INSIDE

Machinery Lubrication

India May - June 2014

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Purchasing LUBRICANTS based on PERFORMANCE

Contents

Machinery Lubrication India
May - June 2014

Publisher's Note

The past month has been quite enlightening as I with other Industry experts, decision-makers and practitioners from around the world congregated for Noria Corporation's 15th Annual Reliable Plant Conference and Exhibition held from April 22-24, 2014, in San Antonio, Texas. The premier event for lubrication, oil analysis and reliability professionals attracted over 1,000 participants, including attendees from 42 U.S. states and 27 Countries.

Nearly 90 learning sessions on a variety of topics were available for attendees to choose from, with case studies on achieving a world-class lube room, improving equipment reliability through root cause failure analysis, overcoming common problems and challenges with lube oil condition monitoring, and developing a lubrication program along with achieving a change in culture. We can easily assess our systems by applying this information and evaluate our strengths and weaknesses.

The exhibition hall featured more than 100 industry-leading companies and organizations showcasing a broad range of products and services. I really liked the format of the learning sessions mixed with exhibit hall time.

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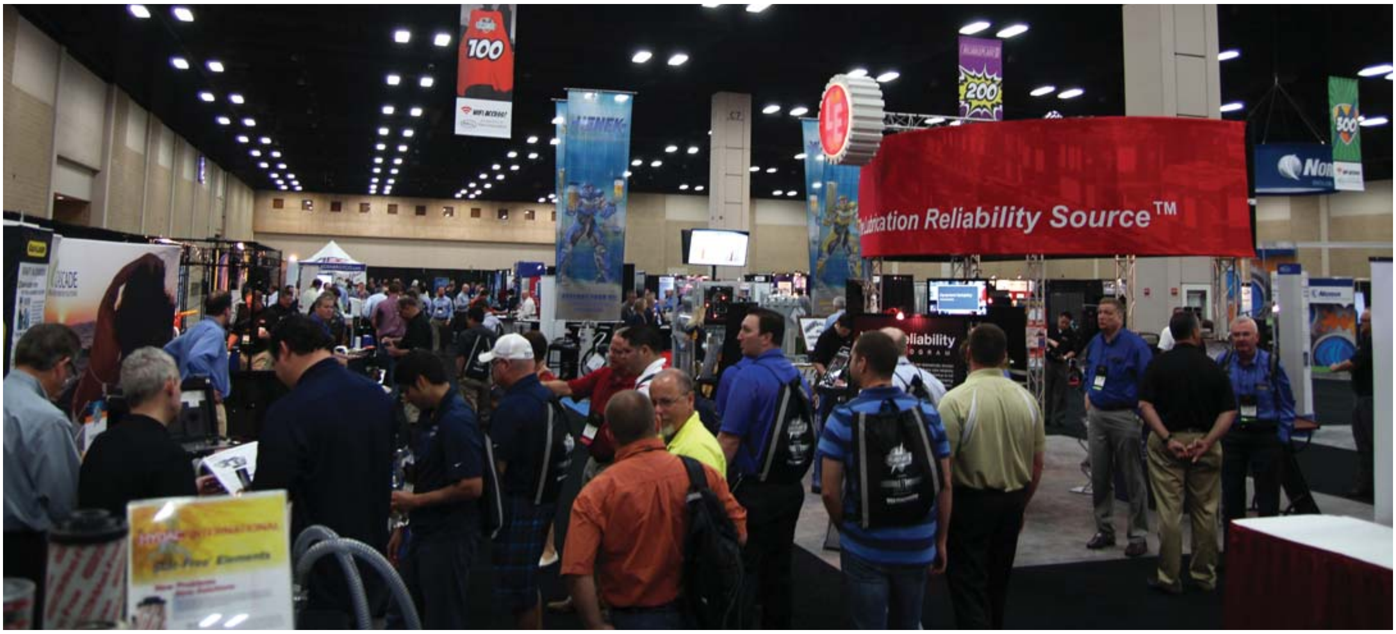
In the opening general session, Noria's Jim Fitch gave an update on the state of the industry which was followed by the presentation of the John R. Battle Award for lubrication excellence to the



Sinclair Wyoming Refinery.

This issue of Machinery Lubrication India throws light upon Purchasing Lubricants Based on Performance. In this price driven market, it is important to take a step back and analyze whether long terms cost effectiveness and machine reliability is achieved.

We also cover various aspects of interpreting an oil analysis report as well as inputs on in-service and hydrodynamic cleaning and flushing of turbine oil systems.

Finally, by concentrating on performance specifications, total fluid management (TFM) will take on a whole new dimension. If you choose to go this route, you could achieve end to end lubricant solutions which will help you reduce your operating costs as well as improve machine availability.

As usual we welcome our readers to send in suggestions and comments which enable us to provide more relevant and beneficial content. If you feel this magazine would benefit your colleagues/ team members, please feel free to sign them up on machinerylubricationindia.com and share the knowledge.

Warm Regards,

Udey Dhir

JIM FITCH NORIA CORPORATION

Demand 'RELIABILITY READINESS' from Equipment BUILDERS

When it comes to modern concepts in the field of lubrication and applied tribology, many users these days are far more sophisticated than those who are designing and building the machines they operate. This lack of sophistication by original equipment manufacturers (OEMs) is very evident when you see what's not included with the sale of new machinery. One could assume that what's missing from the machine and its documentation is functionally missing from the knowledge and awareness of the engineers and builders of this equipment. Ignorance is not bliss. The same is true for complacency.

Reliability needs to have shared responsibility. It must be fixed in the DNA of the machine as well as in the minds of operators and maintainers. It's like a reliability chain; every link in the chain must be equally strong in order for the chain's full length to bear the load. *Machinery Lubrication* magazine is primarily devoted to advanced concepts in lubrication from a user's perspective, more specifically lubrication-enabled reliability. Users not only have a significant influence on machine reliability during operation but also by what is being done (or not done) by equipment builders to "ready" machines for optimum reliability. They want the machine's design to have an implanted genetic code that enables reliability.

Users define what's expected from OEMs and the machines they deliver. Of course, meeting the minimum required operating performance is a basic need of every machine, but prolonged sustainability of that performance is also important. This is not simply a matter of quality manufacturing to a design specification in order to avoid defects. From the standpoint of reliability, it's more about including design features that have little to do with the machine's functional performance. At first, this may seem unnecessary and wasteful, but when viewed over a timespan of several years, these "extra features" could translate to huge financial benefits.

In sum, OEMs can achieve machine reliability in the following ways (used collectively):

- Design for functional robustness (functional design, material selection, lab and field testing)
- Design for optimum maintainability by the user (ease and effectiveness)
- Quality manufacturing to reduce defects and other anomalies (e.g., Six Sigma)
- Provide a documented equipment

MAINTAINABILITY MACHINE DESIGN FEATURES	CORRECT LUBRICANT	STABILIZED LUBRICANT HEALTH	CONTAMINATION CONTROL	ADEQUATE AND SUSTAINED LUBRICANT SUPPLY
Seals and Leakage				
Use of labyrinth and other premium seal technologies	N/A	Avoids lubricant distress from contamination and low lubricant levels	Reduces the severity of contaminant ingression (dirt, water, process chemicals, etc.)	Reduces leakage-induced starvation
Proper selection and installation of bearing seals and shields	N/A	Reduces excessive heat, churning and contaminant-induced grease degradation	Reduces the ingress of certain contaminants including heat, water and dirt	May reduce leakage, starvation and overlubrication issues

Topics for a Machine Lubrication Manual

- Detailed and illustrated lubrication procedures (oil change, grease change, grease addition, oil top-up, etc.)
- Detailed and illustrated flushing procedures and listing of suitable fluids for flushing
- Oil change interval/regrease interval
- List of all lube points
- Recommended lubricants (performance specification) for all lube points and operating conditions (speeds, loads, etc.)
- Brand/type cross-reference for all lubricants
- Equipment storage protection practices/products, including the use of fogging agents, shaft extension sprays, breathers and vapor-phase rust inhibitors
- Contamination control guidelines including target cleanliness/dryness needs
- Run-in procedures for gears and similar equipment
- Seal compatibility information for system lubricants and other fluids
- Frequency and procedural information for all necessary PMs and inspections
- Comprehensive oil analysis and other condition-based maintenance guidelines

maintenance plan (EMP) (see sidebar on page 3)

Training and education of field-service technicians, operators and maintainers to execute the EMP

Developing Reliability Readiness

Investments in machine reliability should be purposeful. Certainly, there will be costs and even risks associated with reliability initiatives. You aren't trying to maximize reliability but rather optimize it in the context of the user organization. OEMs must be keenly aware of how their machines will be deployed, the operating environment and the minimum needs for reliability. Ideally, they should follow these steps:

1. Determine the overall machine criticality. This process weighs both the probability of failure and the consequences of failure. For more information on quantifying machine criticality, see http://www.machinerylubrication.com/Read/29346/machinery-criticality-analysis.
2. Rank the most likely failure modes. This is often done using failure modes effects analysis (FMEA). If you don't know how the machine is likely to fail, you won't know how to control it. Criticality defines the risk, while FMEA reveals the de-risking opportunities that bring focus and strategy to reliability.
3. Based on criticality and FMEA, develop the specific attributes of the optimum reference state (ORS). As described previously in *Machinery Lubrication* magazine, the ORS is defined as the prescribed state of machine configuration, operating conditions and maintenance activities required to achieve and sustain

Every link in the chain must be equally strong in order for the chain's full length to bear the load.

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specific reliability objectives. In the context of this article, the ORS defines the need for equipment modifications and accessories that optimize the state of lubrication.

While this is the critical beginning of the reliability life cycle, there are many stages that follow to the end of the machine's life. These stages are described at http://www.machinerylubrication.com/Read/2471/reliability-engineers-holistic-physicians-of-machine-care. Again, this article addresses only the first design stage.

Designing for Maintainability

Maintainability is typically defined as the ease, economy, safety and accuracy with which the necessary maintenance of a machine can be effectively undertaken. When machines are designed and built for optimized

MAINTAINABILITY MACHINE DESIGN FEATURES	CORRECT LUBRICANT	STABILIZED LUBRICANT HEALTH	CONTAMINATION CONTROL	ADEQUATE AND SUSTAINED LUBRICANT SUPPLY
General Lubrication System Maintainability				
Optimum selection/use of a lubrication device (spray, mist, circulation, grease, bath, etc.)	N/A	May help stabilize lubricant health	May help reduce the ingress and removal of contaminants	Enables consistent and sufficient supply of healthy and clean lubricant
Lubricant type identification labels	Type on machine matches type on lubricant package	Lower risk of mixed, incompatible lubricants	N/A	N/A
Fully swept (purged) drain sump bottoms	N/A	Reduced residual, degraded oil (previous oil) from last oil change	Water, sediment and other low-lying contaminants are swept out during drains (minimal fishbowl effect)	N/A
Return-line diffusers and tank baffles	N/A	Reduced aeration prolongs oil life	Reduced oil aeration and foaming, enables more efficient and rapid contaminant settling	Fewer oil starvation issues related to aeration and foam
Heat exchangers/coolers	Ensures adequate viscosity to enable required film strength in frictional zones	Keeps oil at a stable temperature for optimum service life and reduces premature additive depletion (dropout, oxidation, etc.)	Reduces the risks of heat contamination effects on additive depletion and base oil oxidation	Ensures proper fluid flow at cold ambient temperatures
Use of engine prelube systems	N/A	N/A	N/A	Reduces engine dry-starts causing momentary starvation
Pressure, flow and temperature sensors	N/A	May indicate lubricant-damaging conditions	May indicate heat contamination	May signal oil flow alarm causing starvation
Inspection Hardware Maintainability				
Bottom sediment and water (BS&W) sight glass	Oil color	Oil color, clarity, sediment, sludge	Sediment, water emulsions, free water, glycol (antifreeze), biomass, varnish	N/A
Bull's-eye 3-D oil level gauges	Oil color	Oil color, clarity, varnish	Water emulsions, oil color, aeration, foam	Oil level, aeration, foam
Correct oil level markings	N/A	N/A	N/A	Visual confirmation of correct oil level
Easy-open inspection hatches/ports	N/A	Visual inspection for bathtub rings, floating debris, foam, aeration, emulsions, corrosion, varnish	Visual inspection for bathtub rings, floating debris, foam, aeration, emulsions, corrosion, varnish	Helps detect foam/aeration-induced oil starvation risks
Pressure differential gauges on filters (including engine oil filters)	N/A	Gauges help ensure filters are working properly, potentially prolonging lubricant service life	Gauges help ensure filters are working properly to control the concentration of contaminants	Well-filtered lubricants are less likely to cause excessive wear on seals, which can cause leakage and starvation issues
Expanded-metal guards and view windows for easy inspection	N/A	N/A	Visible inspection of potential contaminant ingression sites	Visible inspection of leakage areas and lubricant-delivery methods

