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Machinery Lubrication

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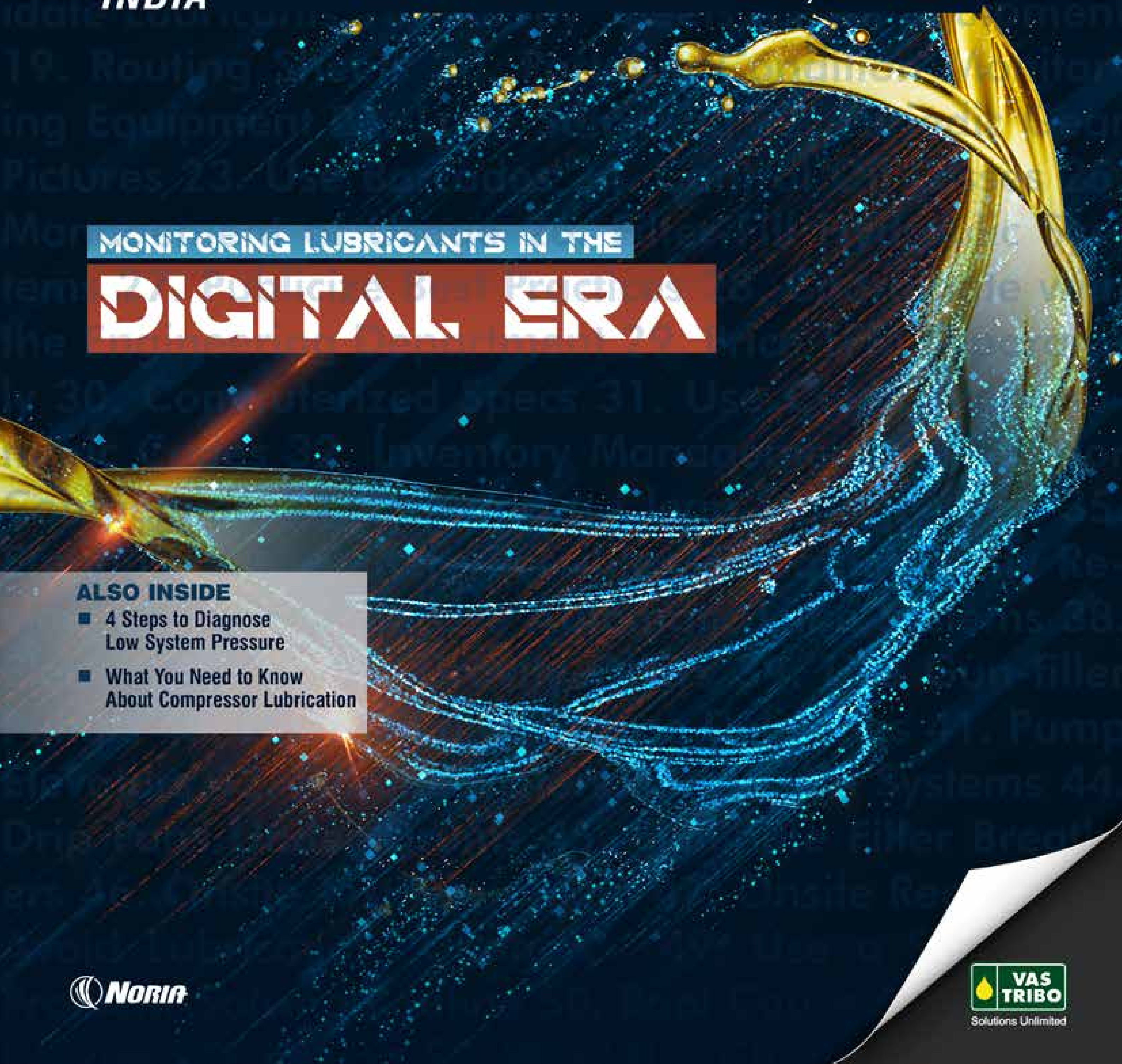

MONITORING LUBRICANTS IN THE DIGITAL ERA

ALSO INSIDE

- 4 Steps to Diagnose Low System Pressure
- What You Need to Know About Compressor Lubrication

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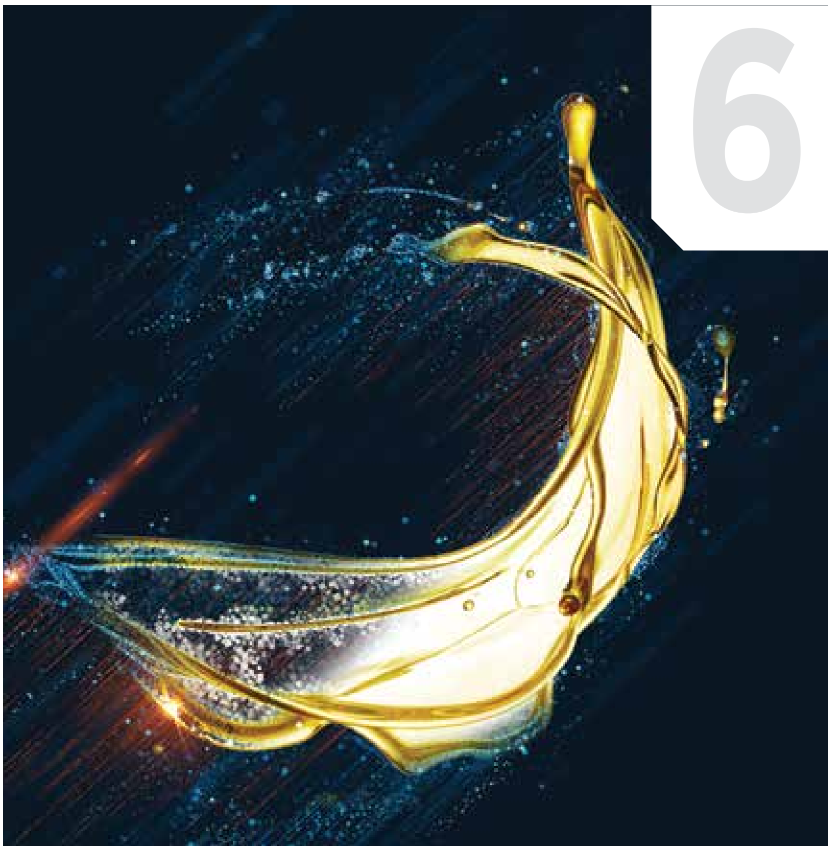

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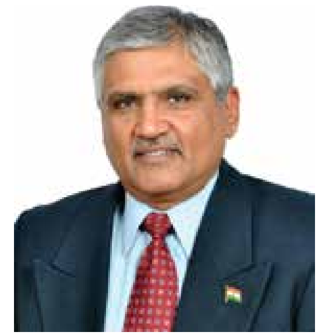


Welcome to edition 51 of Machinery Lubrication India! A very challenging year has finally ended. This year there is a sigh of relief as the world recovers and adapts to the new normal.

Digital transformation is emerging as a driver of extensive change in the world around us. Connectivity has shown the potential to empower millions of people, while providing businesses with supreme opportunities for value creation. Since the industrial revolution, the Oil & Gas industry has played a crucial role in the economic transformation of the world, fuelling the need for heat, light and mobility of the world's population. Today the Oil and Gas industry has the opportunity to redefine its boundaries through digitalization. After a period of falling crude prices and, frequent budget and schedule overruns, together with greater demands of climate change accountability and difficulties in attracting talent, the Oil & Gas industry can provide practical solutions.

While digitalization could be a source of positive change, there are a number of challenges that need to be overcome to realize its full potential for both business and society. In some cases, the gains from digitalization have been inequitable with the benefits not reaching those who need it most. At the same time, the exponential increase in global information flows has created new risks around data privacy and security.

The Oil and Gas industry is no stranger to big data, technology and digital innovation. This edition's cover story focuses on Monitoring Lubricants in the Digital Era. Big data analytics, deep machine learning, artificial intelligence and the rise of the algorithm are driving the newest industrial revolution. Read our cover story to identify how the lubricant monitoring industry has started to change this paradigm as well as speculate where the industry is going and the potential it has to fully embrace Industry 4.0 and the digital revolution.

We would like to thank our readers for the great response to our previous edition's cover story – "50 Lubrication Best Practices You Should Be Using Now" and other articles.

We are giving an opportunity to your company to get featured in our 'Buyer's Guide' for free. Buyer's Guide is a comprehensive directory of companies who offer products and services within the domain of lubricants, lubrication, oil analysis and reliability.

As always, we look forward to your valuable suggestions and feedback.

Enjoy the read!!

Warm regards,
Udey Dhir

Control Moisture Ingression **with Tactical Inspection 2.0**

"Inspection is the top-line priority needed to squelch moisture ingression points through tight and well-managed ingression control."

You don't have to remove what you don't allow to enter. Indeed, it's hard to challenge the logic and value of controlling water ingression, but because moisture is everywhere, achieving bone-dry oil through exclusion alone may not be practical or even necessary. Lubricating oils have different degrees of hygroscopicity (water-loving tendencies), making the control of all dissolved water an almost futile exercise. However, for many applications, it's the free and emulsified water that is the most destructive and, hence, the central target for control and inspection.

Exclusion relates to the process of preventing (excluding) the ingress of water from environmental, machine and process sources. Common points of water ingression include:

1. Water from make-up oil (some supply tanks can collect inches of undetected bottom water)
2. Turbine gland steam seals (e.g., improper pressure regulation)
3. Defective vapor-extraction system (if too high, it can suck in steam, while if it's too low, it can fail to keep up with ingress)
4. Process water in-leakage from pulp and paper production, water treatment plants, sewage treatment plants, etc.
5. Oil cooler leaks

WATER SOURCES IN STEAM TURBINE LUBRICANTS

- Water-contaminated make-up oil — Inspect new oil. Never introduce a cloudy oil into a lube oil reservoir.
- Improper operation of vapor-extraction system — Fans causing too low of a vacuum can result in a build-up of humidity. Fans causing too high of a vacuum (plugged panel filter) can pull in more gland steam or cause oil carry-over to the roof. Regularly inspect and service vapor-extraction fan panel filters.
- Oil cooler leaks
- Excessive leakage from gland steam seals — Inspect the gland inlet and outlet pressure and regulate accordingly.

Tank-top vapor-extraction fan and panel filter.

6. In-leakage of water past seals from washdown sprays, rain and flooding conditions
7. Reservoir and sump headspace vent/breather ingress

Inspection is the top-line priority needed to squelch ingression points through tight and well-managed ingression control. All seven of the listed water ingression sources have the potential to be detected by inspection.

Deferred maintenance of worn seals, defective breathers and coolant leaks creates more expensive maintenance events in the future, including the possible cost of premature oil changes, flushing, oil dehydration and replacement of water-damaged parts. Frequently inspecting and promptly closing off ingression sites are by far the wiser choice and use of maintenance resources.

Inspection, oil analysis and condition monitoring can also be important strategies for providing red-code alerts to periodic water ingression problems. This can be as simple as daily visual inspection of BS&W (bottom, sediment and water) sight glasses, level gauges and live-zone oil samples. In addition to visible inspection, water also can be detected using a number of field-level instruments and pass/fail methods such as the crackle test and calcium hydride detectors.

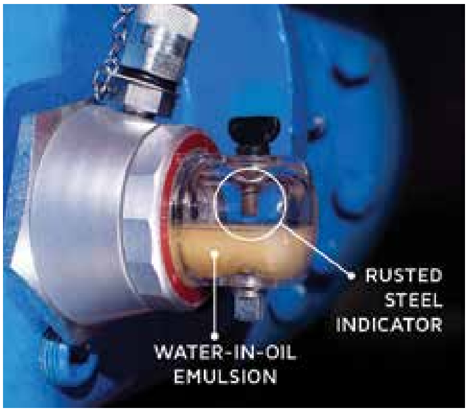
Once a new source of water is encountered, corrective measures can be quickly deployed. When gross water contamination is observed, there is little need to quantify the exact amount in the oil.

Look for Evidence of Moisture and Other Contaminants in Your Headspace

Water removal is the second reason why stabilizing the headspace environment is important. With rare exception, a dry headspace translates to dry oil — they go hand-in-hand. This is because wet is attracted to dry in the same way hot is attracted to cold. Basically, a dry headspace forms a desiccant blanket above the oil and, like a sponge, draws water out of the oil. The lower the relative humidity of the air in the headspace, the faster and more efficient the process of mass transfer of water out of the oil becomes.

Of course, there are other contaminants besides water and dirt, such as air, sludge and heat. However, many lubrication professionals are unaware of the impact of dirt and water contamination on other contaminants. For instance, when emulsified water is allowed to co-exist in the oil, a common consequence is entrained air. Emulsified water changes interfacial tension and impairs the ability of oil to rapidly release entrained air to the atmosphere.

When air fails to detrain, a tertiary consequence is oil oxidation and adiabatic thermal failure, among others. Likewise, when dirt ingresses through tank headspace openings and enters the oil, this dirt abrades surfaces and leads to wear metals. This in turn accelerates the formation of oxide



This sight glass makes the appearance of harmful levels of water easy to observe. The cloudiness of the oil indicates emulsified water, while the rust on the corrosion gauge punctuates the potential damage occurring to exposed internal machine surfaces.

