Machinery Lubrication

India November - December 2015

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INSIDE

5 Ways to Reduce Lubricant Spending

How to Get the Most from Your Particle Counter

Innovative Ways to Transform Your Lube Room

NORIA

VAS TRIBO
Solutions Unlimited

Contents

Machinery Lubrication India
November-December 2015

Publisher's Note

Our Machinery Lubrication India feature story focuses on Lube rooms, at present an essential part of industrial lubrication. As companies realize that lubrication management is essential to maintaining a lean environment, they note that savings can help take the place of revenue. This is especially so when considering the bottom line. It follows, that maintaining a world class lube room is the first place to consider the opportunities for savings over any length of time.

We focus on best lube room practices through case studies of companies which handled their lube rooms in real time. The ideal lube room is outlined across a few scenarios to show how companies across the globe handled it for themselves. All insisted on cleanliness standards being rigorously maintained. Needless to say, the clean lube room is at the core of financial savings for the company concerned. The benefits accrue through less than, or zero contamination-related equipment failures.

Topics dealt with in the last issue have drawn thankful response from professionals and corporates. Most queries were regarding oil analysis and condition based oil changes. The decision as to when to change the oil, we hope, is now made easier. Special tests are now clear and defined, while the all important factor of unnecessary cost avoidance and additional benefits have been outlined. All that remains is their implementation.

The best benefits are returns on investments. Most articles in Machinery Lubrication India of a technical nature help indicate improved style of operations. With the right lubrication solutions companies can create opportunities for themselves to increase productivity and energy efficiency. This last can only improve environmental concerns.

At hand is out tribology knowledge through lubrication management programs towards selection and monitoring.

Warm Regards,

Udey Dhir

JIM FITCH, NORIA CORPORATION

5 Ways to REDUCE Lubricant SPENDING

Lubricant procurement is not the largest expenditure in a typical maintenance budget. However, it is viewed as a real, tangible expense that is frequently targeted for cost reduction. When it comes to lubricants, it is unwise to pretend to save money by "buying cheap." Lubricants are the lifeblood of your machinery. Your machines' life expectancy depends largely on the quality and state of these lubricants to bathe heavily loaded frictional surfaces. Optimum reliability and lubrication must go hand in hand.

Now that you are aware of the perils of poor-quality lubricants and lubrication, let's take a look at the many opportunities to reduce lubricant spending without compromising reliability. Start by writing a simple lubricant specification for each machine. Don't rely solely on the recommendations of the equipment supplier or service manual. Instead, be bold and challenge generic or generalized statements relating to viscosity and lubricant formulation.

Once again, there is a need for caution. I'm not suggesting willy-nilly lubricant changes in an effort to enhance reliability by trial and error. There is always risk associated with changing lubricants. Smart practices, though, can quickly overcome these dangers. Risk should be respected but not feared.

The lubricant specification should be aligned with the optimum reference state for machine reliability. In constructing this specification, you should understand machine failure modes and overall machine criticality as a foundation to defining a machine's precise lubricant needs. There is a vast number of lubricant types available from both major and independent suppliers. Navigating the maze of options can be daunting but often very worth the effort. Find help if needed.

Reducing lubricant spending requires change and initiative. For many organizations, the low-hanging fruit is obvious. Below are five effective strategies for reducing your annual lubricant spending.

1. Precision Optimum-life Lubricant Selection

Optimum means optimum. Don't overspend and most definitely don't underspend. Resist the lure of cheap oil. Attempting to save money by buying economy-formulated lubricants for the

Reducing lubricant spending **requires change** and initiative.

wrong application is hazardous. Likewise, don't be trapped by the false promise of forgiveness. It is equally hazardous to attempt to remedy bad lubrication practices by buying expensive premium lubricants.

Beware of small differences. Selecting an optimum lubricant for a machine application is an engineering process. Small differences in lubricant performance can translate into huge differences in machine reliability and lubricant cost. Don't choose any lubricant; seek the optimum. Be conservative with the number of lubricants in your plant, though. Reduce the number of lubricants in your storeroom to a comfortable and efficient few. The number and range of lubricants you need will depend heavily on the types of machines and their operating environment.

Long-life lubricants in the right application make a lot of sense. They extend drain intervals and lower the cost and risk of premature lubricant failure. Selecting a long-life lubricant can reduce oil consumption in many cases by more than 50 percent. Still, it is important to be prudent. Don't invest in long-life lubricants for an application where they have to be changed frequently for other reasons (e.g., contamination) or where excessive leakage can't be controlled.

2. Proactive Lubricant Life Extension

In normal service, lubricants age over time in a linear fashion. Eventually, they die due to additive depletion or other causes. However, life expectancy is not only related to the quality of the lubricant but also to the type and extent of in-service exposures. The most destructive exposures are contaminants such as heat, air, moisture and water. This has been discussed extensively in the pages of *Machinery Lubrication*. Most users dismiss the opportunity to make practical exposure changes and enhance machine reliability and lubricant life. This is a pity

	GEAR OIL	HYDRAULIC FLUID	TURBINE OIL	MOTOR OIL	TOTAL
Current Annual Spending	$70,000	$120,000	$180,000	$40,000	$410,000
1. Precision Optimum-life Lubricant Selection	-$15,000	-$5,000	-$21,000	-$4,000	-$45,000
2. Proactive Lubricant Life Extension	-$13,000	-$3,000	-$12,000	-$3,000	-$31,000
3. Optimizing the Relube Interval	-$6,000	-$15,000	0	-$5,000	-$26,000
4. Reducing Package Waste	-$1,200	-$2,200	0	0	-$3,400
5. Reducing Leakage	-$500	-$22,000	0	0	-$22,500
Optimized Annual Spending	$34,300	$75,800	$147,000	$28,000	$285,100
Percent Cost Reduction	51%	37%	18%	30%	30%
Annual Savings	$35,700	$44,200	$33,000	$12,000	$124,900

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because contamination control often constitutes the easiest and most certain savings opportunities. Go with what works.

Exposures also relate to topping up a machine that contains remnants of an aged lubricant with a new lubricant. When new lubricants are mixed with oxidized, degraded oils, they quickly degrade. You could say old, damaged lubricants are infested with diseases that can rapidly infect the new incoming lubricants.

In many cases, additives in an aged lubricant should be reconstructed. Rather than disposing of all the oil and then replacing it, a far more economical approach would be to only replace the offending degraded additive. Although this practice may bring criticism from lubricant marketers, there are reputable companies that can help make good science-based decisions.

3. Optimizing the Relube Interval

Don't change a lubricant too soon or too late. Many lubricants are changed using regimented practices or simple guesswork. This is usually the case with automotive oil and filter changes. It is also true with the vast majority of industrial lubricant applications. Frequently, lubricant sumps are purged and recharged far too soon. Use oil analysis as your metric to optimize the interval and avoid premature disposal of an expensive commodity. For instance, if the oil is analyzed at the end of a typical service interval and the remaining useful life (RUL) is found to be 75 percent, extend the interval for the next drain and charge. Keep fine-tuning the interval until an optimum interval is established with reasonable margin for error.

Many machines should not be subject to interval-based oil changes at all. Instead, their lubes should be changed "on condition" and only when there is a true need. Let the oil tell you when it needs to be changed, not the calendar. Condition-based oil changes make the most sense for large sumps of expensive lubricants and/or those requiring periodic top-ups.

42%

of lubrication professionals say performance specifications are the factor that most influences their lubricant purchases, according to a recent survey at MachineryLubrication.com

In certain applications, grease lubrication can also be optimized from the standpoint of the relube frequency and amount. This can be done using grease analysis (with proper sampling) but also by inspecting used grease in bearing and motor rebuilds. The amount and condition of the grease in these bearings can offer insightful information for optimizing the relube interval and volume.

4. Reducing Package Waste

Many lubricants sold in drums and packages fail to get fully consumed. Frequently, unused lubricant is left behind in the package. Various strategies can help to minimize waste oil, including using smaller packages or bulk oil. These tactics should be optimized for the machine or group of machines in which the lubricant is used.

Another culprit of waste is the top-up container. These small containers that are carried to the point of lubricant application are often partially full when they are set aside. The oil left in the container is later questioned regarding its type and condition. This doubt commonly leads to the oil being dispensed into a waste oil container. To prevent this from occurring, make it a practice to label the condition and grade of top-up residuals.

5. Reducing Leakage

Leakage control makes good sense for a number of reasons. Not only are there lubricant consumption savings but also reliability and safety benefits. Don't turn a blind eye to leakage; address it early. Avoid Band-Aid fixes, and instead seek permanent and complete solutions.

The table on page 3 offers a hypothetical example of the potential for reducing lubricant consumption and overall annual lubricant spending. The opportunities vary considerably depending on the current amount of waste and inefficiency in your plant. If you are uncertain of your potential for savings, hire a specialist to perform an assessment that benchmarks your current practices to the optimum reference state (best practice).

As previously stated, it's not necessarily about buying cheaper lubricants but rather the optimum selection of lubricants and a proactive strategy for reducing lubricant consumption. Once these efficiencies are put in place, the savings you gain will recur each year, resulting in a nice annuity with minimal effort and investment. ■

About the Author

Jim Fitch has a wealth of 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.

Innovative Ways to Transform Your Lube Room

As part of its annual Lube Room Challenge, *Machinery Lubrication* once again asked readers to submit exceptional lube rooms that incorporate best-practice features. Several readers were proud to show how their lubricant storage and dispensing methods have been transformed. The following entries illustrate how a properly designed lube room marks an important step in the journey toward lubrication excellence.

AGCO Brazil

AGCO is a global agricultural machinery manufacturer with five factories in Brazil that produce tractors, combines, sprayers and implements. The maintenance department in Canoas had the goal of increasing the availability and reliability of its equipment machining and assembly line as well as reducing machine downtime, especially those stoppages caused by lubrication failure.

In 2012, it was apparent by the condition of the lube room that something needed to be changed. It was common to see unmarked oil drums, grease drums without lids and mixing of different types of lubricants caused by a lack of identification on packaging. Lubricant consumption was also high, as many oil changes were made to compensate for the cross-contamination occurring in the lube room.

In early 2013, after an analysis of the maintenance group and an audit of the lubricants in use, an action plan was developed to implement best practices and training of the lubrication staff. This would lead AGCO Brazil to a model of world-class lubrication.

The organization's team of lube technicians received training on lubrication practices, which enabled these professionals to perform tasks with the highest quality standards. A new lube room was built to solve the problems of contamination and lubricant blending while also improving cleanliness.

The current lube room incorporates storage tanks with a filtering system to ensure a higher oil cleanliness level along with color-coding to identify lubricants and storage containers to prevent the mixing of different lubricant types. Every machine's lubrication point also has a nameplate that indicates the correct lubricant for each application.

Today, oil sample reports show that the contamination problems have been resolved. Oil consumption has also decreased, as it is no longer necessary to change oil prematurely. This allowed AGCO to achieve a cost savings of $30,000 in 2013.

The previous lube room had several sources of oil contamination.

AGCO's new lube room offers access control.

An absolute filtration system was designed to improve the oil cleanliness level.

The current storage system employs color-coding.

