INSIDE

Accessorise Your Equipment for Enhanced Reliability

Grease Sampling Methods Matter

Machinery » Lubrication

INDIA January - February 2019

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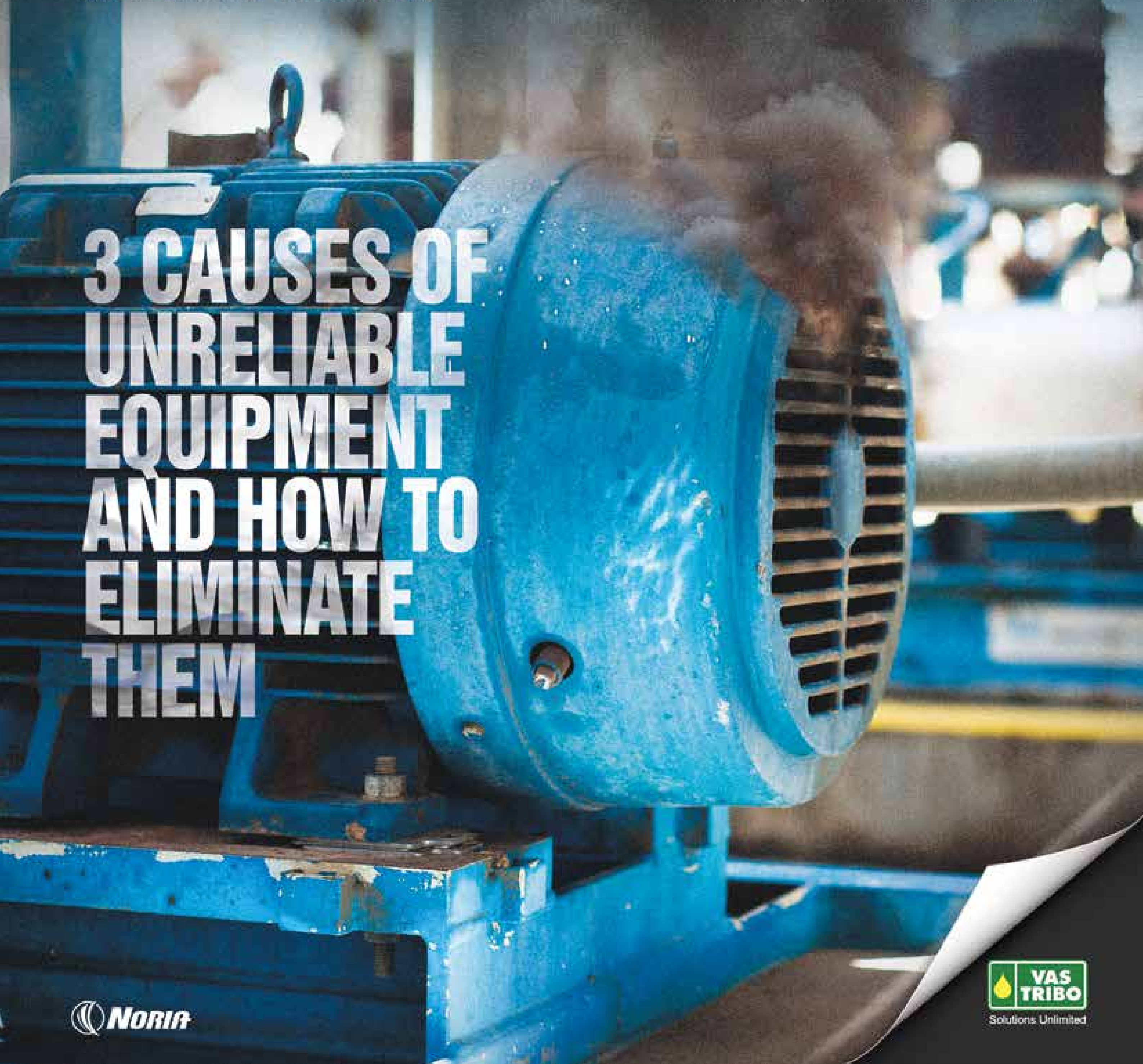


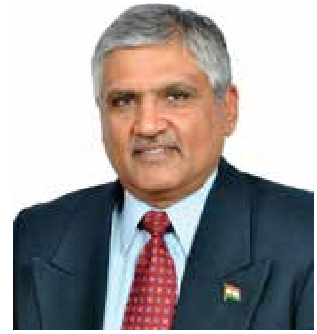
3 CAUSES OF UNRELIABLE EQUIPMENT AND HOW TO ELIMINATE THEM

TABLE OF CONTENTS

Machinery Lubrication INDIA

EDITORIAL FEATURES

Publisher's Note



During the early 90's, an abundance of literature on lubrication was available, but the content of this literature did not provide a practical guide to setting up a lubrication plan or how to align all departments according to such a plan. Therefore, a simplified lubrication framework, which takes a holistic approach to lubrication, was devised to set up a cost-effective lubrication control system.

Having reliable equipment demands a deep understanding of equipment failure modes and strategies to prevent them. There can be a multitude of factors that lead to equipment failure. It takes a strategic approach to improve equipment reliability. Changing parts before they fail can be a solution to prevent unexpected failures or predicting equipment failures can be a solution but it is only 50% accurate. No matter your strategy, you need to be proactive in order to achieve sustainable results.

Improper lubrication is leading factor that accelerates mechanical corrosion and wear which ultimately leads to premature failure of machines. If you don't have any maintenance program implemented in your facility, make sure you pay due attention to lubrication.

Lubricant contamination is one of the major day-to-day maintenance problems. Do you think new oils are absolutely clean and free of all contaminants? The manufacturing process of the lubricants is the first possibility of contaminants entering the lubricants. The contaminants can also enter through seals making it necessary for equipment reliability experts to perform oil analysis and clean oils before making them a part of the equipment. The industrial environments where poor lubrication practices are followed experience severe mechanical wear of components. Metal components corrode rapidly due to particle contamination and use of substandard or wrong lubricants. It may seem superfluous to mention that mechanical wear takes place when machine surfaces rub against each other. Wear materials and dirt are some of the common contaminants that need to be removed from the system in order to ensure equipment reliability.

To actively eliminate all the causes of unreliability, focus on developing an effective lubrication program.

We would like to thank our readers for the immense response to our previous edition's cover story – "Track your Lubricant's journey to optimize machine health" and other articles. Our current issue's cover story is "3 causes of unreliable equipment and how to eliminate them" which will help our readers to understand the reasons of equipment failure.

I cannot sign off without giving special thanks to our advertisers, subscribers and authors.

We welcome your feedback & suggestions.

Wishing you all "Happy and Prosperous New Year 2019" filled with abundance joy and treasured moments.

Warm regards,

Udey Dhir

Jim Fitch | Noria Corporation

Ghost Riders That **Haunt Your Oil**

Beware of those invisible particles not reported by most oil analysis labs

"These contaminants, which go unnoticed by maintenance staff and unmeasured and unreported by oil analysis labs, need to be exposed and understood."

The definition of a contaminant is any foreign "something" that enters a lubricant during formulation, packaging, transport, storage or service. Contaminants compromise the lubricant's integrity, performance and service life as well as impart harm to the machine. No lubricant is indemnified from their effects or can safely co-exist with contaminants. So too, there are no lubricants or machines that can realistically be defined as contaminant-free.

The hazards brought on by various types of contaminants have been covered extensively in the pages of *Machinery Lubrication* magazine. We've shown how the damage can progress slowly or attack suddenly and destructively. Either way, contaminants are a serious lubricant disease that merit vigilant attention by lubricant analysts and reliability professionals.

Solid contaminants (also known as particles) come in wide-ranging

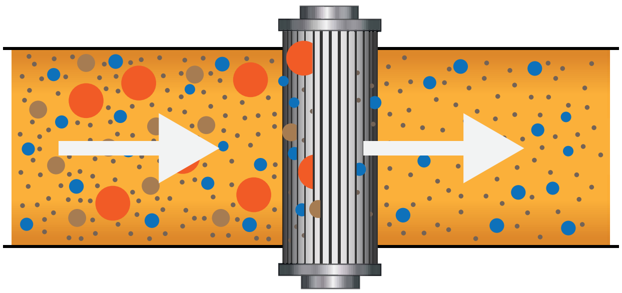


Figure 1. Small particles can pass unimpeded through a filter.

sizes, shapes, hardness and composition. Often missed in the discussion on particle contamination are the ghost riders that lurk in your oil. These contaminants, which go unnoticed by maintenance staff and unmeasured and unreported by oil analysis labs, need to be exposed and understood.

Defining Ghost Riders

Today's owners of lubricated mechanical assets want to minimize maintenance and repair costs. Consumables like lubricants are often targeted for cost reduction. These days, lubricants are formulated to be increasingly robust and resistant to chemical degradation from heat, oxidation and operating conditions. This physical and chemical stability enables fewer oil changes and lowers the cost of lubricant consumption.

This is a good thing, but sadly there is a downside to extended oil drains or, in some cases, no oil drains. The longer a lubricant remains in service, the longer it is exposed to particle contamination from a variety of ingression sources. Additionally, most particles that invade a lubricant are very small. Small particles enter more easily than large particles. For instance, for each 10-micron particle that ingresses into the oil, there may be ten 3-micron particles.

This small-particle dominance is compounded further by filtration. Most machines with circulating oil have filters. However, most filters remove particles based on size exclusion. This means they don't remove all particles but rather just certain particles above specific micron sizes (based on the average pore size of the filter media). For simplicity, we can refer to this as the filter's particle size cut-off.

Those particles larger than the filter's size cut-off are conveniently disposed of with each filter change. The particles smaller than the filter's size cut-off stay with the oil and in the machine. This results in a growing population of small particles that are uncontrolled by filtration. Because of their extremely small size, they also are not prone to settling (Stoke's law) but rather embed tightly into the oil, held by viscosity, circulation and Brownian motion (like food dye in water).

To what size of particles are we referring? Well, if the filter has a 10-micron cut-off, then all particles smaller than 10 microns are ghost riders. By total weight, most of these particles may be submicron (i.e., less than 1 micron in size). These include organic matter (soft, insoluble contaminants that can lead to sludge and varnish) as well as inorganic hard particles from environmental dust and wear debris. Remember, the human eye can see particles down to about 45 microns. Therefore, we can confidently say that ghost riders are only visible with the aid of microscopes and similar laboratory methods.

The Lurking Dangers of Small Particles

Don't assume you're completely safe if you have a good filter, even if it is a high-capture-efficiency 3-micron filter. Yes, filters are important, and many deliver exceptional performance by mitigating the exposure and risks of particle contamination. When larger particles are quickly filtered from the oil, they can't damage machine surfaces and can't be crushed into small particles in the

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size range of our ghost riders. For sure, good filtration is essential to contamination control.

The concerns and risks associated with small particles will vary depending on the type of lubricant and the type of machine. The following is a brief listing of the dangers and harm imposed on lubricants and machines from the abnormal presence of small ghost-rider particles:

Polishing and Increased Mechanical Friction

Many machines are exposed to periodic or continuous boundary lubrication. This means that, due to slow speed and/or high unit loading, the lubricant is unable to maintain an oil film. This results in surfaces that rub mechanically in sliding frictional zones. Wear is only controlled by the mitigating action of extreme-pressure (EP) and anti-wear additives. However, these additives do little to impede the abrasive damage caused by small particles, leading to polished and honed surfaces under common boundary conditions. The higher the population of these small particles, the more wear damage that results. Of course, where there is wear there is excessive friction, higher energy consumption and negative environmental consequences, all of which are not good.

Silt Lock

Small particles are commonly referred to as silt-sized particles or just silt. These particles can jam and pack into narrow oil ways, glands and orifices. They can restrict oil flow, leading to lubricant starvation, and impair mechanical movement (e.g., in a servo valve), causing motion impediment.

