the reasons could be because the amount of air pumped into the oil depends on the viscosity. Highly viscous oils generate a high counter-pressure. The higher the viscosity, the lower the amount of entrained air and foaming characteristics. Air entrainment in a gearbox also functions differently than in a hydraulic system.

Flender Foam Test

The measurement of foaming characteristics according to Flender is standardized in ISO/DIS 12152. Inside the Flender foam test rig, a horizontal pair of spur gears rotates at 1,405 revolutions per minute. Lubricant is filled into the apparatus until the spur gears are covered halfway up the side. The gears start to turn for five minutes and splash air in the oil like a mixer.

After 90 minutes, any change in the oil phase, oil dispersion and foam volume are documented. The percentage increase in the oil volume one minute after stopping the instrument as well as the percentage increase in the volume of the air-oil dispersion five minutes after stopping the instrument are two important values in evaluating and assessing the test.

For the percentage increase in the oil volume one minute after stopping the instrument, the following rating should be used:

The upper limit of more than a 15-percent increase in the oil volume one minute after stopping the instrument does not equate to an actual foaming limit for existing gearboxes. This limit is only valid for the test instrument and the standardized test procedure. It is based on the experiences of Siemens (Flender) in meeting the requirements of Flender gearboxes.

The percentage increase in the volume of the air-oil dispersion five minutes after stopping the instrument is limited to a maximum of 10 percent. This limit is required by leading manufacturers of oil pumps to avoid cavitation.

Case Study #1: Lifting Gearbox

Excessive foaming in an industrial gearbox containing 1,000 liters of gear oil was observed during operation. Contamination or mixing of different oils or other fluids is the most common cause. Therefore, a sample of the new oil was requested. One sample was taken from the middle of the oil reservoir and another from the foam. The results are shown in Table 5.

Elemental analysis revealed the cause of the excessive foaming – the oil was contaminated by another fluid. The analysis also showed differences in additive elements of the new oil, the foam and the sample from the gearbox's oil reservoir.

	8031962 Gearbox	8021706 New Oil
Water (Wt.-%)	<0.1	<0.1
Silicon (ppm)	0	9
Kin. Viscosity (40°C, mm²/s)	330.9	330.8
Kin. Viscosity (100°C, mm²/s)	37.4	38.2
Viscosity Index (VI)	162	166
Boron (ppm)	31	33
Phosphorus (ppm)	371	414
Zinc (ppm)	0	0
Barium (ppm)	0	0
Sulfur (ppm)	4,932	5,013
Foam S1 (ml/ml)	110/110	10/0

TABLE 6. Oil analysis results of a sample from a filled gearbox

	8021708 Filtered Oil	8021706 New Oil
Water (Wt.-%)	<0.1	<0.1
Silicon (ppm)	2	9
Kin. Viscosity (40°C, mm²/s)	330.1	330.8
Kin. Viscosity (100°C, mm²/s)	38.1	38.2
Viscosity Index (VI)	167	166
Boron (ppm)	31	33
Phosphorus (ppm)	422	414
Zinc (ppm)	0	0
Barium (ppm)	0	0
Sulfur (ppm)	4,938	5,013
Foam S1 (ml/ml)	10/10	10/0

TABLE 7. Oil analysis results for a sample of filtered new oil

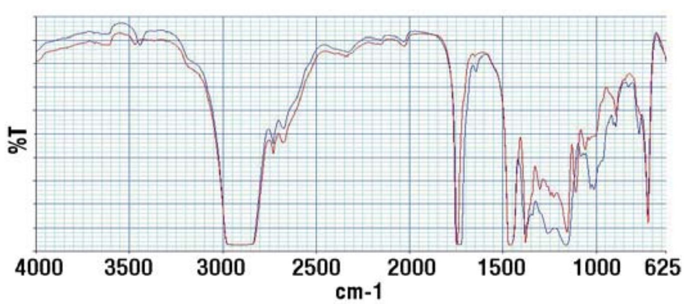


FIGURE 3. An infrared spectrum of an oil sample from a newly filled gearbox

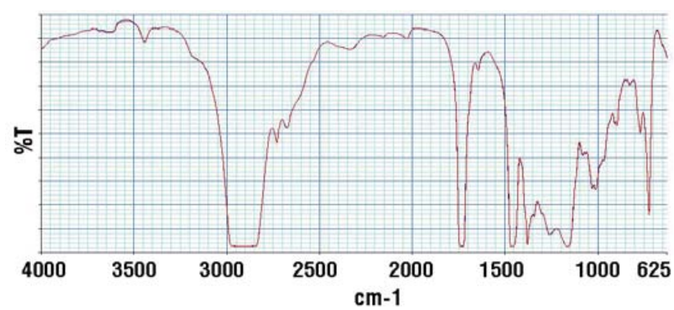


FIGURE 4. An infrared spectrum for a sample of filtered oil

Case Study #2: New Oil After Filling a Gearbox

When new oil was used to fill a gearbox and the gearbox was started, the oil showed an increased foaming tendency. The customer believed the cause of the increased foaming tendency was the removal of anti-foaming agents due to bypass filtration. To obtain more information, oil samples from the new oil and from the oil in the gearbox were analyzed (Table 6).

The results showed the silicon-based anti-foaming agent had been completely removed. There were also small changes in additive content. An infrared spectrum of the gearbox sample in comparison to the fresh oil can be seen in Figure 3.

The spectrum revealed cross-contamination by another fluid. A fresh oil volume was then filtered to determine if bypass filtration was the only reason for the foaming or if cross-contamination also had an effect. After filtration, a sample was taken and analyzed (see Table 7).

The analysis showed that the anti-foaming agent was not completely removed. A small amount (2 parts per million) remained. Although the slight changes in the amount of anti-foaming agent are not visible in the infrared spectrum (Figure 4), a good correlation of the sample before and after filtration is evident.

Some filter manufacturers have even included the Flender foam test in their testing procedures to avoid problems with removed anti-foam agents.

Case Study #3: Main Gearbox of a Wind Turbine

A wind turbine's main gearbox was initially filled with a mineral oil. After operating for 25,000 hours, the oil was changed, and a switch was made to a synthetic polyalphaolefin-based oil. The new filling started to foam almost immediately. Oil analysis was utilized to determine whether the gearbox was flushed properly (see Table 8).

Small changes in the element concentrations were visible. The infrared spectrum (Figure 5) shows the contamination more clearly. The brown graph represents the spectrum of the old oil, while the blue graph is the new oil, and the red graph is the oil from the gearbox after the oil change.

