INSIDE

How to Verify Oil Filtration Efficiency

Why Grease Cleanliness Should Not Be Overlooked


# Machinery Lubrication

INDIA September-October 2018

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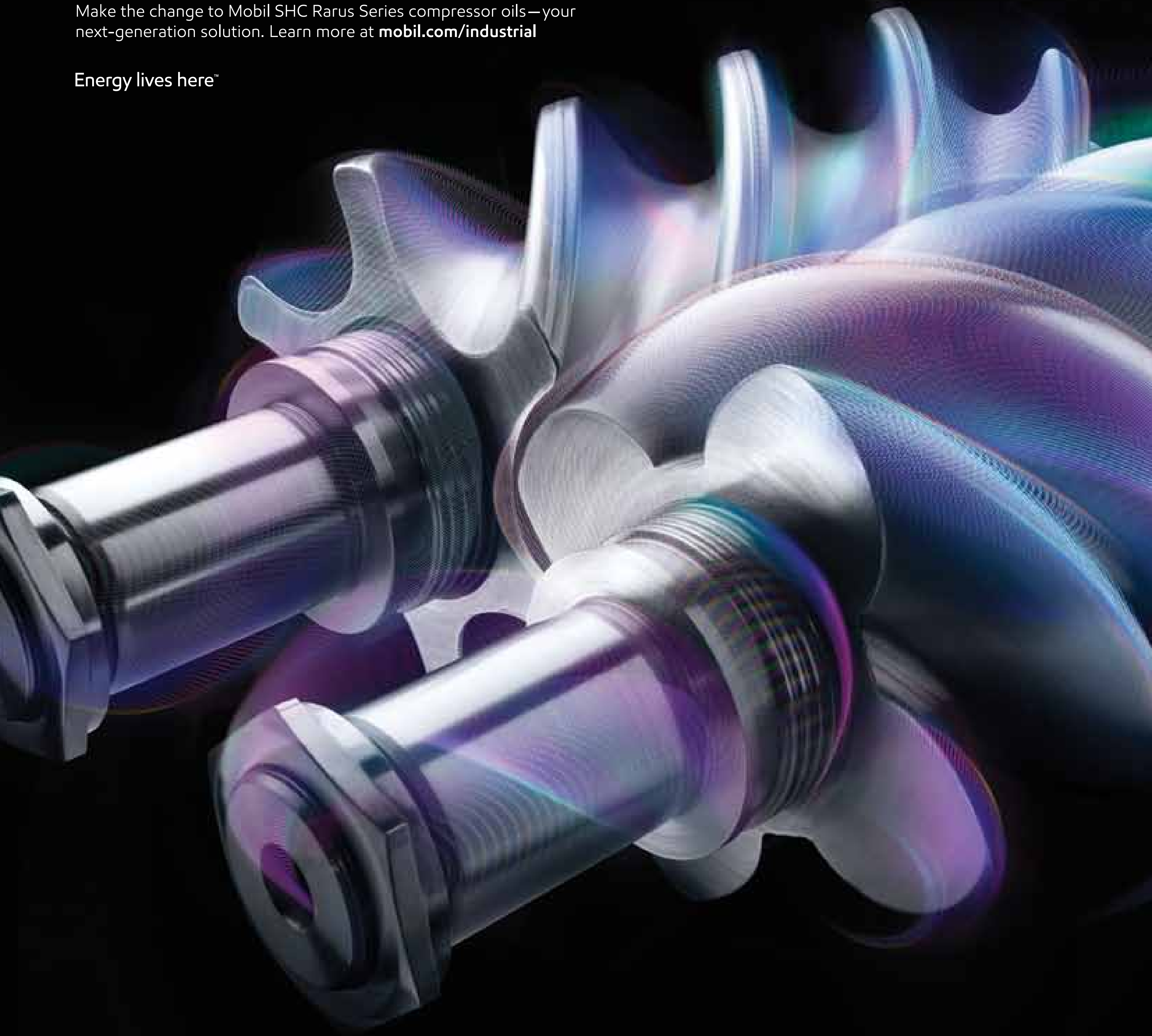
## HOW TO PREVENT EQUIPMENT FAILURES WITH WEAR DEBRIS ANALYSIS

NORIA



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# Publisher's Note

In recent years, new approaches and techniques have been advanced to improve the detection of incipient and developing faults in bearings and gear units using wear debris analysis. As opposed to the application of any singular new or emerging technology, these new methods are more systematic and functional. It begins with improvements in the sampling process to enrich the data and proceeds through the use of specific strategies and tactics. After detection is confirmed, the final analytical phase involves wear particle identification using both classic and advanced techniques.

Qualitative analyses of the particle morphology, is seen as an important factor in deciding what action to take once a problem has been identified, because it assists in identifying the source, severity and mechanism of wear. As important as the physical testing of the sample is the method of communicating results to management.

The benefits of obtaining better intelligence on the health of equipment from correct testing, interpretation and data processing provide management with important information for strategic machine maintenance.

The common goal when it comes to wear debris analysis is to achieve the highest level of machine reliability at the lowest possible cost. However, to reach this goal, several subsidiary objectives must be systematically targeted and achieved. These objectives will be referred to as strategies and, in sum, define the pathway for applying wear debris analysis in attaining machine reliability. It is common to be introduced to wear metal data that fails to exhibit consistent or explainable trends. The data may appear to be fragile, moving erratically without any apparent reason. There are other times when additional predictive maintenance (PdM) technologies confirm a problem, yet no measurable indication from wear metal analysis appears.

Much of these results are caused by poor data quality associated with either the sampling process or the analyses. In other cases, the data is too weak or is lost in the noise range. Most of these problems can be overcome by employing modern techniques and tactics.

Regardless of the technology deployed, it is difficult to obtain good estimates of the residual life of operating machinery. Such information is considered valuable in defining the corrective measures and urgency. When combined with all available conditional information, wear debris analysis can assist in estimating how far wear has progressed and the minimal response time needed.

There are many excellent case studies that have validated the successful application of wear debris analysis in industrial machinery. For the organizations, the benefits and savings emanating from increased machine reliability is real. Success in effectively implementing such programs using wear particle analysis depends on many assorted goals, strategies and tactics. Together, they form an important plan that may depend more on technique and less on technology.

For well-engineered programs, wear particle analysis may be the most penetrating and early warning system of all maintenance technologies in use.

We would like to thank our readers for the encouraging response to our previous edition's cover story – "100 ways to improve your lubrication program" and other articles. Our current issue is on "How to prevent equipment failures with wear debris analysis" which will help our readers to find whether inadequate lubrication or poor maintenance practices are to blame for your equipment problems.

We welcome our readers to participate by sending their feedback & contributing articles and case studies. Best wishes for Navratri & Diwali.

**Warm regards,**

**Udey Dhir**

# Guidelines for **Developing a World-class Inspection Plan**

"A well-constructed inspection plan enhances the likelihood and **magnitude of successful and sustained deployment.**"

Like most business plans and strategies, an inspection plan should be built from the top down. It should begin with a clear statement of corporate goals and objectives related to asset management. This approach is addressed in ISO 55001. Another global standard currently under construction by the International Council for Machinery Lubrication (ICML), ICML 55 focuses on optimized management of lubricated assets. It is aligned to ISO 55001 guidelines as well.

A full-on inspection plan should also be a detailed and comprehensive document to ensure that key features and functional elements are not overlooked. From there, it can be abridged or streamlined for quick review by technicians and operators. The unabridged version of the plan can even serve as a rough curriculum for training and competency testing for both current and aspiring new inspectors.

A well-constructed inspection plan enhances the likelihood and magnitude of successful and sustained deployment. The discussion that follows is more about codifying the structure of an inspection plan, including the tasks and main features that should be incorporated when writing a plan.

Modern reliability and asset management programs expect documented, procedure-based work plans. This reduces the risk of variability, uncertainty and drift over time. The plan is best if it is consensus-based and continually improved. Before considering the input of stakeholders in writing the inspection plan, first get everyone on the same page through training or self-study on the fundamental elements of Inspection 2.0.

Consensus-based inspection plans tap into the knowledge and experience of skilled practitioners, old-timers and others with valuable craft skills. This provides a helpful foundation related to the machine's operating conditions, critical inspection points, reliability history and known failure modes. It also establishes buy-in or ownership among operators, mechanics, technicians and other stakeholders who will be asked to both execute and respond to the plan.

Furthermore, a well-constructed inspection plan communicates the importance of effort and purpose. It documents that Inspection 2.0 differentiates considerably from the conventional inspection practices of the past and that these differences are necessary to achieve the optimized level of machine reliability established by the asset owner.

When writing your inspection plan, consider the following topics:

## Multiple Disciplines

For many (but not all) organizations, inspections should be cross-disciplinary. They should include lubrication, mechanical maintenance, electrical, safety and operational inspections. It makes little sense to conduct one survey for lubrication followed by a similar survey for electrical systems on the same machine. If your plant has different maintenance planners for different maintenance functions (mechanical, electrical, production, etc.), inspections can easily be divided once the information has been gathered. The critical path is getting good data and all the data. The rest will fall in place accordingly.

## Common Goals

Inspection should be purposeful. It should provide routine answers to important questions about the health and condition of the machine overall as well as of the individual components and the lubricant. Inspection is a vital condition monitoring method that requires unification with other companion methods. All condition monitoring activities and technologies should conform to or align with corporate goals and business objectives, particularly as they relate to asset management and machine reliability.

As mentioned, it should start at the top and become increasingly granular and prescriptive as it works down into the specific tasks of condition monitoring and inspection. For instance, if the corporate goal is to increase earnings per share, then inspection must directly and indirectly be structured toward achieving that goal. This might come from increased worker safety, lower maintenance costs, greater asset utilization (productivity) and reduced energy consumption.

## Ranked Failure Modes

What are the questions that inspections are supposed to answer? There could be many, but one is always the general state of your machine's health. Specifically, is there confirmation of health or evidence of incipient or impending failure conditions? Therefore, you need to know the types of failures to be looking for, ranked by likelihood and risk factor. You also must know which inspection tasks and methods can alert you to a failure in progress and

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"What are the questions that inspections are supposed to answer? There could be **many, but one is always the general state of your machine's health."**

perhaps how advanced it might be.

Next, you should understand the root causes associated with each of these ranked failure modes and how these root causes might be recognized by inspection. One root cause can be associated with multiple failure modes. To prevent the onset of failure, it's important to catch root causes early. All known high-risk failure modes should have at least one or more methods in your inspection plan that can reliably reveal their presence.

So, when writing an inspection plan, cross-check that all inspection methods and tasks are aligned to a prominent failure mode or its root cause and that there are no high-risk failure modes that don't have an associated inspection method or task for early detection. This will bullet-proof your inspection strategy when executed properly.

## Machine Inspection Ownership: Operator or Resident Expert?

Each task or method defined by the inspection plan must be performed with seriousness of purpose. The inspector should be responsible and accountable for quality work. In some organizations, the best choice for such an inspector is the machine operator. This is the person who works near the machines and can recognize subtle differences between what is normal and abnormal. This approach is often referred to as operator-centric inspection.

In other cases, the inspector may be a specialist who works full-time in all disciplines of condition monitoring. Perhaps the inspector is the resident expert who only does inspection routes. The advantage here is the ability to have more rigorous training and continuous practice. If you combine deep inspection knowledge with a linguistic understanding of other condition monitoring technologies (e.g., oil analysis, vibration, thermography, etc.), the value and effectiveness can be tremendous. Regardless of whether the inspection plan is operator-centric or supported by a resident expert, it must clearly define responsibilities.

