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November - December 2024

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Lubrication Excellence & CONTAMINATION CONTROL Demands a Clean Workshop.

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Publisher's Note

In this edition of Machinery Lubrication India, we turn our focus to the foundational role of lubrication practices in achieving operational excellence. Across industries such as construction, mining, steel, cement, and power generation, effective lubrication strategies form the backbone of reliability and efficiency. These practices, often overlooked, hold the potential to not only reduce failures but also significantly optimize costs and improve productivity. As we explore these themes, we are reminded of the value of forward-thinking leadership, the kind embodied by visionaries like Ratan Tata. His commitment to innovation, resilience, and achieving higher standards serves as a guiding light for industries striving to excel in a competitive environment. His legacy reinforces a powerful message: success is built on continuous improvement and an unwavering dedication to quality.

Lubrication practices are far more than technical procedures; they are strategic tools that drive performance, reliability, and efficiency. From contamination control to oil condition monitoring, these practices ensure machine reliability, extend equipment life, and minimize costly unplanned downtime. This edition explores vital topics like oil storage, failure diagnostics, vibration analysis, and IoT integration in predictive maintenance, emphasizing a proactive approach. Clean storage systems, advanced filtration, and regular health monitoring are not mere options—they are essential investments for long-term operational success.

Modern technologies, such as IoT and advanced monitoring systems, are revolutionizing maintenance by offering actionable insights that prevent failures and reduce costs. However, the success of these advancements depends on organizations' readiness to embrace change, adapt processes, and invest in workforce training. Technology alone cannot replace the value of strong leadership, which is essential for driving these initiatives forward.

Effective leaders inspire innovation, navigate challenges with resilience, and foster a culture of continuous learning and improvement. By prioritizing best practices and embracing new opportunities, leaders in machinery maintenance pave the way for greater reliability, efficiency, and competitiveness, ensuring long-term success in a rapidly evolving industrial landscape.

As the year draws to a close, we are presented with an opportunity to reflect on the progress made and the goals yet to be achieved. The holiday season offers a moment to appreciate milestones, express gratitude, and prepare for the year ahead. In this spirit, we encourage our readers to use this time for introspection and renewal, to set intentions for a future rooted in sustainability, innovation, and excellence. Lubrication practices, when integrated with vision and strategy, serve as a catalyst for transforming operations and driving industries toward unparalleled reliability and efficiency.

At Machinery Lubrication India, our mission is to provide insights, tools, and inspiration to help you navigate this journey. Your feedback and support are invaluable as we continue to refine our content to meet your evolving needs. Together, we can champion the practices, technologies, and leadership that will shape a more reliable and efficient future. Thank you for being an integral part of our journey, and we look forward to continuing to explore new frontiers in lubrication excellence with you in the coming year.

Warm regards,
Udey Dhir

Bennett Fitch | Noria Corporation

STOP STORING OIL DRUMS UNPROTECTED!
IT COULD COST YOU IN THE LONG RUN.

The significance of properly storing oil drums cannot be overstated when it comes to lubrication and long-term machine reliability. The correlation between unprotected oil drum storage and eventual machine failure is undeniable. Within these seemingly innocuous containers lies a potent source of contamination, harboring dirt and moisture that can wreak havoc on machinery.

Despite this knowledge being common among professionals, the urgency to address it often falls by the wayside. Unlike the proverbial squeaky wheel that demands attention, the neglect of proper oil drum storage can easily go unnoticed. Compounding this issue is the challenge of retroactively pinpointing storage conditions as the root cause of machine failure.

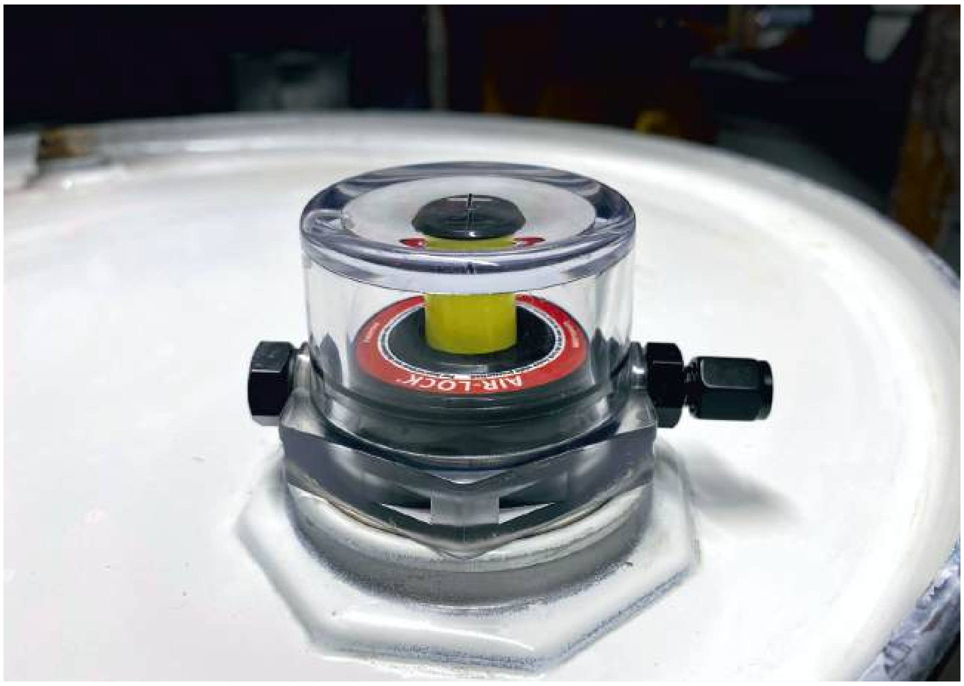
Consider this: How often do we trace a bearing failure back to the conditions in which its originating oil drum was stored?

The truth is that the repercussions of leaving oil drums unprotected set the stage for failure right from the start. It's not just about the oil becoming riddled with sludge and degradation products; rather, it's the gradual deterioration of crucial lubricant properties. From **shortened oxidative oil life to compromised friction and wear protection, insufficient foam suppression, water emulsification, and impaired filterability**— the consequences are manifold.

What makes this situation particularly insidious is how these early-stage deficiencies obscure their connection to eventual machine failure. When lubricant performance issues manifest during service, it's all too easy to lay blame on the manufacturer or chalk it up to a bad batch of oil.

However, the reality often reveals a different story — a story of oil inadequately stored.

Fortunately, solutions exist for those willing to take proactive measures. Implementing simple safeguards like ingress-prevention devices, such as the **Air-Lock by Luneta**, not only preserves oil integrity but also translates into substantial cost savings down the line. It's time to recognize the critical role of proper oil drum storage in safeguarding machinery performance and longevity.



Typical Oil Degradation

Oil doesn't last forever and degrades over time because of what it's exposed to. Water, Heat, Air, and catalytic Metals (WHAM) are all examples of contaminant exposures that directly degrade the oil. Oxygen and moisture can lead to oxidation and hydrolysis, respectively. Increased temperatures expedite these chemical reactions (due to the Arrhenius rate rule). And one of the most prominent drivers of oil oxidation is the presence of catalytic wear metals and water in the oil together. All these are bad things that lead to machine failure.

When oil in a machine starts to oxidize, it may appear dark and sludgy if you check the sight glass, for instance. An even better way to spot this problem is through oil analysis, which can detect changes like increased viscosity and acid levels.

When oil is freshly made, it's at its peak condition, with all its base oil quality and additives intact. However, as it's exposed to factors like heat, air, and moisture (WHAM), its oxidative life starts to decline. This happens because the oil's antioxidant additives are used up through decomposition. This process can happen anywhere, whether it's during storage, transfer, or while in use.

Oil analysis indicators are typically measured while the oil is in service. However, if the oil is stored in poor conditions, its initial condition may already be compromised. This could mean its oxidative life, or the level of additive depletion, might start off lower than expected, which can further weaken it from the start.

How much the oil deteriorates depends entirely on how much WHAM the oil is exposed to in storage and for how long. Unfortunately, drums are not made to fully protect the oil and can allow contaminants and moisture to seep in over time through daily thermal syphoning effects.

Even small temperature changes can draw in contaminants and moisture through the gaps around the bungs. And this is not just 55-gallon drums storing oil, but any fluids being stored in a typical drum.

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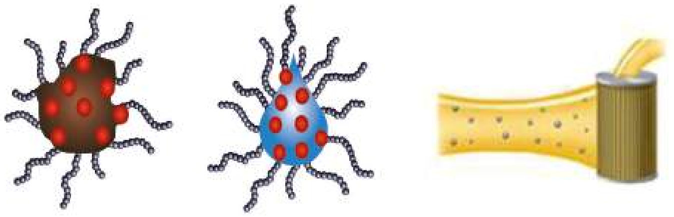
Additive Separation

As mentioned above, additives in oil can break down as they shield the base oil from contaminants. This is mainly done by antioxidants. Additionally, some additives are naturally drawn to contaminants because of their chemical properties, known as polarity, which makes them naturally bond with other polar materials.



These additives can "hitch a ride", so to speak, on particles or water, and move out of the main oil supply. Examples include metal deactivators and dispersants (which cling to particles) and emulsifying agents (which attach to water). Over time, these additives may separate out or get filtered during oil purification processes.

All of these issues can be avoided by ensuring that oil remains clean and dry, whether it's in use or in storage.

Oil Contamination in Storage Leads to Costly Negligence

Now that you have a fundamental understanding how oil can degrade and additives can deplete if contaminants are allowed to sit in the oil (either in storage or in-service), let's delve into how storing-drums without protection can lead to costly oversights:

1. **The Cost of Machine Wear and Tear :** The cascade of damage initiated by unfiltered particles is alarming. Each ingressed particle acts as a progenitor of further particulate generation, aprocess that exponentially escalates wear and tear. The stark contrast between systems with high-quality filtration and those without illustrates the critical role of proactive contamination exclusion.
2. **The Cost of Moisture Contamination :** Moisture's insidious effects on oil and machinery are well-documented, with even minimal water presence leading to drastic reductions in component lifespans. The economic argument for moisture exclusion, particularly through simple solutions like Air-Lock, is irrefutable when considering the costs of damage and downtime.
3. **The Cost of Reactive Measures :** While oil filtration and dehydration are essential, they representa significant financial outlay. These reactive measures, although necessary, are far more costly compared to the preventative exclusion of contaminants. Keeping contaminants out in the early stages of oil storage with maintenance-free strategies presents an economically sound alternative.
4. **The Cost for Oil Consumption and Operational Costs :** Contamination not only shortens oil life but also exacerbates oil consumption and leakage issues, such as through seal damage. By minimizing contaminant ingress and maintaining cleaner oil, many companies have reported more than an 80-percent reduction in leakage. This directly contributes to reduced oil consumption, fewer oil changes, and lower operational costs.
5. **The Cost of Poor Performance and Increased Energy Consumption :** The impact of contamination extends beyond wear and machine failure, affecting energy consumption and machine performance. If machines are allowed to run with contaminated oil, there is sluggish or erratic machine function. This is the case with hydraulic pumps and actuators that lose volumetric effi ciency due to contaminant-induced wear. All the while, there is increased energy consumption from friction and wear.

Conversely, clean and dry oil — free from the burdens of particulate and moisture-induced wear —ensures optimal effi ciency and extends the long-term lifecycle of machinery.

Your Action Item: Stop Contamination Early

You've heard it all before : get out of the reactive maintenance mode and embrace a proactive approach. One significant step in this direction is ensuring the cleanliness of oil drums during storage using effective technologies. While there may be a small initial cost involved, the long-term benefits in terms of economics, operations, and the environment far outweigh it.

Taking action to protect oil drums from contaminants demonstrates a forward-thinking approach to maintenance, particularly as we strive for excellence in our practices. Implementing protection devices like the Air-Lock not only reduces the risk of machine failure but also fosters a culture of responsibility among those managing lubrication. This simple proactive measure sets a standard for cleanliness throughout the oil's lifecycle, from storage to dispensing and usage in machinery.

By prioritizing contaminant exclusion in oil storage, we not only improve machine performance but also signal our commitment to operational excellence and sustainability. It's time to stop hesitating and start taking decisive steps to safeguard the health of our machinery through smarter lubricant management practices.

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Lubrication Excellence & CONTAMINATION CONTROL Demands a Clean Workshop.

Introduction

In various industry sectors, individuals draw upon their collective work experiences to shape work processes and procedures. Over time, some practices become obsolete, while others become ingrained and recognized as industry best practices worldwide.

This article aims to enlighten readers about specific lubrication best practices that offer tangible benefits, such as reduced maintenance costs, increased machine uptime, minimized impact of failures, and enhanced overall reliability. While numerous such practices exist, our focus will center on the construction and mining sector. However, it's essential to note that these practices are easily adaptable to other sectors, including steel, cement, power plants, and paper mills.