Additive Tie-up

A high density of small particles exposes the oil to an extensive amount of surface area (the collective outer-shell surfaces of all particles). Many of the lubricant's additives are polar, meaning they are naturally attracted to both machine and particle surfaces. Examples include friction modifiers, dispersants, rust inhibitors, metal deactivators, detergents, anti-wear and extreme-pressure additives. When these additives hitch a ride on particles, they lose their functional value to the oil and machine. The particles occupy (tie up) this role instead. The scrubbing of additives by small particles is a common additive depletion mechanism. The more particles, the more the depletion. This results in lost or impaired corrosion protection, oxidation stability, film strength, dispersancy (soot control) and deposit control.

Loss of Demulsibility

Many particles are emulsifying agents. In other words, they inhibit the natural settling of free water out of the moving oil and instead bind the water into a tight emulsion within the body of the oil. This allows the water to be carried into frictional zones, leading to accelerated wear, and also exposes the polar oil additive to microscopic water globules, contributing to hydrolysis and depletion. Small rust particles are particularly prone to forming oil-water emulsions.

Oxidation by Metal Catalysts

Metal particles (especially iron and copper) promote or catalyze base oil oxidation. This condition is more pronounced when the particles are in the presence of abnormal levels of heat and water contamination. Wear debris is the principal source of metal particles in the oil. If this debris is not quickly filtered out, these particles can be crushed into smaller particles. The comminution of particles exposes a greater nascent metal surface area to the oil and its additives. Eventually, the oxidation inhibitors are spent (fully depleted), and the base oil reaches its breaking point, followed by a runaway state of oxidation. There is no way to remediate oxidation other than a complete drain, flush and oil change.

High Air Hang Time

All lubricants have significant levels of dissolved air (invisible to the naked eye). Changes in oil pressure and temperature can cause the air to evolve from a dissolved state to a bubbly, entrained-air state (Henry's law). Small particles aid the transition by providing nucleation sites for emerging air bubbles. Highly pure lubricants have a greater tendency to produce large, buoyant air bubbles (rapid air release). Conversely, highly contaminated oils, including those rich with organic solids, lead to the formation of small air bubbles, which impair buoyancy and result in slower air detrainment (Stoke's law effects). As has been discussed previously in this magazine, there are numerous negative consequences to bubbly, aerated oil.

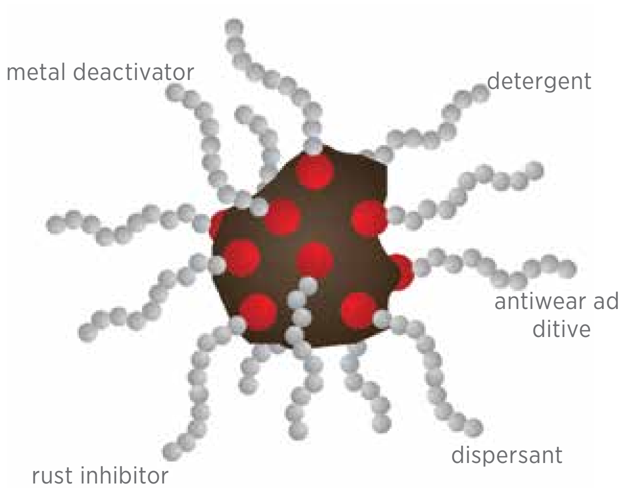


Figure 2. Many additives are attracted to particle surfaces and will adhere tightly. When the particles later get removed by filters or settle to sump floors the additives are stripped from the oil. Those particles that stay suspended in the oil keep the additives occupied and unable to perform their intended function.

	BASIC PATCH TEST	PATCH FERROGRAPHY	MICROSCOPIC PARTICLE COUNT	GRAVIMETRIC ANALYSIS	PARTICLE MICRO PATCH IMAGING (PMPI)	FILTERABILITY	PORE BLOCKAGE PARTICLE COUNT	MEMBRANE PATCH COLORIMETRY (MPC)
Related Standards	SAE ARP 4285	ASTM D7684	ISO 4407	ISO 16232-6	16232 7&8	ISO 13357	BS 3406	Pending ASTM Standard
	ASTM D7670		ASTM F312-08	ASTM D4898 - 90			ISO 21018	
	FTM 3012/3		FTM-3009	ISO 4405				
Non-quantitative Indication of Total Solids	No	No	No	Yes	No	No	No	Yes
Submicron Particles	No	No	No	Yes	No	Yes	No	Yes
Quantification of Total Solids	No	No	No	Yes	No	Yes	No	No
Soft Insolubles Quantification	No	No	No	Yes	No	No	No	Yes
Wear Debris	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Elemental Composition	No	No	No	No	No	No	No	No
Visual Indication of Solids	Yes	Yes	No	Yes	Yes	No	No	Yes
Availability of Test Method (Commercial Labs and Vendors)	Yes	Yes	Limited	Limited	Limited	Limited	Limited	Yes

	SEM/ EDX	ICP Spectroscopy	RDE Spectroscopy	Sediment Content	Optical Particle Counting Methods	Blotter Spot Test	Ultracentrifuge	Ferrous Density Tests
Related Standards	ISO 16232-8	ASTM D5185	ASTM D6595	ASTM D2273	ASTM D7647	None	None	None
					ISO 11500			
Non-quantitative Indication of Total Solids	No	No	No	Yes	No	Yes	Yes	No
Submicron Particles	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Quantification of Total Solids	No	No	No	Limited	No	No	Limited	No
Soft Insolubles Quantification	No	No	No	Yes	No	No	Yes	No
Wear Debris	Yes	Yes	Yes	No	Limited	Limited	No	Yes
Elemental Composition	Yes	Yes	Yes	No	Yes	No	No	No
Visual Indication of Solids	Yes	No	No	Yes	Limited	Yes	Yes	No
Availability of Test Method	Limited	Yes	Yes	Limited	Yes	Limited	Limited	Yes

Exposing Ghost Riders Through Oil Analysis

Many machines that hold large volumes of circulating oil have no scheduled oil change interval. Instead, oil analysis is used to alert the approaching end of the remaining useful life (RUL). This is referred to as a condition-based oil change. This works very well if the tests conducted by the laboratory fully assess all factors that define the oil's health and condition.

For instance, if you only monitor oxidation stability, the premature depletion of corrosion inhibitors might go unnoticed. Condition-based oil changes depend on vigilance and the comprehensive assessment of all important factors and attributes of lubricant health and performance. Some labs do a good job with this. Others cut corners.

Many common laboratory methods have substantial blind spots when it comes to quantifying the actual concentration of small particles in oil. This is true for particle counting, elemental spectroscopy, ferrous density, analytical ferrography and others. Table 1 provides a list of various oil analysis tests and the ability of these methods to quantify or even roughly indicate the presence of ghost-rider size particles in oil.

One test stands out due to its capability to report a single numerical value for total solids (hard and soft). This test is gravimetric analysis. It can be enhanced using solvents like toluene and hexane to isolate and quantify the soft insoluble particles and hard particles separately. Other tests in this table can also be effective, especially when combined with additional testing methods. For example, data from two or more of the following tests can provide a practical understanding of small particle contamination: ultracentrifuge, MPC, blotter spot testing, elemental spectroscopy and submicron patch testing.

Removing Ghost Riders from Your Oil and Machine

Some types of depth filters have the ability to remove many particles well into the submicron range. This can impart significant control, particularly if the filters are used throughout the life of the oil. Often the effectiveness of these filters will vary depending on the particle size and composition. There are also charged-particle separators of various types that can prove effective. When all else fails, the most practical solution may simply be to perform an oil change. This is a more logical choice for small sump machines compared to those holding thousands of gallons of oil. ***ML***

About the Author

Jim Fitch is the CEO and a co-founder of Noria Corporation. He has a wealth of "in the trenches" experience in lubrication, oil analysis, tribology and machinery failure investigations. Contact Jim at jfitch@noria.com

3 CAUSES OF UNRELIABLE EQUIPMENT

AND HOW TO ELIMINATE THEM

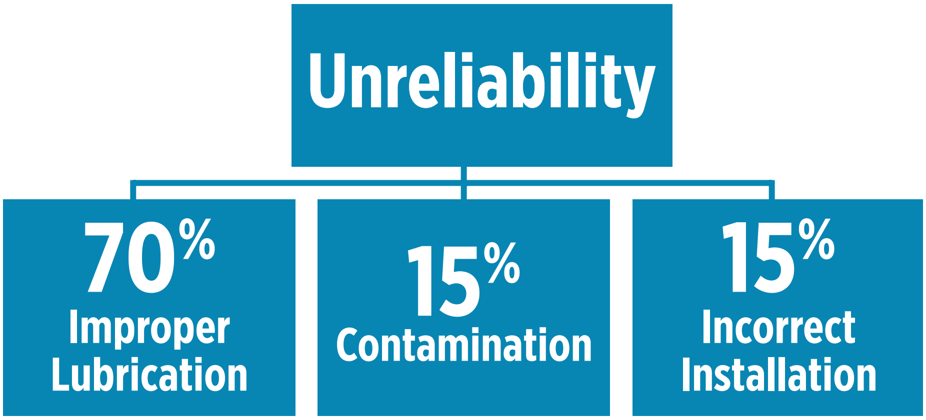
By Dr. Nathan C. Wright

Reliability is all about getting out in front of your equipment, understanding its failure modes and stopping them from happening. A lot of elements cause equipment failure, and because of this, about 90 percent of failures happen randomly. You can try to prevent failure by changing your parts before they fail; this works 12-18 percent of the time. You can attempt to predict their failure, but this is only 50 percent accurate. To achieve reliability, you need to be proactive.

Although equipment fails for a lot of reasons, they all fall into one of three major categories: improper lubrication, contamination and incorrect installation. Of these three, lubrication, or better said, improper lubrication is the most prominent.

Improper Lubrication

Improper lubrication drives mechanical wear and corrosion, which leads to



premature failure of your lubricated assets. If your organization does nothing else to improve reliability, you should address lubrication. It offers the biggest bang for your buck and can be implemented relatively cost effectively because most organizations are already spending money on lubrication and just need to know how to do so effectively.

Webster's dictionary defines lubrication as the application of some oil or grease substance to diminish friction. Although this definition is valid, it does not encompass everything that proper lubrication can achieve. It is this simple definition that often explains why organizations place little or no importance on lubrication. They lack a thorough knowledge of reliability and how lubrication impacts it.

Think of your lubrication systems as the circulation system in your body. To stay alive, you need to do a lot of proactive reliability efforts. The driving force behind the need for a lubrication program is the fact that 70 percent of all unreliability is caused by a lack of a lubrication program. Improper lubrication causes mechanical wear and premature equipment/component failure or unreliability.

Mechanical Wear

Mechanical wear of equipment components is common, particularly where improper lubrication is an issue. Particle and moisture contamination, along with the wrong or degraded lubricants, are the prevalent factors in creating rust on metal components. This increases the oxidation rate, which leads to increased acid within the components.

Mechanical wear happens when machine surfaces rub against each other. Abrasive wear takes place when particles enter the system, commonly through contaminated lubricants. These particles are usually dirt or wear materials, and they lead to three-body abrasion known as surface fatigue, which pits and scores machine surfaces. This results in premature failure and unreliability.

Adhesive wear occurs when two surfaces come in direct contact and transfer material from one face to the other. This happens when lubricants cannot support the load, where surfaces suffer from lubricant starvation or when the wrong lubricant is used.

Metal fatigue is another form of mechanical wear. An example would be if you worked a wire back and forth to cut it without tools. The more you move the wire back and forth, the harder the metal works; the fatigue increases, ultimately resulting in a brittle point that snaps. This is the effect contaminants have on metal surfaces. Over time, this constant flexing will fatigue the metal, causing premature failure.

The Institute of Mechanical Engineers has found that "every $1,000 invested in proper lubrication yields a savings of $4,000." This is a great return on investment in anyone's book and an example of how to justify a project and fund your reliability efforts.

Corrosion

Acid is a byproduct of the reaction between additives in the oil and water. Lubricant contamination has many paths. The manufacturing process of the lubricants is the first place contamination enters the system, but it can also enter through seals, creating a caustic environment that results in wear. This can happen if you do not understand the lubricant's additive package, because you can end up with corrosive damage. An example would be using an extreme-pressure additive with yellow metal (copper, brass, etc.), because some of these additives are corrosive to this type of metal. This is another instance where you need someone on your team who understands this problem and is qualified to review and eliminate it from happening.