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Publisher
Udey Dhir - udeydhir@tribologysolutions.com

Creative Director
smassociates@gmail.com

Advertisement Sales (US/Canada)
Brett O'Kelley - bokelley@noria.com

Advertisement Sales
(India/all other countries)
Jhumpa Mukherjee -
admin@machinerylubricationindia.com

CORRESPONDENCE
You may address articles, case studies, special requests and other correspondence to our

Operation office :

Editor
213, Ashiana Centre, Adityapur,
Jamshedpur-831013, India
email : editor@machinerylubricationindia.com
Tel: +91-657-2383238
Tel:(USA): +1-918-960-9738

Marketing Office
Rider House, 136,
Sector 44, Gurgaon-122003, Haryana
National Capital Region, India

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insolubles, leading to surface deposits and varnish. The list of secondary and tertiary consequences of dirt and water contamination is almost endless.

Although not always practical, touching the inside ceiling of a reservoir to look for condensation water on your fingers can provide a quick indication of saturated moisture in your sump or reservoir. Additionally, a highly visual sight glass, such as the one shown on the left, can quickly reveal emulsified water and evidence of corrosion caused by moisture. *ML*

About the Author

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

EXAMINE TANK-TOP HARDWARE FOR HIDDEN INGRESSION SITES

- Inspection hatches should hinge down against gaskets and be held by compression clamps or bolts.
- Roll filter covers should be sealed tight in a similar manner.
- All tank-top ports, such as vertical-entry float switches, flanged return ports and breather blower connections, should be sealed and elevated.
- Where possible, fill ports should not be used as a vent/breather.
- Male quick connects with dust covers are best for adding make-up oil (while filtered).
- Off-line filters can serve a similar purpose.

This headspace breather is installed but not being used. Air has easier access to the tank headspace through the hatch, which is propped open by the hose. Inspection must verify that all ingression sources are battened down tightly and can effectively exclude the entry of particles, moisture and other contaminants.

TRAPPED HEADSPACE MOISTURE FOLLOWS A PRECIPITATION CYCLE

Trapped moisture is destructive to lubricants and machines. The headspace needs to have the ability to breathe and exhaust unwanted moisture. Often, this is prevented by reservoir design and the false notion that a sealed reservoir is a good thing. This is how it works:

The Precipitation Cycle:

1. The headspace holds moisture. Lack of air movement and breathers prevent moisture from exiting.
2. The machine is turned off for a few hours each day, and the headspace and oil cool.
3. Condensation sweats the headspace ceiling and walls.
4. Water drips into the oil where it is absorbed, and free water puddles on the sump floor.
5. Later, warm, circulating oil picks up the water.
6. Circulation and heat allow the water to evaporate back to the headspace.
7. The cycle repeats each day.

Rainmaker machines can overwhelm lubricant rust-suppression additives.

MONITORING LUBRICANTS IN THE DIGITAL ERA

By Glen Parkes, Baker Hughes

Big data analytics, deep machine learning, artificial intelligence and the rise of the algorithm are driving the newest industrial revolution and have been for quite some time. The ability to capture data, create digital twins and autonomously alter, optimize and even control a machine's performance from the other side of the world is now part of the fabric of many companies and industries. In short, everyone now strives to be "digital."

However, for all this talk of digital and Industry 4.0, the manner in which industry monitors arguably the most critical part of any machine — its lifeblood, its lubricating oil — still pre-dates this new digital movement and largely entails someone physically taking a sample of the oil, placing it in a plastic cup, handwriting the details of the oil and the machine, putting the sample in an envelope, sending it to a laboratory and waiting patiently (sometimes weeks) for a result showing the status of the oil at that small snapshot in time. Alternatively, a sample may be taken and tested locally using either a testing kit or a machine, giving a less exhaustive single snapshot.

This article will identify how the lubricant monitoring industry has started to change this paradigm as well as speculate where the industry is going and the potential it has to fully embrace Industry 4.0 and the digital revolution.

DATA IS USELESS

The push for "digital" relies heavily on the data that a system can ingest, and thus "data" has become very much in vogue. Now, there is almost an obsession with data, but by itself, data is completely useless. I personally own a well-known brand of fitness tracker watch. This fitness tracker has a wonderful feature that tracks my sleep. When I wake up, I almost obsessively check my phone, download the data and look at my sleep pattern. It can tell me how long I slept, whether I woke up during the night and even how deeply I slept over the course of the night. The analytics appear to be sound, and even the data is presented in a user-friendly manner. So, what does this data mean? What do I do with all this information? What changes do I make based on the data? What outcomes are derived from this sleep-tracking feature? None. Zip. Zero. It's purely useless data.

Data falls into two categories: what can it tell me and what do I need to know? In this case, the data falls under the first category. Data that doesn't drive outcomes is useless data.

For data to be meaningful, it must follow four rules: analysis, interpretation, context and outcome.

ANALYSIS — The data must be fundamentally sound. Raw numbers do not provide meaning. The raw data must be turned into a useful output.

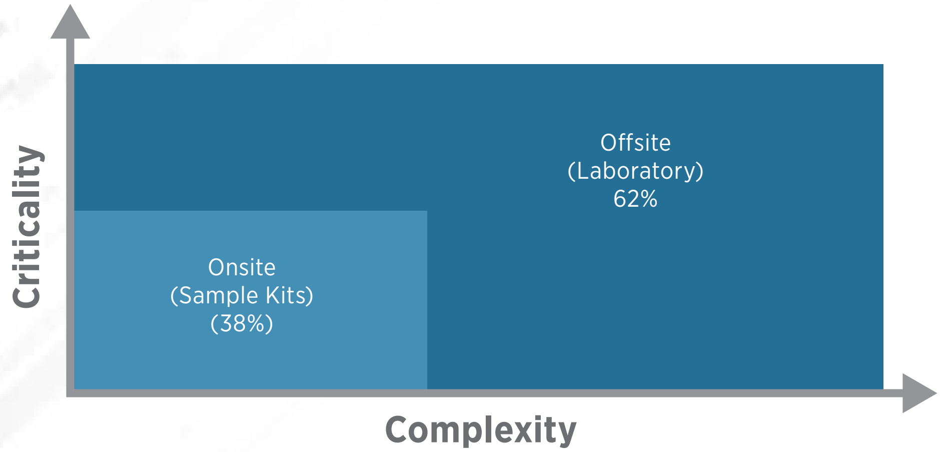
INTERPRETATION — What does the data mean? How do the numbers relate to the reality of a situation?

CONTEXT — This element is largely ignored yet provides the most important insight. Context of the conditions surrounding the data can be as important as the data itself.

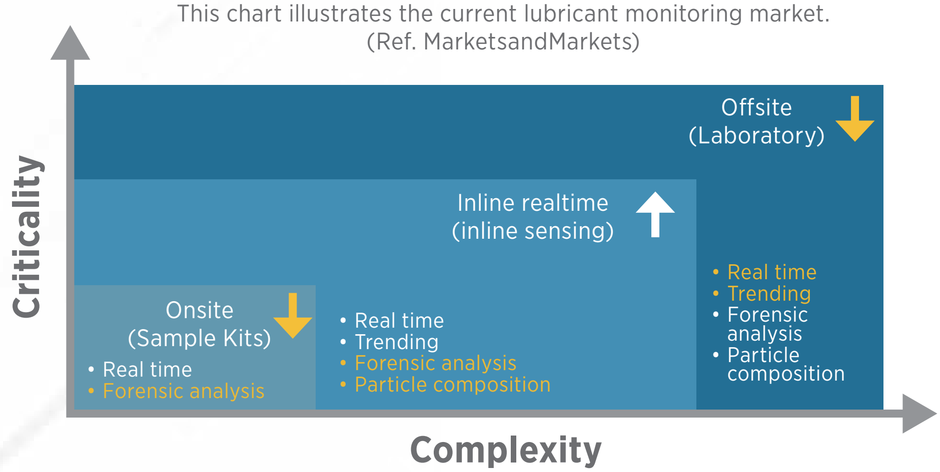
OUTCOME — This is another often ignored feature of data. As per the sleep tracker example, if data doesn't drive a clear outcome, then it has no meaning.

Consider measuring a person's weight. Let's say a man weighs himself, and the (digital) scale shows that he is 184 pounds (83 kilograms). Is this good? Is this a healthy weight? At this point, you only have analysis. Without the other three elements, this data is useless.

For interpretation, let's say you compare his weight to a weight/height chart. By this interpretation, 184 pounds (83 kilograms) for a man who is 6-foot-3 is a normal weight. This usually is where the data investigation ends, with analysis and interpretation, the correlation of single numbers versus specifications, and basic interpreted results. Green, yellow and red



This chart illustrates the current lubricant monitoring market. (Ref. MarketsandMarkets)



This graphic depicts how the lubricant monitoring market may appear in the near future.

results are normal in industry, especially in oil monitoring reports.

What's missing are the context and outcome. Without context, you are assuming that someone who is 184 pounds (83 kilograms) and 6-foot-3 is healthy. Context comes in many forms, but the most common is trend analysis. In this example, what if the man weighed 215 pounds (98 kilograms) four weeks ago? By trend analysis, you can assume that something is wrong, and he in fact is not healthy. That amount of weight loss over a short period of time is indicative of a potentially serious illness. Therefore, understanding the context of data can change the entire picture.

What outcomes can be derived from this information? It can take many forms. The person may understand the underlying issues and be able to self-correct, or he may seek further, more detailed analysis by visiting a doctor.

The relevance to the oil analysis industry is twofold. First, oil analysis is primarily focused on analysis and interpretation. The very nature of sampling indicates a single data point taken at a snapshot in time, i.e., a person's weight measurement. This frequently is married to a static specification (or height/weight chart), and a result is given based purely on that single point in time (red, yellow or green). Analysis and interpretation, with no context and rarely an outcome, are the norm. Outcomes appear at a later stage once a person has conducted a more thorough interpretation of that data, often with a significant time lag between sampling and outcome. I have seen many examples of an asset experiencing a catastrophic loss event during this time lag.

Secondly, compare data accuracy versus context. Many times, during discussions around some of the new real-time lubricant monitoring technologies/sensors, I am asked about the performance of the solution versus laboratory analysis. This is a great question with a simple answer. What are you looking for? Laboratories always will be able to provide a much more detailed analysis of lubricants. Sensors and sensing solutions will never fully replace the insight of a lab. The sensor science just does not exist. Labs can offer accuracy levels to multiple decimal places and distinguish between different wear metal particles down to single parts per million. There will always be a need for this level of accuracy, but you must keep in mind your answer to the original question (what are you looking for?).

There are two clear and distinct paths to this question. On the first path, at the asset level, in real time, during the running of the asset, you primarily need to know three simple things: is everything OK, what's wrong and what should I do? On the second path, after a major failure, forensic analysis should be performed, an autopsy on a failed asset. In this instance, post-failure, many more questions need to be answered, such as why did it fail, what is the root cause and what do we need to address on other assets to prevent their failure?

The first path is where the need for new digital technology that drives real-time data comes into play. Data that is "good enough" but provides what you need to know (rather than what you can be told) is much more valuable in real time with context than extremely accurate data taken at a single snapshot in time.

Consider again the person's weight analogy. The man wears a device on his wrist that measures and tracks his weight and other health indicators such as blood pressure, heart rate, etc. The software on the wearable device can track the data trends and provide context as well as interpreted results based on known boundaries. This data is not as accurate as you would get at a hospital, where large machines would be used to measure each individual indicator. However, the data is "good enough," it's in real time, it tracks trends and therefore offers context. It has the four elements of good data: analysis (the device takes measurements and converts them into data), interpretation (it puts the relevant data into charts that show what the data means), context (it looks at trends over time and often has context around what activity you were doing at the time), and outcome (some devices now recommend actions based on the results).

Data that is good enough but shows context can often be much more valuable than precise data at a single point in time. For the lubricant monitoring industry, this is relatively new. Sampling has been the norm for a long time, with the focus more on accuracy and what can be told rather than what you need to know. Utilizing "good enough" data may rankle some industry purists, but I believe that is where this industry and many others are going.

REAL-TIME INLINE SENSING

The emergence of real-time inline sensing is disrupting the industry. I often am asked what the impact will be on laboratories and sample kit providers, but no one has a definitive answer for how much disruption these inline sensors will cause. However, the nature of real-time analysis has obvious consequences for laboratories. If the emergence of "good enough" data takes hold, this will impact the market share of laboratories.

The only saving grace for offline sample kits over inline sensors is cost. The current cost of inline sensors is higher than a sample kit, even if the value of inline sensing outweighs that of a sample kit. Of course, the expectation with sensors is that the cost will come down over the next few years. In fact, according to Rob Lineback of IC Insights, the cost of industrial internet of things (IIoT) sensors dropped more than 90 percent over the last 15 years. This trend undoubtedly will continue, and the price reduction will erode the sample kit market share over the next few years. Sample kits and inline sensors will become direct competitors.

Much has been written about the emergence of real-time oil analysis. Although this new technology is making strides, it still has limitations. Most real-time inline sensors are single measureands or at best measure two or three elements of lubricating oil. They can provide good analytics and interpretation while offering a degree of trending, yet they seem to lack a more holistic approach to asset health. Measuring an oil's viscosity, wear particles and water content or even trending these conditions can be useful and produce data that is good enough, but it doesn't give you the whole picture of an asset's health.