Compass Minerals

Over the past 18 months, Compass Minerals' division in Ogden, Utah, has put considerable time and money into creating a best-practice lube storage and dispensing building as well as in taking oil samples and attaching color-coded lube identification tags to each piece of equipment. The company is now seeing great results from its efforts and has even noticed a change in its employees.

Compass Minerals began its journey by formulating a plan and obtaining management buy-in. Starting from the ground up, the approach involved training technicians, developing lube routes, incorporating air breathers, purchasing new lubricant/oil-handling containers, and constructing a new lubrication building with storage racks and a filtration system.

After the new lubrication building was completed, an open house was held and daily training was provided for two weeks. This was intended not only to celebrate the opening of the new lube room but also to allow all maintenance and operations personnel to see and learn about the new building, including how and where to get oil/grease and why oil cleanliness is so important. Noria's "Lubrication Basics for Machinery Operators" video was shown as part of the training.

In 2015, Compass Minerals plans to have new color-coded grease-fitting protector covers and oil sample ports installed on all equipment. The company is committed to maintaining a world-class lubrication system and has already started seeing cost savings/payback, which is expected to continue for years to come. The employees are excited to see what the future holds.

Previously, there was no filtration of oils.

Cross-contamination had been a problem for Compass Minerals with its old oil-handling containers.

Now all oil is filtered at least twice and sometimes three times.

Compass Minerals' old lube building was not secure or organized.

The first-in/first-out method is now used for storing oil drums.

The new lube building provides more security and temperature control.

Indiana-Kentucky Electric Corp.

When beginning its lubrication program, the Indiana-Kentucky Electric Corp. (IKEC) in Madison, Indiana, had an old lube room that was dusty, dirty and wet when it rained. Cross-contamination was widespread. There were no desiccant breathers, and the same pumps were used to remove oil from all drums. The manual dumping rig also presented a safety hazard.

In addition, there were no methods for managing inventory or rotating the stock of lubricants. Greases were stored wherever they were used and not according to best practices. Miscellaneous filters, parts, etc., were also stored in the lube room.

At one point, IKEC had 177 drums of oil, some of which were 10 years old. There were also more than 1,600 tubes of grease, which would have been enough to grease the company's equipment for 40 years. Obviously, no lubricant consolidation or just-in-time procurement methods were being utilized.

With the company's flue-gas desulfurization facility coming online along with all of its new equipment, there was no place to store lubricants. By working with its oil supplier, IKEC was able to reduce its inventory to 50 oil drums. It also consolidated greases and other lubricants where possible.

Reducing its inventory by 60 percent allowed IKEC to make a number of modifications to its lube room. A heating, ventilation and air-conditioning (HVAC) system was added to maintain a climate-controlled temperature of a constant 72 degrees. A filtration system with 16 filtering compartments, tanks and dispensers was also purchased. Upgrades were made to the room's electrical system, lighting, flooring and drum storage racks. The amount of oil ordered, which had been excessive, is now controlled.

The new state-of-the-art lubrication warehouse is the epitome of proper contamination control and safety practices with reduced clutter, a new drum racker and drum lift, a color-coded filtration system and matching oil containers with labels.

The Indiana-Kentucky Electric Corp. was able to reduce its lubricant inventory from 177 oil drums to 50.

Among the modifications IKEC made to its lube room included a new floor coating and first-in/first-out drum storage racks.

IKEC's new lube room features a filtration system with 16 filtering compartments, tanks and dispensers.

The new lube room is also fork-lift accessible.

Suncoke Energy

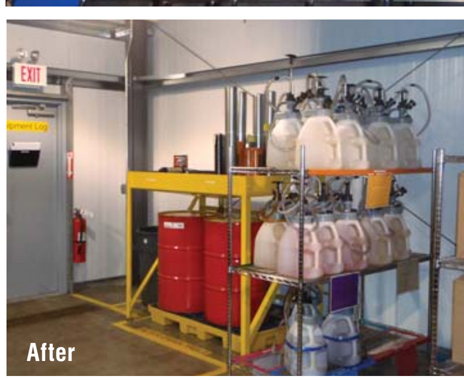
Suncoke Energy's Brandon Lisch has been waiting for the chance to show the improvements that have been made at his facility in Middletown, Ohio. Prior to implementing a lubrication program, all lubricants were stored outside or within an opened conex trailer. Coal and coke dust accumulated on transferring equipment, oil drums and grease cartridges. Oil pumped directly from the drums without prior filtration or testing of lubricant properties. There was no lubricant identification system in place, and lids were left off reusable containers. Drum pumps were not properly sealed or dedicated to specific lubricants. The facility had no stock rotation system or training on lubrication best practices. Dirty lubricants were applied to machinery, and cross-contamination of lubricants occurred. Poor oil sampling practices were also in use.

In just over a year's time, Suncoke was able to correct these issues. The facility's current lubrication practices include dedicated storage tanks with filtration capabilities, reusable totes with a quick-coupling system and desiccating breathers, a quality-assurance testing program for oil received from the distributor, and dedicated portable filtration carts. A new lubrication building was designed and constructed for housing lubricants in a controlled environment. There is also controlled access to the lube building. A color-coding system has been implemented including grease guns with anodized color-coded barrels and colored washers/Zerk caps. The first-in/first-out lubricant rotation method is being utilized, and employees are trained on lubrication best practices. In addition, filtration of new oil within drums must now meet the company's set cleanliness standards. Suncoke's next step is to take its program to a world-class level.

Before Suncoke implemented its lubrication program, coal and coke dust accumulated on transferring equipment, oil drums and grease cartridges.

A new lubrication building was designed and constructed to house lubricants in a controlled environment.

Lids often were left off reusable containers, and drum pumps were not properly sealed.



A color-coding system has been implemented in Suncoke's new lube room including grease guns with anodized color-coded barrels and colored washers/Zerk caps.

Dedicated storage tanks with filtration capabilities are now in use.

International Paper's Georgetown Mill

International Paper's mill in Georgetown, South Carolina, is in the process of installing lube rooms throughout the mill as part of its lubrication excellence program. The "Powerhouse" area was the first to complete its lube room. Prior to building the new lube room, barrels of oil were stored in an open building under turbine generators. This area of the building was impossible to keep clean due to large roll-up doors that remained open and the close proximity of ash-handling conveyors. Transferring oil from drums to portable containers was not possible without introducing contamination.

While the lubrication technicians did an excellent job of keeping the drums covered and the oil as clean as possible, everyone knew that a lube room was essential in achieving the company's goal of world-class lubrication.

Many hours were spent researching what was available and how to build and equip a lube room based on the limited funds and space. Eventually, the decision was made to use self-contained pump and filter assemblies which have the same components as the filter carts that had been used previously. The same filter unit has also been installed on hydraulic tanks in this area of the mill. The company plans to utilize this work to standardize lube rooms across the mill as much as possible.

The filter units in the lube room are supplied with 55-gallon drums of oil as opposed to the more expensive and bulkier tanks that are available. This helps to keep costs down and makes the best use of the limited space while achieving the cleanliness goals. The drums have been outfitted with adapters, which are sealed with O-rings to prevent contaminant ingression.

Two different contractors were employed to erect the concrete-block building and fabricate the custom stainless-steel sink, shelves, etc. Everything else was completed with mill labor, from the ceiling and equipment installation to the painting, lights, electrical and HVAC installation. The total time to complete the lube room from when construction began was approximately one year.

Filters, grease and other supplies are now stored in a nearby storage room, which doesn't require the same controlled environment.

Previously, oil drums at the Georgetown mill were stored in an open building with covers or plastic bags to keep out contaminants.

Each type of oil has a separate pump and filter system to filter and fill the portable containers. The bulk systems in the field and the filter carts are equipped with identical pumps and filters. Recirculation lines to circulate oil in the drums are planned for the near future.

The mill's lube room is equipped with an HVAC unit, which provides positive pressure, a constant temperature range and low humidity.

Upper Occoquan Service Authority

The Upper Occoquan Service Authority (UOSA) is a wastewater treatment facility in northern Virginia with a capacity of 54 million gallons of water per day. Changes were recently made to the facility's lube room which greatly improved its organization and usefulness.

Before the lube room was revamped, most of the plant's oil was stored outdoors in large metal containment lockers. This created an unorganized mess, and the variable temperatures wreaked havoc on the oil. Now all oil is stored inside the new lube room, which not only is more user-friendly but also allows the supply to be controlled.

Currently, hundreds of oil analysis tests are conducted each year on UOSA's gearboxes and drives. Desiccant filters are used on breathers, and the plant has begun the process of filtering its larger gearboxes to extend the life of its oils.

The facility has found that filter carts are a remarkable tool that can save thousands of dollars. The only drawbacks have been the expense of the filter cartridge replacements and the overall size of the carts needed for the plant's large drives. UOSA plans to buy a large cart for its clarifiers and dedicate it for this purpose. All 37 of the facility's clarifiers use the same oil, with 10 to 18 gallons in each drive. Several smaller carts may be required for the plant's other gearboxes, which have drives that hold 2 to 3 gallons or less.

In addition, UOSA is retrofitting many of its gearboxes so that oil samples can be drawn from the same location each time. With hundreds of gearboxes and drives, this has been an expensive endeavor. The facility is also trying to determine whether its desiccant breathers are worth the costs.

While oil analysis and new oil filtration have been beneficial for the plant, cross-contamination remains an issue. However, everything UOSA has done so far has been a step in the right direction.

Before UOSA's lube room was revamped, its oil storage was an unorganized mess. The new lube room is more user-friendly and allows lubricant inventories to be better controlled.

JOHN MARTINEZ, TATE AND LYLE

ROOT CAUSE ANALYSIS: From Detection to Implementation

Root cause analysis is an important component to any maintenance department. Its goal is to eliminate the source of equipment failures, not simply the symptoms, in order to prevent those issues from recurring. Performed correctly, it can reduce problem areas in the plant and allow for more consistent, stable production.

Setup and Documentation

When beginning a root cause analysis, you will need to be able to capture all failures that require investigation. There should be a system for viewing all of the failures that have occurred over a set period of time. For larger plants, this information should be reviewed daily. In smaller plants, weekly or monthly may suffice, depending on the number of failures and the frequency of their recurrence.

After evaluating the failures over time, your next step is to determine when a root cause analysis is necessary. A quick way to do this is to establish a trigger or a desired service life for your equipment. This can be measured in months or years and will be different for each equipment type. An example would be using a baseline of three years for motors and one year for a pump. With these guidelines, any motor failure in less than three years and any pump failing in less than one year would call for an analysis to be performed. The lone exception would be for critical equipment. If an extremely critical piece of equipment fails, a report may be required.

Create a Database for Tracking Failures

Once you have a list of failures, begin tracking the number of failures and the status of the analysis. To do this, you will need to create a database where all root cause reports can be viewed in one place. At the very least, the database should include the equipment number or name, the date of the failure, the date of the last failure, the area where the equipment is located, the notification or work order number, a brief explanation of the failure, possible solutions and the name of the person responsible for the solution.

An example of this type of database is shown on page 30. Please note that not all the information will be readily available and may not be entered into the database until much later in the investigation. However, as much information as possible should be included to help establish which facts are already known.

Gather Equipment Information and History

The next part of the process may be the most critical. Gather as much information as possible, including what happened during the failure and the equipment's failure history. Find out what has been tried previously to correct the problem. If these solutions did not work, you will save time by not trying them again.