Activities

Let us fist assume that following facilities exist at your plant or mill. Our discussion will gradually proceed based on the utilization of these facilities:

1. Wash and sanitization station
2. Assembly area
3. Disassembly area
4. Testing area
5. Parts storage

These facilities are applicable for major components like engine, hydraulics, transmission, gearbox, etc. The importance of safety, housekeeping, and training cannot be ruled out.

A. Housekeeping

Good housekeeping is essential for any facility across the globe. It can function as a showroom of sorts for customers. The initial impression the customer gets should ideally generate positive feedback.

Good housekeeping increases the efficiency of the plant. The "wow" expression from the customer could be the difference between landing a contract or being lumped in among "the rest".

Housekeeping is a daily activity. There must be a dedicated housekeeping team, disciplined and taking the right precautions to keep the facility clean and contamination-free. Accumulation of dust on floor, work benches, racks and shelves, visual cobwebs are indications of poor housekeeping and can impact the overall functioning of the plant.

Training Program

Training and education are essential part for the success and growth of any organization. Trained employees feel empowered and if the situation calls for it, can be prepared to take quick, simpleaction without waiting for their boss's approval.

Training must be imparted from the bottom to the top of the company, with different training modules for each level. This is a program that consists of formal classroom training along withon-the-job training.

It must be structured, systematic, consistent, and on-going. Each training session must be documented — from the names of trainers, trainees, date and time of training, and the topics covered during the session.

B. Shop activities

1. Work Bench

A. Top of the bench must have a thick durable plastic coating in order to prevent direct metal-to-metal contact. This is especially true for sensitive parts.
B. Daily cleaning habits must be adopted.

2. Air Supply Lines from Shop Air Compressor

A. Filter, regulator, and lubricator (FRL) must be fitted at each point of use to ensure consistently clean, dry air. Lubricator must be used to clean pneumatic tools.
B. Airborne contaminants are found to be in the range of 1-10 micron size. Air fi lters must be in the same micron range.
C. There must be a maintenance process that includes:

- Daily water draining
- Daily pressure check
- Frequent air filter replacement
- Maintenance tag at the point of use
- Documentation in hard- or soft-copy format

A clean work area and air compressor are demonstrated here:

3. Parts and Critical Components Ready for Assembly

A. Every single part, component (small and large) must be stored off the floor.

B. Strong, durable plastic pallets may be used while keeping in mind safety and security.
C. Pallets must be free of dust/dirt.
D. Components must be properly covered with shrink wrap to prevent settling of dust.
E. Dedicated stands must be locally fabricated to keep large components like engines, crankshafts, camshafts, etc.
F. All open ports must be adequately protected using proper size caps and plugs prior to assembly.

4. Workshop Floor and Walkway

A. Shop floor may be sealed. This will prevent oil from sticking to the floor or from seeping down into the soil.
B. If degradation of the floor is noticed, these must be repaired quickly to prevent the debris from contaminating other parts and components inside the shop.
C. There must be yellow lines bordering the shop or plant that restrict outsiders from being able to walk through.
D. In some parts of the world where sawdust is used to cover oil spillage, the use of oil-absorbent pads and lint-free clothes are strongly recommended instead.

5. Component Wash Area

A. Any used oil must be drained completely in a waste oil container for disposal.
B. Washing machine with automatic soap solution, high pressure, and hot water — these conditions will ensure proper cleaning of dirt, mud, and other debris.
C. Again, good housekeeping of the entire wash area is strongly recommended.

6. Parts Storage Area

A. Oil filters must be properly protected with their original packaging and opened only prior to use. If left unprotected, filter pores will be contaminated with dirt and dust.
B. Filters must be repackaged if the original packaging is damaged.
C. All hoses and tubes in contact with fluid must be protected with proper size caps and plugs.
D. A sufficient quantity of caps and plugs must be in stock.
E. Hose-cleaning gun, projectiles, and accessories may be procured for adequate cleaning of the same when found unprotected.
F. O-rings and seals must be stored in ziplock bags in closed cabinets. These bags must not be stapled to prevent dust ingression through pin holes.
G. Again, an aggressive housekeeping program in this area must be in place.

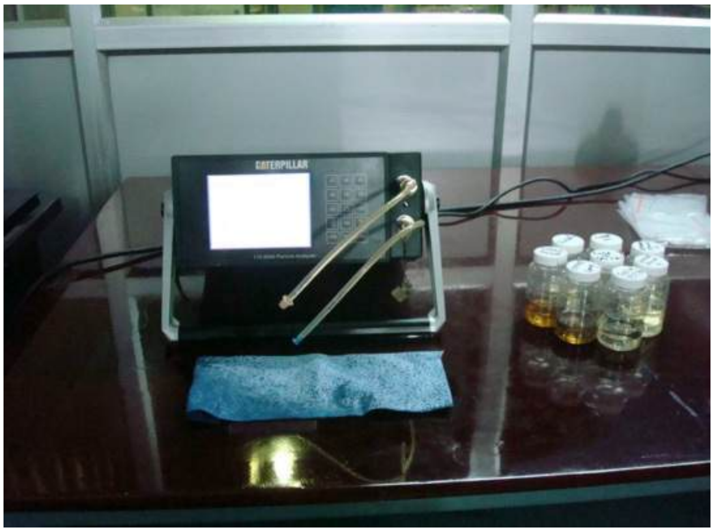
These images below illustrate how parts and fluid-carrying hoses can be stored with protection and how workplace cleanliness is maintained:

7. Fluid Storage, Handling, and Dispensing

A. Oil barrels (208-liter capacity) may be stored vertically or horizontally. If stored vertically under the sky, then barrel covers must be used. Top of the barrels must be cleaned daily to prevent accumulation of dust and water. When stored in horizontal position, we must make sure that the bungs are in the 3 o' clock and 9 o' clock position.
B. When the barrels (oil and fuel) are half filled, one of the bungs must be equipped with a small desiccant breather.
C. For larger storage reservoirs, both inlet and dispensing line must be equipped with proper sized oil filters and desiccant breathers to maintain cleanliness of the fluids.
D. The drain valve must be positioned at the lowest point of the tank.
E. Consistency, documentations, maintenance tags are obvious part of this activity.
F. Reservoir cleaning frequency must be established to avoid contamination from bottom sediments.
G. Smaller volume may be dispensed through a sealable & reusable (S&R) plastic container.
H. New oil transfer to machine sump from the storage tank or reservoir may be done using an oil transfer pump and a proper micron-size filters.
I. Hydraulic, transmission, and gearbox oil may be cleaned using a filter cart during scheduled preventive maintenance intervals.
J. It is practically possible to bring down particle count data to ISO 18/16/13 (or NAS 7). The facility can think of increasing the life of the oil along with the life of the component. This happens because the component will run with relatively clean oil for a longer period of time.
K. Again, all data, and observations are to be documented meticulously for future reference.
L. All fluids in the facility must be monitored closely in terms of cleanliness level. Immediate actions must be taken if the target cleanliness level is not achieved for any fluid.
M. SOPs and checklists may be displayed at various strategic locations in the shop.

Wash area, dispensing clean fuel, fluid filtration, and cleanliness check of fluids are displayed in the following images:

These are some of the most fundamental best practices available in



public domain 1-11.Caterpillar Inc., US, has customized these practices primarily for its mining dealerships across the globe. Senior leadership must be on-board to launch an all-out assault against harmful contamination. Investment is required.

As shown in Tab 1, many of these expenses are consumable in nature.

Tab 1

Sr No	Activity	Description	Remarks	Relative Expenses*
1	Housekeeping	Clean Workspace	Low Hanging Fruit Immediate Implementation	1
2	Training & Education	Awareness, Logic & Evidences	Low Hanging Fruit Immediate Implementation	1
3	Work Bench	Thick, Non-Metallic Cover	Gradual Implementation	2
4	Air Supply Lines	Consistent, Clean, Dry Air	Low Hanging Fruit Immediate Implementation	1
5	Parts & Critical Components	To prevent Air Borne Dust Ingression	Low Hanging Fruit Immediate Implementation	1
6	Workshop Floor & Walkaway	Clean Work Place	To Be Implemented	3
7	Component Wash Area	Washing Machine With Conditions Mentioned Before	To Remove Residual Dust, Mud	3
8	Parts Storage Area	Good Housekeeping and Contamination Control Program	To Protect Parts from Dirt & Dust	1
9	Fluid Storage & Handling	To Consistently Supply Clean, Dry Fluid	Oil Filter Cart & Particle Counters	3
10	Houses & Tubes	To Clean Unprotected Hoses & Tubes	Hoses, Cleaning Gun & Accessories	3
11	Caps & Plugs	To Protect all Open Ports and Hoses & Tubes	Low Hanging Fruit, Immediate Implementation	1
12	Shrink Wrap	To Cover Parts & Critical Components	Low Hanging Fruit, Immediate Implementation	1
13	Oil Barrel Covers	To Protect Top of Oil Barrels	Consumables	1
14	Oil Filters & Breathers	To Prevent Ingression of Dirt, Dust & Moisture	Low Hanging Fruit, Immediate Implementation	1

*1 = cheap, 2 = medium expensive, 3 = expensive

A few CAPEX investments are necessary. However, these high value items may be procured in a planned phase wise manner. Floor sealing is an expensive activity. This expense may be incurred in later phase. Let other practices during this period, such as procurement of consumables, cleaning and housekeeping, protection of filters and hoses, modification/retro fitment jobs, and collecting data all fall into place.

Tab 2 and Tab 3 summarize which work practices will be obsolete and which best practices will be implemented.

C. "Failure is success in progress."

The practices described above may be implemented initially as an on-going reliability initiative. Gradually, over time other practices may be added to the process. These practices, when implemented successfully, confirm the importance of a two-way proactive approach to maintenance: 1) The prevention of contaminants to invade the system and 2) The removal of contaminants already present in the system.

Contamination-control practices and best lubrication practices are virtually one in the same. Two service shops are shown in Fig 4. I, personally, would prefer to approach the shop from the left to get my machine components repaired. I strongly believe readers will concur with my observations.

This is a never ending journey. Organizations who dare to participate in this journey have to keep moving continuously. First, there will be paradigm shift in work practices before efforts for continuous improvement begins. It requires a dedicated team with laser focus and equally committed leaders and managers.

As explained above, shop personnel are not doing different jobs; they are doing the same jobs in adifferent way. This change and culture transformation has a huge impact on the entire team.

Tab 2	Current Practices to Vanquish
Sr No	Description
1	Poor Housekeeping
2	Use of Funnels, Hand Pumps
3	Open Hatches on Tanks
4	Goose-Neck Vents & Old Unfiltered Breathers
5	Drums Stored Outside with Bungs Exposed to Atmosphere
6	Galvanised Oil Container
7	Any Open Oil or Grease Container
8	Damaged Floor, Dirty Work Bench, Use of Sawdust
9	Air Supply Without FRL, Fuel Line Without Fuel Filters

Initially, there may be tremendous resistance to accept these new practices. Rigorous training and education coupled with strong leadership at this juncture are extremely pertinent.

Tab 3	Best Practices to Implement
Sr No	**Description**
1	Clean, Well Organised Oil Barrels
2	Dedicated Filling & Dispensing Systems Including Level Gauges, Breathers, Pumps, Quick Connects
3	Oil Filtration System to Provide Clean, Dry Oil
4	Desiccant Filter Breathers
5	Lint Free Cloth to Clean Oil Leakage & Seepage, Oil Absorbant Pads to Clean Large Oil Spills
6	Sealed & Reusable Plastic Containers
7	Shop Air Supply with FRL System
8	Good Housekeeping
9	Ongoing Training and Education

There will be failures, fumbles, disappointment in this journey towards new normal. But adopt the saying, "Failure is success in progress". See your commitment to implementing best practices at your plant as a success in itself.

Yes, it's a continuous endeavor towards optimum machine reliability. But nothing is more worth it in the long run, for your machine, plant, and overall business goals and objectives.

Acknowledgement

The author is grateful to Gailwell Commosales India Pvt. Ltd., and Caterpillar Inc., U.S., for providing the opportunity to be actively involved in condition monitoring, contamination control, and lubrication best practices.