Developing a Lubrication Program

To proactively address the single most common cause of unreliability, you need to develop a lubrication program. To start a lube program, you must understand that there are several different substances that can be used to lubricate a surface. The most common are grease and oil. The selection of the proper grease should be done with the utmost diligence to address all equipment needs. Many manufacturers sell inferior grease, and the thickening agent and oil separate. This leads to lubrication-based

For proper lubrication, you must store, handle and deliver the best lubricants to your equipment.

failures, because once the oil separates, the grease loses its protective quality.

I have seen organizations use extension hoses to make grease points easily accessible. This can be a machine killer, depending on your grease. You need to know the amount of time the grease will sit in the line based on the frequency of application and the amount. The wrong grease will allow the oil to leach out of the thickening agent, and all you will be providing the lubricated asset with is the thickening agent, devoid of oil. What would appear to be a great idea to an uninformed organization could be a self-inflicted wound.

Decision-making

When making the decision to undertake any project, you must understand what constraints you have. The constraint can be displayed as a triangle. A graphical representation of this decision-making is shown on page 12. One leg of the triangle is cost, the next is time, and the final one is quality. The middle of the triangle is traditionally risk. I like to look at these projects with an eye on the opportunity and not the risk. All projects have associated risk and opportunity. Your job is to look at the risk and mitigate it to the best extent possible, or to look at the opportunity and maximize it.

My recommendation to all organizations is to never compromise on quality. For me, the decision on how to approach the project comes down to cost and time. If cost is the determining factor in your organization, then it will take more time. The reverse is also true: if you want results in a quicker timeframe, then the costs will increase. The decision on costs and time needs to be made by looking at the opportunity. Organizations that keep their eye on the opportunity will gain an advantage over their competitors.

Partnerships

There are some distinct steps necessary to achieving a lubrication program that will deliver the desired results. You need to build a business case by determining the costs of benchmarking your site, gathering data, and designing and implementing the program. The first step you must take is to benchmark where your organization is today. If you don't have the internal resources to conduct this benchmarking or time is an issue, collaborate with an outside subject-matter expert who has the expertise to help you pull together all aspects of a lubrication program.

Organizations that make the mistake of allowing their lubrication provider to do any of this work without verification do so at their own peril. Every case that I have seen where the provider was also in charge of design ended with substandard results. Providers will offer free studies and other services which are enticing to organizations that do not know better and are budget-driven. If this is the path you take, you should save your money. Few providers have qualified representatives to accomplish what is needed. Without a qualified reliability leader in your organization who knows the difference, you will not achieve the desired results.

The Goal

The goal of your lubrication program is to keep your equipment clean, cool and dry. For every 10 degrees C or 18 degrees F, you increase or decrease the component life by 50 percent. If you have the right program storing, handling and delivering the best lubricants to your equipment, you can do more with less just by changing your lubricant suppliers.

Contamination

Contamination can be segmented into the contamination of your lubricants and spare parts (specifically in their storage and handling), and the physical contamination of the equipment, caused by poor housekeeping. Again, it is relatively cost-effective to get your teams to perform housekeeping and store your lubricants and spare parts correctly. However, it can be difficult to achieve if your leaders lack the necessary skills to lead their teams. Poor housekeeping is a direct representation of a lack of leadership, so addressing this problem should be focused on your leaders, not their teams.

The importance of keeping things clean cannot be overemphasized. Contamination will attempt to enter your operation at every opportunity it is given. To combat this, you need to be out in front of where it can enter. Most contamination will come into your operation through the entrances and exits, but your operation itself may also be a source.

Stores

The start of your contamination prevention program should be your storeroom. The way you receive and store your repair parts will set the stage for your plant's reliability. This contamination control starts with your vendors. If you do not have a specification for how you will receive your spares, you are missing a key aspect of obtaining reliability. Your specifications must start with your cleanliness standards. The parts or materials you are receiving will drive these standards. You should visit the vendor and understand how the parts are being stored before their delivery to your plant. At no time should you allow a part to enter your facility if you do not know what conditions it has been subjected to. If you miss this opportunity to improve reliability in your operation, you are allowing your vendors to set your standards.

I am always disheartened to hear maintenance and reliability leaders tell me that they cannot control what happens to the parts before they enter their facility. This cannot be further from the truth. Once the part has entered your facility, you need to make sure it is cared for as well as all the other parts of your operation. All too often, organizations pay no attention to their spares until they install them. This is too late. The parts in your storeroom must be treated and maintained as if they are already installed in your equipment. The storage of gearboxes, motors, belts, bearings, cylinders, etc., will dictate your ability to deliver on reliability. Depending on your organization's manpower and stores facilities, you may want to review and decide where and how all your spare parts are stored. It is not necessary to have one or more of everything in your storeroom.

The decision on what to store is one that requires a lot of discussion and should be devoid of emotion. There are significant costs associated with storage of parts. The average is 20 percent of the cost of inventory. So, if your stores value is $1 million, it costs you $1.2 million to keep those stores. If you stock the right stores and eliminate all duplicates and spoiled stores, you save money and obtain another funding source for reliability efforts. This affects your organization's free cash flow.

If you are not storing parts correctly, it costs you even more money when you install them and they fail prematurely. The cost of downtime will prove that if you do not maintain your stored parts in a reliable state, you are better off letting your vendors store the parts correctly at their site and delivering them to you when needed. This may sound extreme, but if you add up all the time you spend storing parts incorrectly and compare it to the reliability of having them stored correctly, you will see that you can make more product and spend less on replacing new parts gone bad.

Equipment Cleaning and Lubrication Standards

This step identifies what work can be accomplished by operators to prevent further deterioration of the equipment. During the kaizen (improvement) event, the team defines what the operators will clean and inspect, and how they will do it. Again, I stress that only employees who have been properly trained in lubrication should be allowed to lubricate your equipment. This will define how often it must be done to keep the equipment in optimum (base) condition. Training the operators is not the end but the beginning. Developing the operator is how you make these efforts sustainable.

Contamination control can be accomplished by reducing or eradicating contaminants through housekeeping efforts. The most common types of contamination are dust particles, wall and floor materials, packaging and crate particles, fibers, shavings from moving parts, other poorly maintained surfaces, liquids not being cleaned up, and equipment left damp to rust. These and many other damaging contaminants can infiltrate critical equipment areas in many ways. The goal is to find and eliminate them all.

The proliferation of contamination will lead to product damage and recalls, which are detrimental to the business. Businesses are not protecting themselves from the effects of contamination, and their products are suffering from these unsafe processes. Eighty percent of all contamination enters the process through entrances and exits. Therefore, one of the first logical steps to proactive reliability is the implementation of a contamination control program for lubricants and spare parts aimed at their entrance into the building.

Steps to Contamination Control

Heat, moisture, air and particles

rob equipment of life, but with rigid contamination control practices, fluids can last indefinitely. This, in turn, prolongs the life of the equipment's components and keeps the machine running at the highest level of efficiency. Additionally, the costs to start a proactive contamination control program are covered by reliability cost savings.

A contamination control program can be employed in three steps. First, start by setting target fluid cleanliness levels for all equipment. Second, select and install filtration equipment (or upgrade the existing filter rating) and contamination prevention techniques to achieve the cleanliness levels. Finally, monitor cleanliness at predetermined intervals to achieve the desired levels.

Contaminant Monitoring: The Cornerstone of Contamination Control

For the same reason you do not drive a car without a working fuel gauge, you shouldn't attempt proactive reliability without a monitoring program. Monitoring will give you the data you need to ensure that your machinery is operating within contamination standards. Proactive reliability addresses much more systemic elements of a reliability program, rather than inspecting the machine itself. This approach is more diligent and looks to manage the difficulties that can contribute to equipment wear and tear as opposed to the failure.

Stopping contamination does not cost a lot of money, but it does take a lot of hard work. I know hard and work are dirty words, but doing the right thing is rarely easy.

Incorrect Installation

Improper installation starts with your equipment design. Those charged with the design of your equipment need to understand reliability and design it into your equipment first and foremost. Designing the equipment for reliability and maintainability will set up your organization for success. To remember how to combat this portion of unreliability, I think of it as having the right person with the right part at the right time. Improper installation is made up of several parts; start your elimination of unreliability before the systems enter your building.

Design for Reliability

Designing for reliability is the most recent term for engineering equipment for reliability. Ensuring that there are no hard-to-reach points that require the equipment to be shut down to service will increase maintainability and, as such, will achieve reliability right out of the gate. It is during this phase that the importance of an experienced reliability professional is clear. Without the experience to know what failure modes or other issues will arise with the equipment once it is installed in your plant, you will spend a lot of money and lose a lot of productivity after the fact when these failure modes and issues arise during production. Organizations fail to recognize the importance of this phase in ensuring reliability and entrust it to young engineers or senior engineers without the experience to eliminate these issues before they arise.

This can be made even worse by handing this responsibility over to suppliers. Providing the equipment manufacturers with your organization's specifications will go a long way toward setting up your facility for success. All too often organizations are more focused on the short-term cost of the equipment and pat themselves on the back for getting it cheaply. This is another failed approach that is prevalent in all industries today.

One of the best arguments for establishing these specifications is achieving standardization throughout your facility. Requiring manufacturers to build to your specifications and not theirs will pay for itself hundreds of times over, absorbing any increased costs associated with the requirement. Equipment manufacturers use the cheapest materials they can get away with in their construction to increase their profit margins. If you do not demand quality, you will not receive it. By standardizing, you will reduce your development and materials costs. If you have little variation in your plant equipment, you will need to stock fewer parts, and your operators and technicians will need to have knowledge of fewer systems. All these things result in lowering the costs of operating and maintaining the equipment.

Demanding that all the equipment's service points be accessible while the machine is in operation will require fewer non-productive hours to proactively maintain the equipment. If your return on investment is calculated by the equipment's productivity, then maximizing the hours it can run will give you the best results.

The final stage in designing for reliability is to conduct a factory acceptance test (FAT). This refers to the functional test that is performed by vendors once they complete the assembly of the equipment. This test will verify that the equipment meets the specifications and functionality agreed upon in the purchase agreement. Before the equipment reaches the plant, it is imperative that an organization put the equipment through its paces and recreate all failure modes during this phase to work out the bugs in the factory and not in the plant.

Spare parts management is another important element of incorrect installation. If the storeroom is run improperly (poor inventory, stock-outs, etc.), the rest of the reliability operation does not stand a chance. The level of service in an organization's storeroom is a solid indication of the effectiveness of its reliability efforts. Having the right parts is key to the elimination of improper installation. Without the right parts at the right time, reliability is not possible. What is the impact of not having the right parts? The delay caused by trying to expedite parts to the plant increases downtime and costs. If this delay is beyond acceptable time restraints, then it becomes necessary to use an alternative part. This increases downtime and costs as well. Also, it requires additional repairs to remove the alternative parts and install the correct parts once they arrive. Now you incur more downtime, costs and wasted reliability resources, which distracts the team that could be working proactively to address other issues. Of course, downtime is a loss of production and finished product. This impacts customers and their confidence in the organization.

The Storeroom as Partner

The main ingredient for success from the storeroom is to continuously monitor the needs of reliability and to adapt and partner with it. To manage this relationship, the storeroom must be deliberate in its communications. Reliability must know what assistance it will receive and in what fashion to count on the storeroom.

From a reliability standpoint, there is an expectation of parts availability. Most of the time this expectation can be met. However, when it comes to certain parts, this expectation is not realistic due to costs. Reliability management and the storeroom need to communicate to operations in these situations to manage their expectations. Setting storeroom expectations after analyzing the failure modes and their impact on downtime is the most effective way to ensure reliability.

The best time to decide which parts are to be stocked is when the equipment is new and before it is placed into service. The original equipment manufacturer, the part suppliers and the reliability leaders should work together to determine necessary spares. Once the equipment has generated historical data, reliability can adjust inventory levels and increase or decrease the stock on hand. In larger organizations, a parts inventory planner can enhance the determination of stocking levels, re-order points and replenishment trigger levels.

