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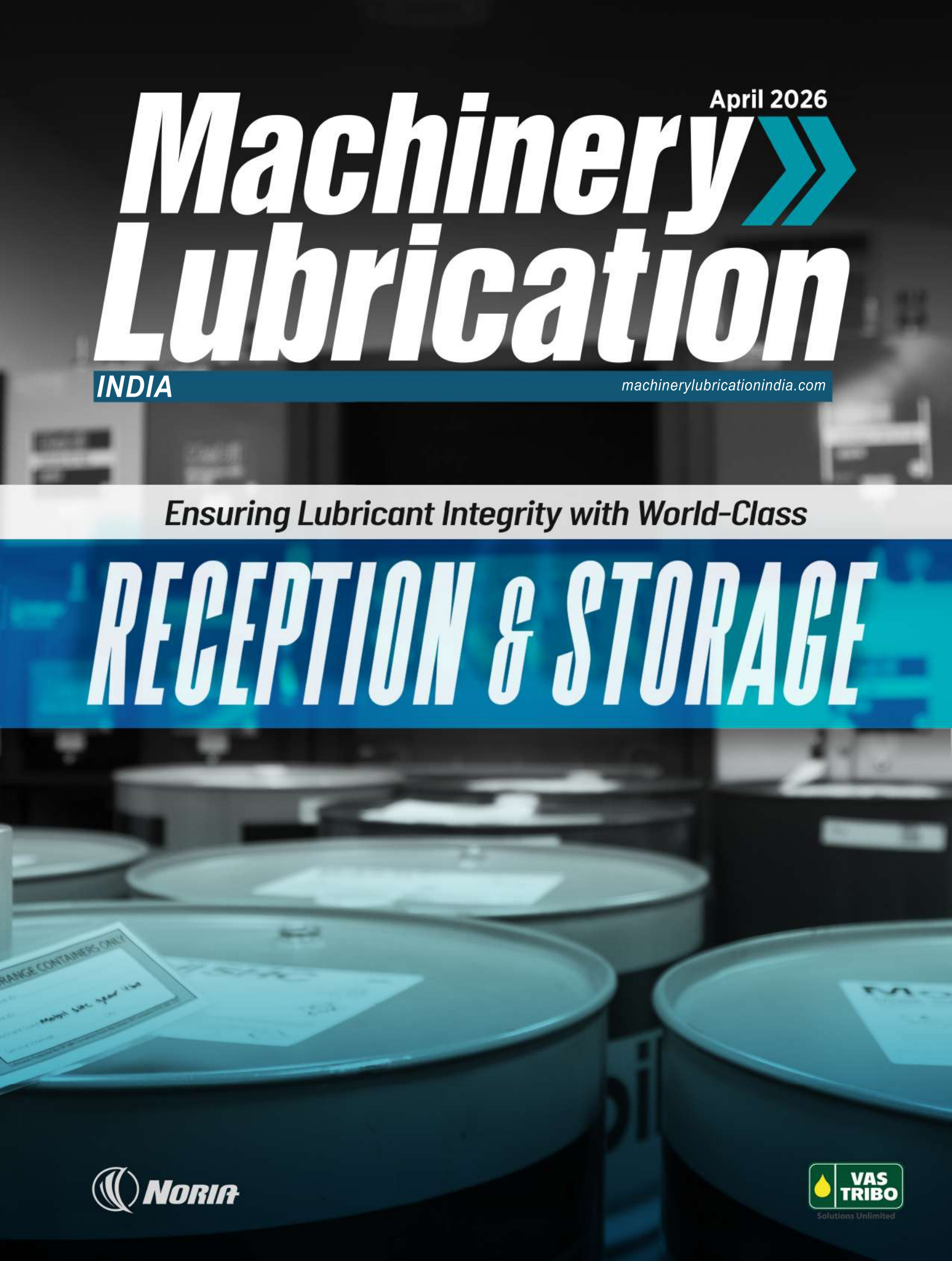
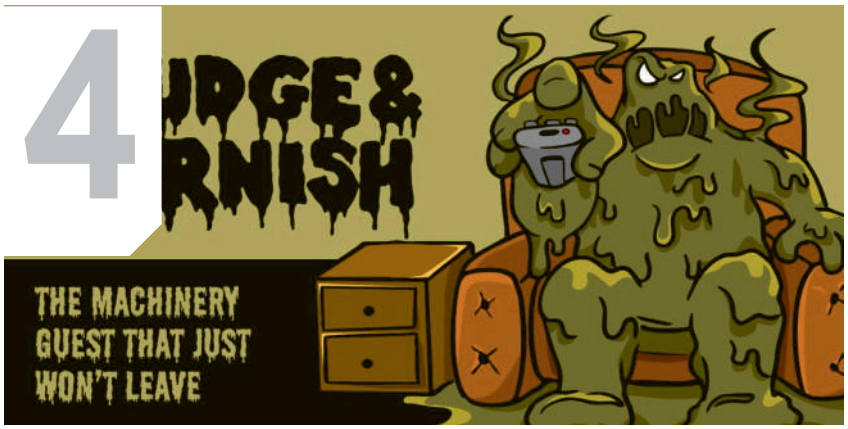
Ensuring Lubricant Integrity with World-Class

RECEPTION & STORAGE



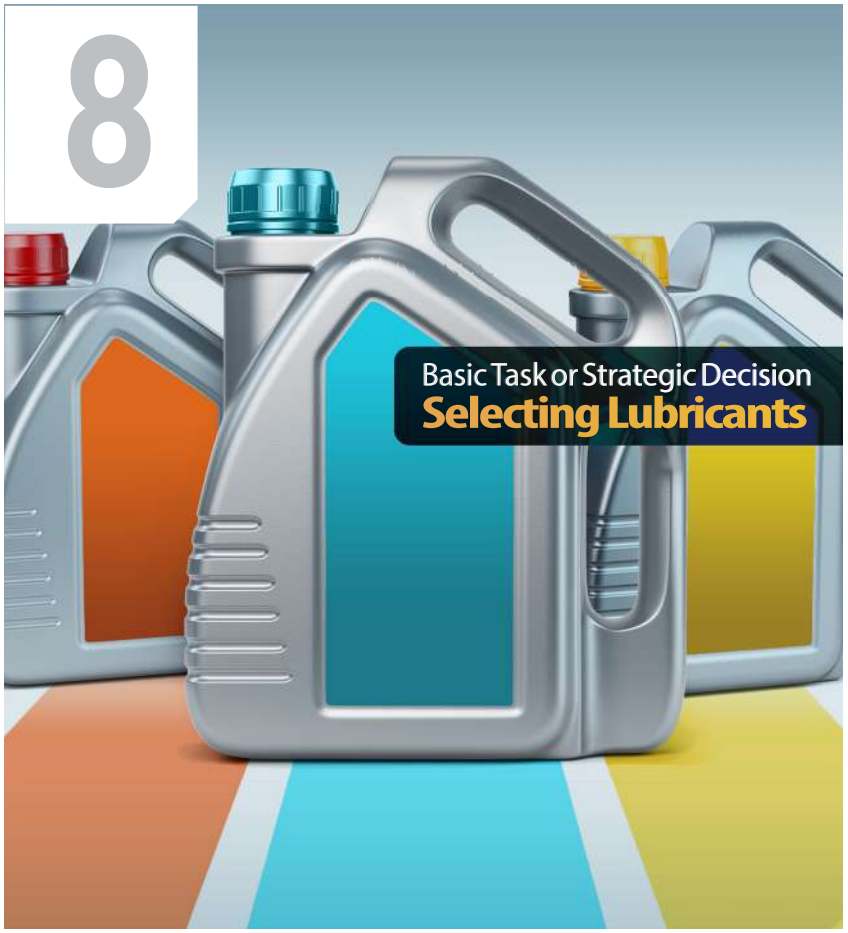
AS I SEE IT

Demystifying Sludge and Varnish



COVER STORY

Ensuring Lubricant Integrity with World-Class Reception & Storage



From the Asian Desk

EDITORIAL FEATURES

Publisher's Note

In the high-stakes theater of 2026, the margin for error has not just narrowed—it has evaporated. In a world defined by geopolitical volatility, precision is no longer a choice; it is our only shield. As we navigate the opening months of this year, India stands in a unique position of global strength, still vibrating with the collective energy of our historic T20 World Cup defense. That victory on home soil was far more than a sporting achievement; it was a masterclass in the "preparedness mindset." It proved that when a system is optimized, when every player understands their specific role, and when the fundamentals are executed with surgical precision, success becomes a repeatable habit rather than a lucky break. It is this exact spirit of meticulous discipline that we must now translate from the cricket pitch to the plant floor.

However, as the cheers from the stands fade, a more sobering reality sets in. With intensifying conflicts in West Asia and the resulting logistical strain on the Strait of Hormuz, the global energy market is under siege. Brent Crude's surge is a wake-up call that the era of "cheap and easy" industrial inputs is over. For the Indian industrialist, the message is clear: the lubricants powering our refineries, steel mills, and power plants are no longer just "consumable oil"—they are strategic reserves. In this "War Economy" for industrial fluids, wasting a single drop to poor handling or contamination is not merely a maintenance oversight; it is a blow to our national industrial resilience.

This is why our current cover story, "Lubricant Integrity: **The Front line of Reception and Storage,"** is perhaps the most critical technical roadmap we have published in this decade. We often obsess over complex additive chemistry and high-end synthetic formulations, yet we frequently ignore the "birth" of reliability at the loading dock. I have long maintained that mastering the transition from the delivery truck to the storage rack is the single most accessible lever for improving plant-wide efficiency.

By treating lubricant reception as a high-stakes audit rather than a routine warehouse chore, we shift our entire operational philosophy from "reactive replenishment" to one of **Total Asset Integrity.** This article provides a comprehensive blueprint to ensure that the molecular architecture of your fluids remains uncompromised by the harsh ambient dust and humidity of the Indian landscape. It is a positive, proactive shift that transforms your lube room from a dark cost-center into a visible reliability powerhouse. When we protect the integrity of the lubricant before it ever touches a bearing, we are effectively investing in the "compound interest" of machine life.

To support this strategic transition, this edition serves as a 360-degree manual for the modern engineer. We have curated a diverse range of insights, from **Demystifying Sludge and Varnish** and **Oil Analysis Explained** to identifying **4 Types of Oil Filter Failures.** We explore the efficiency gains of the **E-Commerce Revolution** in procurement and the simple brilliance of **Follower Plates** for grease drums. Whether you are focused on **The Vital Role of Tribology or Mastering the Stribeck Curve,** every page is designed to fortify your frontlines. We also emphasize the "small wins," such as **Why Clean Sample Bottles are Key,** and offer a rare **Face-to-Face with B.B. Patra, Country Head (Lubes) at Indian Oil Corporation Ltd.** On a more personal note, we explore why **Sleep is a Strategy** for the leaders tasked with steering these complex operations.

As we celebrate the harvest festivals of **Baisakhi, Vishu, and Puthandu,** let us remember that a bountiful harvest is always the result of disciplined sowing. Let us carry the "World Cup spirit" into our maintenance programs, choosing the precision of a champion over the convenience of a bystander.

We advance together.

Warm regards,
Udey Dhir

Jim Fitch | Noria Corporation

DEMYSTIFYING SLUDGE AND VARNISH

You could tar your roof with it. It sticks to everything. It spreads like cancer. You thought you were getting rid of it with the oil change and flush, but it is back again - lurking in your oil and gripping the insides of your machine - sludge and varnish.

Does this sound familiar? Maybe you have it now. Do you know what causes sludge and varnish and how to stop them from spreading? Do you know how to prevent it from coming back later? More importantly, do you understand its destructive potential?

More Cases of Sludge and Varnish

In industrial equipment, Noria has seen a surprising surge in sludge and varnish cases in recent years. There are many possible explanations, but perhaps the biggest contributor evolves from the increasing demand for machinery reliability. Today, there is more awareness in the user community of the impact that sludge and varnish has on lubrication and machinery health. People are making closer inspections, asking more questions and are less tolerant of its presence.

Additionally, we are seeing increasing use of low-solvency base stocks (hydrocracked and PAOs for instance) that could be amplifying problems. These base stocks, on one hand, are more thermally and oxidatively robust. On the other hand, they may be more prone to lay down and coagulate oil degradation products (oxides, salts, carbon fines, etc.), leading to sludge and varnish.