MAINTAINABILITY MACHINE DESIGN FEATURES	CORRECT LUBRICANT	STABILIZED LUBRICANT HEALTH	CONTAMINATION CONTROL	ADEQUATE AND SUSTAINED LUBRICANT SUPPLY
Oil Analysis				
Properly selected and located primary and secondary live-zone oil sampling valves	More accurate oil analysis confirms the right lubricant is in use	More accurate oil analysis confirms the health of the lubricant	More accurate oil analysis detects and quantifies the presence of a range of contaminants	More accurate oil analysis can detect air entrainment issues and thermal degradation/wear conditions
Proper installation of magnetic wear debris inspection plugs	May reveal inadequate film strength from wrong oil in machine frictional zones	May reveal inadequate film strength in machine frictional zones from degraded lubricant (additives, viscosity, etc.)	May reveal inadequate film strength in machine frictional zones from contaminated lubricant	May reveal inadequate film strength in machine frictional zones from lubricant starvation
Online oil analysis sensors	Sensors can confirm the use of the right lubricant	Sensors can detect degrading lubricant properties	Sensors can report the concentration	N/A
Contamination Control Maintainability				
Quick-connects for adding or draining oil, periodic portable filtration and flushing requirements	N/A	Contamination control prolongs lubricant life	Minimal use of funnels, contaminated fill ports, etc.; contamination control from flushing and filtration	Simplified oil change and control of oil level
Quality headspace management (breathers, headspace purge, dehydration, etc.)	N/A	Reduced contaminant ingression extends oil service life	Reduced water, dirt and process contaminants	N/A
Suitable performance, quality and location of filters	N/A	Contamination control prolongs lubricant life	Faster and more effective removal of damaging contaminants	Reduced risk of contaminant-induced internal and external lubricant leakage causing starvation issues

maintainability, many benefits are realized including:

- Increased reliability
- Lower overall costs of enabling reliability
- Decreased time to complete maintenance tasks
- Fewer maintenance errors
- Reduced maintenance injuries
- Less training required to perform tasks
- Improved troubleshooting effectiveness

In seeking lubrication-enabled reliability (LER), the vast majority of the opportunity comes from paying close attention to the "Big Four." These are vital attributes to the optimum reference state needed to achieve lubrication excellence. The "Big Four" individually and collectively influence the state of lubrication and are largely controllable by machinery maintainers, especially if a machine is designed and built for optimum maintainability. The "Big Four" are:

1. Correct lubricant in use (meets reliability objectives)
2. Stabilized lubricant health (physical and chemical properties)
3. Contamination control
4. Adequate and sustained lubricant level/supply

While it may seem to be an oversimplification to reduce lubrication excellence to just four basic objectives, as a practical matter, not much else is required. See the tables on pages 2, 4 and 5 to learn how machine maintainability can be applied in the context of the Big Four.

Role of Buyers/Purchasing

Before buying new machinery, an engineering specification should be carefully and thoroughly developed. Engineers charged with writing these specifications should be educated on modern concepts in machinery lubrication. Simply working as an engineer or having an engineering degree alone does not qualify. Instead, training by leading consultants and instructors is strongly advised.

Training should be followed by certification compliant to ISO 18436-4 and similar standards. Noria recommends that engineering specifications for new equipment only be written by professionals with Machine Lubricant Analyst (MLA) Level II and III certification credentials. A specification should address many, if not all, of the maintainability features shown in the preceding tables. It must also address hardware and design features that are not permitted. These might include ring oilers, drip oilers, screen filters, snorkel vents, high-watt-density tank heaters, long pump suction lines, etc.

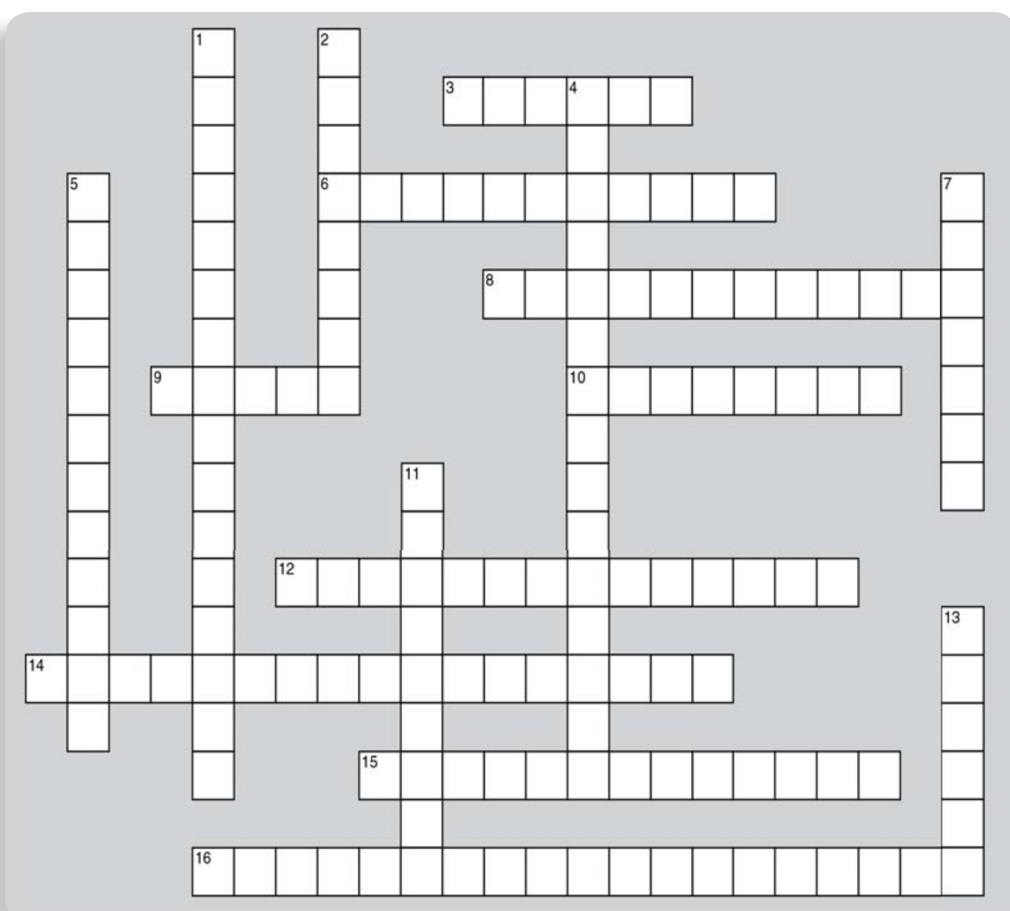
Consider having the specification carefully reviewed by an outside lubrication consultant, especially for the most reliability-critical machines. Remember that the cost of retrofitting needed maintainability hardware will be many times the cost of the same hardware when installed at the factory (as part of the original bill-of-material).

Conversely, buying machines stripped to the bones in an attempt to reduce costs is almost always false economy. The astute reliability professional views new equipment in terms of the cost of ownership, not simply the cost of purchase. Most important is the overall machine reliability, which includes repair costs but also equipment utilization (uptime), maintainability (PMs, inspections, etc.), safety and other factors. All of these should drive the business decision to invest in reliability readiness.

About the Author

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

Crossword Puzzler»



Get the solution on page 25

Across

3 A ported or closed cover for the end of a filter element.

6 A fluid circulation process that is designed to remove contamination and decomposition from a lubrication-based system.

8 Compound containing only carbon and hydrogen.

9 Removing air from a liquid, usually by ultrasonic and / or vacuum methods.

10 A device used to convert fluid energy into mechanical motion.

12 A device that converts hydraulic fluid power into mechanical force and motion by transfer of flow under pressure.

14 A method of separating two components from a mixture.

15 The porous device that performs the actual process of filtration.

16 Sudden, unexpected failure of a machine resulting in considerable cost and downtime.

DOWN

1 A highly porous material produced from dehydroxylated aluminium hydroxide that is used as a desiccant and has a filtering medium.

2 Oil – isoluble material that result from oxidation and decomposition of lube oil and contamination from external sources and engine blow-by.A filter located in a line conducting fluid from a pump or motor housing to a reservoir.

4 The pressure encountered on the return side of a system

7 A base stock or blend of base stocks used in an API – licensed engine oil.

11 The temperature to which a combustible liquid must be heated so that the released vapor will burn continuously when ignited under specific conditions.

13 A lubricant composed of an oil or oils thickened with a soap, soaps or other thickener to a semisolid or solid consistency.

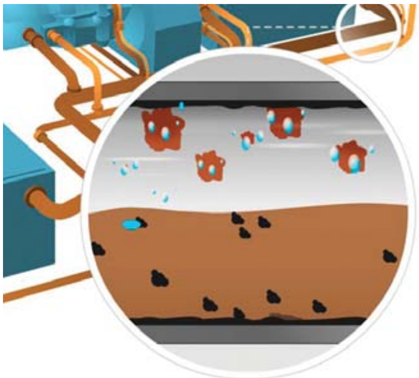
WOJCIECH MAJKA AND TOMAS KLIMA, ECOL, POLAND

Hydrodynamic Cleaning and FLUSHING of Turbine OIL SYSTEMS

One of the most important but underestimated factors impacting the operation of turbines (both steam and gas) and other machinery is the condition of the oil, especially its "mechanical" cleanliness (presence of solid particles). Although the need for appropriate oil care is commonly accepted among power plants with regular maintenance practices, the cleanliness of the oil system interiors (piping, tanks, coolers, etc.) remains an issue. Problems caused by dirty oil systems in machinery such as turbo-generators, turbo-compressors, turbo-pumps and other large-scale oil systems (hydraulics, large stationary diesel engines, etc.) are quite common.

The most reasonable and responsible maintenance strategy is to maintain the proper condition of the oil and oil system based on a correctly applied oil analysis program, determining not only basic oil parameters but also answering questions regarding the potential of varnish formation and other aging-related properties along with the general oil and component condition. Temporarily controlling the system's interior is also advised (using endoscopy, visual inspection of friction nodes, control of used filter elements within their exchange process, etc.). Of course, the lubricant quality matters as well.

Unfortunately, from time to time, plants experience significant problems related to lubrication. A big part of these problems is associated with the purity of the oil. While many industry experts speak about the role of oil contamination, the issue of achieving purity of both the oil and oil system is often neglected or not discussed in detail.



Dirt in an oil system

Benefits of Hydrodynamic Cleaning and Flushing of Oil Systems

Hydrodynamic cleaning and flushing with oil at turbulent flow rates offers many advantages, such as:

- Long-term system and oil purity
- Retention of the natural protective oxide layer on the inner walls of the pipeline system
- Reduced quantities of flushing oil
- Reduced wear of lubricated parts and extended mean time between repairs
- Significant increase in oil durability (reduced quantities of replacement oil)
- Higher equipment availability
- Significant reduction of filter insert consumption
- No turbine outages due to dirt in the oil system
- Reduced total operation costs

So what can you do when severe deposits, sludge, varnish or rust formation occurs in an oil system, or when a newly assembled oil system is corroded or contaminated with chemical preservatives or machining debris? What can be done with large quantities of wear debris inside an oil system after severe seizure and breakdown of a bearing?

For trouble-free operation,

contaminants must be removed from the oil system. However, in extreme cases, the level and type of impurities may exceed the separation capability of the system filters and threaten future equipment operation, resulting in loss of production. The standard maintenance approach then is not enough. Immediate cleaning of the entire interior of the oil system with subsequent turbulent flushing should be performed. Often, if the oil doesn't meet specific requirements, oil replacement (exchange) is also required.

Because proper cleaning of an oil system is not easy within an overhaul process or when assembling a new system, a variety of technologies and strategies have been used, such as mechanical cleaning with ramrods, chemical cleaning (with solvents, oil additives, etc.), steam blowing or utilizing different oil flushing procedures. In dirty oil systems, most of these practices do not produce the desired results within a reasonable amount of time and money. Frequently, positive results do not last long but diminish, resulting in the need for additional cleaning.

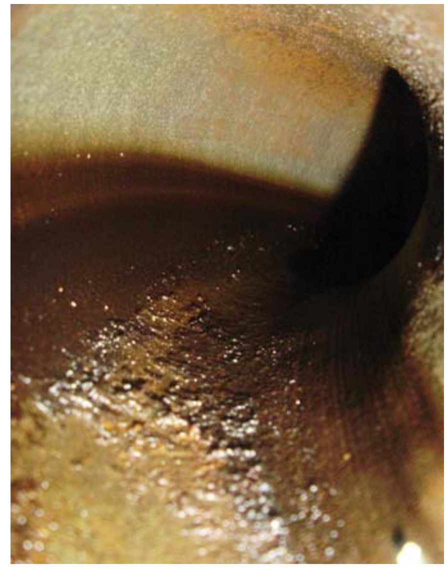
With the cost of operating dirty lubrication systems in turbines far too significant to neglect, more efficient solutions have been developed. One effective method of preparing new oil systems and restoring operated oil systems for future reliable operation involves the technology of hydrodynamic cleaning and flushing of oil systems. This alternative to obsolete or inefficient methods has become a preferred choice of many original equipment manufacturers (OEMs) and power-generation repair companies.

The Problem of Dirty Oil Systems

One of the most expensive and underestimated problems associated with the use of machinery is the inadequate cleanliness of the oil system. It results in low oil cleanliness, thus leading to most maintenance problems and to related extra expenses (production outages, repairs, penalties and loss of customers).