Case Study #4: Cement Mill Gearboxes

During a scheduled downtime, the oil in two industrial gearboxes was changed. Due to the positive experiences with the oil, the same oil type was used again. After the oil change in both gearboxes, increased

	2295772	1504280	2155316
	After Oil Change	New Oil	Old Oil
Water (Wt.-%)	<0.1	<0.1	<0.1
Silicon (ppm)	16	25	0
Kin. Viscosity (40°C, mm²/s)	332.3	325.1	318.8
Kin. Viscosity (100°C, mm²/s)	36.7	36.5	23.4
Viscosity Index (VI)	157	160	92
Calcium (ppm)	0	0	0
Phosphorus (ppm)	393	432	197
Zinc (ppm)	3	0	22
Barium (ppm)	0	0	0
Sulfur (ppm)	3,992	3,857	10,690
Acid Number (mgKOH/g)	0.94	0.99	0.82
Flender Foam (%)	18	-	-

TABLE 8. Test results from old and new gear oil

	1702513	1702514	1702515
	Gearbox A	Gearbox B	New Oil
Oil Usage (hours)	500	210	0
Water (Wt.-%)	<0.1	<0.1	<0.1
Silicon (ppm)	4	2	3
Kin. Viscosity (40°C, mm²/s)	204.3	200.7	216.1
Kin. Viscosity (40°C, mm²/s)	18.8	18.6	18.97
Viscosity Index (VI)	101	103	98
IR-Oxidation (A/cm)	7	11	-
Calcium (ppm)	15	18	18
Phosphorus (ppm)	175	163	156
Zinc (ppm)	5	6	7
Molybdenum (ppm)	859	861	852
Sulfur (ppm)	10,752	10,768	10,690
Acid Number (mgKOH/g)	0.83	0.79	0.85

TABLE 9. Test results for new and in-service gear oils from cement mill gearboxes

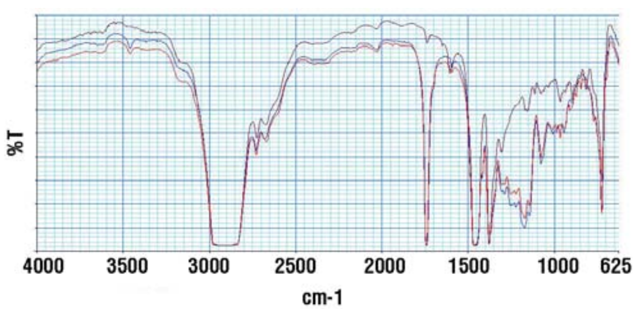


FIGURE 5. An infrared spectrum of an oil sample from a wind turbine's main gearbox

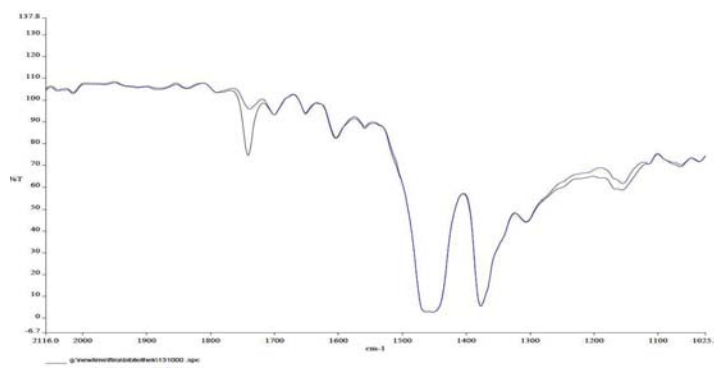


FIGURE 6. Part of an infrared spectrum for a contaminated gear oil

foaming was observed. The gearboxes were stopped again, and the customer complained to the oil manufacturer about the "bad oil quality." The oil manufacturer took samples from the foaming oil in both gearboxes and from the new oil that was delivered (see Table 9).

The elemental analysis results were not unexpected. Only the viscosity of both gearbox samples was slightly decreased. This decrease was within the limits for ISO VG 220. However, in comparison to the fresh oil sample from the same batch, it was noticeable. The infrared-oxidation value was also abnormal and much too high for this limited usage. The infrared spectrum indicated contamination with an ester-containing fluid (see Figure 6).

While discussing the results, the customer revealed that a cleaner had been used. The cleaner contained ester-based components, and its viscosity was very low. It became obvious that the cleaner was the reason for the increased foaming.

In conclusion, the formation of foam or finely dispersed air bubbles is one of the most frequently discussed phenomena in the operation of gearboxes. Excessive foaming can lead to serious operational problems as well as safety and environmental hazards.

Different standardized test procedures are available to estimate the air release and foaming properties of lubricating oils. However, the common test methods for air release (ISO 9120, ASTM D3427-12 and IP 313) and foaming properties (ASTM D892, ISO 6247 and IP 146) do not provide reliable information for industrial gear oils. Therefore, a special test (Flender foam test, ISO 12152) has been developed and standardized. This test delivers much more reliable results and can improve the reliability of gear oils. The examples given in this article demonstrate the application of these test procedures and offer an overview of a variety of foaming problems as well as their causes.

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ExxonMobil Lubricants Private Limited

Case Study-
Samruddhi Industries

Mobil DTE 10 Excel 68 helped Samruddhi Industries improve hydraulic efficiency by 4.28%, leading to annual savings of INR 179,400/USD 3,000

Today's globally competitive business world drives manufacturers to get the most out of their equipment. Even small increases in machine productivity can mean the difference between profit and loss. Additionally, environmental concerns demand focus on sustainable business practices and energy efficient systems. In response, industrial and mobile equipment hydraulic systems have become smaller and lighter, and utilize higher pressures to achieve maximum system efficiency. Hydraulic fluids with reduced environmental impact can provide sustainable solutions that support both environmental and economic goals.

Fluids that are used in industrial and mobile equipment applications operate in a wide range of environments and temperatures. It is not difficult to find a lubricant to meet these requirements, but there can be performance concerns if the fluid is not properly formulated. Fluids with a wide operating temperature range are often formulated with special viscosity improver additives to improve both high and low temperature viscometrics; and these additives are subject to shearing forces that can reduce their effectiveness in service.

Advanced hydraulic fluids are available to meet the demands of these systems, as well as to contribute to overall hydraulic system and energy efficiency. These hydraulic fluids transmit pressure and energy, seal close-clearance parts against leakage, minimize wear and frictions, remove heat, flush away dirt and wear particles and protect surfaces against rusting. Other than these functions, the correct hydraulic fluids for the correct machine also have the capability to advance productivity, reduce energy consumption and thus help in monetary savings.

This case study on Samruddhi Industries Limited – one of the leaders in manufacturing unbreakable plastics in India, exemplifies how ExxonMobil supported Samruddhi industries Limited to document energy savings, leading to "Advancing Productivity".

In 2000, Samruddhi Industries set up its manufacturing plant at Sangli, in Maharashtra. Currently they have three units in Sangli which house 26 Injection Molding Machines. Most of these machines were "in-service" with existing hydraulic oil. Samruddhi industries were keen on documenting energy efficiency savings and supporting the cause of sustainability.

ExxonMobil recommended using Mobil DTE 10 Excel 68 in their Windsor Armour 150 Injection Molding Machine. The product has significantly "lower traction coefficient" than traditional Zinc (ZnDDP)-based hydraulic fluids. Over 40% reduction in this property resulted in "increased efficiency" directly relating to improved equipment productivity.

On observations over a month, Samruddhi Industries Limited recorded reduction in cost of unit production. Mobil DTE 10 Excel 68 displayed an energy efficiency of 4.28%; resulting in an overall savings of INR 179,400 for all 26 machines annually.

Key benefits of using Mobil DTE 10 Excel 68 included:

1) Reduction in energy consumption
2) Outstanding Shear Stability facilitated wider operating temperature range
3) Ultra Clean Performance and Oxidative and Thermal Stability resulting in longer oil drain and filter change interval

Progressive condition monitoring through ExxonMobil' SIGNUM used oil analysis program, to monitor the durability of both equipment and lubricant, was recommended to achieve these benefits.

Mobil DTE 10 Excel series provides "ultraclean" performance which helps in keeping systems free of deposits for up to 3 times longer than competitive hydraulic fluids. This is due to Mobil DTE 10 Excel Series hydraulic oil's "advanced additive technology". In Mobil's proprietary laboratory test, Mobil DTE 10 Excel series has shown improved thermal stability. Better oxidative and thermal stability means the oil holds up better to higher temperatures which lead to longer oil life and reduces sludge type deposits or varnishes. Again, better thermal stability properties provide longer oil life and fewer sticking servo valves.