We are also noticing more users pushing lubricants to the limits by extending oil drains and in some cases, improperly top-treating in-service oils with additive concentrates. Many used oils are now being reconditioned and returned to service or blended with new oil. In certain instances,these somewhat progressive practices may lead to more frequent and severe sludge and varnish problems.

In addition, many organizations are doing a better job at controlling leakage through better maintenance. Oddly, this can contribute to more frequent cases of sludge and varnish problems. When leakage is reduced, so too is the replenishment of fresh additives and base-stocks that come in with makeup oil. This has the practical effect of shortening the oil's life.

In contrast, companies generally are maintaining equipment cooler, cleaner and dryer than in the past, and are better at deploying oil analysis. These improved practices normally have a positive and stabilizing effect on lubricant health and reduce the risk of sludge and varnish problems.

Causes of Sludge and Varnish

The approach of detecting and analyzing sludge and varnish problems in machinery is not the same as used oil analysis. In many instances this is because the evidence is not always in the oil. The sludge and varnish should be analyzed directly, using a com-

pletely different set of tests and evaluation parameters. Still, used oil analysis plays an important diagnostic role to help reveal candidate causes as well as to rule-out others.

The conditions that commonly lead to sludge and varnish problems vary, which complicates the process of identifying the root cause analytically. There are at least 25 unique lubricant degradation mechanisms leading to sludge or varnish formation. A few of these include:

- Aeration of the fluid
- Sparking from static electricity
- Bulk thermal degradation
- Antifreeze contamination
- Soot coagulation
- Bulk oil oxidation
- Hydrolysis
- Prolonged cold storage
- Grease contaminated oil
- Caustic detergent contamination
- Nitration
- Coking on hot surfaces
- Radiological contamination
- Poor engine combustion efficiency and blowby
- Highly aromatic fuels
- Sulfation (fuel, H2S, etc.)
- Lead corrosion reactions
- Reactive compressor gases
- Additive incompatibilities
- Base oil incompatibilities

Upon looking at the above list, it is obvious that the prescribed corrective action relies on the accurate discovery of the specific and often-elusive root cause. Without this, correcting the problem is reduced to the costly and lengthy process of trial-and-error. There is a unique remedy for each cause.

It is always good advice to keep an accurate history of the conditions and observations that lead up to the occurrence of sludge and varnish. The troubleshooting process depends on building a case file containing each little piece of information and timeline.

Machine Inspections

Lubricants degrade in different ways, and the products of this degradation are essentially referred to as sludge and varnish. These products are generally unstable in the oil and, as such, are looking for a place to land, that is, to deposit themselves. In certain instances, the deposits form on machine surfaces at the exact location where the oil has degraded, for example, hot surface coking. In other cases, the oil degrades in one location but deposits condensed on a surface elsewhere.

Over time, some deposits can thermally cure (become baked-on) to a tough enamel-like coating. Other types of deposits, generally in cooler zones, remain soft or gummy. Sludge is not always black or even dark. It may appear clear and grease-like, similar to petroleum jelly. The following are examples of where and how sludge and varnish might occur:

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- Black crusty deposits on mechanical seals
- Gold adherent films on spool valves in EHC hydraulic systems
- Charcoal-like deposits on babbitt sleeve bearings
- Gooey-brown mayonnaise on diesel engine oil filters
- Black scabby deposits on thrust-bearing pads
- Lumpy, tar-like globs in dryer bearing drain lines (paper machine)
- Grayish gummy deposits on NG engine discharge ports
- Carbonaceous residue of servo strainers
- Hard black enamel on piston crown and ring lands
- Cottage cheese-like gunk clinging to engine valve covers
- Drab-color slime on compressor oil filters

Damage Caused

The deposits that form on machine surfaces interfere with the reliable performance of the fluid and the machine's mechanical movements. They can also contribute to wear and corrosion or simply just cling to surfaces. For example, deposits on the spool of a servo control valve can tighten the interference fit between the spool and bore. Compounding this are the adherence properties of varnish, which can stick particles from the oil to silt lands, leading to common silt-lock valve failure.

Other types of sludge and varnish-type failures include plugged orifices, damaged mechanical seals, plugged discharged ports on compressors, journal-bearing failure, premature plugging of oil filters and diesel engine combustion-zone wear.

Most organizations that suffer from sludge and varnish problems have these three needs:

1. They want to know the root cause of the problem.
2. They need simple solutions to quickly return the lubricant and machine back to service.
3. They want to know how to prevent the root cause from reoccurring.

Because of the impact sludge and varnish has on lubrication and machine reliability, for the past several years, Noria has been on a crusade to learn everything we could about it. We have conducted extensive laboratory investigations.

We have amassed stacks of analytical material. We have conferred with experts and academics. We have combed through hundreds of pages of technical literature. And we have gone to the field to see it in the machines where it lives.

Noria Media

Ensuring Lubricant Integrity with World-Class

RECEPTION & STORAGE

The path a lubricant takes from refinement to deployment is critical, and any weakness along that path can compromise an entire lubrication program. A world-class lubricant reception and storage program isn't built on chance, and it represents the vital link between delivery and deployment.

These programs are meticulously constructed from the ground up, with seemingly routine processes that ensure lubricant integrity, maximize equipment reliability, and achieve lubrication excellence. By mastering these foundational elements, a facility can successfully elevate its lubrication program to create excellence.

Receiving New Lubricants

The journey of a lubricant from refinery to machine is filled with potential pitfalls. While much emphasis is placed on proper storage, handling, and application, the crucial first step – lubricant reception – is often overlooked. This initial stage sets the tone for the entire lubrication program. A poorly executed reception process can introduce contaminants, compromise lubricant quality, and lead to premature equipment failure, costly downtime, and diminished productivity.

Think of lubricant reception as a quality control checkpoint. It's the moment to verify that what's being delivered matches the specifications, cleanliness standards, and overall quality expected. This involves more than simply signing a delivery receipt. It requires a meticulous inspection of containers, a thorough documentation review, and, in some cases, on-site testing.

An important aspect to understand is that new oil does not equal clean oil. This means that by establishing a robust reception protocol, a program is doing much more than just accepting a delivery; it's building a foundation for a successful lubrication program. This proactive approach ensures that only clean, high-quality lubricants enter a facility, safeguarding critical equipment and maximizing facility investment.

Setting Cleanliness Standards

Upon arrival, each lubricant shipment should undergo a rigorous inspection. This includes verifying the container's integrity, checking for leaks or damage, and confirming that the product matches the accompanying documentation. Samples should be taken and tested for key properties, such as viscosity, water content, additive levels, and particle count, to ensure compliance with specifications.

For example, one key marker and measurement critical to lubricant reception practices deals with the cleanliness and dryness of the lubricant –ISO 4406. With ISO 4406, lubricant cleanliness is measured using a particle counter and reported based on this ISO standard. By utilizing this standard, facilities can create and maintain robust cleanliness targets, helping to build a benchmark for how clean a variety of lubricants must be to Fulfill their intended applications properly. This also creates a consistent lubrication reception process, helping to ensure standards are met and maintained across the board to prevent machine contamination and reduce critical asset failure.

This same idea can be directly applied to target lubricant dryness, where a facility can quickly discover the amount of water in a lubricant. The reported dryness and cleanliness numbers can also ensure the delivered lubricants meet the supplier's targeted expectations. If these targets are not met regularly, a facility may have cause to switch lubricant suppliers.

While these steps can often be overlooked, they can have the most significant impact on preventing contamination across the facility. To support these efforts, a detailed reception checklist should be implemented to standardize the process and ensure no critical steps are missed. By prioritizing lubricant reception, a facility is not just receiving a shipment; it's actively protecting essential equipment and helping to ensure the long-term effectiveness of its lubrication program.

The Importance of Proper Lubricant Storage

Because a facility's investment in high-quality lubricants is only as valuable as their condition when applied to machinery, a world-class lubrication management program's job doesn't end at the delivery docks. It must also include proper lubricant storage practices.

Proper lubrication storage isn't just about tidiness; it's about safeguarding the entire lubrication program. Improper storage can silently erode lubricant performance by allowing contamination to ingress, thereby degrading a lubricant's properties. This can turn a facility's lubrication from partner

in performance to a potential threat to all critical machinery. A well-organized and controlled storage environment impacts lubricant quality, equipment longevity, and overall maintenance efficiency.

Lubricants are not just fluids but essential working components in mechanical systems. To ensure optimal performance, a facility must treat lubricants with the same care as any other critical part. Proper storage safeguards the lubricant's quality, prevents contamination, and minimizes the risk of premature deterioration, ensuring that only clean, effective lubricants are put into service.

Protection Against Time and the Elements

A dedicated storage space is essential to safeguard lubricants and maintain their readiness. The surrounding environment plays a critical role in preserving lubricant integrity. Silent adversaries, such as extreme temperatures, temperature fluctuations, and humidity, can compromise the protective qualities of stored lubricants.

These environmental conditions facilitate air movement, effectively causing lubricant containers to "inhale" contaminants, such as through openings on loose drum bungs. This process allows moisture, particles, and air to enter the container, directly compromising the quality and effectiveness of the lubricant's base stock and additive package.

Effective lubricant management also requires understanding that lubricants are subject to natural degradation over time. While manufacturer guidelines provide a foundation for determining shelf-life, lubricant specifications should still be verified upon delivery due to variations in additive packages. Immediate storage in ideal conditions is essential. The cleanliness and efficiency of a lubrication room directly impact the lubricant's longevity and effectiveness.

A First-In, First-Out (FIFO) system should be employed to maintain lubricant quality, guaranteeing that older stock is utilized first. Additionally, precise inventory management and balancing minimum and maximum stock levels are essential. Overstocking ties up valuable storage space and increases the risk of lubricant degradation and spoilage.

Conclusion

The journey to lubrication excellence is not a single leap, but a series of deliberate steps. Ultimately, a world-class lubrication program aims to prevent contamination and consistently deliver high-quality lubricants to critical machinery.

Achieving this world-class lubrication program hinges on a establishing and maintaining a proactive, meticulous approach to lubricant reception and storage. These seemingly routine processes are, in fact, the pillar of equipment reliability and operational excellence.

By treating lubricants as vital components and prioritizing cleanliness and environmental control, facilities can prevent contamination, extend lubricant lifespan, and ultimately achieve world-class standards in lubrication management.

Bennett Fitch | Noria Corporation

OIL ANALYSIS EXPLAINED

Oil analysis is a routine activity for analyzing oil health, oil contamination and machine wear. The purpose of an oil analysis program is to verify that a lubricated machine is operating according to expectations. When an abnormal condition or parameter is identified through oil analysis,immediate actions can be taken to correct the root cause or to mitigate a developing failure.

To get the most out of oil analysis, it's essential to establish a regular sampling program. This includes selecting the right equipment, using proper sampling techniques, and adhering to schedule that matches your machinery's operating conditions. Oil samples can either be sent to a lab for analysis or tested in-house with on site oil analysis equipment for quicker results,enabling faster decision-making and corrective actions.

Why Perform Oil Analysis

An obvious reason to perform oil analysis is to understand the condition of the oil, but it is also intended to help bring to light the condition of the machine from which the oil sample was taken. There are three main categories of oil analysis: fluid properties, contamination and wear debris.

Fluid Properties

This type of oil analysis focuses on identifying the oil's current physical and chemical state as well as on defining its remaining useful life (RUL). It answers questions such as:

- Does the sample match the specified oil identification?
- Is it the correct oil to use?
- Are the right additives active?
- Have additives depleted?
- Has the viscosity shifted from the expected viscosity? If so, why?
- What is the oil's RUL?

Contamination

By detecting the presence of destructive contaminants and narrowing down their probable sources (internal or external), oil analysis can help answer questions such as:

- Is the oil clean?
- What types of contaminants are in the oil?
- Where are contaminants originating?
- Are there signs of other types of lubricants?
- Is there any sign of internal leakage?

Wear Debris

This form of oil analysis is about determining the presence and identification of particles produced as a result of mechanical wear, corrosion or other machine surface degradation. It answers questions relating to wear, including:

- Is the machine degrading abnormally?
- Is wear debris produced?
- From which internal component is the wear likely originating?
- What is the wear mode and cause?
- How severe is the wear condition?

You need to know if any actions should be taken to keep the machine healthy and to extend the life of the oil. Oil analysis for machines can be compared to blood analysis for the human body. When a doctor pulls a blood sample, he puts it through a lineup of analysis machines, studies the results and reports his conclusions based on his education, research and detailed questions asked to the patient.