Impurities can enter the oil system during assembly, upon execution of overhauls or simply from the immediate surroundings. They also are created during operation due to oil degradation and corrosion processes. In process machinery, compressed gas often carries different impurities and can interact with the base oil or oil additives while entering the oil system through wet seal glands. These contaminants accumulate in the oil system interiors, creating different deposits.

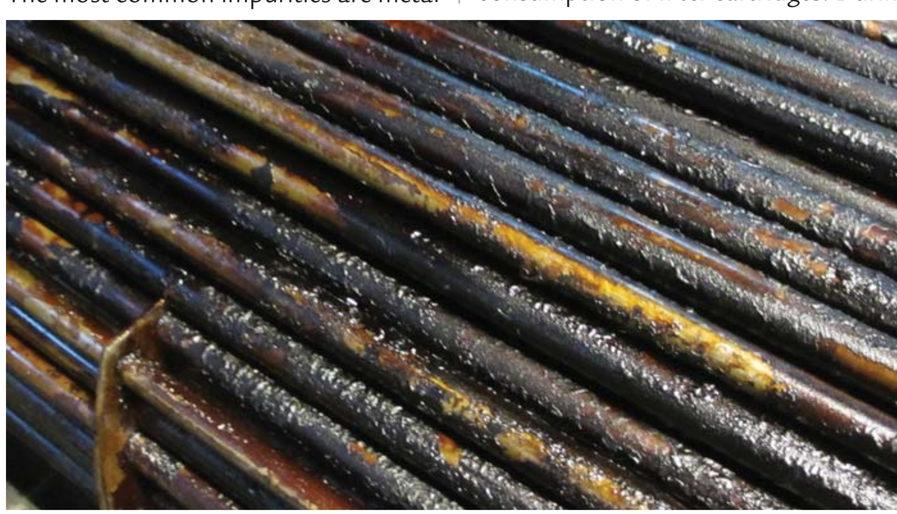
Impurities are the main cause of premature wear and can lead to equipment breakdown. The most vulnerable parts include bearings, hydraulic actuators and controllers, gearboxes, drive-shaft seals, pumps, oil coolers, filters and reservoirs.



A dirty oil pipeline (sludge and corrosion in the return line)

The most common impurities are metal debris from machining, welding slag, sealants or other materials used during assembly or repairs, oil system corrosion products (mainly rust), solid impurities, wear metal particles, and water from oil coolers or steam gland leaks and from ambient humidity. Impurities sometimes include gases (e.g., light hydrocarbons or ammonia) and cooling liquids. Other troublesome impurities involve oil degradation products from aging and thermal stress, which create insoluble chemical compounds that are responsible for varnish and sludge formation.

Impurities also lead to increased consumption of filter cartridges. During



An oil cooler covered by sludge from oil-aging products

Magnetic ferrous particles attached to magnets from an oil system

operation, these impurities are carried by oil to lubricated components, depositing on the inner walls of pipelines, coolers, tanks and other elements.

The presence of water accelerates the creation of corrosion inside the system. The current trend is to build oil systems from stainless steel. However, some parts that can corrode rapidly (armature, tanks, etc.) may still be made of carbon steel. In older systems, which are made mostly of carbon steel, the problem of corrosion is significant. These systems are prone to corrode quickly, especially in parts that are not permanently filled with oil (gravity return lines, tank roofs, etc.), due to water condensation on these surfaces.

With oil such a key component of any mechanical device, problems related to the lubricant often turn into problems with the machinery. In most cases, impurities in the oil mean interruptions in machinery operation.

Particles in the oil that can be damaging to lubricated components may be very different in size, depending on the cleanliness requirements given by the component manufacturer. However, the dangerous size normally is smaller than the human eye can see (less than 40 microns). In practice, a machine consists of many components (e.g., bearings, sealing glands, hydraulics, etc.), so the purity of the oil and the system should meet the requirements of the most demanding component. In a typical turbine system, hydraulics require the highest oil cleanliness and the smallest average size of dangerous particles.

Practical Applications

Hydrodynamic cleaning and flushing of oil systems is quickly becoming a preferred choice of OEMs and maintenance/repair companies. Since 1994, more than 450 different turbine oil systems have been serviced with this technology, including newly commissioned and refurbished machinery ranging from:

- Turbo-generators (steam and gas turbines)
- Process turbo-compressors and blowers (hydrocarbons, synthesis gas, hydrogen, air, ammonia, etc.)
- Boiler feed pumps with hydrokinetic couplings and gearboxes
- Large industrial diesel engines (including auxiliary power supply in nuclear power plants)
- Large marine diesel engines
- Large hydraulic and lubricating oil systems in steelworks and rolling mills
- Central lube oil distribution systems in plants

Is Flushing Always Enough?

Most available standards, recommendations and industry practices place a lot of attention on the flushing process before startup of the system. While turbulent flushing of dangerous-sized contaminants will prepare an oil system for safe operation, only a well-designed flushing procedure will be effective. In many cases, even the most turbulent flows will not remove well-attached/sticky deposits from the system walls. When flushing a system in which such deposits are present, reaching the required oil cleanliness can be difficult. Indeed, achieving reasonable oil cleanliness can take a long time.

In addition, during initial startup and regular operation of a turbine when conditions are quite different than when flushing (system vibrations from machinery, high temperatures, different flow velocities, shocks from pump starts, valves opening, etc.), it is common for new particles to detach from remaining (after flushing) dirt from the system walls. Diminishing oil cleanliness is then usually observed. This type of situation is most often visible when severe deposits are present in the system, especially varnish, sludge and rust. Some of the mentioned impurities cannot be cleaned by means of turbulent flushing only. Prior to flushing, thorough cleaning of the system should be performed.

Hydrodynamic Cleaning Technology

Cleaning an oil system is not an easy process. Many irregular and rough surfaces made of metal, narrow spaces, recesses between flanges, etc., demand lots of effort and expertise to detach any deposits in order to remove them from the system with turbulent flushing.

Hydrodynamic cleaning with high-pressure water jets and subsequent high-velocity oil flushing of systems offers a viable alternative to other frequently insufficient and obsolete methods. This cleaning and flushing technology can be an effective method of preparing new oil systems and restoring operated systems regardless of their size and complexity.

The technology includes three phases: hydrodynamic cleaning using water at very high pressure, flushing of the system with oil at high (turbulent) flow rates and with full-flow absolute filtration, and post-assembly bypass oil filtration prior to equipment startup.

The core of this technology involves cleaning all the inner surfaces of the oil system with high-pressure water jets utilizing suitable nozzles, immediate drying and application of a protective turbine oil spray to the dried surfaces, followed by flushing with continuously filtered oil at sufficient pressure and flow rates.

Step 1: Hydroblasting

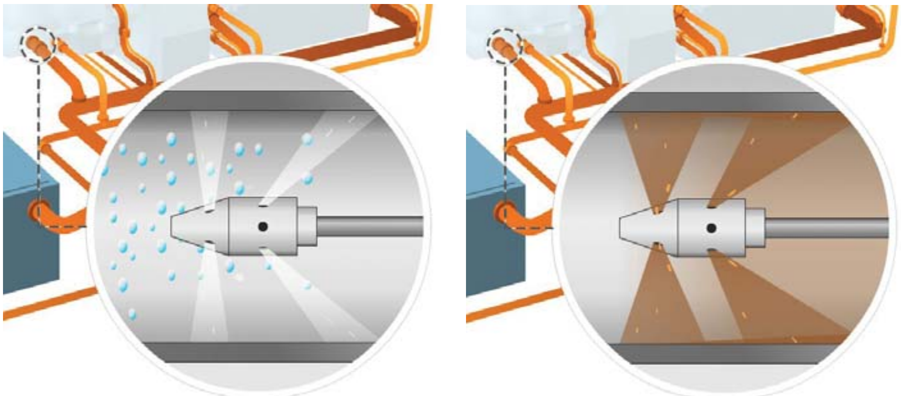
During hydroblasting, the inner surfaces of the system are blasted with high-pressure water in order to detach soft deposits (loose wear debris, sand and dust grains, products of the oil-aging process, sludge, biological deposits, resins, asphalts, greases and corrosion-protective layers), as well as hard deposits like corrosion products, rust, welding slag, varnish residue and machining residue that is partially attached to the surface. The following activities are carried out in the course of the cleaning process:

- High-pressure water hydroblasting of all the interiors of pipelines and other elements of the oil system (coolers, reservoirs, bearing stands, etc.) using suitable equipment (elastic lances, nozzles, water guns, etc.).
- Immediate drying of cleaned surfaces using filtered, compressed air.
- Application of anti-corrosive protection on dried surfaces (spraying with lubricating turbine oil) until flushing occurs.
- Protection of open flanges from environmental dust and dirt until the flushing process takes place.

An oil pipeline after hydroblasting

This advanced technology allows disassembly of only necessary small parts of the oil system (pumps, valves, fittings, coolers, etc.). The goal of hydroblasting is to ensure all of the system's interiors are free of corrosion, sludge, varnish and other deposits. The pressurized water mechanically removes/detaches such deposits from the inner surfaces of the oil system and carries them outside the system by means of a water stream. The water used for cleaning is sweet, potable water or decarbonized water from the power plant, so the risk of system contamination by any chemicals is eliminated. Future flushing is then possible by oil that will be further operated in the turbine.

The hydroblasting process



The process of drying an oil system (left) and application of a turbine oil spray as anti-corrosive protection

Immediate drying of the cleaned surfaces using filtered, compressed air and applying a protective layer of turbine oil (spray) prevent against secondary corrosion of the cleaned oil system. The system remains completely dry after the hydrodynamic cleaning phase, thus eliminating the risk of water ingression into the oil during flushing.

Step 2: Flushing with Filtered Oil at High Flow Rates

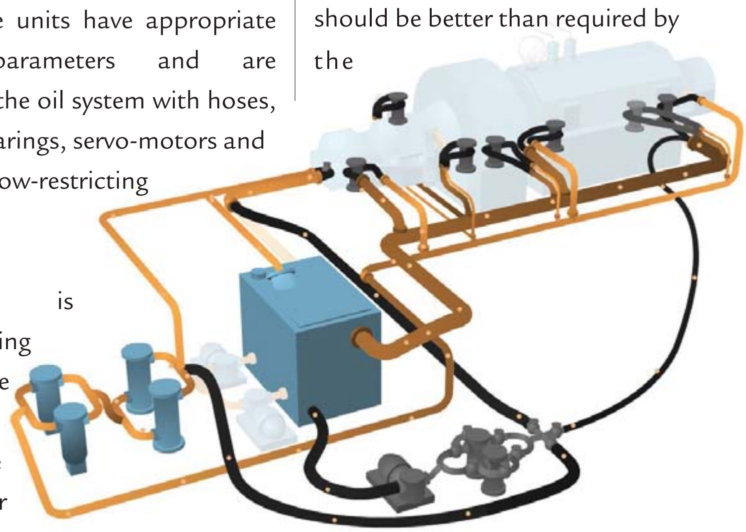
During this step, all impurities that remain in the system after hydroblasting are removed while ensuring the appropriate purity of the oil in the system. The system is flushed using special filtration and pumping units with turbulent flows at rates ranging from 13,000 to 20,000 liters per minute. These units have appropriate operating parameters and are connected to the oil system with hoses, manifolds, bearings, servo-motors and other flow-restricting elements.

Flushing is performed using fresh turbine oil, which will remain in the system for further use. A separate batch of flushing oil is not needed. The flushing process continues until the predetermined purity criteria are reached in each location of the system. During this time, the oil temperature and direction of its flow are changed in order to move out remaining impurities.

Effective flushing of the oil system is based on the following three factors:

1. Flow rates at all pipeline sections should be sufficient to invoke turbulence.
2. The oil cleanliness class measured in various locations of the system should be better than required by the turbine manufacturer (e.g., 17/15/13 according to ISO 4406). The oil's purity is measured during the flushing process using appropriate instruments and according to a predetermined schedule. Cleanliness requirements can also be set higher upon request.
3. No solid particles greater than 150 microns are deposited on the 100-micron mesh strainers installed in strategic locations throughout the system. Smaller particle sizes may also be warranted.

Depending on the customer's requirements, the oil purity criteria can



Turbulent flushing with full-flow absolute filtration

Hydroblasting of an oil system

A flushing skid in operation

Bypasses on a turbine bearing of a large steam turbine

be more stringent. However, in most cases, the typical result is much better than a cleanliness class of 14/13/10.