Utilize all of your resources. Talk to electricians, mechanics, shift personnel, operators, clean-up crews and anyone with knowledge of the equipment. These individuals may offer important clues as to why the problem occurred and possibly even solutions or suggestions for improvements. This is imperative if the failure happened on the weekend or on a specific shift. Speak to those who worked during the shift for details on how and why the failure happened when it did. Start the process as soon as possible. The sooner you start, the more accurate the information will be and the easier it will be to recover or remember.

Next, check your plant's system that tracks equipment failures. You should be able to see the frequency of the failures and can then ask questions, such as does this failure occur in a periodic timeframe or a specific time of day/year, i.e., every three months, only at night, in the winter, etc. If the analysis is performed early enough, you may be able to observe the equipment while it is still running and on the verge of failing, e.g., a leaking pump that has not yet been changed. You can then evaluate the equipment's running conditions, some of which may be a source of damage.

In addition, always inspect the equipment when it is disassembled to determine which components failed and to look for signs of damage not visible from the outside. These might include indications of overheating, lack of lubrication, misalignment and vibration.

Be sure to take pictures and document everything. Use a notebook or tablet and a digital camera. You can't remember everything that happened or exactly how it looked, especially if you are writing the report days or weeks later. A photograph is also one of the best ways to show how bad the failure was to those who did not see it.

Writing Reports

When writing the report, remember that you want readers to be able to understand and follow everything being presented. Avoid technical words or overly complicated terminology. Keep it simple and stick to the facts. The report may be read by a large number of people who do not have the same experience or specialized knowledge that you do.

Do not include anyone's name. Instead, use only job titles unless you need to assign a name to the solution. The report should not become a blame-game or finger-pointing exercise. You also do not want to alienate any individuals because they may not offer you information the next time you are investigating a failure.

Photographs provide the best way to show the magnitude of a failure.

Include the photographs taken while gathering information. If someone does not believe a condition or problem exists, there is no denying it when you have a picture of it. Be sure to write captions to help describe what is shown in the photographs in case an object or situation is not easily recognizable.

Every report should at least include the equipment information, the date of the current and last failure, an explanation of the failure and the findings with an idea of the root cause, an explanation of the past history, the proposed solution, an assignment of a person(s) to the solution, and appropriate data to help explain the failure (pictures, graphs, trends, etc.).

Reviewing Reports

Schedule a meeting to review all the reports and to come to an agreement as to what the solution should be. Send the reports in advance of the meeting to give everyone a chance to look over and discuss the issues and possible solutions beforehand. This is better than first presenting the reports during the meeting and not allowing individuals to conduct their own research or investigation.

Attendance at the meeting should be mandatory for area managers and engineers, maintenance managers, maintenance coordinators (both electrical and mechanical), area process supervisors and key process technicians, mechanics and electricians. Attendance may be optional for the operations manager, plant manager and planner. You can establish the meeting's importance by having the plant and operations manager question absent managers and engineers as to why they were not in attendance.

Review each report, even if the failure was small, to make everyone aware of what happened and what is being done to prevent future failures. Come to an agreement on what the next steps should be so it is the entire group's decision rather than just one person's idea. Now you have a team of 10 to 20 individuals who are invested in the results.

The frequency of your meetings should depend on how severe the failures are

ROOT CAUSE ANALYSIS RECORDS								
DATE OF FAILURE	WORK ORDER #	DATE OF LAST FAILURE	AREA	EQUIPMENT ID NUMBER	FAILURE DESCRIPTION	SOLUTION	PERSON RESPONSIBLE	DATE COMPLETED
01/02/2014	90057499	01/18/2013	ALC	P-5680 Ferm. 80 Recirc. Pump	Seal leaking	Pump operation	Doyle Baxter	01/31/2014
01/02/2014	90056756	10/15/2013	BRG	C-4514 Pellet Airbelt	Take-up roll bearing failed	Research bearing type	Kenny Evans/ Kurt Bradley	NOT DONE
01/03/2014	90057464	12/02/2013	REF	P-6926 Car Wash Return Pump	Seal failed	Power monitor option	John Martinez/ Jeff Mitchell	02/25/2014
01/03/2014	90057353	03/25/2013	W/M	M-3107 3rd Grind Mill #1 (Fixed End)	PdM bearings impacting/ packing failed	Look into new packing/ adjusting packing	Kurt Bradley/ Matt Prock	NOT DONE
01/06/2014	11071264	01/14/2013	REF	P-6640 Raffinate MR Feed Pump	Seal failed	Change seal type on 3,600-rpm pumps	Kenny Evans/Matt Prock	02/03/2014

An example of a database for tracking equipment failures

and how many have occurred. The more failures, the more often you should have meetings to discuss the problems.

Implement and Track Changes

Changes should be monitored by a lead person (usually a maintenance or reliability engineer). This person will create a method to track changes and observe what did or did not work. The team will also need to assign an individual and a date for completing the proposed solution. The lead person will then contact this individual to determine if the change has been made and if it was successful.

A meeting should be scheduled for the lead person to review the solutions with the team. This will allow the group to understand what has been done to solve the problem and if the suggested action worked or if additional time or resources are needed. Similar to the database created previously, a simple document can be used to chronicle which ideas have been implemented and which remain to be carried out.

Success Stories

As you continue your root cause analysis program, be sure to use success stories to credit yourself, your team and the overall plant. Not everyone is aware of the changes you have made or the problems that the team has solved. Making this known to team members will show them how their efforts are making a difference and having a positive impact. Try to spread the word plant-wide in a newsletter or as a topic in a plant meeting. The more people who are cognizant of the effect that the root cause team has had on their job, the more willing they will be to provide you with information and suggestions to help in your investigations.

Following are a few success stories that show how root cause analysis not only can impact a plant's bottom line but also make workers' jobs easier.

Wet Mill Sump Pump

A wet mill sump pump failed on average every two to three months over a three-year span. The solution was implemented in July 2011, and no failures have occurred since. While this was not a huge cost savings, it was a nuisance to both mechanics and technicians. Previously, mechanics had to replace the pump four to six times a year, and technicians had to walk in 4 to 6 inches of wet slop each time the pump failed.

Wet Mill Gearbox

A wet mill gearbox was failing every three to four months over a two-year span. The failures would upset the process system and reduce production by 40 percent whenever the conveyor was down. In February 2011, the maintenance team designed a new seal. The gearbox has not failed since.

Finished Product Pump

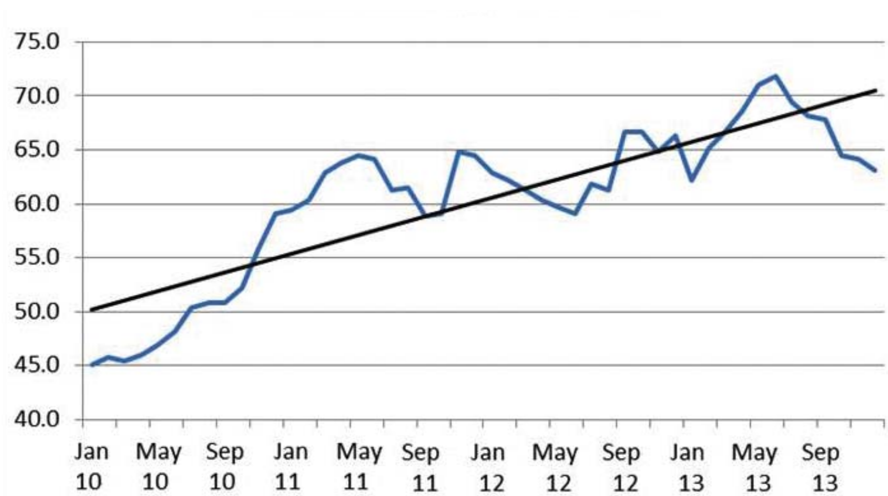
A finished product pump failed every three months over a five-year span. After many attempts to fix it, the problem was finally corrected in May 2012. The pump was then replaced in November 2013. The correction prevented five failures before the pump was replaced for a savings of more than $400,000 when factoring in product reduction during the 12 hours the system would be down.

Finished Product Recompressor

A finished product recompressor was rebuilt and modified over a five-day shutdown. When the compressor was started, onsite oil analysis found water in the oil. Root cause analysis showed that the heat exchanger had developed a leak while it was down. The oil analysis saved more than 18 hours of downtime for a savings of $140,000. This did not include the possible damage to the new equipment.

2010-2013 Pump MTBF - Loudon Plant

2009-2013 Motor MTBF - Loudon Plant



These examples show how root cause analysis can lead to improvements in mean time between failures for a plant's pumps and motors.

Pump and Motor MTBF

Through root cause analysis, better lubrication practices, vibration and oil analysis, an improvement in mean time between failures (MTBF) for both pumps and motors was achieved. Since MTBF was tracked in 2009, pump life increased from 50 months to 63.2 months as of December 2013. This was an increase of almost 25 percent in pump life over five years. The motors had an even greater increase of 78 percent from 148 months in January 2009 to 263.5 months in December 2013.

Final Thoughts and Suggestions

A root cause analysis program can offer benefits for almost any plant. It eliminates repeating problems and allows you to focus on other issues. Always try to gather as much information as possible. If you don't solve the problem the first time, the additional information may be useful for a future solution.

Along those same lines, you should

include as many people as possible in the root cause meeting. This will enable you to form a team of people who care about the problem and are involved in the decision-making or changes. Although you may come up with a solution, it doesn't necessarily mean that it will get accomplished. You must follow up on the suggestions and assign individuals to each of them for accountability. If someone is not tracking the changes, they will never be completed.

Concentrate on the easy wins and the critical big problems. The easy wins will get some buy-in from other areas of the plant, which will cause others to want to be more involved in the solutions. The critical problems are those that will have the most impact on the plant, either the most repeated failures or the most savings if eliminated.

In terms of costs, track the savings from the changes that have been made during the analysis. You may not track every single change but be sure to include the more valuable ones. This will give you the opportunity to justify the program's value.

Form a team to help gather information and come up with solutions. If you try to do it all on your own, you will not succeed. There are simply too many items to track and changes to make. While you would like to have the entire plant as part of your team, utilize trusted technicians and maintenance personnel who have shown some interest. Provide feedback on how they have helped, when the changes will be made and if they were successful. The more of an impact they feel they have, the more they will want to help.

As you create your team, don't focus on whose fault it was but rather on what the problem is and how to reach a solution. In the end, the goal is to eliminate the source of the issues instead of the person who did the wrong thing.

Finally, relay to everyone involved that root cause analysis is performed to help everyone at the plant. The more people believe this and see the difference that it can make, the more they will want to be involved. More importantly, when they realize how it can help them, they not only will give you more information, but they also will come to you with their problems because they know that you produce results. ■

WES CASH | NORIA CORPORATION

How to Get the MOST from Your PARTICLE COUNTER

Particle contamination is known to cause countless machine failures. One of the best tools to measure and understand this root cause is particle counting. Few facilities utilize the power of this test to its full potential and instead just look at the counts as a way to gauge oil cleanliness. By understanding what the particle counter is telling you and employing proper sampling locations, you can make better use of the information in your oil samples.

> The **benefits** of particle counters are **truly limitless** as long as you are conscious of what you are doing and understand the results.