The Mini Lab 153 is an on site oil analysis lab that performs 4 tests to determine fluid properties,contamination, and wear.

Likewise, with oil analysis, careful oil samples are taken, and elaborate machines yield the test results. Laboratory personnel interpret the data to the best of their ability, but without crucial details about the machine, a diagnosis or prognosis can be inaccurate. Some of these important details include:

- The machine's environmental conditions (extreme temperatures, high humidity, high vibration, etc.)
- The originating component (steam turbine, pump, etc.), make, model and oil type currently in use
- The permanent component ID and exact sample port location
- Proper sampling procedures to confirm a consistently representative sample
- Occurrences of oil changes or make-up oil added, as well as the quantity of makeup oil since the last oil change
- Whether filter carts have been in use between oil samples
- Total operating time on the sampled component since it was purchased or overhauled
- Total runtime on the oil since the last change
- Any other unusual or noteworthy activity involving the machine that could influence changes to the lubricant

Interpreting an oil analysis report can be overwhelming to the untrained eye. Oil analysis isn't cheap, and neither is the equipment on which it reveals information. Every year, industrial plants pay millions of dollars for commercial laboratories to perform analysis on used and new oil samples (unless they are performing oil analysis in house at a much lower price point).Unfortunately, a majority of the plant personnel who receive these lab reports do not understand the basics of how to interpret them.

What to Look for When Reviewing an Oil Analysis Report

1. Read and check the data on the oil type and machine type for accuracy.
2. Verify that reference data is shown for new oil conditions and that trend data is at an understood frequency (preferably consistent).
3. Check the measured viscosity.
4. Verify elemental wear data and compare to reference and trended data. Use a wear debris atlas to match elements to their possible source.
5. Check the elemental additive data and compare to reference and trended data. Use a wear debris atlas to match elements to their possible source.
6. Verify elemental contamination data along with particle counts and compare with reference and trended data. Use a wear debris atlas to match elements to their possible source.
7. Check moisture/water levels and compare to reference and trended data.
8. Verify the acid number and base number and compare to reference and trended data.
9. Check other analyzed data such as FTIR oxidation levels, flash point, defensibility, analytical ferrography, etc.
10. Compare any groups of data that are trending toward unacceptable levels and make justifications based on these trends.
11. Compare written results and recommendations with known information on the oil and machine, such as recent changes in environmental or operational conditions or recent oil changes/filtration.
12. Review alarm limits and make adjustments based on the new information.

Typically, an oil analysis report comes with a written summary section that attempts to put the results and recommendations in layman's terms. But, since the laboratory has never seen the machine or know its full history, these recommended actions are generic and not tailored to your individual circumstances. Therefore, it is the responsibility of the plant personnel who receive the lab report to take the proper action based on all known facts about the machine, the environment and recent lubrication tasks performed.

Oil Analysis Tests

For a standard piece of equipment undergoing the normal recommended oil analysis, the test slate would consist of "routine" tests. If more testing is needed to answer advanced questions,these would be considered "exception" tests.

Routine tests vary based on the originating component and environmental conditions but should almost always include tests for viscosity, elemental (spectrometric) analysis, moisture levels, particle counts, Fourier transform infrared (FTIR) spectroscopy and acid number. Other tests that are based on the originating equipment include analytical ferrography, ferrous density, defensibility and base number testing.

OIL ANALYSIS CATEGORY	TESTS
Fluid Properties	Viscosity, Acid/Base Number, FTIR, Elemental Analysis
Contamination	Particle Counting, Moisture Analysis, Elemental Analysis
Wear Debris	Ferrous Density, FTIR, Elemental Analysis

The table on the left shows how tests are used in each of the three main oil analysis categories.

Viscosity

Several methods are used to measure viscosity, which is reported in terms of kinematic or absolute viscosity. While most industrial lubricants classify viscosity in terms of ISO standardized viscosity grades (ISO 3448), this does not imply that all lubricants with an ISO VG 320, for example, are exactly 320 centipedes (cSt). According to the ISO standard, each lubricant is considered to be a particular viscosity grade as long as it falls within 10 percent of the viscosity midpoint (typically that of the ISO VG number).

32% of lubrication professionals would not understand how to interpret an oil analysis report from a commercial laboratory, based on a recent poll at MachineryLubrication.com

Viscosity is a lubricant's most important characteristic. Monitoring the oil's viscosity is critical because any changes can lead to a host of other problems, such as oxidation, glycol ingression or thermal stress ors.

Too high or too low viscosity readings may be due to the presence of an incorrect lubricant,mechanical shearing of the oil and/or the viscosity index improver, oil oxidation, antifreeze contamination, or an influence from fuel, refrigerant or solvent contamination.

Limits for changes in the viscosity depend on the type of lubricant being analyzed but most often have a marginal limit of approximately 10 percent and a critical limit of approximately 20 percent higher or lower than the intended viscosity.

Acid Number/Base Number

Acid number and base number tests are similar but are used to interpret different lubricant and contaminant-related questions. In an oil analysis test, the acid number is the concentration of acid in the oil, while the base number is the reserve of alkalinity in the oil. Results are expressed in terms of the volume of potassium hydroxide in milligrams required to neutralize the acids in one gram of oil. Acid number testing is performed on non-crankcase oils, while base number testing is for over-based crankcase oils.

An acid number that is too high or too low may be the result of oil oxidation, the presence of an incorrect lubricant or additive depletion. A base number that is too low can indicate high engine blow-by conditions (fuel, soot, etc.), the presence of an incorrect lubricant, internal leakage contamination (glycol) or oil oxidation from extended oil drain intervals and/or extreme heat.

Extend Lubricant Life with Proven Lubricant Chemistry Management

In turbine applications, removing the dissolved molecules that accumulate and cause mechanical problems in hydraulic systems and lube oil applications is paramount to maintaining an application's optimum operation and restoring lubricants outside OEM specifications.

Patented ICB™ Ion-exchange Filters target fluid chemistry, removing varnish molecules and restoring lubricant solvency. This engineered workhorse, like anything else, exhausts with time. To maintain an application's optimum operation and restore lubricants outside of OEM specifications,time-based change intervals for ICB filters are essential.

FTIR

FTIR is a quick and sophisticated method for determining several oil parameters including contamination from fuel, water, glycol and soot; oil degradation products like oxides, nitrates and sulfates; as well as the presence of additives such as zinc dialkyldithiophosphate (ZDDP) and phenols.

The FTIR instrument recognizes each of these characteristics by monitoring the shift in infrared absorbance at specific or a range of wavenumber. Many of the observed parameters may not be conclusive, so often these results are coupled with other tests and used more as supporting evidence. Parameters identified by shifts in specific wavenumber are shown in the table below.

WAVENUMBER	OIL PARAMETER
1750	Oxidation (for mineral oils)
3540	Oxidation (for organic ester)
815	Oxidation (for phosphate ester)
1150	Sulfation (possibly from high-sulfur fuel contamination)
1630	Nitration (typically with natural gas engines)
3625	Water ingression (for organic ester)
3400	Water ingression (for mineral oils)
2000	Soot (combustion chamber blow-by contamination)
880, 3400, 1040, 1080	Glycol ingression
800	Diesel fuel ingression
750	Gasoline fuel ingression
795-815	Jet fuel ingression
3650	Phenol inhibitors additive depletion
980	ZDDP anti-wear/antioxidant additive depletion

Bennett Fitch | Noria Corporation

Elemental Analysis

Elemental analysis works on the principles of atomic emission spectroscopy (AES), which is sometimes called wear metal analysis. This technology can detect the concentration of wear metals, contaminants or additive elements within the oil. The two most common types of atomic emission spectroscopy are rotating disc electrode (RDE) and inductively coupled plasma(ICP).

Both of these methods have limitations in analyzing particle sizes, with RDE limited to particles less than 8 to 10 microns and ICP limited to particles less than 3 microns. Still, they are useful for providing trend data. Possible sources of many common elements are shown in the table below.

The best way to monitor this type of data is to first determine what is expected to be in the oil. An effective oil analysis report will provide reference data for the new oil so any amounts of additive elements can be easily distinguished from those of contaminants. Also, because many types of elements should be expected at some level (even contaminants in certain environments), it is better to analyze trends rather than focus on any specific measurement of elemental analysis data.

ELEMENT	POSSIBLE SOURCES
Aluminum	Pistons, bearing, pumps, thrust washers
Antimony	Bearings, grease
Barium	Rust and oxidation inhibitor additives, grease
Boron	Anti-corrosion additives in coolant, dust, water
Calcium	Detergent/dispersant additives
Chromium	Piston rings in internal combustion engines
Copper	Bearing, brass/bronze alloys, bushings, thrust washers
Iron	Shafts, rolling-element bearings, cylinders, gears, piston rings
Lead	Bearings, fuel additives, anti-wear additives
Lithium	Grease, additives
Magnesium	Transmissions, detergent additives
Molybdenum	Piston rings, electric motors, extreme-pressure additives
Nickel	Bearings, valve train turbine blades
Phosphorus	Anti-wear additives, extreme-pressure gear additives
Potassium	Coolant additives
Sliver	Bearing cages (plating), gear teeth, shafts
Silicon	Dust/dirt, defoamant additives
Sodium	Detergent or coolant additives
Tin	Journal bearings, bearing cages, solder
Titanium	Bearing hub, compressor blades
Zinc	Neoprene seals, grease, anti-wear additives

Particle Counting

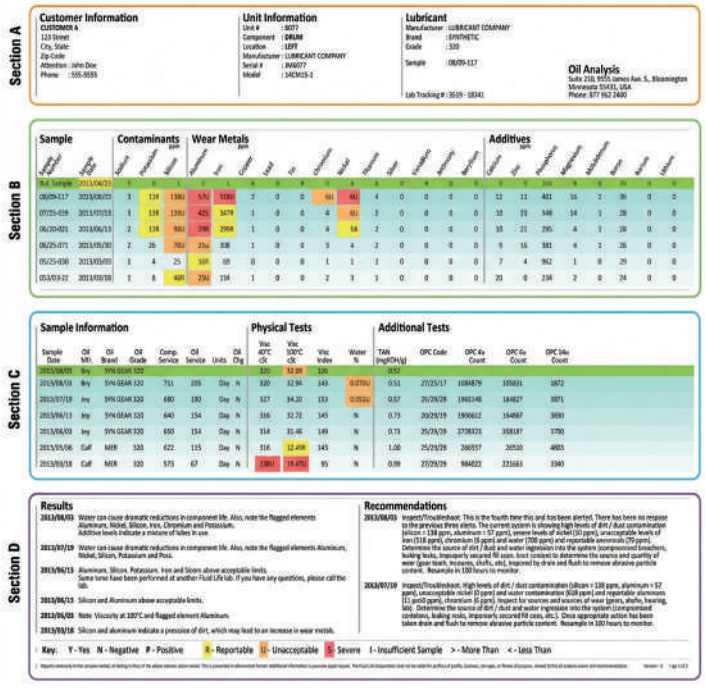
Particle counting measures the size and quantity of particles in the oil. Many techniques can be used to assess this data, which is reported based on ISO 4406:99. This standard designates three numbers separated by a forward slash providing a range number that correlates to the particle counts of particles greater than 4, 6 and 14 microns. Here's an illustration of how different particle counts are assigned specific ISO codes.

Moisture Analysis

Moisture content within an oil sample is often measured with the Karl Fischer titration test. This test reports results in parts per million (ppm), although data is often shown in percentages. It can find water in all three forms: dissolved, emulsified and free. The crackle test and hot-plate test are non-instrument moisture tests for screening before the Karl Fischer method is used. Possible reasons for a moisture reading being too high or too low would include water ingression from open hatches or breathers, internal condensation during temperature swings or seal leaks.

Interpreting Oil Analysis Reports

The first thing to check on an oil analysis report is the information about the customer, originating piece of equipment and lubricant (see Section A of the sample report below). Including these details is the customer's responsibility. Without this information, the effectiveness of the report will be diminished.