Having an inventory that reflects and supports the current operation is one of the most important steps you can take to improve cost, work efficiency and reliability. The objective is to have the right parts in the right place at the right time.

Combining resources from the organization and the storeroom partner to focus on the goal of cleansing the inventory is part of inventory accuracy. This includes providing overall coordination in fulfillment of the expectations.

Improper installation can be compared to a milking stool — it has three legs that keep it from falling. The three legs are training, stores and design. If any one of these is not present, the person sitting on the stool must try to balance while also trying to produce. If you have three sturdy legs, the person/organization has the foundation to perform at its peak in this area. Which organization do you want to work for and what type of leader do you want to be? ***ML***

Every organization focuses on cost cutting to maintain profitability and to remain competitive in the market. Continuous increase in cost of raw material and maintenance is challenging organizations to find ways to maintain its profitability. Camso Loadstar, a leading tyre manufacturing company, based in Srilanka, have realized the importance of Lubrication to achieve high level of reliability, increase productivity and reduce maintenance cost couple of years back and have benefitted with world class lubrication practices. In a discussion with Machinery Lubrication India, Mr. Mahesh Goonesekere–Director Engineering, Camso Loadstar tells about their journey of Lubrication Excellence.

R/Admiral Gamini Mahesh Goonesekere USP, JP, (RETD) He is an experienced Chartered Engineer with over 35 years of professional and naval experience. He has served as Director General Engineering- Sri Lanka Navy and presently serving as Director Engineering of Camso Loadstar.

1. What made you realize that transformation program is needed in the field of lubrication in your company?

Lubrication is considered as the main blood line of machine or major equipment which has a major impact to its life time in operation. This was an area in our company which had not paid much attention during operation. With the effective root cause analysis mechanisms of our company, we found that many failures were associated with the lubrication of machinery. Therefore we realized that lack of specific knowledge of lubrication types; handling procedures and predictive analysis of lubrication were key areas which needed attention.

Reliability team of Camso Loadstar, Srilanka
Left to right: Mr.Prageeth Jayakody, Mr.Yasith Chandrasiri, Mr.Dinuka Dayananda, Mr.Mahesh Goonesekere – Director Engineering, Mr. Kalana Nissanka, Mr.Ishanth Sameera and Ms.Mayuri Sumanadasa.

2. How you started this program?

Focusing on increasing machine reliability a global initiative was taken by Camso Loadstar to establish Reliability Centered Maintenance (RCM) in 2013 with a Vision of consolidating and optimizing maintenance activities across all plants to achieve world renowned best practices. We have initiated several RCM strategies as CMMS (Computerized Maintenance Management System), PdM (Predictive Maintenance), Planning and Scheduling, etc. We came to know about Noria through internet and publications. RCM Senior Manager and I decided to attend Reliable Plant Conference and Workshop at Ohio in 2015. That was the starting point of this transformation in Lubrication Management in our organization.

Subsequently, we approached Noria and VAS Tribology and requested them to guide us to achieve towards excellence in lubrication in the journey of 'Reliability'. The major programs conducted were multiple Lubrication Technical training programs, Lubrication Program Development (LPD) – Benchmark assessment (Phase-1), Engineering Design (Phase 2), Implementation (Phase 3).These programs played a key role in transforming our current lubrication practices to best world class standard practices.

3. What were the major challenges that you faced during the transformation journey?

- Change Management
- Ownership
- Sustainability

4. How you overcome those challenges?

Change Management: This was the major challenge we have faced. Technicians were used to certain indigenous methods from inception. Convincing and training them was the main focus area. This was achieved with the assistance of Noria publication and Lubrication DVDs. In most occasions we had to repeat the same program many times to convince people. Certain practical cases were shown against the Best Practices. These activities were followed by continuous coaching at floor level. The main path to success is the willingness of our team for change.

Ownership: Identifying and selecting application for lubrication handling was not considered as critical. In General it was done with basic experience. As a result we have developed and designated a new discipline in the engineering carder called Engineering Mechanic-Lubrication (EML). It was taken very positively as they engaged in knowledge upgrade and skill development with a specific identification. Further a state of the art lube storage and handling rooms were established under the guidelines of Noria/VAS Tribology. They were empowered to lead the Lubrication Program at each plant which they did with pride and motivation.

Sustainability: The most essential part is continuous engagement in the program. We conduct periodical audits to measure the current state against the world class level. Gaps identified through these audits are converted to action plans and monitored for further improvements.

5. How you trained your team to take these challenges?

The Central Engineering Division – RCM Department has a technically sound team of Reliability Engineers who have the capability to implement entire program under project management structure. A special category named EML was developed to sustain the process with adequate training programs, finally evaluated with a skill assessment program. They were also trained for lube tasks and routines by the Reliability Engineers.

All Reliability Engineers were trained under Noria / Lubrication Institute and certified by ICML.

6. What benefits you achieved through this program?

Camso Loastar, Srilanka facility has now incorporated world class lubrication management practices. It now offers well-equipped lube room, Lubricant Identification System (LIS), contamination control hardware and robust oil analysis program.

- Easy identification of Lubricants with Lubricant Identification codes which completely avoided cross contamination of Lubricants.
- Cleanliness levels for Lube storage rooms and across the plants where lubricants are used.
- Effective Oil sampling and oil filtration procedures.
- Lubrication metrics (KPI) for continuous improvement.
- World Class Lubricant Storage & Handling facilities with best practices. Our new lube room has also been featured in the list of winners of "Lube Room Challenge" for the year 2018.
- Reduced number of Lube types from 104 to 39 without deviating from the OEM standards.
- Reduction in Lubricant consumption by 41% since 2016.
- Gear Oil cleanliness level has improved from 26/25/21 to 21/18/13 and Hydraulic Oil cleanliness level improve to 23/21/14 to 18/17/12.

7. What is your way forward?

It is a long term journey in the journey of implementing best practices. Monetary benefits were obvious within shorter span of three years directly impacting the bottom line. Now, Camso Loadstar is progressing towards the cultural change to enhance Lubrication enabled Reliability.

It is expected and planned to reduce further 10% by FY 18/19, and also focused to achieve ISO cleanliness levels of 16/13/09 for Hydraulic oils and 19/17/14 for Gear Oils by 2020.

8. Your message to the reliability community looking for transformation in their lubrication program?

We are indeed proud that our lubrication program has been benchmarked by external entities and visited our facility to learn further on the subject. We would like to welcome all who are interested to exchange knowledge on this subject and we wish to learn from them as well. This is just a beginning, there are many more to learn. It would be interesting to create an active blog to share knowledge and comment on lubrication through a digital platform which may create access to the entire community.

5 Steps for More Effective **Hydraulic Troubleshooting**

"Hydraulic troubleshooting is a step-by-step process. By following these five steps, you can become a troubleshooter and not simply a parts changer."

Have you ever been asked to troubleshoot a hydraulic issue? Whether you are a maintenance person, salesman, service provider or consultant, you should follow the same guidelines when diagnosing and fixing the problem. What happens in many plants is that troubleshooting is done by a parts-changing process, which can be expensive in downtime and part costs. Plus, when the machine finally becomes operational, no one has learned anything because so many random things were done. To effectively diagnose a hydraulic problem, use the following five steps:

When gathering information, be sure to check the condition of the filters.

1. Identify the Problem

Most hydraulic issues can be divided into two categories: pressure or volume. A pressure issue is one where the pressure won't build high enough to operate the machine properly. For example, a press may require 3,000 pounds per square inch (psi) to machine a part or compress a board, but the pressure only builds to 2,000 psi. If the issue is speed related, then a volume problem is most likely occurring. This means that either the pump is not delivering the required amount of oil or there is bypassing somewhere in the system.

A maintenance manager at a plywood plant recently called and wanted to talk about a hydraulic problem on his lathe. After being asked a few key questions, he admitted that he didn't really know what the problem was.

"Let me go talk to the crew and get more information," he said. It's hard to fix something if you don't know what the problem is.

The most difficult hydraulic issues to solve are those that happen

A blown fuse on a solenoid-operated valve resulted in unnecessary downtime at a plant in Arkansas.

Reading a hydraulic schematic can identify a problem before the first part is replaced.

intermittently. In one case, a hydraulic motor would stop rotating for a few seconds but wouldn't do it all the time. Several hours went by before the motor did it again. When the hydraulic and electrical systems were checked, everything appeared normal while operating. The electrical cabinet just happened to be open during one stoppage, and a red light illuminated on the amplifier card for a few seconds and then went off. The red light indicated the power supply voltage had dropped below 21 volts. After much research, a loose wire was found in the cabinet. The intermittent stopping of the motor was a volume problem. When the power supply voltage dropped below the acceptable level, the pump was de-stroked to a zero flow output.

2. Gather Information

Once you've identified the type of problem, the next step is to gather information. More than likely when you arrive at the problematic hydraulic system, some things have already been done. Have any pressure or electrical adjustments been made? Have any hydraulic components been changed out? If so, do the new components have the exact part number as the components that were replaced? One number or letter difference in the part number may mean that the valve will not work in the system.

Several years ago, a positioning problem was identified on an oriented strand-board press in Georgia. The position of the platen was controlled at four different points with linear-displacement transducers. The pressure in the ram that controlled one of the corner rams was fluctuating excessively. After 11 hours, it was determined that the replacement position-control valve had one letter different than the original valve. Once the correct valve was installed, the press operated normally.

Visual checks must be made during this process to assess the oil level, filter condition, leakage, pump coupling condition, etc. Also, ask for the latest oil analysis report to verify the oil's cleanliness level.

I was recently called to troubleshoot an issue at an automotive plant where five pumps had been changed in 24 hours. When I arrived, I asked if anything had been done prior to the repeated failure of the pumps. The supervisor said that a hose failed in the system and that the reservoir was refilled with fluid during the shift change. Shortly after that, the issues with the pumps started. After inspecting the system, I did not see a breather cap on the reservoir. Apparently, when the first-shift oiler refilled the tank, he did so by removing the breather cap. Once filling was completed, the second-shift oiler installed a pipe plug on the threads where the breather was originally mounted. Now there was no place for air to enter the reservoir, which resulted in the failure of the pumps.

Machine operators can provide some of the best information as to what is occurring. While maintenance workers may only show up when a machine malfunctions, the operator knows how the machine feels, sounds and runs. This individual usually has data displayed on a screen and understands when a pressure, position or other indicator is reading incorrectly.

3. Review the Schematic

The best times you will spend troubleshooting is while reading and tracing a hydraulic schematic. Frequently, valves are inside manifolds or located in out-of-the-way places. By following the lines on the schematic, you can often find the problem before the first part is changed out.

Several years ago, I was flown to a plant in Arkansas that was having speed issues with a large stacker. The stacker was supposed to operate at fast and slow speeds. The problem was that it only operated in the slow mode of operation. When I arrived, several millwrights, electricians, supervisors and the plant manager were near the machine. I asked for a hydraulic schematic of the system. One millwright said, “We never use those because they’re locked up in the plant engineer’s office.” I told him that this was one time we were going to need it because several of the valves were located on and inside a manifold. Once the schematic was found, I identified one solenoid-operated valve that had to be energized in order for the stacker to lower. When the valve was manually actuated during the fast cycle, the stacker lowered quickly. The issue was a blown fuse on the solenoid-operated valve. The plant could have saved hours of downtime had it taken the time to troubleshoot from the schematic when the machine first went down.

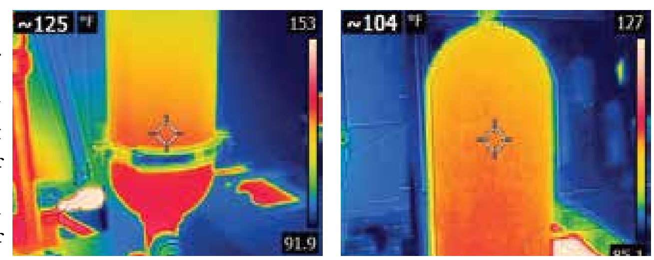
4. System Troubleshooting and Adjustments

After you have identified the problem, gathered information and reviewed the schematic, you should verify that the system pressures are set properly. This includes the pump compensator, relief valve, pressure-reducing valves and other pressure-control valves in the system. Also, ensure that all the accumulators are pre-charged with dry nitrogen. Many times an issue can be resolved by simply setting the pressures to the appropriate level.