One of the most basic forms of proactive maintenance in a lubrication program involves setting target cleanliness levels for different machine types. More often than not, the ISO 4406:99 particle count levels are used for this objective. While this may offer a quick classification of the oil's cleanliness, you should delve deeper into the numbers to see what truly is occurring.

4X as many particles (1,301/321/41 → 5,000/1,300/160); one more particle (2,500/640/80 → 2,501/641/81)

4 µm	6 µm	14 µm	ISO Code
1,301	321	41	18/16/13
2,500	640	80	18/16/13
2,501	641	81	19/17/14
5,000	1,300	160	19/17/14

The ISO standard looks at three different particle size ranges: 4, 6 and 14 microns. However, most particle counters can provide information for several more sizes, sometimes up to 100 microns. These counts are then compared to the Renard series table to establish standard particle count values such as 18/16/12.

Although it is a good practice to set goals and targets based upon these numbers, if your focus is only on the ISO code, you may fail to consider the results from the particle counter. Generally, for every increase in the ISO code, the amount of particles in the oil sample doubles. However, since the chart is arranged as a series, there may be as few as one more particle that raises the ISO code or as many as four times the number of particles. Therefore, it isn't always sufficient to use this number to drive your actions.

Knowing the individual particle counts and from where the oil sample was extracted will be essential for your oil analysis program. When a report comes back from the lab, it is easy to look at the ISO code and determine a course of action. However, if you examine the individual counts, you can begin to gauge whether the actions you are taking to achieve your cleanliness targets are effective.

For example, say you have a system that is decontaminated with a portable filter cart. The goal is to clean the system to an ISO code of 18/16/13. Your reports continue to show a higher ISO code of 19/17/14. Normally, you might think the oil is still dirty and that you should continue filtering, but upon checking the individual particle counts, you see that you are only a single particle away from achieving the goal. With another quick round of filtering, you can reach your target.

Monitoring individual particle sizes can provide other important information. For instance, take the case of filter performance. A number of filters on the market are touted as 3-micron filters, but not all of them have the same efficiency for capturing particles at that 3-micron size. This is commonly referred to as the filter's beta rating or beta ratio. By using a particle counter and taking samples before and after the filter, you can look at the individual particle counts to help determine the filter's true efficiency and micron values.

This practice can also help you select filters for specific machines and understand a filter's life expectancy. If you analyze particle counts before and after the filter, you can evaluate whether the filter is deteriorating in service. The farther apart the particle counts, the better the filter is performing. The closer the numbers are, the worse the filter is functioning.

For systems without permanently mounted filters or even those that are periodically decontaminated with a filter cart, the particle count can help monitor the size of the contaminants found in the machine. This test can ensure that the seals and breathers are doing their jobs. If the particle counts are increasing and the metal amounts are relatively unchanged, you can be fairly confident that dirt is the contaminant causing the increase.

52%

of lubrication professionals say their plant utilizes a particle counter, based on a recent survey at MachineryLubrication.com

One of the most common mistakes when using a particle counter is failing to properly agitate the sample prior to introducing it to the machine. Remember, particles settle to the bottom of the sample bottle and must be agitated to resuspend them. Otherwise, you cannot ensure that you are getting representative information. The ASTM D7647 standard outlines some of the criteria for agitation with the use of optical particle counters. Depending on the sample volume and the viscosity of the fluid, the agitation time may range from only a couple of minutes to as much as 10 minutes. This is why it is important to leave headspace or ullage in the sample bottle.

While it is possible to agitate or shake a sample by hand, if you have a number of samples to run through the machine, this could take a long time. A paint shaker can make the process easier. Simply mount a sample bottle to the paint shaker, throw the switch and walk away for a couple of minutes. The shaker will resuspend the particles so you can be sure that you are getting accurate results from which to draw conclusions.

It no longer is uncommon to see a particle counter in a lube room. Decades ago, this technology was reserved only for laboratories. Of course, using a lab to run a particle count test is perfectly acceptable, but you can improve your turnaround time by performing this test onsite.

The benefits of particle counters are truly limitless as long as you are conscious of what you are doing and understand the results. These devices have come a long way over the past decade in both their accuracy and affordability. There are now many makes and models available that can work well, provided they are handled with care.

A particle counter can be a great tool in any lube technician's arsenal. If you haven't explored the possibility of purchasing one, you should.

8 Proactive Maintenance Uses for Particle Counting

1. Routinely verify that in-service oils are within targeted cleanliness levels.
2. Check the cleanliness of new oil deliveries.
3. Quickly identify failed or defective filters.
4. Confirm that seals and breathers are effectively excluding contaminants.
5. Confirm that systems are properly cleaned and flushed after repair.
6. Confirm that new hydraulic system are cleaned and flushed before use (roll-off cleanliness).
7. Identify the improper use of dirty top-up containers and poor maintenance practices.
8. Identify the need and timing for portable filtration systems.

About the Author

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

Jeremy Wright | Noria Corporation

HOW COLD Temperatures Affect Your LUBRICANTS

As winter weather settles in across much of the United States with cold fronts creeping in from the north, have you ever thought about the effects these temperature changes can have on your equipment's reliability? All machines and lubricants have practical limits when it comes to operating temperatures. Often the focus is only on the upper limit, since high temperatures can wreak havoc on the health of the lubricant and the machine, as well as cause safety concerns in some cases. However, rarely do you hear someone discussing the lower limits.

At extremely low temperatures, such as those experienced during the startup of equipment found outside on a cold winter morning, the fluid within the housing can reach a point where it actually congeals and will no longer flow. This limit is called the pour point. In circulating systems, the viscosity becomes so high at this point that the oil flow is restricted. Components will then starve of lubrication, which leads to an early metal-on-metal death.

Of course, circulating systems aren't the only ones that rely on oil flow. Imagine how a splash-lubricated gearbox handles a cool, thick fluid. When these gearboxes are designed properly and using the correct fluid viscosity, oil is brought up to the gear tooth interface and even to the shaft bearings and other reduction stages higher in the sump as the gearset runs through the oil sump level. When the oil viscosity is increased to the point where it will no longer flow, the submerged gear will push congealed "chunks" of lubricant out of the way and will not lift it to the other components within the housing that desperately need to be lubricated. Another side effect of the increased viscosity is a higher startup torque. This increased load may be enough to cause a catastrophic failure or at least consume a massive amount of energy because of the excessive friction.

The effects on viscosity are not the only attacks the lubricant must endure from the cold. In extreme cases, blended base oils can begin to separate into different phases. This separation process is called stratification. The additives are also susceptible to becoming insoluble at colder temperatures. When they become insoluble, additives tend to gravitationally separate from the base oil and form deposits at the bottom of the sump. If the equipment requires these additives and they are in the form of a sludge or deposit at the bottom of the sump, the lubricant's performance will be hindered and the machine could be damaged.

What is considered cold? Most base oils and greases are able to withstand moderate temperature dips to 0 degrees C and many to minus 10 degrees C without much decrease in performance. However, at minus 20

56%

of Lube-Tips subscribers say cold temperatures have caused problems for the lubricants at their plant

Always select a lubricant with a pour point that is at least 10 degrees C lower than your lowest expected startup temperature.

degrees C and beyond, some lubricants become unsuitable and begin to reach their pour point. The pour point is dictated by the base oil quality as well as the presence of certain additives. A good rule of thumb is to always select a lubricant with a pour point that is at least 10 degrees C lower than your lowest expected startup temperature.

At temperatures lower than minus 20 degrees C, simple mineral base oils will no longer perform sufficiently, so alternatives must be found. Polyalphaolefin (PAO) synthetic oils are among the front runners in performance for base oils at cold extremes of minus 20 degrees C and lower. PAOs do not contain the wax that lower quality, cheaply refined mineral oils do, and this allows for excellent flow, even at low temperatures. Some PAOs have pour points as low as minus 50 degrees C.

One property that aids in a PAO's fight against cold weather is its high viscosity index. Simply put, viscosity index is the rate at which the viscosity changes with respect to a temperature change. Having a higher viscosity index means that the lubricant's viscosity does not change at as high of a rate compared to a lubricant with a lower viscosity index. This is a good thing. What ends up happening is the viscosity range that is useful to the machine gets extended over a much larger temperature distribution.

To evaluate cold-weather performance, several ASTM standardized methods can be used, including tests for pour point, low-temperature torque and flow pressure for greases. In recent years, the research and development of lubricants in extreme cold conditions has come a long way. Lubricants are now being developed specifically for cold-weather applications.

Even though proper lubricant selection is of the utmost importance, there are other more fundamental steps that can be taken to solve your cold-temperature issues. These include heaters, larger feed lines, fewer pipe restrictions in pumping systems, changing application methods, etc.

Understanding what happens to your lubricants at cold temperatures is your first line of defense. So the next time you walk into your plant on a cold morning and prepare to start up the equipment, please think about the consequences of the cold temperatures on your lubricants and the machinery.

About the Author

Jeremy Wright is the 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 Machinery Lubrication I and II training courses. 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.

JIM FITCH | NORIA CORPORATION

RECOGNIZING the Causes and Hazards of SILT LOCK

Do you know about silt lock? This common condition causes motion impediment failure in certain machines. While this type of failure usually doesn't involve wear or permanent internal damage to the machine, it is sudden and abrupt. Silt lock is the result of solid contamination and is amplified by other conditions that must be controlled where possible. It is most often associated with hydraulic systems and produces seizure or jamming of components.

Because of its lack of warning or predictability, silt lock is responsible for some of the most devastating and destructive catastrophes in mechanical machinery. These include mechanical casualties, prolonged production losses and even loss of human life. Silt lock has been found to be the root cause of countless failures related to aircraft, spacecraft, passenger cars, elevators, turbine generators, tower cranes, etc.

Obliteration-Prone Electrohydraulic Valves

Electrohydraulic valves are used extensively in modern hydraulic systems. They couple the immediate response of electrical control with the high power of hydraulics. In other words, they rapidly convert electrical energy to powerful and responsive mechanical energy. Because the structure of these valves is generally more complicated and intricate than ordinary control valves, they are less tolerant to solid contamination.

Typical examples of such valves include solenoid, pulse-width modulated (PWM), proportional control and servo valves. For example, electrohydraulic valves are critical to steam turbine performance and include steam throttle valves, trip solenoid valves and intercept valves. In gas turbine service, you might have an inlet guide vane valve (on peaking units) and/or a gas control valve (in base load units).

As shown in Figure 1, silt particles less than 10 microns can enter the clearances between the spool and bore in the leakage path. This obliteration of the clearance space can result in increasing static friction of the spool when the valve is actuated. This can cause a stick-slip movement, which is also known as a hard-over condition. Servo valves are particularly prone to this form of contaminant failure due to their high performance demands. For instance, a stick-slip of valve movement in commercial aircraft hydraulics might result in the loss of critical control during a landing sequence.