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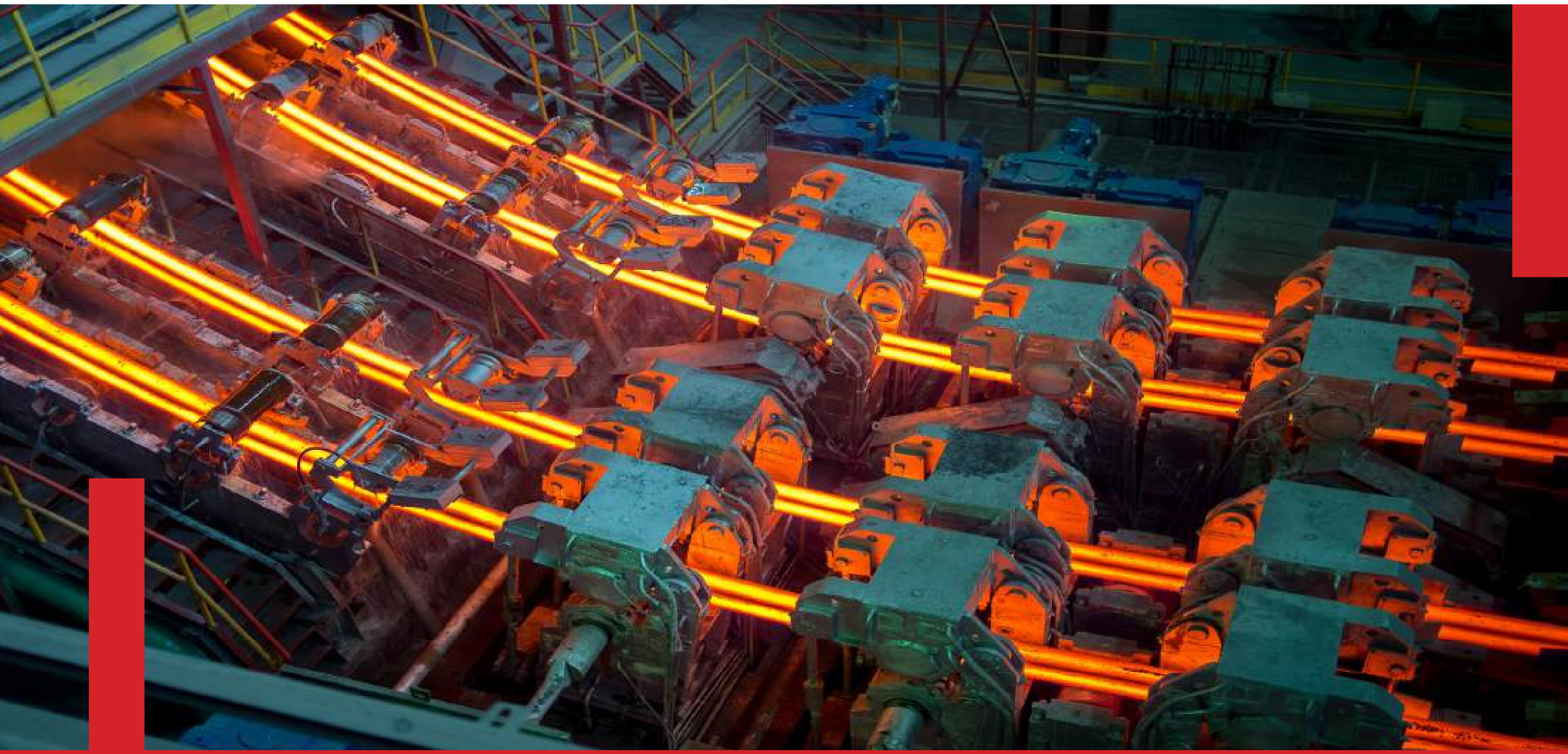


In today's hyper-competitive industrial landscape, the efficiency of machinery is crucial. From paper mills to automotive plants, lubricants serve as the lifeblood of operational success, preventing breakdowns, reducing friction, and ensuring that complex systems function smoothly. But in an era defined by rapid technological evolution and stricter regulatory standards, conventional lubricants often fall short. Specialty lubricants are engineered solutions customized to meet the demanding environments and intricate machinery of diverse industries. As a pioneer in this sector, Molygraph Lubricants stands out with its commitment to innovation, quality, and sustainable growth.

The Critical Role of Specialty Lubrication

Industrial machines operate under extreme pressures, temperatures, and environmental challenges, making generic lubricants insufficient. Specialty lubricants are specifically designed to tackle these unique requirements, ensuring that equipment operates efficiently and reliably over prolonged periods. By reducing friction, wear, and energy consumption, specialty lubricants not only cut down on operational costs but also contribute to sustainable practices by extending the lifespan of industrial machinery. In industries like food processing, pharmaceuticals, and high-temperature manufacturing, the right lubricant can be the difference between smooth operations and costly downtimes.

Manufacturing excellence and energy efficiency are crucial to success in a fiercely competitive global market. Companies increasingly prioritize sustainability while striving to enhance equipment longevity and efficiency. This trend is especially prominent in high-demand environments like steel mills, where continuous casting processes expose machinery to extreme operating temperatures and heavy loads, often pushing conventional lubricants to their limits.

Molygraph has pioneered lubrication solutions specifically engineered for such critical applications, enabling their customers to meet both efficiency and sustainability goals.

A recent success story: Remarkable 58% Cost Savings with Molygraph Ultramill Grease PU Premium

A leading steel manufacturer experienced challenges using lithium-based EP grease in their continuous caster bearings, where extreme temperatures caused the grease to melt, resulting in high consumption and frequent reapplications. The excess grease required to prevent bearing failure led to high maintenance costs and compromised productivity.

Key Challenges

- Conventional lithium grease failed at high temperatures, compromising equipment.
- Frequent regreasing was necessary to maintain optimal temperatures and avoid breakdowns.

To overcome these challenges, Molygraph introduced them to Ultramill Grease PU Premium—a polyurea-thickened, high-temperature grease engineered to withstand extreme environments while reducing maintenance needs.

Benefits of Ultramill Grease PU Premium:

- High Resistance to Ageing, Oxidtion, and Corrosion: Provides reliable performance in continuous, high-heat applications.
- Superior Anti-Wear Properties: Protects bearings and mechanisms under heavy loads.
- Wide Temperature Range Flow Characteristics: Ensures efficient lubrication, reducing the risk of breakdown in high-temperature operations.

Application Areas of Ultramill Grease PU Premium

- Continuous caster bearings
- Roller and plain bearings in heavy equipment
- Hot blowers in steel mills and other high-temperature applications

About Molygraph Lubricants

For over three decades, Molygraph Lubricants has provided innovative, high performance lubrication solutions across a diverse range of industries, including steel, mining, cement, food processing, and power generation. Our commitment to sustainable solutions, quality, and technical support helps industrial operations worldwide drive productivity, reduce environmental impact, and enhance equipment performance. By working closely with various clients, they create customized solutions tailored to the unique demands of their industries, environments, and goals.

With an ISO-certified production process, they are dedicated to delivering consistent quality across every batch of lubricant. ISO 9001, ISO 14001 and ISO 45001 certifications underscore their commitment to quality and environmental sustainability.

A Robust R&D and Testing Facility

At the core of their innovation lies the state-of-the-art R&D and testing facility. Equipped with cutting-edge analytical instruments and staffed by a team of experienced scientists, their lab serves as the foundation of product development efforts. Their R&D facility is accredited for rigorous testing, and the specialists conduct extensive trials to ensure each lubricant meets specific performance benchmarks. This meticulous process includes tests for viscosity, oxidation stability, wear resistance, and environmental impact, guaranteeing that every product released from their lab is optimized for reliability and performance.

Their in-house R&D capability allows to adapt to market needs rapidly, creating tailored solutions that set new benchmarks in specialty lubrication. This commitment to innovation has positioned Molygraph as a trusted partner for industries around the world, empowering them to achieve better operational efficiency, cost savings, and sustainability.

Expansion Plans : A New State-of-the-Art Manufacturing Plant

As Molygraph continues to grow, so does their commitment to expanding production capabilities. In response to increasing demand and the vision for sustainable growth, they announced the establishment of a new manufacturing plant. This facility will be equipped with advanced production technology, enabling them to scale their output while maintaining the high standards of quality and environmental responsibility that Molygraph is known for. This strategic investment is part of Molygraph's long-term vision to solidify their position as a global leader in specialty lubrication solutions, offering our clients innovative, reliable, and environmentally friendly products.

For more information, visit -

https://www.molygraph.com/

UTILIZING AN OIL CONDITION-MONITORING PROGRAM (OCM) TO EXTEND THE LIFE OF A WIND TURBINE

Wind-energy asset owners are confronted with critical business decisions as their wind farms approach the end of their operational lives. This forces these decisions to be made around life extension, repowering or full decommissioning for these assets.

Despite continuous innovation in designs, lubrication systems, improvements in the different materials and lubricants used, maintenance problems in wind turbines still persist. They persistmainly as a consequence of the fatigue of the components or by external contamination (water, air, dust particles), there by causing a drastic reduction in the useful life of these components.

If we consider the outbreak of the health crisis caused by Covid-19 and the Russia-Ukraine war, the lubricant industry has challenges with the limitation of raw materials, especially processed oil. The lack of this component delays the manufacturing processes of oils and greases, and therefore, requires that end users, in the case of large wind-turbine manufacturers, implement new tasks that allow the life extension of these products before an imminent reduction in their supply.

Through the study of these events, we have been able to understand these modes of degradation, which has led us to propose new alternatives within the OCM – Oil Condition Monitoring programs. These programs have allowed us to improve the early detection of possible failures, thus extending the useful life of the wind turbines.

Introduction

With a service contract including upgrades to improve and extend the original design life, windturbines can keep producing for up to 10 additional years with minimal risk. Repowering by installing larger and more efficient turbines is also an attractive option, which can be combined with life extension.

However, repowering can be made diffi cult by lengthy and uncertain authorization procedures. It requires additional investments in decommissioning and new turbines.

Decommissioning the wind turbines may be relevant if neither life extension nor repowering are viable options. In this case, the asset owners incur the immediate costs of clearing the site, as well as the opportunity cost of not having their permits extended.

To do so, the wind-turbine components must be inspected to ascertain their integrity and the risk of failure during continued operation. The type of inspection may vary based on the extent of operational data available and the problems encountered previously by the turbine's components.

Despite these options that are available to start up, it has been demonstrated that many turbines are able to operate beyond their design lives.

Future Trends To Expect in OCM

According to recent studies from Wind Europe, within the next five years, approximately 38 gigawatts of European wind farms will reach 20 years of operations, which means that there is alarge number of turbines (around +35,000), representing 16% of installed wind capacity in Europe. Without a doubt, the decision on lifetime extension is complex, and experiences to date are limited. Most of the aging capacity is in Germany, Spain, France, UK, and Italy, which also have out-of-date fleets.

From 2021 to 2028 an average of four-gigawatt turbines per year will safely and profi tably extend their operational lifetime. Results indicate that end-of-life solutions will develop a significant market over the next five years.

The application of updated load simulation and inspections for technical lifetime extension assessment differs between countries. A major concern is the uncertainty about future electricity spot-market prices, which determine if lifetime extension is economically feasible.

In several instances, the lifetime of a wind farm may be extended through minor and low-costrepairs. Through this project, it has been possible to demonstrate during the last few years that monitoring the different components through oil analysis and being able to better anticipate possible failures, has helped a lot in the extension of the useful life of these components.

Conclusions

I. Oil Condition monitoring (OCM) has proven to be a very valuable tool within the wind industry and should be installed to identify changes in the turbine's components. As a result, remedial action can be better planned to maintain reliability in a cost-effective manner.

II. As part of Life Extension through the OCM, all critical components of the load-path of the turbine must be evaluated to secure a thorough maintenance program. These components include: gear box, main shaft bearings, bearing housing, bearing housing (bedplate bolted joint), yaw system, main bearing, blade bearing, and hydraulic system.

III. The level of wear in most of the turbines may have resulted in lower load capacity than originally estimated. As a result, the gearbox of the turbine is often free from signifi cant damage. Therefore, in many cases, the repairs needed to extend the lifetime of the turbine are generallyminor and cost-effective.

IV. Many failure modes have measurable response and develop over time. These are the ideal applications for condition-based maintenance (CBM). OCM can provide early warning of potential failure if the measurement parameters are correctly chosen and measured with accurate methodology using the visible spectroscopy (color) technique.

V. It has been possible to apply a very fast technique - color in gearbox oils, that allow us to establish an excellent relationship between certain standard variables, such as acid number or metals by AES-ICP, FTIR.

VI. This new degradation oil method is capable of fully quantitatively determining the color of the oil sample, as well as different characteristics that can be evaluated by analyzing its visible spectrum. This method also makes it possible to detect incipient stages of oil degradation, unlike traditional methodologies that are only sensitive at advanced stages of oil degradation.

VII. The results obtained are only applicable for those lubricating components. This study does not cover other important parts within the turbine for which it is not possible to apply the OCM technique.