## Inspection Points

Inspection points are physical locations on the machine that must be defined clearly in the inspection plan. These could be couplings, shaft/seal interfaces, breathers, hose connections, sight glasses, gauges, etc. Some inspection points are not visible. For instance, consider the inspection task of touching the upper inside wall of the gear case through the fill port with your fingers. The inspection is looking for moisture condensation and soft deposits. This inspection point is not visible but necessary to assess certain headspace and lubricant conditions. Another example might be the use of a probe or dipstick to reach into the machine to collect inspection data.

Some inspection points may need to be created or installed. A large, inspection-ready machine is usually accessorized with an array of inspection windows, gauges, test points, sample valves, sediment bowls, etc., which are required to fully achieve the inspection objective. Inspection readiness enables better inspection quality (effectiveness) and frequently faster inspection, too. While there may be some costs associated with inspection hardware installation by the asset owner, the benefits can often produce multiples of that cost.

## Inspection Tasks and Methods

Knowing where to inspect is just the start. Next,

**26%**

of lubrication professionals say enabling inspections of their in-service oil and machinery would be the most likely reason for making machine modifications at their plant, based on a recent poll at MachineryLubrication.com

perform the inspection (or make the observation) as designated by the inspection plan. This can be extremely simple (e.g., determining the oil level from the sight glass) or much more complex (e.g., using a laser pointer to confirm the presence of hard or soft particle contamination). If the task or method involves many steps or requires special techniques or tools, the inspection plan must reference a procedure. The procedure is a documented method of performing certain inspections and includes the steps, tools and means of data collection.

## Inspector Skills, Training and Qualification

Inspection 2.0 requires qualified inspectors who possess the skills needed to perform the tasks and methods in the inspection plan. The more complex the inspection method or task, the more there is a need for a detailed inspection procedure and training by the inspector to that procedure. An inspector must qualify to perform inspections.

This means you can't give the inspection assignment to just anyone regardless of education, work experience or responsibility. Engineers with advanced degrees don't have the skills to meet the inspection tasks defined by Inspection 2.0. It's like fly fishing. You can't give a rod and a box of artificial flies to a highly educated individual and expect him or her to wade into the stream and catch trout. If this person has never fished before, no trout will be caught.

## Tools Needed

Inspection must be enabled to achieve condition monitoring quality and effectiveness at its full potential. This is the essence of Inspection 2.0. As mentioned, this increasingly means modifying and accessorizing machines to inspect better and to reach new inspection points. Inspectors also need a toolbox, as would any professional or tradesperson, to function fully in their craft. Many tools or inspection aids enable inspections that otherwise could not be performed. In other cases, they might reduce the time required to complete an inspection and/or enhance the quality and effectiveness of the inspection. The inspection plan (or the referenced procedure) should list each of the tools needed. Don't cripple inspection performance by pretending to save money scrimping on inspector tools.

## Inspection Findings and Data Collection

The type of inspection data to be collected and the manner in which it will be reported should be included in the inspection plan. This can reduce the variability that could occur if, for instance, two inspectors performed the same inspections on the same inspection point using the same methods and inspection aids. It is best if data collection is uniform and has structure. This is the concept behind using a form or checklist for paper-based data collection.

Handheld electronic data collectors can show images and comparators to more precisely score an inspection result or finding. Rather than a binary yes or no response, the results may be scaled from 1-10. Each possible result on this scale is defined by a range of comparator images or a short narrative using the data collector's software interface. This reduces individual subjectivity and provides a scalable, analog-like feature to capture and quantify the degree of changing conditions.

Numerical data collection from inspection routes can be integrated with condition monitoring software to reveal patterns of changing conditions across an array of data types on the same machine and machine condition.

## Inspection Routes

Many inspection points can be compiled and arranged into a route for a given plant or job site. This is especially helpful when a specialized inspection instrument or tool is used on only a few machines or inspection points. Its use can be scheduled and a route established. For example, a portable water contamination tester (for lubricants) may only be needed on machines that are used intermittently and are near water sources. In other cases, it might not be a particular tool but rather a specific skill that only one inspector has, such as training in ultraviolet leak detection.

Most inspections are performed daily by the same inspectors or operators who are assigned to a group of machines. In these situations, routes are not needed. The inspection plan should document all the inspection routes.

## Health and Safety Issues

As previously mentioned, inspection procedures should be specified for each machine inspection task or method as defined in the inspection plan. All inspection procedures should fully cover any relevant health and safety issues.

## Metrics and Compliance

All areas of business and business processes require measurement and reporting. From this information, managers can make better and more informed decisions based on accurate representations of the state of their machines. This is both at a macro level (the forest) and a micro level (the trees). So too, managers need lagging indicators (what just happened) and leading indicators (what's going to happen). Data for these metrics can come from numerous condition monitoring sources and then be filtered and streamlined for decision-makers to use. Inspection is a great source of information related to machine reliability and asset management. This is especially the case when the data quality is at the level defined by Inspection 2.0.

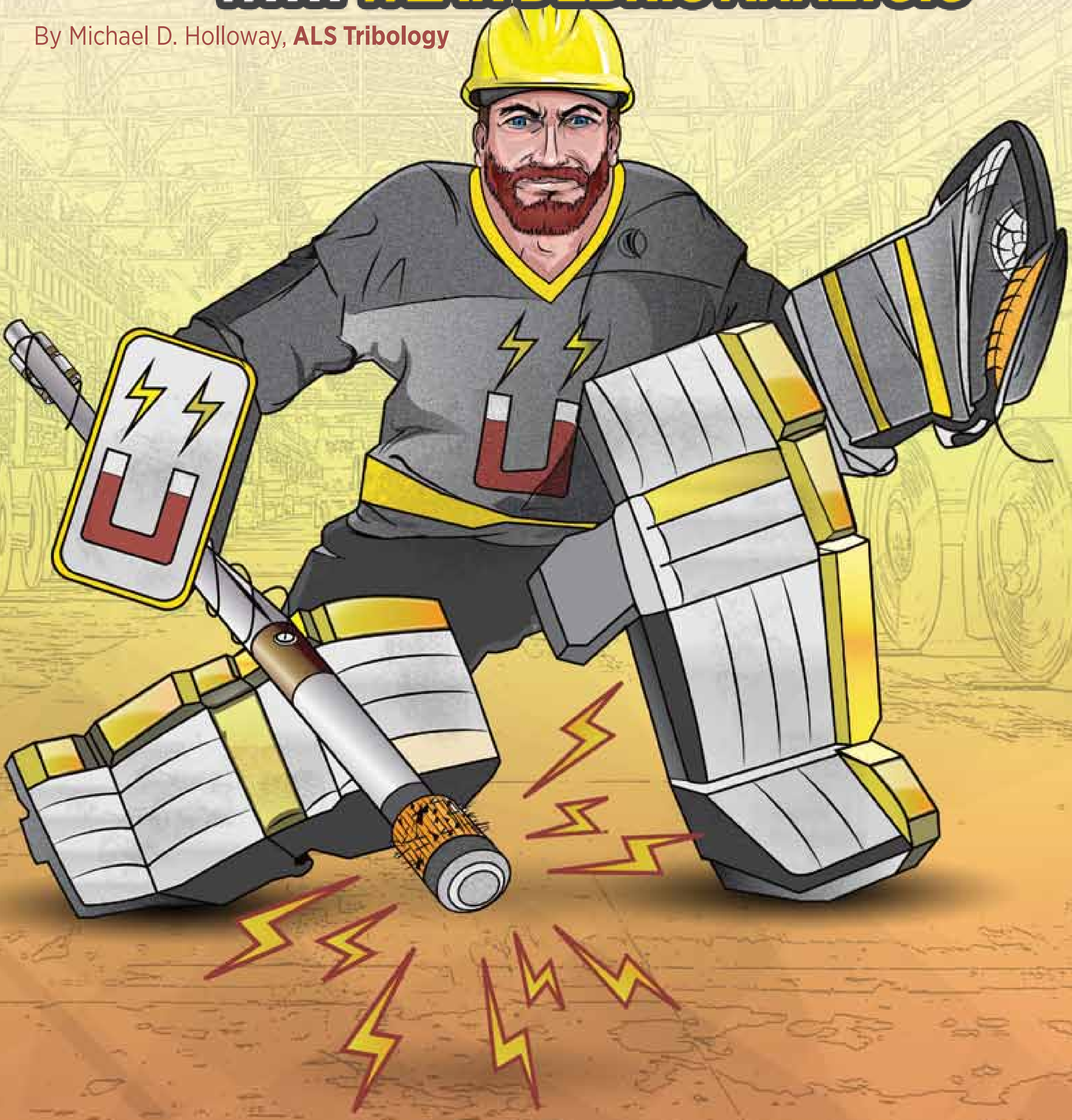
Finally, metrics should include compliance. Inspections often trigger work orders to remediate current problems found by inspectors. Are these getting done in a timely fashion? Compliance may also be needed to verify that all inspection routes are being completed effectively.

## 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.

# HOW TO PREVENT EQUIPMENT FAILURES WITH WEAR DEBRIS ANALYSIS

By Michael D. Holloway, **ALS Tribology**



Lubricated components fail for a variety of reasons. These reasons can be categorized based on the type of failure, specifically early failures, random or event-dependent failures, and condition-based failures.

An early failure event may be the result of inadequate lubrication. When a system is at rest, unless the bearing has hydrostatic lubrication applied, the sliding surfaces will be in contact. As the components begin to rotate, the surfaces remain in contact until the lubricant film is established. During this time, the highest incidence of failure persists. As a film is formed and surface-active additives begin to protect, a lubrication regime is established. Prior to this occurring, surface asperities and particulate will contribute to surface wear and possible part failure.

When there is an imbalance or non-uniform tolerances between part surfaces or the wrong materials or components are used, there is the possibility for premature wear. Poor maintenance practices, workmanship and installation can all lead to an early failure event. Various particles can indicate these scenarios.

Another failure class is random or event-dependent. These types of failures can occur at any point during the system's life cycle. They are caused by too much speed or overloading a component. As speed and load increase, there is an opportunity for the sliding or rolling surfaces to come in contact, generating heat, as well as for particulate to contact the surfaces. In both situations, the surfaces and particles produce wear.

Condition-based failures are primarily due to contamination – both internally generated from wear debris (normal or accelerated) or external sources such as dirt or processed product. The contamination can also be liquid or gas. Gases like hydrogen sulfide or pure oxygen can produce severe corrosion, which generates wear particles. Liquids such as fuel and coolants will contribute to system failures in engines. Water is the most prevalent contaminant that causes metal oxidation and lubricant degradation in oil-lubricated systems. These fluids compromise the viscosity of the oil, resulting in surface contact or oxidation product development. This leads to an increase in the opportunity for failure.

## When Early Failure Occurs

Each asset has a lifespan. Often it isn't until premature failure occurs that an in-depth investigation will ensue. Whether inadequate lubrication, component defects or poor maintenance practices are to blame, routine oil analysis combined with wear debris analysis can indicate a pending failure. Although it is not realistic to perform wear debris analysis on every asset, it is reasonable to test critical assets for wear debris on a scheduled basis. It is also recommended to perform wear debris analysis when beginning an oil analysis program. This will help establish which assets may be most vulnerable to failure.

## When to Perform Wear Debris Analysis

The lubricant can provide insight into what is occurring within a system without having to

3 Categories of Wear Particles

| Fluid or Particle Wear | Sliding, Rolling and Impact Wear | Chemical Wear |
| --- | --- | --- |
| Abrasive | Adhesion | Corrosion |
| Erosive | Spalling/Fatigue | Electro Corrosion |
| Cavitation | Brinelling | Electric Discharge |
| Polishing | Fretting (Corrosion) | |

disassemble and inspect the machinery. Prior to an oil sample being drawn for wear debris analysis, it is prudent to consider overheating, vibration and high system pressure. These may indicate if the oil should be analyzed for wear debris.