THE FUTURE OF LUBRICANT MONITORING IN THE DIGITAL ERA

As stated previously, the digital era and the IIoT have largely been ignored by the lubricant monitoring industry (perhaps with some exceptions). We have seen how inline sensor capability has started to emerge by providing real-time, if not limited, insights. Where will or can this industry go in the future? I believe there will be several trends in this space, including increased measurement parameters (analysis), non-oil-based data ingestion (context), asset data ingestion (context), deeper machine learning (interpretation), ecosystem integration (outcome), and machine control (outcome).

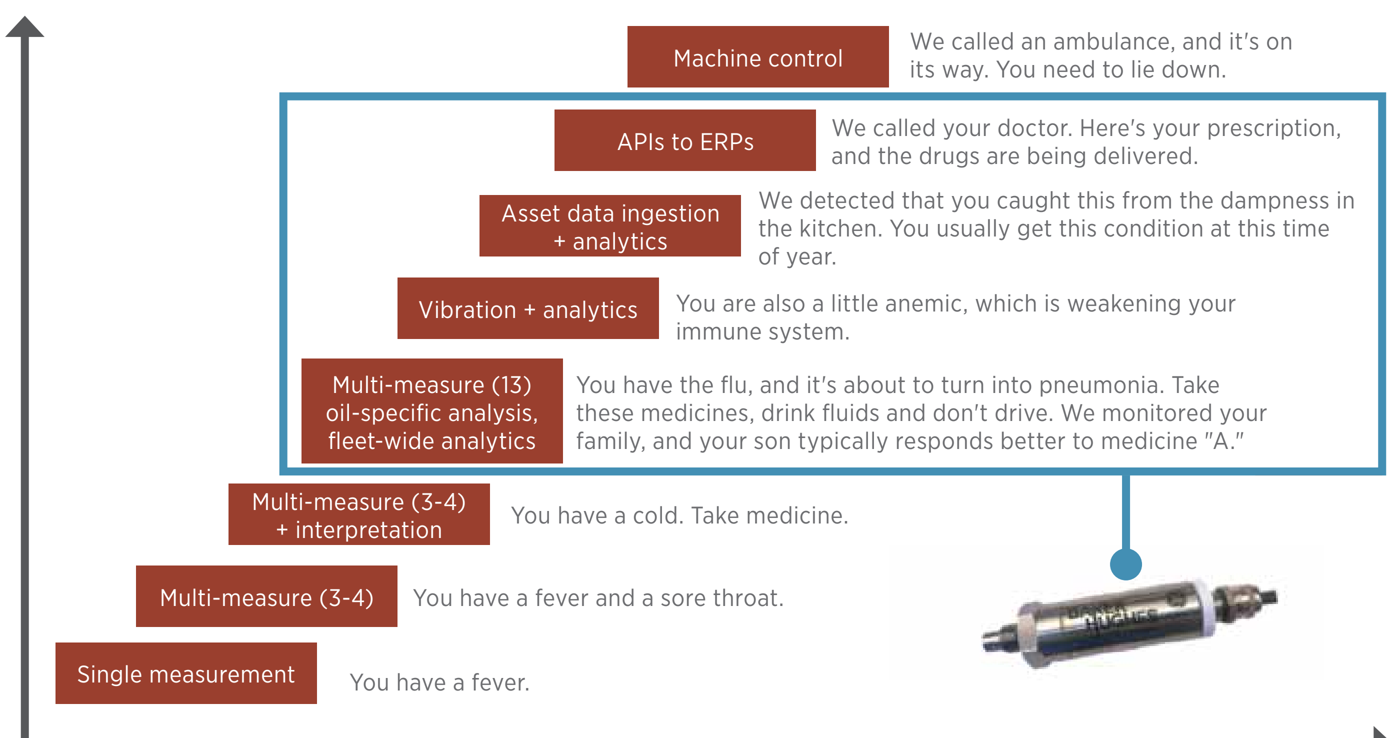
The true potential of oil analysis has yet to be realized, and unlocking this potential is where I see industry going. Adding more measurements, ingesting more data and then processing that data into meaningful, yet simple outcomes will be the first improvements, but it won't be the end. No matter how good it is, data operating in isolation can be cumbersome. Integrating data and outcomes into an operator's ecosystem and infrastructure is where the real value starts to materialize. Automating outcomes based on digital oil data is the ultimate goal, and it isn't that far out of reach.

MOVING FORWARD INTO THE DIGITAL WORLD

Certain industries have been early adopters of Industry 4.0 and the digital revolution, such as the media, information technology and finance, while others are catching up fast, including oil and gas and advanced manufacturing. The lubricant monitoring industry has lagged far behind and arguably has yet to jump onto the digital train. This is surprising, as the potential for digital monitoring of lubricating oil is significant. The industry is suffering from a lack of an incoming talent pool, with an aging workforce and specialized skill-set drain. The adoption of digital tools and automated monitoring not only could help fill the gap in the talent pool but may also create new opportunities. Perhaps in the not too distant future, data scientists will be as much in demand as chemical engineers.

The rise of the digital era in lubricant monitoring doesn't rely solely on converting analog data to digital, replicating existing manual practices into digital visualizations of the same practices. At the core of this revolution lie bigger and more philosophical questions, such as "What do I need to know?" and "What do I do with the information?" Is there more value in "good enough" data, which shows "what I need to know" and is measured and communicated in real time, than exact accuracies taken at a single snapshot in time? I believe there is.

Data that not only offers analysis and basic interpretation but also includes context and simple outcomes and actions must be the way forward, especially as millennials enter the workforce. Digital monitoring tools that can be incorporated into an operator's ecosystem, can be accessed and acted upon by any skill level in the operation, and provide real-time answers to the three basic questions of "Is everything OK?," "What's wrong?" and "What should I do?" will be key to taking the lubricant monitoring industry forward into the digital world. ***ML***



This illustration offers a glimpse into the future of the lubricant monitoring industry along with a corresponding health analogy.

4 Steps to Diagnose Low System Pressure

You can troubleshoot any system by eliminating the components that could not be causing the problem, isolating the components that could be causing the problem and then making checks of the possible culprits.

Most hydraulic system failures can be classified as either a pressure problem or a volume problem. It normally is easy to tell which of these you are experiencing if you understand the difference between pressure and flow. This critical concept was covered in my recent article titled "Hydraulic Pressure vs. Flow: Understanding the Difference." Armed with this knowledge, you can troubleshoot any system by simply eliminating the components that could not be causing the problem, isolating the components that could be causing the problem and then making checks of the possible culprits.

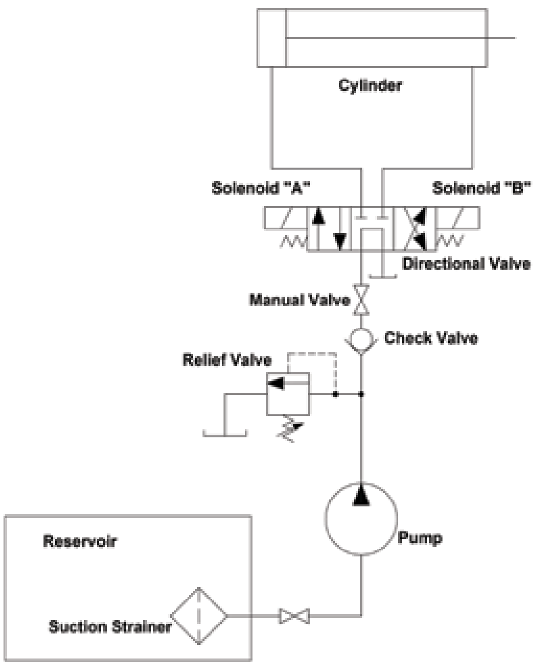
In my experience, once a pressure problem is encountered, the first component to be changed is the hydraulic pump. This frequently is a mistake. A common misconception is that pressure comes from the pump, thus making it the most likely suspect. Quite the contrary, while it is possible for the pump to be the cause of a pressure problem, it certainly isn't the most likely cause. Usually, something else is faulty. The fastest way to determine the real cause while protecting the system from further damage is to use the following four essential steps.

1. Gather Information

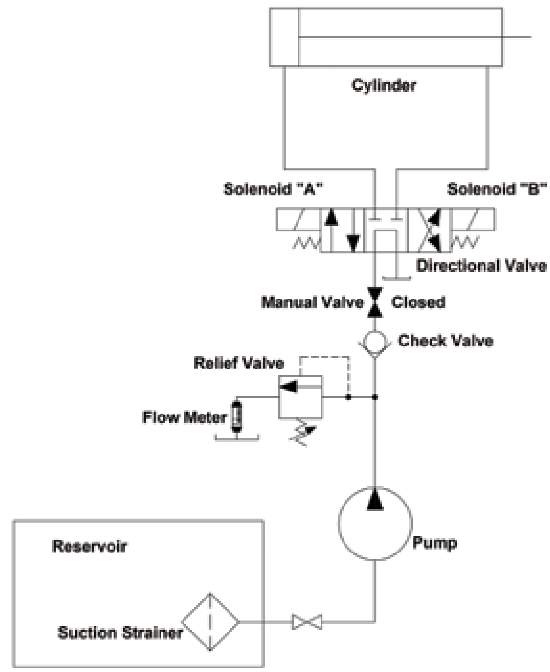
This step is often skipped in the interest of saving time, but it is very important in troubleshooting. A lot of information can be gathered in a short period of time. The most critical piece of information is the system schematic. Use it to trace the flow through the system and determine which of your components could be causing the problem. A typical schematic containing components common to most systems is shown on page 13. You also will need to have a good understanding of the symptoms. Was the system working fine and then suddenly lost pressure, or did it happen gradually? Was it accompanied by a strange noise or an increase in temperature? If so, where in the system did the sound or heat originate?

2. Isolate the Power Supply

A well-designed system typically will have some way to isolate the power supply from the rest of the machine. A manual valve is commonly used, but it



An example of a typical schematic for a hydraulic system.



A schematic with a flow meter installed in the relief valve tank line.

may be necessary to plug a line. In the example schematic, there is a manual valve between the system relief valve and the directional valve. Close it and see what, if anything, changes. This often can cut your troubleshooting time in half. For instance, if the pressure is low and nothing moves, but when the manual valve is closed, the pressure builds and the relief valve begins to dump, you know the power supply is working fine and the problem is somewhere downstream. By the same token, if nothing changes, obviously the problem is in the power supply.

3. Make the Easiest Checks First

Once you have traced the flow on the schematic, identified all the components that could cause a pressure problem and isolated the power supply to determine which part of the system has the problem, start making checks. List the suspect components in order of the easiest to the most difficult to check and make the easiest checks first. I have frequently seen people make the mistake of going immediately to the worst-case scenario, spending hours and large sums of money to replace very expensive components only to find that they were not the cause of the problem.

In almost every troubleshooting class I teach, someone relates a story of a time when they thought they had a major high-cost component failure but eventually found the problem to be a stuck check valve, hand valve that had been left open, blown fuse or some other simple thing that they had missed. Think back over your career. Isn't it usually the simple things that fail? Try the easy checks first and work your way to the hardest. Even if it does turn out to be the big component, not much time will have been lost on the simple things.

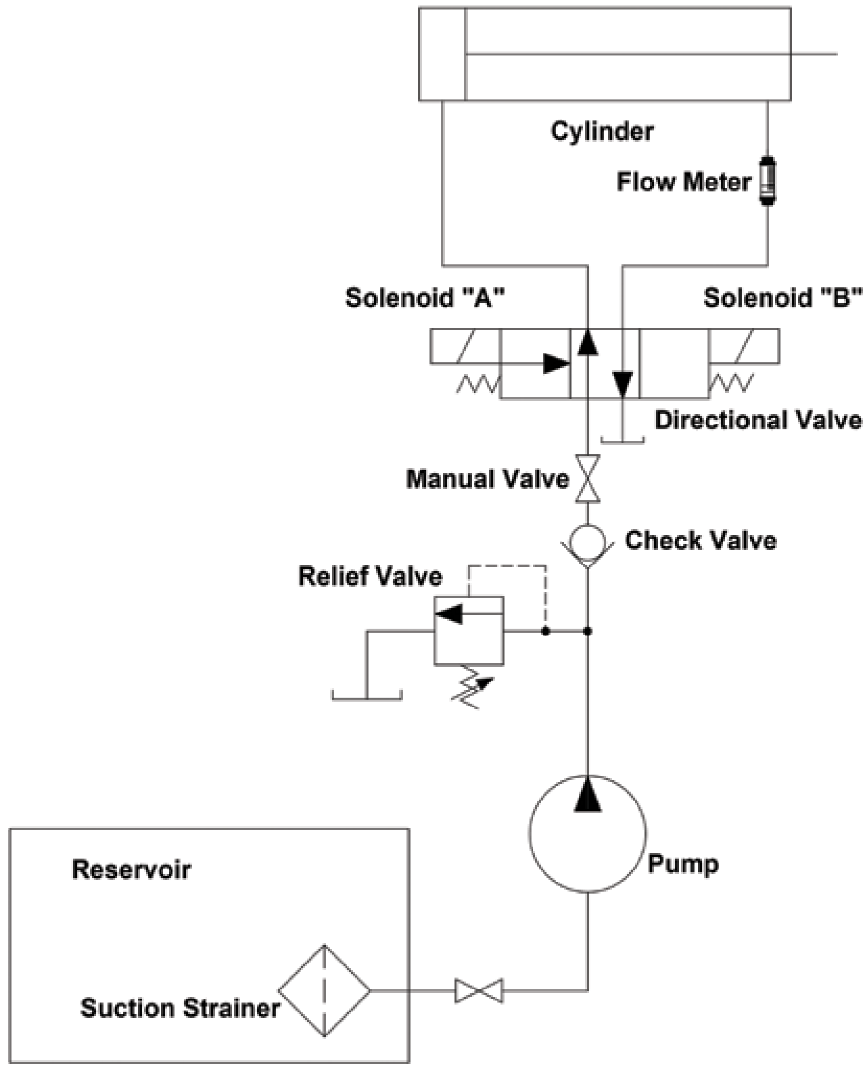
In the previous example, let's assume no change in pressure was observed by isolating the power supply, suggesting one of the power supply components to be at fault. In this system, there is a suction strainer, pump and relief valve. Any of these components could cause a loss of pressure. Is there a whining sound? If so, perhaps the pump is cavitating. The most common cause of cavitation is a plugged suction strainer. The suction strainer typically is inside the reservoir, below the oil level, out of sight and out of mind. It isn't checked or cleaned as regularly as it should be.