Ref. Fluid Life

Knowing which piece of equipment the oil was sampled from affects the ability to identify potential sources of the measured parameters,

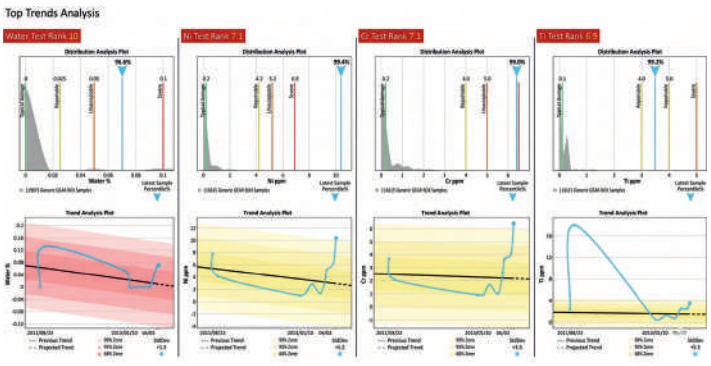
especially wear particles. For example, the originating piece of equipment can help associate reported wear particles with certain internal components.

The lubricant information can provide a baseline for several parameters, such as the expected viscosity grade, active additives and acid/base number levels. These details may seem straightforward but are often forgotten or illegible on the oil sample identification label or request form.

The next section (Section B) of the oil analysis report to examine is the elemental analysis or FTIR breakdown. This data can help identify contamination, wear metals and additives present within the oil. These parameters are reported in parts per million (ppm). Still, this does not mean a contamination particle, for example, can only be indicated by sodium, potassium or silicon spikes.

In the example above, the rise in silicon and aluminum could indicate dust/dirt contamination as the root cause. One likely explanation for these spikes is that as dirt (silicon) enters the oil from an external source, three-body abrasion occurs within the machine, causing wear debris including aluminum, iron and nickel to increase.

With a better understanding of the metallurgy within the system's components, any spikes in wear metals can be better associated, allowing a proper conclusion for which internal components are experiencing wear. Keep in mind that for trend analysis, it is important that samples are taken a tan appropriate and uninterrupted frequency.



Graphs in an oil analysis report can help illustrate notable trends in the data. (Ref. Fluid Life)

With elemental data related to contaminants and wear metals, alarms are set for upward trends in the data. For elemental data about additives, alarms are set for downward trends. Having a baseline of new lubricant reference data is critical in assessing which additives are expected and at what levels. These baselines are then established to help determine any significant reduction in specific additives.

Another section of the oil analysis report presents previously identified sample information from the customer such as oil manufacturer, brand, viscosity grade and in-service time, as well as if an oil change has been performed. This is important data that can provide an explanation for what could be false positives in alarming data changes.

The "physical tests" section of a report offers details on viscosity at both 40 degrees C and 100 degrees C, along with the viscosity index and percentage of water. For common industrial oils, the viscosity measurement at 40 degrees C is usually given, since this correlates to the oil's ISO viscosity grade. If the viscosity index must also be calculated, such as for engine oil, then these additional viscosity measurements will be identified. The viscosity for engine crankcase oils is reported at 100 degrees C.

Water contamination, which often is measured by the Karl Fischer test, is presented in percentages or ppm. While some systems are expected to have high levels of water (more than10,000 ppm or 10 percent), the typical alarm limits for most equipment are between 50 to 300 ppm.

The "additional tests" section shows two final tests: acid number (AN) and particle size distribution (aka, particle count). When analyzing the acid number, you should have both a reference value and the ability to trend from past analysis. The acid number often will jump considerably at some point. This may be your best indicator for when the oil is oxidizing rapidly and should be changed.

SELECTING OIL ANALYSIS TESTS BY APPLICATION

Test or Procedure	Paper Machine Oils	Motor and Pump Bearings	Diesel and Gas Engines	Hydraulics	Air and Gas Compressors	Chillers and Refrigeration	Transmissions, Final Drives, Differentials	Industrial Gear Oils	Steam Turbine Oils	Gas Turbine Oils	EHC Fluids
1. Particle Count	R	R	R	R	R	R	R	R	R	R	R
2. Viscosity											
a. 40°C	R	R	-	R	R	R	R	R	R	R	R
b. 100°C	-	-	R	-	-	-	-	-	-	-	-
3. AN	R	E(5a)	-	R	R	R	R	R	R	R	R
4. BN	-	-	R	-	-	-	-	-	-	-	-
5. FTIR											
a. Ox/Nit/Sul	R	R	R	R	R	R	R	R	R	R	-
b. Hindered Phenols	-	R	-	R	R	-	-	R	R	-	-
c. ZDDP	-	R	-	R	R	-	R	R	-	-	-
d. Fuel Dil./Soot	-	-	R	-	-	-	-	-	-	-	-
6. Flash Point	-	-	R	-	R*	-	-	-	-	E(2b,5D)	-
7. Glycol-ASTM Test	-	-	E(14b)	-	-	-	-	-	-	-	-
8. Ferrous Density	E(1)	E(1)	R	R	R	R	R	R	E(1)	E(1)	R
9. Analytical Ferrography	E(8,14a)	E(8,14a)	E(8,14a)	E(8,14a)	E(8,14a)	E(8,14a)	E(8,14a)	E(8,14a)	E(8,14a)	E(8,14a)	E(8,14a)
10. RPVOT	-	-	-	-	R	-	-	-	R	R	-
11. Crackle	R	R	R	R	R**	R	R	R	R	-	R
12. Water by KNF	E(11)	E(11)	E(11)	E(11)	E(11)**	E(11)	E(11)	E(11)	E(11)	-	E(11)
13. Water Separability	R	-	-	-	R**	-	-	-	R	-	-
14. Elemental Analysis											
a. Wear Metals	R, E(1)	R, E(1)	R	R, E(1)	R, E(1)	R, E(1)	R	R, E(1)	R, E(1)	R	R, E(1)
b. K, Na, B, Si	R	R	R	R	R	R	R	R	R	R	R
c. Additives	R	R	R	R	R	R	R	R	R	R	R

**Gas compressors only ** Air compressors only ***For phosphate ester fluids, consult the fluid supplier and/or turbine manufacturer. R = Routine testing E = Exception test keyed to a positive result from the test in parentheses*

The last section of the oil analysis report generally provides written results for each of the final few test samples along with recommendations for required actions. Typically, these recommendations are entered manually by laboratory personnel and based on information provided by the customer and the data collected in the lab.

If there is an explanation for the data that stems from something not explicitly stated by the customer, the results must be reinterpreted by those familiar with the machine's history of environmental and operating conditions. Understanding the information given here is

critical. Remember, there is always an explanation for each exceeded limit, and the root cause should be investigated.

In addition to the raw data shown throughout the oil analysis report, graphs can help illustrate notable trends in the data. Below is an example of trended data points from analyzed data, with the water test having the most notable unfavorable spike.

Along with the trend data, graphs should show typical averages, warning (marginal) limits and alarm (critical) limits. These limits should be modified depending on the type of data collected, the type of lubricant and the machine's known operating conditions.

Standard alarm limits will be set by the oil analysis laboratory. Yet, if there is any reason to adjust these limits higher or lower, they should be identified properly.

Examples of limits that should be lowered would be those for critical assets or assets that are consistently healthy. A small spike in data would be cause to run an exception test or an immediate second sample for analysis.

In such cases, a second sample would ensure the data received is representative of the oil conditions and not simply a human error in sampling or analysis. If exception tests are needed, the chart above shows which tests would be appropriate when a given routine test limit has been exceeded.

What Is the Best Oil Analysis Lab?

Oil analysis labs have varying capabilities and specialties. Some focus more on specific types of lubricants, such as engine oil, as compared to industrial lubricants like turbine or circulating oil. Most offer a wide array of testing to provide useful information and actionable data.

With all the variables to consider, it would be virtually impossible to identify a single lab as being the best. Simply put, the right oil analysis lab for you will be the one that delivers quality data in a reasonable time and at a reasonable price.

To better understand your lab's capabilities, open an honest dialogue with them and ask about their core competencies. Be upfront about the type of testing you would like performed. Also, inform the lab about your machine classes (gearboxes, turbines, hydraulics, engines, etc.) and inquire about their expertise with these types of equipment.

Probe into their turnaround times and discuss their price for analysis. Don't forget to ask about volume discounts. This could be a way for both you and the lab to benefit from the partnership. You'll also want to read *How to Select the Right Oil Analysis Lab.*

Do I Need to Find an Oil Analysis Lab Near Me?

The geographic location of an oil analysis lab is tertiary to the quality of the data and the turnaround time for the results. Selecting a lab that can conduct the type of testing required for your plant with a high level of confidence in the data should be your primary concern.

Look for ISO-accredited laboratories that take part in the ASTM Crosscheck Program. This will give insight into the usefulness of the data coming from the lab.

Having a lab nearby does offer some benefits, as it would allow for frequent surprise audits where you could hand-deliver samples to the lab, tour the facility and watch the analysis as it is performed. There may also be a chance to save on shipping costs.

Depending on how close the lab is, the samples might even arrive on the same day. Yet, there would be minimal savings in turnaround time, since most data from the lab will be transmitted electronically.

What If I Want to Perform Oil Analysis On Site?

The AMETEK Spectro Scientific Field Lab 58 on site oil analysis lab offers a rugged design and can generate over 20 oil analysis parameters in less than 10 minutes.

Performing oil analysis on site offers significant advantages, including faster results, reduced downtime, and the ability to make immediate decisions based on real-time data. On site analysis eliminates the wait time associated with sending samples to an external lab, allowing maintenance teams to catch potential issues early and take action before they escalate. However, selecting the right equipment is crucial to ensure accurate and reliable results. Tools like the AMETEK Spectro Scientific Mini Lab Series and the Field Lab 58 provide comprehensive on site testing capabilities, allowing users to monitor wear metals, contamination, and lubricant degradation right where the equipment operates. By investing in quality on site oil analysis equipment, companies can maximize machinery uptime and make smarter, data-driven maintenance decisions.

What Is an Oil Analysis Kit?

An oil analysis sampling kit should include everything required to obtain a representative sample from a piece of equipment. Generally, the lab performing the analysis will offer this kit with their service. It should contain disposable tubing, a sample label, a vessel for mailing back the sample and a sample bottle.

Verify that the bottle in the kit is at least certified as "clean." Tools often not found in the kit include a vacuum sampling pump, an adapter to attach to a sample port, and a purge bottle for flushing purposes. These are all required items that you should keep in your internal kit.

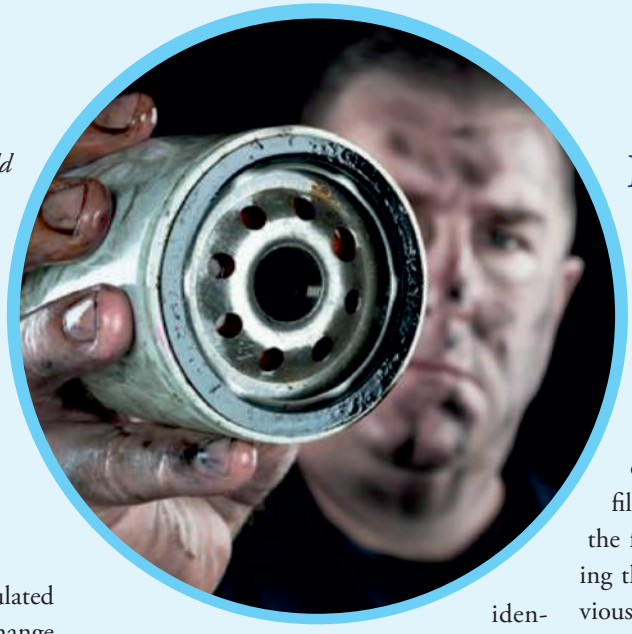
An oil analysis test kit has equipment that will allow for on site testing of new and in-service oils. Many kits can provide valuable data on key parameters such as viscosity, acid number, moisture content, particle contamination and wear debris. Before being allowed into the plant, all new lubricants should undergo these tests along with laboratory analysis.

Based on inspection results or other condition-based maintenance (CBM) technologies, an oil analysis kit can quickly reveal the condition of the equipment and the lubricant. Each kit should be stored in the lube room and contain testing devices such as a Visgage, acid number/base number test strips, a calcium-hydroxide water-content tester and a patch test kit. You'll also want to take a look at *The Basics of Used Oil Sampling*

4 TYPES OF OIL FILTER FAILURES AND HOW TO PREVENT THEM

"Which type of filter failure mode should you be most concerned about: plugging, channeling, fatigue cracks or media migration?"

Each of these failure types has a distinct failure mechanism and method of detection. While they all are bad, they can be prevented or detected with simple system analysis.



Plugging

Filter plugging occurs when oil has circulated in the system for too long without a change or other routine examination. The filter is saturated or covered in carbon sludge or other failure products like varnish. Oil analysis may show no trend indicating this type of failure, but the system will register an increased pressure differential across the filter, as the flow path is all but stopped. Routine changes of the filter and in the oil system will help to prevent this type of failure.