After one of my courses in Oregon a few years ago, a student asked me to look at a system that was running extremely hot.

It is important to verify that all system pressures are set properly.

He wasn’t exaggerating, because when the reservoir was photographed with an infrared camera, it revealed a temperature of 320 degrees F. I checked the tank line of the relief valve, which should have been at ambient temperature. However, I found a temperature of 340 degrees F. This indicated that the relief valve was stuck open or set below the compensator setting or that the pump’s compensator spool was stuck. When the relief valve was set 250 psi above the compensator, almost immediately the temperature started dropping.



Use an infrared camera to check accumulators.

Installing a manual valve in the line to a prepress ram helped troubleshoot a pressure problem at a plywood plant.

Another issue detected in this system was that the accumulator manual dump valve was partially open, allowing oil to flow to the tank, generating heat. Twenty-four hours after the pressures were set and the dump valve was closed, the temperature dropped to 132 degrees F.

A valve that was stuck open proved to be an issue in an injection-molding machine that would not rotate at the proper speed.

Once the pressures are set, make temperature checks throughout the system to confirm that no excessive bypassing is occurring. This can be done with an infrared camera or temperature gun. Typically, there are several tank lines in a hydraulic system that should be at ambient temperature. These include manual and automatic accumulator dump valves, air bleed valves and relief valves used with pressure-compensating pumps. The suction line and case drain of a variable displacement pump should also be checked for excessive heat generation. It is important to record the temperature of the lines when the system is operating normally to establish a reference.

Check the accumulators used for volume with an infrared camera. When cycling frequently, the bottom half or two-thirds of the shell should be hotter than the top half or one-third. The pre-charge pressure should be checked with a charging rig for accumulators that do not cycle regularly or that are used for shock and to maintain pressure.

The key to troubleshooting pressure problems is to isolate various points in the system. Oil will always take the path of least resistance. If the machine is experiencing a pressure problem, then oil is most likely bypassing in the system.

Recently, a plywood plant was only building 1,400 psi in its prepress rams when 2,100 psi was required. The line to each ram was photographed with an infrared camera. The line to one ram was 142 degrees F, while the lines to the other three rams were 120 degrees. F. A manual valve was installed in the line to the ram that was hot. When the manual valve was closed, the pressure built up to the normal level of 2,100 psi. The problem was the prefill valve for that ram was stuck open, allowing all the pump volume to bypass back to the tank at 1,400 psi.

Many times a valve that is stuck open can be removed from the system to check for wear and contamination. A few months ago, the extruder motor on an injection-molding machine would not rotate at the proper speed. This indicated a volume problem in the system. Several tests were conducted, including installing flow meters to check the pump volume and inserting mechanical stops in the manifold valves to prevent them from opening. When removing one logic valve to install the mechanical stop, the valve was found to be stuck open. This valve was teed off the line to the hydraulic motor, which allowed the oil to bypass back to the tank.

5. Reliability Checklist

When the issue is solved, the toolboxes are loaded up and everyone usually goes back to their normal duties. What should be done at some point in the near future is to develop a reliability checklist on the system. This list should consist of pressure and temperature readings, filter and breather conditions, oil cleanliness, condition of the hoses and clamps, current readings on the electric motor, voltages to proportional valves, etc. These checks should be made regularly to avoid unscheduled downtime. The recorded information will be a useful tool when future hydraulic issues occur.

When a machine goes down, panic management frequently kicks in and parts start being changed. Often times the problem can be very simple. Several years ago, a press was down for five days because of an O-ring stuck in the drain line of a pressure-control valve.

Hydraulic troubleshooting is a step-by-step process. By following the five steps in this article, you can become a hydraulic troubleshooter and not simply a parts changer. *ML*

About the Author

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Mohammad Aatif | VAS Tribology

Accessorise your Equipment for **Enhanced Reliability**

When it comes to accessories, there is a common misconception among industrial fraternity that the accessories supplied by manufacturer along with the equipment are sufficient for machine inspection and its maintenance. However, it is not always true. Fact is that the most of the manufacturers usually provide only basic accessories along with the equipment to perform its intended functions. This is primarily because of its competitiveness, as every supplier wants to supply equipment as cheap as possible. They mostly focus on the basic requirement of the customer. For example, the main function of a gearbox is to achieve required torque and speed ratio. For such requirements, supplier's main objective would be to fulfill these needs first. The gearbox might not include the required breather to avoid contamination in a dusty and humid environment, best level indicator to assist in inspection, standard oil sampling hardware to collect representative oil sample, nor proper drain arrangement required for lubrication excellence. Applying this to our real life, on purchase of an automobile in its basic form, one gets only the essential things required to drive it. For user's superior experience and better convenience, one needs to additionally buy accessories. One can buy better Seat Cover, advanced navigation system, Dash Camera, Fog Light, Luggage Holder, etc, as the case may be. In a similar way, for predictive maintenance, better inspection, improved reliability and best lubrication practices, there is always a need to replace or modify those basic accessories supplied along with the equipment.

This article is intended to provide a walkthrough of the common, useful and low cost accessories available in the market and its features that can help in enhancing the reliability of critical equipments. The accessories can help in prolonging asset life, preventing breakdown and thereby reducing maintenance cost.

Grease Nipple Cap

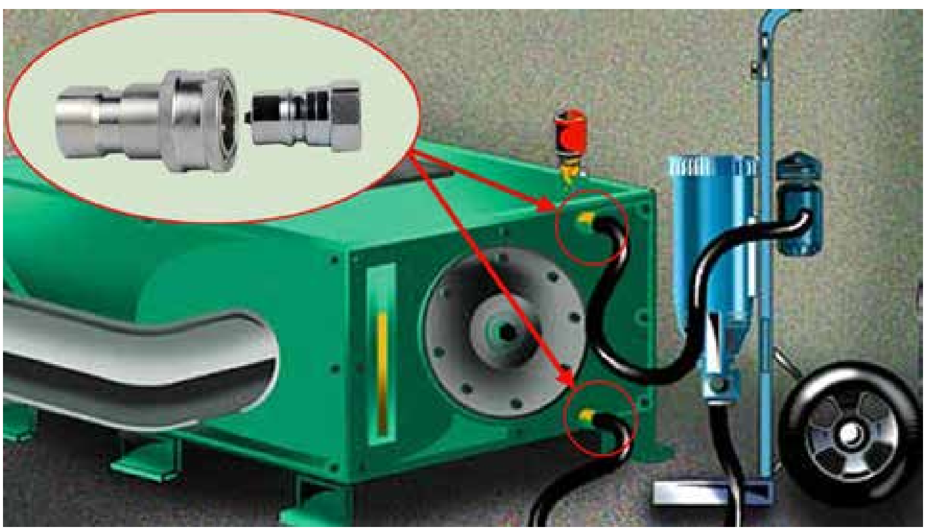
Grease Nipple Cap is a low-cost effective solution to protect grease nipples from external contamination. It helps in guarding the grease nipple against dirt and moisture. These are available in variety of colors

Colored grease nipple caps.

thus it can also help in identifying the grease to be applied on the machine, through color codification system. It thereby avoids the cross contamination of the lubricant .It can also provide an option for frequency indication. Re-greasing frequency can be indicated on the top of these caps by using different symbols. Plastic material also reduces any chance of corrosion over a period of time. Ease of availability, extreme low cost and ease of installation makes it a perfect piece of accessory that can be fitted to any manually greased application.

Quick Connect

Quick connect provides secure and quick connection of hoses to machines that can be conveniently attached or detached. It provides speed and convenience to repeatedly connect and disconnect fluid lines. It enables ease of oil filtration, ease



Quick connect application on filter cart and reservoir.

of oil transfer and ease of drain through portable filter cart. It has affordable price. In many equipments, there may already be a provision to install the quick connect, the equipment just needs slight modification to fit it. Also, by sizing the quick connects corresponding to different lubricant types, chances of cross contamination (due to wrong filter cart use) can be avoided.

Bottom Sediment and Water (BS&W) Bowl

Bottom Sediment and Water (BS&W) Bowl is made of very tough and durable

Bottom sediment and water (BS&W) bowl.

plastic and they act as collection chamber on oil sump applications. Installed on the drain port, it collects water, wear debris and solid contaminants. It helps in monitoring, detecting and purging of bottom sediment, water and debris in lube oil. By periodic monitoring it can also detect abnormal change in oil color and can indicate corrosion of internal parts. Moreover, it does not cause downtime and work disruption for its inspection.

Magnetic Plug

Magnetic plug is similar to straight thread drain plug but it has permanent magnet fastened to the plug body. While machine is in operation this magnet attracts and holds abrasive ferrous metal particles preventing their circulation through the lubrication system. These abrasive, ferrous metal particles

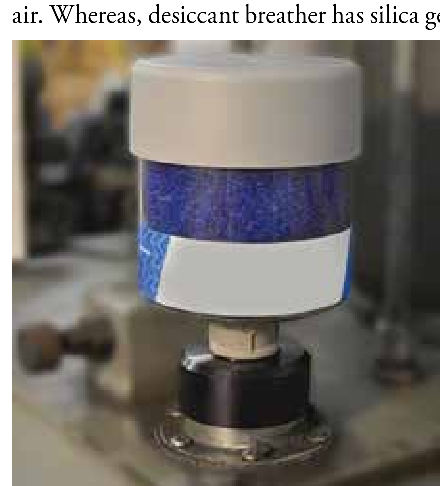
Magnetic plug.

are generated in lubricating system primarily as a result of wear and tear. Magnetic plug also facilitates in capturing vital information about the major wear occurring in machine without actually opening the machine and helps in detecting abnormal wear of machine components.

Standard Breather

Breather ensures only clean and dry air enters inside the reservoir during breathing. During breathing process, depending on the operating environment, fine atmospheric debris and moisture along with the air can get inside the system. If this contaminated air is allowed to enter inside the system, it can lead to degradation of lubricant and machine components.

Breather can be classified into two major categories: spin on type filter breather and desiccant media breather. Spin on filter breather has filter media that can filter the solid contaminants coming along with the air. Whereas, desiccant breather has silica gel



Desiccant breather.

media along with the filter. Silica gel media allows the breather to absorb the moisture from incoming air.

While selecting a breather it is very important to consider, cleanliness and dryness requirements of the system. One type of breather does not fit all the applications. It is also important to have proper 'close circuiting' of the reservoir, by avoiding any open vent, to ensure breather's effectiveness. Also, in order to indicate service requirement, it should be equipped with vacuum service indicator. Color changing type silica gel media should be preferred to indicate its saturation point.

Oil Sampling Hardware

Getting representative oil sample is a primary factor in achieving consistency and accuracy of oil analysis result. One of the steps to

Oil sampling valve.

achieve this is to install a right sampling valve at the right location.

As discussed earlier, most of the machines (except a few modern hydraulic machine supplied by major Original Equipment Manufacturers (OEMs)) are not equipped with any kind of sampling valve. If user wants to get the representative oil sample, they must modify their machine to install sampling hardware. In certain complex machines, one may also require to install secondary sampling valve(s).

Condition Monitoring Pod (CMP)

Condition Monitoring Pod is early fault detection, multi-parameter machine inspection tool that consists of a combination of 3-D sight glass, corrosion indicator, magnetic plug, as well as, oil sampling valve. This all in one pod lets inspection technician quickly observe oil level, color and clarity, oil aeration and foaming, corrosion, varnish and wear debris.

With one time modification, it can provide long term benefits. It facilitates oil sampling, magnetic plug inspection, serves as an oil level gauge to check oil level, detects foaming, detects signs of corrosion and indicates oil color change. One can quickly identify root causes and symptoms of failure that would have previously gone undetected.

Condition monitoring pod (CMP).

About the Author

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Why You Should Be Using Procedure-based Maintenance

> "Procedure-based maintenance has the opportunity to drive significant improvements in safety, reliability and operations."