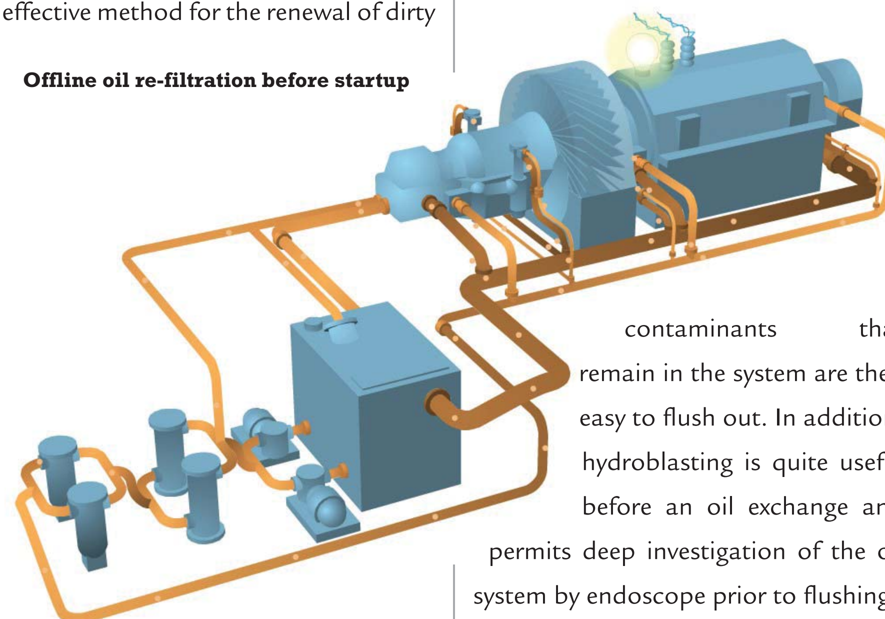
Step 3: Bypass Oil Filtering Before and During System Startup

In order to remove post-assembly impurities introduced after flushing, bypass oil filtration in the main oil reservoir is performed before and during the system startup. The duration and filtration criteria are adapted to the specific operational requirements.

Safe and Effective

The technology of hydrodynamic cleaning and flushing with oil at turbulent flow rates provides a highly effective method for the renewal of dirty and corroded systems to "like new" condition while also being suitable for newly assembled oil systems.

Offline oil re-filtration before startup



Hydroblasting not only disinfects the system from aging products, old oil, protective layers or other chemicals that might contaminate fresh oil, but also shortens the future flushing process because most impurities are removed by water. The small amount of contaminants that remain in the system are then easy to flush out. In addition, hydroblasting is quite useful before an oil exchange and permits deep investigation of the oil system by endoscope prior to flushing.

Flushing after hydroblasting is fast and efficient, allowing a completion date to be set and a schedule to be maintained with no extra time needed for prolonged flushing. With this technology, proactive maintenance based on oil analysis can be implemented.

The method is entirely safe for the natural environment, as pure water is the cleaning medium, and the wastewater contains only impurities detached from the inner system surfaces along with trace quantities of oil washed from the system. Long-term warranties in regards to the system cleanliness are also a possibility. ■

Manifolds and temporary connections on a small steam turbine

UMESH MALIK, CHIEF ENGINEER
SUB-CONTINENT EXXONMOBIL LUBRICANTS PVT. LTD

A case study on reduced bearing failure and improved productivity with the use of Mobil Grease XHP 222

A recent joint study commissioned by consulting rm McKinsey and the Confederation of Indian Industry (CII) highlights India as the most favoured country to capitalise on emerging trends that increasingly favour global delivery models in automotive technology development and manufacturing, owing to a skilled workforce coupled with low-cost technology design and manufacturing capabilities.

Here is a case study of how the right industrial lubricant can improve performance, increase productivity and thereby, contribute to the bottom-line.

Swastik Pipes Limited was facing issues such as grease washout by coolant, increased bearing temperature, high regreasing frequency.

Swastik Pipes Limited has been one of India's leading manufactures and exporter of T.T. Swastik Band high quality Mild Steel/Carbon Steel ERW Black and Galvanized Pipes/Tubes since 1973.Swastik Pipes is also manufacturing LINE PIPES as per APL Spec.5L since December 2005. Its advancement state-of-art manufacturing facilities with ISO 9001: 2000 and APIQ1 approvals has achieved national and international recognition.

Swastik Pipes Ltd. is one of the leading manufacturers of ERW Pipes and Tubes, Steel Tubular Poles, Cold Rolled Sheets and Strips in North India. The facility is located in Bahdurgarh, Haryana and equipped with state-of-the-art equipment.

Mobil Grease XHP 222 decreases bearing failure by

50%

At its manufacturing facility in Bahadurgarh, Haryana, India, sophisticated machines produce CR Coils, galvanized coil, ERW tubes, steel galvanized coil, CRCA coils and sheets and galva- nized products in desired speci cations and nishes. Swastik Pipes Limited had started manu- facturing CR coils and strips in year 2003 with annual capacity of 1 lac MT / annum in various sizes and thickness.

CR production plant consists of two 4 HI and one 6 HI cold rolling mills along with bell furnaces, skin pass, slitting, cut to length and testing facilities. In the CRM rollers bearing lubrication, SPL was using competitor lithium-thickener EP2 grease. SPL had to be regreased or topped up frequently to avoid bearing failures and maintain the running temperature of the bearings. SPL was also facing other issues like getting the grease to dry, dust entering into the bearings, grease bleeding etc. The main problem encountered by the SPL in CRMs was grease washout because of coolant used in process.

Mobil Grease XHP 222 decreases grease consumption by

33%

After discussing with Mobil FES team and NIS engineers Mobilgrease XHP 222 was suggested as a solution.

Switching to a Mobilgrease to reduce bearing failures and to reduce temperatures

The innovation of Mobil Grease XHP 222 was of greater convenience to Swastik Pipes Limited. The application of Mobil Grease XHP 222 overcame the problem of grease washout by coolant, increased bearing temperature, and high re-greasing frequency. There was substantial increase in bearing life which further resulted in considerable savings in Total Cost of Owner- ship for Swastik Pipes Ltd. And, has led the annual saving of Rs. 235275/-.

Mobil Grease XHP 222 provides good sealing and intercepts dust from entering into bearings. It absorbed and continued to hold its consistency even after a long duration. It worked well at temperatures as high as 100 Deg c. There was considerable amount of improvement in Mill reliability, Decrease in bearing failure and grease consumption, along with this Mobilgrease XHP 222 enhanced Mill availability by 8 Man days/ annum. All these combined resulted in an increased production and saved US$10,000 by reduction in bearing failure and grease consumption.

Saving $10000 (₹590000)

Switching to Mobilgrease XHP 222 resulted in considerable savings in Total Cost of Ownership for Swastik Pipes Ltd. Moreover, a considerable increase in the duration of regreasing intervals to approximately three times more than the competitor lithium thickener grease was observed. Previously SPL used to top up on daily basis which has now scheduled to after every third day with Mobilgrease XHP 222.

Though Swastik Pipes Limited had been using Lithium thickener EP2 grease for a long period but the notable results provided by Mobil Grease XHP 222 drove the company to take full advantage of the bene ts obtained from the same.

Bene ts:

- Improves productivity
- Decreases bearing failure by 50%
- Decreases grease consumption by 33%
- Improved Mill reliability
- Increase in Mill overhauling schedule and hence enhanced Mill availability by 8 man days/annum

Impact:

- Cut down Mills stoppage by 8 days by increasing overhauling schedule.
- $10,000 savings achieved by reduction in bearing failure and grease consumption.

JEREMY WRIGHT NORIA CORPORATION

How LUBRICANT SUPPLIERS Impact Machine RELIABILITY

Plants often do not take into account the effect that the lubricant supplier can have on machine reliability. If left unchecked, the results can be catastrophic.

You might be surprised what you can learn from a quick visit to your lubricant supplier. Does your supplier know your reliability and lubrication goals? How can suppliers help you succeed if they have no idea that you are playing for the same team?

Supplier audits are a small part of Noria's service offerings. In this article, I will share a few key tips that have been learned over the years so you can be better informed when visiting your supplier.

I like to use a simple checklist when conducting a supplier audit. It helps remind me to be vigilant on key practices and physical attributes that are associated with the optimum reference state of handling lubricants. I usually start with an overview of the storage facility and how lubricants are handled. The first observation should be related to the identification of lubricant-handling equipment. Are all lines and tanks clearly marked for a specific lubricant? If not, the likelihood of cross-contamination becomes significantly higher.

The warehouse should also be in good condition. It must be free of spilled oil, settled water and dust. The building should be enclosed and, if possible, climate-controlled. All products should be in sealed containers, stored indoors away from direct sunlight and not allowed to collect rain water on the top edge.

62%

of lubrication professionals never visit their lubricant supplier, according to a recent survey at MachineryLubrication.com

The inventory in the warehouse should be rotated so that the oldest containers are being used first, while the newest containers are sent to the back. Remember that the cleaner, cooler and drier the lubricant is kept (even when in the sealed drum), the longer it will last.

If you can witness the handling and transferring of lubricants during your supplier visit, watch for instances of cross-contamination. Make sure that all transport lines are product-dedicated or at least flushed well between uses. For bulk incoming

5 Tips for Dealing with Your Lubricant Supplier

1. Audit your oil supplier routinely.
2. Establish clear parameters and work with suppliers to help them achieve the improvements that are necessary.
3. Expect the lubricant supplier to conform to new, higher- quality expectations.
4. Include mill mechanics and lube technicians in the process.
5. Provide training to reinforce the necessity and benefit of the new measures.

transfers, check if samples are taken to verify compliance for both properties and performance. These samples should be kept on record for at least six months. Also, see if you can find current seals on all meters showing calibrations within the last year.

In the packaging area of the plant, you will want to make certain that at a minimum the supplier is filtering the incoming oil through a 60-mesh screen. Again, confirm that meters and scales are up to date on their calibration. Inspect the condition of the drums prior to being filled. Are they reconditioned? If so, what processes do they have in place to prevent clean oil from being put into a dirty drum?

Ensure that the empty drum inventory is stored appropriately as well. Every particle that contaminates the drum from this point will have an effect on your program. You will either have to remove it through filtration or suffer the consequences of particle contamination in your machine. Keep in mind that the cleaner the supplier can keep the oil, the less time, energy and money you will have to spend later in its life cycle to get it to an acceptable level for your machines.

Your lubrication knowledge will be a tremendous asset when visiting your supplier. If you are not confident in your knowledge, just remember "clean, cool and dry." Look at everything with this in mind and ask yourself if the lubricant is being kept as clean, cool and dry as possible. You then will have your answer as to how well your supplier is helping you achieve your reliability initiatives.

About the Author

Jeremy Wright is vice president of technical services for Noria Corporation. He serves as a senior technical consultant for Lubrication Program Development projects and as a senior instructor for Noria's Fundamentals of Machinery Lubrication and Advanced Machinery Lubrication training. He is a certified maintenance reliability professional through the Society for Maintenance and Reliability Professionals, and holds Machine Lubricant Analyst Level III and Machine Lubrication Technician Level II certifications through the International Council for Machinery Lubrication. Contact Jeremy at jwright@noria.com.


Flash points
ALLSTAR
Rust Prevention
Oxidation Stability
Performance Specification
Oil Separation
ISO Cleanliness
Performance Specification

Purchasing Lubricants Based on Performance

By Thomas L. Lantz, Lantz Consulting Services

Lubricants initially arrive in industrial plants usually via one of two methods:

1. New equipment generally comes with a "lubricant list" from the equipment supplier with a few recommendations for each application. Brand names are typically listed, a selection is made and, if it works satisfactorily, it is chosen.
2. Maintenance personnel express concern to a supplier or a competitor about a lubricant's performance, and a change is made.

There are other ways lubricants are acquired, but in each case, maintenance personnel don't know why a product does or does not work; they simply accept the outside expert's opinion. In these situations, maintenance workers may not realize there are several products in the plant with different brand names but similar characteristics. They may be unknowingly contributing to the proliferation of products in the plant. Without understanding what makes the products work, the maintenance person may be reluctant to consolidate. In this case, there is little encouragement for competition and no reason for any oil company to lower its prices. Naturally, maintenance personnel want their equipment to have the highest quality lubricants but at a reasonable price. How can this be accomplished?

Jim Fitch's "Hazards of Changing Lubricant Brands" article in the November-December 2013 issue of Machinery Lubrication put the maintenance person's concerns in perspective. The article brought to mind a system that was developed and used for many years at a U.S. steel company. In order to address the concerns discussed in Fitch's article, the company established a system whereby lubricants and hydraulic fluids were purchased by performance specifications. If a product worked in an application satisfactorily, it was tested to determine which ASTM tests (or others) it would pass that were relevant to the application. A specification was then written around those test results that could be placed out for bid by the purchasing department. If a lower bid was received, the competitor was asked to submit a sample to an independent lab to verify a few very important requirements. If successful, the lowest bidder was awarded the business for a specific period.

Lubricants are unique in that objective lab tests are available to the user that will predict field performance. Very few maintenance products have this advantage.

This article will outline the pros and cons of using a specification system, how to launch such a system and make it work, and how to handle exceptions. If a company's lubricant purchases are substantial and could benefit from a 10- to 15-percent reduction in costs, this system may offer an advantage while assuring only the highest quality lubricants are used in the equipment.

What is a Performance Specification?

Every lubricant and hydraulic fluid has a detailed list of tests that must be passed at the oil company before it is released for shipment. The experts at the oil company know how the fluid must perform in your equipment. Several organizations (ASTM, SAE, etc.) have devised lab tests that will measure various aspects of this performance.

For instance, because viscosity and viscosity index are very important in most lubricants, numerous tests have been devised and agreed upon by industry experts to measure these parameters. Figure 1 provides a list of some of the more common tests for oil and grease.