Many countries around the world that installed their first wind farms are now reaching the end of their planned service life, meaning decisions will soon need to be made around life extension, repowering, or full decommissioning for these assets. Life Extension is a cost-effi cient and profi table method for maximizing the initial investment. The OCM technique can help ensure major decisions like these are made carefully and with consideration to the condition-based factors discussed in this article.

This article was from the authors' conference presentation at the 2023 Reliable Plant & Machinery Lubrication Conference & Exhibition. To learn more about Reliable Plant & Machinery Lubrication 2024,

A GLIMPSE OF WHAT'S NEW IN TODAY'S CONDITION-MONITORING AND LUBRICATION IOT TECHNOLOGY

IoT (Internet of Things) technology has signifi cantly transformed various industries, and the oil and lubrication condition-monitoring sector is no exception. The integration of IoT in this domain has brought about enhanced efficiency, reduced downtime, and improved maintenance practices.

Introduction to IoT in Condition Monitoring

Before we dive into a few of the condition-monitoring technologies that are being offered today, let's take a minute to just refresh what we mean when we refer to "IoT". IoT, or "The Internet of Things," refers to the network of interconnected devices that can communicate and exchange data over the internet. In the oil and lubrication condition-monitoring industry in particular, IoT is applied to gather real-time data from machinery, analyze it, and provide insights into the condition of equipment.

This proactive approach enables predictive maintenance while minimizing unplanned downtime and optimizing operational effi ciency.

Benefi ts of IoT in Condition Monitoring

The application of IoT technology in the oil and lubrication sector brings several advantages. These can include:

- **Predictive Maintenance :** IoT enables the monitoring of equipment conditions in real-time, allowing for predictive maintenance based on actual usage and wear, rather than fixed schedules.
- **Reduced Downtime :** By predicting potential issues, IoT helps in scheduling maintenance during planned downtimes, minimizing unexpected breakdowns and disruptions.
- **Cost Efficiency :** Predictive maintenance and reduced downtime contribute to cost savings by preventing major breakdowns and extending the life span of equipment.
- **Data-Driven Decision Making :** The data collected through IoT sensors provides valuable insights, empowering decision-makers to optimize operational processes and resource allocation.

IoT Tech in Oil and Lubrication Condition Monitoring

Wireless Sensors : One of the foundational elements of IoT in condition monitoring is the use of wireless sensors. These sensors are attached to critical components of machinery to monitor variables in conditions such as temperature, vibration, and pressure. Companies like UpKeep provide wireless connectivity solutions suitable for industrial IoT applications.

Machine-Learning Algorithms : The data collected by IoT sensors is often vast and complex. Machine-learning algorithms offer a way to accurately analyze this data to identify patterns and anomalies.These algorithms can also predict potential issues in equipment based on historical data, thereby contributing to proactive maintenance.

Industrial IoT Platforms : Industrial IoT platforms can serve as a sort of central hub for managing and analyzing IoT data. These platforms, such as what's offered by Acoem USA, can provide a unified interface for monitoring equipment conditions, generating reports, and implementing maintenance strategies. Companies can also arrange and conduct facility tours remotely and in great detail by utilizing some of the many advantages that IoT platforms provide in industrial settings.

Smart Lubrication Systems : Companies like Pulsarlube offer smart lubrication solutions that integrate IoT technology. These systems are designed to monitor lubrication levels in real-time, ensuring optimal performance and preventing damage due to inadequate lubrication. The data from these systems contribute to predictive maintenance strategies and enhanced worker safety in some critical but dangerous industrial applications.

SaaS : In addition to the technologies above, companies such as Asset Watch also provide condition-monitoring solutions on a software-as-a-service basis. By combining tools and services that may include the application and troubleshooting of wireless sensors, fast and adaptable network solutions, cutting-edge software, and access to knowledge and insights from experts, companies and maintenance professionals can reap such benefi ts as reduced downtime and real-time, remote monitoring of entire facilities, to name a few.

The integration of IoT in oil and lubrication condition-monitoring has ushered in a new era of efficiency, connectedness, and cost-effectiveness. Wireless sensors, machine-learning algorithms, industrial IoT platforms, smart lubrication systems, and SaaS solutions are among the exciting products driving this transformation in maintenance and reliability.

As this technology continues to evolve at an increasingly rapid pace, addressing new and complex challenges and embracing future trends will be crucial for maximizing the potential of IoT and ensuring the reliability and longevity of critical equipment in the oil and lubrication sector. Here are a couple of the aforementioned companies that are taking on those very challenges and working to provide reliable and efficient condition-monitoring technology in today's ever-evolving market.

A SOBERING REALITY: HOW IGNORING OIL AND VIBRATION ANALYSES IMPACT YOUR BOTTOM LINE

Integrating vibration and oil analysis in industrial plants plays a significant role in predicting and preventing equipment failures. While vibration analysis is commonly used, this article highlights the under utilization of oil analysis despite its ability to detect potential failures much earlier.

We will show the importance of using both techniques together, as they provide complementary information and enhance the overall approach to predictive maintenance. Implementing both vibration and oil analysis can offer a comprehensive understanding of equipment health and enable timely interventions, ultimately preventing costly breakdowns and improving maintenance strategies in industrial plants.

Why Do We Need Oil and Vibration Analyses?

Using both vibration analysis and oil analysis provides a much better predictive maintenance (PdM) solution compared to relying solely on vibration or oil analysis alone. This is because mechanical issues, such as soft foot or loose mounting bolts, can be detected through vibration analysis long before wear

particles show up in oil analysis.

On the other hand, while vibration analysis is effective in identifying certain markers related to equipment health, it may not capture early lubrication issues that can lead to failure. By incorporating oil analysis alongside vibration analysis, lubrication issues can be detected and addressed long —maybe years — before they escalate into more severe problems detectable by vibration.

The Signs Were There

In May 2020 at a coal-fired power plant in the Midwest, the oil was changed on a $150,000 conveyor gearbox that was supposed to be filled with an ISO 320 gear oil. However, in July 2020, an oil sample was taken and exhibited a viscosity of 183 centistokes (cSt), 148 parts per million (ppm) of iron, and a Particle Quantifier Index (PQI) of 234.

This was a clear indicator that the wrong lubricant was in the machine and damage was occurring. In October 2020, the viscosity tested at 175 cSt, with 57 ppm of iron and a PQI of 170. In July 2021, the viscosity slightly increased to 178, with 74 ppm of iron and a PQI of 171.

The February 2022 oil sample showed a

higher viscosity of 212, partially due to oxidation, 84 ppm of iron, and a PQI of 78. In November of 2022, a noise was detected, and another oil sample was taken. The sample showed a viscosity of 209, an iron content of 39, a PQI of 10, and a copper content of 9ppm, indicating bearing-cage damage was probably occurring.

Vibration sensors were installed, and an eminent failure was predicted.

These oil sample results highlight the progressive degradation of the equipment over time, with indicators of potential failure appearing in oil analysis two years ahead of the corresponding vibration abnormalities. Had the vibration sensors been installed earlier, they likely would have detected the issue sooner, but not before the damage became irreversible.

By ignoring the oil-analysis data, only 43% of the 10-year design life of the gearbox was realized, resulting in a loss of $85,000 of the usefulness of the gearbox alone. This figure did not even consider the lost production value.

Calculating the Cost

If we can determine the wear rate of a particular component, we can calculate the costs of our current state of lubrication. ISO 281:2007 can give some insight into the relative life of bearings.

This may take considerable effort to determine the correlating wear rates. However, one other source may be the Life Extension Table (LET) that was published by Noria Corporation more than twenty years ago and is still a key resource for most maintenance programs.

In addition to the Life Extension Table, you can also find the Machine Life Extension Calculator by clicking here on Noria website.

Once we have established the wear rate, we can make some financial calculations. Here are three examples:

1. A gearbox has a value of $30,000.00. It was designed to last 10 years if we keep the oil at the cleanliness level of 19/16/13 and water content at 100 ppm, as prescribed by the manufacturer. If we have managed to keep the water and particles at the prescribed levels, then we will not have gained or lost any value. If we have done this for a year, we will show that there are nine years of life left in the equipment and it is expected to achieve the planned life.
2. We have the same gearbox a s above, but we have kept it cleaner than the manufacturer's specification and achieved a 19/15/12. This will give us a wear rate about 10% slower than anticipated in the original design. For our value, we will divide the component cost by the number of days it was designed to be in service, which works out to $8.22 a day. If we have achieved this for a year, we will show that we can expect an extra 36.5 days of service and have gained $300 in value. The calculations are: 365 x 10% = 36.5 and 36.5 x $8.22 = $300.03. We will show a remaining life expectancy of 9 years and 36.5 days. If we continue to maintain that level, we project to get one extra year of life and a value of $3,000.
3. In this scenario, we have not achieved the desired cleanliness level and are wearing 10% faster than normal. We would show after one year that we have lost 36.5 days and $300 in value. If we do not correct the situation, we show that we anticipate one less year of service than designed, and will end up losing $3,000 in value.

Please note that it is possible to reduce the wear in the third scenario and that the lost value can be recaptured if the right corrective actions are taken early. This is why it is important to have the proper sample frequency so that the situation can be corrected in a timely manner before too much useful life has been lost.

Echoes of Defects: How Vibration Analysis Breaks the Silence

When elevated levels of impact and non-synchronous peaks are observed in the vibration spectrum, it raises concerns about the equipment's condition. In this case, the analyst noticed impact levels exceeding 10g at the input shaft of the gearbox, near the drive end. To investigate further, the analyst requested an oil analysis sample and a lift check on the input shaft.

To minimize downtime, the oil sample was taken as the first step. The intention was to gather information about the gearbox's health without taking the asset offline. However, the oil analysis report revealed no upward trend in wear metals or gross particle counts, indicating that the gearbox's condition was not deteriorating.

Despite the oil analysis results, the analyst proceeded with a lift check on the input shaft, which required the asset to be taken offline. This check involved measuring the clearance at the bearing. The lift check unveiled a clearance of 0.015 inches — well above the specified limit for the unit. As a result, the customer decided to procure a new gearbox, recognizing the presence of a fault.

These results clearly demonstrate the importance of understanding both vibration and oil analysis data and recognizing that they can sometimes provide conflicting results. It emphasizes the need for a comprehensive approach to fault diagnosis, where reliance on a single diagnostic technique is not recommended. Ultimately, the diagnosis should be driven by the specific fault within the asset and should not rely solely on one diagnostic technique.

Harmonious Interplay: Vibration and Oil Analysis in Problem Diagnosis

A vibration analyst noticed gear mesh harmonics on a recent wave form and asked the plant if a recent oil sample was available to share with the lubrication team. The oil sample report showed that an ISO 220 was the current lubricant and in good health, a side from being a bit dirty.

The oil analyst noticed the temperature sensor on the vibration probe was at 130 degrees (Fahrenheit) which was probably cooler than the actual oil temperature. A quick inspection of the equipment tag showed that an ISO 320 was called for when temperatures were above 125 degrees F.

If only one method of condition monitoring had been employed, the problem could not have been isolated as quickly.

The Bottom Line

Utilizing vibration and oil analyses together provides you with complementary information to enhance the overall approach to maintenance — ultimately preventing costly breakdowns and improving equipment performance in the long-term. Monetary and time savings impact can be calculated more accurately, enabling cost justifications for an improved lubrication program. The harmonious interplay between vibration and oil analysis in problem diagnosis illustrates how combining both methods enables quicker and more accurate identification of issues and offers the necessary, broader blanket of protection than using only one of the two methods alone.

This article was a featured learning session at the 2023 Reliable Plant & Machinery Lubrication Conference & Exhibition. To learn more about this visit the conference website.

UNDERSTANDING MAINTENANCE AND RELIABILITY KEY PERFORMANCE INDICATORS

Using KPIs to Analyze Failures in Your Lubrication Program

Key Performance Indicators (KPIs), when identified and aligned properly especially in the lubrication industry, can save your plant, your job, and your career. If management truly understood the power of KPIs, things would change quickly. Infact, managing without KPIs gives one the feeling of being lost with no hope.

Think of driving a car with the wind shield painted black. You can't see where you are going but you do get a glimpse of where you've gone, through the rear view mirror. You don't know if you were successful or not until either its too late, or disaster strikes.

With the car example in mind, your results are:

- Car goes in the ditch – high cost (or worse)
- You never reach your destination – business goals not met

This is a serious problem, and it costs companies around the world billions of dollars as a result of what, I consider, a lack of management control. Peter Drucker, the great industrial revolutionary stated: "You cannot manage something you cannot control and you cannot control something you cannot measure."

Defining and Understanding KPIs

Let's first get down to basics and define KPIs. Within maintenance, we must first define the performance we want to measure.