Imagine an operation in which there are no lost-time accidents, overall equipment effectiveness (OEE) is increasing, and there is a plan to address the skills shortage. These sites do exist, and chances are they're using procedure-based maintenance. This type of maintenance simply involves having all maintenance activities documented in a procedure. The procedures are followed step by step when conducting breakdown, corrective and preventive maintenance.

This level of operational excellence comes with discipline, not just discipline that deals with people doing what they should be doing (or not doing), but discipline to the process and eliminating variation. That is the goal of procedure-based maintenance: to eliminate variation in all aspects of maintenance, including data collection, repairs, calibration and commissioning. Another goal of procedure-based maintenance is to eliminate and reduce the odds of mistakes by maintenance staff. By ensuring that all activities are performed the same way, organizations can accomplish three key deliverables: build a knowledge library to survive the skills gap, identify key areas of variability and reduce that variability to achieve consistent outcomes from activities, and minimize the odds of a mistake during maintenance activities.

The use of procedures must be thought out well in advance. Without this thought-out approach, the adoption of the procedures will fail. The procedures need to be organized so they can be quickly located. They must be written in a way so there is no misinterpretation of the task's meaning and so non-native English speakers can understand. Lastly, they must be utilized by the staff, with feedback captured and used to improve them.

History of Procedures in Maintenance

The use of procedures can be traced back many decades, and the results speak for themselves. Consider the U.S.S. Thresher, which was lost along with 129 lives on April 10, 1963. An investigation into the loss of the submarine concluded that it was the result of flooding most likely caused by the failure of a seawater system component that may have been reinstalled improperly during a shipyard overhaul. There were additional factors, but the primary finding was that the component was reinstalled incorrectly.

The outcome of the investigation led to the U.S. Navy implementing a new program to address submarine safety. This program was known as "SubSafe." The SubSafe program required detailed written procedures and checklists to be developed and followed to the letter by all personnel engaged in maintenance of specified components of all systems affecting submarine safety. To date, the Navy has not lost a submarine due to a maintenance mistake under the SubSafe program. This shows the impact that a robust procedure-based maintenance program can have on reliability and safety.

Later in the 1960s, there was a focus on improving the reliability of commercial aircraft. This study, which was published by Nowlan and Heap, brought to light that most failures were not induced by time or wear but were either random or triggered by improper maintenance or installation. Looking at the six failure patterns, it was observed that failure pattern six, which experiences a high level of infant mortality followed by a random, consistent failure rate, was more prevalent at 68 percent. This indicates that the highest probability of failure is when the equipment is new or just overhauled. So, what led to the spike in the probability of failure? The causes could be related to design, manufacturing defects, installation defects, improper commissioning, improper routine maintenance, and maintenance workmanship.

Considering the causes of the high probability of failure for new or recently overhauled equipment, it was determined that more maintenance was not the answer. The solution was related to controlling the variation in activities. These activities included such things as design reviews, supplier quality and certification programs, and the development of procedures for operating and maintaining equipment. There was a conscious effort to move away from relying upon on-the-job training, intuition, etc., toward the use of detailed, technical procedures. As a result of these changes, along with the move to condition-based maintenance from time-based maintenance, worldwide aircraft incident rates have fallen from nearly 40 incidents per 1 million takeoffs in the early 1960s to just one or two incidents per 1 million takeoffs in 2016.

Importance of Procedures

Procedure-based maintenance serves to address two key issues when performing maintenance activities. First, it reduces the variation that occurs when many craftspeople are conducting the same work. Consider how many ways there are to rebuild a pump. How does the disassembly happen? Does the disassembly occur with a precision torch and hammer, or does it take place with the proper tools? Does the rebuild happen in a clean room or in a dirty shop which can contribute to contamination? Are the parts inspected according to a standard or left to the experience of the rebuilder? Is there a standard list of parts that are replaced, or is it left to the inspection? Is a thread-locking component used during reassembly? Are the clearances checked based on experience or technical specifications? Are fasteners tightened using a torque wrench or the strength of the rebuilder? How is the pump tested before being put back into stock or service?

If you were to ask a group of craftspeople these questions, you likely would get a wide range of answers, and two people would not have the same process for rebuilding and commissioning a pump. This variation makes it virtually impossible to establish a root cause of a premature failure or poor performance of a rebuilt pump. A procedure based on the experience of the staff can capture the collective knowledge and put it into a repeatable and consistent method, eliminating this variation.

Secondly, procedure-based maintenance minimizes the odds of an individual making a mistake. There are various types of factors that can contribute to an error, and it is important to understand these factors to ensure that procedures are written to address them.

For example, anthropometric factors are those related to the size or strength of the person performing the activity. These are primarily addressed through a redesign or tools and not with procedures.

Human sensory factors are those concerned with the ease in which people can see, hear, feel and even smell what is going on around them. These are also mainly addressed by redesigning or with tools and not through procedures.

Physiological factors refer to environmental stresses, such as high or low temperatures, excess noise, humidity, etc. Once again, these cannot be addressed through procedures.

Psychological factors are related to the causes of which mistakes are made. Psychological errors are divided into two types: unintended errors, which occur when someone does a task incorrectly, and intended errors, which happen when someone deliberately sets out to do something, but what they do is inappropriate. The intended error can be either a mistake or violation. A mistake is a misapplication of a good rule, an application of a bad rule or an inappropriate response to an abnormal situation. A violation is when someone knowingly and deliberately commits an error. Procedures help to address unintended errors and mistakes but not violations.

"Well-written procedures eliminate misinterpretation and drive clarity."

By accounting for the different ways activities are performed, the types of mistakes made and utilizing a feedback cycle, procedure-based maintenance takes the knowledge from all the craftspeople and incorporates it into the procedure. The result is the safest, most efficient and reliable way to complete the task.

How Procedures Impact Reliability

Once procedure-based maintenance is in place, the operation will see noticeable improvements in five key areas: safety, reliability, start-up failures, mean time to repair and knowledge management.

Safety will improve as tasks are well planned out with the risks identified. This allows the development of effective risk-reduction activities. Also, the procedures can be used in the event of a failure, which can lower the risks associated with unplanned work.

Reliability will increase as tasks are completed consistently with proper technical specifications. This reduces premature failures. In the event a failure occurs, it can be analyzed to determine the root cause, since the procedures and activities are defined and consistent.

Start-up failures will decrease, as procedures will ensure that all bolts are tightened properly, the area is inspected, all foreign objects are removed, and proper commissioning activities are performed.

The mean time to repair will be reduced, as a procedure is available that will decrease the time to repair and all the required information is readily available.

Knowledge management is another benefit of procedure-based maintenance. With this approach, the experience and knowledge of veteran craftsmen can be captured in procedures and transferred to junior craftsmen.

Getting Started in Procedure-based Maintenance

Procedure-based maintenance is used by many industries that require high uptime, such as nuclear power, nuclear navy and aviation, to name a few. But just because these industries use it doesn't mean you can't. Here is what you need to get started in procedure-based maintenance:

Start by documenting the steps to complete preventive maintenance (PM) tasks. Walk through every task and document each step of the procedure, including any specific technical specifications. Once the procedure has been developed, review it and make sure it represents the best practice in completing the task. This may take many revisions or reviews. The procedure may be developed by a senior craftsperson, a planner or by having recent retirees come back to provide the information.

Create a checklist that can be used when completing the procedure. Checklists are employed in all major industries as a way to make certain that nothing is missed. There may be pushback in utilizing a checklist, as craftspeople may say they are skilled. However, doctors and pilots use them to ensure nothing is missed, so why shouldn't craftspeople?

Define a training and certification program for the new procedures that will require craftspeople to be trained on the task and procedure-based maintenance before being allowed to perform critical activities. This training should be performed by the individual(s) responsible for developing the procedure.

Once the craftspeople have been trained, reinforce the use of the procedures. Conduct audits to verify that they are followed and that only trained personnel are using them. Try to reward those who embrace procedure-based maintenance.

Also, utilize the feedback provided on the procedures. This does not mean taking all feedback as absolute truth. Instead, it means reviewing, evaluating and either using the feedback or providing explanations as to why the feedback will not be used. This type of approach will help guarantee that feedback is provided.

As more maintenance tasks are converted to procedures, develop and use a single template. This will foster consistency across an organization, making procedure-based maintenance easier to put in place and sustain.

One caution when using craftspeople to write procedures is to first train them on the process. Procedures need to be specific and actionable without any unnecessary information. Another approach is to have a craftsperson write the procedure and then have it edited by a technical writer. Both approaches have their pros and cons, so be sure to choose the right one for your organization.

Writing Usable Procedures

Writing procedures is not an easy task. Many people have different opinions on the sequence, specifications, etc. Once this is sorted out, the procedure should be written in a way so it can be followed by all craftspeople, including non-native English speakers. Thankfully, with English being the universal language of aviation, we can continue to learn from the aviation industry. This industry has developed simplified, technical English.

Simplified, technical English is a controlled version of English that is designed to help the users of English-language maintenance documentation understand what they read. Technical writing can be complex and difficult to understand, even for native English speakers. Simplified, technical English makes procedures easy to understand and follow, eliminating language issues and reducing premature and maintenance-induced failures.

Simplified, technical English provides a set of writing rules and a dictionary of controlled vocabulary. The rules cover grammar and style. The dictionary specifies the words that can be used and those that can't. For the words selected, there is only one word for one meaning, and one part of speech for one word.

Some of the benefits of simplified, technical English include reducing ambiguity, enhancing the clarity of technical writing, improving comprehension for people whose first language is not English, and increasing equipment reliability by lowering the probability of defects being introduced during maintenance and assembly.
The simplified, technical English specification is not easy to learn, but

training and software are available. Even without becoming an expert, you can still make your procedures more readable and drive reliability. Begin with some basic writing guidelines and by reviewing the procedures before they are issued. Some of the best practices for writing procedures include the following:

- Use short sentences. The recommended maximum limit is 20 words in a procedural sentence and 25 words in a descriptive sentence.
- Restrict noun clusters to less than three nouns.
- Restrict paragraphs to less than six sentences.
- Avoid slang or jargon.
- Avoid the passive voice.
- Be as specific as possible.
- Use articles such as "a/an" and "the" wherever possible.
- Use simple verb tenses (past, present and future).
- Write sequential steps as separate sentences.
- Put commands first in warnings and cautions, with the exception of certain conditions.
- Use the word "that" after subordinate clauses that use verbs such as "make sure" and "show."
- Introduce a list item with a dash (hyphen).
- Use graphics where needed to clarify meaning. A picture is worth a thousand words.
- Use the word "warning" to protect against harm to personnel but the word "caution" to protect against equipment damage.

Once the procedure is written, review and delete any information that is not relevant (i.e., instead of synthetic lubricating oil, use only oil). Well-written procedures should help to eliminate any misinterpretation and drive clarity to the craftsperson performing the activity. Here is an example of how the wording of a procedural step could be open to interpretation. The task "replace the filter" could mean either to put back the filter that you took out or to install a new filter.

Now you can see how one person might perform a task and how another would perform it differently. Once the task is clear, a technical specification should be added so the task can be performed to a standard, such as "Tighten to 15 foot-pounds." The result of making the task clear and adding a specification would be, "Install a new filter and tighten to 15 foot-pounds." This task is simple, clear, easy to understand and can be performed in a consistent and repeatable manner.

If an organization decides not to follow simplified, technical English, there at least should be a standard in place for writing procedures so everyone is doing it the same way. Although it may sound crazy to have a procedure for writing a procedure, it is vital for consistency and repeatability.

Having Staff Use Procedures

One of the most difficult parts of implementing procedure-based maintenance is the change it brings to an organization. Indeed, there will be a change in the way maintenance is performed for all levels of the maintenance department. For example, craftspeople must follow procedures and specifications and rely less on personal experience and intuition. Maintenance supervisors are now focused on ensuring the procedures are used and updated. Planners become more determined to update the procedures so they are readily available for use.