Once an oil sample is tested, certain indicators will encourage the use of wear debris analysis. The first indication will be an increase in wear metals like iron, aluminum and copper. Second, check to see if there has been an increase in the particle quantifier index (PQI). The PQI is a test that measures the distortion of a magnetic field applied to the sample while still in the bottle. Used to quantify ferrous particulate, it is beneficial when utilized in conjunction with the wear metal concentration. The test has limitations, as it does not measure nonferrous metals, and a single large particle reads like many smaller particles. When the PQI is lower than the iron levels, chances are there are no particles larger than 10 microns. If the PQI increases dramatically while the iron levels remain consistent or decrease, larger ferrous particles are being generated. This increasing trend should trigger ferrography or wear debris analysis.

## Wear Debris Analysis

Ferrography can be direct reading or analytical. In direct-read ferrography, a magnetic sensor measures ferrous particulate up to 200 microns. The results are reported in DS (less than 5 microns) and DL (greater than 5 microns). The ratio between the two indicates the severity.

Direct-read ferrography is excellent for trending ferrous wear particles and is often used as a screening tool for analytical ferrography, which explores the shape and size morphology of the captured particles. The measurement of particles is expressed as a unitless wear particle concentration (WPC) value and a ratio of small to large particles. If the ratio of large particles (DL) to small particles (DS) increases, this suggests a greater generation of large particles.

In analytical ferrography, a slide is produced with the aid of magnets to separate wear debris and arrange particles according to size. A microscope is used to identify the type of generating wear mode based on the particle's shape and size. The oil sample is diluted for improved flow down the glass slide. The slide rests on a magnetic cylinder, which attracts ferrous particles. The ferrous particles align themselves, with the largest particles deposited at the entry point. Nonferrous particles flow downstream and are randomly deposited. Solvent is added to the remaining sample. After the solvent evaporates, only the particles are left on the slide. The slide is then analyzed by a trained technician.

There are three main categories of wear particles: fluid or particle wear, sliding/rolling/impact wear, and chemical wear. The table above summarizes these categories and lists the mechanisms of each.

## Abrasive Wear

Abrasive wear particles are typically formed from the cutting of a hard, sharp particle or from severe sliding. They can also form as a result of a bearing or gear misalignment. Two-body abrasive wear may be due to a misalignment or an asperity of a harder metal component, which allows gouging of the opposite rotating softer metal. Three-body abrasive wear is often caused by foreign particles in the oil. The harder dirt particle imbeds itself into a softer metal and gouges away metal from the rotating component. These wear particles are referred to as cutting, gouging, ploughing or scratching particles.

Abrasive contamination can generate cutting wear particles that are long and curly, with length-to-width ratios ranging from 5-to-1 to 50-to-1. A common abrasive particle would be sand or dirt. Sand is made of silicon dioxide, while dirt is generally ferrous or aluminum oxides with organic material. These sand and dirt particles usually are induced through a compromised breather element or through seals, O-rings, gaskets, etc. They may be transparent, translucent, opaque, crystalline or a birefringent material.

## Erosive Wear

Erosive wear particles are generated by the loss of material due to the repeated impact of hard particles at a high velocity. Often the extent of erosion varies by the velocity, angle of inclination, particle type and concentration. This occurs in pumps, valves, nozzles and even elbows.

## Cavitation

Cavitation involves the removal of material by repeated implosion of bubbles near or on the metal surface. The bubbles produce violent shockwaves that fatigue the surface until material is removed. This is common in pumps and journal bearings.

## Polishing

Polishing is the continuous removal of material on one or more surfaces by very fine abrasive particles. It creates a shiny, mirror-like surface. The width of

the groove (or scratch) generated by the abrasive is generally 5 to 10 percent of the grit diameter.

## Adhesive Wear

Adhesive wear occurs when excessive speeds, temperatures and loads allow metal-to-metal contact. As the two surfaces meet, the metal welds together. The metal surface may appear scuffed or scored with uneven metal chunks attached to it. Adhesive wear from severe sliding normally involves rectangular particles with striations parallel to the direction of elongation.

In its mild state, adhesive wear is known as "frosting" and is typically not a major concern. In the severe state, substantial material may be removed as a result of metal-to-metal contact. This is sometimes referred to as sliding wear or galling.

## Spalling or Fatigue Wear

Spalling or fatigue wear is seen when loading or contamination is heavy. Maximum sheer stresses occur below the rolling contact surface. This creates a pit or dent, also known as a spall. It begins as a crack below the rolling surface and propagates over time to the point where metal particles are generated from the fatigued surface. The particles typically are round spheres and may appear as black circles with shiny centers under a microscope. They usually are 5-10 microns in size, indicative of bearing fatigue prior to a spalling condition. The spall site produces a weakened state on the surface, and failure can ensue.

## Fretting Corrosion

Fretting corrosion wear occurs between two surfaces as a result of small amplitude oscillations. These oscillations generate oxide debris, which has the appearance of rust or corrosion, hence the term "fretting corrosion." Under microscopic analysis, the particles are characterized by a red oxide color and a uniform pattern. Another form is a complex type of wear that arises in static, oscillating systems. This also takes place in concert with corrosion. The combination of abrasion from wear debris particles with oxidative corrosion is sometimes called false brinelling due to its similar appearance to small-scale plastic deformation. This frequently is seen in idle equipment that is subject to vibration from transportation or adjacent equipment.

## Corrosive Wear

Corrosive wear is caused by an acidic attack on the equipment's internal surfaces. It creates a layer of corrosion products that are subsequently removed by the sliding action. This is not a wear mechanism from a mechanical process, but rather a chemical process. The particles, which are normally less than 1 micron in size, will align themselves on the outside edges of a ferrogram. The surface wear pattern is usually even and uniform.

In conclusion, wear debris analysis is a valuable tool that can complement an in-service oil analysis program. While it may not be necessary for all assets, critical equipment can benefit greatly from this type of testing.

# How to Verify Oil **Filtration Efficiency**

Most maintenance professionals know that clean oil can result in significant cost savings and that oil analysis can be used to reveal the state of lubricants and machines. However, as online particle counters and other sensors become increasingly popular, it is important to be aware that one number does not tell the whole truth about a system's conditions. It takes experience and a variety of tools to translate the vast amount of information that an oil sample carries. Understanding this language by using appropriate tools and efficient oil filters will help you reduce operation and maintenance costs associated with downtime, component wear and oil replacement.

> **"Filters are not created equal** and cannot be tested using the same standards."

For example, consider an online particle counter installed to remotely monitor particles in hydraulic oil. It may show an ISO code of 16/14/11, which would lead you to believe that everything is perfect in the hydraulic system, but is it? Unfortunately, the particle counter cannot detect submicron or very large particles (greater than 200 microns), an installation fault in the counter, if the oil viscosity is off, or if additives have depleted. It also is unable to distinguish the oil color or smell, oxidation, acidity, varnish, water separation efficiencies (demulsibility), or problems with air release or foam. Therefore, you still need to perform traditional oil analysis and onsite tests.


Oil with and without varnish

## Old-school Methods to Verify Filter Efficiencies

A sample can provide a lot of information about an oil's properties and system condition, even prior to shipping it to the laboratory. The following onsite methods can help you translate this information into corrective actions and verify the filter efficiencies of your oil system.

### Visual Inspection

Examine the oil color. Is it comparable to new oil? Oxidation changes the oil color from amber to dark brown. Black usually indicates soot from combustion byproducts or entrained air causing micro-dieseling. Check for air leaks at the suction side of the system pump. Do you see any large wear particles as black or shiny sediment? These would be greater than 100 microns. Use the crackle test (oil drop on a hot plate) to reveal the water level above 1,000 parts per million. Look for cloudiness, emulsions or free water. Does water ingress into the oil system? Check the oil's demulsibility by mixing the oil with water (50/50) and time the separation. More than 5 percent emulsions or more than 20 minutes to separate means the water separation by coalescence or centrifugal forces is severely impaired. Engine

oils, esters, polyalkylene glycols and most environmentally acceptable lubricants can keep water in suspension so there is no free water.

### Shake the Sample

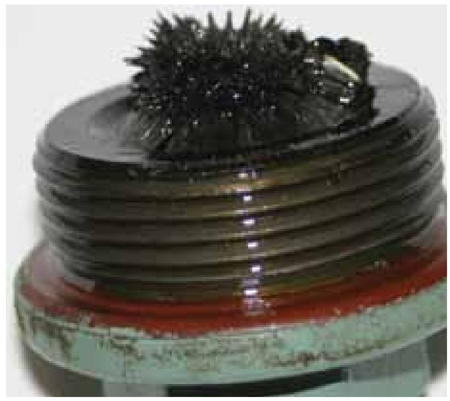
Shaking an oil sample will indicate the foam and air-release properties. Observe how fast the bubbles release and rise through the oil. Look for surface foam. Oil containing particles, water and varnish will hold entrained air longer and may create foam. If the air rises slowly, have a lab test the air-release properties. Clean oil will release air faster and reduce the foaming tendency.

### Cool the Oil

Warm oil will dissolve varnish and water easily, while the same oil will be hazy and less clear when cold. Place the oil sample in the refrigerator overnight. A powerful light and a white paper with black lines will make it easy to see any difference. Varnish and water will fall out of solution in cold machine areas and result in jerky valve movements, corrosion, etc.

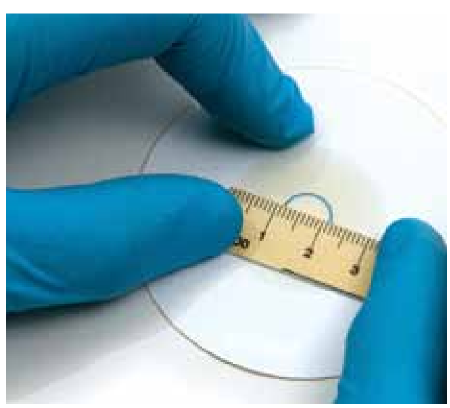
### Use a Magnet

Break off a piece of a used filter element. Iron wear particles are usually magnetic, so if a strong neodymium magnet can lift the material, you have problems with machine wear. You can also hold the magnet to an oil sample bottle to attract iron. Note that iron particles can be black like soot, shiny as silver or amber/brown like varnish/rust. If you can see iron in the oil or on the used filter, have a lab perform a particle quantifier/wear particle concentration test.



### Inspect the Filter Element

Inspect a used filter for shiny particles from metal wear, such as iron or brass. Break up the used filter element to see multi-layer buildup, which should be clean on the back. If not, the filter has not performed as intended. A USB microscope (magnifying 200-400 times) can reveal the color, size and shape of captured particles. Photos of magnified particles can tell more than a thousand words and help predict a wear situation. A ferrogram can show even more.

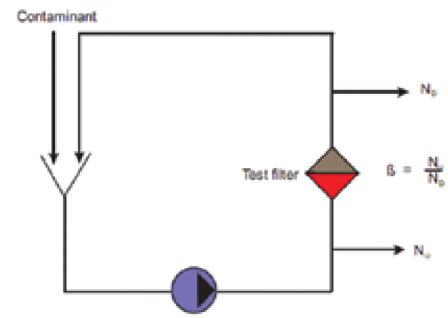


### Blotter Spot Test

A drop of used engine oil on chromatographic paper will reveal soot, glycol and fuel dilution. Excessive soot contamination causes the dispersant additives to deplete, which will form a black spot on the paper. Oil with good additives will lift soot particles easily and show a dark gray color across the paper. Glycol forms a black, sticky paste with sharp edges, which is unable to travel on the paper. Fuel dilution can be seen under ultraviolet (UV) light, as a fluorescent ring will appear after 24 hours.