The results of this demonstration clearly show the impact of increasing hydraulic efficiency. Use of efficient hydraulic fluids in plastic injection molding machines can be expected to reduce energy consumption and increase cycle time, leading to 'Advancing Productivity'.

About ExxonMobil Lubricants Private Limited

Customers have relied on ExxonMobil lubricants for more than 120 years. Marketed in nearly 200 countries and territories worldwide, ExxonMobil products stand for performance, innovation and expertise. As an industry leader in synthetic lubricants, a full range of ExxonMobil products is available in the automotive, commercial and industrial business sectors. ExxonMobil recognises that business success and social responsibility go hand in hand. To that end, ExxonMobil works closely to support the communities where they operate and pledges to maintain the highest ethical standards, comply with local laws and respect local and national cultures. The term "ExxonMobil" is used for convenience only, and may include Exxon Mobil Corporation or any of its affiliates.

Mobil Industrial Lubricants is a business of Exxon Mobil Corporation. Today, Mobil Industrial Lubricants are used extensively in many industrial market sectors - including power generation, general manufacturing, metal working, food and beverage processing, pulp and paper, cement, construction, metals and mining. Every day, Mobil-branded lubricants help enable industrial companies to successfully boost productivity, enhance the performance and life of their equipment, increase profitability and reduce downtime.

For more information on Mobil Industrial's range of lubricants and services, visit mobilindustrial.com

Machinery Lubrication Training for Balmer Lawrie Team

Balmer Lawrie & Co. Ltd. is a diversified PSE under the Ministry of Petroleum & Natural Gas, Government of India. Taking forward its aggressive Marketing and Branding strategy for its 'Balmerol' range of lubricants, a three day training on 'Essentials of Machinery Lubrication' was conducted at Kolkata for their Industrial marketing team followed by ICML's MLA-I certification, as a part of their competency enhancement program. The training was conducted through M/s Lubrication Insititute. licensed partners of Noria Corporation, USA.

Shri Probal Basu – C&MD, Shri Sothi Selvam – Director (Manufacturing Businesses) and Shri Ananda Sengupta – COO (Greases & Lubricants), graced the occasion, along with the faculty Mr. Micheal J Hooper.

Wes Cash | Noria Corporation

CHOOSING a HIGH-SPEED GREASE

Most industrial facilities have bearings that rotate faster than normal processing equipment. When it comes to lubricating these pieces of equipment, not all lubricants behave the same way. For grease-lubricated components, the effects of the grease on the bearings can lead to increased heat, drag and ultimately premature failure. By properly selecting a grease that can handle these higher speeds, you can help minimize any potential failures caused by mismatching the lubricant to the application.

GREASE TYPE	BASE OIL VISCOSITY (40°C)	SPEED FACTOR (NDM)
Slow-speed, high-pressure, industrial grease	1,000-1,500 cSt	50,000
Medium-speed, high-pressure, industrial bearing grease	400-500	200,000
EP, NLGI #2, multi-purpose grease	100-220	100,000-200,000
High-speed, high-temperature, long-life grease	<70	600,000
High-speed, long-life grease	15-32	>1,000,000

High-speed Applications

During my frequent plant visits, I often am asked about the temperature at which bearings should operate. Inevitably, the bearings that seem to be running the hottest are the ones that rotate the fastest. For example, on a recent trip, I inspected an overhanging fan. This fan was belt-driven at a 1-to-1 ratio from a large electric motor. The speed of the motor was set at 1,750 revolutions per minute (rpm). Since there was no reduction or increase in pulley size, it is safe to assume the speed of the bearings was quite similar. These bearings were greased with a product that was much too thick for them, leading to the generation of excess heat and shortening the bearing life. By matching the grease properties more closely to the bearing needs, you can help prolong the life of the bearing.

While this example paints a picture of a type of machine in most plants (fans), it is common to find high-speed applications in other components as well. For instance, some pumps that are directly coupled to a motor and have grease-lubricated bearings may spin in excess of 2,000 rpm. The same holds true for certain mixers, agitators and blowers. These components may suffer if a multi-purpose grease is simply applied without much regard to the needs of the bearing. To understand what the bearing requires in terms of lubrication, you must first learn how to determine the speed factor of a bearing.

OPERATING TEMPERATURE	DN (speed factor)	NLGI NO.*
-30 to 100°F (-34.4 to 37.7°C)	0-75,000	1
	75,000-150,000	2
	150,000-300,000	2
0 to 150°F (-17.7 to 65.5°C)	0-75,000	2
	75,000-150,000	2
	150,000-300,000	3
100 to 275°F (37.7 to 135°C)	0-75,000	2
	75,000-150,000	3
	150,000-300,000	3

** Depends on other factors as well, including bearing type, thickener type, base oil viscosity and base oil type.*

Calculating the Speed Factor

The speed factor is a term that helps define the relationship of the speed at which a bearing rotates with the size of the bearing. There are two main ways to calculate this factor. The first is known as the DN value, which uses the bearing inner diameter multiplied by the speed at which it rotates. The second method is known as the NDm value. This uses the bearing's median size, also known as the pitch diameter, and the rotation speed to calculate the speed factor.

IMPACT OF BEARING CONDITIONS ON BASE OIL VISCOSITY SELECTION

ISO VG (cSt@40°C)	Application Examples	Load	Speed	Oil Separa-tion*	Pump-ability*
22	High-speed Spindles	Low	High	High	High
100	Large, High- speed Electric Motors				
150	Wheel Bearings				
220	Paper Mills, Multi-purpose, Industrial				
460	Paper Mills, Steel Mills				
1000	Mining Equipment Crushers, Bearings, etc.				
1500	Very Low Speed, Heavy/Shock Loads	High	Low	Low	Low

**Oil separation and pumpability are also influenced by grease consistency and thickener type.*
***Scales indicate directionality.*

The speed factor can help you determine a variety of lubricant properties, which you can then utilize to select the proper lubricant. Among these properties would be the viscosity of the oil and the National Lubricating Grease Institute (NLGI) grade of the grease for the application.

Viscosity

The most important physical property of a lubricant is the viscosity. Viscosity is what determines how thick or thin the lubricating film will be based upon the load, speed and surfaces in contact. This must be matched to the needs of the bearing. Most general-purpose greases have a base oil viscosity of around 220 centistokes. While this type of grease may work fine for moderate speeds and loads, when the bearing speed increases, the viscosity must be reduced accordingly.

There are many ways to calculate viscosity. By utilizing the speed factor mentioned earlier, you can use standardized charts to identify an appropriate viscosity for the bearing at the operating temperature. In the previous example of the fan bearing, the NDm value of the bearing was 293,125, which led to a base oil viscosity of approximately 7 centistokes. The bearing was operating at around 150 degrees F. With a standard viscosity index of 95, this equates to an ISO 22-32 base oil viscosity. If you were to use a standard multi-purpose grease, this bearing would receive about 10 times the viscosity needed. Although some excess viscosity isn't necessarily a bad thing, this level would be a bit extreme.

Excessive viscosity can lead to excess heat generation and increased energy consumption. Both of these are detrimental to the health of the bearing and the lubricant. The hotter the bearing runs, the lower the viscosity of the grease becomes. This can cause increased grease run-out and require more frequent applications of fresh lubricant. The energy consumption can also add up over time, resulting in money lost due to nothing more than the increased drag from excess viscosity.