Helping an organization through this change is not easy. It will require a well-thought-out approach. I personally like to use the awareness, desire, knowledge, ability and reinforcement (ADKAR) framework. This method enables organizations to plan and manage the change being implemented as well as bring people along with the change. Each step in the framework provides specific actions that should be taken, such as awareness of the need for change, desire to participate and support the change, knowledge of how to change, ability to implement required skills and behaviors, and reinforcement to sustain the change.

The whole purpose of using a framework like ADKAR is to identify any concerns associated with the change, address those concerns, express how the change will benefit the staff, provide the knowledge and training, and finally demonstrate that the change is not a flavor of the month. The more time spent planning and managing the change, the more likely the change will be adopted and sustained.

Procedure-based maintenance has the opportunity to drive significant improvements in safety, reliability and operations. But before an organization can jump into procedure-based maintenance, there must be a plan for how it will be implemented, who will write the procedures, to what standard the procedures will be written and how the staff will be trained on the new procedures.

With procedure-based maintenance having been adopted by the U.S. Navy, aviation and nuclear power industries, the results have been proven. If these types of organizations are using procedure-based maintenance, what is preventing your organization from using it? *ML*

Grease Sampling Methods Matter

"The best analysts at the top laboratories in the world cannot produce meaningful results from samples that have been taken incorrectly."

After developing a lab in the power plant and focusing primarily on analysis of oils from the plant's critical components like turbines, pumps and large motors, I was approached one day by one of our valve engineers. The question: Could I also analyze greases? I had been training in analytical ferrography and had the equipment at my disposal. I was also aware of a "grease solvent" and a special process to dissolve the grease using glass beads. Armed with that equipment, I instructed the engineer to start bringing me samples.

After a month, I had received nearly 400 grease samples and had dissolved them all. I spent countless hours at the microscope identifying the particles I saw. I wrote reports for each sample and created a summary, showing my "dirty dozen" of the worst valves. I felt satisfied that I had taken on this new challenge and come up with valuable information for my plant. However, after reviewing my report and investigating the valves I had targeted, the valve engineer had bad news for me. Some of the valves that I had identified as the worst actors were found to be in good shape. In other cases, there were known bad actors that I had identified as being fine. In other words, I was told that they had no further need for my services on valves.

Figure 1. A motor-operated valve (MOV) lubrication test stand

How could I have gotten things

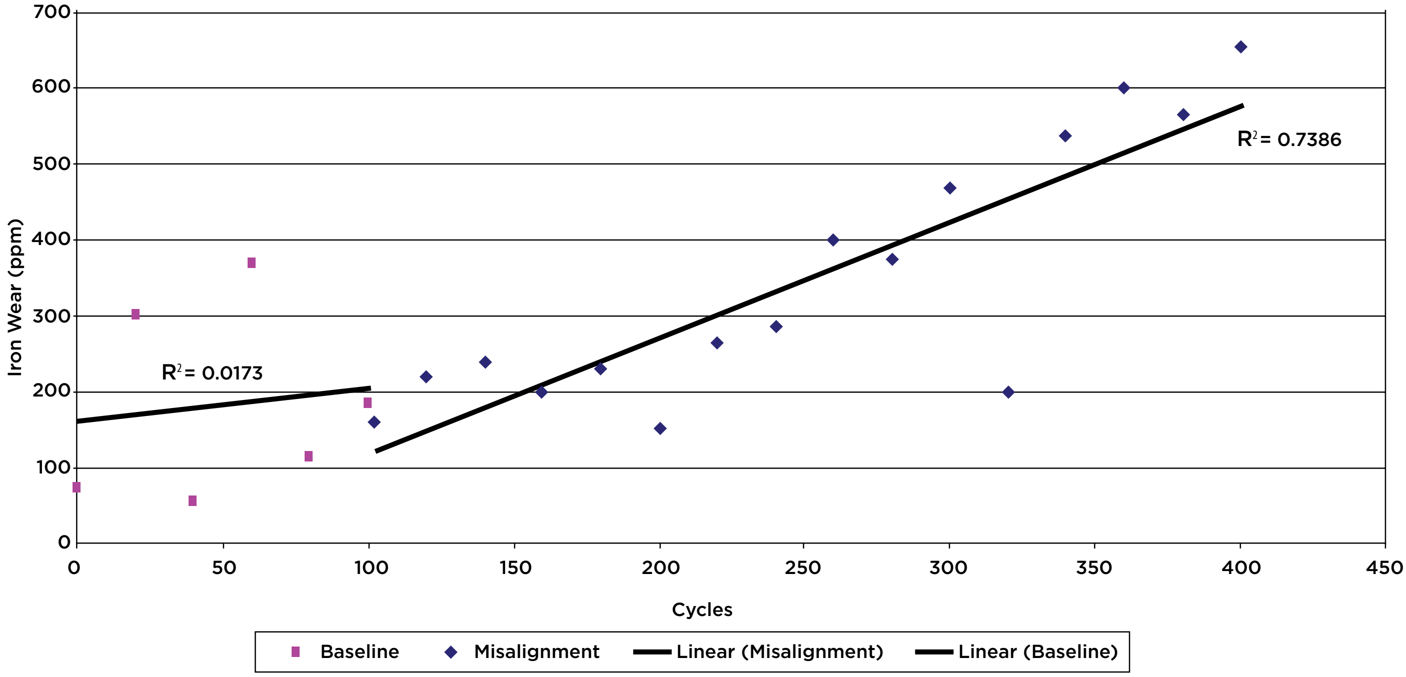


Figure 2. A grease wear trend in a misaligned MOV gearbox

so wrong? I looked back over my notes and took a second look at my ferrography slides. Had I misidentified the samples? Had I missed some clear signs that the separated particulate was telling me? After a review, I couldn't see where I had fouled up. I returned to the engineer and asked a question that should have been the very first one I asked at the start of the project: How were the samples taken? The answer gave me insight into the problem.

"We shoved cable ties into the housing and wiped them off on the mouth of your oil sample bottles."

Over the next hour, we both came to the realization that the sampling method was at the heart of the problem. It was likely that the grease that was adhering to the cable ties was "opportunity grease," the material closest to the access plug. As we began to understand how the grease moved in the housing, it became clear that the samples I analyzed were in many cases grease that was not currently active in the lubrication of the valve gears. A few of the "dirty dozen" turned out to be valves that had failed in the past but had since been rebuilt and were operating very well. What we had discovered was old particulate from the previous damage that was not completely cleared from the housing and ended up on the cable tie.

We learned a lot through this failed project about the valve grease and how it functioned in the gearbox, but we learned very little about the condition of the valves. I found that my failure to first address the sampling challenge had resulted in the previous month of my career producing very little actionable data for my company.

Several years later, I was afforded the opportunity to participate in a research project for the Electric Power Research Institute (EPRI). EPRI member utilities had identified a need to better understand greases and how they worked in power plant equipment. From this, the Nuclear Maintenance Application Center (NMAC) of EPRI assembled the funding for the "Effective Grease Practices" research project and guideline. Among a number of areas of investigation was a focus on the challenges and best practices for motor-operated valve (MOV) grease sampling and analysis.

This gave me the opportunity to determine where my prior efforts to sample MOV grease had gone wrong and share those findings with the industry. Nick Camilli of EPRI provided the insight and leadership that resulted in the construction of an MOV test stand (Figure 1). This test stand allowed us to try various methods of sampling and characterize the movement of the grease in the valve while in operation. Sampling tools and methods were developed that were incorporated into a new ASTM standard for in-service grease sampling (ASTM D7718).

Additionally, the test stand was used to create a known higher wear condition to see if this could be detected by the grease sampling and analysis process. After the motor to the gearbox was deliberately misaligned, the result was a clear change in the measured wear content of the grease obtained by the new recommended sampling method, as seen in Figure 2.

A few years later, while attending an MOV conference, I overheard some engineers discussing the lubrication of MOV valve stems. Their concern was with short-stroking valves and the challenge in ensuring that an effective coating of grease was being delivered to the valve stem and stem nut when it was impossible to move the stem to expose most of the threads. Why was the application of grease so critical in this application? Because the MOVs are tested by measuring the force of the motor through power signal analysis. By looking at the power signature of the motor, the closing force of the valve was inferred. This is only valid when the coefficient of friction for the stem and stem nut interface is properly accounted for. If a stem is not fully lubricated, and the friction is higher than the calculations assume, then the force (and thus the power signature) normally sufficient to fully seat the valve is suddenly inadequate.

Knowing the challenge at hand, I returned to the lab to try out some solutions for relubricating the stem. Our first efforts failed, as we were unable to design a fixture that could be connected to the valve stem and deliver the high pressure of new grease required to displace the old and provide a new, reliable layer of lubricant. It was at a picnic where I got the chance to discuss this problem with my uncle. Roy Leitz had a long career as a welder and pipefitter. He was also used to solving difficult problems. One such challenge he had was in sealing the high-vacuum valves of NASA's space simulation vacuum chamber in Sandusky, Ohio. As he told me the story of how his team had overcome the challenges of sealing out the atmosphere to produce the world's largest vacuum chamber for simulating the conditions of space, we came upon a design solution for fixing the leaking fixture to relubricate the valve stem. The result was a new way to lubricate valve stems in critical applications like the MOV by taking a completely different experience and applying what had been learned. Not only had we developed a way to relubricate the valve stem, but in the process had created a new sample of the grease that had been in service, offering the potential for new condition data from the grease.

It took a long and painful experience in analyzing hundreds of meaningless samples to help me realize the importance of lubricant sampling. The best analysts at the top laboratories in the world cannot produce meaningful results from samples that have been taken incorrectly. It is essential that we focus not only on the task of generating analysis data but also in ensuring that the data will have value. This can only be achieved with accurate and representative samples from motor-operated valves and all other critical grease-lubricated machines. *ML*

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

Quick Filter Check

When checking differential filter clogging indicators, be sure that the pilot holes in the filter body (the ones that feed the indicator with oil pressure) are clear of debris. This will help ensure you are receiving the correct signal.

Did You Know?

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

Have Some Tips?

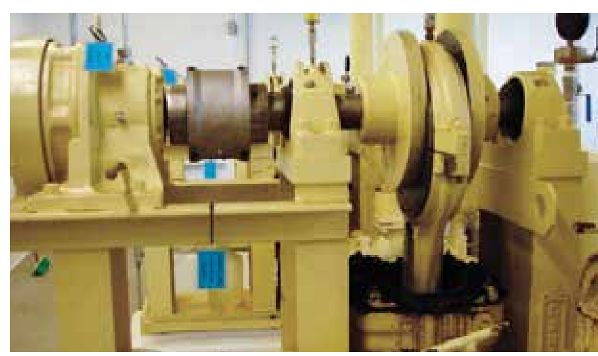
If you have a tip to share, email it to admin@machinerylubricationindia.com

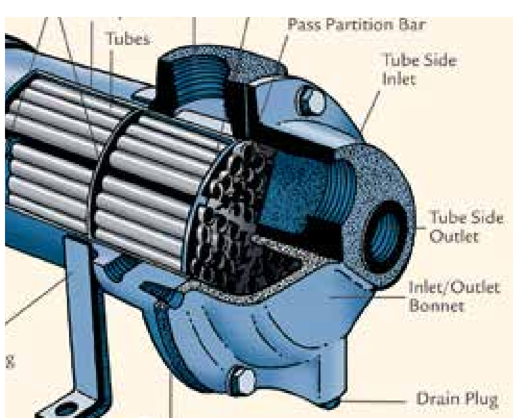
Tip for Reducing Bearing Failures

If you are experiencing premature anti-friction bearing failures, you should not only look at your lubrication practices but also your installation practices. When induction bearing heaters are used, the inner race heats faster than the outer race. This causes a thermal differential between the inner and outer race of the bearing, which will reduce the bearing’s internal clearance. If this differential is allowed to climb high enough, all internal clearance in the bearing can be eliminated and damage to the balls and races can occur.

Smart Valve Labeling

A good way to make sure valves are put in the proper operating position after maintenance is to affix permanent tags on the valves indicating their normal operating position. Wording such as, “This valve normally open for operation,” is very helpful. A pre-startup checklist will add another layer of protection.