## Multi-pass Test and Depth Oil Filters

While the methods described previously can verify oil filter efficiencies, so can filter tests like the multi-pass test (ISO 16889). This test is designed for pleated

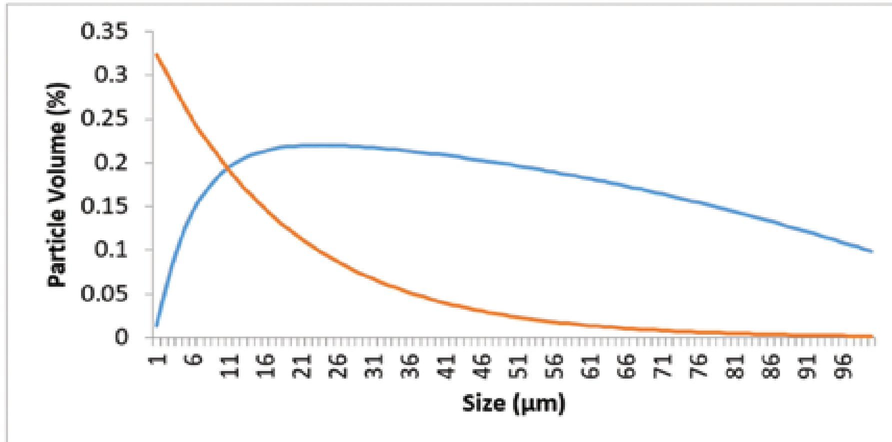



Multi-pass test

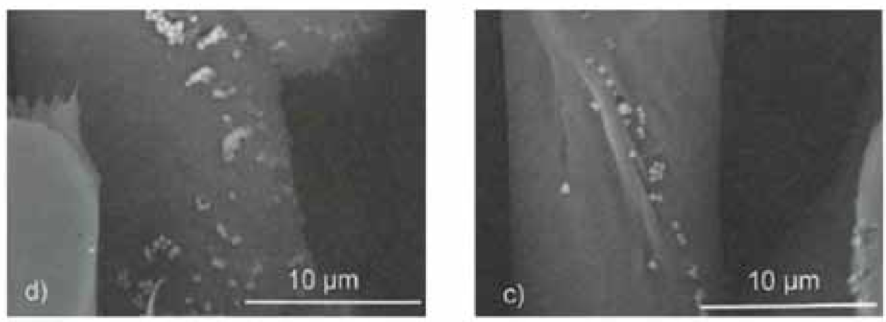
pressure filters to establish a measure for manufacturers to illustrate the performance of oil filters. It can also be used by end users to compare the properties and performance of various filters. The beta value expresses an efficiency quota at a given particle size. For example, Beta3=75 means for each 3-micron particle that has escaped through the filter, 75 pieces of 3-micron particles have been retained. This can be calculated into an efficiency percentage as: (1 – (1/75)) x 100 = 98.67 percent.

Unfortunately, multi-pass tests cannot be used for depth filters. Most of these tests utilize medium test dust (ISO 12103-A3), which consists of large, lightweight ceramic particles. These particles are easy to capture in a pleated filter element, but at a constantly high ingress, they will block the surface of a dense cellulose depth filter. Therefore, the results will show only a fraction of the true efficiency and dirt-holding capacity of the depth media.

In real-world applications, wear particles, such as iron, are heavy and will slowly press their way through the thin sheets in pleated




The graph above shows the particle distribution sizes in medium test dust (blue) vs. real wear particles in oil (orange).




Submicron particles adhere to the surfaces and crevices on special cellulose fibers.

filter elements, with any pressure pulses or shocks making it worse. Consequently, in most applications, an in-line pressure filter will not perform as well as its multi-pass test result. Adding an off-line depth filter is recommended to ensure performance.

### Cellulose Depth Filters vs. Pleated Filters

You may have heard that an oil filter made of cellulose is not as good as a filter made of glass fiber. If you are referring to pleated filter elements, then it is correct that a thin filter material of cellulose is not optimal. Water and particles will wear on the thin sheets, which will break over time. Caterpillar recommends an in-line pressure filter made of cellulose be used for a maximum of 500 hours with diesel engine lube oil.

However, do not be misled into thinking that all cellulose depth filters are the same. Some depth filters incorporate a completely different design and do not wear over time. These filters use strong, specialized cellulose fibers for strength and improved filter efficiency, especially for the retention of very small particles. Then again, are extremely small particles (0.2 to 4 microns) important when particle counting most often looks at particles that are 4 microns and larger, e.g., 4, 6 and 14 microns? Consider the dynamic oil film thickness in gears, roller bearings and servo valves. They are all less than 3 microns. This is why off-line depth filters have been chosen for more than 80,000 heavily loaded wind turbine gearboxes running dynamic oil film thicknesses below 1 micron.

When it comes to the retention of particles smaller than 6 microns, cellulose depth filters have excellent performance. They also have a high dirt-holding capacity for submicron particles and can maintain their capture efficiency even when loaded with particles. Thus, cellulose depth filters release few small particles under stress and pressure bursts. In addition, many of these filters can absorb water from oil, and some types can even remove varnish. High base number values and a lower acid number can be maintained if special cellulose blends are used to reduce acidity, oxidation byproducts and submicron particles.

Installing an off-line cellulose depth filter can often result in longer oil service life, sometimes by as much as three to five times. For example, Volvo engines on mobile mining equipment are now running 1,500 hours instead of requiring 250-hour oil change intervals. The oil analysis results have also never looked better.

In conclusion, used oil and filters carry a lot of information about your oil and machine components. Although it may not seem easy to interpret this information at first, there are a number of tools available to do so. Remember, all oil filters are not created equal and cannot be tested using the same standards. Keeping your oil clean, cool and dry is the most efficient way to reduce the operating and maintenance costs associated with downtime, component wear and oil replacement.

# The Importance of **Check Valves** in **Hydraulic Systems**

Check valves are the simplest form of hydraulic devices in that they permit free oil flow in one direction and block oil flow in the opposite direction. Check valves may also be used as a directional or pressure control in a hydraulic system.

In Figure 1, oil is flowing in from the left side port, through the check valve and out the right side port. If the pressure equalizes or is higher in the right side port, the check valve will close and block flow in the opposite direction.

The spring rating varies based on how the valve is used in the system. One of the most common locations for a check valve is immediately downstream of the hydraulic pump (Figure 2). Notice that no spring is shown with the check valve symbol. When used in this application, the spring pressure rating is usually 1-5 pounds per square inch (psi) and therefore not shown with the symbol. In this case, the valve is used as a directional control in that it allows oil flow from the pump to the system but blocks flow in the reverse direction. This is commonly called a pump isolation check valve. This valve serves four purposes within the system, which are detailed below:

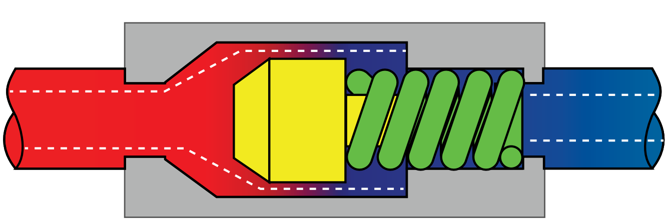


**Figure 1.** In this system, oil flows from the left side port, through the check valve and out the right side port.

## Block Pressure Spikes

The check valve will block pressure spikes back to the pump. Depending on the pressure, oil flows from the pump to the system at a speed of 15-30 feet per second. When a directional is de-energized to block flow or a cylinder fully strokes, the oil is rapidly deadheaded. The pressure in the line can quickly increase by two to three times. The check valve should then close and block the pressure spikes to the pump.

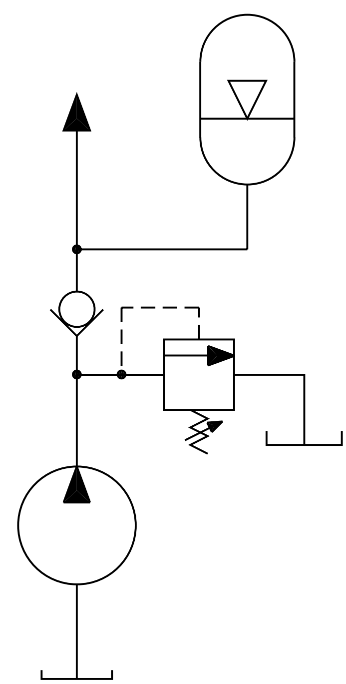


**Figure 2.** Check valves are often located immediately downstream of the hydraulic pump.

I recall a plywood plant changing four pumps due to cracking of the pumps' housings. This occurred over a week's time on the debarker hydraulics. When the plant ran out of pumps, the staff finally took out the check valve and found that the piston and spring were no longer in the valve. This $150 check valve cost the company $15,000 in replacement pumps and another $50,000 in machine downtime. That was one expensive check valve. The truth is that if one mechanic had looked at the schematic and known why the check valve was in the system, the replacement of the pumps and subsequent expenses would have been avoided.

## Prevent Oil Lines from Draining

When a system is shut down, it is important to maintain oil in the lines. In many cases, the pump is mounted below the level of the system valves, cylinders and motors. The check valve downstream of the pump will prevent the lines from draining once the electric motor is turned off. If the oil in the lines drains through the pump and into the reservoir, a vacuum will occur. Air will be pulled into the lines through the O-rings and seals of the valves and actuators. This can create issues when restarting the system, as the air will need to be bled out.

## Block Oil Flow from the Accumulator

Some systems have a hydraulic accumulator installed downstream of the pump and check valve. When the system is turned off, there is pressurized fluid inside the accumulator. The check valve will block flow from the accumulator, preventing the reverse rotation of the pump. You can observe the pump shaft or electric motor fan to verify that the check valve is good. Please note that all systems using an accumulator should have a method of bleeding the hydraulic pressure down to zero psi when the system is turned off.

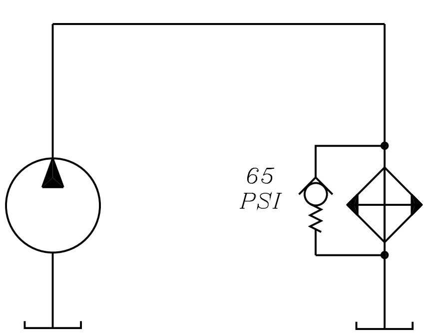



**Figure 4.** A check valve may also be used as a relief valve to protect a heat exchanger.

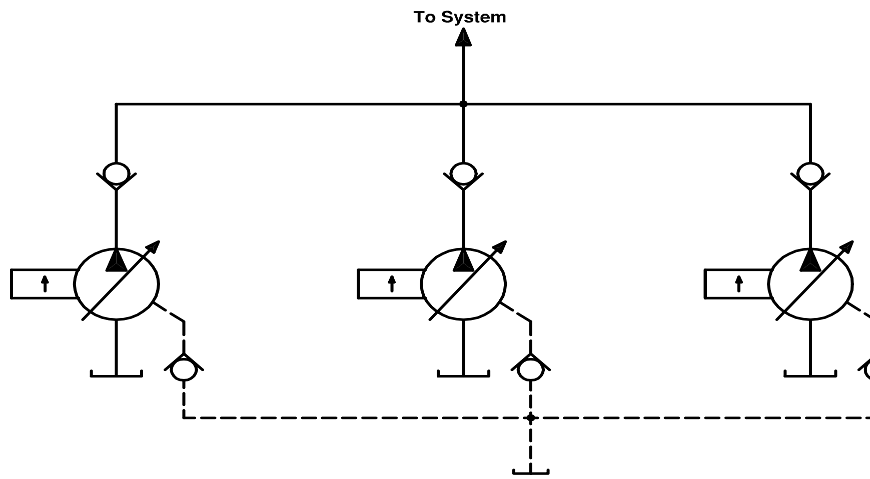



**Figure 3.** In some systems, one pump is used as a backup or spare, with each having a check valve at the outlet port.

## Prevent Oil Flow from the Online Pump to the Offline Pump

On many systems, one pump is used as a backup or spare (Figure 3). Each pump will have a check valve at the pump outlet port. The check valve will block flow from the online pump to the offline pump, preventing reverse rotation.