With grease, it is common to be able to lubricate bearings easily until they reach speed factors greater than 500,000. This is when specially formulated high-speed greases are employed. Some greases on the market are touted to work up to speed factors of 2 million. However, it is worth noting that not all greases are created equal, and not all can perform well at varying speed levels.

Channeling Characteristics

One property of a lubricating grease that can determine how it will lubricate at high speeds is called channeling. This term is used to define how well grease can flow and fill a void left in its surface. Method 3456.2 of Federal Test Method Standard 791C offers one way to test the channeling characteristics

6 Factors for Selecting a High-speed Grease

1. **Base Oil Viscosity** – Ensure the viscosity adequately provides the lubricating film but is not too thick to cause excessive heat and drag.
2. **Channeling Characteristics** – The grease should be able to channel so excess heat isn't generated from grease churning.
3. **Dropping Point** – The dropping point of the grease should exceed the operating temperature by a wide margin to avoid excessive bleed and possible bearing failure.
4. **Thickener Type** – Choose a thickener that can provide the proper dropping point, channeling and bleed characteristics. Also, if you use multiple greases, check the thickener types for compatibility in case of accidental mixing.
5. **NLGI Grade** – The consistency of the grease will have an impact on the bleed characteristics and channeling properties of the finished lubricating grease.
6. **Additive Load** – Most applications require additives to help the oil lubricate. For greases, a wide variety of chemical and solid additives can be blended to aid in film strength and reduce friction and wear.

of a lubricant. In this test, grease is applied to a container, and the surface is leveled off. After the temperature has been stabilized, a steel strip, known as the channeling tool, is pulled through the grease, leaving behind a void or channel in the grease. After 10 seconds, the grease is checked to see if it has flowed back into the channel or covered the bottom of the vessel. If the grease has filled the void, it is known as non-channeling. If the grease did not fill the void, it is labeled as a channeling grease.

Channeling greases are more easily pushed out of the way of the element as it rotates, thus leading to less churning and less temperature gain. Greases that are non-channeling flow back into the path and can result in the generation of excess heat.

Thickener Type

Aside from the base oil viscosity, another grease property that impacts its channeling characteristics is the thickener type. The thickener in a grease is commonly referred to as the sponge that holds the oil. The structure of the fibers in the thickener can affect certain grease properties, such as channeling, bleed, dropping point and overall consistency. Some grease thickeners have long fibers, while others have short fibers. Short-fibered thickeners will have a smoother texture. More complex thickeners, as well as those with lithium, calcium, polyurea and silica thickeners, are short-fibered. The greases formulated with these thickeners typically have better channeling characteristics and are more easily pumped.

Long-fibered thickeners, such as those with sodium, aluminum and barium, tend to have worse channeling characteristics. The longer thickener fiber can also be sheared through the churning process, which can cause a change in consistency. In addition, since these greases often flow back into the channel that has been cut by a bearing, they can result in an increase in heat and exacerbate the shearing process.

NLGI Grade

The base oil viscosity and the amount of thickener concentration greatly influence the NLGI grade of the finished lubricating grease. The NLGI number is a measure of the grease's consistency. The higher the NLGI number, the thicker the overall consistency. The scale ranges from 000 (fluid like) to 6 (solid block). When it comes to high-speed greases for rolling-element bearings, the NLGI grade tends to go up while the base oil viscosity goes down. This balance is to ensure there isn't excess oil bleed from the thickener. Based upon the bearing's speed factor as well as the temperature in which the bearing operates, you can draw solid conclusions about the appropriate NLGI grade of the grease.

Bearing Type

Rolling elements in bearings come in a variety of shapes. The shape of the element makes an impact on the required viscosity, NLGI grade and regreasing interval. This all has to do with the amount of surface area in contact with the grease between the element and the race. The more surface area, the more the oil will be wrung out of the thickener. Also, the bearings that have more contact (spherical, cylindrical, needle, tapered roller, etc.) tend to be more heavily loaded than a standard ball bearing. This added load lends itself to an increased separation rate as well as the need for higher viscosity base oils.

Dropping Point

Perhaps one of the most notable considerations when selecting a high-speed grease is the temperature at which the bearing will operate. To ensure the selected grease will perform at elevated temperatures, you should check the dropping point of the grease (ASTM D566 and D2265). These test results can be found on most all grease technical data sheets. The test uses a small cup with a hole in the bottom in

BEARING TYPE	RELATIVE LIFE OF GREASE
Deep-groove, single-row ball bearing	1
Angular contact, single-row ball bearing	0.625
Self-aligning ball bearing	0.77-0.625
Thrust ball bearing	0.2-0.17
Cylindrical, single-row roller bearing	0.625-0.43
Needle roller bearing	0.3
Tapered roller bearing	0.25
Spherical roller bearing	0.14-0.08

TYPICAL MAXIMUM OPERATING GREASE TEMPERATURE
• If dropping point (DP)<300° F, subtract 75° F from the DP
• If 300° F<DP<400°F, subtract 100° F from the DP
• If DP>400° F, subtract 150° F

which the grease is applied to the inside walls. A thermometer is then inserted but does not touch the grease. This apparatus is then heated until a single drop of oil separates and drips out of the bottom of the cup. The temperature at which this occurs is the dropping point of the grease.

A high dropping point is important for bearings operating at elevated temperatures. However, just because a grease has a high dropping point doesn't mean the base oil can withstand elevated temperatures. The dropping point does not equate to the maximum usable temperature. There should be a buffer between the temperature at which the bearing operates and the dropping point of the grease.

Incompatibility Issues

When changing grease types, it is important to remove as much of the old grease as possible to minimize any incompatibility issues with the new grease. If feasible, disassemble the equipment and clean out as much of the grease as possible.

Although the majority of applications will be properly lubricated with a general-purpose grease, for those instances when the NDm value is excessively high, it is essential to ensure the lubricant is able to protect the equipment. Even if you are diligent and select a grease based upon all the previously mentioned properties, the only way to truly know if the grease will perform in the desired manner is to conduct a field trial. Monitor the bearing temperature and look for any signs of grease or oil leaking out from the seals or purge vents.

Finally, be sure to do your homework and calculate the NDm values of your bearings in order to select the appropriate lubricant. With proper attention and lubricant selection, your high-speed equipment will enjoy a longer service life. ■

About the Author

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Micheal Brown | Noria Corporation

WHY YOU Should Reclaim and RECYCLE USED OIL

Going "green" by becoming ecologically and environmentally responsible is an excellent practice that does not always have to cost your organization money. In many cases, it can actually save money. A number of industries have begun reclaiming or recycling used oil because it makes good business sense. These include automotive manufacturers, steel mills, paper mills, sugar mills, process plants and power generation plants.

Unfortunately, some companies do not reclaim or recycle used oil because they think they don't have the time to devote to these programs. The engineering/reliability managers of these plants are often so busy managing the day-to-day processes that little or no attention is paid to the total lubricant life cycle, which in most instances would make their process more reliable and less expensive to maintain, especially when it comes to reclaiming oils.

Reclaiming and recycling used oil offers many benefits, such as increased machine reliability, considerable cost savings on oils, less time spent on oil change-outs, reduced environmental contamination and decreased waste disposal costs. Re-refining used oil requires about one-third the energy of refining crude oil to lubricant quality. Also, consider that it takes 42 gallons of crude oil but only one gallon of used oil to produce 2½ quarts of new, high-quality lubricating oil.