Once a list of important performance specifications is compiled for a given product such as a gear oil, any

TEST NO.	NAME	APPLICATION
GREASE TESTS		
D-2596	4-Ball EP	Measures film strength of base oil
D-2266	4-Ball Wear	Measures wear resistance of greases
D-1742	Oil Separation	Measures tendency of grease base oil to separate from soap
D-4048	Copper Corrosion	Measures grease tendency to corrode copper, bronze and brass
D-942	Oxidation Stability	Measures grease tendency to combine with oxygen
D-217	Penetration	Measures the stiffness of grease
D-1831	Roll Stability	Measures resistance of grease to change stiffness after working
D-4049	Water Sprayoff	Measures resistance of grease to resist heavy water spray
D-2509	Timken Test	Measures film strength of base oil in grease
OIL TESTS		
D-445	Viscosity	Measures an oil's resistance to flow (indicator of film strength)
D-2270	Viscosity Index	Measures change of viscosity with temperature
D-92	Flash and Fire Points	Indicates dilution by volatile fluids
D-97	Pour Point	Lowest usable temperature without heating
D-130	Copper Corrosion	Indicates corrosive action of an oil on copper, bronze or brass
D-2711	Demulsibility	Measures the ability of an oil to separate from water
D-4172	4-Ball Wear	Measures wear prevention ability of a lubricant
D-3604	Elastomer Compatibility	Measures effect of a lubricant on elastomers at static conditions
D-892	Foam Resistance	Measures the tendency of a lubricant to foam in systems

Figure 1. Common tests for oil and grease

successful product must be tested to determine the numbers or evaluation for each test. Compatibility is always a concern when switching products. The steel company's solution was to give the competing supplier the responsibility of assuring that its product would mix properly with the incumbent product. Any problems in this area were the responsibility of the new supplier. Removal and disposal of the contaminated tank contents were also part of their job. Of course, this rarely needed to be done.

Figure 2 is a typical performance specification for a gear oil. A complete written specification from which the summary sheet is derived is too extensive to be reproduced here. A comprehensive set of summary sheets for several types of oil and grease may be obtained by contacting the author at tomlantz1@yahoo.com.

How a Performance Specification is Written

While the above information offers details on how to assemble the essential data, writing the specification is more involved. Plant personnel often see lubricants as their domain. They issue requisitions to the purchasing department and expect all the details to be taken care of, including the issuing of a purchase order to the supplier of the plant's choice. The purchasing department often will talk to competitors about supplying a comparable product. This is a common source of conflict between the plant and the purchasing department. Both groups should have input into these decisions.

The steel company's solution to this problem was to form a committee composed of both plant and purchasing personnel who worked on the specification together. The procedures for qualifying new suppliers and the bidding process were agreed on by both parties and strictly followed. Each plant in the corporation was represented on the committee, and all parties kept a three-ring binder of all the specifications.

Even after the specifications were written, meetings were held periodically to consider any new information acquired, problems encountered that might be due to a product or changes that a supplier thought was necessary.

The science of lubricant testing is constantly evolving, and staying up to date is imperative. The steel company also learned that most oil suppliers take great pride in their quality control, and problems that initially were attributed to the oil company often were the result of something the plant had done or an equipment malfunction.

Importance of Code Numbers

In order to wean everyone in the maintenance department away from brand names, it is imperative to establish a coding system. Every performance specification written may have a name, but it also needs a number.

The steel company's system involved all maintenance products (gears, bearings, couplings, lubricants, etc.) and thus required long numbers, but the last three digits were unique to a specific product. For lubricants and hydraulic fluids, those three digits acquired the title "maintenance code" or MC number. All drums, in-plant tanks, supplier paperwork and written specifications had to have these code numbers. Although the drums and paperwork from a supplier might have brand names on them, the MC number had to appear as well.

There are four basic reasons for this strict adherence to code numbers:

1. To prevent maintenance personnel

LUBRICANT SPECIFICATION			
PRODUCT: EXTREME PRESSURE LUBE OIL		MAINTENANCE CODE NUMBER: MC - 43, 51, 87, 21, 93, 71 & 31	
Test No.	**Description**	**Test Limits**	**Comments**
D-2270	Viscosity Index	Minimum=85	
D-445	Viscosity	See Figure 3	
D-92	Flash and Fire Points		
D-97	Pour Point	See Figure 3	
D-189	Conradson Carbon	Should contain no more than 2.5% residue	
D-130	Copper Corrosion	No worse than Class1-b	3 hours at 212°F
D-874	Sulphated Ash	Matter of record	
D-892	Foam Characteristics	Less than a trace after 10 minutes	
D-665	Rust Prevention	No rust after 24 hours	Procedure A
D-2711	Demulsibility	See Figure 3	
D-1298	API Gravity	Matter of record	
D-1500	Color	Matter of record	
D-3604	Elastomer Compatibility	Weight change +2% -1%; Volume change +5% -2%	
D-4172	4-Ball Wear	Limit is 0.35 mm with 40 kg load	
ISO 4606	ISO Cleanliness	Cleaner than 21/18 on delivery	
D-2893	Oxidation Test	Viscosity increase less than 5%	312 Hours (13 days) at 100°C
D-664	Neutralization Number	Not to exceed 1.0	
D-2782	Timken Test	Pass 60-pound load	
D-2783	4-Ball EP	Weld=250 kg; LWI=45 kg	
FZG	Gear Tooth Wear	9 stages; wear less than 10 mg	

Figure 2. A typical performance specification for a gear oil

from thinking in terms of brand names.

2. To simplify computer systems that record the lubricants to be used in a given piece of equipment. If a change must be made, a new brand name is brought in under the existing code and no change in the computer is required.
3. Survey sheets and routing lists used by the lubrication technician would require constant updating if brand names were used. MC numbers eliminate this problem.
4. Tanks permanently installed in the plant may have the MC number stenciled on them if there is little chance a change will be required.

Vendor Relationships

One of the main reasons for the specification system is to prevent "cozy" relationships between vendors and plant personnel. When this situation occurs, prices tend to rise whether quality rises or not. Conflicts then occur between plant personnel and the purchasing department, as the latter attempts to stabilize prices. Using the specification system allows an "arm's length" relationship. Looking primarily at the test results promotes objectivity. Of course, quality consistency, dependable deliveries and knowledgeable service are considered as well. No one likes vendors who provide inconsistent quality, unreliable deliveries or spotty service.

Adjusting Specifications

The performance specification should be considered a "living" document. It must be periodically adjusted to reflect new knowledge. Once written, the specification may become outdated by new developments in the field. New tests may be devised that assess a parameter better than previous versions. The consensus of opinion among industry experts might also change regarding which parameters are important or which test provides the best measurement. Therefore, vendors are encouraged to offer suggestions on ways to improve the specifications. Their input can be valuable.

Exceptions

It does not pay to employ performance specifications on low volume items. Below a certain dollar amount, the use of specifications is a waste of time. Simply find something that works and use it if the cost is not excessive. However, in a multi-plant organization, small quantities in several plants can add up to enough money to make using a specification worthwhile. Every situation is different, and good judgment must be used.

One of the questions that might be

Maintenance Code No.	ISO VG	Viscosity Limits (cSt @ 40° C)	Viscosity Limits (SSU @ 100° F)	Pour Point °F (Maximum ASTM D-97)	Demulsibility % Water in Oil (Maximum)	Characteristics Total mL Free Water (Minimum)	ASTM D-2711 mL Emulsion (Maximum)
MC-43	68	61.2-74.8	284-347	-15° F (-26° C)	1	80	2
MC-51	150	135-165	625-764	-10° F (-23° C)	1	80	2
MC-87	220	198-242	917-1121	-10° F (-23° C)	1	80	2
MC-21	320	288-352	1334-1631	0° F (-17.8° C)	1	80	2
MC-93	460	414-506	1918-2344	0° F (-17.8° C)	1	80	4
MC-71	680	612-748	2834-3465	10° F (-12° C)	1	80	4
MC-31	1000	900-1100	4169-5095	20° F (-6.7° C)	1	80	4

Figure 3. Examples of maintenance codes assigned for various lubricant tests

asked when considering the use of specifications is: "Do we need to consolidate our products?" According to the Pareto principle (80/20 rule), 80 percent of the lubricant volume in a plant should be concentrated in 20 percent of the individual products. Take a survey of the products and the volume used of each. If the results do not conform to the 80/20 rule, your plant might be a candidate for lubricant consolidation. In other words, if relatively equal volumes of many products are in use, duplication might exist.

Benefits and Disciplines of the Specification System

The most obvious benefit of the specification system is lower prices. This can be easily seen. What goes unseen is the high-quality products you obtain while forcing oil companies to compete. However, by instituting a specification system, plant maintenance people are compelled to learn what works and why. This may be a challenge in some plants.

The willingness to perform testing is critical. You do not need to have an onsite laboratory, but you must find a quality offsite lab. While a few tests can be performed onsite with inexpensive equipment, most require expensive equipment and a qualified technician. A few ways to reduce these costs are discussed below. These two disciplines — learning what works and why, and the willingness to conduct testing — are essential.

Intangible Benefits

When you have a "system" in place for purchasing lubricants, vendors tend to be more careful with your products' quality. Knowing that you test and won't hesitate to complain or have a bad load pumped out at their expense will keep everyone honest. Also, those vendors who live by "sharp" practices or high costs don't even bother to solicit your business. My personal experience has proven this to me repeatedly.

Testing

As mentioned previously, it is recommended to randomly test every truckload of bulk oil and drum shipments. The steel company did this because of the large volumes purchased. Tests are generally priced individually, and some are expensive. To lower costs, the steel company selected a few critical tests for each load and assumed the rest were OK. However, this may have been overkill. You could take a sample, label it and store it in case of future problems. As confidence in a vendor grows, this would be an acceptable practice.

Remember, buying lubricants by performance specifications puts lubrication on a professional base. Vendors would rather deal with people who understand lubricants and what makes them work. When the user's understanding increases, the vendor may see the need to increase his or her own knowledge.

In the last 20 years, various organizations have devised certification tests to evaluate vendor and user knowledge in the lubrication field. This effort has vastly improved the knowledge of everyone involved. Now vendors know that if a problem occurs, they will receive a rational hearing rather than a screaming, emotional response. Vendors become more service-oriented and better problem-solvers instead of mere order-takers.

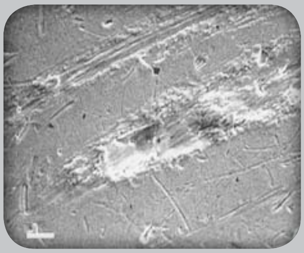
At the same time, customers become better problem solvers when they have records that show the important parameters have not changed. They must probe deeper to see if the problem might have been caused by something they did or did not do.

Finally, by concentrating on performance specifications, total fluid management (TFM) will take on a whole new dimension. If you choose to go this route, no longer will you be at the complete mercy of the TFM manager. The knowledge gained by focusing on the lubricant specifications will enable you to ask all the important questions and insist on critical reports.

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. Adhesive wear can be described as:



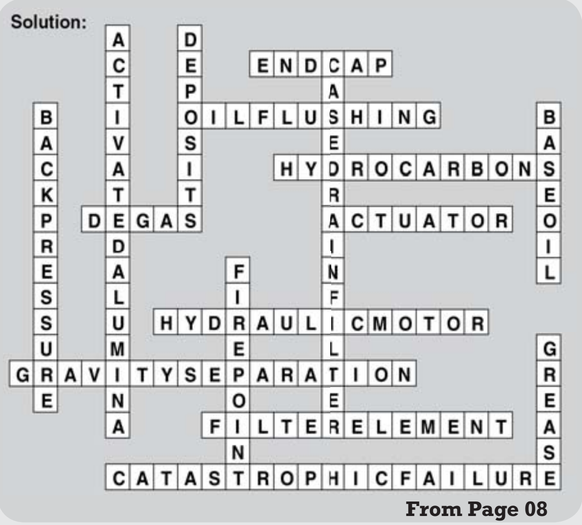
A) The adhesion of wear debris to a layer of varnish
B) The adhesion of a layer of oil to the metal surface
C) The transfer of silicon particles from one metal surface to another
D) The transfer of metal from one surface to another through a localized welding process
E) None of the above

2. Oil samples from an off-line (kidney-loop) filtration circuit should be taken:

A) Downstream of the pump, upstream of the filter
B) Downstream of the reservoir, upstream of the pump (before the pump)
C) Downstream of the filter
D) From the sump
E) From the drain plug

3. Compatibility of different greases:

A) Is only a minor issue and often can be ignored
B) Is a major issue that is dependent on the thickener used
C) Is independent of the thickeners used
D) Can be linked to the age of the grease involved
E) Is dependent only on the base oil used



From Page 08

Answers:

1. D
Other names for adhesive wear include galling, scuffing, seizing and severe sliding. Adhesive wear normally occurs during machine starts, loss of film strength and overload/overspeed conditions. Proper lubricant selection is essential to control this wear mode.

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

3. B
Compatibility of different greases is a serious issue that mainly depends on the thickener type. In general, most grease thickeners are incompatible, so extreme caution is required when switching from one grease type to another.

By Suzy Jamieson, ICML

World-Class RELIABILITY STARTS with a Solid Foundation

When it comes to developing, implementing and sustaining a reliability-improvement program, long-term success ultimately depends on a solid foundation. Indeed, it is the foundation that will determine whether the current initiative will be just another fad or actually achieve the results you have set out to accomplish. It is also important to know the elements that are in place will withstand the test of time and weather the storms that will inevitably come your way.