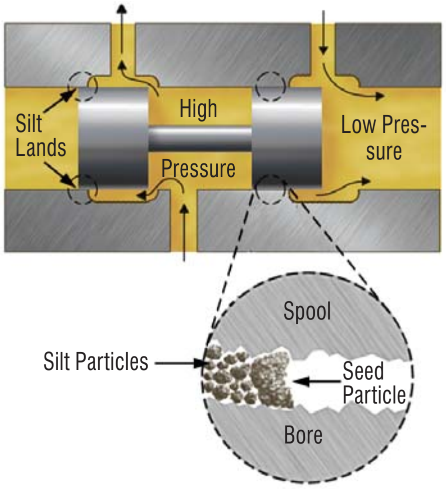


Figure 1. Silt particles migrate into the clearances between a valve's spool and bore, increasing friction when the valve is actuated.

Critical Risk Factors

Particles generally don't act alone in causing silt-induced motion impediment failures. Most often it is a team effort that increases both the magnitude and frequency of the risk. These risk factors are described below:

Particle Size and Clearance

As with contaminant wear, particle size matters. Very large particles can't enter the working clearance and are swept aside. Very small particles pass through the clearance without restriction. However, clearance-sized particles cause the highest risk. This is seen in Figure 2 where 10-micron particles exhibited greater static friction in spool valves compared to particles that were

30 microns and 0-5 microns.

In valves, silt lock generally occurs as a result of an eccentric position of the spool as it rests in the bore. Due to the weight of the spool, the annular clearance varies from submicron in the bottom position to 10-50 microns in the space above. A single tramp particle may be all that's needed to seed the obliteration process, as shown in Figure 1. This primary particle narrows the clearance, allowing the smaller and more highly populated secondary particles to load into the clearance space. These secondary particles are the "silt" that causes the high static friction (stick-slip or complete seizure), resulting in motion impediment failure.

Dwell Time

Many valves are in constant motion, while others remain at rest until needed. These may be governor valves in a turbine electrohydraulic control (EHC) system or landing gear hydraulic valves in commercial aircraft. When a valve remains stationary, the fluid leakage path across the silt land (the zone where silt particles pile up) is exposed to more and more particles. Given enough dwell time, the particle buildup (obliteration) is sufficient to arrest movement of the valve and cause motion impediment failure. The influence of dwell time can be observed in Figure 2.

Most aircraft valves mitigate the dwell time/obliteration risk by keeping the valve spool fluttering, a design condition called "dither." Nonetheless, as most seasoned airline pilots will tell you, these valves are still known to stick on occasion. Television audiences were able to see an example of contaminant-induced valve stiction a few years ago on "America's Funniest Home Videos." A life-sized hydraulic Abraham Lincoln was shown moving erratically during a showing of Disneyworld's Hall of Presidents.

Oil Pressure Differential

Oil is always trying to move from high to low pressure. In typical electrohydraulic valves, the annular space between the spool and the bore is all that separates high pressure from low pressure. Oil leaks through this pathway at a higher velocity with increasing operating pressures. This results in more particles being exposed to the silt lands and more packing force on the particles, causing static friction.

Water Contamination

Free and emulsified water in oil will preferentially occlude to most solid particles such as dirt. The hydrogen bonding in the water molecules causes strong attractive forces similar to the clumping of wet sand. Laboratory studies have shown that moisture sharply aggravates bird's-nest obliteration in valves, orifices, glances and other tight-clearance flow paths.

Varnish and Sludge

Varnish is a soft, gummy deposit that collects on internal machine surfaces. It tends to be more acute on metal surfaces that are cooler than the oil. Varnish condenses on these cool surfaces, producing a sticky residue. Electrohydraulic valve surfaces are a common destination for varnish insolubles in oil. Nearby particles can get stuck on these adherent surfaces. This condition is known as the "fly paper" effect (see Figure 3). The synergistic result greatly increases the risk of silt lock and stiction.

Controlling the Silt Lock Risk

Maintenance and reliability professionals don't have the convenient ability to redesign machinery or even change operating demands to reduce the risk of silt lock. However, they can influence the conditions to which the machine and its components are exposed. This would include controlling particle contamination (exclusion and removal), water contamination and varnish potential. With suitable diligence, not only is the risk of silt lock significantly reduced, so too is the risk of wear and corrosion mode failures.

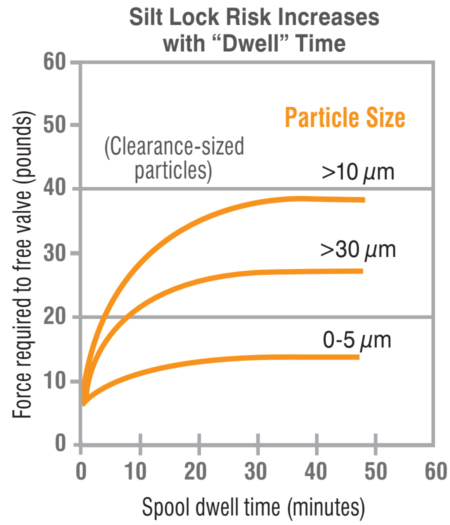


Figure 2. Clearance-sized particles produce the highest risk of silt lock.

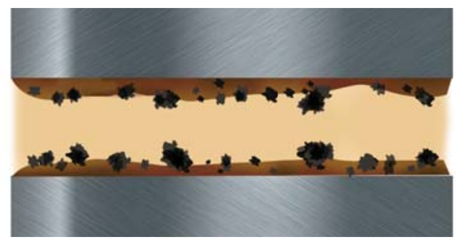


Figure 3. "Fly paper" particles

About the Author

Jim Fitch has a wealth of 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.

DAVID KINTNER JR., LEPRINO FOODS

Gearbox Condition Monitoring Through Used Oil Analysis

When the city of Fort Collins, Colorado, purchased new planetary gearboxes for its wastewater sludge dewatering centrifuges, it decided to implement a proactive used oil analysis maintenance strategy. This decision resulted in significant cost savings.

Unconventional Machinery

Two of the machines were installed new in 1998 at a cost of $619,000 each. They replaced existing sludge dewatering belt-filter presses. The new machines were complex by comparison, requiring additional research in the proper maintenance to ensure years of cost-effective, reliable service. Appropriate maintenance tasks also had to be developed for this new equipment.

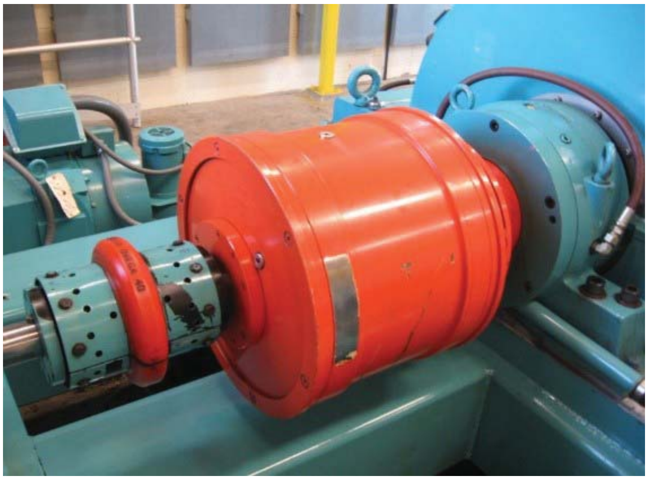
The centrifuges are critical to the Water Reclamation and Bio-Solids Division. The belt-filter presses have since been decommissioned, although technically they are on standby as backups. However, for various reasons, startup and re-use of these filter presses are not encouraged.

Each centrifuge has a bowl assembly that is V-belt driven by a 300-horsepower, AC-induction motor at approximately 1,748 revolutions per minute (rpm). The driven bowl speed is roughly 2,800 rpm. A back-driven scroll assembly within this bowl rotates at approximately 3 rpm less than bowl speed. The scroll regulates the rate at which the dewatered solids exit the machine in order to obtain an optimum percentage of dewatered bio-solids. The scroll is powered by a back-drive system that consists of a 100-horsepower DC motor and synchronous belt drive turning the planetary gearbox. The average service duty is approximately six to 10 hours per day, four to five days per week. Loss of one of these centrifuges would mean extended hours of operation for the remaining centrifuge and more labor hours for the operations staff.

Sludge dewatering centrifuges

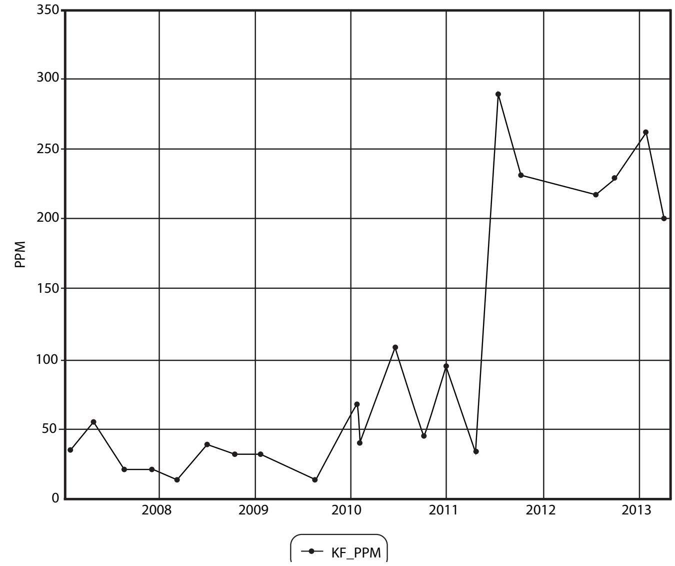
A Proactive Maintenance Strategy

After the manufacturer's maintenance recommendations and guidelines were reviewed, it was concluded that the proper gear oil level would need to be maintained. The manufacturer's lubrication schedule specified an annual oil drain and replacement of the gear oil. The quantity and type of oil required was 15 quarts of synthetic gear oil. The manufacturer also suggested a gearbox exchange program in which the gearbox would be replaced

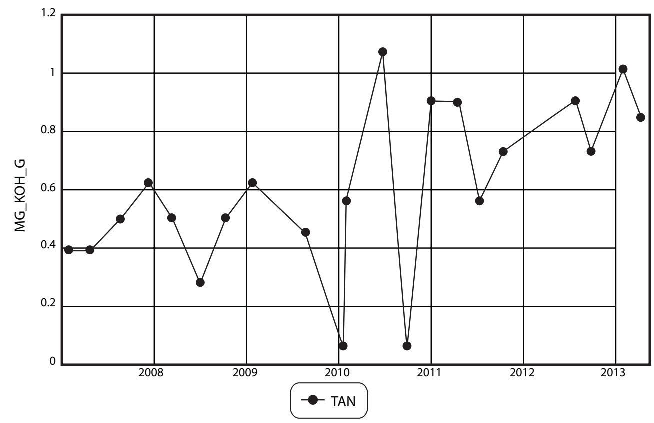


A two-stage planetary gearbox

A 300-horsepower, AC-induction motor and bowl drive assembly



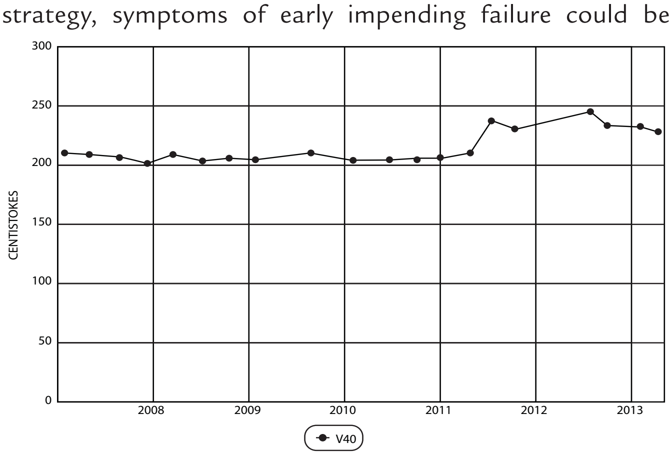
Water by Karl Fischer from 2007-2013



Acid number from 2007-2013

every two years with a factory-reconditioned gearbox. The exchange cost was estimated at $8,000 each, not including labor.