Oil Reclamation

Reclamation and recycling are related processes but with significant differences. Reclamation is the act of salvaging, recovering or reclaiming. In this context, the oil is rescued from normal degradation. It generally involves cleaning, drying and adsorption to remove water, acids, sludge and other contaminants. The reclaiming of oil is mostly a nonchemical process that restores an in-service lubricant to good health by removing impurities.

For the most part, reclamation can and should be done onsite to mitigate the chances of cross-contamination. Reclamation may also take place offsite where the vendor of the reclamation service drains the existing oil and replaces it with previously reclaimed oil. Keep in mind that if the oil is removed from the plant and reclaimed at an offsite location, the potential for cross-contamination increases tremendously. In addition, if an oil spill or accident occurs during transport to the facility, the owner of the oil is liable.

Some oils like motor oils cannot be reclaimed, while others should not be reclaimed due to the costs involved. Additive formulations may be proprietary, or the additives are not easily sourced. There is also the question of whether the reclaimer would be able to finance the liability of equipment damage, downtime and/or bodily harm if there was a mixup with the viscosity or additive formulation. The best option is to have your newly reclaimed oil tested by a reputable lab to ensure it complies with the machine's original equipment manufacturer (OEM) specifications before it goes back into service.

Recycling Oil

Recycling is the act of returning something or a part of something back to useful service, which may be different from the original application. Whether it is in an engine, gearbox, hydraulic system or turbine, all lubricant oil eventually reaches the end of its useful life and must be drained from the machine, sump or reservoir.

Some forms of oil recycling can be done onsite. If your plant produces large amounts of used oil that can't be reclaimed, this used oil can be turned into lubricant oils or fuel for burning in boilers, industrial furnaces, etc. On the other hand, if your used oils must be sent offsite because they are too badly contaminated with different viscosity/base oils and chemicals, or your plant does not have the volume to justify onsite recycling, make certain that the used lubricants are handled and processed in an environmentally acceptable manner by a waste-removal/recycling company. A number of recycling organizations are available, but you must ensure that you are dealing with a reputable company that processes the oil correctly in compliance with your local laws and U.S. Environmental Protection Agency (EPA) regulations.

Is Reclaiming the Best Option?

Keeping your oils in service as long as possible is beneficial to your business in many ways. The cleaner and drier the oil, the longer your machines will last. Therefore, cleaning your oils while they are still in service and not allowing them to be used to the point of no return (viscosity degradation/oxidization) makes perfect sense. To achieve this, you first must know which oils can be reclaimed. Typically, reclaimable oils include hydraulic oils, turbine oils, circulating oils for bearing lubrication, paper machine oils, gear oils, quench oils, some metalworking fluids, transformer oils, some synthetics and several specialty fluids.

Next, you need to determine your oil's remaining useful life through oil analysis. Do not just rely on interval-based oil changes for your reclamation program. You may be leaving the oil in the machine too long. Employ a quality laboratory to conduct the testing and make sure you have a baseline sample from the new oil as a reference for the viscosity, cleanliness and additive levels. This will help you discover what's happening to the oils in your machinery and how their life is being impacted.

The oil should be tested for the following:

- Viscosity at 40 degrees C (ASTM D445)
- Acid number (ASTM D664)

- Rotating pressure vessel oxidation test (ASTM D2272)
- Water separation at 130 degrees F (ASTM D1401)
- Trace metals analysis (ASTM D5185)
- Cleanliness level standards (ISO 4406:99)
- Pressure differential scanning calorimetry (ASTM D6186)

Plant personnel should be trained to read sample reports and to take samples correctly with the right equipment. You may need to outfit your machinery with better breathers, quick connects and filters to keep as much contamination out of the machines/systems as possible.

Reclamation involves the oil being filtered and cleaned of debris, sludge and fine particles. Centrifuging is also used to remove suspended particles and some water. Many oil reclamation units dry the oil by heating it and applying a vacuum. Vacuum dehydrator units can be utilized onsite and are great assets if the costs can be justified. If not, you will need to have your oils reclaimed offsite.

Selecting a Reclamation Company

To help determine a prospective reclamation company's credibility and expertise, it is important to ask a few simple questions, such as whether the oil is tested before and after it is reclaimed, if particle count data is provided at the site during reclamation, what the cost savings associated with reclamation are, if the oil can be refortified legally and accurately onsite, whether the original formulators are involved, and how the reclamation will impact the machine's warranty.

In conclusion, all plants should have a coordinated plan for managing used lubricating oil, including how much oil is reclaimed and how much is recycled. Cleaner production methods and a focus on minimizing waste are the first steps to reduce used oil. However, once the oil reaches the end of its useful life, it should be either reclaimed or recycled. If reclaimed, the oil may continue to serve its designed function for many more operating hours. Rigorous testing and record-keeping will be necessary for this approach.

If the used oil is a mixture of contaminants and waste oils or has been severely degraded and cannot be reclaimed, then it should be reprocessed by a recycler or repurposed into fuel. Of course, all of this is dependent on the type of contamination in the used oil.

Finally, be sure to follow all local laws and the EPA's regulations for used oils. If you do not, harsh fines may be imposed. ■

What is Used Oil?

The U.S. Environmental Protection Agency (EPA) defines used oil as "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."

Oils used as lubricants, hydraulic fluids, heat transfer fluids, buoyants and for other similar purposes are considered used oil. Some examples include engine oil, transmission fluid, lubricating oil, hydraulic oil, gear oil, transformer fluid, cutting oil, tempering or quenching oils, greases and brake fluid.

Used oil does not include oils made from vegetable- or animal-based oils, oil wastes that have never been used (e.g., virgin oil spills), antifreeze, kerosene, or petroleum distillates used as solvents.

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K.N.V.SUBRAHMANYAM

Used Oil Analysis a Reliability centered approach

A machine's operating life is most often determined by the oil that lubricates its load-bearing surfaces. Good lubrication normally provides long life, even under harsh operating conditions, and poor lubrication results in short life, even under mild operating conditions. Industrial machines are generally supposed to have 40,000 hours (about 5 years) mean time between failures (MTBF). This can only happen if you have "good lubrication". If you have "poor lubrication" or "no lubrication" you get a far shorter operating life.

"Nearly 10% of the maintenance budget is lost due to poor lubrication practices".

Reliability Centered Lubrication (RCL) is an approach to lubrication that is focused on designing a program for Lubrication and Oil Analysis by taking into account operational conditions, best practices, and modifications required to both machine and facility.

Current Maintenance Analysis | RCL planning | Implementation | Keep it on

Reliability Centered Lubrication (RCL) uses industry standard calculations to determine appropriate lubricant recommendations, including lube type, re-grease volumes, and re-lube intervals. Furthermore, the RCL process uses Failure Modes Analysis (FMA) to establish appropriate Oil Analysis test slates and test intervals.

It is important to understand that poor lubrication practices always results in high down time of equipment and reduce the machine availability. Poor lubrication practices include improper handling of lubes, wrong oil addition, wrong oil top ups, improper flushing of the reservoirs, tanks, etc. A small mistake like wrong oils addition would lead to great changes in viscosity of the lube in operation and can cause big damage to the equipment internals. Typically true with improper flushing practices before oil changes results in lubricant pre-mature degradation and can lead to increased wear.

How equipment fails??..