Is it the performance of the equipment? Is it the performance of the spare parts warehouse? Is it the performance of the maintenance function?

This may seem like a simple question but often I see companies that mix their KPIs as they have not defined the specific area of the business for which they are attempting to measure performance. Let's assume we want to measure the performance of the maintenance function.

There are really two kinds of KPIs to choose from in measuring any particular function of a business.

These two kinds of KPIs are called Leading Indicators and Lagging Indicators (also referred to in this document as Leading KPIs and Lagging KPIs).

"Leading KPIs lead to results"
Example: Scheduled Compliance

"Lagging KPIs are the results"
Example: Maintenance Cost
(affected if scheduling is not working)

Leading Indicators are those that we use to manage a part of the business, while Lagging Indicators are those that measure how well we have managed. With Leading Indicators therefore, it is possible to directly and immediately respond when a poor result is found. With Lagging Indicators, we get value from knowing how well we performed, but we have little opportunity to immediately affect under performance.

Instead, when we see an unacceptable Lagging Indicator, we must typically drill down to the Leading Indicators to uncover the cause of the underperformance, and from there we can implement appropriate changes. Leading Indicators for the maintenance function are those that measure how well we are conducting each of the steps in the maintenance process.

For example, a Leading Indicator for the work planning element of maintenance process could be "the percentage of planned jobs that were executed using the specified amount of labor". If the planner is estimating labor correctly, we will see a high percentage of jobs completed using the planned amount of labor hours. If the maintenance manager finds that the value of the KPI is lower than expected, he/she can speak with the planner to discuss how best to improve the results immediately – possibly for the remainder of that day.

With all KPIs, by definition, we are measuring past performance, so I am not suggesting that Leading Indicators can be tweaked to improve upon past performance. But you can see in this case, that if we are managing using Leading Indicators, we can respond immediately when needed.

So, Leading Indicators measure how well we're performing our jobs while Lagging Indicators measure results. We manage using Leading Indicators, and we react to results using Lagging Indicators.

In the example above, a Lagging Indicator would measure the results of how well we managed the maintenance function. In a situation where the maintenance function is well managed, we would expect an appropriate balance between the cost of maintenance and the plant availability. A Lagging Indicator could therefore be the actual maintenance cost for a month, as a percentage of the budgeted maintenance cost for that month.

If the actual maintenance cost for last month is found to be 110% of budget, there is really very little we can do to directly influence the performance of this KPI today. Instead, we would look at all of the Leading Indicators, probably including those that measure the performance of our maintenance process, to determine whether those values give us a signal for managing the problem.

Unfortunately, in our quest for excellence, we often are attracted to outside consultants that offer"Benchmarking" services, claiming to provide all of the KPIs we need to effectively run our business. Be careful, when considering these services, that you are not signing up for a laundry list of Lagging Indicators, since they won't help you with managing; they'll just quantify the problem you already acknowledged when you sought outside help.

Figure 1 shows how Leading Indicators for the maintenance process can provide management capability, while the Lagging Indicators show us how well we have managed the maintenance function. Leading Indicators such as "% of rework", and "% of PM's executed ontime" will affect the overall performance of the maintenance process, which will result in a certain level of maintenance function performance. The Lagging Indicators in this case which are affected by these Leading Indicators are "Maintenance Cost as a % of budget" and "Plant Availability".

At least one of these Lagging Indicators will suffer if there is sufficient under performance in the Leading Indicators. In this following example you see the alignment of the maintenance process as KPIs transition from leading to lagging.

Figure 1 - Leading and Lagging Indicators
Figure 2 does not show the specific KPIs that would be used to manage the maintenance process. Instead I have listed some of the ones I prefer to use in the table below, along with the world class level, where applicable.

In the same way that we use KPIs in the maintenance function example, we can use them in other areas of the business. This approach is particularly interesting where multiple functional areas each play a role in a given goal, such as plant reliability. Plant reliability is a shared responsibility of the maintenance, production and engineering functions. Leading indicators for each departmental process would feed the lagging indicators for the department function, which would then summarize to the plant level as shown in Figure 3

The Problem

Most of the problem is management should learn to manage their operations through KPIs (both leading and lagging). In my 30 year plus career, I have seen many plants shut their doors forever. They blamed the closing on many reasons but the one thing they all had in common was that NONE had properly managed with the KPIs. The metrics or indicators they managed with were ones like:

- Cost
- Asset Availability
- Equipment downtime
- OEE

All of these measurements or indicators, while useful for measuring performance,

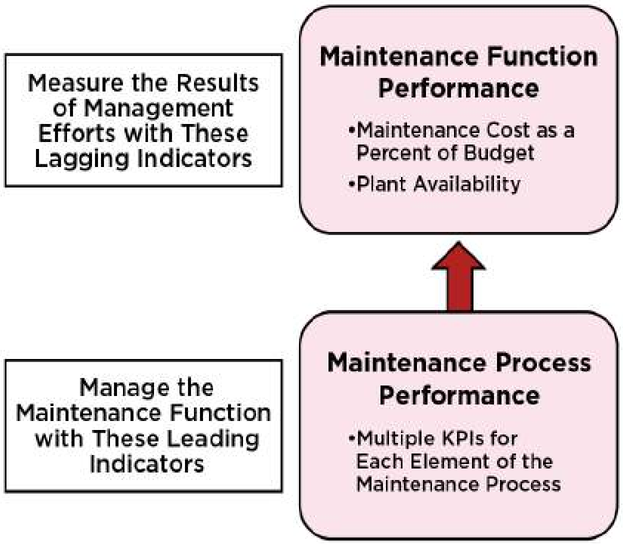


Figure 1. Leading and Lagging Indicators

cannot be used to manage the maintenance and reliability process. They are simply the results of all the actions that have taken place in the maintenance and reliability process. Again, you cannot manage results.

You can only manage the processes leading to the results. If your company uses any of the above metrics to manage their operation, without Leading Indicators they are in a reactive mode. Companies must ask themselves some very basic questions:

- Does your company differentiate between those KPIs which can be used to manage (Leading Indicators) from those that we can use to measure results (Lagging Indicators)?
- Does your company measure performance of the maintenance process, where they can easily manage when needed?

If Leading Indicators show under performance, then the under performance will affect the Lagging Indicator which could be reliability, cost, capacity, etc. People must understand the relationship between a Leading and Lagging Indicator and their affects on the maintenance and reliability function.

Most maintenance managers are told to control cost, improve reliability and increase asset availability with no idea where the problem may be in their maintenance process. Unfortunately many lose their job as a result. The fact is you cannot control cost, reliability, or availability without managing the maintenance process.

John Day, (retired) Alumax: Since 1999, Alumax has been a leader in all alloys of aluminum. Their Mt. Holly plant was rated as one of the best maintained plants in the world for over 20 years. John Day, the company's former engineering and maintenance manager comments on how he managed using KPIs:

"Hundreds of companies visited our plant, paying $1000 each to see

#	Type of KPI	Measuring	Key Performance Indicator	World Class Target Level
1	Result/ Lagging	Cost	Maintenance Cost	Context Specific
2	Result/ Lagging	Cost	Maintenance Cost/ Replacement Asset Value of a Plant and Equipment	2 - 3%
3	Result/ Lagging	Cost	Maintenance Cost/ Manufacturing Cost	< 10 - 15%
4	Result/ Lagging	Cost	Maintenance Cost/ Unit Output	Context Specific
5	Result/ Lagging	Cost	Maintenance Cost/ Total Sales	6 - 8%
6	Result/ Lagging	Failures	Mean Time Between Failure (MTBF)	Context Specific
7	Result/ Lagging	Failures	Failure Frequency	Context Specific
8	Result/ Lagging	Downtime	Unscheduled Maintenance Related Downtime (hours)	Context Specific
9	Result/ Lagging	Downtime	Scheduled Maintenance Related Downtime (hours)	Context Specific
10	Result/ Lagging	Downtime	Scheduled Maintenance Shutdown Overrun (hours)	Context Specific
11	Process/ Leading	Maintenance Strategy	Percentage of work requests remaining in "Request" status for less	80% of all work requests should be processed in 5 days or less.
12	Process/ Leading / Planning Element/ Lagging	Planning	Percentage of work orders with man-hour estimates within 10% of actual over the specified time period.	Accuracy of greater than 90%
13	Process/ Leading	Planning	Percentage of work orders over the specified time period, with all planning fields completed.	95%+
14	Process/ Leading	Planning	Percentage of work orders assigned "Rework" status (due to a need for additional planning) over the last month.	This level should not exceed 2% to 3%
15	Process/ Leading	Planning	Percentage of work orders in "New" or "Planning" status less than 5 days, over the last month.	80% of all work orders should be possible to process in 5 days or less. Some work orders will require more time to plan but attention must be paid to 'late finish date'.
16	Process/ Leading / Scheduling Element/ Lagging	Scheduling	Percentage of work orders over the specific time period, having a scheduled date earlier or equal to the late finish or required by date.	95%+ should be expected in order to ensure the majority of the work orders are completed before their 'late finish date'.
17	Process/ Leading	Scheduling	Percentage of scheduled available man-hours to total available man-hours over the specified time period.	Target 80% of man-hours applied to scheduled work.
18	Process/ Leading	Scheduling	Percentage of work orders assigned "Delay" status due to unavailability of manpower, equipment, space or services over the specified time period.	This number should not exceed 3% to 5%
19	Process/ Leading	Execution	Percentage of work orders completed during the schedule period before the late finish or required by date.	Schedule compliance of 90%+ should be achieved.
20	Process/ Leading / Execution Element/ Lagging	Execution	Percentage of maintenance work orders requiring rework.	Rework should be less than 3%.
21	Process/ Leading	Follow-up	Percentage of work orders closed within 3 days, over the specified time period.	Should achieve 95%+ Expectation is that work orders are reviewed and closed promptly.

Figure 2. Specific Examples of Leading and Lagging Indicators

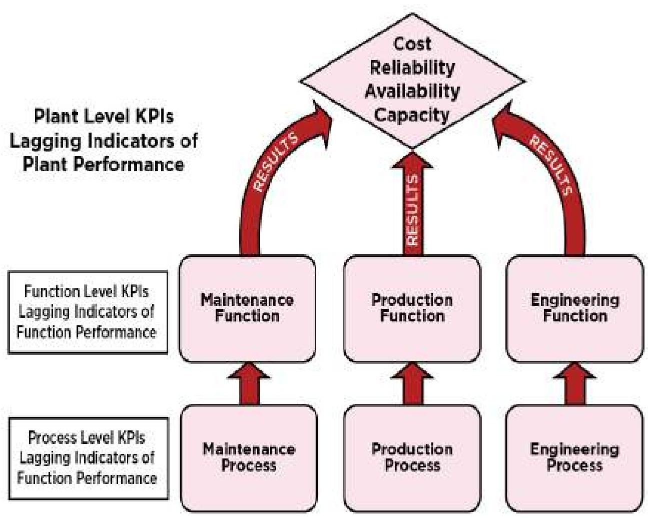


Figure 3. The use of Leading and Lagging Indicators across functional areas

our maintenance program upclose, but only a few learned from their visit." John feels they missed out on how Alumax managed with aligned KPIs.

John was also invited to visit over 500 plants in the US, Canada, and Australia and says, "The one thing over 90% of them had in common was they could not effectively manage their plants because they had no Leading KPIs in place. Many of these companies were crying for help but did know which way to go." Most managed only with Lagging Indicators and made decisions based indicators such as cost and reliability.

John learned early in his career that without Leading KPIs you cannot manage the maintenance and reliability of equipment. "For over 20 years, I could see problems brewing long before they would become a serious issue. Alumax had a system in place where we could measure everything in our maintenance process - from Leading Indicators such as the identification of potential failures through to the lagging financial results of all actions performed by maintenance."

This separation of Leading and Lagging KPIs allowed him to make management decisions when Leading KPI underperformance was identified before cost and reliability (the Lagging Indicators) were impacted.

According to John, there is a simple reason why most companies don't succeed: They don't know what information needs to be collected. In 1979, John worked with Alumax's accounting department to establish over 60 financial accounts just for maintenance.

These financial accounts were linked to leading KPIs in the maintenance process which provided information needed to manage proactively. In turn, these KPIs were linked to equipment performance – also Lagging Indicators.

Each of these Lagging KPIs had established benchmarks which measured if the maintenance process was in or out of control. This approach may sound complex, but once you have it in place, management can truly manage the reliability of plant equipment.

John shared with me 13 years of KPI data that was so impressive it would bring tears to any maintenance and reliability professional's eyes. Describing the data, John stated, "Everyone froma maintenance person to the plant manager had KPIs they looked at on a daily or weekly basis in order to make basic and immediate management decisions.