The city began exploring ways to extract a representative used oil sample from these gearboxes for oil analysis. If the condition of the gearboxes could be determined through a predictive strategy or a root cause analysis proactive strategy, symptoms of early impending failure could be monitored and detected. The root causes of these detected symptoms could then be identified and eliminated, or at least controlled. Ultimately, oil drains could be extended and the associated maintenance costs reduced with less generation of used oil and less need for new oil replacement. There would also be a greater understanding of the condition of the new gearboxes, increasing reliability and decreasing maintenance costs.



Oil viscosity at 40 degrees C from 2007-2013

Obtaining Representative Oil Samples

Due to the planetary design of the gearboxes, it was not possible to obtain a representative oil sample during normal operation, and extracting the samples would not be conventional. A small, rigid brass pipe nipple was fabricated into the gearbox oil plug to provide a means of collecting a sample via gravity into an ultraclean container supplied by the offsite oil analysis laboratory.

The sample was collected immediately after shutdown. If it was not obtained within 30 minutes of shutdown, the gearbox outer shell and input shaft were manually rotated numerous revolutions before flushing the sample collection fitting and taking the sample.

The planetary gearbox assembly with the guard shroud removed for viewing

After frequent oil sampling to establish baseline data, the sample frequency was initially set at quarterly and later updated to 500 hours of operation. An hour meter was also installed on the drive motor instrumentation.

Representative used oil samples, as well as new oil samples, were collected, labeled with all pertinent data and sent to the oil analysis lab. Cleanliness targets were set at ISO 18/16/13. The new samples would provide a means of determining the physical properties and additives within the oil.

The lab's oil analysis test slate included a variety of standard tests such as ISO cleanliness, kinematic viscosity at 40 degrees C and 100 degrees C, water by Karl Fischer, acid number and elemental spectroscopy. All of the oil analysis reports and recommendations received from the lab were closely reviewed to monitor the oil's physical properties, contamination and/or wear metals.

Extending Oil Drains

The oil was not replaced at the manufacturer's suggested one-year runtime interval because the oil analysis reports continued to be favorable. ISO cleanliness was diligently maintained through offline kidney-loop filtration using micro-glass filters.

As the two-year maintenance interval approached, there was no data-driven reason to replace the gear oil, let alone to exchange the gearboxes. The original equipment manufacturer (OEM) was contacted to inquire whether exchanging the gearboxes was still recommended. The OEM's response was, "You are doing what no other customer of ours currently does. I'd keep it up. The exchange program is not necessary with this comprehensive strategy."

Continued Cost Savings

Now fast forward to 2013. The two planetary gearboxes are still in service, and all parameters continue to be carefully monitored. The original oil was replaced with an ISO viscosity grade 220 polyalphaolefin (PAO) synthetic gear oil after the 10 gallons of oil that came with the new machines ran out. Considering the initial estimate of $8,000 per gearbox every two years, the cost savings of reconditioned gearbox purchases alone totaled more than $112,000.

An ISO VG 220 synthetic gear oil replaced the original oil.

The city of Fort Collins' oil analysis program continues today in the capable hands of the Water Reclamation and Bio-Solids Division's maintenance staff. These skilled craftsmen still employ a proactive maintenance strategy with these gearboxes as well as with many other assets in the division. On several occasions, in order to thoroughly clean the internal cavities of these machines, the staff has completely disassembled, cleaned and rebuilt each of these centrifuges, saving the city tens of thousands of dollars. Through it all, the planetary gearboxes have been removed and re-installed without the need for replacement.

While the city's oil analysis program includes a number of other assets, with several worthy of their own testimonials, the proven strategy for these two planetary gearboxes continues to speak for itself.

DAVID KINTNER

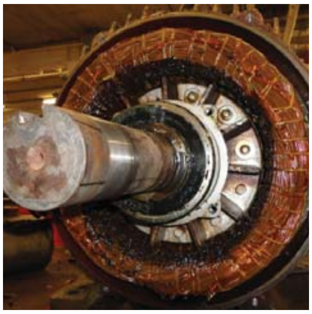
What a Maintenance Reliability Program Should Look Like

The hardest part of starting a reliability program is freeing up time to work on proactive tasks. The maintenance department at Leprino Foods spent most of its time repairing broken equipment. The technicians were so busy that they didn't have time to think about how to proactively solve their issues. There was a lack of organization. Too much time was spent looking for original equipment manufacturer (OEM) manuals, searching for parts and troubleshooting equipment.

Slowly the idea of working smarter not harder was introduced. For instance, instead of hunting for OEM manuals in an unorganized drawer in the parts room, parts and other items were scanned and searched for electronically. The technicians worked on their troubleshooting techniques to shorten the time it took to make repairs and minimize the mistakes they were making.

The idea of asking why was encouraged. Why were a high number of motor and AC drive failures being experienced? Why were gearboxes failing? Why was there an excessive amount of grease in the windings in almost all the motors that were inspected after failure? The technicians were accustomed to removing a motor, putting a repair tag on it and turning it over to the parts room to be sent out for repair before moving onto the next asset.

This remains a learning process. Considerable time was spent demonstrating how a proactive mindset can make all the difference. Through experience, it was learned that most moderate to complex issues could be rooted all the way back to the most basic task. For example, a bearing may be undergreased or overgreased. The wrong lubrication may also be used on the wrong application.



The majority of failures were caused by overgreasing, undergreasing, overtensioning belts, sheave misalignment, shaft misalignment, imbalance, etc.

Powder buildup in the motor seal area was caused by clearance in the seal, which was likely due to an overtensioned belt. Once the seal wore out, ingression was inevitable.

Starting with the Worst Actors

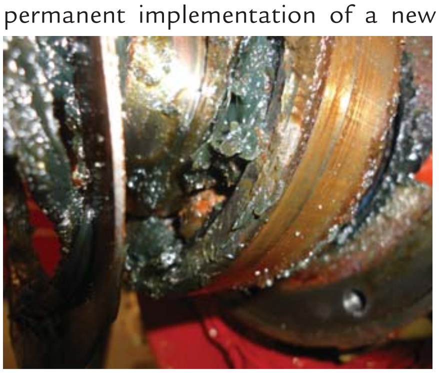
The worst actors had to be addressed in the plant. Utilizing a computerized maintenance management system (CMMS), the functional locations that seemed to have the biggest issues were identified along with the most damaging failure modes.

One case study from the plant in Allendale, Michigan, involved a whey-powder dryer system. The plant was experiencing premature bearing failure with all six of the dryer exhaust fans and was lucky to get a year of service life from the load and motor bearings. After a failure analysis was performed, an action register was selected and a multitude of issues began to be addressed, such as researching and observing installation, lubrication, loading and precision maintenance practices. Some of the issues discovered were incorrect bearing installation, bearing overgreasing, improper belt tensioning and incorrect sheave alignments.

During installation, it was determined that the bearings weren't being gapped properly on the shaft. The initial amount of grease applied to the bearing housing was also excessive. Everything was a "hurry-up" situation, so the belts were never tensioned properly, nor were the sheaves aligned. In fact, the V-belts were replaced a couple of years ago, so the correct tensioning gauges were not even in-house.

An experienced application engineer was brought in to analyze this problem along with some other areas that had lubrication application concerns. It was soon realized that all of the technicians and managing personnel believed that more grease was always better. The plant was also caught in the trap of trying to use one grease for all of its bearing applications.

Standard operating procedures (SOPs) were developed for bearing installation practices, belt tensioning and laser alignments. Currently, the technicians are being trained on how to perform these functions correctly and efficiently. They have come to understand that making something as simple as possible will assist with the permanent implementation of a new methodology.



Water ingression was also an issue.

Fine-tuning Lubrication and Oil Analysis

The plant continues to fine-tune its lubrication practices. This has been the hardest part of the transformation. Methods have been developed to alert personnel when there is possible overgreasing of a bearing, but the details are still being worked out for achieving the right amount of grease at precise intervals.

Another major step at Allendale was the implementation of a condition monitoring program. In the past, the plant experienced limited success with predictive tools including a vibration meter, outsourced infrared imaging and oil analysis. This was a great first step, but it was limited for a number of reasons. The infrared imaging agreement was restricted to twice a year. The technicians were tasked with making repairs, with some more successful than others. The effectiveness of the repairs wouldn't be known for another six months. Electrical problems occurred as a direct result of these missed opportunities.

Two 100-horsepower motor failures and three large AC drive failures were experienced in one year. The failure modes were electrical and could have been avoided if infrared routes had been developed for these areas. The vibration routes were based on a total root mean square (RMS) meter, which simply looks at total vibration in a system. If the system's vibration increased, the technician generated a work order to investigate.

While the oil analysis program functioned well, rarely did anyone pay attention to it. Samples were pulled and sent to the lab, but the plant seldom acted on the results. Reports noted contamination and gear wear with suggestions to "replace oil" and "investigate gear wear." Unfortunately, the majority of the recommended actions were not completed. If the planner/scheduler had time, he would occasionally look at some of the issues and create work orders, but there was no consistency.

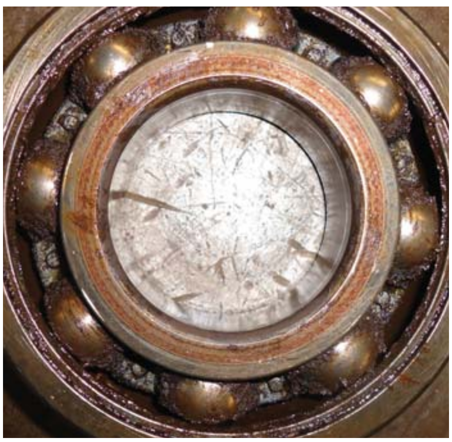
Streamlining Condition Monitoring

The first step to correct this was to reduce the amount of equipment being monitored. Previously, everything was monitored, including a $100 gearbox that wouldn't shut down the process. The plant's CMMS contained an ABC indicator with a cost-of-failure descriptor. Any asset ranked from six to nine was considered a critical piece of equipment. Of course, this would change over time, but it was a good starting point.

Specification sheets were created, and critical failure modes were determined for the equipment to be monitored. A large portion of the machines to be tested had some redundancy. However, just because a piece of equipment was to take the place of another didn't mean it couldn't be considered critical. Many of these setups weren't cycled or maintained properly.

Once all the logistics were accomplished, such as determining routes, developing predictive maintenance work orders and installing vibration pads on machines, the training portion of the program began. The budget included thermography

Installing brass pads in mounting locations allowed for repeatable data collection.


Water and particle contamination continue to be a massive obstacle.


Faulty venting led to this water contamination.

and vibration analysis certifications as well as Machine Lubrication Technician Level I certification through the International Council for Machinery Lubrication.