The M.I.T. Study clearly indicates the root causes of surface degradation are improper lubrication, Lubricant contamination and mechanical problems on the machinery components. Furthermore lubricant health conditions in operating conditions are greatly affected by contaminations like air, water, process gases, leakages etc. From the M.I.T. study it is also evident that every wear particle generated has got a root cause and the root cause is very well connected to the equipment operating and loading conditions. Maintenance personnel need to look in to the way of how the lube oils are being degraded and equipment components are subjected abnormal wear with their

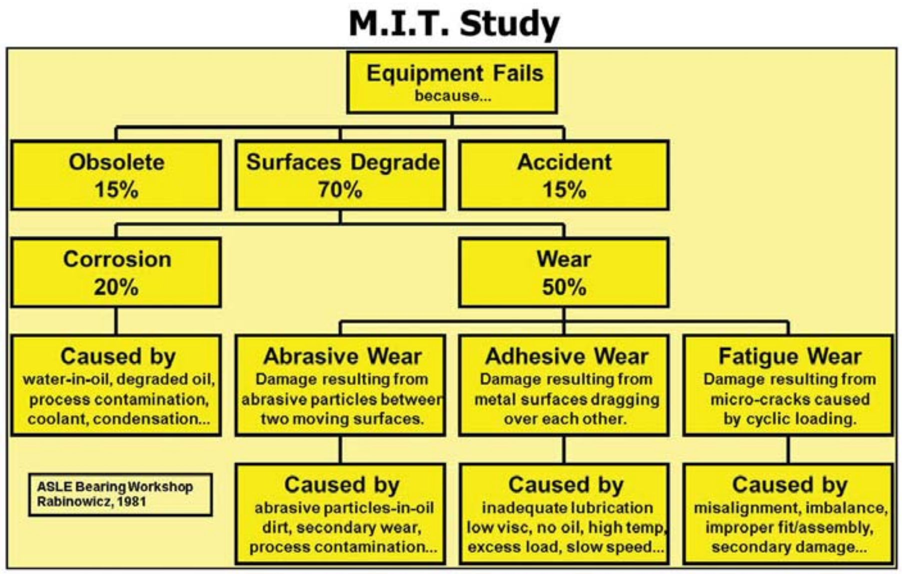


Fig.1 M.I.T Study indicates root causes of Equipment wear.

operating environments and should implement a proper reliability centered maintenance approach to protect the lubricant health condition and there by the protection of critical assets from abnormal wearing resulting from these conditions.

The above study on common causes of bearing failures clearly indicates where we need to start from as far as the Reliability centered approach to take up. Out of all reasons 47% of bearing failures are due to dirt-contamination in the bearing oils. Hence the start point for RCA is nothing but to make sure to provide healthy, contaminant free lube oil to the components. Apparently the next root causes mis-alignment, mis-assembly issues, over load on the equipment components results wear particles generation and the next objective in RCA would obviously be Used Oil Analysis as these operating and mechanical wearing can be well detected by used oil analysis in the very early stages of failure. Even lack of lubrication, corrosion related issues can be well addressed with proper used oil analysis testing.

In Reliability centered maintenance, contamination control has got vital role in driving the operational goals like extending the oil drain intervals, systematic approach of oil top ups, increasing the machine availability.

There are 5 factors in maintaining good lubrication:

- Clean oil
- Dry oil
- Oil with the right properties
- Contamination Control
- Wear debris monitoring

Contamination control is in-fact a 3 step cyclic process which include

Monitoring the contamination- This starts from checking the incoming quality of lubricants, lubricants storage environment, proper usage of lube oil transfer containers, process environments etc.

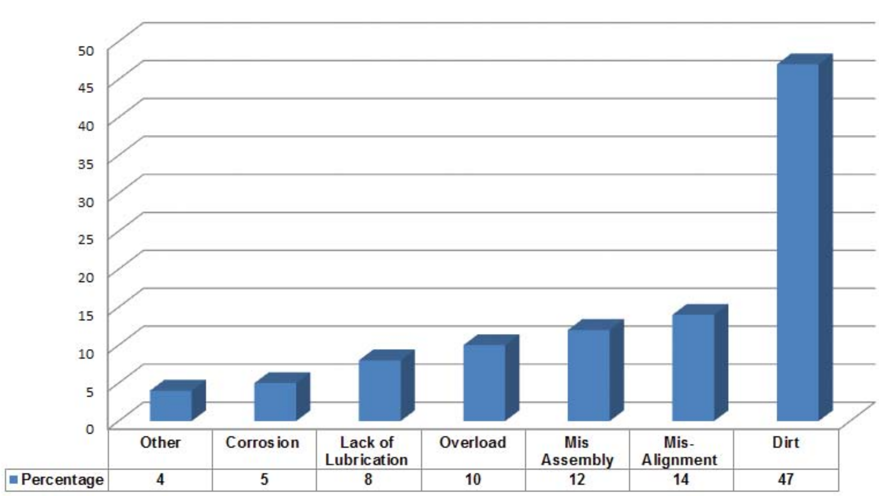
Control the contamination- Once identified the source of contamination, one can take an immediate maintenance to control the incoming contamination and making sure a clean oil is flowing to the components. Remember only a clean, dry oil can give best lubrication to your equipment.

Correcting the contamination- Root sources of contamination to be identified and redesign the filtration procedures, breathers, vents, seals locations if necessary.

Used Oil Analysis, though it has got many objectives but from the maintenance personnel perspective it should provide answers for

- data on the operating condition of the equipment
- The analysis results not only establish the condition of the oil but should also establish the condition of the equipment.
- Enables a predictive/Proactive strategy to be adopted
- Predictive – Actions performed in an attempt to predict/foresee a developing problem by providing systematic analysis.
- Proactive – Actions performed in an attempt to rectify a developing or existing problem by providing root cause analysis and diagnosis.
- Measurably Extend Life of Oil
- Measurably Extend Life of Equipment
- Increase Production/Machine Availability
- Reduce Maintenance expenses & Reduce Breakdowns

Importance of Contamination monitoring & Used oil analysis.



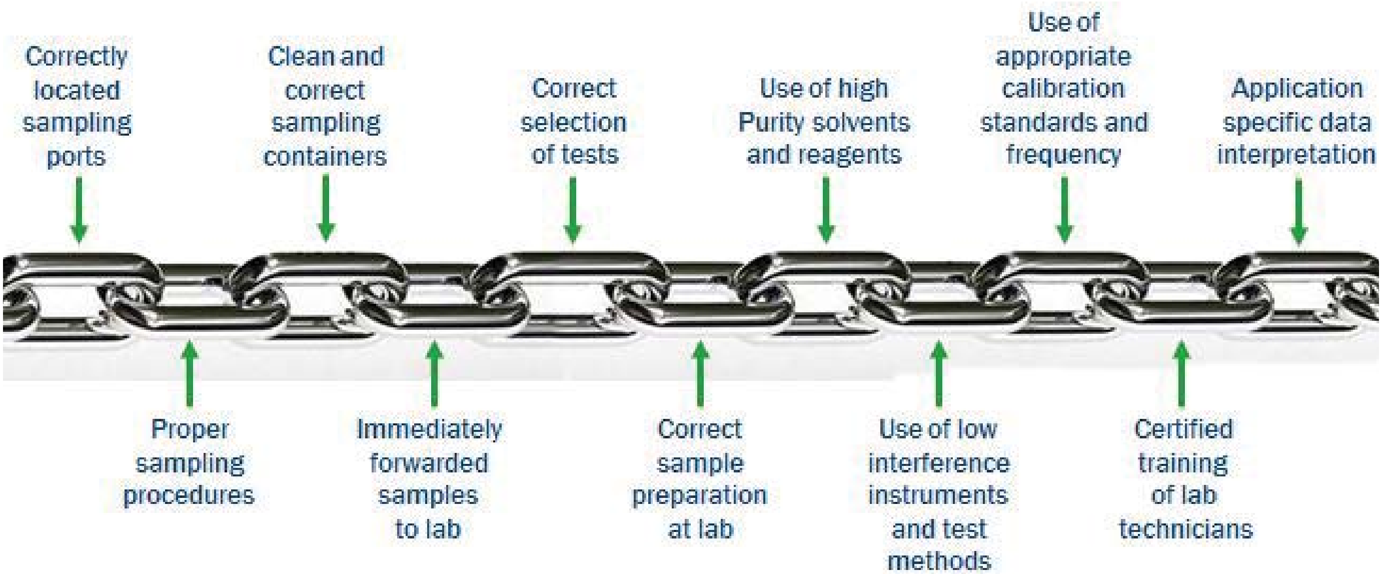
Common causes of Bearing failures Ref: Derived from TAPPI Study