Each level in our organization utilized a small number of Lagging KPIs, along with a bigger number of Leading KPIs that were important to managing their part of the business." In reviewing Alumax's KPIs over a 13 year period, I found that their maintenance cost (a Lagging KPI) did not increase but was constant. Maintenance cost as a percentage of return on asset value held at around 3% for all of those years.

Equally impressive was that the controllable plant operating cost was very constant over this same time period. This Lagging Indicator data pointed to the obvious fact that the reliability of equipment directly correlates to operating cost.

By managing the maintenance and reliability process, element by element using Leading Indicators, Alumax was able to achieve these results. John's experience validates that managing with both Leading and Lagging KPIs is the only way to effectively manage an operation in order to achieve the results expected to succeed in a business.

By the way, over 26 years ago I was blessed to work for John Day at Alumax and enjoyed everyday I worked for him. The solution How much money do corporations lose every year due to plants not managing with good leading and lagging KPIs?

The costs may be too high to calculate, so we must stop these massive loses now by putting a plan in place to develop and align KPIs. This section may save your plant or your job. But I warn you, don't look for short cuts in the process I am about to explain because there are none.

Step 1: Educate management, from executive level to floor level supervisors, on KPIs and how they Leading and Lagging Indicators should be aligned to meet the business goals. You then must provide a similar education to the maintainers and operators.

Step 2: Define and assess your current maintenance and reliability process against a future state. A future state is known maintenance and reliability "best practices". As part of this assessment, you must develop a business case with financial opportunities and cost of change. This step continues the education process and creates an awareness of the opportunity at hand.

Step 3: Develop a plan based on the assessment to include financial opportunities and cost on a timeline. This plan must include:

a. The definition of the elements of your maintenance and reliability process (work identification, planning, scheduling, work execution, etc.)
b. Workflow Process for each element in your maintenance and reliability process
c. The definition of roles and responsibilities for each task
d. The definition of Leading and Lagging KPIs in each element of your maintenance and reliability process in each element
e. Targets and World class benchmarks that are established against the defined KPIs.

Step 4: Implement the process and begin managing based on Leading Indicators. I would begin measuring only a few KPIs at first (maximum of 5). Then allow people at the lowest levels to make the decisions required ensuring your maintenance and reliability process is proactive and effective. The use of Leading KPIs is a great awareness tool and will bring everyone into the decision-making process.

This process is not easy however it is not magic either. Developing KPIs is a time consuming process but one which must be done in order for a company to survive.

THE ROLE OF LUBRICATION IN ROOT CAUSE AND FAILURE ANALYSIS

It's a scenario most people are all too familiar with. Despite our best efforts a component failed in the plant and brought production to a stand-still. These failures are the bane of reliability and are often analyzed to determine failure modes, learn lessons to avoid future failures, and in some cases, to redesign the machine or environment to maximize uptime of the equipment.

Terms like Root Cause Analysis (RCA) and Failure Reporting, Analysis and Corrective Action System (FRACAS) get thrown around, and teams of people are assembled to look at the failure from various aspects of operations, maintenance, environmental, and the list goes on. Ultimately, the goal is to determine what specifically happened that led to machine failure, so we don't have the same thing occur time and again.

But the question remains, what role should lubrication play in all this?

Lubricant analysis exists in many forms within a facility — from the front-line staff performing inspections, all the way up to real-time sensors that provide data on the various parameters of the component. All this data is significant and should be integrated together. Each type of condition-monitoring technology has its own strengths and weaknesses but blending methods together can provide a better snapshot of what may actually be going wrong with that piece of equipment.

When it comes to lubrication analysis, the main data sources should include:

- **Inspection Results –** The technicians or operators that are involved in the daily rounds at a facility hold a tremendous amount of information and experience. Reviewing notes on sight glass inspections (level, foam, emulsions, deposits, etc.) can help point towards a lubricant failure, or perhaps even, lubricant starvation. The same is true for audible inspections, noting any abnormal noises that may have occurred.
- **Oil Sampling Data –** This represents one of the largest areas of routine data gathered to be trended and analyzed for early warnings or symptoms of machine failure. Looking back at such test results around fluid health, contamination, and machine wear debris can often point toward a likely failure mechanism.
- **Grease Sampling Data –** Similar to oil data, grease holds valuable information,

as well. While not as common as oil insight into how well the grease is maintaining its properties and if there are significant amounts of contamination and wear debris present.

- **Filter Analysis –** Often over looked, the filter is a vault of information, especially as it relates to failures of lubricated equipment. Wear debris often becomes larger in size and concentration as failure progresses. Analyzing the shape and metallurgy of the particles in the filter can provide useful information about specific components that may be wearing,while also potentially shedding some light on the wear mechanism.
- **Sensor Data –** Sensors come in a variety of forms, each revealing different aspects of the lubricant or machine. With many sensors providing data at a high frequency, information can be analyzed to determine if there were any abnormal trends leading up to the failure event. If none are found, it may present a reason to reexamine where the sensors are installed and the specifi c parameters they are monitoring.

There are many different strategies to perform a root cause analysis, but they all share some similarities. With the same end-goal of determining what happened and how to avoid it from happening again, there has been the use of many methods, including the five whys, fishbonediagrams, fault tree analysis, scatter plot analysis, to name a few.

The Phases of Proper Failure Analysis

All these tools are valuable in helping to utilize the failure-analysis method that makes the most sense for your facility or organization. To simplify, here are five main phases I recommend should be followed:

1. **Data Collection –** This includes fact-finding, interviewing witnesses of the event, and determining if there were other sequential events that may have occurred with the failure. During the data-collection phase, it is important that evidence is preserved as much as possible. This includes documenting final running conditions, taking photographs of the equipment and components, and securing data samples much like the data mentioned above. Diligence is the key to avoid incurring any impact to the integrity of the data gathered during this step.
2. **Assessment –** During the assessment phase, the analytical methods such as the five whys maybe employed. The overall goal of this step is to analyze the data and determine if it reveals the root cause of the failure. Often times, root causes get grouped into one of many of the followingcategories including:
    a. Equipment/Material Problems
    b. Design Problems
    c. Procedural Problems
    d. Human Error
    e. Training Deficiency
    f. Management Problems

While this is not an exhaustive list, a single failure may have multiple reasons that caused it to get to a catastrophic case. For instance, the bearing wasn't lubricated properly because the scheduled PM frequency was too long. Some technicians may just chalk this up to a lubrication issue and not look at the other aspects of what all was occurring.

3. **Corrective Action –** This represents the plan of remediation to fix the issue and stop it from occurring again. Often times, this plan will involve various departments such as maintenance, reliability, engineering, and operations. Depending on the complexity of the corrective action, a complete redesign/ rebuild of the equipment or environment that houses the equipment may be the most prudent. These cases are rare but do occur.
4. **Inform –** The actions to prevent reoccurrence must be reported to the parties that will be responsible for implementing them. It is also a good practice to share the information with the departments that have an impact on the future operation of the asset. Sometimes, this may involve planners when a PM or BOM needs to be updated to reflect the changes stemming from this process.
5. **Follow-up –** As with any process a verifi cation step is often employed to ensure that the corrective action plan was put into place. This may also include more detailed analysis moving forward such as increasing the rate of lubricant sampling, inspections, and testing of the equipment.

There are different types of failures that may require more significant analysis. For instance, a single-point failure that occurs when a single component fails might be solved in a matter of minutes and not require a regimented RCA process. Multi-point or sequential failures can be more difficult to determine the true root cause, and as such, require more focus and investigation to get to the real culprit.

Understanding when and where to deploy your RCA process can be based on many criteria.Usually, RCAs are reserved for those failures that are serious, complex, and repeating. If this isn't the case, a simplified model of RCA can be used effectively without tremendous risk to the organization.

Don't get discouraged if the process is hard or if the root cause is elusive. Be diligent and stick with it. Over time, you'll find you've become adept at solving the tricky case of machine failure.

HOW TO QUANTIFY SEVERITY OF WEAR AND CONTAMINATION WITH A FILTERGRAM

This article reports diesel engine oil analysis data, demonstrating the use of filtergram x-ray fluorescence to quantify severity of wear and contamination. Two independent measurements were performed on each filtergram specimen: pore blockage particle count and x-ray fluorescence (XRF) large particle elemental analysis. Causal inflections in ASTM D7720 cumulative distributions indicate severity thresholds for filtergram XRF elemental analyses.

What Can You Expect to Learn?

1. Filtergram particle quantifier (FPQ) measures particle count and ISO code for particulate debris accumulated on a > 4-micron filtergram.
2. X-ray fluorescence (FPQ XRF) reports elemental analysis of the particulate debris on each filtergram specimen.
3. Wear and contamination severity determination requires analysis of greater than 4-micron debris including Fe, Cr, Ni, Cu, Sn, Pb, Al, and Si, in addition to particle count.
4. Filtergram specimens retain wear debris if needed for future reference, defect elimination and root cause failure analysis (RFCA).

Introduction

This presentation demonstrates the use of ASTM D8127 Filtergram X-ray Fluorescence to quantify abnormal wear originating from iron alloys, white metal alloys, and yellow metal alloys in a population of 52 in-service diesel engine oil samples. These in-service oil samples were tested with a pore-blockage particle counting process extracts, and retains particulate matter larger than 4-microns on the filtergram specimen. Each filtergram is nondestructively tested with energy dispersive x-ray fluorescence (XRF) to measure elemental composition including iron (Fe), chromium (Cr), nickel (Ni), copper (Cu), lead (Pb), and tin (Sn) to quantify abnormal wear from hundreds of moving engine components in every engine oil sample.

World wide engine oil analysis extensively focuses on optical emission spectroscopy (OES) to measure Fe, Cr, Ni, Cu, Pb, Sn and Si to quantify abnormal wear and contamination. However, the molecular to ultra-fine particle size limitation for OES obscures its effectiveness for distinguishin abnormal component wear and engine-oil dust contamination for the following: 1) there are numerous molecular-to-micron sizes that range as normal or benign sources of these seven elements, and 2) severe wear and dust contamination debris are typically larger than the OES particulate measurement range.

OES measurement range detects all seven of these elements in engine oil originating from many sources. For example, "rising copper concentration can reach well over 300 ppm".

As alarming as this sounds, it has been reported that copper sulfide, even in these high concentrations, is generally benign and, as such, may not be associated with (cause or effect) cooler failure, accelerated wear or lubricant oxidation. Copper found in diesel engine oils can come from wide-ranging sources and can exist in the oil in varying states.

From the oil analyst's perspective, determining the source, nature and state of copper is essential to correctly interpreting the alarm, in terms of engine reliability and the appropriate response. Although very valuable, [OES] elemental analysis has only limited capability and, in fact, may produce false alarms or mask real alarms unless other tests are performed concurrently or on an exception basis."

The filtergram particle quantifier with X-ray fluorescence (FPQ XRF) performs pore blockage particle counting, followed by energy dispersive X-ray fluorescence multielemental analysis, per ASTM D7684, ASTM D8127 and ISO 21018-3. Figures 1 and 2 show the filtergram particle quantifier (FPQ) as having an active area on the 4- micron filter membrane where wear debris accumulates. The FPQ specimen is labeled, XRF elemental analysis is performed, and the specimen is retained for visual and microscopic examination.

Figure 1. Filtergram for collection of > 4-micron wear debris from in-service oil samples:

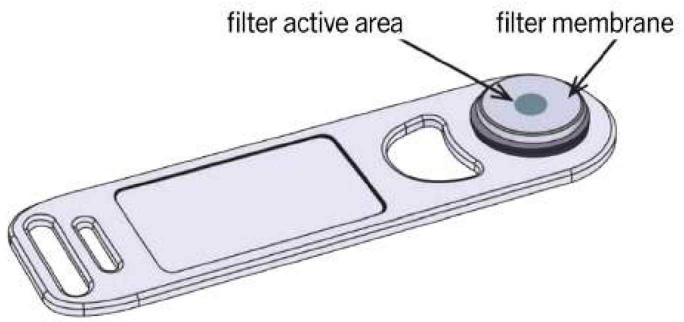


Figure 2. Inserting FPQ Filtergram specimen in position for XRF x-ray fluorescence of the filteractive area:

Figure 3 outlines the two-step process for extracting >4 micron particulate from in-service oil samples and measure the elemental composition of debris deposited onto the filter active area.