Of course, the pump cannot deliver more oil than it can take in, which can result in reduced flow. Sometimes the flow can be drastically reduced. This often will occur gradually with the increase in sound corresponding to reduced speed, but it can

A suction strainer typically isn't checked or cleaned as often as it should be.

also happen suddenly if a large amount of sludge is stirred up by turbulence in the reservoir. Usually, it only takes a few minutes to check by pulling the suction line and inspecting the strainer. If it is blocked, it can be cleaned with compressed air.

If there is no whining sound, check the relief valve. With the system deadheaded, try to adjust the relief valve. If it will not adjust, chances are it could be stuck open. Bleed down any residual pressure, lock out the system and pull the relief valve. Look inside for trash, bent or broken springs, excessive wear, or anything that could keep it from seating properly. Pay particular attention to orifices. In one case, the relief valve had been pulled and checked prior to my arrival. I was told that they had found two orifices, but both were clear. I asked that they pull it again so that I could check it myself before we eliminated it as the problem. Sure enough, there was a third orifice that they had not seen, and it had a small piece of debris, perhaps the size of a grain of sand, lodged inside. We cleaned the orifice, reassembled and reinstalled the relief valve, and the pressure came back up to normal.



A schematic with a flow meter installed in the cylinder's rod-side line.

The final possibility in the power supply is the pump. In the example system, a fixed-displacement pump is used. The best way to check this pump is through the system relief valve. Install a flow meter in the relief valve tank line. Sometimes, this is not possible due to the machine configuration. Perhaps the relief valve is attached directly to the reservoir or mounted in a manifold that is directly attached to the reservoir. In this case, install the flow meter in the pressure line of the pump.

If the hand valve is closed, deadheading the system, you know that any flow from the pump has only the flow path through the relief valve back to the tank. Turn the relief valve adjustment counterclockwise to a very low pressure. Some relief valves do not have a stop on their adjustment, so it may back all the way out. Adjust the valve counterclockwise until no spring resistance is felt.

When the system is turned on, the pump flow should dump across the relief valve at a very low pressure. Since there is no resistance to the pump flow, it will deliver all or nearly all its flow. Gradually increase the pressure setting of the relief. If the pump can maintain flow with the relief valve set at the normal system pressure, the pump is good. If, however, the flow drops as the pressure is increased, the pump should be replaced.

Suppose pressure built in the system when the hand valve was closed to isolate the power supply. Then you know the problem is downstream. Bypassing across the directional valve or across the cylinder is causing the pressure loss. In most systems, the directional valve would be the easier component to check first. Are the solenoids firing? Notice the tandem center position. There will be no pressure in the system unless one of the solenoids is energized. Check for a magnetic field with a metal ruler or small screwdriver while each solenoid is energized.

A hand pump can be used to test a directional valve for bypassing.

A good way to test a directional valve for bypassing is to remove the lines from the manifold, cap off its "A" and "B" port lines and attach a hand pump with a gauge to the "P" port line. The "T" port can be run to a bucket so you can observe any oil that bypasses. In the case of the example, notice the tandem center position. Because of the tandem center, you can only test the valve when it is in its "A" and "B" positions. Manually shift the valve to its "A" position, holding it shifted while operating the hand pump. Bring the pressure up near the normal system pressure and see if it holds. Try the same with the valve shifted to the "B" position. Pressure should hold for at least one minute with no bypassing to the tank. If pressure drops immediately, the valve is bad and must be replaced.

If the valve is good, test the cylinder. Remove any load from the cylinder. This may require disconnecting the rod from whatever it moves and may be time consuming, which is the primary reason testing the cylinder should be last. Fully extend the cylinder, then shut down the system and bleed any pressure, leaving the cylinder extended. Install a flow meter in the cylinder's rod-side line. Power up the system and apply pressure to the full piston side of the cylinder. There should be no flow reading on the flow meter, and you should not be able to see fluid moving inside.

4. Make Good Decisions

Use a logical progression of troubleshooting. Often, I see the "shotgun" method of simply changing parts until the problem goes away. This is wasteful not only in part costs but also downtime as well. Never remove a component unless you have good reason to believe it is bad. Whenever something is removed from the system, the lines are open to airborne contaminants. Contaminants much too small to see can do serious damage. While you may be fixing a problem today, you very well may be adding more problems later. ***ML***

About the Author

Jack Weeks is a hydraulic instructor and consultant for GPM Hydraulic Consulting. Since 1997 he has trained thousands of electricians and mechanics in hydraulic troubleshooting methods. Jack has also taught radio-wave propagation for the U.S. Air Force and telecommunications equipment operation and repair for the Central Intelligence Agency at American embassies overseas.

Marc Vila | Petronor

How **Oil Mist** Can Increase **Equipment Reliability**

"Oil mist is considered best practice by the hydrocarbon processing industry and is recommended within the specifications of the American Petroleum Institute."

Oil mist is an aerosol mixture of one part oil to 200,000 parts air. It is generated by passing high-velocity air through an orifice that pulls oil into the air stream. The high-velocity air stream breaks the oil into particle sizes of 1 to 3 microns, thus the resemblance to cigarette smoke or steam. The same air, at a much lower velocity and pressure, then transports these small oil particles through a distribution system to the equipment to be lubricated. These small particles are referred to as dry mist and are much too small for lubricating purposes; however, they are easily transported throughout distribution systems over distances of 600 feet.

For lubricating bearings or other equipment, dry mist is converted into wet mist prior to the equipment being lubricated. This is accomplished by passing the dry mist through a reclassifier (Figure 1). As these small particles pass through the reclassifier orifice, the increased turbulence causes the particles to stick together and grow in size. At this point, the oil mist is referred to as wet mist. The larger wet mist particles are now applied to bearing surfaces and can lubricate rolling-element bearings.

As wet mist is applied to the equipment with an air-flow velocity of 24 feet per second, this same air must also be vented from the

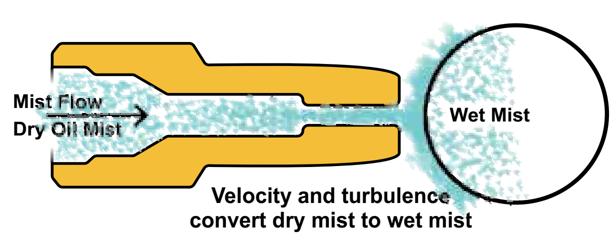


Figure 1. Oil mist reclassification.

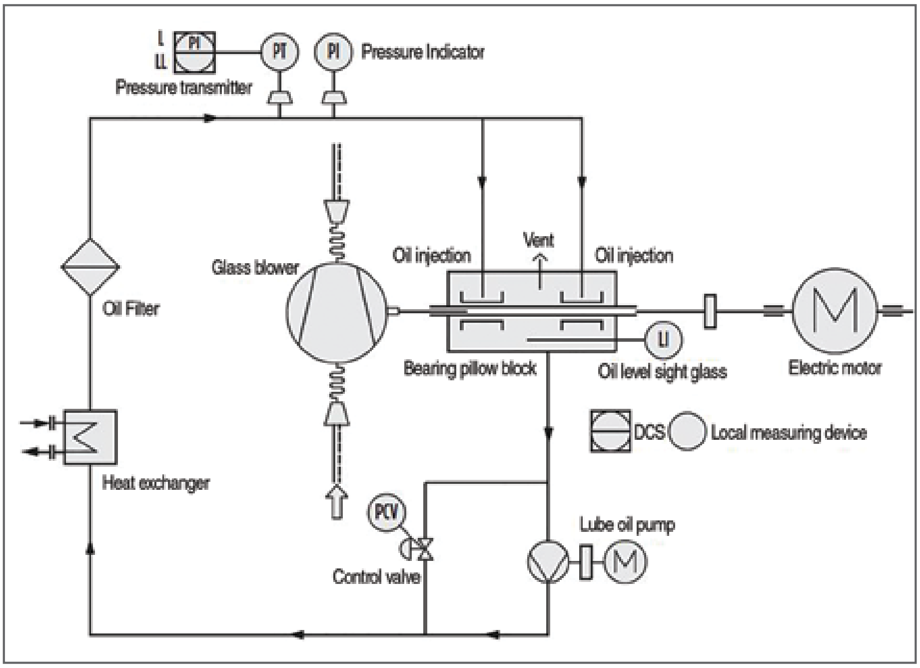


Figure 2. The gas blower's original oil console. (Ref. *Hydrocarbon Processing Magazine*)

bearing housing to allow the mist to move onto and across the bearings to provide lubrication. The flow of oil mist into the bearing housing creates a slight positive pressure (above atmospheric pressure) inside the bearing housing, which prevents the intrusion of airborne contaminants. The flow of oil mist supplies continuous lubrication to the bearings and passes onto a vent point. The excess oil mist must be contained and collected below the equipment for reuse or disposal.

This method is an excellent means of lubrication for bearings with speeds of 500 to 3,600 revolutions per minute (rpm), and is preferred for bearings operating in the 10,000 to 15,000 rpm range where splash lubrication is ineffective. Oil mist is also considered best practice by the hydrocarbon processing industry and is recommended within the specifications of the American Petroleum Institute (API).

Verifying That Oil Is Reaching Each Bearing

The reclassifier, which controls the amount of lubricant being applied to each bearing, is sized using the same calculations for rotating equipment bearings. Reclassifiers can create back pressure throughout the mist feed lines. Plugging in the lines causes high pressure, while a broken line will result in low pressure. An oil mist generator monitors the pressure, using high- and low-pressure alarms, as well as the mist density for under- and overlubrication of the equipment.

Installation of the piping system should be closely monitored for cleanliness. Once the system has been installed, it should be blown with air for eight hours for additional cleaning. After startup, only one thing can plug the system's reclassifiers — wax from paraffin-based oils. The waxing problem is well known to most oil mist users. Synthetic lubricants or high-grade, wax-free mineral oils are commonly used in these systems. Should waxing occur, all the reclassifiers can become plugged within an hour, causing numerous alarms to sound in the control room. With modern-day oil mist systems, plugging of reclassifiers is a rare occurrence when quality lubricants are used.

Suitable Equipment for Oil Mist

Oil mist is recommended for most types of rolling-element bearings operating between 500 to 15,000 rpm. The most common applications are pumps and motors. Approximately 30,000 pumps in the U.S. refining industry are lubricated with pure oil mist, along with an equal number of motors.

Lubricants Used in Oil Mist Systems

A diester-based oil is preferred for oil mist systems but is not required. All major lubricant manufacturers have mineral and synthetic oils that can work well in these systems. An ISO viscosity-grade 100 oil is recommended for most systems except where temperatures commonly fall below 32 degrees F. In cold-climate systems that operate at temperatures below 32 degrees F for long periods of time, most users drop down to an ISO viscosity-grade 46 or 68 oil.

When selecting a lubricant, contact other oil mist users in the area to see which lubricants are being used and how they are performing. All oils are not equal. Most are blended for sump or splash lubrication. With oil mist, the oil is broken down into micron-sized particles, which may allow the additive package to fall out of suspension if the oil is not properly blended.

Be careful with mineral oils that have a paraffin base. Too much paraffin can plug the reclassifiers in the system during hot summer or cold winter temperatures. Therefore, always select paraffin-free oils and never use automotive oils in oil mist systems.

Minimum/Maximum Operating Temperatures

Oil mist does not have a high or low operating temperature. However, oil mist generators will have a low ambient temperature of minus 40 degrees. For hot climates, air coolers are included in the units to prevent heat damage to the electronic components. After the oil mist is generated, it becomes the same temperature as the header pipe. The outside temperature has no effect on the oil mist particles that are in suspension within the piping system.

Pure oil mist is often used on process pumps that have temperatures of 600 to 750 degrees F. Rolling-element bearings seldom operate at temperatures higher than 200 degrees F.

Keep in mind that oil mist does not support combustion and is well below the limits for flammability. It also is below the Occupational Safety and Health Administration's allowable limit of 5 milligrams per cubic meter of air for an 8-hour period. With a closed-loop system, the amount of oil in the air is far below the allowable limit.

System Reliability

Oil mist systems have no moving parts, so there is nothing to wear out. According to mechanical engineering expert Heinz Bloch, an oil mist generator is 99.99 percent reliable. The two requirements for the generation of oil mist are clean instrument air and clean oil. Electricity is not necessary for system operation.