3-Step Cyclic strategy for contamination control practices

Fix the weak link- Vital task in starting Reliability centered approach to implement the Used Oil analysis.

RCA based Used Oil Analysis needs continuous improvement.

Any condition monitoring technique requires periodic data to interpret the exact condition of equipment. Used oil analysis starts with identifying the proper sampling locations, understanding of what testing measurements needs to be taken for each application, define the sampling frequencies on criticality based, interpreting the Oil Analysis results to your own operating conditions and



taking appropriate maintenance actions on time.

What testing to take up & When to take up???

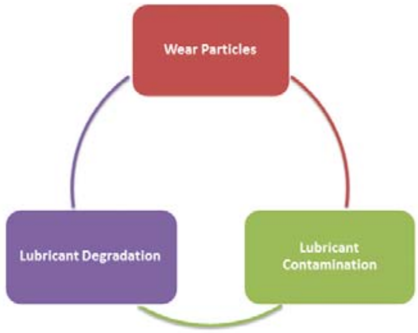
A general approach to the Used Oil Analysis for most critical equipment's.

Proper testing frequencies are essential for the success of getting benefited from used oil analysis. While selecting the sampling frequencies it is important to consider the type of equipment being monitored, oil change frequencies, criticality of the equipment, process environments etc.

Besides the routine oil analysis, there is a need based oil analysis testing required to be performed for better control over varnish related issues, corrosion based wear, cavitation effects, etc. This can be better guided by taking up the specific issues with OEM and professional oil analysis labs.

Wear particles generation mode and size can tell you the operating modes and root causes of abnormal wear in equipment components at an early stages. Most OEM's recommend Spectroscopy/Elemental analysis in their routine monitoring activities and ferrography/Wear Particle analysis is advised based on the severity of wear elements in spectroscopy. At Reliability centered approach it is recommended to carry out both ferrography and spectroscopy because spectroscopy

OIL ANALYSIS TESTS	GEARS/ BEARINGS	HYDRAULICS	TURBINES/ COMPRESSORS	ENGINES
Routine (Monthly or every 3 months depending on equipment criticality)	1.Kinematic Viscosity @ 40,@100 deg.c & Viscosity Index 2. Moisture content 3. Total Acid Number 4. Ferrography Analysis 5. Spesctroscopy	1.Kinematic Viscosity @ 40 deg.c 2. Moisture content 3. Total Acid Number 4. Particle count/NAS value 5.Spectroscopy analysis	1.Kinematic Viscosity @ 40,@100 deg.c & Viscosity Index 2. Moisture content 3. Total Acid Number 4. Particle count/NAS value 5.Spectroscopy analysis	1.Kinematic Viscosity @100 deg.c 2. Moisture content 3. Total Base Number 4. Flash point 5.Soot % 6.Spectroscopy analysis 7. Coolant dilution 8.Oxidation, Nitration, Sulphation
Once in a 6 months/ Need based	1.Foaming Characteristics 2.Spectroscopy	1. Emulsion Characteristics 2.Foaming Characteristics	1. Ferrography 2. Emulsion Characteristics 3. Foaming Characteristics.	1. Ferrography
Advanced tests once in a Year or as suggested by OEM/general practice	RPVOT for large sumps. Rust Prevention characteristics.	1. RPVOT 2. Air release Value	1. RPVOT 2. Air release Value 3. RULER & MPC	1. Cylinder Scrape down analysis and any other tests suggested by OEM.



Used oil analysis provides answers for Lubricant condition, Lubricant Contamination & Equipment Wear.

cannot detect particles of size more than 8-10microns and ferrography acts like a value addition in understanding the exact severity of wear generation, generation mode, source of wear, etc. In certain complicated applications like aero engines even advanced techniques like Energy Dispersive X-Ray fluroscence(ED-XRF) spectroscopy is also recommended to find the exact component wear. Again filter debris analysis also serves a very important role to understand the large particle generation rate and severity.

Interpret the oil analysis results that suits to your own operational conditions..

Do not just go by simple equipment tags Normal/Caution/Warning, in addition to this understand the reports why they tagged so because every sample tested that carries very useful and important information about the equipment wear, lubricant condition and contamination. It is very much possible to control certain physical properties, contaminants and wear particles by just changing or correcting the operating conditions and or maintenance practices. It helps to foresee certain types of abnormal wear that grow up in the system in the very early stages which can be corrected and or controlled by providing clean and dry lubricant.

Conclusion: Reliability centered approach to the used oil analysis is a continuous improvement process in understanding the ongoing predominant abnormalities in the equipment's at an early stages there by helps in understanding the root causes of failure. Many of the times RCA helps to reduce the severity of damage, reduce the secondary damage, increase the machine availability, reduce the break downs and maintenance expenses.

About the Author

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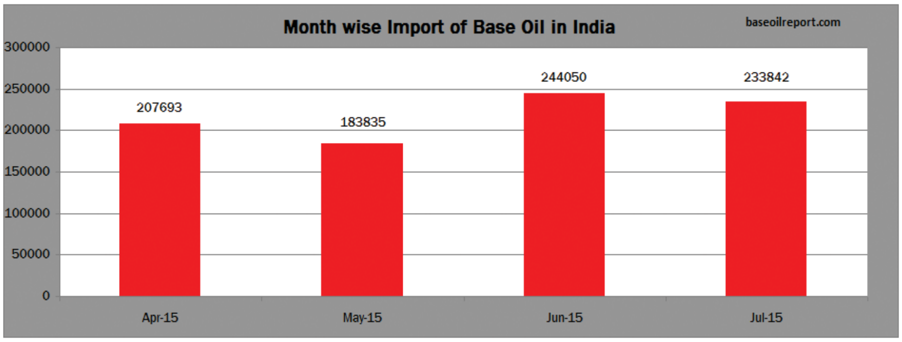
DHIREN SHAH

BASE OIL REPORT

Weak Chinese factory output and an increase in crude oil production from Saudi Arabia weighed down crude oil prices in early Monday trading. West Texas Intermediate, the U.S. benchmark price for crude oil, was off by a fraction of a percent from the previous close to trade at $44.47 per barrel before the start of trading in New York. Brent crude oil lost 1.1 percent from the previous session to fall to $47.59 per barrel. A string of bad economic news from China has put downward pressure on crude oil prices, pushing Brent down nearly 4 percent from Sept. 1. The Organization of Petroleum Exporting Countries said in its September market report Chinese economic growth expectations were revised downward by 0.1 percent to 6.8 percent in 2015 and 6.4 percent in 2016. OPEC said this could spill over into the European economy. Weak economic momentum and high supplies are keeping crude oil prices lower. Nevertheless, OPEC said demand for oil should improve next year.