The main focus for the condition monitoring program was the development of the vibration analysis program. At first, no one at the plant knew how to analyze anything. Testing equipment was researched, and a piece of vibration equipment was purchased that could diagnose most of the plant's issues without in-house analysis. The analysis equipment would also produce vibration spectrums and time waveforms.

Two factors prevented success with this program. The first was the lack of repeatability in data acquisition. The second was not having a solid grasp of how the equipment worked in the processes. Plant personnel set out to gain this knowledge. They spent a great deal of time learning how to collect data, realizing that vibration pads worked best. Installing brass pads in the mounting locations allowed for repeatable data collection. The accelerometer screwed right into the mount, allowing for the same placement every time. Techniques were also developed to place systems into manual mode during the test in order to control loading. This wasn't always perfect, and not every system could be switched to manual mode when needed. The work order was rescheduled for a later date if this was the case.

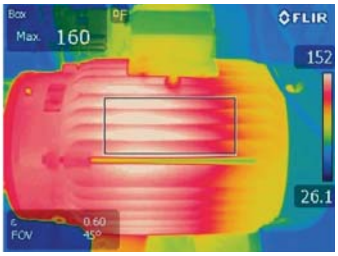
Initially, the plant adhered to the diagnosis from the testing equipment until it was noticed that some of the diagnoses weren't always accurate. To continue the program's progress, the decision was made to develop the ability to analyze spectrums. Certification training began soon afterward. This was a huge step. While personnel were accustomed to the idea of using test equipment to monitor machines for failures, they didn't realize how important it would be to rule out certain repairs. They have since successfully used the equipment to identify flow noise and particular attributes of a system such as eccentric rotors.

Frequently, work orders are generated to have a gearbox or motor repaired, only to discover that isn't the issue at all. In one recent example, the work order stated, "There is a loud vibration and noise, which seems to be coming from the primary gearbox." This wasn't on the critical equipment list, so it wasn't regularly monitored at this point. However, the gearboxes were expensive to replace, and a considerable amount of labor was required to complete the repair. A vibration test was performed. After analysis, it was determined that there were harmonics out to the tenth order of the motor speed. The technician was asked to lock it out, remove the belt and test the motor. The motor ended up being the issue. It had loose, out-of-tolerance end bells. A new motor was installed, and the entire system was retested. The new test results revealed no further problems.

Deploying Infrared Thermography

Prior to developing its infrared program, the plant outsourced this function. As the program was built and equipment was purchased, the first thing noticed was that many of the previously made repairs were still exhibiting the same hot spots. A number of steps were needed to get the program up and running. The image collection process was simplified by building templates for the camera. Now, whenever an area is to be

An infrared camera was used to identify electrical issues, overheated windings and overgreased bearings.



Cooling issues caused this motor (left) to overheat. Powder under the fan cover completely blocked the forced air's path.

surveyed, the templates for the area can be downloaded. Before, it took two predictive technicians to complete a survey — one to operate the camera and another to open and shut the motor control centers. Image analysis was performed once the images were downloaded to their respective folders.

The boundaries of the original infrared imaging route were expanded to include roof panels and some critical equipment subpanels that were not inspected initially. In addition, a standard operating procedure was developed to generate a work order for any deficiencies found. This included a follow-up infrared scan to ensure the anomaly had been corrected.

While infrared and vibration routes have been added, the plant is also in the process of re-evaluating its PMs to eliminate tasks that will be covered by infrared, vibration, oil analysis or motor analysis.

Recently, an offline motor tester was purchased. This provides the ability to find winding faults and grounded windings. It can also be used to test for broken rotor bars and eccentricity. The meter can measure impedance, phase angle, current-to-frequency response, etc.

During the last two years, the plant's emergency work orders have trended down each year, while unplanned work orders have risen only slightly. However, the unscheduled work-order cost increase will involve maintenance and repairs only; no downtime will be incurred. Of course, the plant's preventive maintenance program will continue to be adjusted. After all, a proactive mindset never stops. ■

Indian Oil's Servohyvis EE 46 Product Launch

Indian Oil Corporation Ltd. launched their newest product – a new long drain hydraulic oil Servohyvis EE 46 at the most recent CII exhibition EXCON, held in Bangaluru. The launch took place on 26th November 2015.

The premium product Servohyvis EE 46 from Indian Oil is formulated with the aid of DYNAVIS® Technology. Servohyvis EE 46 would provide users in the mining and construction sector with benefits of lower fuel economy and gains in productivity.

This niche hydraulic oil developed for excavator applications will be marketed in 20 ltrs, 50 ltrs and 210 ltrs barrels available across India.

HPCL Graduate Engineers trained with Lubrication Institute

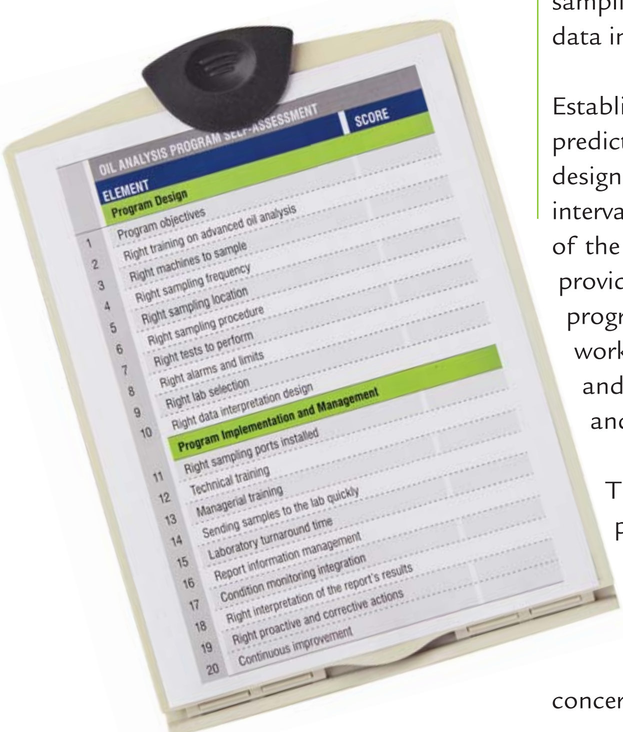
L to R Seated: S. Singh, M. Akmal, U. Dhir (Faculty), N. Divakar (Principal), L. Viraraghavan (Faculty), M. Sahu, S. Darshan.
Standing: V. Vishal, P. Gupta, N. Shinde, P. Meshram, A. Khare, F. Mohammede, K. Nageendrababu.
Back Row: A. Chauhan, P. Singh, R. Kumar, A. Yamini, A. Deep, N. Kumar.

17Graduate Engineers of HPCL trained on 'Essentials of Machinery Lubrication' from 14-16th October 2015 at the HPCL Management Development Institute, Nigdi, Pune. Mr N.Divakar(Principal)handed over the training certificates to participants at the valedictory function on 16th Oct 2015 .The training was conducted by Lubrication Institute, an associate of VAS Tribology Solutions.

ALEJANDRO MEZA | NORIA CORPORATION

ASSESSING the Effectiveness of YOUR OIL ANALYSIS Program

How effective is your oil analysis program? To determine the answer, it is necessary to conduct a self-assessment of your program's design and management. Many oil analysis programs have limited potential because of a lack of vision. This may be the result of insufficient training or not understanding the capabilities of oil analysis. Too often the person responsible for the oil analysis program has simply accepted a program proposed by the lubricant vendor or a third-party laboratory, assuming that it will be suitable for the organization's needs. While this assumption is not always wrong, the question becomes whether the program has been appropriately customized for the plant's machine conditions, equipment criticality and reliability objectives.



This article will describe how to perform a quick self-assessment to evaluate the effectiveness of your current program.

Program Design

The first step is to assess the design of your oil analysis program, including the objectives, training, machine criticality, sampling frequency, test slates, sampling locations, alarms and limits, sampling procedures, lab selection, and data interpretation.

Establish whether the program has a predictive or proactive focus, or if it is designed to maximize oil change intervals. Is analyzing incoming oil part of the program? It is also essential to provide the appropriate training to the program manager so he or she can work with the laboratory to design and understand the program's goals and features.

The machines included in the program should be based on their criticality, which is defined according to the costs, maintainability, safety and environmental risks or concerns.

Sampling procedures must be executed reliably to ensure consistency of the oil samples. Sampling intervals should be set in relation to several parameters such as machine criticality, environment severity, oil age and machine age. Because oil contaminants vary in concentration at different points in a machine or lubrication system, it is critical to choose the best sampling locations. Once the sampling point is identified, it may be necessary to install a sampling port.

Test slates should be chosen according to the program objectives and equipment criticality. Tests can be focused to analyze lubricant health, contaminants and wear debris, and can be classified as routine and exception tests.

Alarms and limits should alert you when a specific parameter is beyond the normal condition. They may be based on the original equipment manufacturer's recommendations and historical information but should be validated and adjusted to the specific machine's characteristics.

The laboratory selection must take into account technical capabilities (tests and experience), quality assurance, information management, customer service and cost. Data interpretation should be generated from the failure modes and metallurgy of the machine. While there are typical failure modes for machines, a specific analysis should be conducted for critical machines according to their operating conditions.

> Through regular assessments, you can revitalize your oil analysis program and maximize its potential.

Program Implementation and Management

Your program's implementation and management should also be evaluated. These elements include the sampling ports installed, training and skills management, sending samples to the lab, the laboratory's turnaround time, condition monitoring integration, results interpretation, proactive and corrective actions, and continuous improvement.

When implementing the program in the field, one of the first actions should be to install sampling ports in the correct locations with the necessary devices that allow taking a clean, reliable sample.

Training must be offered at different levels of the organization. Practical/procedural training should be required for technicians or operators who will take and label samples. Technical and interpretative training should be given to engineers or technicians who will interpret the information and confirm the actions to take. Managerial training should be provided to managers and supervisors responsible for the program's implementation, execution and continuous improvement.

Samples need to be sent to the laboratory within 24 hours after being obtained. The ideal laboratory turnaround time is 24 hours from the time the sample is received until the report is sent. Quickly sending samples to the lab along with a short turnaround time will be valuable in case there is an abnormal condition that requires prompt action.

The lab's reporting software should have the ability to analyze trends for better detection of potential failures as well as access historical information for continuous feedback. Failure detection capabilities can be enhanced when two or more predictive technologies are combined, such as vibration analysis and oil analysis.

Appropriate interpretation should come from the data interpretation design along with knowledge of the current operating conditions for the particular machine. When abnormal conditions are reported, specific actions must be taken. Simple actions may include filtering or changing the oil when it is contaminated, while more complex actions may involve investigating the root cause of the contamination to eliminate it.

64% of lubrication professionals say their oil analysis program is reviewed at least on an annual basis, according to a recent survey at MachineryLubrication.com

Be sure the program is reviewed periodically or whenever there are changes to the plant's machines, lubricants, oil analysis results or reliability objectives.

Program Assessment

A self-assessment can be completed by scoring each of the 20 essential elements (shown on page 54) on a scale from 1 to 4. A score of 1 would indicate that the element hasn't been considered or there is no information on whether it has been included in the program design/implementation. A score of 2 should be recorded when there is little evidence that the element has been considered. A score of 3 signifies that appropriate documentation is available showing that the element has been considered for the program. A score of 4 would suggest that the element has been considered, discussed and documented for the program design/implementation. The final score is the sum of the 20 individual scores.