In regard to the air supply, the maximum consumption is 30 standard cubic feet per minute (SCFM) for a large system that would serve 50 to 80 pieces of equipment. Should the air supply system go down, there likely would be many more issues to be concerned with, as the process unit or plant would be shutting down.

A typical oil mist system uses 2 gallons of oil per 24 hours. A fully instrumented oil mist generator has a 9-gallon misting chamber and a 75-gallon bulk reserve. Many process plant installations include an additional 110-gallon bulk oil tank, thus providing an oil supply of approximately 200 days of continuous operation.

Dry Sump or Pure Mist?

Dry sump or pure mist is the preferred lubrication method for most rolling-element bearings, including pumps, motors and pillow-block bearing applications. Pure oil mist can also provide superior lubrication over traditional oil sump or grease lubrication. Where there is no oil level in the bearing housing, oil mist is the only means of lubrication. The preferred flow of oil mist is through the bearings, side to side or top to bottom.

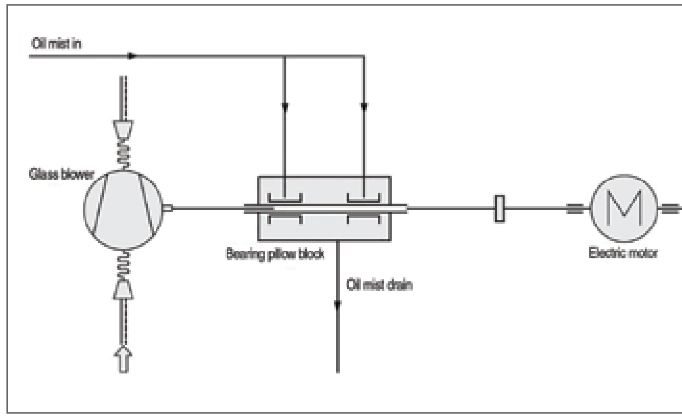


Figure 3. The upgraded lubrication system incorporating oil mist (Ref. *Hydrocarbon Processing Magazine*)

Figure 4. A gas blower lubricated by oil mist.

Pump and motor manufacturers are quite aware of oil mist systems, and most have designed their equipment for use with this type of lubrication. Current API standards also support the use of oil mist for equipment lubrication and preservation.

Technical Risks

Oil mist systems are relatively simple, operating at 0.73 pounds per square inch with a flow rate of 20-24 feet per second. With no moving parts to wear out or fail, many systems in the refining industry have exceeded 40 years of operation. Turnkey installations can be provided by the supplier. Training for operations and maintenance personnel normally is offered onsite, along with customer support and service. Routine maintenance contracts are common in most facilities.

Case Study

The Petronor oil refinery in northeastern Spain recently installed pure oil mist in the pillow block of a gas blower that originally was equipped with an oil console. The final conversion involved a dual pillow-block bearing arrangement for an air blower in the refinery's sulfur unit. All the rotating machines in the plant were lubricated by oil mist except for this blower, which was a requirement of the plant licensor.

Since its startup, the blower had experienced multiple lubrication issues related to the oil console, such as oil cleanliness deficiencies and clogged oil injectors. The main pump also failed because the bearing's pillow block had a very small oil volume and no constant-level oiler, so even a slight drop in the oil level put the pump and machine at risk.

After the system was studied by a design engineer, it was concluded that the oil console was unnecessary and too complicated to lubricate the pillow block. Oil mist, which already was installed on the surrounding machines, was determined to be the best option for simplifying the system and boosting the reliability of the blower.

During the upgrade, the oil console and related instrumentation were dismantled. The system's current design (Figure 3) is much simpler. Now, the blower works much better than before, and the conversion cost was less than $6,000.

Lessons Learned

What can be learned from this case study is that reliability engineers often need to question the original design of their lubrication systems and refute underlying assumptions to improve reliability. System designs frequently are complex without justification. Complicated systems do not always mean reliable systems. Finally, consider oil mist as a possible lubrication method based on its proven ability to reduce equipment failure rates while increasing availability and throughput. ML

Manoj Srivastava

Chain oil drips on the component

The incident being referred is from automobile industry. The body is painted and then taken into oven for curing the paint.

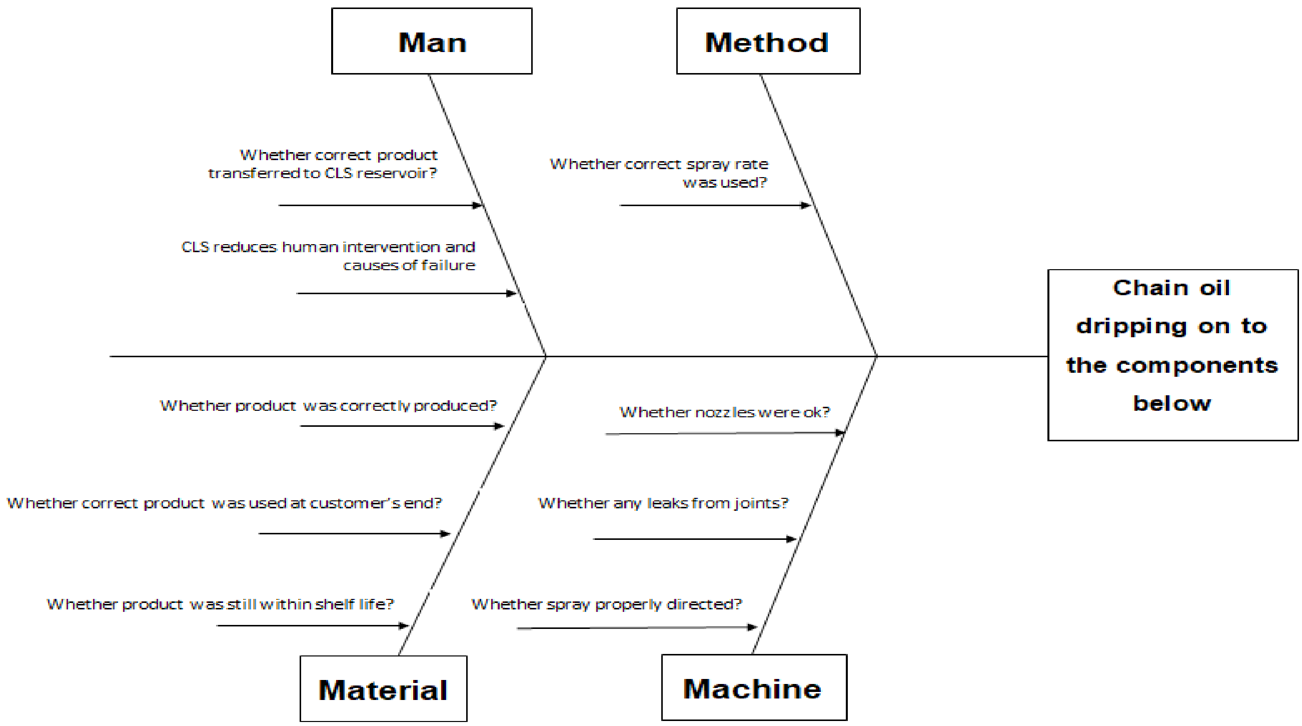
The transportation from paint shop to the curing oven is through conveyor chains, from which the components are suspended. The components moving on these chains enter the curing oven. Needless to say the chains need to be lubricated. If sufficient and timely lubrication is carried out, the performance of conveyor improves and the chain life gets extended. On the other hand, if there is improper lubrication then the movement becomes erratic, friction increases, power consumption increases etc.

The incident dates back to when I was working with the manufacturer of chain lubricants, among other things. We received a complaint from one of the reputed manufacturers that their chain lubricant was thin, did not have enough adhesiveness and hence was dripping on to the component below. This led to presence of oil on the painted component when it was entering the oven and after curing they could observe streaks on painted surface which, obviously, was unacceptable.

On visiting the customer, we noticed that every 5th component was having oil streak which means that oil was dripping on approximately every fifth component.

The possible reasons were quickly listed on a fish bone diagram – the classic man, material, machine & method template.

- **Man:** The system adopted at customer's end was centralized lubrication system which reduces human intervention and thus, causes of failure.
- **Man:** It was verified that correct product was transferred from our packaging to reservoir of centralized lubrication system.
- **Machine:** the nozzles were verified to be ok.
- **Machine:** the spray from the nozzle was correctly directed at chain parts.
- **Machine:** there were no leakages from the piping/ tubing of centralized lubrication system.
- **Material:** The batch sheets at our end confirmed that the product was produced as per recommended SOP and was meeting all the specified parameters.
- **Material:** The product was within its shelf life i.e., not an expired product.
- **Material:** The customer was using the correct product. The seal was verified ruling out pilferage. And sample from their end was tested in our lab to confirm that product was not contaminated and its parameters were matching the batch parameters.
- **Method:** correct spray rate was being used.



Last two points made us re-think and slowly it dawned on us.

Earlier the customer was using a mineral oil based product and our product was synthetic. It made sense that the spray rate would have to be modified to suit our synthetic product.

Though the viscosity of our product was same as that of oil earlier used by them but the lubricity was different since it was made from synthetic base. We had to make some trial and error adjustment to the spray rate. And ultimately, at about 75% of earlier rate we reached a stage where there was no dripping.

The problem was solved and the customer got an additional advantage - on account of reduced spray rate, they saved on lubrication cost.

About the Author

Manoj Srivastava graduated as Chemical Technologist. He has 32 years rich experience in strategic planning, plant operations with proven abilities in enhancing production process operations, optimizing resources, capacity utilization, escalating productivity & operational efficiency while curtailing costs and expenses in various lubricant companies in India and Africa (Tanzania). He is experienced in carrying out lube surveys/ audits & lubrication training for end customers. Contact Manoj at manojsri64@gmail.com

"What are lubricant churning and bearing torque, and **how do they affect gears, bearings and the lubricant?"**

Bearings and gears require a certain amount of force to begin turning and to continue turning once they are set in motion. The measure of this force is commonly referred to as torque. Running torque is usually less than starting torque. These forces are variable depending on several parameters.

Lubricant churning is one of the more common factors that affects both bearings and gears. It occurs when the bearing or gear must churn through the lubricant as it performs its regular task. The majority of these machines are splash-lubricated, which means they must operate at the proper lubricant level to be able to lift and splash lubricant to all surfaces inside the machine. This is where lubricant churning can become an issue.

If the lubricant level is too high, either because too much oil has been added or the bearings have been overgreased, the machine must work harder to push through the added lubricant. This is the basis of that churning condition.

It can be compared to walking along the beach. If you reach ankle-deep water, it is still fairly easy to move (equivalent to running torque). However, if the tide comes in or you venture out into deeper water, it becomes much more difficult to walk. This requires you to work harder and causes you to tire out quicker.

The same thing happens to a machine when the lubricant level is too high. It works much harder to push through the added lubricant, which results in higher operating temperatures, decreased efficiency and a reduction in the life of both the lubricant and the machine.

Besides the lubricant level, another variable is the lubricant being used. Since the most important physical property of a lubricant is viscosity, the proper viscosity must be selected according to the speed, load, temperature and general running conditions of the machine. If the viscosity is too thin, then excess friction due to metal-on-metal friction is generated, causing machine wear and premature failure. If the viscosity is too thick, this leads to viscous drag, which causes very similar issues as having a lubricant level that is too high. Neither of these situations is desirable for the equipment.

By choosing the right lubricant as well as ensuring the appropriate lubricant level, you can give your equipment the best chance for error-free operation.

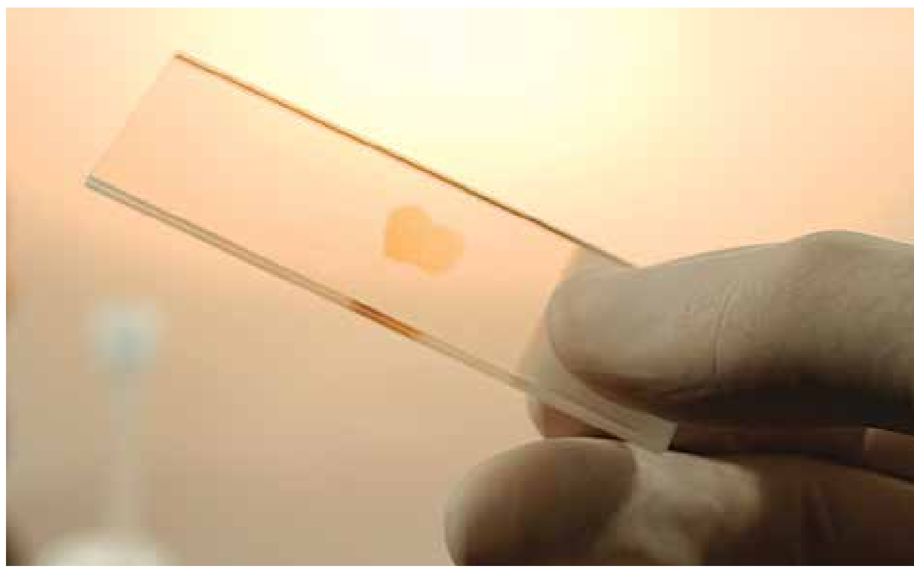
"I would like to perform optical particle analysis. Do you have any suggestions or recommendations for this? **I have some particles and a microscope, but I am looking for information that describes this oil analysis method so I can try it for myself."**

Implementing a procedure to characterize contaminant particles found in lubricants and becoming proficient in this technique will require considerable study and practice. First, you should set goals for the analysis, like determining the particle size, metal type and wear failure modes. This information can be obtained from a particle characterization sample such as a ferrogram, filtergram or patch test.