I remember being called into a papermill that kept losing one of the two pumps on its chemi-washer drives. The shaft seal of one pump continually blew out. When the mill ran out of spares, personnel had to ship their last pump by air freight to the factory in New York. The timeline was so critical due to downtime costs that the pump was still warm when they received it back from the factory. Just prior to installing the pump, we removed the check valve in the case drain line and found it stuck in the closed position. This prevented the oil in the pump case from draining, which resulted in blowing out the seal.

Frequently, a check valve is used for pressure control. A common application is to employ it as a relief valve to protect a heat exchanger (as shown in Figure 4). In this case, the spring rating is usually 65-100 psi. If the oil is cold, the inlet pressure to the cooler may reach the check valve's rating. The check valve will then open and direct the pump volume around the cooler. A check valve will also provide protection for an air-type heat exchanger if the tubes become contaminated.

A few years ago while teaching a class at a sawmill, I observed the students doing their hands-on exercises on the edger. Although a check valve was shown on the schematic to protect the air cooler, the lines to the check valve were plugged off. I asked one of the mechanics about it. He said the check valve was taken off years ago and that they had changed the cooler the week before because of ruptured tubes.

When troubleshooting hydraulic systems, most everyone looks for something large to be the problem, such as a pump, valve or cylinder, but every component has a function. Be sure you understand the purpose of the check valves in your systems.

## About the Author

Al Smiley is the president of GPM Hydraulic Consulting Inc., located in Monroe, Georgia. Since 1994, GPM has provided hydraulic training, consulting and reliability assessments to companies in the United States, Canada, the United Kingdom and South America. Contact Al at gpm@gpmhydraulic.com.

# TEST YOUR KNOWLEDGE

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

## 1. Which wear mechanism involves a collapsing bubble to do damage?

A) Adhesive wear
B) Erosive wear
C) Cavitation wear
D) Corrosive wear
E) Delamination wear

## 2. When storing lubricant drums outside, it is best to:

A) Store vertically (with the top surface flat) in the open sunlight
B) Store at an angle with the openings at the high and low positions
C) Store horizontally and covered
D) Cover them with a sheet of plywood
E) Store them upside down

## 3. Moisture exists in which of the following forms (related to oils)?

A) Free, dissolved and entrained
B) Dissolved and free
C) Demulsified
D) Entrained and foam
E) Dissolved, emulsified and free

## ANSWERS

**1. C**
When bubbles transfer from low to high pressure zones, they implode, producing intense pressure and surface damage (cavitation wear).

**2. C**
When storing lubricants outside, it is better to store them horizontally and to cover them in order to prevent contaminants (particularly water and dust) from entering the drum through bungs.

**3. E**
Dissolved water exists when the moisture concentration is below the oil saturation point (solubility limit). Emulsified water exists when the moisture content is within or more than the saturation range based on the properties of the oil/water mixture. Some or all of the water above the solubility limit forms a stable emulsion. Free water normally appears when moisture content is higher than the saturation point and the oil has good demulsibility (ability to separate from water).

Rich Wurzbach | MRG Labs



# Why Grease Cleanliness Should **Not Be Overlooked**

"Many of the tools that work for oil, such as filtration and moisture removal technologies, aren't readily applicable to grease."

Many years ago, while venturing out into a power plant to take my first oil samples from plant machinery, I was accompanied by a seasoned mechanic. He was there to ensure I didn't do anything detrimental to the machine in my sampling efforts and to top off any reservoirs that were low following the sample being taken.

With my dip-tube and stand-off rod method, along with the large, accessible oil-fill cap in the motors, I was able to take most of the samples without a significant drop in the oil level. However, one was close to the lower limit before the sample was taken, so we agreed that it should be topped up.

The mechanic looked around and spotted a bucket sitting near the motor. I asked if it was appropriate for that bucket to be used to get new oil to top off the level. Wouldn't it be a bit dirty? The mechanic agreed, pulled a rag out of his back pocket, wiped the inside of the bucket and proceeded to the lube storage room to get his top-up charge of oil.

We now know better and realize that the debris in that bucket was going to be flushed into the motor and cause damage to the bearing. The debris undoubtedly contributed to abrasive and fatigue wear, and the life of that bearing was irreparably harmed.

Today, the recognition of the damage and machine life reduction produced by dirt and moisture contamination has led to an entire industry focused around keeping oils clean. Protecting oil supplies, filtering them when they get dirty and preventing contaminants from entering machines while they are in operation are proven strategies to extend machinery life.

The mechanic wiping the bucket with his rag had no way to know just how dirty his bucket really was, relying only on his vision

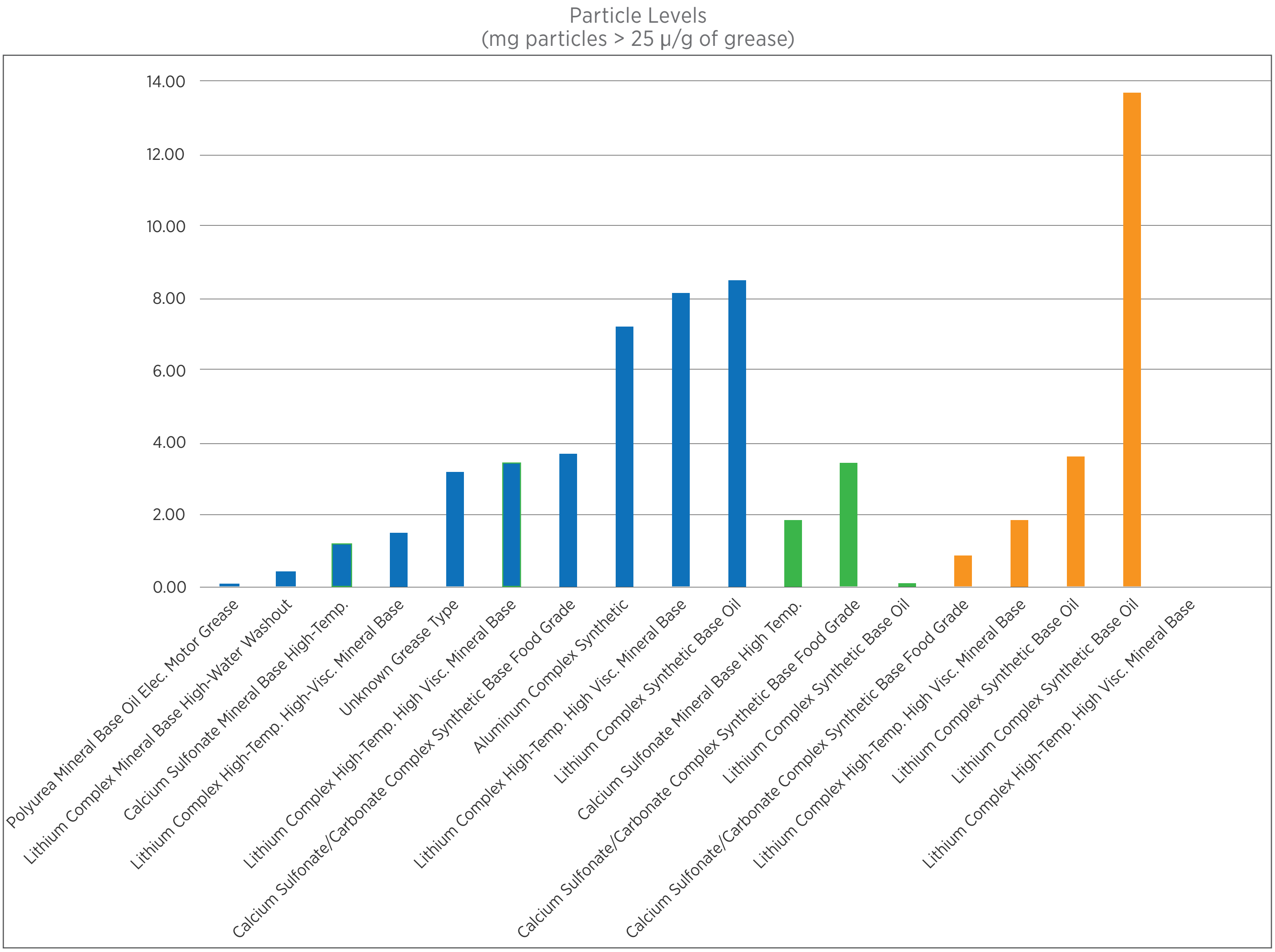



**Figure 1.** Particle levels in new greases (green), from grease guns (brown) and from the machine (blue)

as a measure of cleanliness. Therefore, we monitor the effectiveness of our filtration and exclusion efforts through careful oil sampling, particle counting and moisture analysis. Top reliability programs not only sample oil from their machines but also check the cleanliness of new oil supplies, transfer containers and the quality of oil while it is being remediated through filtration and separation technologies.

## What About Grease?

It's understood that particles in oil lead to bearing and gear abrasion, three-body cutting wear in plain bearings, and surface fatigue through particle denting in rolling-element bearings. A study by the National Research Council of Canada assigned 80 percent of bearing failures to particle-initiated failure modes across several industries. In addition, high water levels in oils contribute to corrosion, loss of lubricating film strength and impeded function of vital additives. But what about grease? Hard particles in grease are similarly introduced to bearing and gear surfaces, resulting in the same failure modes. High moisture levels in greases can also impact lubricating films and interfere with grease and additive functionalities. Is anything being done about this?

Perhaps grease cleanliness gets little attention because the problem is not obvious. When severe moisture levels are present in oil, the oil becomes cloudy or separates into a free water phase. Even high dirt concentrations, if left still in a clear container to settle, will become apparent as a deposition layer, although the individual particles may not be visible. On the other hand, grease keeps its contaminants in suspension within the thickener matrix, hiding even severe cases of contamination from our eyes. Grease analysis is mostly an afterthought, a tool only used in the most specialized cases.