Sometimes we overlook the obvious. As a society, we invest considerable time and energy aiming for great heights yet often forget that crucial ingredient for making sure we do not fall flat on our faces once we have reached the top. In other words, you have to crawl before you can walk. No matter how great an idea seems in theory, it is a long, uncertain journey from design to actual results, especially for anything worthwhile.

As with most other things in life, you must start at the bottom. In the case of reliability programs, this means the hands-on personnel, the shop-floor staff or the technicians. They are the human foundation of any reliability-improvement program. Without them, their buy-in and a solid foundation of technical skills, no amount of reliability theory, philosophy or trendy gadgetry will make the program stand when it is shaken – and it will be shaken. After all, as any maintenance and reliability professional knows, things do not always go according to plan.

Be sure to value and respect the technicians and the crucial role they play in the outcome of any plant reliability-improvement program. It is in your best interest to recognize the direct impact they have on the culture change. Respecting and supporting them in their professional development and teaching them not only what they should or need to be doing but also why will make all the difference.

Common sense and mutual respect can go a long way, even in our plants. Give technicians a solid start by providing them

Benefits of ICML Certification

Quality certification programs not only can provide standards and guidelines for professional recognition but also a multitude of benefits for individuals, organizations and industry.

For Individuals

Earning an ICML certification acknowledges your expertise in machinery lubrication and/or oil analysis to troubleshoot and ensure reliability of lubricated equipment. The lubrication and oil analysis community, your employer, clients and peers will recognize your ICML credential as a symbol of the skills and knowledge you've gained through experience. ICML certification shows that you are a professional with the ability to successfully utilize machinery lubrication and/or oil analysis for your organization or client.

As an ICML-certified professional, you also receive the following benefits:

- Industry recognition of your knowledge and proficiency in machinery lubrication and/or oil analysis techniques.
- Logos and a certificate to enable you to identify your ICML-certified status to colleagues or clients.

For Employers and Organizations

Through certification, organizations can maximize their return on investment in oil analysis. ICML certification delivers the following benefits:

- A standardized method of determining training needs and measuring results
- A reliable benchmark for hiring, promoting and career planning
- Employee recognition and rewards that validate their expertise
- Improved employee ability to ensure machine reliability
- Quality assurance for outsourced oil analysis and lubrication services

For Industry

Certification brings much-needed credentials to an up-and-coming lubrication and oil analysis community. Benefits to the community include:

- Respect for oil analysis and lubrication professions
- Increased professionalism within the community

with the proper tools they need to succeed. This means ensuring they have the appropriate job description and pre-established procedures that are clearly taught and monitored through proper supervision.

The importance of skills development cannot be overemphasized. This will require technical training for tradesmen as well as operators, followed by an audit of their skill set, i.e., competency testing in the technologies they will utilize when monitoring the condition of your assets.

As you develop technicians to be future leaders within your program, new mentors will emerge. Empowering them with career potential and recognition of their worth and contributions to the overall health of the plant's reliability and availability will instill the pride everyone deserves in his or her professional role. Suddenly you will find yourself with in-house experts eager to make a difference. The intangible benefits you will see are the same as those experienced and documented by many world-class operations.

The crucial first step is to understand where you are currently. Establish your starting point, not only in relation to your practices and your team's skill level (be it in lubrication, for example, or other areas), but also where you aim to be, such as a benchmarked world-class parameter. Knowledge of the steps needed to get where you want to go is an obvious necessity, as is knowing where your limited resources are best spent – and everyone has limited resources. Ultimately, wherever your higher return-on-investment opportunity lies, that is where your focus should be.

To learn more about ICML's certification programs, please visit www.lubecouncil.org.

RECENT RECIPIENTS OF ICML CERTIFICATIONS

The International Council for Machinery Lubrication (ICML) would like to congratulate professionals who have recently achieved certified status through ICML's certification programs from exams conducted in India. ICML offers certification in the areas of oil analysis and machinery lubrication. The following is a list of recently certified professionals in the area of machinery lubrication who have attained their status as a certified Machine Lubricant Analyst (MLA), Machine Lubrication Technician (MLT).

ICML Certified From Lubrication Institute

Name	Company	Country	Certification
Ajay Suvarna	Petrolabs	India	MLA I, MLT I
Ajit Kumar Verma	Tata Steel	India	MLT I
Ashvin S.	Electro Kleen Systems	India	MLA I
Ayub Pasha Shaik	Predict Technologies India CP Ltd	India	MLA II
Baskaran Ramesh	Petrolube (T) Ltd.	India	MLA II
Charly George	Cirra Consultants Pvt Ltd.	India	MLA II
Ipsita Hota	Vedanta Aluminum Ltd	India	MLA I
K.N.V Subrahmanyam	Petrolabs	India	MLA II, MLA I, MLA III
M. Hussam Adeni	Petronum Trading	India	MLA I
Mohammad Sayeed Ansari	Raj Petro Specialities Pvt. Ltd.	India	MLT I
Palanisamy Duraisaamy	Excell B Enterprises	India	MLT I, MLA I, MLA II, MLT II, MLA III
Pooja Gropalkrishna Joshi	Gulf Oil Corporation Ltd	India	MLT I
Pradeep Nair	Atlas	India	MLA II
R. Ramesh Raja	Raj Petro Specialities Pvt. Ltd.	India	MLA I
Rajinder Negi	Petrolabs	India	MLT I
S. Janakiram	Petrolabs	India	MLT I
Saugata Roy	Tractors India Pvt Ltd	India	MLA I
Seemant Shripad Joshi	Schaeffler Group	India	MLA I
Shailender Prashad	Petrolabs	India	MLA II
Shantanu Das	Croda Chemicals	India	MLT I, MLA I, MLA II, MLA III
Somesh Sabhani	Gulf Oil Corporation Ltd	India	MLT I
Vedang Ghanashyam Bhagwat	Chem-Tech Laboratories	India	MLA II
Md. Feroje Alam	Chevron	Bangladesh	MLA II
Md.Sadeaque ul Islam	Chevron	Bangladesh	MLA II
Minhaj Uddin Ahmad	Chevron	Bangladesh	MLA II
Mohammad Baktier Uddin Chowdhury	Chevron	Bangladesh	MLA II
S.A.P.R. Jayathissa	Loadstar (Pvt) Ltd	Sri Lanka	MLA 1
Sattambiralalge Don Ishnath Sameera	Loadstar(Pvt)Ltd	Sri Lanka	MLT1, MLA1
Nitin. Prabhakar Desai	Enoc Lubricants & Grease Manufacturing Plant	U.A.E	MLA I
Venkatesan Narayanan	Yemen LNG Company Ltd.	Yemen	MLA II

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ANATOMY of an Oil Analysis REPORT

This is the fifth part of a series of "anatomy" lessons within *Machinery Lubrication*. In this issue, a specific device or object will not be dissected but rather the content provided in a typical oil analysis report, including how to interpret the data and other findings. These interpretations may decide either the cost or avoidance of machine failure and downtime.

Interpreting an oil analysis report can be overwhelming to the untrained eye. Oil analysis isn't cheap, and neither is the equipment on which it reveals information. Every year, industrial plants pay millions of dollars for commercial laboratories to perform analysis on used and new oil samples.

Interpreting an oil analysis report can be overwhelming to the untrained eye.

Unfortunately, a majority of the plant personnel who receive these lab reports do not understand the basics of how to interpret them.

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

What to Look for When Reviewing an Oil Analysis Report

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

Why Perform Oil Analysis

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

Fluid Properties

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

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

Contamination

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

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

Wear Debris

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

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

Ultimately, you need to know if any actions should be taken to keep the machine healthy and to extend the life of the oil. Oil analysis for machines can be compared to blood analysis for the human body. When a doctor pulls a blood sample, he puts it through a lineup of analysis machines, carefully studies the results and reports his conclusions based on his education, research and detailed questions asked to the patient. Likewise, with oil analysis, careful oil samples are taken, and elaborate machines yield the test results. Laboratory personnel interpret the data to the best of their ability, but without crucial details about the machine, a diagnosis or prognosis can potentially be inaccurate. Some of these important details include:

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

Oil Analysis Tests

For a standard piece of equipment undergoing the normal recommended oil analysis, the test slate would consist of "routine" tests. Alternatively, if additional testing is needed to answer advanced questions, these would be considered "exception" tests. Routine tests vary based on the originating component and environmental conditions but should almost always include tests for viscosity, elemental (spectrometric) analysis, moisture levels, particle counts, Fourier transform infrared (FTIR) spectroscopy and acid number. Other tests that are based on the originating equipment include analytical ferrography, ferrous density, demulsibility and base number testing.

The table above shows how tests are utilized in each of the three main oil analysis categories.

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

32%

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

Viscosity

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

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

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

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

Acid Number/Base Number

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

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

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

FTIR

FTIR is a quick and sophisticated method for determining several oil parameters including contamination from fuel, water, glycol and soot; oil degradation products like oxides, nitrates and sulfates; as well as the presence of additives such as zinc dialkyldithiophosphate (ZDDP) and phenols. The FTIR instrument recognizes each of these characteristics by monitoring the shift in infrared absorbance at specific or a range of wavenumbers. Many of the observed parameters may not be conclusive, so often these results are coupled with other tests and used more as supporting evidence. Parameters identified by shifts in specific wavenumbers are shown in the table above.

Elemental Analysis

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

particle sizes, with RDE limited to particles less than 8 to 10 microns and ICP limited to particles less than 3 microns. Nevertheless, they are useful for providing trend data. Possible sources of many common elements are shown in the table on the right.

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

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

Particle Counting

Particle counting measures the size and quantity of particles in the oil. Many techniques can be used to assess this data, which is typically reported based on ISO 4406:99. This standard designates three numbers separated by a forward slash providing a range number that correlates to the particle counts of particles greater than 4, 6 and 14 microns. To view an illustration of how different particle counts are assigned specific ISO codes, visit http://www.machinerylubrication.com/Read/29525/sample-new-oil.

Moisture Analysis

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

Interpreting Oil Analysis Reports

The first thing to check on an oil analysis report is the information about the customer, originating piece of equipment and lubricant (see Section A of the sample report on page 49). Including these details is the customer's responsibility. Without this information, the effectiveness of the report will be diminished. Knowing which piece of equipment the oil was sampled from affects the ability to identify potential sources of the measured parameters, especially wear particles. For example, the originating piece of equipment can help associate reported wear particles with certain internal components. The lubricant information can provide a baseline for several parameters, such as the expected viscosity grade, active additives and acid/base number levels. These details may seem straightforward but are often forgotten or illegible on the oil sample identification label or request form.

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

Section A

Customer Information
CUSTOMER A
123 Street
City, State
Zip Code
Attention : John Doe
Phone : 555-5555

Unit Information
Unit # : 6077
Component : DRUM
Location : LEFT
Manufacturer : LUBRICANT COMPANY
Serial # : JM6077
Model : 14CM15-1

Lubricant
Manufacturer : LUBRICANT COMPANY
Brand : SYNTHETIC
Grade : 320

Sample : 08/09-117

Lab Tracking # : 3519 - 18341

Oil Analysis
Suite 210, 9555 James Ave. S., Bloomington
Minnesota 55431, USA
Phone: 877 962 2400

Section B

Sample		Contaminants (ppm)			Wear Metals (ppm)												Additives (ppm)							
Sample Number	Sample Date	Sodium	Potassium	Silicon	Aluminum	Iron	Copper	Lead	Tin	Chromium	Nickel	Titanium	Silver	Vanadium	Antimony	Beryllium	Calcium	Zinc	Phosphorus	Magnesium	Molybdenum	Boron	Barium	Lithium
Ref. Sample	2012/04/25	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	383	0	0	30	0	0
08/09-117	2013/08/03	3	18R	138U	57S	518U	2	0	0	6U	10S	4	0	0	0	0	12	31	401	16	1	36	0	0
07/25-039	2013/07/19	3	13R	100U	42S	347R	1	0	0	4	6U	2	0	0	0	0	10	23	348	14	1	28	0	0
06/20-031	2013/06/13	2	12R	98U	39S	299R	1	0	0	4	5R	2	0	0	0	0	10	21	395	4	1	28	0	0
06/13-071	2013/06/03	2	10	75U	31U	208	1	0	0	3	4	2	0	0	0	0	9	16	381	4	1	26	0	0
05/23-040	2013/05/06	1	4	26	10R	69	0	0	0	1	1	1	0	0	0	0	7	4	362	1	0	29	0	0
03/25-022	2013/03/18	1	8	48R	20U	134	1	0	0	2	3	1	0	0	0	0	20	0	234	2	0	18	0	0

Section C

Sample Information								Physical Tests				Additional Tests				
Sample Date	Oil Mfr.	Oil Brand	Oil Grade	Comp. Service	Oil Service	Units	Oil Chg	Visc 40°C cSt	Visc 100°C cSt	Visc Index	Water %	TAN (mgKOH/g)	OPC Code	OPC 4u Count	OPC 6u Count	OPC 14u Count
Ref. Sample	Joy	SYN GEAR 320						320	34.78	154		0.85				
2013/08/03	Joy	SYN GEAR 320		711	205	Day	N	320	32.94	144	0.070U	1.01	27/24/17	1084879	105831	1172
2013/07/19	Joy	SYN GEAR 320		696	190	Day	N	317	34.50	153	0.061U	0.57	28/25/19	1785148	269817	3871
2013/06/13	Joy	SYN GEAR 320		660	154	Day	N	315	32.72	145	N	0.72	28/25/19	1909612	164867	3553
2013/06/03	Joy	SYN GEAR 320		650	144	Day	N	314	33.46	149	N	0.73	29/26/19	2728322	358187	3780
2013/05/06	CHE	MER	320	622	116	Day	N	316	32.49R	144	N	1.00	25/23/19	268557	65519	4843
2013/03/18	CHE	MER	320	573	67	Day	N	238U	19.47U	93	N	0.59	27/25/20	984022	221635	9336

Section D

Results
2013/08/03 Water can cause dramatic reductions in component life. Also, note the flagged elements Aluminum, Nickel, Silicon, Iron, Chromium and Potassium.
Additive levels indicate a mixture of lubes in use.