Channeling

Channeling, also known as media pore erosion, is where the filter weave or screen is bombarded by high-speed abrasive particles, such as sand or wear metal. These particles slowly erode the filter material or lodge in the filter pores and force themselves through, irreversibly expanding the pores. This usually can be prevented by checking and maintaining the system's gaskets and seals. Failure can be identified in oil analysis reports by observing an upward trend in the number of large particles in the particle count test.

Fatigue Cracking

Fatigue cracking, also called media matrix deformation, is where the filter weave warps due to operational stresses, such as violent cycle shifts of pressure and flow. Some forms of woven filter media can be reinforced with simple metal screens. In other cases, the filter may need to move inside the system, possibly even "off line" into a kidney-loop circulating line to keep the filter away from the higher pressures. This mode of failure will restrict oil flow through the filter and force a bypass around it, resulting in an upward trend in the total particle count on analysis reports.

Media Migration

Media migration, or media matrix rupture, is similar to fatigue cracking, but instead of warping the filter and bypassing it, the high pressure/flow transient partially destroys the filter and ruptures the material out of the filter structure. In addition to normal contaminants not being caught in the filter, new contaminants are introduced in the form of the failed filter pieces circulating through the system. Plus, anything previously captured by the filter is now at risk of being re-released. Rupture problems only increase in the presence of abrasive particles such as sand or wear metal. Failure can be identified by the oil system showing low or no pressure drop across the filter and oil analysis revealing an increase in the total particle count.

Media migration is the worst type of filter failure, as it essentially is the other three modes happening simultaneously. It can be the most difficult to immediately detect, and the introduction of large, broken filter pieces into the system can cause catastrophic damage to downstream components. You can prevent this failure mode by conducting daily visual inspections of the system, observing pressure and flow behavior, properly analyzing oil samples, and performing routine maintenance activities like inspecting and changing the oil and installed filters.

E-COMMERCE REVOLUTION:
How To Streamline Buying Lubrication Tools and Equipment

Facilities across the globe are finding themselves face to face with a hyper-competitive industrial landscape, making it more critical than ever to have an organized, intentional strategy to keep their machinery running as efficiently and reliably as possible.

By preventing costly downtime, minimizing equipment failures, and extending the useful life of machines, a precisely designed and well-executed lubrication program is a crucial component of that strategy. To do this, technicians must be provided with the right tools at the right time to perform their lubrication and maintenance jobs correctly.

Did You Know?

Remarkable Return on Investment numbers have been generated in many of the world's most successful lubrication programs, often eclipsing the 1,000% mark and being realized within the first six months of lubrication program investment.

Source: Machinery Lubrication

However, this task has proven more complex than ever in recent years. This is due to a rapidly expanding market that has been inundated with new tools and equipment, all proclaiming them to be the greatest and best performing option on the market.

While Original Equipment Manufacturers (OEMs) having pride in their product is not inherently bad, it can create challenges for technicians and managers in separating the truly effective tools and equipment from those being boosted by effective marketing strategies. Like a diner trying to choose from an extensive menu, being spoiled for choice makes it difficult to determine what the best options are for their unique needs.

So, in a world with seemingly endless options and information, how are decision makers to compare thousands of products from a range of vendors to find the best tools for their team's needs?

One solution lies in centralized e-commerce marketplaces that use their expertise to vet a variety of lubrication solutions before providing the best options to decision-makers. This type

of system allows purchasers to acquire tools, hardware and supplies from across the spectrum of manufacturers, all in a single streamlined transaction.

What Is Industrial E-Commerce?

Finding the best products for a host of maintenance and lubrication tasks can be challenging. Purchasing for varied needs like contamination control, condition monitoring, and lubricant storage and handling can often lead to guesswork, which in turn can lead to overspending.

This is where a well-built e-commerce marketplace can shine. Instead of sifting through countless brand sites and decoding marketing, decision-makers can turn to a single site that specializes in sourcing lubrication tools and equipment from across the industry.

More than just another open-ended marketplace, solutions-driven resources like this are designed with a specific end-user in mind. This means putting critical information at the forefront of the experience and inspiring confidence in the purchasing process.

Quality marketplaces evaluate and recommend products based on the highest and most current industry standards, not marketing promises and tactics. This allows end users to trust that their decisions are made based on accurate and relevant information, and that their investment ingoing to the right tools for the job.

In addition, a good site provides the added benefit of procurement simplicity. End users no longer need to manage multiple vendors or deal with last minute product quality or compatibility issues on an individual basis. Everything a technician needs in their tool belt to create a world-class lubrication program is all housed in a single place and can be bought and managed as a single transaction.

The Benefits of Quality Investments

The consequences of poor lubrication tools and practices can be shocking, and they become especially apparent when considering the compounding effects of reactive maintenance,unplanned downtime, and equipment failures. In fact, at least 10% of a plant's entire annual

maintenance costs can be saved or redirected to other initiatives when a proper lubrication program is in place.

By sourcing the appropriate tools from a centralized e-commerce platform that actively vets products for quality and effectiveness, industrial facilities can optimize their maintenance and lubrication budgets, confidently make their investments, and achieve a greater level of operational success and efficiency.

Additionally, by avoiding the second-guessing and buyer's remorse, end users and technicians can focus solely on keeping operations running at maximum efficiency, avoiding expensive breakdowns and failures, and defining more unique "big picture" projects to help increase the success of the entire department and facility.

The Right Tools for the Job

In an oversaturated market bursting with new tools and technologies, the right choice is not always obvious. It also isn't a "one size fits all" approach. By leveraging a centralized e-commerce marketplace that makes finding the best and most appropriate tools and supplies easy, end users can eliminate uncertainty, streamline their lubrication programs, and set their facilities up for success.

FOLLOWER PLATES:

A Simple Contamination Prevention Solution for Pumping Grease Drums

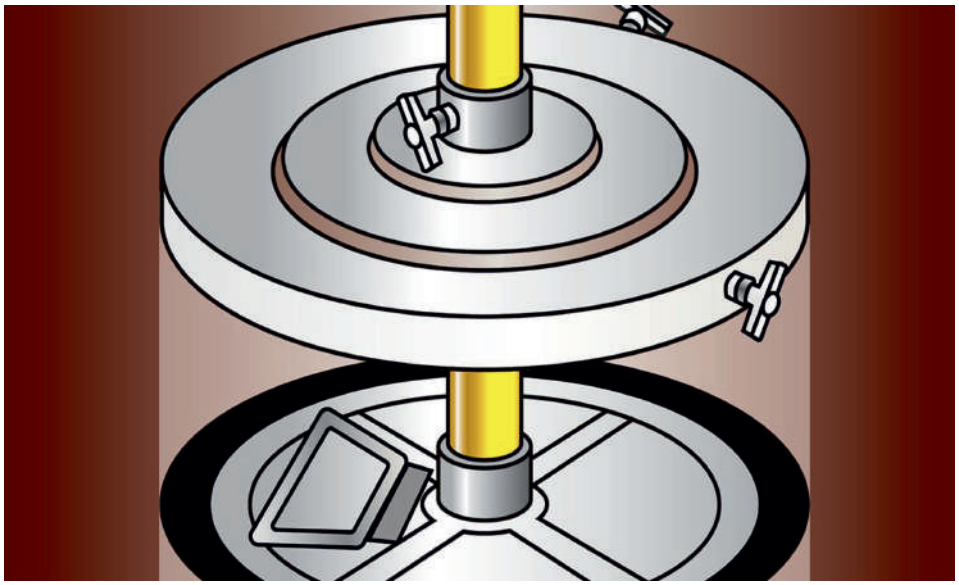
Grease is comprised of three components – oil, a thickener, and additives.

Thickeners impact grease capability and compatibility. Compared to oil, greases are better for leakage control and sealing against contaminants, which are one of the leading causes of mechanical failures.

Grease can remain in equipment for extended periods of time under a variety of conditions. However, grease is difficult to drain and doesn't circulate, meaning if the grease is contaminated while in service, the particles will remain in place and cause significant damage to the bearings.

Additionally, rolling element bearings operate in an elastohydrodynamic regime. According to Machinery Lubrication, this regime occurs when the lubricant comes between surfaces where a small contact area and a rolling motion exist, such as ball bearings.

These conditions create high-contact pressures – sometimes hundreds of thousands of psi –meaning that if water or particle contaminants are present, they become incredibly destructive.



Contamination Control Strategies

The most commonly used strategies found in contamination control programs are a combination of:

1. Preventing contaminants from ever entering
2. Removing contaminants through filtration systems

It is possible to remove contaminants from oil once introduced by using filtration systems. However, it is always advisable to minimize the contaminants from entering the system to avoid lubricant degradation and additive depletion. It will always cost more to remove dirt than it is to keep it from entering in the first place.

In contrast, once contaminants are present in grease, they are nearly impossible to filter out. This means the only option for a grease contamination control strategy is to prevent contaminants from ever entering.

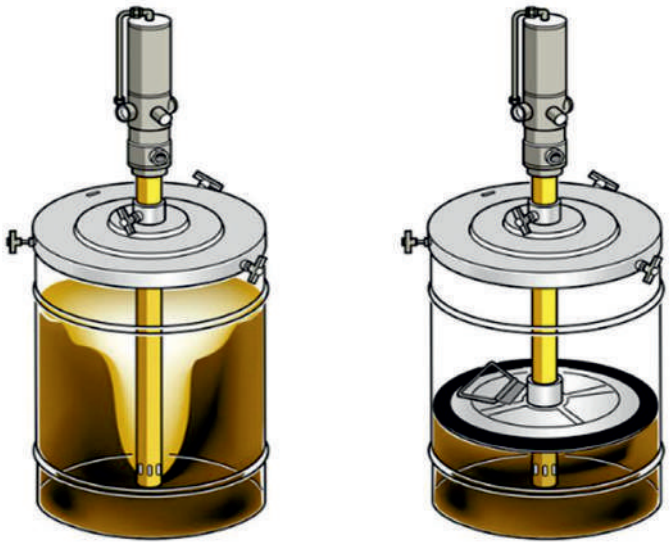
Unfortunately, it's common for end users to unintentionally expose grease drums to contaminants. This seriously affects the quality of the grease and the machine parts. One simple and sometimes overlooked solution is a follower plate.

What is a Follower Plate?

A follower plate is a tool capable of pumping grease directly from the drums. In this process, a pump creates a vacuum that pulls the follower plate to the bottom of the drum, collecting the grease along the way.

The follower plate has four core benefits:

1. Keeps the grease clean and preserves its characteristics.
2. Compresses the grease, preventing air pocket formation and pump cavitation.
3. Helps collect grease from the bottom of the drum, which would otherwise remain stuck.
4. Improves the pump's overall capabilities.



Benefit 1: Keep the Grease Clean

Keeping grease clean should be a crucial objective for every workshop and technician.

The purpose of keeping grease clean is to safeguard the longevity of the lubricated parts or systems. This is because the lubricant film separating the contacting surfaces—whether rolling or sliding—is usually very thin, anywhere from less than 1m up to 10m. Particles larger than the film thickness can be detrimental to the smooth running and service life of the bearing.

Additionally, grease cannot be effectively filtered after formulation. There are two main reasons for this:

1. Filtration requires the fluid to flow and mix to help remove contaminants uniformly. Because grease doesn't possess these characteristics, filtration is not effective.
2. Standard filtration methods generally disrupt and break down the grease's thickener, which is designed to give the grease its consistency and keep the grease in place when in service

Benefit 2: Compress the Grease

If grease is left open and not compressed, air pockets can form. These air pockets can disturb the lubrication system and damage the pump through cavitation – the mechanism by which vapor bubbles (cavities) in a fluid grow and collapse due to local pressure fluctuations.

Benefit 3: Help Collect Grease

When a follower plate isn't used, the drum can't be completely emptied, leading to wasted grease. In some cases, there can be as much as 5 kg of waste per 180 Kg drum.

Extended to the number of grease drums consumed in a workshop, this grease waste can be enormous and justify the purchase of a follower plate.

Benefit 4: Improve Pump Capabilities

When grease isn't compressed, a facility can experience several challenges, including:

- Affecting the flow of the grease.
- Affecting the life of the pump.
- Under-lubricating machines.

Selecting a Follower Plate

The diameter of the follower plate depends on the diameter of the grease packaging. The mass of the plate is also a good criterion since the compactness of the grease will rely on the pressure exerted on it.