## Cleanliness Standards for Grease

Nearly 15 years ago, the U.S. military recognized the flight safety impact of greases and placed requirements to protect the performance of their assets. Two standards (Mil Spec MIL-G-81322 and MIL-G-81937) were developed for aircraft and instrumentation greases. The particle

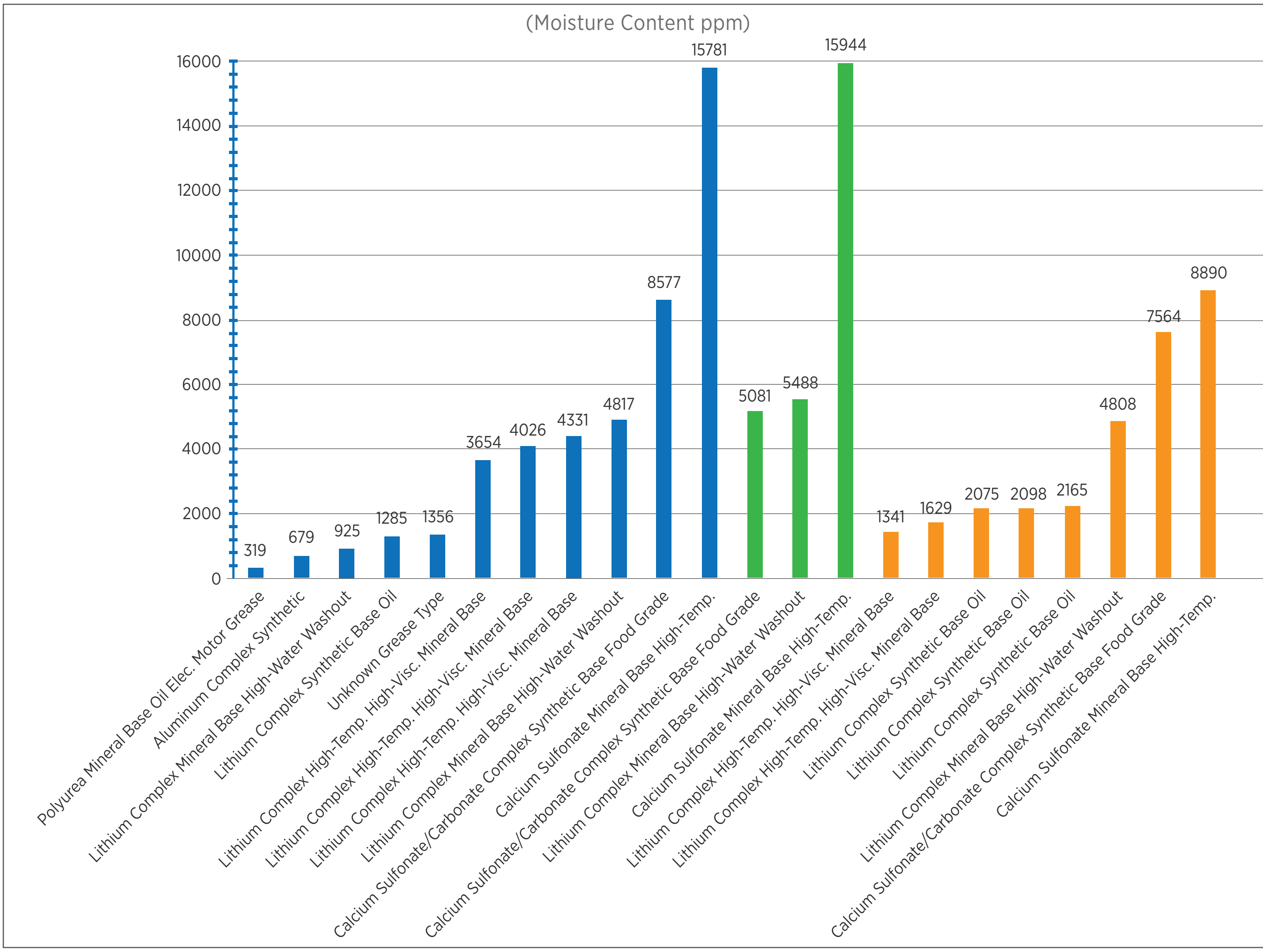



**Figure 2.** Moisture levels in new greases (green), from grease guns (brown) and from the machine (blue)

cleanliness for aircraft greases was established at a very low level, while the instrumentation greases' level was even lower. The aircraft grease cleanliness standard required less than 1,000 contaminant particles per cubic centimeter between 25 and 74 microns, and no particles larger than 75 microns. Instrumentation grease was less than 1,000 particles per cubic centimeter between 10 and 34 microns, and no particles larger than 35 microns.

How do currently available commercial greases stack up against these requirements? A recent study of new, deployed and in-service greases showed that very few met these requirements, and some were downright filthy. "Deployed" grease refers to a grease that has been removed from its original packaging but not yet placed into a machine housing or component. This includes grease in an auto-luber reservoir or loaded into a grease gun awaiting transfer to the machine.

Figure 1 shows the initial results of this study, presenting the particulate content in milligrams of debris per gram of grease, of particles greater than 10 microns. An approximate equivalent for the Mil Spec aircraft grease requirement would be approximately 0.1 milligram per gram. Of the greases tested, only two in their new packaging met this target, while seven others failed. Some were close, but others had nearly 100 times this amount of particulate. The new packaging samples are highlighted in blue, showing values ranging from 0.07 to 8.5 milligrams per gram for particles greater than 25 microns.

**80%**

of lubrication professionals do not have a grease analysis program at their plant, according to a recent survey at MachineryLubrication.com

## Controlling Contamination in Grease

When there is too much particulate in your oil, the course of action is clear: filtration of the lubricating oils through the application of multiple technologies. However, when you have dirty greases, the path forward is not so clear. Grease cannot be filtered effectively after formulation for two main reasons. Mixing and flow of a fluid is necessary when introduced to a filter to ensure uniform opportunity to remove particulate from the fluid, which is not typically achievable with grease. Secondly, normal filtration methods generally disrupt and break down the grease's thickener, which is designed to give it consistency and keep it in place within the machine. Therefore, you must ensure the cleanliness of greases in their manufacturing, packaging, handling and introduction to the machine. While in the machine, you must use effective seals to keep out contaminants or utilize a strategy of grease purging to keep the contaminants at bay. Of course, this only works if the grease you use to purge is confirmed to be clean.

In addition to particles and the damage they can do, you must consider moisture in greases as well. When high moisture is present in oils, phase separation or cloudiness allows you to see these very high levels. However, the same clarity seen in dry oils is not present in greases. As moisture levels increase in greases, these high levels are not always visually obvious.

As Jim Fitch pointed out in a recent *Machinery Lubrication* article, "… it takes only a small amount of water (less than 500 parts per million) to substantially shorten the service life of rolling-element bearings." Using this as a guide, we find that out of 22 greases tested in this same cleanliness study, only one met this criteria for dryness. Most greases showed moisture levels higher than 1,000 parts per million (ppm), with the wettest greases in the study having more than 10,000 ppm.

Not all greases are equally affected by moisture, and the grease types that showed the highest level in this study have been cited to be less sensitive to the effects of higher moisture levels. However, it is interesting to note that one grease saw its moisture concentration cut in half (from nearly 15,000 ppm to almost 9,000 ppm) after being placed in service within the machine.

Even so, it may not be a good strategy to use your machines to dry out greases. Perhaps the first steps would be understanding the moisture levels your new and stored greases are starting with, then working with your suppliers and improving your storage methods to reduce the initial moisture levels as low as possible. By doing so, you stand to gain substantial increases in bearing life and grease performance.

Perhaps it's time to take the focus on lubricant cleanliness, which has been applied so effectively to oil, and expand it to include grease. Many of the tools that work for oil, such as filtration and moisture removal technologies, aren't readily applicable to grease. However, there are several things you can do to improve grease cleanliness, starting with taking the required measurements to determine just how clean (or dirty) your current grease supply is.

While a continued focus on oil cleanliness remains important, the next logical step in making substantial gains in equipment reliability and life extension may be achieved by taking a closer look at the contaminants hiding in your greases.

# "Which would be the best application of oil: an oil lifter (ring and collar) or oil circulation in a ventilator (large roller bearing with medium speed)?"

Oil application methods vary based on a number of variables such as speed, size, lubricant viscosity and ambient conditions. You must match the lubricant delivery mechanism with how the machine is expected to operate. Otherwise, large amounts of wear can be generated, causing downtime and potentially excess energy consumption.

It is important to understand the benefits and weaknesses of each method. Oil lifting devices are among the oldest lubricant delivery mechanisms. They utilize the machine's rotational movement to pick up oil and transport it to the component that needs to be lubricated.

The biggest difference between a ring oiler and a collar oiler is how it is affixed to the shaft. Ring oilers are not attached to the shaft but simply ride on it (sometimes in grooves) and lift the oil where it needs to go. Collar oilers are firmly attached to the shaft and rotate with it accordingly. Both ring oilers and collar oilers must operate at a defined shaft speed and be sized appropriately to lift the proper oil volume to lubricate the machine.

While these devices are simple and generally require little maintenance, there are some inherent drawbacks in their use. Perhaps the biggest potential problem involves insufficient oil levels. The oil level inside the machine must be continually inspected to ensure the lifting device can function properly. An oil level that is slightly too high or too low can greatly impact the effectiveness of these devices.

In cold conditions, there is also a risk of channeling, which means the lubricant viscosity is too high to be lifted. During startups and shutdowns, rings and collars may simply not lift enough oil to lubricate the machine. This can lead to boundary conditions and increased wear of the internal machine parts.

Circulating oil systems are common for large, complex equipment, but they can be adapted to work on most oil-filled housings. Machines operating with circulating oil tend to run cooler. The lubricant also tends to last longer in these systems.

Circulating oil systems typically have a larger volume of oil, and the additional piping and pumps allow you to better condition the oil with filters and heat exchangers built into the oil loop. Of course, there is added cost for these systems, and they must be monitored for leaks and to ensure the pump is working properly.

If feasible, it would be best to go with a circulating system, as its benefits far outweigh the negatives. While this will cost more, you can better lubricate your machine if the circulating system is installed correctly. To help prolong the life of the machine and potentially the lubricant, be sure to include filtration in this type of system. Over time, this may pay for the upgrade of the system.

# "What could cause a substantial reduction in the specific lubricating oil consumption (SLOC) value for a gas engine?

*There are some instances in which we have seen a sharp decline in the daily top-up of lube oil. What are the probable causes? Is crankcase ventilation pressure the culprit?"*

To understand the reduction in oil consumption, you must first determine where the oil is going. This will help diagnose the reason for the measured decline.

Some degree of oil consumption is to be expected in all engines. What is considered normal or acceptable will vary based on the application and the design of the engine.

Some engines consume oil by design from the very first time they are started. The consumption may be as much as one quart per 1,000 miles and yet still be considered acceptable.

Speed and load also affect oil consumption. The higher the revolutions per minute, the more oil will be consumed. The added pressure on the seals and gaskets allows some of the oil to find its way around and get burned away in the combustion chamber.

In addition, the condition of the seals and gaskets should be considered. The older and more worn the seals are, the more oil will be consumed.

High operating temperatures can also impact oil consumption. The hotter the engine runs, the lower the viscosity will be. Once again, it will be easier for a thin oil to reach the combustion chamber and get mixed and burned with the fuel. Keep in mind that there is a point at which the oil's smaller molecules will evaporate. If the oil being used has a viscosity that is below the recommendation of the engine manufacturer, oil consumption will occur for the same reason.

High volatility is another factor in oil consumption. Usually found with lower quality base oils, the volatility is the evaporation of smaller oil molecules. This oil vapor reaches the crankcase headspace and is often pulled into the intake and consumed by the combustion process.

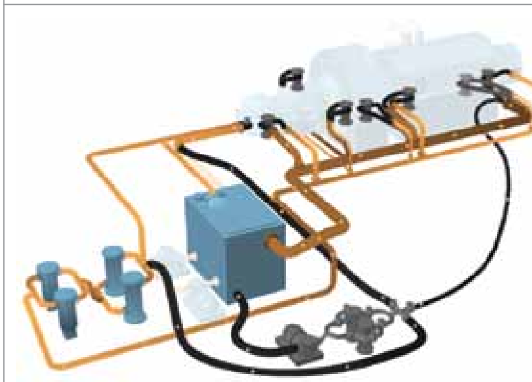
So, what could cause a sharp decline in oil consumption? With so many variables, it can be difficult to pinpoint a single offender. It may be just the right combination of a few factors. The most likely causes are simple things like a viscosity change, a lubricant quality change, a seal that was once leaking but has now stopped or operational severity changes.

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

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

## How Water Contamination Affects Oil Viscosity

It’s important to understand what can happen to the viscosity of an industrial lubricant, such as hydraulic or gear oil, when it is contaminated with water. A common misconception is that the water will reduce the viscosity of the lubricant. In fact, if an excessive amount of water is “whipped” into the oil in such a way that it forms a stable emulsion, the viscosity can increase, sometimes dramatically so. The oil/water emulsion will not lubricate as well as clean, dry oil. Not only that, but the viscometrics of an emulsion are different than that of oil, so other problems such as poor valve response or high-pressure drops across filters can occur.