2013/07/19 Water can cause dramatic reductions in component life. Also, note the flagged elements Aluminum, Silicon, Nickel, Potassium and Iron.

2013/06/13 Aluminum, Silicon, Potassium, Iron and Nickel above acceptable limits.
Some tests have been performed at another Fluid Life lab. If you have any questions, please call the lab.

2013/06/03 Silicon and Aluminum above acceptable limits.

2013/05/06 Note Viscosity at 100°C and flagged element Aluminum.

2013/03/18 Silicon and aluminum indicate a presence of dirt, which may lead to an increase in wear metals.

Recommendations
2013/08/03 Inspect/Troubleshoot. This is the fourth time this unit has been alerted. There has been no respose to the previous three alerts. The current sample is showing high levels of dirt / dust contamination (silicon = 138 ppm, aluminum = 57 ppm), severe levels of nickel (10 ppm), unacceptable levels of iron (518 ppm), chromium (6 ppm) and water (700 ppm) and reportable potassium (19 ppm). Determine the source of dirt / dust and water ingression into the system (compromised breathers, leaking seals, improperly secured fill-caps, etc.). Inspect to determine the source and severity of wear (gear teeth, bearings, shafts, etc), followed by drain and flush to remove abrasive particle content. Resample in 100 hours to monitor.

2013/07/19 Inspect/Troubleshoot. High levels of dirt / dust contamination (silicon = 100 ppm, aluminum = 42 ppm), unacceptable nickel (6 ppm) and water contamination (610 ppm) and reportable potassium (13 ppm) and iron wear (347 ppm). Inspect for sources and severity of wear (gears, shafts, bearing, etc). Determine the source of dirt / dust and water ingression into the system (compromised breathers, leaking seals, improperly secured fill-caps, etc.). Once appropriate action has been taken drain and flush to remove abrasive particle content. Resample in 100 hours to monitor.

Key: Y - Yes N - Negative P - Positive R - Reportable U - Unacceptable S - Severe I - Insufficient Sample > - More Than < - Less Than

Results relate only to the samples tested, all testing is done at the above address unless stated. This is presented in abbreviated format. Additional information is available upon request. The Fluid Life Corporation shall not be liable for any loss of profits, business, damages, or fitness of purpose, related to this oil analysis report and recommendations. Version - 1 Page 1 of 2

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

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

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

Another section of the oil analysis

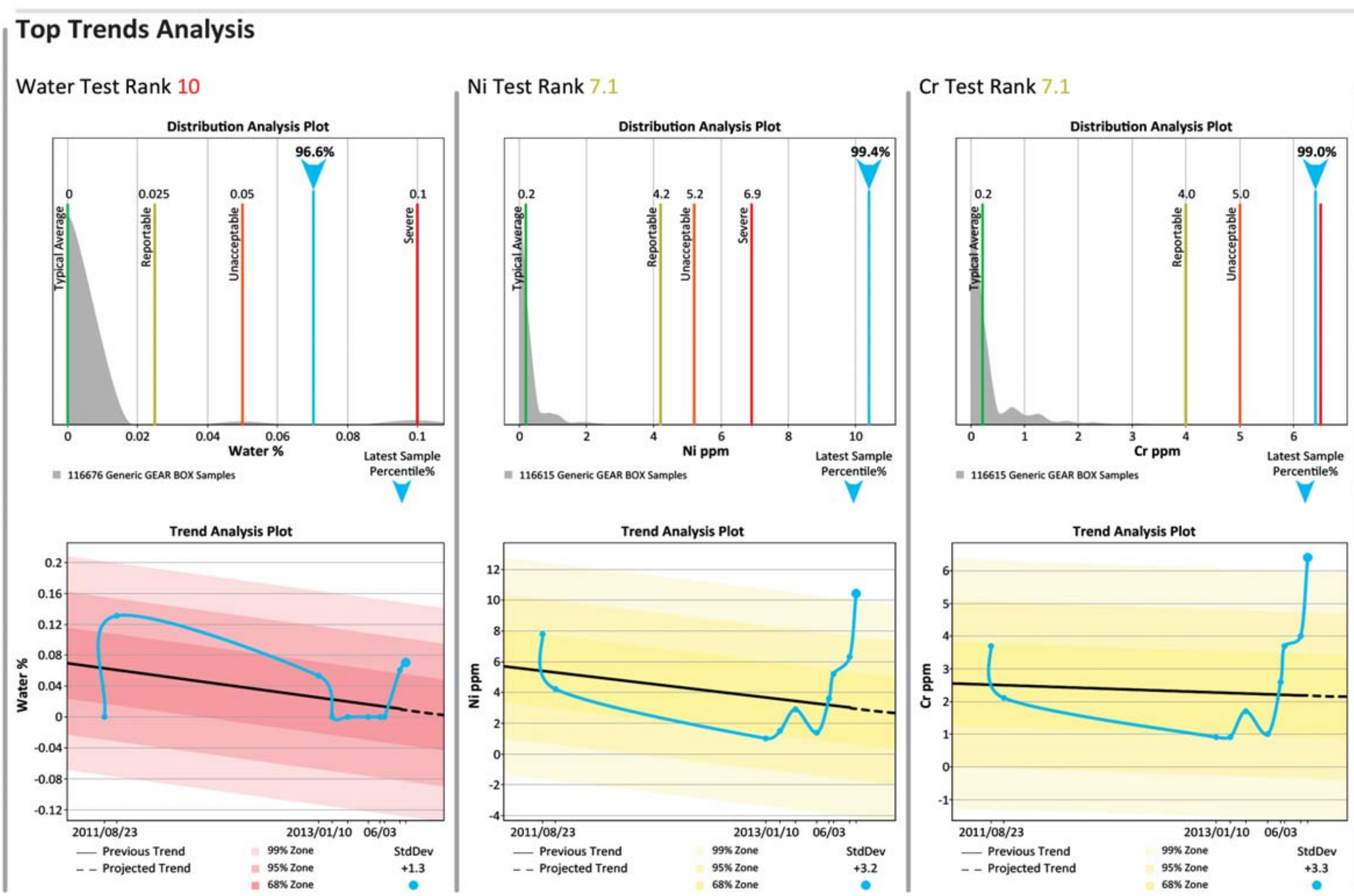
report presents previously identified sample information from the customer such as oil manufacturer, brand, viscosity grade and in-service time, as well as if an oil change has been performed. This is important data that can provide an explanation for what could be false positives in alarming data changes.

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

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

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

The last section of the oil analysis report generally provides written results for each of the final few test samples along with recommendations for required actions. Typically, these recommendations are entered manually by laboratory personnel and based on information provided by the customer and the data collected in the lab. If there is an explanation for the data that stems from something not explicitly stated by the customer, the results must be reinterpreted by those familiar with the machine's history of environmental



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

SELECTING OIL ANALYSIS TESTS BY APPLICATION

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

***Gas compressors only ** Air compressors only ***For phosphate ester fluids, consult the fluid supplier and/or turbine manufacturer.**

R = Routine testing

E = Exception test keyed to a positive result from the test in parentheses

and operating conditions. Understanding the information given here is critical. Remember, there is always an explanation for each exceeded limit, and the root cause should be investigated.

In addition to the raw data shown throughout the oil analysis report, graphs can help illustrate notable trends in the data. Below is an example of trended data points from analyzed data, with the water test having the most notable unfavorable spike. Along with the trend data, graphs should show typical averages, warning (marginal) limits and alarm (critical) limits. These limits should be modified depending on the type of data collected, the type of lubricant and the machine's known operating conditions.

Standard alarm limits will be set by the oil analysis laboratory. However, if there is any reason to adjust these limits higher or lower, they should be identified properly. Examples of limits that should be lowered would be those for highly critical assets or assets that are consistently healthy. A small spike in data would be cause to run an exception test or an immediate second sample for analysis. In such cases, a second sample would ensure the data received is representative of the oil conditions and not simply a human error in sampling or analysis. If exception tests are needed, the chart above shows which tests would be appropriate when a given routine test limit has been exceeded.

About the Author

Bennett Fitch is a technical consultant with Noria Corporation. He is a mechanical engineer who holds a Machine Lubricant Analyst (MLA) Level II certification and a Machine Lubrication Technician (MLT) Level II certification through the International Council for Machinery Lubrication (ICML). Contact Bennett at bfitch@noria.com.

Mobil SHC™

Where industrial productivity begins℠

SHANKAR KARNIK

Asia Pacific Mobil SHC Brand MANAGER, EXXONMOBIL LUBRICANTS PVT. LTD.

In conversation with Machinery Lubrication India

Q1. How do you see the Mobil grease market in India?

The Mobil Industrial Lubricants' product portfolio in India is well positioned to support the economic and industrial growth taking place in the country. We have an excellent balanced portfolio of state-of-the-art, well proved, high-performance lubricants that can cater to the needs of many industrial market sectors - including power generation, general manufacturing, plastics, food and beverage, pulp and paper, metals, cement, construction and mining - all backed by ExxonMobil's technology leadership & unmatched industry expertise. Customers rely on ExxonMobil because of the quality of our products, our reliability, technological excellence and close association with many leading original equipment manufacturers and builders. Our products have demonstrated the ability to withstand performance stresses and are backed by technical services designed to provide customers with smooth operations.

Q2. What is your product portfolio & do you have any plans to increase your portfolio for the steel sector in particular in India?

We offer a comprehensive range of greases that are each expertly formulated to meet the demanding operating conditions often found in steel mills. From gearboxes and bearings to U-joint shafts and hydraulic systems, Mobil Industrial Lubricant offers a solution for every process and equipment in a steel mill — each one formulated to offer outstanding protection and oil life

Our comprehensive line of synthetic and premium lubricants for iron and steel machinery includes

- Mobil SHC 600 ,Mobil SHC Gear, Mobil Rarus SHC 1000 air compressor oils, Mobil Vacuoline 100 circulating system oils for plain bearings in rolling mills and Mobil Vacuoline 500 heavy-duty circulating oils for No-Twist Rod mills

Among greases we have:

- Mobil SHC Polyrex™––a family of high-performance bearing greases that are capable of delivering exceptional equipment protection even under temperatures as high as 170 degrees Celsius.
- Mobilith SHC™– – synthetic high-temperature greases for use in plain and rolling element bearings, kiln roller bearings and in slag transfer rail car bearings, grease filled industrial gear cases subject to high temperatures, where conventional semi fluid greases will not provide acceptable lubricant life and in non-driven heavy-duty truck trailer wheel hubs

And our premium range includes:

- Mobilgrease XHP – multipurpose lithium complex grease developed for a wide variety of applications and severe operating conditions common in the steel sector
- Mobil Centaur XHP™ – a family of calcium sulfonate greases that deliver a balanced combination of water washout and water spray-off resistance, as well as excellent corrosion protection in these severe wet environments, making them ideal for steel and mill equipment.