The consistency of the grease also plays a role in selection; for example, an NLGI 1 grease may need a lighter follower plate than an NLGI 3 grease.

THE VITAL ROLE OF TRIBOLOGY:

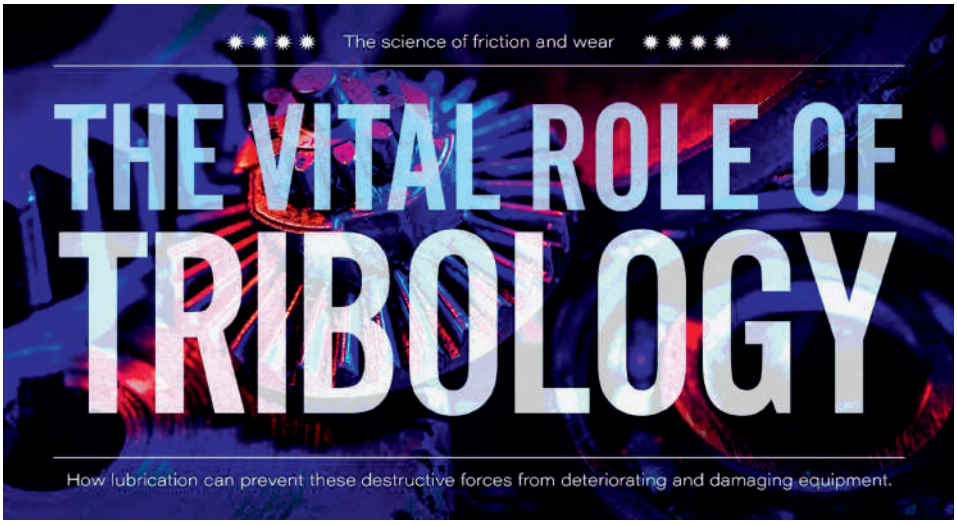
Protecting Critical Equipment Against Friction and Wear

On the quest to become a world-class facility, where productivity, uptime, and reliability can mean the difference between success and constant struggle, one facet of industrial maintenance cannot be overlooked or overemphasized –the world of tribology.

At its core, tribology is the science of friction and wear, and how lubrication can prevent these destructive forces from deteriorating and damaging the critical equipment central to successful operations. By understanding and minimizing the negative effects of friction and wear, maintenance teams can protect valuable equipment, prevent costly downtime, and ultimately help build and maintain a reliable world-class facility.

Lubrication's Role in Tribology

Industrial machines are regularly exposed to extreme conditions, often involving exposure to damaging contaminants as well as variable loads, speeds, and temperatures. Combined with the near-constant motion that has various machine surfaces interacting, these factors can create and intensify opportunities for friction and wear on equipment components, leading to reduced efficiency, frequent reactive maintenance, and costly downtime.



By properly selecting and applying lubricant and maintaining good lubrication practices, many of these consequences can be minimized or avoided. Lubrication helps control friction and wear by creating a protective barrier between the moving machine parts where surfaces may come into contact.

By understanding and applying the principles of tribology, facilities in every industry can se-

lect and apply the proper lubricants for their specific needs to help minimize and avoid the adverse effects of friction and wear. As a result, facilities can see marked improvement in machine performance, equipment lifespan, and energy efficiency.

Forms of Friction and Wear

To fully understand the impact of tribology on machine health, it's important to know the multiple forms of friction and wear. Grasping the potential for harm allows team members to be more vigilant and spot the early warning signs before severe damage can occur.

At its core, friction is the "resistance to relative motion between two bodies in contact." There are several forms of friction, including:

Sliding: Two objects move against each other

Rolling: One object rolls on another object.

Static: An object is held at rest until a force overcomes it and the object begins to move against another object.

Fluid: A solid object moves through a liquid or gas.

Wear, the other potentially destructive force, can be described as "the gradual removal, damaging, or displacement of material on solid surfaces." Common forms of wear include:

Abrasive: A rough surface cuts a softer surface.

Adhesive: Material is transferred from one surface to another through a localized welding process.

Fretting: Two surfaces have repeated cyclical rubbing.

Erosive: Solid or liquid particles invade an object's surface.

The Impact of Tribology on Industry

By addressing these potential hazards with effective tribological strategies, facilities can optimize their operations and achieve significant benefits, including:

Increased Equipment Lifespan: Minimizing wear and friction can extend the operational life of essential equipment and reduce the need for repairs and replacements.

Enhanced Efficiency: By reducing friction, facilities can lower their overall energy consumption, reducing costs and environmental impact.

Improved Safety: Quality lubricants and lubrication practices help equipment function reliably and effectively, thereby reducing the risk of unexpected failure and the opportunity for safety hazards.

Reduced Maintenance Costs: Proactive maintenance initiatives reduce the maintenance costs associated with repairs, replacements, and lost production from unplanned downtime.

Improved Product Quality: Proper lubrication allows equipment to operate at a higher efficiency, ensuring production standards are consistently met and the company can become a strong market competitor.

While at first glance tribology may seem to be just a heady, "academic" topic, an understanding of the mechanics of lubrication, friction, and wear provides users with a very practical perspective. By understanding how lubrication impacts overall operational efficiency and how to combat against destructive forces, facilities can proactively protect their critical equipment and achieve operational excellence.

In a world where every moment of downtime can have lasting consequences, tribology is more than just theory; it is the cornerstone upon which world-class lubrication programs are built.

MASTERING THE STRIBECK CURVE:

A Maintenance Engineer's Guide to Bearing Reliability

Executive Summary

Tribological research indicates that 70% of bearings lose their usefulness due to avoidable surface degradation. In the demanding environments of Indian Steel, Cement, and Power plants, mastering the transition between lubrication regimes and implementing the "5 Rights" (5R) approach is the difference between seamless operation and trillions of dollars in lost productivity.

1. The Invisible Cost of Surface Wear

Mechanical wear is a primary driver of industrial inefficiency, with historical research by MIT suggesting that 6% of the U.S. GDP is lost annually to this phenomenon. Simply put, surface degradation—whether through corrosion, mechanical wear, or fatigue—can be directly attributed to ineffective lubrication practices.

Common Pitalls in Heavy Industry:

- **Under- and over-application** of lubricants.
- **Contamination,** specifically from particles and moisture.
- **Incorrect lubricant choice,** including poor viscosity selection or inadequate additive packages.
- **Neglect** of calculated service intervals.

Proper lubrication does more than reduce friction; it facilitates heat dissipation, noise reduction, corrosion protection, and contaminant removal.

2. The Hierarchy of Lubrication Regimes

The level of protection a bearing receives depends on the thickness of the lubricant film, categorized into distinct regimes. The Stribeck Curve graphically depicts how friction relates to sliding speed, load, and viscosity.

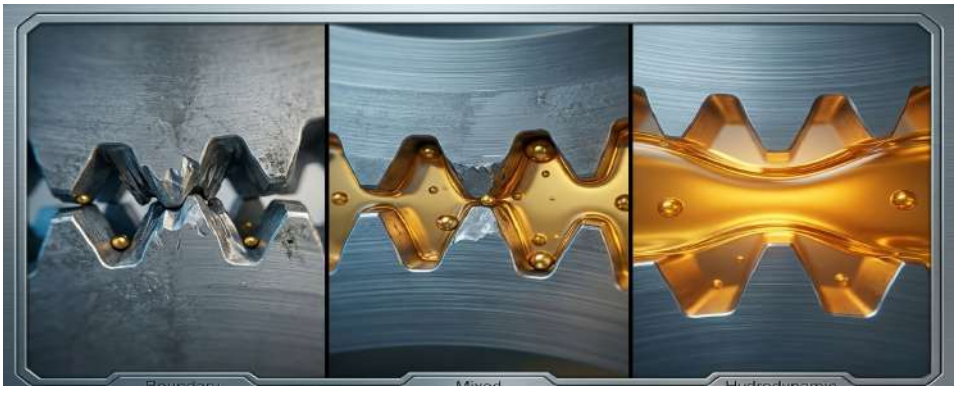


Figure 1: From Friction to Fluid

(Using the "5 Rights" to reach the gold-shaded "Full-Film" zone where virtually wear is eliminated)

A. Boundary Lubrication (High Friction / Low Speed)

- **Condition:** Opposing surfaces are in direct contact or separated by a minimal oil film.
- **Characteristics:** Over 90% of the load rests on surface asperities (microscopic peaks).
- **Technical Risk:** Accelerated wear and "welding" of asperities without proper anti-wear(AW) or extreme pressure (EP) additives.

B. Mixed-Film Lubrication (The Transitional Stage)

- **Condition:** A regime where both surface asperities and the lubrication film share the load.
- **Maintenance Focus:** Requires stability under fluctuating loads and speeds to prevent shifting back into boundary contact.

C. Full-Fluid Film Lubrication (Optimal Separation)

- **Hydrodynamic Lubrication (HDL):** Occurs at high speeds where a thick film fully separates surfaces, common in steam turbines.
- **Elastohydrodynamic Lubrication (EHL):** Occurs under high loads where film pressure causes elastic deformation of surfaces, typical in gears and rolling element bearings.

3. Strategic Comparison for Plant Operations

Feature	Boundary	Mixed	Full-Film (HDL/EHL)
Surface Contact	Maximum metal-to-metal	Partial contact	No contact; fully separated
Load Carrier	Surface peaks (>90%)	Shared between peaks/film	100% carried by lubricant
Film Thickness	Minimal/Insignificant	Transitional	1 to 5 Microns
Friction Level	Very High	Variable	Minimal (Internal fluid resistance)

4. The "Invisible Killer": Understanding Mcron-Level Threats

In a full-film regime, the lubricant layer is incredibly thin—typically 1 to 5 microns. Because humans only begin to see objects at 40 microns, the particles that destroy your bearings are effectively invisible to the naked eye.

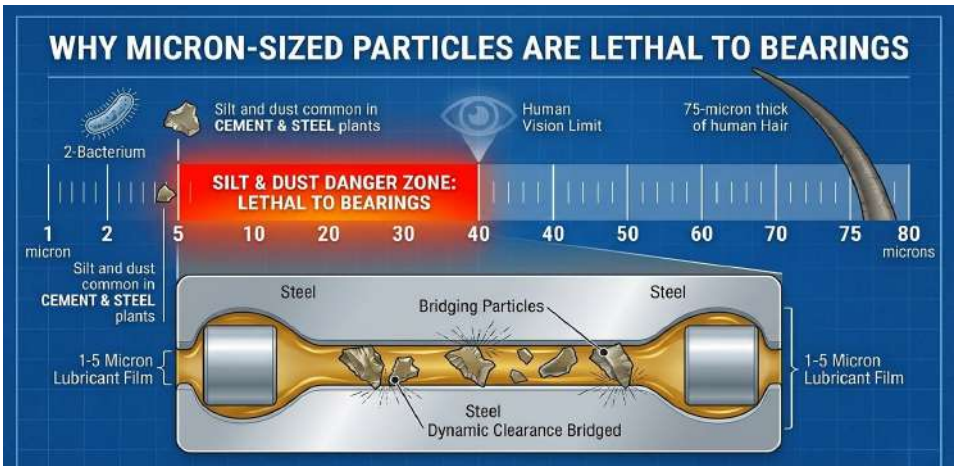


Figure 2: The Invisible Threat Scale

(Visualizing how a 5-micron silt particle bridges a 1-micron lubricant film, causing catastrophic surface damage.)

In the dust-heavy environments of Cement and Steel plants, silt or dirt (~5 microns) can easily enter the bearing area and bridge the lubrication film, leading to premature failure.

5. Conclusion: Implementation via the 5R Approach

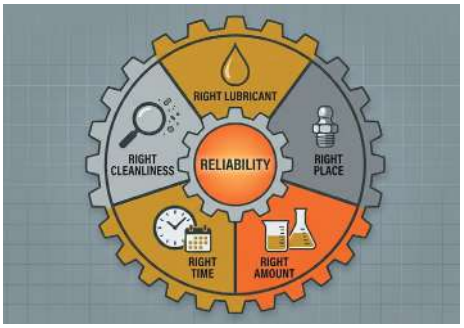


Figure 3: The 5R Reliability Compass

(A circular framework for maintenance teams to audit daily lubrication tasks.)