## Bearing Lubrication Caution

It is important that rolling-element bearings lubricated by an oil circulation system do not rotate at any time in the dry condition, especially after a long period when most of the oil will have drained away from the bearing. Rotation under this condition can cause severe damage to the rolling surfaces. This situation may be avoided by ensuring that the oil pump, which supplies the oil to the bearings, is started before the machine drive system is put into operation.

## Check Makeup Valves in Oil Sumps

The oil sumps of modern gas engines are getting smaller while the power outputs are increasing. This puts increased stress on the oil in circulation. Many sump levels are controlled automatically by makeup valves. Check the setting of these valves, as they can often be set low, which means you do not get the full charge of oil in the sump and face shorter drain periods. Also, make sure you drain the oil cooler as well as the sump during the oil change, as there is often a considerable amount of old oil (up to 10 percent) held in the pipework just ready to contaminate your fresh oil.


### Did You Know?

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

### Have Some Tips?

If you have a tip to share, email it to editor@noria.com.

By Paul Hiller, ICML

# 3 Ways the ICML Awards Can Benefit You

To check the dates and locations of upcoming MLT exam sessions or to apply for an exam, visit the ICML website at **icmlonline.com.**

For the past 17 years, the International Council for Machinery Lubrication (ICML) has recognized a variety of plants, programs and individuals with two prestigious awards: the Augustus H. Gill Award for oil analysis excellence and the John R. Battle Award for lubrication excellence. While these awards inherently support the organization's mission to facilitate growth and development of machine lubrication as a technical field of endeavor, some companies may refrain from nominating themselves or their customers unless they understand the positive impact of doing so.

However, there truly is no downside to the ICML awards. Generally speaking, the more applications you submit, the more tangible the benefits you will receive, whether you win an award or not. These benefits can be seen at three distinct levels: industry, plant and practitioner.

## Industry Level: Rising with the Tide

When competing for an award, every team needs a rival to defeat. Sometimes the rival is a longstanding competitor in the market. It could also be another plant in your company or even mediocrity itself. The Gill and Battle awards have established industry-wide benchmarks that everyone can achieve. By fostering a sense of urgency and competition, these benchmarks make it possible for companies to target and attain new performance goals they might not otherwise pursue.

As more companies reach new levels of performance, the number of nominations for the ICML awards is likely to increase. Meanwhile, industry standards benefit globally from these practical efforts. As the old idiom says, "A rising tide lifts all boats." Nevertheless, industry can only learn from your experiences if you nominate your company for an award.

## Plant Level: Make Money, Save Money

At the plant level, you can expect both external and internal benefits. Assuming your company depends on trust and credibility to help convert prospects into paying customers, how can you establish these traits as part of your external brand? Effective tactics include third-party validation, such as customer referrals/testimonials, peer reviews and industry awards.

If your plant wins the Gill or Battle award, you shouldn't keep it a secret. You can impress customers and prospects by telling them about your award in every available platform. Winning either award is an exceptional accomplishment that your company can parlay into media exposure via your own public relations and social media channels over and above ICML's promotional efforts. It's free publicity to enhance your brand.

Internally, if your frontline technicians and analysts see your company consistently making awards submissions, they will know that corporate leaders are serious about quality lubrication and oil analysis programs. The very presence of a trophy, along with the knowledge that submissions are being made to win it, reinforces high-performance expectations across the plant. It clearly communicates that reliability initiatives start at the top. Ideally, such a goal-driven environment brings clarity and focus, making it easier (and less expensive) for practitioners to maintain continued excellence and reliability.

Consulting and training organizations that have helped their customers implement a world-class lubrication or oil analysis program can also earn some bragging rights if their customers win an award. But they can only win if they apply. Don't wait for that to happen. You can nominate your clients for the Gill or Battle award, and let ICML follow up with them to confirm.

## Practitioner Level: Better Employees Equal Better Returns

Can a corporate-level award motivate practitioners on the plant floor? It can if the award is properly ascribed to their individual efforts and commitment. Studies have shown that awards and recognition, feeling like part of the decision-making process, and a sense of achievement are stronger motivators than money. The ICML awards address these motivators by validating that team members are working for a winner. They also demonstrate that all certification training and new practices are worthy of peer acknowledgment.

Why is this important for individual practitioners? Motivated employees bring better returns for their company. Meeting and exceeding personal performance goals will help employees gain self-confidence and exercise self-reliance. The cumulative impact within a lubrication or oil analysis program leads to more reliable achievement of plant-level goals. Never underestimate the motivational power of a purpose (e.g., an industry award) that is bigger than oneself, especially when combined with continuing education that teaches the how and why of lubrication and oil analysis.

## Next Steps: The Deadline for 2018 Submissions Is Approaching

If your company wins an ICML award, don't rest on your laurels. Apply again. Even if you win multiple awards, keep applying. A good rule of thumb is to nominate your best success stories every year. Remember, you want your competitors, customers and team members to know that your commitment to excellence is ongoing. Why? Because everyone likes to do business with winners, and you don't want to be the company that looks marooned amidst a sea of industry advancements.

Completed applications for the Augustus H. Gill and John R. Battle awards are being accepted through Dec. 31, 2018, so start preparing yours today through the ICML website at www.icmlonline.com. The winners will be announced at Reliable Plant 2019.

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### Advanced Oil Analysis

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# The Pros and Cons **of Polishing Wear**

Polished machine surfaces can improve equipment performance by reducing friction and increasing efficiency. There are many ways to polish machine surfaces, with the results depending on the desired outcome. When it comes to lubricants, additives can be used to help chemically polish these surfaces during the running-in process. However, problems can arise if you do not understand the proper way to polish surfaces or how lubricant selection factors into the equation.

## What Is Polishing Wear?

ASM International defines polishing wear as the interactions between two solids that remove material from and produce a polished finish on one or both of them. If you think of a polished surface, you might imagine something that reflects light or appears very bright. When I was a child, I remember seeing cans of silver polish used on serving trays and utensils to restore their original luster. These polishing compounds usually fall into two categories: chemical compounds and abrasive compounds. Each has a purpose and reason for use.

**46%**

of lubrication professionals say abrasive wear is the most common wear mode in machinery at their plant, according to a recent survey at MachineryLubrication.com

## Abrasive Polishing

Abrasive compounds are often pastes with a solid particle blended into them. After the compound is applied to a surface, it is rubbed with a cloth or against another solid surface. During this action, the abrasives cut and score the surfaces, resulting in a polished face. This is a common practice with engine valves, as polishing can improve performance and prevent carbon buildup. Another term for this type of polishing is mechanical polishing, since it requires mechanical force to move the parts together. Sometimes these abrasive compounds are called grinding or lapping compounds.

This form of abrasive wear occurs inside machines when small particles are suspended in the lubricant and become trapped between moving components. These particles in the oil can act like a polishing compound and begin polishing the parts in which they come into contact. You can see this kind of polishing wear in most systems, although it is particularly prevalent in gears and hydraulics.

## Chemical Polishing

Chemical polishing happens when a chemical is corrosive enough to remove the surface layer of metal, exposing the underlying metal, which typically is reflective and very polished. This type of polishing is most like the silver polish mentioned earlier. In this mechanism, a mildly corrosive compound is applied to a surface. The compound then reacts with the surface material, forming a soft film on the metal. When the polish is removed, it takes this soft film with it, leaving behind an unoxidized and often brightly polished surface.

## The Pros of Polishing Wear

Polishing wear can be used to your advantage. When machine parts are highly polished, there tends to be less drag or friction between the parts. This will help with the equipment's efficiency by reducing amp draw, fuel consumption and possibly even the operating temperatures.

Machine surfaces are often rough with microscopic projections known as asperities. These asperities greatly contribute to the friction between moving parts. The larger the asperities, the more friction will be generated, which must be overcome during operation. A good example of this would be rubbing two pieces of sandpaper against each other. Each piece of grit on the paper represents an asperity. If rubbed together, the individual pieces of grit come in contact and require more force to pass over each other. When machine parts are finely polished, it is like reducing or removing the grit from the paper. Less or smaller grit means less force and less surface damage when these parts move relative to one another.

In terms of lubrication, more polished machine surfaces require a smaller lubricating film for protection. The goal of a well-oiled machine is to have a lubricating film that is larger than the surface asperities. When the surfaces are very rough, the film must be larger. This is typically achieved by using higher viscosity lubricants. The higher the viscosity, the more viscous drag in the machine and the more fuel or energy that must be consumed to churn through the lubricant. If the machine parts are finely polished and have smaller asperities, the lubricant film can be smaller, and subsequently a lower viscosity lubricant can be used. This means less viscous drag and better energy efficiency.

"Although polishing wear can have both good and bad consequences, **it usually is best to avoid any wear mode."**

## The Cons of Polishing Wear

Although polishing can be beneficial in many ways, it can also be a negative process if it occurs unintentionally. Unintended polishing may take place when a concentration of solid contaminants reaches a certain point in both the size and number of hard particles. While the machine is operating, this mixture of oil and particles moves throughout the system. These particles begin cutting into the machine surfaces, leaving behind small, linear scrapes that ultimately lead to a polished surface.

Another example of how polishing can happen unintentionally is when the wrong additive package is selected for a piece of equipment. Many gear oils rely on the addition of extreme-pressure (EP) additives to aid in lubricating moving parts in boundary lubrication regimes. Some of these EP additives are chemically aggressive and actually eat or pit into machine parts, causing chemical polishing.

When the additive package is matched appropriately with the machine, this chemical reaction will be mild, and the soft metal film formed by the polishing process can be beneficial in reducing machine wear during boundary lubrication conditions. When the additive package is not matched correctly, the resulting chemical wear becomes far too extreme, removing more surface metal and ultimately reducing the machine's surface profile. As the surface profile is reshaped, the parts do not mate together as well and in some cases can lead to catastrophic failure.

Machines most susceptible to aggressive chemical polishing are those that employ the use of a soft metal or a softer metal alloy. A good example would be a worm-drive gearbox. Frequently, the worm is made of steel, while the worm wheel is made of brass or some copper alloy. Chemically aggressive EP additives will attack the soft copper. This polishing process typically will go beyond the mild surface polish and turn into severe chemical corrosion, leading to the eventual failure of the machine.



## Prevention

To ensure the oil you use will not cause severe chemical polishing, check the lubricant's technical data sheet for the results of the ASTM D130 test, which is known as the copper strip corrosion test. How the lubricant performs on this test will tell you how corrosive the fluid and additives are to softer metals.

The test takes a strip of freshly polished copper and subjects it to the candidate fluid. After it is heated, the strip is examined for corrosion. The results are reported on a scale ranging from 1A (virtually no corrosion) to 4C (severe corrosion). If you have soft metal alloys in your equipment (worm gears, some hydraulic valve spools, etc.), select a lubricant with a 1A rating. If the machine doesn't have softer metals, you can choose a more aggressive lubricant and still have less risk of extreme chemical polishing.

It is possible to catch polishing wear before it becomes a problem. Perhaps one of the easiest ways to determine if polishing is taking place is to perform a visual inspection of the machine parts. These inspections can be done with a borescope. Check the mating surfaces for light reflection, which is typically the telltale sign of polishing wear.

In the event you can't visually inspect the machine surfaces, study your oil analysis reports. Examine the wear debris and determine whether the trends are linear, supporting a normal wear pattern, or if the machine is beginning to produce more debris than in the past. Although it may be difficult to conclude from the reports whether the wear mechanism is polishing wear, this will give you some indication of a potential problem before it creates the need for equipment replacement or a rebuild.