Self-Assessment Interpretation

Programs with scores of 80 and higher are working well but still may have a few areas that can be enhanced. An implementation plan that addresses specific issues can help you achieve greater reliability. Programs that score between 50 and 79 have their strengths, but several aspects need to be corrected. Programs scoring below 49 have a number of opportunities for improvement. Scores in this range indicate that you may be missing critical information from your machines.

Regardless of your current score, there is always room to improve. Through regular assessments, you can revitalize your oil analysis program and maximize its potential. ■

About the Author

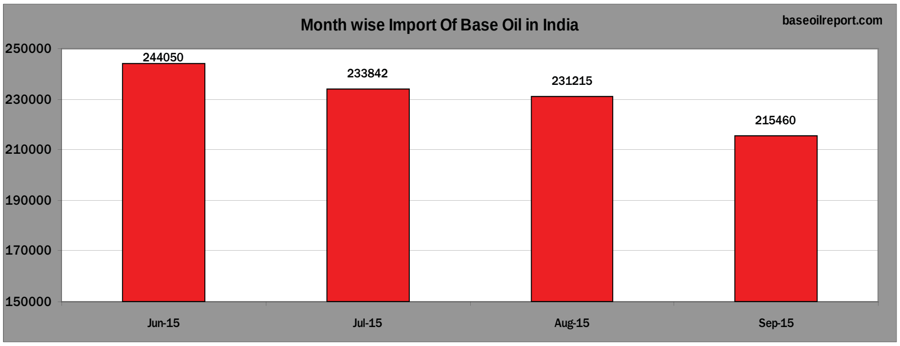
Alejandro Meza is a senior technical consultant with Noria Corporation. He has more than 20 years of experience in the lubricant industry, technical services, quality assurance, training, consulting and development in the United States, Brazil, Mexico and the Americas region. Contact Alejandro at ameza@noria.com to learn how Noria can help you assess your oil analysis program.

DHIREN SHAH

BASE OIL REPORT

India's oil imports from Iran fell 41.5% in October from a year ago to the lowest in seven months, as state-run refiner MRPL cut imports due to a maintenance shutdown. India, Iran's top customer after China, took 181,200 barrels per day (bpd) oil from Tehran in October, down 22.3% from September. Mangalore Refinery and Petrochemicals Ltd (MRPL), which operates a 300,000-barrels-per-day (bpd) coastal refinery in southern India, is a key Indian oil client of Iran. The refiner had shut nearly 46% of its crude processing capacity for about a month from 18 September for planned maintenance. MRPL planned fewer purchases of Iran oil for last month as its biggest crude distillation unit (CDU) was shut. While MRPL received about 45,000 bpd Iranian oil in October, private refiner Essar Oil took about 136,300 bpd. India, the world's fourth-biggest oil consumer, bought 21.8% less Iranian crude for the January-October period at about 212,600 bpd. India's imports from Iran for the year-to-date have been dragged down by deep cuts in shipments by New Delhi in the first quarter of 2015, under pressure from the United States to keep its imports within the limits of sanctions targeting Tehran's disputed nuclear programme. In the first seven months of India's fiscal year, running from April through October, its oil imports from Iran jumped 5.6% to 249,100 bpd as refiners raised purchases after the July deal that may mean the removal of sanctions next year.

During the period June 2015 to September 2015, India imported 924568 MT of Base Oil. The country imported 244050 MT in June, 233842 MT in July, 231215 MT in August and 215460 MT in September 2015. Compared to the previous month i.e. August 2015 Base Oil import of the country has decreased by 7% in September 2015. Compared to the same month last year i.e. September



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

Month	Group I - SN 150 Iran Origin Base Oil CFR India Prices	N-500 Korean Origin Base Oil CFR India Prices	J- 500 Singapore Origin Base Oil CFR India Prices	Napthenic Base Oil HYGOLD L2000
September 2015	USD 510 – 515 PMT	USD 635 – 650 PMT	USD 625 - 635 PMT	USD 605 - 625 PMT
October 2015	USD 490 – 495 PMT	USD 615 - 620 PMT	USD 605 - 615 PMT	USD 585 - 605 PMT
November 2015	USD 450 – 455 PMT	USD 575 - 580 PMT	USD 565 - 575 PMT	USD 545 - 565 PMT
	Since September 2015, prices have gone down by USD 60 PMT (12%) in November 2015.	Since September 2015, prices have decreased by USD 65 PMT (10%) in November 2015.	Since September 2015, prices have marked down by USD 60 PMT (10%) in November 2015.	Since September 2015, prices have dipped down by USD 60 PMT (10%) in November 2015.

2014, Base Oil import has gone up by 5% in September 2015.

The Indian base oil market remains steady with inventories at optimum levels with surplus of imported grades. During the month of September 2015, approximately 215460 MT have been procured at Indian Ports of all the grades, which is 7% down as compared to August 2015, Major imports are from Korea, Singapore, USA, UAE, Iran, Taiwan, France, UK, Netherlands, Japan, Italy, Belgium, etc. Indian State Oil PSU's IOC/HPCL/BPCL basic prices for SN – 70/N – 70/SN – 150/N -150 marked down by Rs. 1.50 per liter, while SN - 500/N - 500 down by Rs. 4.70 per liter. Bright Stock price was also marginally down by Rs. 1.00 per liter. The prices are effective November 02, 2015.Hefty Discounts are also offered by refiners for lifting sizeable quantity. Prices for the second half of the current month remains unchanged. Group I Base Oil prices for neutrals SN -150/500 (Russian and Iranian origin) are offered in the domestic market at Rs. 33.25 – 33.55/34.00 – 34.10 per liter, excise duty and VAT as applicable ex Silvassa in bulk for one tanker load. Further reduction in prices is not ruled out. At current level availability is not a concern.

The Indian domestic market Korean origin Group II plus N-60–70/150/500 prices at the current level have been marginally up. As per conversation with domestic importers and traders prices reflects minimal changes for N – 60/ N- 150/ N - 500 grades and at the current level are quoted in the range of Rs. 34.10 – 34.25/35.10 – 35.50/36.40 – 36.75 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. Discounts are offered for lifting sizeable quantity. 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.0.35 – 0.45 per liter on basic prices. Light Liquid Paraffin (IP) is priced at Rs. 35.70 – 35.80 per liter in bulk and Heavy Liquid paraffin (IP) is Rs.39.10 – 39.25 per liter in bulk respectively plus taxes extra.

During the month of September 2015, India imported 215460 MT of Base Oil. While India imported the huge quantum in small shipments on different ports.

Approximately 11382 MT of Light & Heavy White Oil has been exported in the month of September 2015 from Chennai, JNPT, and Village Ponneri and Raxaul. Compared to August 2015; exports of the country have gone up by 20% in the month of September 2015.

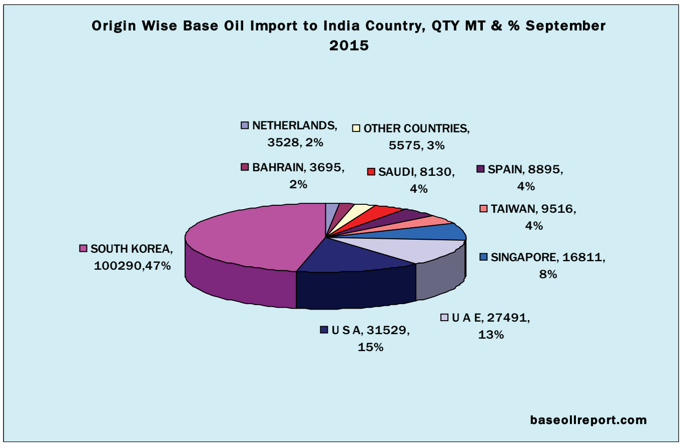
Approximately 2860 MT of Transformer Oil has been exported in the month of September 2015 from JNPT, Chennai and Village Ponneri from refiners, suppliers, buyers, traders, agents, consultants, lubricant companies, professionals and logistic providers as well as any other entities of the base oil value chain. Base Oil Report is a comprehensive marketplace for global

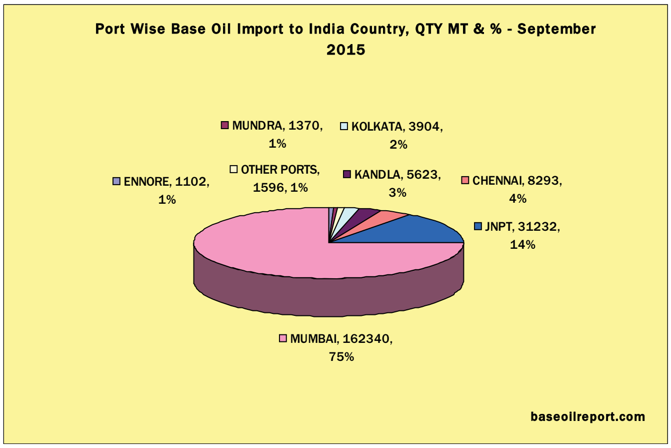
Export of Light & Heavy White Oil						
Argentina	Columbia	Greece	Kenya	Pakistan	South Africa	UAE
Australia	Cuba	Indonesia	Latvia	Peru	Spain	UK
Bahrain	Djibouti	Iran	Malaysia	Philippines	Sri lanka	USA
Bangladesh	Dominican Re	Iraq	Morocco	Poland	Sudan	Ukraine
Brazil	Ecuador	Israel	Myanmar	Russia	Taiwan	Uruguay
Bulgaria	Egypt	Italy	Nepal	Saudi Arabia	Tanzania	Vietnam
China	Guatemala	Ivory Coast	Netherlands	Senegal	Thailand	Zaire
Costa Rica	Germany	Japan	New Zealand	Sierra Leone	Tunisia	
Chile	Ghana	Jordan	Nigeria	Singapore	Turkey	

Approximately 11382 MT of Light & Heavy White Oil has been exported in the month of September 2015 from Chennai, JNPT, and Village Ponneri and Raxaul. Compared to August 2015; exports of the country have gone up by 20% in the month of September 2015.

Export of Transformer Oil in January 2015						
Bangladesh	Indonesia	Morocco	Oman	South Africa	Sri lanka	UAE
Brazil	Iran	Nepal	Paraguay	Saudi Arabia	Tanzania	Uruguay
Djibouti	South Korea	Nigeria	Peru	Singapore	Thailand	Vietnam
Ghana	Kenya	New Zealand	Philippines	South Africa	Turkey	

Approximately 2860 MT of Transformer Oil has been exported in the month of September 2015 from JNPT, Chennai and Village Ponneri.





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Dhiren Shah (Editor – In – Chief of Petrosil Group)

Dhiren Shah is a Chemical Engineer and Editor – In – Chief of Petrosil Group, who started his career with a reputed transformer oil manufacturing company in India as Sales Engineer and enhanced his knowledge by undergoing a business management course at the Indian Merchants Chamber. He later ventured and specialized in imports and logistics of petroleum products for 10 years and in 2002 became part of the Petrosil Group. He is instrumental in developing the various Petrosil brands. He loves to read and travel and is also an avid internet surfer.

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