Advantages for this 2-step process include:

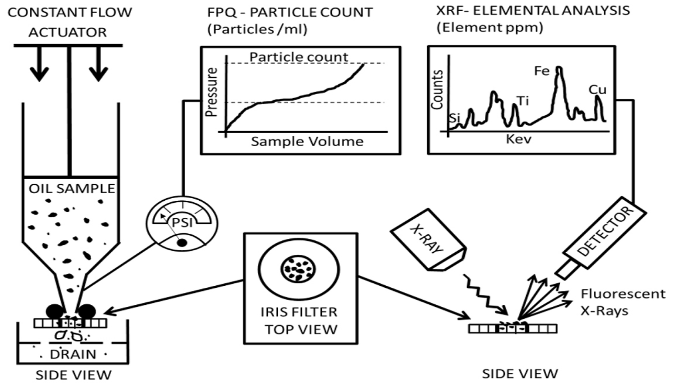
Fast solvent-free method:

- No dilution or acid digestion sample preparation.
- Suitable for field conditions.
- Repeatable, consistent, particle presentation with measured volume for PPM concentration calculation.

Powerful data for advanced wear detection:

- Particle count measurement result.
- Non-destructive XRF test reports 16 elements (PPM): Fe, Ag, Al, Cr, Cu, Ni, Pb, Si, Sn, Ti, Mo,Co, Mg, W, V & Zn.
- Specimen with debris available for future investigation.
- Correlates with other large particle techniques.

Figure 3. Filtration Particle Quantifier (FPQ) Technique (ASTM D8127):

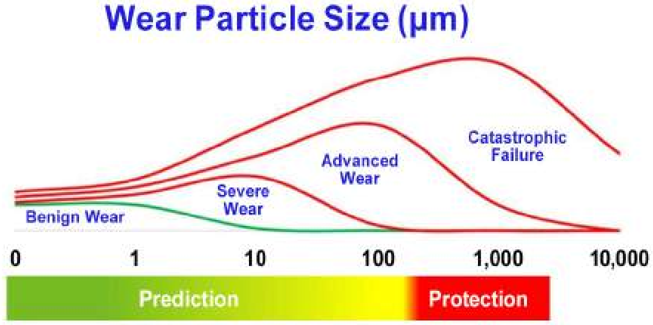


Severe Wear Debris

Severe sliding, rolling fatigue, and bending fatigue are failure mechanisms that exponentially shorten functional life of machine components. Damage from each mechanism is cumulative and progressive.

Wear debris from each of these mechanisms carries evidence about the damaged component, the insults causing damage, and the stage or severity of failure progression. Benign wear severe, advanced, and catastrophic wear presented in Figure 4, represent increasing severity levels.

Figure 4. Diagram of wear-particle sizes ranging from sub-micron to very large:

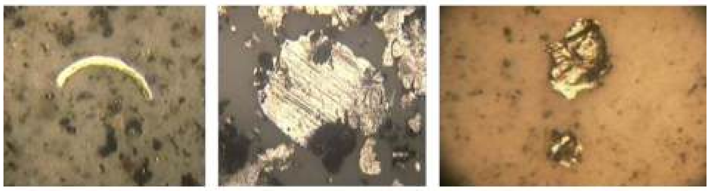


Abnormal abrasion, adhesion, and fatigue (Figure 5) are large wear particles in base metals, not just oxides.

- Microspall particles range between 10 mm and 50 mm.
- Laminar particles and chunks range from 50 mm to several hundreds of microns.
- Optical emission spectroscopy is blind to large particles.

Filtergram particle quantifier (FPQ) measures particle count and ISO code for solid particulate debris accumulated on a > 4-micron filtergram. This includes the important stages of severe wear and advanced wear that lead to catastrophic failure wear-debris, with size ranges shown on Figure 4. Notice that the range for prediction of impending catastrophic failure requires measuring wear debris in the OES blindspot range from 4-micron to 2-millimeter size range.

Figure 5. Example images of abnormal abrasion, adhesion, and fatigue wear debris:



Severity Limits for FPQ XRF and OES Data

A population of 52 in-service engine oil samples were tested with fi ltergram XRF and also with OES. ASTM D7720 cumulative distributions shown in Figure 6 were used to select preliminary severity limits. Preliminary XRF severity limits for Fe, Cr, and Ni quantify abnormal wear from cylinders, piston rings, gears, shafts, timing wheels, timing chains, valve tappets, guides, crankshaft, camshaft, rocker arm shaft, piston pins, roller bearings, and oil pumps.

Furthermore, preliminary XRF severity limits for Cu, Sn, Pb, and Al quantify running surfaces of connecting rod bearings, rocker arm shaft and piston pin bearings; and Si quantifies air intake dust. OES severity limits used here are accepted OES industry-standard alarm limits.

Figure 6. Cumulative distribution severity limits for Fe, Cr, Ni, Cu, Sn, and Al for this population:

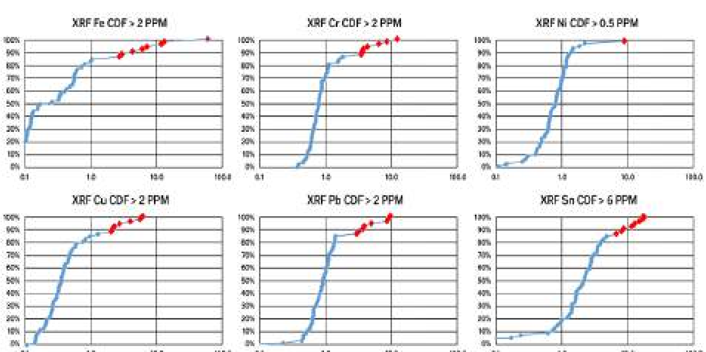


Table 1 reports the preliminary severity limits for XRF based on cumulative distributions and reports within industry accepted limits for OES measurements:

PARAMETER	XRF (PPM)	OES (PPM)
Iron (Fe)	2	60
Nickel (Ni)	0.5	11
Chromium (Cr)	2	31
Copper (Cu)	2	31
Tin (Sn)	6	10
Lead (Pb)	2	41
Aluminum (Al)	3	26
Silicon (Si)	11	41

Alarming parameter values based on these limits are highlighted in Tables 1 and 2. Samples are numbered from #1 to #52, in order, based on largest to smallest XRF Fe measurement. Alarming wear-metal parameter values are shown highlighted for samples #1 to #9. There are not any alarming parameters for Samples #10 to #52.

XRF results show high severity ranking for samples #1 through #7 based on multiple ferrous alloy (Fe, Cr, and Ni) and nonferrous alloy (Cu, Pb, Sn, Al) parameters. Also, XRF shows high severity for sample # 8 based on Fe and is supported by elevated Cr. Finally, sample #9 has high severity based on Sn, supported by elevated Pb.

OES results show alarming Fe and Al for samples #2 and #5.

Table 2. Samples #1 to #26 reporting Filtergram XRF, ISO>4, and

Sample	Filtergram XRF Fe	Filtergram XRF Cr	Filtergram XRF Ni	Filtergram XRF Sn	Filtergram XRF Pb	Filtergram XRF Cu	Filtergram XRF Al	Filtergram XRF Si	Filtergram ISO>4	OES Fe	OES Cr	OES Ni	OES Pb	OES Cu	OES Al	OES Si
#1	60.5	6.4	0.06					4.9	25	15.9	3.9	0.34	0.43	2.7	3.5	7.1
#2	19.4	12.1	0.11				6.1	6.9	26		13.1	3.53	0.67	15.1		8.3
#3	12.0	8.5	0.88					5.8	26	51.0	4.9	4.50	2.10	16.7	16.8	7.3
#4	7.2	8.6	0.11			2.8	4.8	3.5	25	12.8	8.4	0.30	0.60	1.7	8.0	7.0
#5			0.21	4.0		2.7	0.2	2.2	26		5.9	8.95	1.89	19.8		14.1
#6	4.4	4.3	0.09			2.1	7.0	2.1	25	26.4	8.9	0.41	0.97	5.3	5.7	7.9
#7	3.8	3.5	0.18		3.6	2.3	7.8	1.8	26	45.8	7.1	1.85	1.08	13.3	19.9	11.6
#8		1.59	0.18	6.7	1.2	1.3	3.0	8.6	25	36.8	2.4	1.14	0.75	14.4	9.6	6.9
#9	1.1	1.78	0.18		2.8	0.9	3.4	8.6	25	50.4	4.6	1.34	1.81	10.1	7.9	6.8
#10	1.0	0.77	0.04	1.4	1.3	0.5	1.4	8.8	24	7.6	6.6	0.90	0.80	3.1	2.7	7.3
#11	0.81	0.87	0.08	2.2	0.9	0.6	1.7	8.6	24	8.9	6.6	0.30	0.50	3.0	2.6	3.5
#12	0.72	0.58	0.18	4.3	1.3	0.4	0.7	8.3	25	53.6	3.2	3.00	1.20	12.1	10.5	4.3
#13	0.63	1.09	0.05	3.5	0.6	0.5	1.6	1.3	25	20.3	3.3	0.60	1.20	10.3	3.2	3.7
#14	0.61	1.06	0.14	0.0	0.6	0.7	1.9	8.9	22	11.0	10.2	0.34	0.46	18.5	7.6	4.0
#15	0.57	0.86	0.08	1.8	0.6	0.3	1.3	8.5	22	6.6	6.8	0.70	0.60	9.6	2.7	3.4
#16	0.57	1.52	0.05	3.5	1.0	0.5	2.3	1.7	23	14.1	14.6	0.10	0.10	8.2	8.9	2.0
#17	0.57	0.87	0.00	1.6	0.8	0.3	2.3	8.8	24	9.1	8.8	0.60	0.90	2.0	3.3	10.5
#18	0.55	0.75	0.03	1.7	0.8	0.3	0.8	8.8	22	8.5	4.6	0.20	0.40	4.9	7.9	1.0
#19	0.54	0.49	0.01	0.0	0.8	0.3	0.8	8.2	21	16.8	2.3	0.00	0.50	12.1	3.4	2.0
#20	0.49	0.99	0.08	4.8	0.4	0.4	0.2	1.6	25	27.1	3.0	0.60	0.50	13.0	4.9	3.8
#21	0.43	0.71	0.04	1.4	1.0	0.8	0.7	8.8	20	42.2	7.9	0.30	0.50	16.2	12.3	2.2
#22	0.40	1.00	0.05	1.7	0.5	0.4	1.3	8.4	22	21.2	2.4	0.30	0.10	13.5	10.9	1.1
#23	0.35	1.06	0.06	2.8	0.6	0.3	1.7	8.6	21	19.7	9.4	0.20	0.90	8.8	7.3	12.2
#24	0.34	0.62	0.13	1.6	0.9	0.4	1.1	8.8	24	8.9	8.9	0.40	1.20	3.6	3.3	9.9
#25	0.33	0.66	0.06	2.4	0.7	0.4	0.0	8.2	24	18.4	2.2	0.20	0.50	11.1	3.5	2.3
#26	0.26	0.79	0.08	2.3	1.0	0.3	2.0	8.4	25	24.5	3.2	0.90	0.80	8.8	3.2	2.2