With a ferrogram, wear particles are captured on a glass surface, which is placed in a magnetic field. For this reason, it has a bias toward ferromagnetic particles from iron or steel, but it also can capture non-ferrous particles. This is frequently referred to as analytical ferrography. Engines, most gearboxes, rolling-element bearings and most hydraulics are among the types of equipment that are most likely to produce magnetic wear particles.

A ferrogram is easy to heat-treat for identification purposes and has excellent transmission of bottom light. Unfortunately, the particles tend to pile up, and the preparation equipment is generally more expensive.

On the other hand, a filtergram has no bias toward ferrous particles and is easy to prepare. The necessary hardware is also less expensive. However, it is more difficult to distinguish metal types and to prepare two membranes (one ferrous and one non-ferrous). Special patches are also required for heat-treating, and the transmission of bottom light is not as effective. Equipment with critical non-ferrous frictional surfaces include worm gears, stainless-steel machinery and turbomachinery with bronze or Babbitt bearings.



A patch test, also called patch ferrography, can be used to collect all types of solid particles in oil, since the fluid is simply filtered through a patch or paper. With this method, there is no bias toward a ferromagnetic element or metallic debris.

After particle samples are taken and analyzed with a microscope, it is possible to heat the sample to observe color changes in the particles. This helps to identify the metal type. This procedure is typically run in ferrograms.

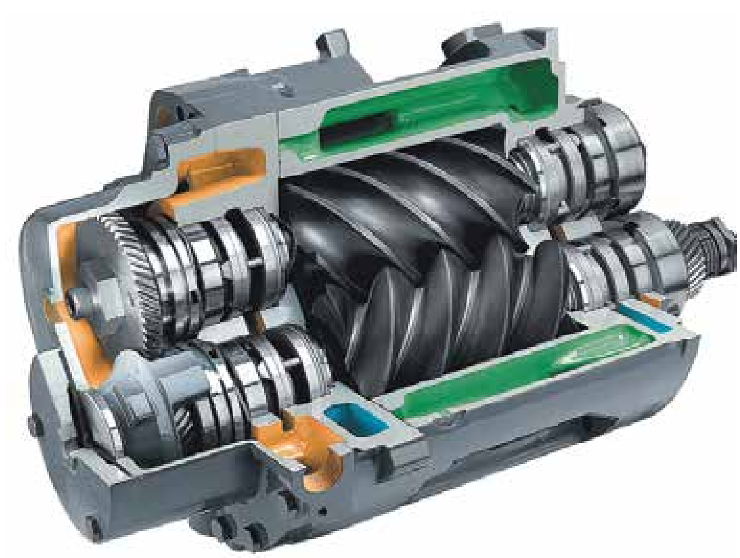
For reference, be sure to consult the corresponding ASTM methods (D7684-11 and D7690-11). Noria's oil analysis training courses can also provide more information about these techniques and the value of oil analysis. *ML*

Matthew Adams | Noria Corporation

What You Need to Know About **Compressor Lubrication**

> "The better you understand a compressor's function, the effects of the system on the lubricant, which lubricant should be selected and what oil analysis tests should be conducted, the better your chances of maintaining and enhancing the health of your equipment."

Compressors are an integral part of almost every manufacturing facility. Commonly referred to as the heart of any air or gas system, these assets require special attention, particularly their lubrication. To comprehend the vital role lubrication plays in compressors, you must first understand their function as well as the effects of the system on the lubricant, which lubricant to select and what oil analysis tests should be performed.



Compressor Types and Functions

Many different compressor types are available, but their primary role is almost always the same. Compressors are designed to intensify the pressure of a gas by reducing its overall volume. In simplified terms, one can think of a compressor as a gas-like pump. The functionality is basically the same, with the main difference being that a compressor reduces volume and moves gas through a system, while a pump simply pressurizes and transports liquid through a system.

Compressors can be divided into two general categories: positive displacement and dynamic. Rotary, diaphragm and reciprocating compressors fall under the positive-displacement classification. Rotary compressors function by forcing gases into smaller spaces through screws, lobes or vanes, while diaphragm compressors work by compressing gas through the movement of a membrane. Reciprocating compressors compress gas through a piston or series of pistons driven by a crankshaft.

Centrifugal, mixed-flow and axial compressors are in the dynamic category. A centrifugal compressor functions by compressing gas using a rotating disk in a formed housing. A mixed-flow compressor works similar to a centrifugal compressor but drives flow axially rather than radially. Axial compressors create compression through a series of airfoils.

Effects on Lubricants

Prior to the selection of a compressor lubricant, one of the primary factors to consider is the type of strain the lubricant may be subjected to while in service. Typically, lubricant stressors in compressors include moisture, extreme heat, compressed gas and air, metal particles, gas solubility, and hot discharge surfaces. Keep in mind that when gas is compressed, it can have adverse effects on the lubricant and result in a noticeable decline in viscosity along with evaporation, oxidation, carbon depositing and condensation from moisture accumulation.

Once you are aware of the key concerns that may be introduced to the lubricant, you can use this information to narrow your selection for an ideal compressor lubricant. Characteristics of a strong candidate lubricant would include good oxidation stability, anti-wear and corrosion inhibitor additives, and demulsibility properties. Synthetic base stocks may also perform better in wider temperature ranges.

Lubricant Selection

Ensuring you have the proper lubricant will be critical in the health of the compressor. The first step is to reference the recommendations from the original equipment manufacturer (OEM). Compressor lubricant viscosities and the internal components being lubricated can vary greatly based on the type of compressor. The manufacturer's suggestions can provide a good starting point.

Next, consider the gas being compressed, as it can significantly affect the lubricant. Air compression may lead to issues with elevated lubricant temperatures. Hydrocarbon gases tend to dissolve lubricants and, in turn, gradually lower the viscosity. Chemically inert gases such as carbon dioxide and ammonia may react with the lubricant and decrease the viscosity as well as create soaps in the system. Chemically active gases like oxygen, chlorine, sulfur dioxide and hydrogen sulfide can form tacky deposits or become extremely corrosive when too much moisture is in the lubricant.

You should also take into account the environment to which the compressor lubricant is subjected. This may include the ambient temperature, operating temperature, surrounding airborne contaminants, whether the compressor is inside and covered or outside and exposed to inclement weather, as well as the industry in which it is employed.

Compressors frequently use synthetic lubricants based on the OEM's recommendation. Equipment manufacturers often require the use of their branded lubricants as a condition of the warranty. In these cases, you may want to wait until after the warranty period has expired to make a lubricant change.

If your application currently utilizes a mineral-based lubricant, switching to a synthetic must be justified, as this often will be more expensive. Of course, if your oil analysis reports are indicating specific concerns, a synthetic lubricant can be a good option. However, be sure you are not just addressing the symptoms of a problem but rather resolving the root causes in the system.

Which synthetic lubricants make the most sense in a compressor application? Typically, polyalkylene glycols (PAGs), polyalphaolefins (POAs), some diesters and polyolesters are used. Which of these synthetics to choose will depend on the lubricant you are switching from as well as the application. Featuring oxidation resistance and a long life, polyalphaolefins generally are a suitable replacement for mineral oils. Non-water-soluble polyalkylene glycols offer good solubility to help keep compressors clean. Some esters have even better solubility than PAGs but can struggle with excessive moisture in the system.

Oil Analysis Tests

A multitude of tests can be performed on an oil sample, so it is imperative to be critical when selecting these tests and the sampling frequencies. Testing should cover three primary oil analysis categories: the lubricant's fluid properties, the presence of contaminants in the lubrication system and any wear debris from the machine.

Depending on the type of compressor, there may be slight modifications in the test slate, but generally it is common to see viscosity, elemental analysis, Fourier transform infrared (FTIR) spectroscopy, acid number, varnish potential, rotating pressure vessel oxidation test (RPVOT) and demulsibility tests recommended for assessing the lubricant's fluid properties. Fluid contaminant tests for compressors likely will include appearance, FTIR and elemental analysis, while the only routine test from a wear debris standpoint would be elemental analysis. An example of oil analysis test slates and alarm limits for centrifugal compressors is shown below.

Because certain tests can assess multiple concerns, some will appear in different categories. For example, elemental analysis may catch additive depletion rates from a fluid property perspective, while component fragments from wear debris analysis or FTIR may identify oxidation or moisture as a fluid contaminant.

Alarm limits often are set as defaults by the laboratory, and most plants never question their merit. You should review and verify that these limits are defined to match your reliability objectives. As you develop your program, you may even want to consider changing the limits. Frequently, alarm limits start out a bit high and change over time due to more aggressive cleanliness targets, filtration and contamination control.

Understanding Compressor Lubrication

In regard to their lubrication, compressors can seem somewhat complex. The better you and your team understand a compressor's function, the effects of the system on the lubricant, which lubricant should be selected and what oil analysis tests should be conducted, the better your chances of maintaining and enhancing the health of your equipment. ***ML***

Number	Parameter	Standard Test Method	Units	Nominal	Caution	Critical
Lubricant Properties Analysis						
1	Viscosity @ 40°C	ASTM D445	cSt	New oil	Nominal +5%/-5%	Nominal +10%/-10%
2	Acid Number	ASTM D664 or ASTM D974	mgKOH/g	New oil	Inflection point +0.2	Inflection point +1.0
3	Additive Elements: Ba, B, Ca, Mg, Mo, P, Zn	ASTM D5185	ppm	New oil	Nominal +/- 10%	Nominal +/- 25%
4	Oxidation	ASTM E2412 FTIR	Absorbance /0.1 mm	New oil	Statistically based and used as a screening tool	
5	Nitration	ASTM E2412 FTIR	Absorbance /0.1 mm	New oil	Statistically based and used as a screening tool	
6	Antioxidant RUL	ASTM D6810	Percent	New oil	Nominal -50%	Nominal -80%
	Varnish Potential Membrane Patch Colorimetry	ASTM D7843	1-100 scale (1 is best)	<20	35	50
Lubricant Contamination Analysis						
7	Appearance	ASTM D4176	Subjective visual inspection for free water and particulate			
8	Moisture Level	ASTM E2412 FTIR	Percent	Target	0.03	0.2
		Crackle	Sensitive down to 0.05% and used as screening tool			
Exception	Moisture Level	ASTM D6304 Karl Fischer	ppm	Target	300	2,000
9	Particle Count	ISO 4406:99	ISO Code	Target	Target + 1 range number	Target + 3 range numbers
Exception	Patch Test	Proprietary Methods	Used for verification of debris by visual examination			
10	Contaminant Elements: Si, Ca, Mg, Al, etc.	ASTM D5185	ppm	<5*	6-20*	>20*
* Depends on contaminant, application and environment						
Lubricant Wear Debris Analysis (Note: abnormal readings should be followed by analytical ferrography)						
11	Wear Debris Elements: Fe, Cu, Cr, Al, Pb, Ni, Sn	ASTM D5185	ppm	Historic Average	Nominal +SD	Nominal +2 SD
Exception	Ferrous Density	Proprietary Methods	Proprietary Methods	Historic Average	Nominal +SD	Nominal +2 SD
Exception	PQ Index	PQ90	Index	Historic Average	Nominal +SD	Nominal +2 SD

An example of oil analysis test slates and alarm limits for centrifugal compressors.

About the Author

Matthew Adams is a technical consultant for Noria Corporation, concentrating in the field of predictive maintenance. He has experience in multiple condition-based maintenance technologies and focuses the majority of his attention on lubrication program development, training and general consulting. Matthew holds a Machine Lubricant Analyst (MLA) Level III certification and a Machinery Lubrication Technician (MLT) Level I certification through the International Council for Machinery Lubrication (ICML). Contact Matthew at madams@noria.com to find out how Noria can help you maintain the compressors at your facility.

TEST YOUR KNOWLEDGE

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

1. Surface fatigue can be described as:

A) Adhesion

B) Pitting caused by surface corrosion

C) Metal fracturing due to chemical damage

D) Surface-initiated pit formation caused by cyclic loading

E) Plastic deformation of the metal's surface

2. Oxidation stability is not detectable and not monitored with:

A) Acid number

B) Karl Fischer

C) RPVOT

D) Fourier transform infrared (FTIR) spectroscopy

E) Voltammetry

3. Sampling a wet sump gearbox with a small oil circulation system should be done where?

A) Downstream of the pump, upstream of the main pressure-line filter

B) Downstream of the sump, upstream of the pump (before the pump)

C) Downstream of the main pressure-line filter

D) From the sump

E) From the gearbox drain plug

ANSWERS

1. D

Other names for surface fatigue include contact fatigue, spalling, pitting, etc. It is associated with components such as anti-friction bearings, gear teeth at the pitch line, cams and rollers. Surface fatigue usually begins with denting due to the presence of particles. The dent forms a stress riser. Repeated cyclic loading causes surface fatigue, which eventually results in pits and then large spalls.

2. B

The Karl Fischer test is used to quantify water content and is not used to detect or monitor oxidation. The other listed tests are used to detect or measure oxidation stability of oil.

3. A

This is to assess the actual condition of the oil before it gets filtered.

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

Pre-Flush for Better Oil Samples

It is important to recognize that the amount of tubing, the size of the sample port and the volume of static oil in relation to the location of the sample port can all disturb overall quality of the sample. For an effective, data-rich sample, appropriate pre-sample flushing volumes should be included in sampling procedures and should be specific for each individual sample port. The industry rule of thumb is to pre-flush six to 10 times the total volume of static oil in a sample tube, port, port adapter and any dead legs of pipe in the systems upstream of the sample port location.