The fate of a bearing is in the hands of the maintenance department. To minimize surface degradation to negligible levels, plants must adopt the 5 Rights of Lubrication:

1. **Right Lubricant:** Ensuring correct viscosity and additive packages for the load.
2. **Right Place:** Ensuring the lubricant reaches the interaction zone.
3. **Right Amount:** Avoiding the heat build-up of over-application or the wear of under application.
4. **Right Time:** Precise intervals to maintain film integrity.
5. **Right Cleanliness:** The most critical factor in high-dust environments.

About the Author

Chander Mohan Sharma (C M Sharma) brings over three decades of hands-on experience in industrial lubrication. A former Senior Manager at Tata Steel, he superannuated after a distinguished career overseeing lubrication across project planning and plant operations. His expertise spans critical equipment in the Steel, Power, Mining, and Cement industries. Today, he continues to share his knowledge through consulting and training assignments across India, helping industries strengthen their lubrication and reliability practices.

Ravi Kiran

WHY CLEAN SAMPLE BOTTLES ARE KEY TO RELIABLE OIL ANALYSIS

In high-stakes industries like Steel, Cement, and Power, the accuracy of a fluid sample depends entirely on the bottle that holds it. Even when the oil inside a machine is clean, dirt introduced during sampling or storage can ruin laboratory results. This leads to "false readings" that trigger expensive, unnecessary maintenance or, worse, hide a real system failure. To stop this, the industry uses the ISO 3722 test method to measure how many particles a container adds to a sample.

ISO 3722: The Method, Not the Metric

A common misconception is that ISO 3722 provides a "pass/fail" grade. In reality, the standard only defines how to extract and measure the particles. It involves rinsing the container with a clean fluid and counting the debris released.

Because the standard does not set specific limits, each plant must decide what is "clean enough" based on how sensitive their machines are.

Defining Your Cleanliness Tiers

To keep things simple on the shop floor, many organizations use three main categories based on the number of particles found (specifically at the > 10 µm size):

Figure 1: What the eye misses, the machine feels: Guard your precision with ISO 3722

Classification	Particle Limit (≥ 10µm)	Typical Industry Application
Clean	≤ 100 particles/ml	Gearboxes, Coal Mills, Conveyor Drives
Super Clean	≤ 10 particles/ml	Steam Turbine Control Oil, General Hydraulics
Ultra Clean	≤ 1 particle/ml	Steel Mill Servo-Valves, High-Pressure Systems

The Danger of "Microscopic Silt" (Sub-10 µm)

While particles larger than 10 µm cause immediate abrasive wear, modern precision systems are increasingly threatened by "silt" in the 4–6 µm range. In servo-controlled systems with microscopic clearances, these fine particles interfere with spool movement and degrade control accuracy.

A container may technically meet "Clean" limits at > 10 µm but still harbor enough 4 µm particles to compromise a sensitive system. Consequently, reliability leaders are shitiing monitoring to lower thresholds like > 4 µm and > 6 µm.

Beyond the Bottle: Sampling Discipline

Achieving "Ultra Clean" results requires more than just buying the right hardware. Even the cleanest container cannot compensate for poor sampling discipline.

- **Keep it Sealed:** Do not open the bottle until the exact second you are ready to take the sample.
- **Watch the Dust:** Never leave caps open or place them on dirty surfaces in the plant.
- **Flush the Line:** Always flush the sampling port thoroughly before collecting the oil to ensure you are testing the actual system fluid.

Summary

By combining the standardized extraction methods of ISO 3722 with strict internal limits and disciplined handling, organizations can protect the integrity of their oil analysis programs. In the race for reliability, ensuring your sample bottle is as clean as your system is not just best practice—it is a technical necessity.

THE 5-MINUTE SAMPLING CHECKLIST

- Purge the Port: Flush 10x the dead-space volume before collecting.
- Down-facing Cap: Hold the cap facing down to avoid airborne dust.
- The 80% Rule: Fill to 80% to allow lab agitation; seal immediately.

About the Author

Ravi Kiran is a Technical Manager at Aswartha Condition Monitoring Engineers, specializing in ferrography and oil analysis for machinery health diagnostics. He has practical experience in wear debris analysis, lubricant contamination control, and lubricant health monitoring. His work focuses on improving equipment reliability and predictive maintenance through advanced lubricant analysis techniques.

Face-To-Face:
BANKIM BEHARI PATRA

Country Head (Lubes), Indian Oil Corporation

"Future-ready industries don't just consume lubricants-they integrate intelligence, security, and innovation into every drop."

Bankim Behari Patra
Country Head (Lubes), IndianOil

Inside this Conversation: In this exclusive feature, we explore the 34-year career of Bankim Behari Patra —from the technical rigors of Chemical Engineering and Quality Control to his role leading India's largest energy major.

Bankim Behari Patra, Country Head (Lubes) at Indian Oil Corporation Ltd., is a seasoned corporate leader with over 34 years of experience in business strategy, digital transformation, and lubricant innovation across Indian and international markets. He has played a pivotal role in shaping IOC's long-term lubricant strategy, driving transformative programs such as *Disha – Route to Market Transformation,* and championing sustainability through circular economy practices.

His career includes senior leadership positions in quality control and global lube sales, where he spearheaded product launches, market expansion, and operational excellence. Internationally, his tenure as Senior Vice President at Lanka IOC PLC broadened his expertise in bitumen and petrochemical trade across Sri Lanka, Maldives, and Indonesia.

With a Master's in international marketing from Cardiff Metropolitan University and a Chemical Engineering degree from Calcutta University, Mr. Patra has earned multiple awards for business excellence. His professional journey reflects a commitment to innovation, environmental stewardship, and building future-ready organizations in the energy and lubrication sectors.

Indian Oil – Brief Profile

Indian Oil Corporation Ltd. (IndianOil) is India's largest integrated energy major and a Fortune 500 company, playing a pivotal role in fueling the nation's economic progress for over six decades. As the country's leading refiner, marketer, and fuel retailer, IndianOil operates an extensive and robust energy ecosystem that spans refineries, cross-country pipelines, fuel stations, LPG distributorships, aviation fueling facilities, petrochemicals, lubricants, and alternative energy solutions. With a customer base that touches the lives of millions every day, IndianOil stands as a symbol of reliability, national service, and technological excellence.

Its lubricants brand SERVO remains India's most respected and wide-

ly used lubricant brands. With a portfolio covering automotive, industrial, marine, and specialty lubricants, SERVO caters to diverse sectors including manufacturing, mining, power generation, defense, and transportation. Known for its advanced formulations, performance consistency, and ability to meet stringent OEM specifications, SERVO has earned global recognition and is exported to over 45 countries. The brand's strong presence in motor sports, defense applications, and heavy industries underscores its reputation for reliability under the most demanding conditions.

INDIANOIL FAST FACTS

- Market Dominance: India's largest integrated energy major and a Fortune 500 company.
- Base Oil Production Surge: Expanding base oil capacity from 0.6 to 1.7 MMT to bolster domestic supply security.
- Global Footprint: Operates the World's largest lubricant blending plant at Manali, Chennai.
- Growth Leader: Servo Holds largest market share in Indian Lubricant Market.
- Self-Reliance: Only company in India producing all kinds of base oils.
- Green Vision: Strategically developing ecosystem for Used oil refining and RRBO based products.

Driven by a strong commitment to innovation and digital transformation, IndianOil continues to modernize its operations through advanced analytics, automation, and customer-centric platforms. Sustainability lies at the heart of its long-term vision, with strategic investments in bio fuels, green hydrogen, renewable energy, electric mobility, carbon neutral initiatives, and circular economy models. Its efforts in environmental stewardship, community development, and inclusive growth have earned IndianOil recognition as one of India's most socially responsible corporations.

Guided by its core values of Care, Innovation, Passion, and Trust, IndianOil continues to shape the nation's energy landscape—balancing growth with responsibility, tradition with transformation, and national priorities with global aspirations. As India moves toward a sustainable energy future, IndianOil and its flagship brand SERVO remain steadfast in their mission to deliver energy and lubrication solutions responsibly, efficiently, and equitably to every corner of the country.

Q1: What is the biggest Lubricant Supply Chain Risk or Raw Material Vulnerability in the Indian market, and what steps is IOCL taking to mitigate this for business continuity?

The primary risk in India's lubricant market is the volatility in base oil and additive supply, as global disruptions can significantly impact both availability and pricing stability. At present, India imports nearly 60% of its base oil requirements, making the industry particularly vulnerable to external shocks such as geopolitical tensions, supply chain bottlenecks, and fluctuations in crude oil markets.

We mitigate these risks through a focused strategy of backward integration and capacity expansion. Increasing our base oil production from 0.6 MMTPA to 1.7 MMTPA significantly enhances domestic supply security and reduces reliance on imports. In parallel, the expansion of blending capacity—supported by our newly commissioned world's largest blending plant at Manali, Chennai—provides a strong foundation for lubricant supply assurance. This advanced blending infrastructure allows for greater formulation flexibility, enabling us to adapt efficiently to variability in raw material quality and availability.

Additionally, our diversified sourcing strategy for additives, combined with long-term partnerships with key suppliers, strengthens supply chain resilience. We are also actively working toward the localization of additives to further reduce import dependence and improve cost stability over the long term. The integration of digital forecasting tools enhances demand planning accuracy and optimizes inventory management, ensuring timely availability of products.

By strengthening domestic manufacturing capabilities and embedding advanced supply chain intelligence, we are able to ensure business continuity, maintain operational reliability, and consistently meet the evolving needs of customers across diverse industries.

Q2: What is IOCL's strategy for meeting the demands of the Indian Electric Vehicle (EV) market with specialized e-fluids and thermal management solutions?

India's transition to electric mobility fundamentally reshapes lubrication and fluid requirements, and IOCL views this not as a demand disruption but as a strategic technology evolution. Accordingly, our approach is anchored in building a future-ready portfolio of specialized e-fluids and thermal management solutions under the Servo brand.

We have developed a comprehensive EV fluids portfolio that includes advanced e-transmission fluids, dielectric coolants, and specialty greases tailored for high-speed electric drivetrains. These products are engineered to address the unique challenges of EVs—

such as higher operating speeds, increased thermal loads, and the need for electrical insulation—while enhancing overall system efficiency and durability.

A key pillar of our strategy is focused R&D, particularly in the domain of battery thermal management and friction optimization. By improving heat dissipation and reducing energy losses in driveline components, our solutions contribute directly to extending battery life, improving vehicle range, and ensuring operational safety.

Equally important is our localized manufacturing and blending capability, which allows us to respond with agility to evolving OEM specifications and market demands. We actively collaborate with automotive manufacturers through co-development initiatives, ensuring our products are aligned with next-generation EV architectures and performance requirements.

In essence, IOCL's EV strategy is built on three pillars: innovation in advanced fluid technologies, manufacturing responsiveness, and deep OEM partnerships. This integrated approach positions Servo as a key enabler in India's electric mobility ecosystem, delivering solutions that prioritize thermal efficiency, durability, and safety.

Q3: What concrete steps is IOCL taking to promote Lubricant Sustainability through efficient Used Oil Re-Refining and Management?

Sustainability at Indian Oil Corporation Limited is guided by a lifecycle-based approach that spans product design, manufacturing, usage, and end-of-life management. We focus on developing energy-efficient formulations and responsibly expanding our portfolio of green products that deliver high performance while reducing environmental impact. High-efficiency synthetic lubricants play an important role by reducing friction, lowering energy consumption, and extending drain intervals, which helps minimize waste generation over the product lifecycle.

A key pillar of our sustainability approach is responsible used-oil management. We actively support structured used-oil collection by partnering with multiple authorized re-refiners, who carry out scientific re-refining to convert used oil into re-refined base oils. These re-refined base oils are already used across many of our lubricant formulations and are supported by multiple green products specifically developed using RRBOs. This helps conserve base-oil resources and reinforces our commitment to circular economy principles.

Sustainability is therefore embedded in our growth strategy, and as Servo continues to expand, we remain committed to responsible manufacturing, efficient resource utilization, and strong alignment with India's environmental objectives. Importantly, our approach is fully aligned with the Government of India's Extended Producer Responsibility (EPR) vision and policy framework for lubricants and plastics, supporting a scalable and responsible ecosystem for resource recovery and reuse.

Q4. How is SERVO planning to expand and diversify its lubricant portfolio to meet the changing demands of automotive, industrial, and emerging sectors?

As the lubricants industry evolves, we are witnessing a clear shift toward premiumiztion, driven by higher equipment performance standards, sustainability expectations, and the need for extended asset life. At SERVO, our strategy is to proactively align with this transition by continuously upgrading and diversifying our portfolio.