OES data
Table 3. Samples #27 to #52 reporting Filtergram XRF, ISO>4, and

Sample Number	XRF Fe	XRF Cr	XRF Ni	XRF Sn	XRF Pb	XRF Cu	XRF Al	XRF Si	Filtergram ISO >4	OES Fe	OES Cr	OES Ni	OES Pb	OES Cu	OES Al	OES Si
#27	0.17	0.81	0.08	2.7	0.0	0.2	0.2	0.6	24	8.3	1.6	0.09	0.73	0.4	2.8	6.2
#28	0.16	0.70	0.07	2.7	1.1	0.4	2.0	2.4	22	17.2	7.7	0.20	0.30	8.2	4.7	1.8
#29	0.16	0.87	0.07	0.8	1.0	0.1	1.2	0.4	24	12.3	7.0	0.20	0.10	1.4	2.9	5.0
#30	0.14	0.84	0.09	3.5	1.1	0.3	0.3	0.8	21	11.3	2.0	0.20	0.20	5.9	3.8	2.9
#31	0.13	1.11	0.10	1.6	0.9	0.3	1.1	1.4	21	9.9	10.0	0.12	0.23	1.7	4.7	5.7
#32	0.13	0.79	0.05	1.9	0.6	0.4	0.6	1.4	22	7.1	0.5	0.53	1.05	3.8	3.4	12.1
#33	0.12	0.70	0.06	1.2	0.5	0.1	0.4	0.6	22	8.2	2.7	0.10	0.60	1.7	3.5	1.8
#34	0.12	0.72	0.12	0.2	1.3	0.6	1.1	0.3	21	16.4	2.8	0.40	0.80	19.8	4.1	2.2
#35	0.12	0.72	0.10	3.1	0.8	0.5	0.8	0.1	22	15.7	2.6	0.60	1.30	11.3	3.6	1.6
#36	0.12	0.79	0.03	1.4	1.3	0.2	1.9	0.3	21	9.5	2.2	0.50	0.70	1.7	2.9	0.9
#37	0.11	0.64	0.10	0.2	1.3	0.3	4.3	10.5	21	7.8	1.0	0.50	0.57	6.3	3.5	1.5
#38	0.11	0.87	0.14	2.8	0.6	0.2	2.0	3.0	23	10.6	5.8	0.34	0.48	1.5	2.6	2.6
#39	0.11	0.37	0.11	1.4	1.0	0.4	2.3	0.7	22	7.9	0.6	0.51	1.22	0.6	3.5	12.1
#40	0.10	0.61	0.06	2.2	0.9	0.4	0.9	0.8	21	6.5	0.7	0.10	0.40	1.9	3.1	12.1
#41	0.10	0.38	0.07	0.9	1.2	0.2	1.4	0.6	21	5.8	0.6	0.10	0.20	1.1	2.9	13.1
#42	0.10	0.94	0.04	1.0	1.1	0.1	1.3	0.3	24	11.5	6.4	0.10	0.50	2.8	2.8	2.4
#43	0.09	0.82	0.01	2.1	0.6	0.3	0.3	0.4	22	14.3	1.9	0.30	0.80	10.8	5.3	1.0
#44	0.09	0.57	0.12	0.7	0.7	0.3	0.9	0.3	22	12.9	1.7	0.46	1.03	7.6	2.6	2.4
#45	0.08	0.62	0.09	2.7	0.4	0.2	1.1	1.4	33	6.0	0.2	0.29	0.16	1.2	3.2	17.0
#46	0.07	0.52	0.06	2.9	0.8	0.2	2.3	0.7	22	5.2	0.6	0.50	0.30	1.3	3.0	11.4
#47	0.05	0.52	0.08	0.0	0.6	0.2	0.6	2.2	22	8.1	0.8	0.50	1.00	4.0	3.0	11.8
#48	0.05	0.59	0.10	2.1	0.2	0.3	1.4	3.3	21	5.5	0.7	0.20	0.20	1.5	2.8	11.4
#49	0.05	0.60	0.03	3.8	0.6	0.1	0.7	3.6	21	5.0	0.7	0.10	0.10	1.0	2.9	11.5
#50	0.05	0.45	0.06	0.6	0.4	0.2	1.9	2.3	21	4.8	0.7	0.20	0.20	0.8	3.0	10.6
#51	0.05	0.60	0.05	1.3	0.7	0.1	1.0	0.7	21	4.9	0.8	0.20	0.30	1.0	2.9	11.4
#52	0.05	0.58	0.07	1.0	0.9	0.3	0.7	0.9	21	4.8	0.7	0.20	0.40	1.3	2.8	9.5

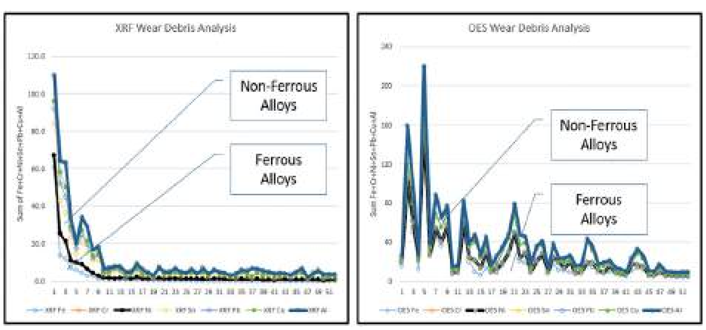
OES data
The graphs in Figure 7 sum up PPM measurements from Tables 2 and 3 and show ferrous and non-ferrous alloys for all samples #1 to #52.

The XRF graph on left shows PPM for > 4-micron wear debris accumulated on the filtergram. Samples #1 through #8 have severe ferrous alloys, samples #1, #2 and #3 have severe white and yellow soft-metal alloys, samples #4, #5, #6, #7 and #9 have severe, soft-white-metal alloys.

The OES graph on right shows PPM for < 4-micron dissolved substances and particulates. In this graph, samples #2 and #4 stand out having high Fe and Al, but the rest looks like noise.

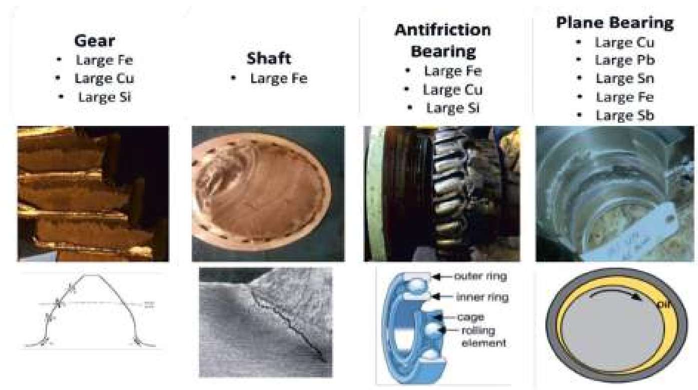
A very important distinction to notice in Table 2 and Figure 5 is the capability to detect and quantify abnormal wear in soft metal alloys.

Figure 7. Sum of wear debris for samples #1 to #52 using XRF (left)



and OES (right):
This table demonstrates multi-element large particle wear debris analysis. Figure 8 identifies crticical rotating machinery assets with similar needs to monitor ferrous alloy, white metal alloy, and yellow metal alloy components.

Figure 8. Wear metal composition for large abnormal wear debris from rotating machinery components:



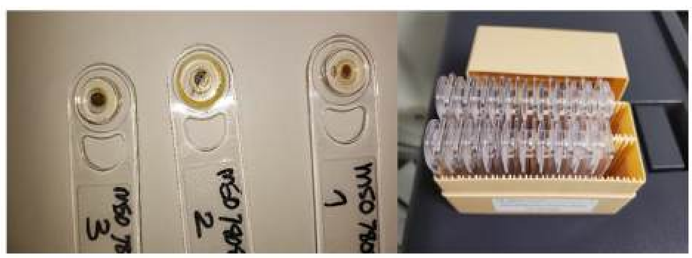
Root Cause Failure Analysis

Analytical Ferrography (AF), Filter Rotrode Spectroscopy (RFS), Scanning Electron Microscopy (SEM) and acid digestion are the standard methods for in-service oil analysis of ferrous and non-ferrous wear debris in the OES blind spot (> 4-micron to 2- millimeter range). Occasionally, one of these time-consuming methods is used with special justifi cation, such as for root cause failure analysis (RFCA).

Filtergram specimens (see Figure 8) are retained and available for:

- Retest and comparison
- Microscopic wear debris analysis
- Future investigation
- Case history example, and
- Defect elimination

Figure 9. Container for filtergrams:



This article presents preliminary severity limits for ferrous and non-ferrous alloys metal components represented by a population of 52 diesel engine oil samples. Preliminary XRF severity limits for Fe, Cr, and Ni quantify abnormal wear from cylinders, piston rings, gears, shafts, timing wheels, timing chains, valve tappets, guides, crankshaft, camshaft, rocker arm shaft, piston pins, roller bearings, and oil pumps.

Furthermore, preliminary XRF severity limits for Cu, Sn, Pb, and Al quantify running surfaces of connecting rod bearings, rocker arm shaft and piston pin bearings, and Si quantifies air intakedust. Filtergram specimens may be retained and available for retest, future reference, defect elimination, and root cause failure analysis (RCFA).

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WINDERGY INDIA 2024 A GLOBAL AND INDIAN CONFLUENCE SETTING NEW INDUSTRY BENCHMARKS

Chennai, October 26, 2024 – The sixth edition of Windergy India, India's premier trade fair and conference for wind energy, concluded successfully at the Chennai Trade Centre from October 23-25, 2024. Organized by the Indian Wind Turbine Manufacturers Association (IWTMA) and PDA Ventures Pvt. Ltd., the event attracted over 300 exhibitors from 20 countries and drew close to 13,000 participants, making it a key platform for innovation and collaboration in India's renewable energy sector.

Windergy India 2024 received strong support from government bodies, including the Ministry of Power, the Ministry of New and Renewable Energy (MNRE), and NITI Aayog, further bolstered by partnerships with leading industry organizations. Notable government and industry leaders attended the event, sharing insights into wind energy's vital role in India's renewable energy transition. Distinguished guests included Shri Sudeep Jain (MNRE), Shri Lalit Bohra (MNRE), and Dr. Aneesh Sekhar (Tamil Nadu Green Energy Corporation), who emphasized India's renewable energy potential. The event featured a strong representation of global industry players, including Envision, Suzlon, GE Vernova, Siemens Gamesa, and Adani Wind, alongside country pavilions from Denmark, Spain, and the UK. These global participants underscored India's emerging position as a key player in the wind energy sector.

Windergy India 2024 also served as a knowledge hub, offering roundtable discussions on offshore wind development, grid infrastructure, and R&D. The event highlighted the collaborative efforts between India and international stakeholders, including Spain, the UK, Denmark, and the Green Hydrogen Organisation, aiming to achieve India's 2030 renewable energy goals.

Additionally, the event included a hands-on workshop on windPRO and energyPRO software, offering valuable insights to both new and existing users. A dedicated session on the final day engaged students from across India, inspiring them to explore career opportunities in the renewable energy sector and contributing to the industry's future workforce.

Windergy India 2024 proved to be a significant milestone, facilitating business networking, fostering international partnerships, and empowering stakeholders to drive sustainable growth in the wind energy sector. The event's success marks a promising future for India's renewable energy ambitions, setting new industry benchmarks for years to come.

For more details on Windergy India 2024 and upcoming editions,
please visit : **www.windergy.in.**
Contact: **Khushboo Bafna**
Email: khushboo@pdaventures.com

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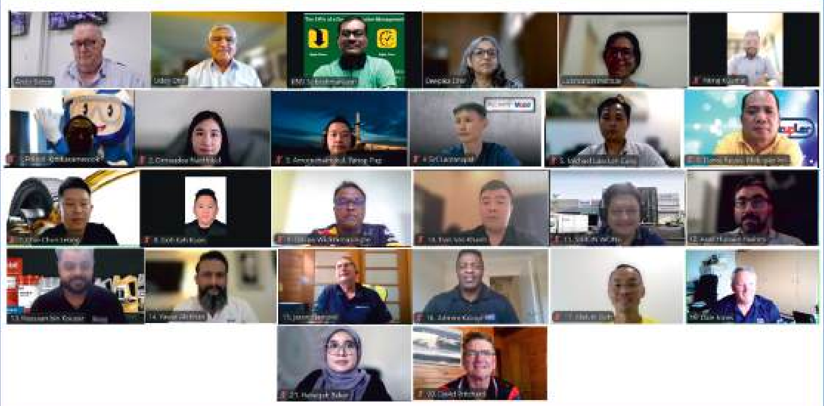

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HPCL Enters US Market with HP SHOX Lubricant

Hindustan Petroleum Corporation Limited (HPCL) has successfully entered the US market with the export of its premium lubricant, HP SHOX OIL DC. This marks HPCL's first venture into the American market, expanding its global footprint to 30 countries. The lubricant has been chosen by Duroshox, a leading manufacturer of vibration isolation solutions, for use in their solar panel dampers at their San Antonio, Texas facility. The move taps into the high demand for quality lubricants in the US, one of the largest markets globally. This strategic entry aligns with HPCL's goal to enhance its presence internationally. HPCL's ED – Lubes, CH Srinivas, highlighted the achievement as a significant milestone in their expansion plans, emphasizing their commitment to growth and collaboration in global markets. The first shipment of HP SHOX OIL DC was dispatched from Mumbai to the US, marking a key step in HPCL's global growth strategy.

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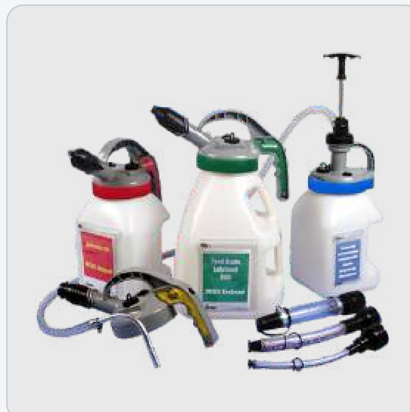

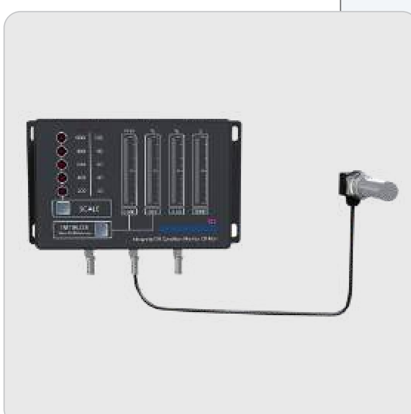

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