Upgrade to a High-Efficiency Filter

One of the biggest culprits for letting dirt into hydraulic and oil reservoirs is the air breather. Many systems come with a standard paper media breather with a nominal rating of about 40 microns. This allows the smaller, more destructive particles to get into the system very easily. Upgrading a standard breather to a high-efficiency filter is easily done using commercial bayonet adapters and quality synthetic hydraulic filters.

Handle Oil Containers with Care

Avoid damage to drums and other large containers during handling. Negligent handling can cause leakage or ingression of dirt. Each container used for in-plant lubricants should be used for only one oil, clearly marked for it and not substituted for another container. It should also be kept clean and sealed to keep out dirt. Never mix lubricants.

Protect Metals with Corrosion Inhibitors

Corrosion inhibitors are additives that suppress oxidation and prevent formation of acids. These inhibitors form a protective film on metal surfaces and are used primarily in internal combustion engines to protect alloy bearings and other metals from corrosion. *ML*

Did You Know?

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

Have Some Tips?

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

Paul Hiller | ICML

How to Determine the Competency of a **Lubrication Program**

An organization's stage of competence can be gauged by the aggregate competence of its team members along with the efficacy of its lubrication program.

Everyone is performing or learning something at any given moment. Some skills we are good at, and others we are not. Yet just because we believe all is well with a particular skill doesn't mean we couldn't be better at it, but how would we ever know? This is where the four stages of competence come into play.

The four stages model provides a means to describe how people learn new skills. Developed roughly 50 years ago by management trainer Martin Broadwell and popularized by psychologist Noel Burch in the 1970s, this model is also known by other names, such as the four stages of learning, the conscious competence ladder, among others.

Most often, these stages are related to the learning journey of an individual, but could they be applied to a maintenance organization? In a nutshell, the four stages represent a progressive matrix of consciousness and competence:

Stage 1: Unconscious Incompetence

A person is blissfully unaware of his or her shortcomings in regard to a particular skill set. The length of time a person remains in this stage depends on how motivated he or she is to learn.

Stage 2: Conscious Incompetence

Once the person is made aware of his or her shortcomings through one or more resources, the person acknowledges that new skills will

be necessary to resolve these deficiencies. Hopefully, the person starts to learn these skills.

Stage 3: Conscious Competence

The person practices these new skills, deliberately thinking through each step and procedure.

Stage 4: Unconscious Competence

The new skills become second nature or habitual, performed competently without any extra concentration or special effort.

Surely, these four stages apply individually to lubrication practitioners who go through the rigors of training and certification. Self-awareness allows people to know not only the stage at which they are currently with a particular skill, but also what they need to do next to get better.

When to Become Certified

It is an honest question: At which stage would we find candidates to be most receptive to training and certification? The answer might be open to friendly debate, but I would suggest that stage 2, conscious incompetence, is where most practical training begins. Although stage 4, unconscious competence, is where certification might make most sense, I would argue that certification is more impactful as a bridge from stage 2 to stage 3 as practitioners start to apply what they are learning.

Stage 1, meanwhile, is where you would find those who are not yet ready for training, because they innocently never consider the value or necessity of exposure to new ideas and information.

Applying the Model to a Plant Lubrication Program

Does this model hold up when applied within the context of a departmental lubrication program? Yes, but this scenario consists of individuals working together in concert, so an organization's stage of competence can be gauged by the aggregate competence of its team members along with the efficacy of its lubrication program through which those team members perform their duties. Because of these conditions, the delineation of the four stages is not as clear, as they tend to overlap.

Regardless, you can see a common pattern across case studies, because even institutional learning starts with the status quo and advances on the strength of curiosity, the reception of good training and the application of "practice makes perfect." Somewhere along the way, the professional certification of individuals, combined with recognition of a plant's success story, can confirm newfound levels of competence.

Stage 1: Lubrication Status Quo — All is Well

At the unconscious incompetence stage, a maintenance organization may be working in its own bubble of key performance indicators (KPIs). Without external data that compares its lubrication performance and expenses to similar organizations or to industry standards, the department subjectively performs activities without knowing whether they are optimized.

Phrases associated with this stage might include, "If it ain't broke, don't fix it," and "We are doing good: only three gearbox replacements this quarter!"

Such an organization likely comprises individuals who possess practical knowledge of such subjects as asset optimization, contamination mitigation, lubricant selection factors, best practices for lubricant storage, etc., but they do not necessarily apply this knowledge or even appreciate their own relevance to the larger scope of business objectives.

In this stage, organizational leaders dispute the benefits of comprehensive lubrication programs and professional certifications, because they naturally assume everything is already as it should be, without realizing things could be better. This is not a resistance to change for change's sake. Rather, it stems from a lack of understanding of the value proposition that training and certification can offer to a lubrication program.

Stage 2: We Can Do That?

At the conscious incompetence stage, someone has presented the organization with evidence that there is tangible value in the formal development and sustained application of a lubrication program. This evidence comes from reading industry magazines, attending conferences and exchanging stories with other companies. Additionally, case studies are good tools to plant seeds of awareness that can shake people out of stage 1 inertia.

Such exposure is often the result of managerial mandates like, "read this magazine," "take this online class," or "attend this conference." There is something to be said for forcing educational opportunities upon lubrication personnel. Managers who require continuing education are doing their teams a favor, helping ensure they do not remain stuck comfortably in stage 1 forever.

Stage 2 is where the term "low-hanging fruit" likely is introduced. Frequently, an internal audit of machinery assets, lubrication procedures and institutional knowledge is conducted at this stage to confirm the potential return on investment (ROI) of new actions that might be initiated.

Not all organizations that become aware of the possibility for improvement turn immediately to third-party consultants for guidance. However, all organizations that want to resolve their recently recognized lubrication deficiencies will start shopping around for training, certification, equipment, products and procedural solutions, regardless of how they eventually intend to manage their lubrication programs. Certifications are always third-party affairs.

Sustainability Is Purpose-driven

Because the pursuit of training can be a daunting task, stage 2 is where most lubrication programs die. This is why an organizational purpose (objectives, goals, etc.) is so important. Any team can increase its aggregate brain trust by sending its most receptive lubrication practitioners to formal training to ensure consistent expansion of institutional knowledge. Ideally, these individuals will train and learn so they can proceed to apply best practices in stage 3.

Of course, change is hard, but it can be made easier if the practitioners perceive a larger organizational purpose. This can be as simple as setting new KPIs to break old maintenance records or focusing on winning an industry award for the facility — anything measurable that helps an organization (and its individual members) to stay motivated and avoid feeling overwhelmed.

From a management perspective, it is essential to be careful when spending training and certification time and dollars to ensure gains are made in areas that are obvious and important to team members. After all, what is the point of increasing your department's competence in areas that don't align with organizational goals?

Stage 3: We Are Doing It!

In the conscious competence stage, the organization faces ongoing challenges spread across several months or years. Those who drive change to lubrication and oil analysis understand that success will require a new plan developed in accordance with the organizational purpose and objectives. This plan must be executed in such a way that creates opportunities for individual practitioners to focus as much as possible on honing their new skills. At an organizational level, it is not just skills that must be practiced but also new policies, procedures and priorities.

Change leaders in this stage understand that success requires compliance even outside the immediate lubrication program. Accordingly, they will encourage cross-departmental training and instruction so all stakeholders (especially at executive levels) recognize the potential value of new lubrication activities.

In stage 3, lubrication program development is focused and deliberate. One of the biggest challenges is breaking down departmental policies or habits in favor of new ones that provide more agility and machinery uptime. This is where you will hear talk about a culture change. Hands-on practitioners are engaged with managers to transform the organization's program to world-class status. Hiring third-party consultants and earning certifications may or may not occur in this stage, but both would certainly accelerate progress through stage 3.

Stage 4: The New Normal

At the stage of unconscious competence, all stakeholder groups are on the same page with high expectations for maintaining new KPIs and new levels of machine reliability that meet business goals. All practitioners, managers and suppliers recognize the big-picture relevance of new lubrication and oil analysis activities. Old habits are no longer a source of friction. The organization understands there is no value in scaling back on any of the changes, because they have verified ROI (e.g., lower expenses, greater uptime, etc.).

Achieving stage 4 as an organization doesn't mean that every part of the lubrication program comes effortlessly to every individual on the team. What it does mean is that institutional resistance to change has ceased and that organizational expectations and capabilities are naturally elevated. Checklists and formal procedures are still necessary to ensure consistency, especially as new hires go through their own individual stages of competence to get up to speed with the team.

Continuing education and certifications are common here, but such activities only occasionally cycle individuals — not entire organizations — back through the stages for specific aspects of the lubrication program. However, over time, the sustained presence of certified practitioners and managers mitigates erosion of an organization's stage 4 competence.

Organizations in this stage set the curve for world-class competition. These are the plants that normally submit applications to the International Council for Machinery Lubrication (ICML) for the annual Gill and Battle awards. To read stories about successful lubrication and oil analysis programs, visit the ICML website at lubecouncil.org.

In Which Stage Is Your Program?

It is no simple undertaking to adopt and embrace lubrication and oil analysis improvements for your organization while simultaneously pursuing and earning professional certifications for yourself and your crew. If you are trying to develop a facility-wide lubrication program, it is important to determine where your colleagues are — and where your organization is — within the four stages of competence. As a leader, your job is to accelerate through the stages as quickly as possible so both your team and plant can soon become unconsciously competent and reap the benefits of lubrication excellence. ***MLI***

Jhumpa Mukherjee | VAS Tribology Solutions

REPORT

White Oils– Global Market and Future Trends

White oil is an important component used in the chemical, pharmaceutical, cosmetics and food processing industries. White oils are generally recognized as a class of highly refined and versatile mineral oils and are generally produced from paraffinic or naphthenic base-stocks from the refineries. White oils are odorless, tasteless, chemically inert, colorless and biologically stable in nature. These oils have excellent storage life and they also do not change color over time. White oils are available in five different grades which are chemically distinct from each other. Most of them contain Vitamin E, which protects it from natural oxidation and steadies it during storage.

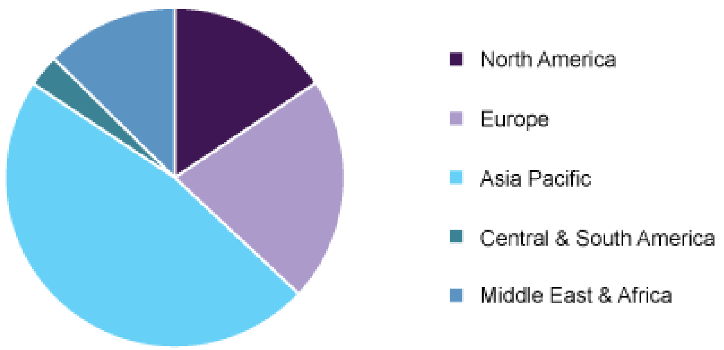
PROPERTIES:

- Colorless, odorless & tasteless
- Extremely pure and stable
- Non-toxic, chemically & biologically inert
- Superior thermal & UV stability
- Hydrophobic / Moisture resistant
- Excellent lubricity and insulation properties

A Brief History

The term 'White Oil' is a little ambiguous in the sense that they are not white at all, but crystal clear. The term for these high purity oils was originally used to differentiate them from less refined darker oils. White oil is similar to petrolatum, which is better known by its brand name, Vaseline, a jellied mixture of solid and liquid hydrocarbons first manufactured out of Pennsylvania crude oil in 1872. Attempting to make their own Vaseline, but with a chemically different kind of oil, Russian engineers instead produced the odorless, colorless, and tasteless white oil. The technology for refining white mineral oil was first established in 1887 in Russia.

Over the next 25 years the process was improved so that high quality white oils could be used for medicinal (or pharmaceutical) and special industrial applications. White oils were exported all over the world, especially to North America, until in 1917 when the US entered the First World War, a number of major US oil companies had to start producing white oils.



Global white oil market share by region, 2019. Source - www.grandviewresearch.com

White oils are a key ingredient in cosmetics

Applications and Global Market of White Oils

In terms of volume, personal care applications led the market with a share of 28.7% in 2019 as per the reports in grandviewresearch.com. This is attributed to widespread product application in the formulation of baby oils, hair and skin care products, such as serums, creams & lotions and makeup products. White oil has the ability to protect skin from the harmful external environment. It is also broadly utilized in the formulation of anti-aging products, which have high demand, especially in various East & North Asian countries. The Asia Pacific led the market in 2019 and accounted for over 51% of the global revenue share.

White oil is widely used in the manufacturing of specialty adhesives and elastomers due to its water and moisture-resistant properties, which are also estimated to fuel the expansion of the global white oil market. White oils are certified safe for their application in

> **"Rising demand in medical & cosmetics applications worldwide is projected to be a key driving factor for the market growth"**

The key sectors driving this growth are as follows-

- **Personal Care–** baby oil, cosmetics, hair care, emollients, lotions and moisturizers
- **Pharmaceutical–** ointments, creams, laxatives and the preparation of gelatinous capsules
- **Adhesives–** as a plasticizer for food contact materials
- **Agriculture–** dedusting agent for seeds, low toxicity insecticide for plants and milking lubricants
- **Food–** a key ingredient in food grade lubricants and release agents for cutting tools, chopping boards and hard surfaces to stop food adhering
- **Textile-** used for spinning, weaving and meshing materials. Also used for sewing machine lubrication
- **Polymers–** extender oil for TPE formulation and plasticizer for food contact containers
- **Others–** candles, trimmer lubricating oil, etc.