We are systematically premiumizing our product range, with a strong focus on high-performance and synthetic lubricants that deliver superior efficiency, longer drain intervals, and enhanced environmental compatibility. This is particularly relevant across modern automotive technologies, advanced industrial systems, and emerging sectors such as renewable energy and electric mobility.

A key pillar supporting this journey is our in-house Group III/III+ base oil capability, which gives us tighter control over quality, cost, and formulation flexibility. This not only strengthens our competitiveness but also enables us to develop products that meet and exceed evolving OEM specifications and global benchmarks.

Our R&D ecosystem remains central to driving this—focusing on next-generation formulations, specialty fluids, and sustainable solutions. By combining deep technical expertise with data-driven insights, we are able to accelerate innovation and respond with precision to application-specific needs.

Through this integrated approach—anchored in premiumization, self-reliance, and innovation— SERVO is well positioned to deliver differentiated, future-ready solutions that not only meet but anticipate the evolving demands of both domestic and global markets.

Q5. How is IOCL leveraging Digital Lubrication solutions and Industry 4.0 technologies to transition industrial maintenance programs to truly predictive maintenance?

At Indian Oil Corporation Limited, digitalization is transforming lubrication into a predictive discipline. We are aligning Servo's ecosystem with Industry 4.0 through integrated data capture, oil condition monitoring, analytics, and centralized dashboards.

Structured digital oil sampling and trending tools provide real-time visibility into lubricant health, contamination levels, and wear patterns. Customers increasingly shift from time-based maintenance to condition-based decision-making.

Integration of lubricant data with plant parameters such as vibration, temperature, and load can be used to generate actionable insights. Predictive alerts would help main-

tenance teams intervene at the optimal moment—preventing breakdowns without unnecessary servicing.
Our digital supply chain tools enhance traceability, optimize inventory, and reduce lead times, particularly for reliability-critical sectors like steel, cement, mining, and power.

Q6. What is IOCL's Lubrication Strategy for maximizing asset life, reducing Total Cost of Ownership (TCO), and specifically guaranteeing a reduction in unplanned downtime?

Our lubrication strategy is built on one principle: reliability drives profitability. We go beyond product supply to become lifecycle partners. Our approach integrates application-specific lubricant selection, contamination control, condition monitoring, and structured reliability audits to maximize asset life and reduce Total Cost of Ownership (TCO).

We emphasize precision lubrication—right product, right quantity, right interval. Advanced synthetic formulations and high-performance additive systems reduce wear, friction, and oxidation, enabling longer drain intervals and lower maintenance frequency.

To minimize unplanned downtime, we deploy structured Used Oil Analysis (UOA) programs that detect early signs of wear, contamination, or lubricant degradation. This enables planned intervention before failures escalate.

As India's leading lubricant brand, our objective is clear: protect critical assets, enhance operational stability, and deliver measurable lifecycle value to customers.

Q7. What is the most significant Lubricant Innovation in Synthetic Base Oil or Additive Technology that IOCL has developed to enhance the performance of modern, high-speed machinery?

Our most impactful innovation lies in formulations designed with advanced synthetic base oil and additive technologies for the evolving demands of high-speed machinery and next-generation engines.
Today's systems operate under extreme conditions, requiring lubricants with high thermal stability, shear resistance, and oxidation control, while also delivering fuel efficiency and lower emissions. In this space, we have developed fuel-efficient, low-viscosity synthetic engine oils that reduce friction, enhance engine cleanliness, and meet the latest OEM and emission requirements.

On the industrial front, our focus has been on high-performance specialty lubricants, including micro-pitting resistant gear oils, long-life compressor oils, fire-resistant hydraulic fluids, and advanced turbine oils for critical, high-end applications. These are enabled through optimized additive chemistry, ensuring cleaner systems, stable performance, and extended service intervals.

Our R&D capabilities, allow us to design and validate formulations aligned with global standards while maintaining strong control over quality and consistency.

The objective is clear: to deliver premium, high-performance lubricants that enhance reliability, improve energy efficiency, and support the most demanding industrial and automotive applications.

Q8. What are the key Reliability Engineering skills needed for the future of maintenance, and what Lubrication Training programs is IOCL providing to bridge the industrial skills gap?

The future demands reliability professionals skilled in tribology, root-cause failure analysis, vibration diagnostics, contamination control, and data analytics. At Indian Oil Corporation Limited, we are bridging this gap through structured training initiatives and seminars for customers.

Our workshops focus on precision lubrication, oil sampling techniques, contamination management, and condition-based monitoring. We integrate digital literacy—training teams to interpret predictive dashboards and correlate lubricant trends with machine behaviour.

We emphasize lifecycle cost thinking over short-term cost reduction. Reliability-centred maintenance principles are embedded into programs conducted across sectors like steel, cement, mining, and power.

Plant-specific clinics empower technicians to transition from reactive maintenance to analytical decision-making.

Our responsibility extends beyond products. We are cultivating a reliability workforce ready for Industry 4.0 and beyond—where human expertise and intelligent systems operate in synergy.

Q9: How do you define a true Industrial Reliability Success Story—is it defined by Zero Unplanned Downtime metrics, cost savings, or the mastery of lubrication best practices?

A true reliability success is cultural, not just statistical. Success means lubrication is strategic, not routine.

It reflects disciplined contamination control, data-driven oil analysis decisions, and scientifically optimized drain intervals.

Downtime reduction and cost savings follow naturally, but prevention mindset is the real milestone.

When teams proactively protect assets, understand lubricant health, and prevent recurrence of failures, reliability becomes sustainable.

Such maturity results in extended equipment life, predictable budgets, and operational stability—hallmarks of industrial excellence.

Reliability Snapshot

- **The Predictive Shift:** Moving from time-based maintenance to **condition-based decision-making.**
- **AI Diagnostics:** Applying Machine Learning to **Used Oil Analysis (UOA)** data to forecast the remaining useful life of assets.
- **Strategic Lubrication:** Lubricants are no longer just consumable-they are evolving into **critical enablers of reliability, efficiency, and performance.**
- **EV Portfolio:** Specialized **e-transmission fluids** and dielectric coolants engineered for high-speed electric drivetrains.
- **Skills Bridge**: Bridging the industrial gap by training technicians in **tribology.**

Jhumpa Mukherjee

SLEEP IS A STRATEGY:
A New Productivity Hack

Every professional wants to perform better: sharper focus, fewer mistakes, better energy.

One of the most powerful ways to achieve this is surprisingly simple: quality sleep.

Have you ever noticed how everything feels harder after a poor night's sleep? You forget small things. You feel irritated faster. Your energy drops.

Sleep restores the brain, balances hormones, improves concentration, and strengthens problem-solving ability. Without it, productivity drops. With it, performance improves naturally.

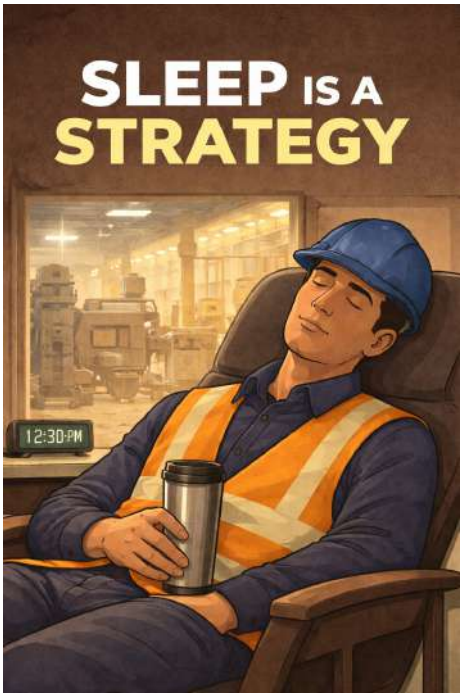
What is the Hidden Cost of Sleep Debt?

Sleep debt doesn't just make you yawn. It quietly alters reaction time, decision-making, coordination, and emotional control. Research consistently shows that being awake for 17–19 hours can impair performance.

Sleep deprivation can lead to:

- Delayed response time
- Reduced concentration
- Memory lapses
- Increased irritability
- Poor judgment under pressure

When we ignore sleep, productivity doesn't rise — mistakes do.



Why Shift Workers Face a Tougher Battle

Night shift professionals fight biology every day. The human body is wired by circadian rhythm — an internal clock that signals alertness during daylight and rest at night. When we work against it, the body doesn't adapt easily.

Common challenges for shift workers include:

- Difficulty falling asleep during the day
- Fragmented, lighter sleep
- Digestive discomfort
- Persistent fatigue

The result? Chronic sleep debt accumulates quietly. The solution is not simply "sleep more." It's sleep smarter.

Micro-Habits That Improve Sleep Quality

Improving sleep doesn't require drastic changes. Small adjustments can make a powerful difference:

1. Protect the Last 30 Minutes Before Bed Avoid screens, heavy discussions, or intense stimulation. Let your nervous system wind down.
2. Control Light Exposure Light directly affects melatonin production; dim the lights to sleep better. For night shift workers, use blackout curtains or eye masks during daytime sleep.
3. Keep Sleep and Work Separate Avoid checking emails or plant updates while in bed. The brain associates spaces with behavior.
4. Hydrate Wisely Dehydration disrupts sleep, but so does excess fluid before bed. Balance matters.
5. Consistency Where Possible Even if shifts rotate, try to maintain a predictable pre-sleep routine. Sleep quality matters more than sleep duration alone.

Power Naps: Myth or Science?

It is a science.

A 15–25 minute nap can significantly improve alertness, mood, and cognitive performance without causing grogginess. In fact, controlled power naps:

- Boost reaction time
- Improve memory
- Reduce mental fatigue
- Enhance decision-making

The key is timing and duration. Keep naps short and avoid entering deep sleep cycles. For industrial professionals working long shifts, structured rest breaks may be a smarter performance strategy than pushing through exhaustion.

We often glorify exhaustion. But the highest-performing professionals, whether athletes, surgeons, or plant leaders, treat recovery as part of the process.

When we begin to see sleep as a performance multiplier rather than downtime, the narrative changes.

About the Author

Jhumpa Mukherjee is a health educator and wellness speaker who believes that well-being and productivity go hand-in-hand. She conducts engaging health awareness sessions for corporates and professionals across industries, making fitness and mental wellness simple, science-backed, and achievable.

Would you like to bring a health session to your workplace?

Let's connect!

HPCL AND VOLVO GROUP INDIA SIGN MOU FOR ALTERNATIVE FUEL DEVELOPMENT

MUMBAI, March 6, 2026 – Hindustan Petroleum Corporation Limited (HPCL) and Volvo Group India have entered into a Memorandum of Understanding (MoU) to collaborate on the development and implementation of clean mobility solutions for the heavy-duty transportation sector. The agreement establishes a framework for joint research into alternative fuels and the supporting technical infrastructure required for large-scale adoption in India.

Focus on 700-Bar Hydrogen and Alternative Fuels

A central component of the MoU is the development of India's first 700-bar hydrogen refueling solution for heavy-duty trucks. This technology is intended to support the National Green Hydrogen Mission by increasing the fuel storage density and operational range of hydrogen-powered commercial vehicles.

In addition to hydrogen, the partnership will conduct application-based research and development for other alternative energy sources, including Liquefied Natural Gas (LNG) and Bio-LNG. The collaboration aims to evaluate the performance and efficiency of these fuels in high-capacity trucking operations across diverse Indian duty cycles.

Technical R&D and Lubricant Validation

Under the terms of the agreement, both organizations will engage in joint technical evaluations at the HP Green R&D Centre (HPGRDC) in Bengaluru. This facility will serve as the primary hub for:

- Engine and Battery Performance Evaluation: Testing the durability and efficiency of Volvo-engineered powertrains when operated with HPCL-supplied alternative fuels.
- Lubricant Validation: Conducting research to certify specialized lubricants tailored for the specific combustion characteristics and thermal stresses of LNG and hydrogen engines.
- Infrastructure Tailoring: Developing refueling protocols and hardware specifications specifically designed for the Indian heavy-duty logistics environment.

Strategic Objectives

The collaboration is structured to support India's goal of achieving Net-Zero emissions by 2070. By aligning vehicle engineering from Volvo with fuel infrastructure and chemical research from HPCL, the partners aim to build a scalable ecosystem for low-carbon freight transportation. The initiative also reflects broader industry efforts to reduce the carbon footprint of the logistics sector, which remains a significant contributor to national greenhouse gas emissions.

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