Advice for Oil Reservoir Baffles and Settling Zones

Baffles are used to prevent fluid just returned to the tank from passing directly back to the pump inlet. For a number of reasons, a longer transit path is considered beneficial, as it encourages better heat conduction from the fluid, better contamination and air separation, and better mixing with the bulk fluid. This is usually accomplished by separating the inlet and outlet by as long of a flow path as feasible. ***ML***

"Can GL-5 gear oil be used in an application where **manual transmission fluid is recommended?"**

The American Petroleum Institute (API) GL rating system is intended for gear oil specifications. While a manual transmission does in fact have gears, it may also contain other components such as synchronizers. The gears and synchronizers have seemingly conflicting requirements. In general, the higher the GL rating, the higher the extreme pressure (EP) protection provided. This is great for reliability and wear reduction in hardened gear sets, but it can spell disaster for synchronizers.

EP additives are often made of a sulfur/phosphorus compound that will adhere to metal surfaces through polar attraction. Once they have coated a metal surface, these additives need only to be introduced to heat and/or pressure (from a collapsing lubricant film) to spring into action and start doing their job. In a hardened gear set, this adds a great deal of wear protection as well as life and reliability to the component.

However, because of the mechanism in which these EP additives work, when they are introduced to softer yellow metals, the results can be disastrous. They attach in the same manner (metal-wetting polar attraction), and when heat and/or pressure is introduced, the additives will chemically attack the softer yellow metals. This aggressive attack can prematurely wear out synchronizers.

GL-4 products typically use about half the sulfur/phosphorus additives of their GL-5 counterparts. This means they provide less protection for the gear set but do not damage synchronizers quite as severely. When a GL-5 gear oil is used in a manual transmission that contains synchronizers, you can expect to find two to four times as much copper in the used oil analysis report as compared to a GL-4 oil. Eventually, the synchronizers will wear to the point that they no longer make contact with the other half of the cone, bottoming out before stopping the opposing gear.

So while an API GL-5 gear oil can be utilized in an application where manual transmission fluid is recommended, there will be a tradeoff. You can anticipate excellent protection for the gears but also a reduction in synchronizer life if these components are made of softer material.

Generally, you should heed the recommendations made by the manufacturer. Issues such as those outlined above are considered during the components' design phase. Manufacturers usually have all the information required to make educated decisions, which are then incorporated into their recommendations.

TEST YOUR KNOWLEDGE

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

1. Which type or form of lubrication is considered to provide a full fluid (oil) film?

A) Elastohydrodynamic
B) Solid Film
C) Boundary
D) Mixed
E) All of the above

2. A typical ISO cleanliness code for new oil would be?

A) 9/7/5
B) 14/12/10
C) 21/19/16
D) 27/25/21
E) 32/30/27

3. Hydrolysis is the breakdown of additives by:

A) Hydrogen
B) Helium
C) Water
D) Filtration
E) Hydrogen embitterment

ANSWERS

1. A

Elastohydrodynamic lubrication is a form of hydrodynamic lubrication (full-film separation). It is called elastohydrodynamic because the lubricated components deform elastically due to high pressure.

2. C

This ISO cleanliness level (ISO 21/19/16) is considered quite high. Contamination normally takes place during blending, packaging, storing, transportation, etc. End users are responsible for checking the quality of incoming oils and taking measures to ensure clean oil is used, especially in machines that require very clean oil.

3. C

In hydrolysis, the additives react with water in the presence of heat to form byproducts such as sulfuric acid and hydrogen sulfides.

ExxonMobil's Global Lubricant Operations Receives Zero Waste to Landfill Silver Validation

ExxonMobil announced recently its global network of lubricants blending and packaging plants, which manufacture all Mobil-branded products, has received the Zero Waste to Landfill Silver validation from UL, making it the first petroleum products company to secure this validation. The company's lubricant operations are successfully diverting over 90 percent of the waste produced in its global plant network from local landfills. More than 50,000 tons of wastes produced per year are being redeployed into new, productive uses that will bring greater value to the environment and the economy.

To achieve the validation, ExxonMobil implemented a range of waste diversion techniques and strategies across its lubricant production network. Specifically, the company identified 14 types of waste products produced at these facilities that could be avoided entirely, reused or recycled. "Customers and consumers can feel confident they are making Mobil lubricant purchasing decisions that help fulfil their personal and business goals, including choosing partners that share in a commitment to reducing environmental impacts," said Bennett Hansen, global lubricants marketing director at ExxonMobil.

ExxonMobil began developing this waste management program in 2012 and by 2015, had implemented it across the globe. "For a company like ExxonMobil, which has operations facilities across the globe, achieving UL's Zero Waste to Landfill Silver validation is no easy feat, the program's rigorous validation process is designed to recognize companies that handle waste in environmentally responsible and innovative ways, and ExxonMobil has implemented a comprehensive, far-reaching program that meets this rigor and reflects its commitment to operating in an environmentally responsible way." said Alberto Uggetti, Vice President and General Manager at UL.

IIT Bombay & PSU Oil Companies to set up "Centre of Excellence"

India, home to more than 1.4 billion people is projected to be the key driver of future global energy demand in the world. The progress of our nation is entwined to meeting the energy demands of the growing population. Oil and Gas contribute to about 29% of the primary energy consumption and the country is highly dependent on imports of crude oil and natural gas. A number of policy measures have been undertaken by Government of India for ensuring energy access, energy efficiency, energy security and energy sustainability. To provide a competitive advantage to India's Oil and Gas industry, Oil & Gas PSUs and IIT Bombay have come together to set up a "Centre of Excellence in Oil, Gas and Energy". The Centre of Excellence is aimed at collaborative Research & Capability Building in the areas of Oil, Gas & Energy. It will work towards developing sustainable solutions and explore new frontiers in technology for future energy needs. The Centre of Excellence will leverage the expertise available with IIT Bombay and the Oil and Gas industry. It will also provide an institutionalised platform for Industry - Academia interactions.

The Memorandum of Understanding (MoU) was signed at Delhi recently between Director, IIT Bombay & CM&Ds of Oil PSUs (IOC, BPC, HPC, ONGC, GAIL, EIL & OIL), in the august presence of Hon'ble Minister of Petroleum & Natural Gas and SD&E, Sh. Dharmendra Pradhan and Secretary Petroleum & Natural Gas, Dr. M.M. Kutty. Senior Officials from MoP&NG and Oil PSUs were also present on the occasion.

The Centre of Excellence is expected to help in fostering innovations and help in developing a future ready energy industry in the Country.

Three days training programs on Advanced Machinery Lubrication, Advanced Oil Analysis and Essentials Machinery Lubrication conducted in Mumbai and Kolkata recently. The training was a great success as the participants enhanced their knowledge on Oil sampling, Lubricant health monitoring, Contamination measurement & control and Wear debris monitoring. The program also covered topics like lubricant selection, troubleshooting, predictive maintenance and more. In addition to learning the right metrics for program implementation and evaluation, participants got a view on the most advanced levels of diagnostics and predictive maintenance. Case studies were also discussed. Essentials of Machinery Lubrication course provide the foundational skill sets for applying best lubrication practices and product knowledge. Companies like Dow Chemicals, IRC Agro Chemicals Pvt ltd., Haldia Petrochemical, Petronet LNG, AK Distributors, Normet, Salalah Methanol Company L.L.C, Oman, Maruti Suzuki, Orient Cement, MJL Bangladesh, Onyx marketing, Pall, Qatar Gas, Emerson, Bharat Petroleum Corporation Limited, Standard Asiatic Oil Company Ltd., Bangladesh participated.

Training on Advanced Oil Analysis in Mumbai

Essentials of Machinery Lubrication training in Kolkata

Participants learned proven industry methods for selecting, storing, filtering and testing lubricants to boost reliability and generate lasting results in machine efficiency/maintenance through these trainings. ICML Certification exam was also conducted at all the locations, where majority of the participants joined the elite group of certified professionals.

For additional details on similar trainings, visit- http://lubrication-institute.com.

BASE OIL REPORT

India secured a six-month waiver on importing crude oil from Iran. Oil and natural gas prices will be volatile but range-bound in 2019, with the medium-term price band for West Texas Intermediate crude in the $50-70 a barrel range. This is significant that India imported 220.4 million metric tonnes of crude in 2017-18. Any dip in global crude prices will reduce India's oil import bill and trade deficit.

The Indian base oil market remains steady with inventories at optimum levels with surplus of imported grades. During the month of November 2018, approximately 285420 MT have been procured at Indian Ports of all the grades. Compared to October 2018, import of the country has increased by 15% in the month of November 2018. Major imports are from Korea, Singapore, USA, UAE, Iran, Taiwan, France, UK, Netherlands, Japan, Italy, Belgium, etc. Indian State Oil PSU's IOC/HPCL/BPCL has changed their base oil numbers as reflected in the price chart effective January 02, 2019. There has been no change in the prices for the second half of the current month.

In the month of November 2018, India imported 285420 MT of Base Oil, India imported the huge quantum in small shipments on different ports like 197759 MT (69%) into Mumbai, 38355 MT (13%) into JNPT, 19965 MT (7%) into Chennai, 8877 MT (3%) into Pipavav, 7203 MT (3%) into Kolkata, 6272 MT (2%) into Kandla, 4852 MT (2%) into Mundra, 1476 MT (1%) into Ennore and 662 MT into Other Ports.

Dhiren Shah
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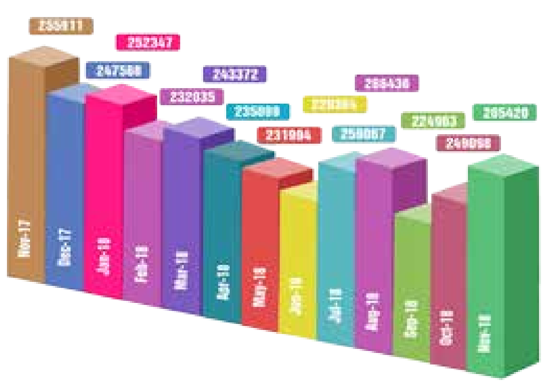
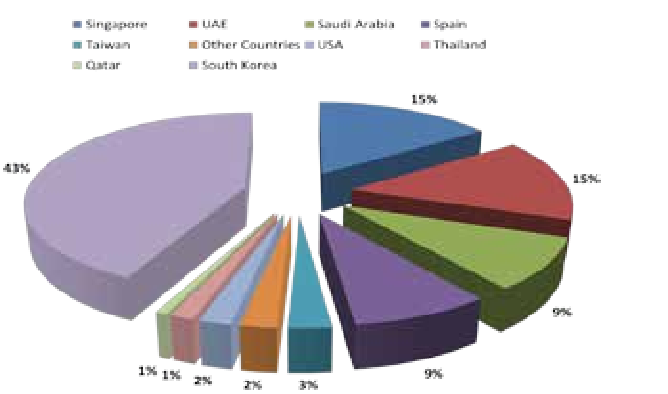
Month wise input of Base Oil in India



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



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

Month	Group I - SN 150 Iran Origin Base Oil CFR India Prices	Group II -N-500 Korea Origin Base Oil CFR India Prices	N- 70 South Korea Origin Base Oil CFR India Prices	Bright Stock USA Origin CFR India Prices
November 2018	USD 740 – 755 PMT	USD 815 – 830 PMT	USD 745 - 755 PMT	USD 1155 – 1165 PMT
December 2018	USD 685 – 700 PMT	USD 720 – 730 PMT	USD 700 - 710 PMT	USD 1030 - 1060 PMT
January 2019	USD 670 – 680 PMT	USD 755 - 770 PMT	USD 680 - 690 PMT	USD 990 - 1000 PMT
	Since November 2018, prices have gone down by USD 75 PMT (10%) in January 2019.	Since November 2018, prices have reduced by USD 65 PMT (8%) in January 2019.	Since November 2018, prices have decreased by USD 65 PMT (9%) in January 2019	Since November 2018, prices have decreased by USD 165 PMT (14%) in January 2019.

OUR OILS GIVE A NATION ITS STEEL

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- **Choicest range from neat and water-soluble oils based on application (Hot/Cold), material to be rolled and reduction to be achieved**
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- **Minimal specific oil consumption**
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