Fortunately, this wear mode can be prevented by ensuring that your lubricant is clean. Filtering the oil will reduce the number of particles that lead to polishing and mitigate or delay polishing wear from occurring. To impede chemical polishing, choose the proper lubricant and additive package. If you don't know which lubricant to select, contact the equipment manufacturer, a lube supplier or a consultant to assist you in this process. Using the wrong lubricant can have disastrous results, while the correct one can provide years of uninterrupted service life. Finally, keep in mind that although polishing wear can have both good and bad consequences, it usually is best to avoid any wear mode, as this will help your equipment last longer and ensure less downtime.

## About the Author


Wes Cash is the director of technical services for Noria Corporation. He serves as a senior technical consultant for Lubrication Program Development projects and as a senior instructor for Noria's Oil Analysis II and Machinery Lubrication I and II training courses. Wes holds a Machine Lubrication Technician (MLT) Level II certification and a Machine Lubricant Analyst (MLA) Level III certification through the International Council for Machinery Lubrication (ICML). Contact Wes at wcash@noria.com to learn how Noria can help you choose the right lubricants and additive packages for your machinery.

ExxonMobil

# Launch of ExxonMobil's breakthrough MOBIL SHC™ ELITE Technology


Glen Sharkowicz, Director of Brand Strategy - Commercial marketing, South Asia Pacific, ExxonMobil, Asia Pacific Pte Ltd and Imtiaz Ahmed, General Manager - Marketing Deployment (Commercial marketing), ExxonMobil Lubricants Private Limited, launching Mobil SHC Elite

ExxonMobil™ recently launched Mobil SHC™ Elite, a breakthrough synthetic gear and bearing circulating oil that is specifically engineered to deliver long lasting protection for machines operating under extreme temperatures in industries such as general manufacturing, metals, energy, and pulp and paper.

Extensive testing shows that Mobil SHC Elite can deliver 12 times the oil life of mineral oils and double the oil life of Mobil SHC 600 synthetic oils in continuous operating temperatures as high as 130°C (266°F), potentially replacing glycol-based lubricants in high temperature systems. This helps reduce the potential risk of mixing glycol-based products with incompatible mineral oils and most synthetic lubricants.

The oil also protects equipment during intermittent temperature spikes of up to 150°C (302°F) and provides up to a 3.6% energy efficiency benefit versus mineral oils.*

"Protecting advanced equipment from high in-service temperatures can be a major challenge for industrial operators, especially if that equipment is difficult to access or take offline," said Glen Sharkowicz, Director of Brand Strategy- Commercial Marketing, South Asia Pacific, ExxonMobil Asia Pacific Pte Ltd. "With Mobil SHC Elite, equipment owners now have an advanced lubricant that can deliver much better oil life and the assurance of extra protection during high temperature excursions during peak production rates."

Following field trials, Mobil SHC Elite has been approved by Siemens for its FLENDER gear units, which depend on robust lubrication protection in rigorous operating conditions.

Mobil SHC Elite is the newest member of the Mobil SHC™ family of synthetic lubricants that provide performance advantages far exceeding the capabilities of conventional oils. These lubricants can help extend equipment longevity and generate potential energy savings, while their significantly longer life lowers maintenance costs and reduces worker exposure during oil changes.

*Energy efficiency relates solely to the performance of Mobil SHC™ Elite Series oils when compared to conventional (mineral) reference oils of the same viscosity grade in gear applications. The technology used allows up to 3.6 percent efficiency compared to the reference when tested in a worm gearbox under controlled conditions. Efficiency improvements will vary based on operating conditions and application.

# India Shifting Towards Group II Base Oils

Base oil consumption in India was 2.1 million metric tons in 2016 and is expected to rise 2.4 million tons by 2020 and 3.2 million tons by 2030. API Group II base oils are gradually gaining popularity in India and are expected to push aside Group I as the dominant grade by 2030. Group I accounted for 71 percent of the total in 2016, or 1.5 million tons, while 400,000 tons of Group II were consumed and 40,000 tons of Group III, accounting for 19 and 2 percent, respectively. By 2020, Group I consumption will slip to 1.4 million tons, Group II will inch up to 600,000 metric tons and Group III should experience a healthy bump up to 100,000 tons, said at the Asia, Middle East and Africa Base oil, Lubricants and Wax conference in Mumbai.

The shift towards more highly refined base stocks will be driven by several factors, including rising original equipment manufacturer demands for finished lubricant performance and increasingly stringent emission norms. Other factors include tougher fuel efficiency standards and advancements in lubricant additive technologies.

The lubricant market in India has been largely dominated by the automotive sector and it will continue to consume the biggest chunk of India's lubricants market. The volume of transportation lubes will rise from 1.1 million tons in 2016 to 1.3 million tons in 2020 and 1.8 million tons by 2030, asserted at the conference. Industrial lubricants consumption, on the other hand, will also experience healthy growth, mounting from 900,000 tons in 2018 to 1 million tons by 2020 and 1.4 million tons in 2030.

Commercial vehicles will maintain its dominance in the market, increasing from 800,000 tons in 2016 to 1 million tons, 73 percent of transportation lubes in 2016. That share is predicted to rise to 75 percent in 2030.

# All India Seminar on "Major advances and Sustainable Developments in Lubrication Domain"


*The Seminar was inaugurated by Mr. Anand Sen, President, TQM & Steel Business, Tata Steel Ltd*

Tata Steel in association with National Grease Lubricating Institute (NGLI) India Chapter and The Institution of Engineers inaugurated a two-day Seminar on 13th & 14th September 2018 titled "All India Seminar on Major Advances and Sustainable Developments in Lubrication Domain" in Jamshedpur.

Lubrication in an integrated steel plant is a subject of significance owing to numerous types of lubricants being used for a diverse range of equipment. Steel plants work under varied operating conditions such as extreme heavy load to very high speeds, low to high temperatures, dusty polluted environment to humid acid environment scenarios. Hence proper selection of lubricants is essential for smooth operations in steel plants and for ensuring reliability of equipment.

Participants from diverse fields including steel plants, OEMs, academia participated in the seminar. There were more than 250 delegates.

The major sessions were Advances in Fire Resistant Lubricants, Advances in Health Monitoring of Lubrication Systems, Advances in Lubricants to increase Re-lubrication intervals, Advances in Lubrication Program management, Advances in Fire Resistant Lubricants and Advances in lubricants for Mining Equipment.

The objective of this seminar was to share the best practices on Lubricants right from the designing stage to its usage for which academic institutions, Lubricant and Grease manufacturers and steel plants are doing a cross sharing of ideas through technical paper presentations. The best technical paper was 'Development of Fire Resistant oil for Mills & Caster area' presented by Mr. Ronald Knecht of Quaker.

Major steel producers like JSW, SAIL Group, JSPL, Bhushan Steel, Vedanta and Essar Steel ;Lubricant and Grease manufacturers; OEMs like Primetals, Paul Wurth and academic institutions such as IIT's, CMERI and RDCIS were the participants at the seminar.

# BASE OIL REPORT

Indian refiners are reducing their intake of Iranian crude oil in preparation for the return of U.S. sanctions on Tehran. The reduction is being seen as an attempt to score a waiver from the U.S. Treasury Department. Loadings for September and October will be lower than 12 million barrels each month, which is nearly half of what they imported earlier this year in preparation for the sanctions.

India imports as much as 80 percent of the oil it consumes, which makes it more vulnerable than other importers to price swings. This vulnerability has, in recent months, been heightened by devaluation in the rupee, which has led to a considerable swelling in its oil bill. In August, government calculations revealed this bill could rise by as much as US$26 billion in financial 2018/2019 if prices remain high.

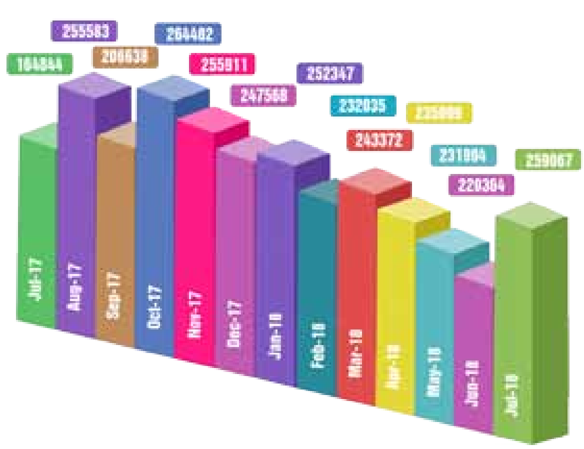
As per the data analysis, import of the country has gone up by 27% during Jan to July 2018, as compared to same period last year i.e. Jan to July 2017. Compared to June 2018, import of the country has increased by 18% in the month of July 2018. India import has gone up by 57% in July 2018, as compared to same period last year i.e. July 2017.

The Indian base oil market remains steady with inventories at optimum levels with surplus of imported grades. During the month of July 2018, approximately 259067 MT have been procured at Indian Ports of all the grades. Compared to last month i.e. June 2018, import of the country has increased by 18% in the month of June 2018.

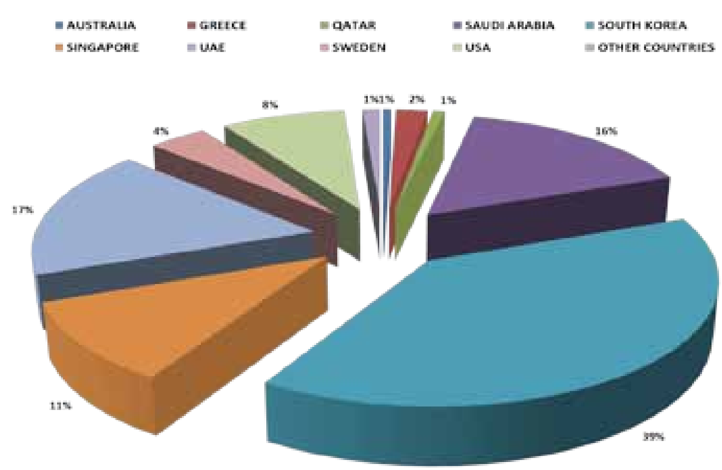
In the month of July 2018, India imported 259067 MT of Base Oil. India imported the huge quantum in small shipments on different ports like 174181 MT (67%) into Mumbai, 27552 MT (11%) into Chennai, 27189 MT (10%) into JNPT, 12253 MT (5%) into Pipavav, 7282 MT (3%) into Kandla, 4696 MT (2%) into Hazira, 4440 MT (2%) into Mundra and 1474 MT (1%) into Other Ports.

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

**Month wise input of Base Oil in India**




**Origin wise Base Oil input to India, Country and %- May 2018**




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

| Month | Group I - SN 150 Iran Origin Base Oil CFR India Prices | Group II -J-500 Singapore Origin Base Oil CFR India Prices | N- 70 South Korea Origin Base Oil CFR India Prices | Bright Stock CFR India Prices |
|---|---|---|---|---|
| July 2018 | USD 780 – 795 PMT | USD 840 – 860 PMT | USD 785 - 795 PMT | USD 1195 – 1205 PMT |
| August 2018 | USD 765 – 780 PMT | USD 825 – 845 PMT | USD 770 - 780 PMT | USD 1180 - 1190 PMT |
| September 2018 | USD 765 – 780 PMT | USD 825 - 845 PMT | USD 770 - 780 PMT | USD 1180 - 1190 PMT |
| | Since July 2018, prices have gone down by USD 15 PMT (2%) in September 2018. | Since July 2018, prices have gone down by USD 15 PMT (2%) in September 2018. | Since July 2018, prices have gone down by USD 15 PMT (2%) in September 2018. | Since July 2018, prices have decrease by USD 15 PMT (1%) in September 2018 |

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