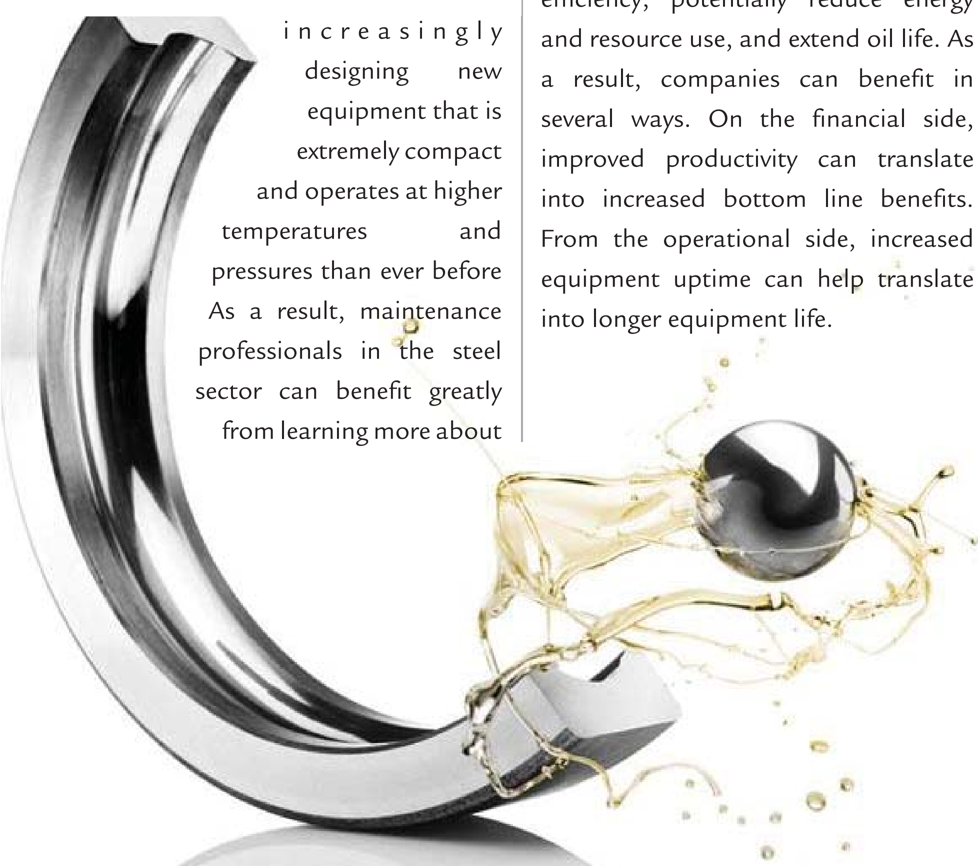
Besides our comprehensive line-up of lubricants and greases, we offer a range of valuable services to our customers to help ensure they can fully realize the benefits our products offer and, equally important, so they can help avoid common issues. ExxonMobil engineers have the technical experience and skills to help our customers maximize their productivity, reduce maintenance costs and increase the operational efficiency of their equipment.

Our range of PES (planned engineering services) includes lubricant evaluations and audits, equipment checks, and more.

- Signum used oil analysis and interpretation
- Hydraulic system inspections
- Grease training on application and use
- Centralized grease system analysis and optimization
- Troubleshoot services

Q3. What kind of productivity levels do you expect your products to deliver for machines particularly in the steel sector?

Today, industrial equipment manufacturers are increasingly designing new equipment that is extremely compact and operates at higher temperatures and pressures than ever before As a result, maintenance professionals in the steel sector can benefit greatly from learning more about how to choose the right grease that will deliver the performance they need to protect their equipment over the long haul.



We specifically design our iron and steel mill oils and greases to meet or exceed industry and original equipment manufacturers' expectations.

Our products are thoroughly tested before they are commercialized, and as a result, they are formulated to meet global quality standards and are compliant with rigorous ExxonMobil management systems for manufacturing, customer service, laboratories, safety, health, and the environment.

For companies in the steel sector, our line-up of Mobil-branded greases is designed to deliver a number of key benefits. These include helping to increase equipment operating efficiency, potentially reduce energy and resource use, and extend oil life. As a result, companies can benefit in several ways. On the financial side, improved productivity can translate into increased bottom line benefits. From the operational side, increased equipment uptime can help translate into longer equipment life.

From a health/safety standpoint, using appropriate Mobil-branded greases that deliver long-lasting performance can help minimize oil consumption and reduce the amount of time maintenance personnel need to conduct oil changes.

All of these benefits go hand-in-hand. And that's why ExxonMobil works so closely with the world's leading equipment manufacturers. To ensure our greases deliver the optimum performance for their intended applications and that we deliver the highest level possible of application expertise.

Q4. How do your products depict Energy efficiency?

Energy efficiency is a key issue for companies in the manufacturing sector. Obviously, from an operating and financial perspective, reducing energy usage can have a positive impact on a company's bottom line.

Also, minimizing energy consumption can help companies demonstrate to their partners and customers that they are committed to sustainable practices.

I am proud to say that the latest additions to our flagship Mobil SHC line of synthetic industrial lubricants not only deliver exceptional, long-lasting performance and protection, they also feature valuable energy efficiency benefits. The latest additions to our Mobil SHC family include the next generation of our popular Mobil SHC 600 Series of synthetic, circulating lubricants, and the Mobil SHC Gear Series, a family of supreme performance synthetic, industrial gear oils.

In controlled laboratory gearbox testing and statistically validated field tests at

customer locations, these Mobil SHC synthetic lubricants were shown to deliver energy savings of up to 3.6 percent when compared with conventional oils.

Based on these exceptional results, these oils have earned ExxonMobil Fuels, Lubricants & Specialties Marketing Company's official designation for "Energy Efficient" industrial lubricants. They will now feature ExxonMobil Fuels, Lubricants & Specialties Marketing Company's proprietary "Energy Efficiency" logo on product packaging.

This Energy Efficiency logo is a visible statement that users can easily recognise and be confident that they are purchasing and using ExxonMobil's potentially energy-saving industrial lubricant technology.

With the outstanding balanced performance and additional energy efficiency benefits that Mobil SHC Gear and Mobil SHC 600 lubricants deliver, we can help our customers maximize their productivity and bring them closer to achieving their sustainability goals.

Q5. How much do you think the steel industry grow in India and in turn help your growth?

The steel sector is one of the key industries of the national economy, and effectively supports the smooth and quick development of national economy.

We specifically design our lubricating oils and greases for the iron and steel mill to meet or exceed industry and original equipment manufacturers' expectations. Thoroughly tested before they are commercialized, Mobil Industrial Lubricants meet global quality standards and are compliant with rigorous ExxonMobil management systems for manufacturing, customer service, laboratories, safety, health, and the environment. From continuous steel casting, to steel plate rolling, to cranes - products must deliver in harsh environments like high temperatures, heavy workloads and pollution. Mobil oils are designed to provide outstanding performance that exceeds industry expectations and ensures sustained reliability of equipment at peak performance under all environments

ExxonMobil shares the industry's commitment to meeting the demand for steel in a safe, sustainable way, offering innovative products and services that help drive business solutions and progress. Many of Mobil Industrial's machine oils can help contribute towards reduced energy consumption and resource use through

- improved energy efficiency
- long oil life
- extended equipment life

ExxonMobil has a Steel Sector Global Marketing Program to meet the growing needs of Indian industry. As part of this program, ExxonMobil offers its customers in the steel sector a comprehensive line-up of advanced technology lubricants and greases along with its application expertise and technical support. Moving beyond offering highly advanced products, ExxonMobil seeks to provide the Indian steel sector a seamless customer experience with a complete package of lubricants solutions and services for unsurpassed production efficiency and productivity

In India we continue to expand our footprint and our field engineering services organization by deploying more engineers on ground so as to be able to reach out to more and more customers. We continue to evaluate the market and when a critical mass is achieved, we will plan additional investments potentially in breaking water facilities.

DHIREN SHAH

BASE OIL REPORT

Crude oil prices were at an all time low in Asia early Monday with the market waiting for cues on events in the Ukraine and the outlook from the Fed later this week. On the New York Mercantile Exchange, U.S. crude oil for delivery in July traded at $101.60 a barrel, up 0.01%, after settling at at $101.58 a barrel by close of trade last week. New York-traded crude oil futures edged higher on Friday, amid indications that the U.S. economy is shaking off the effect of a weather-related slowdown over the winter. Meanwhile, heightened tensions between Russia and Ukraine remained in focus, amid concerns over a disruption to supplies from the region. The conflict between pro-Russian separatists and Ukrainian forces continued on Friday, stoking fears that the crisis will further develop and drag the U.S. deeper into the standoff. The July Brent oil contract rose 1.69% or $1.86 a barrel on the week, amid growing concerns over a disruption to supplies from Libya. The spread between the Brent and the WTI crude contracts stood at $8.17 a barrel by close of trade on Friday, compared to $7.90 in the preceding week.

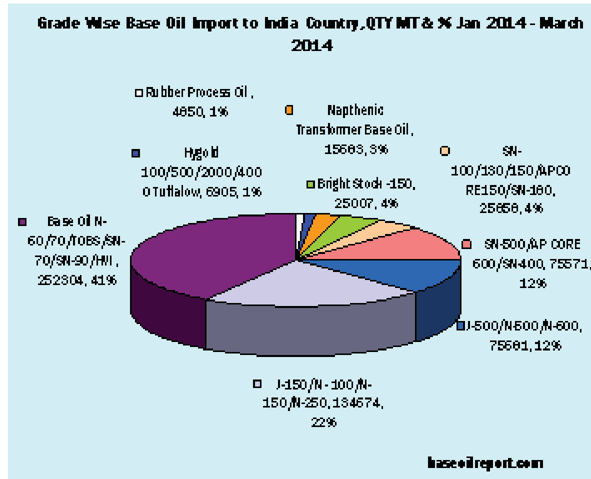
The Third Base Oil & Lubes Middle East Conference 2014 was held at Intercontinental Dubai Festival City, Dubai on 16-17 April 2014 which was jointly organized by Conference Connection & Petrosil Group and Hosted by ENOC. Eminent speakers & Co Chairmen like Mr. Mohammed El Sadak(ENOC Marketing LLC, UAE), Dr Nadim Najim(Al Khaja Holding, UAE),Ms Geeta Agashe(Kline Group, USA), Dr. Henderson(K& E Petroleum Consulting, USA) Dr. Valentina Serra-Holm(Nynas AB, Sweden), Dr.Suhair Abdelhalim(Ford Motor Company, UK), Mr. Bhaskar Mukherjee(Chevron Oronite S.A,UK) and others delivered their presentation on various aspects of the base oils, additives & technology. The Conference was successful and well attended by base oil producers, exporters, importers, additive manufacturers, storage companies, OEM's, consultants,, etc

The Indian domestic market Korean origin Group II plus N-60–70/150/500 prices at the current; level is steady. As per conversation with domestic importers and traders prices have inched up for N – 60/ N- 150/ N - 500 grades and at the current level are quoted in the range of Rs. 60.50 – 60.70/61.70 – 62.10/64.10 - 64.25 per liter in bulk respectively with an additional 14 percent excise duty and VAT as applicable, no Sales tax/Vat if products are offered Ex-Silvassa a tax free zone. The above mentioned prices are offered by a manufacturer who also offers the grades in the domestic market, while another importer trader is offering the grades cheaper by Rs.0.25 – 0.35 per liter on basic prices. Light Liquid Paraffin (IP) is priced at Rs. 61.60 – 62.05 per liter in bulk and Heavy Liquid paraffin (IP) is Rs. 66.05 – 66.20 per liter in bulk respectively plus taxes extra.

Approximately 9381 MT of Light & Heavy White Oil has been exported in the month of March 2014 from JNPT, Mundra, Raxaul LCS, and Chennai port. Compared to last month i.e. February 2014, exports of the country have gone up by 20% in the month of March 2014. It has been exported to Argentina, Algeria, Australia, Bangladesh, Bulgaria, Brazil,

Month	Group I - SN 150 Iran Origin Base Oil CFR India Prices	N-70 Korean Origin Base Oil CFR India Prices	J-500 Singapore Origin Base Oil CFR India Prices	Bright Stock - 150 CFR India Prices
January 2014	USD 915 – 925 PMT	USD 1000 – 1005 PMT	USD 1035 – 1045 PMT	USD 1095 - 1100 PMT
February 2014	USD 915 – 925 PMT	USD 985 – 990 PMT	USD 1020 – 1025 PMT	USD 1065 - 1070 PMT
March 2014	USD 935 – 945 PMT	USD 990 – 995 PMT	USD 1030 – 1040 PMT	USD 1080 – 1085 PMT
April	USD 960 - 970	USD 1025 - 1035	USD 1060 - 1070	USD 1130 - 1150
	Since January 2014, prices jumped up by USD 45 PMT (5%) in April 2014	**Since January 2014, prices has marked up by USD 25 PMT (2%) in April 2014**	**Since January 2014, prices has gone up by USD 25 PMT (2%) in April 2014**	**Since January 2014, prices has increased by USD 45 PMT (4%) in April 2014**

GRADE WISE BASE OIL IMPORT	QTY. in MT	%
J-150/N-100/N-150/N-250	75681	12
Base Oil N-60/70/TOBS/SN-70/SN-90/HVI	134674	22
SN-500/AP CORE 600/SN-400	25858	4
J-500/N-500/N-600	75571	12
SN-100/130/150/APCORE 150/SN-180	25007	4
Bright Stock- 150	15683	3
Naphthenic Transformer Base	6905	1
Rubber Process Oil	4850	1
Hygold 100/500/2000/4000		



Cambodia, Chile, Dominican Re, Canada, Djibouti, Ecuador, Egypt, Germany, Ghana, Hongkong, Indonesia, Ivory Coast, Israel, Italy, Jordan, Kenya, Malaysia, Mauritius, Myanmar, Nepal, Newzealand, Nigeria, Pakistan, Peru, Philippines, Poland, Russia, South Africa, Senegal, Spain, Srilanka, Sudan, Taiwan, Tanzania, Thailand. Turkey, UAE, UK, Ukraine, Vietnam, Yemen and Zaire.

Approximately 3345 MT of Transformer Oil has been exported in the month of March 2014 from JNPT and Chennai port. It has been exported to Bangladesh, Brazil, Malaysia, Iran, Newzealand, Oman, Paraguay, Morocco, Indonesia, South Africa, Srilanka, Saudi, Philippines, Thailand, Vietnam, and UAE.

About the Author

Dhiren Shah is a Chemical Engineer and Editor – In – Chief of Petrosil Group