White oils are used as a component in food grade lubricants for food processing machinery food and dietary products attributed by the halal and the kosher certification to white oil, which has resulted in its rising demand around the globe. White oils are biologically stable product and do not support pathogenic bacterial growth, thus, it is widely used in medicinal & food grades products.

Future Trends

The market globally for white oil is expected to grow at a Compound Annual Growth Rate (CAGR) of approximately 1.5 % during the period of 2019 – 2024 according to a market research site 'Mordor Intelligence'. Asia Pacific (APAC) region is both the largest and fastest growing market for white oil. The personal care and pharmaceutical industries in Asia Pacific (APAC) region are expanding rapidly. APAC is anticipated to dominate the market for white oils with a healthy CAGR during the said period. In India, the largest application of white oils is in the hair oil. The overall cosmetics and pharmaceutical industries account for around three-fourth of the white oil consumption in the country.

Expansion of the white oil market in North America is expected to be noteworthy during the forecast period due to significant demand from the food, cosmetics, and chemical industries. The white oil market in Europe is also projected to expand consistently. Economic and industrial expansion in Middle East & Africa coupled with the rising demand for polymers and specialty chemicals in the region are assessed to boost the white oil market. The white oil market in Latin America is also likely to expand at a slow pace.

Manufacturers of white oils around the globe are putting their best efforts to fortify their market position by acquisitions and technology licensing, adding portfolio of value added products, and developing an enhanced and vigorous distribution network around the globe.

UPCOMING EVENTS 2021

February 16-18, 2021	ICIS World Base Oils & Lubricants	Virtual Meeting Platform; www.icisevents.com/worldbaseoils
March 8-10, 2021	Asian Lubricant Manufacturers Union (ALMU) Annual Meeting 2021	Bangkok, Thailand
April 25-28, 2021	ELGI 32nd Annual General Meeting	Grand Elysee Hotel, Hamburg, Germany
April 28-29, 2021	UNITI Mineral Oil Technology Congress 2021	ICS Exhibition Center, Stuttgart, Germany
May 17-20, 2021	STLE 75th Virtual Annual Meeting & Exhibition	stle.org/annualmeeting
May 19-20, 2021	8th Annual CIS Base Oils & Lubricants Conference	Moscow, Russia

Balmer Lawrie's businesses to be sold off separately

Balmer Lawrie, India's largest grease manufacturer and supplier, is a medium-sized public sector undertaking. It is a stock-listed company and the government owns a majority of shares. Business news site 'Mint' reported that SBI Capital Markets Ltd., the government's advisor for the disinvestment, decided to recommend separate sales because Balmer Lawrie's businesses are so different. It is a Miniratna under the ministry of petroleum and natural gas and is present in eight businesses —travel, industrial packaging, greases and lubricants, leather chemicals, logistics, logistics infrastructure, logistics services, and refinery and oil field services. Throughout its history it has engaged in a wide variety of businesses.

"Given that Balmer Lawrie operates in disparate business areas that are unrelated, perhaps the best way forward may be to offload these eight strategic business units (SBUs) separately. SBI Cap will shortly make a presentation to a committee headed by NITI Aayog CEO Amitabh Kant about the way ahead for the Balmer Lawrie disinvestment," said the source.

Nissan India to hire 1,000 plus workforce to reduce waiting period on Magnite

The compact SUV Nissan Magnite is named the most successful product launched by the company so far, as it has recorded 32,800-plus bookings and 1,80,000-plus enquiries since its launch, the statement said.

Ashwani Gupta, COO, Nissan Motor Company, said, "We are happy to reinforce our industrial strategy with a third shift to meet the increasing customer demand. We hope to continue our contribution to the manufacturing and industrial sector in the country and help create more job opportunities during this uncertain period."

"Nissan India has reached a colossal milestone with the launch of the all-new Nissan Magnite. Customers have given their overwhelming response with a record level of bookings, and as the token of our appreciation, we would like to continue the special introductory price till further notice," Rakesh Srivastava, Managing Director, Nissan Motor India, said.

BASE OIL REPORT

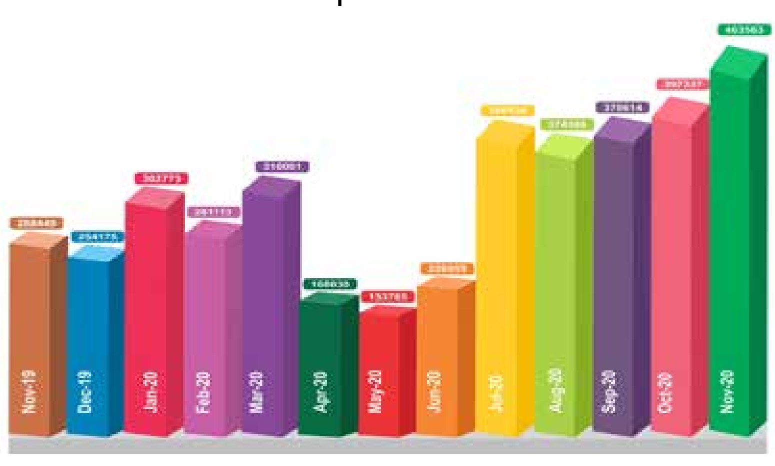
India's crude oil processing registered its first year gain in December 2020, driven by a surge in demand for fuels. Crude oil throughput in December rose 0.9% to 21.02 million tones. At the heart of the pick-up in crude oil processing, fuel consumption rose 4.1% to 18.6 million tons in December, its highest since January 2020.

The Indian domestic market Korean origin Group II plus N-60–70/150/500 prices at the current level are marginally up for lighter grades and heavier grades. As per conversation with domestic importers and traders prices for N – 70/ N- 150/ N - 500 grades and at the current level are quoted in the range of Rupees 55.30 – 55.45/55.25-55.40/62.00 – 62.15 per liter in bulk plus 18% GST as applicable. Discounts are being offered for 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.0.30 – 0.35 per liter on basic prices. Light Liquid Paraffin (IP) is priced at Rupees 56.10 – 56.25 per liter in bulk and Heavy Liquid paraffin (IP) is Rs.66.20 – 66.35 per liter in bulk respectively plus GST as applicable.

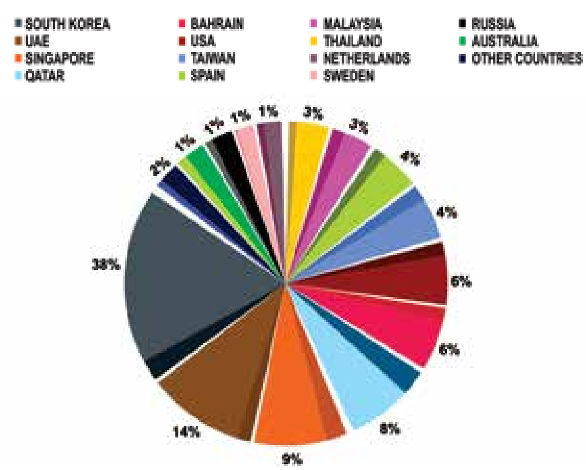
While in the month of November 2020, India imported 463563 MT of Base Oil, India imported the huge quantum in small shipments on different ports like 211608 MT (46%) into Mumbai, 90416 MT (20%) into Hazira, 60899 MT (13%) into JNPT, 26365 MT (6%) into Chennai, 24229 MT (5%) into Mundra, 24026 MT (5%) into Kandla, 16372 MT (4%) into Pipavav, 4965 MT (1%) into Kolkata and 4682 MT (1%) into Other Ports.

Dhiren Shah
(Editor – In – Chief of Petrosil Group)
E-mail- dhiren@petrosil.com

Month wise import of Base Oil in India



Origin wise Base Oil import to India, Country and %- November 2020



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

Month	N- 70 Korea Origin Base Oil CFR India Prices	Bright stock USA Origin CFR India Prices	N- 500 Singapore Origin Base Oil CFR India Prices	RPO Drums (Aromatic Extract) CFR India Prices
November 2020	USD 555 – 570 PMT	USD 625 – 665 PMT	USD 545 – 570 PMT	USD 240 – 255 PMT
December 2020	USD 655 – 665 PMT	USD 720 – 750 PMT	USD 615 - 645 PMT	USD 300 – 315 PMT
January 2021	USD 710 – 740 PMT	USD 805 - 835 PMT	USD 680 - 720 PMT	USD 345 – 365 PMT
	Since November 2020, prices have increased by USD 165 PMT (30%) in January 2021.	Since November 2020, prices hiked up by USD 175 PMT (27%) in January 2021.	Since November 2020, prices have increased by USD 145 PMT (26%) in January 2021.	Since November 2020, prices have gone up by USD 105 PMT (40%) in January 2021.

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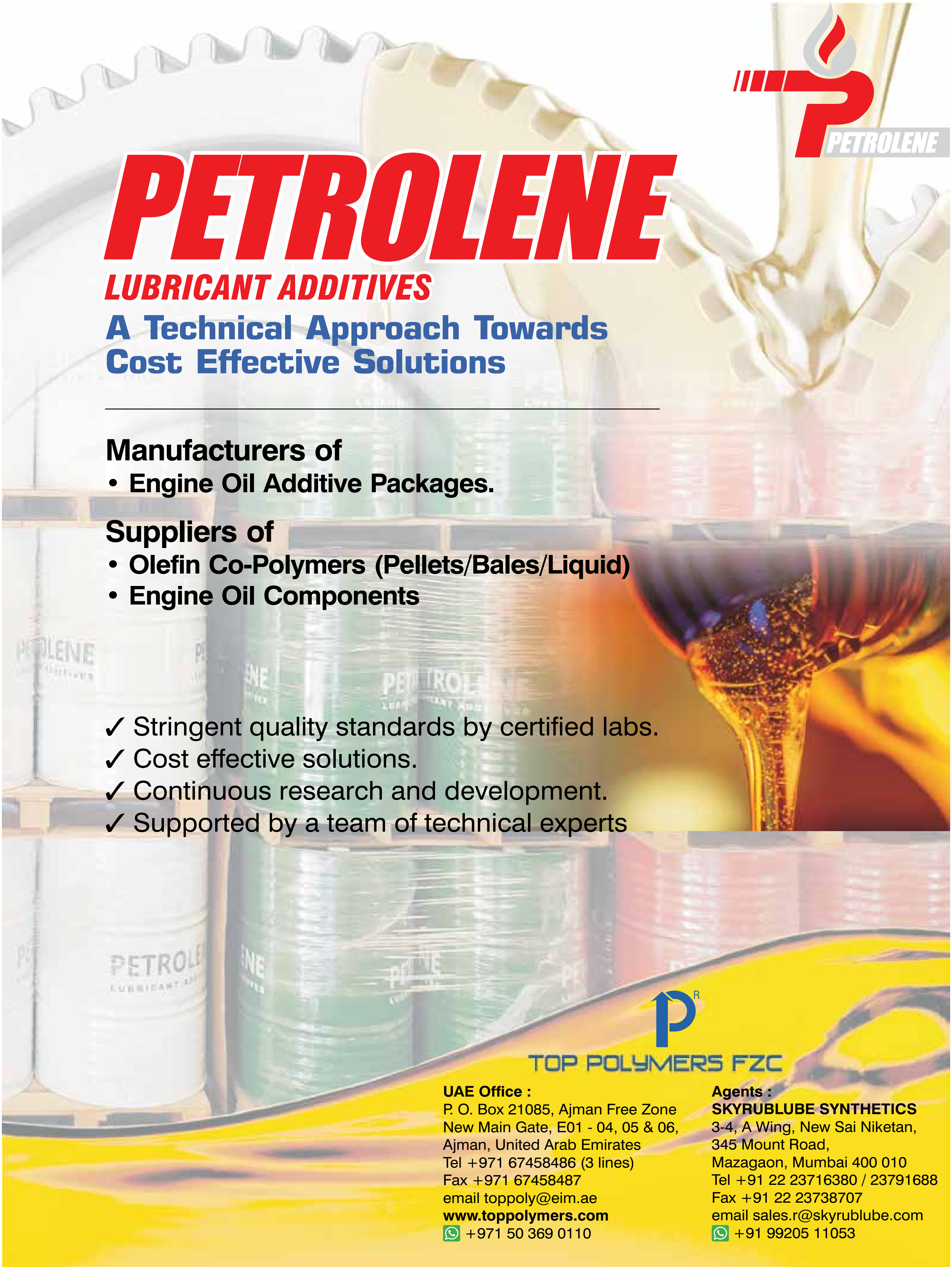
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TOP POLYMERS FZC
UAE Office :
P. O. Box 21085, Ajman Free Zone
New Main Gate, E01 - 04, 05 & 06,
Ajman, United Arab Emirates
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Fax +971 67458487
email toppoly@eim.ae
www.toppolymers.com
+971 50 369 0110
Agents :
SKYRUBLUBE SYNTHETICS
3-4, A Wing, New Sai Niketan,
345 Mount Road,
Mazagaon, Mumbai 400 010
Tel +91 22 23716380 / 23791688
Fax +91 22 23738707
email sales.r@skyrublube.com
+91 99205 11053