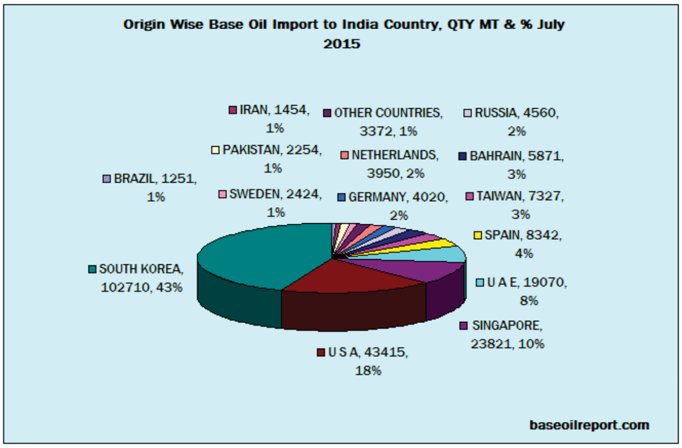
During the period April 2015 to July 2015, India imported 869420 MT of Base Oil. The country imported 207693 MT in April, 183835 MT in May, 244050 MT in June and 233842 MT in July 2015. Compared to the previous month i.e. June 2015 Base Oil import of the country has decreased by 4% in July 2015. Compared to the same month last year i.e. July 2014, Base Oil import was gone up by 6% in July 2015.

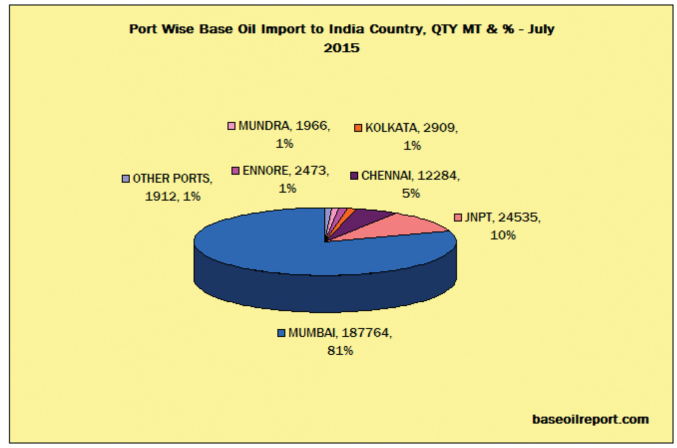
The Indian base oil market remains steady with inventories at optimum levels with surplus of imported grades. During the month of July 2015, approximately 233842 MT have been procured at Indian Ports of all the grades, which is 4% down as compared to June 2015, Major imports are from Korea, Singapore, USA, UAE, Iran, Taiwan, France, UK, Netherlands, Japan, Italy, Belgium, etc. Indian State Oil PSU's IOC/HPCL/BPCL basic prices for SN – 70/N – 70/SN – 150/N -150 marked down by Rs. 0.10 per liter, while SN - 500/N - 500 is decreased by Rs.0.60 per liter. Bright Stock price is down by Rs. 2.60 per liter. The prices



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

Month	Group I - SN 500 Iran Origin Base Oil CFR India Prices	N-70 Korean Origin Base Oil CFR India Prices	J-150 Singapore Origin Base Oil CFR India Prices	Bright Stock Europe Origin CFR India Prices
July 2015	USD 640 – 650 PMT	USD 665 – 670 PMT	USD 715 - 725 PMT	USD 945 - 955 PMT
August 2015	USD 615 – 625 PMT	USD 640 - 645 PMT	USD 690 - 695 PMT	USD 920 - 930 PMT
September 2015	USD 525 – 535 PMT	USD 590 - 595 PMT	USD 620 - 625 PMT	USD 870 - 880 PMT
	Since July 2015, prices have gone down by USD 115 PMT (18%) in September 2015.	Since July 2015, prices have decreased by USD 75 PMT (11%) in September 2015.	Since July 2015, prices have marked down by USD 95 PMT (13%) in September 2015.	Since July 2015, prices have dipped down by USD 75 PMT (8%) in September 2015.





are effective September 01, 2015. Hefty Discounts are also offered by refiners for lifting sizeable quantity. Group I Base Oil prices for neutrals SN -150/500 (Russian and Iranian origin) are offered in the domestic market at Rs. 41.75 – 41.85/42.20 – 42.30 per liter, excise duty and VAT as applicable Ex Silvassa in bulk for one tanker load. At current level availability is not a concern.

The Indian domestic market Korean origin Group II plus N-60–70/150/500 prices at the current level have been marginally up. As per conversation with domestic importers and traders prices reflects minimal changes for N – 60/ N- 150/ N - 500 grades and at the current level are quoted in the range of Rs. 41.50 – 41.80/41.70 – 41.90/44.20 – 44.40 per liter in bulk respectively with an additional 14 percent excise duty and VAT as applicable, no Sales tax/Vat if products are offered Ex-Silvassa a tax free zone. Discounts are offered for lifting sizeable quantity. The above mentioned prices are offered by a manufacturer who also offers the grades in the domestic market, while another importer trader is offering the grades cheaper by Rs.0.35 – 0.45 per liter on basic prices. Light Liquid Paraffin (IP) is priced at Rs. 41.75 – 42.05 per liter in bulk and Heavy Liquid paraffin (IP) is Rs.45.90 – 46.30 per liter in bulk respectively plus taxes extra.

Petrosil Base Oil Report (www. baseoilreport.com) 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 Report is a comprehensive marketplace for global base oil reporting and trading.

Export of Light & Heavy White Oil

Algeria	China	Haiti	Japan	Nigeria	Russia
Australia	Columbia	Indonesia	Kenya	Pakistan	Saudi Arabia
Bangladesh	Djibouti	Iran	Latvia	Peru	Senegal
Belgium	Egypt	Iraq	Malaysia	Philippines	Sierra Leone
Brazil	Germany	Israel	Myanmar	Poland	Singapore
Bulgaria	Ghana	Italy	Nepal	Puerto Rico	South Africa
Cameroon	Greece	Ivory Coast	Netherlands	Romania	Spain
Sri lanka	Sweden	Tanzania	Thailand	Togo	Tunisia
Turkey	UAE	UK	USA	Ukraine	Uruguay
Vietnam			Yemen		

Approximately 8723 MT of Light & Heavy White Oil has been exported in the month of July 2015 Compared to the month of June 2015; exports of the country have gone up by 34% in the month of July 2015.

Export of Transformer Oil in January 2015

Algeriaa	China	Indonesia	Morocco	Paraguay	Saudi
Australia	Djibouti	Iran	Nepal	Peru	Saudi Arabia
Bangladesh	Egypt	Israel	New Zealand	Philippines	Singapore
Brazil	Ghana	South Korea	Oman	South Africa,	South Africa
Sri lanka	Thailand	UAE	UK	Vietnam	Zaire
Zimbabwe					

Approximately 5824 MT of Transformer Oil has been exported in the month of July 2015.

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