Machinery Lubrication

INSIDE

How to Determine Bearing System Life

Advantages of a Unified Condition Monitoring Approach

India September - October 2014

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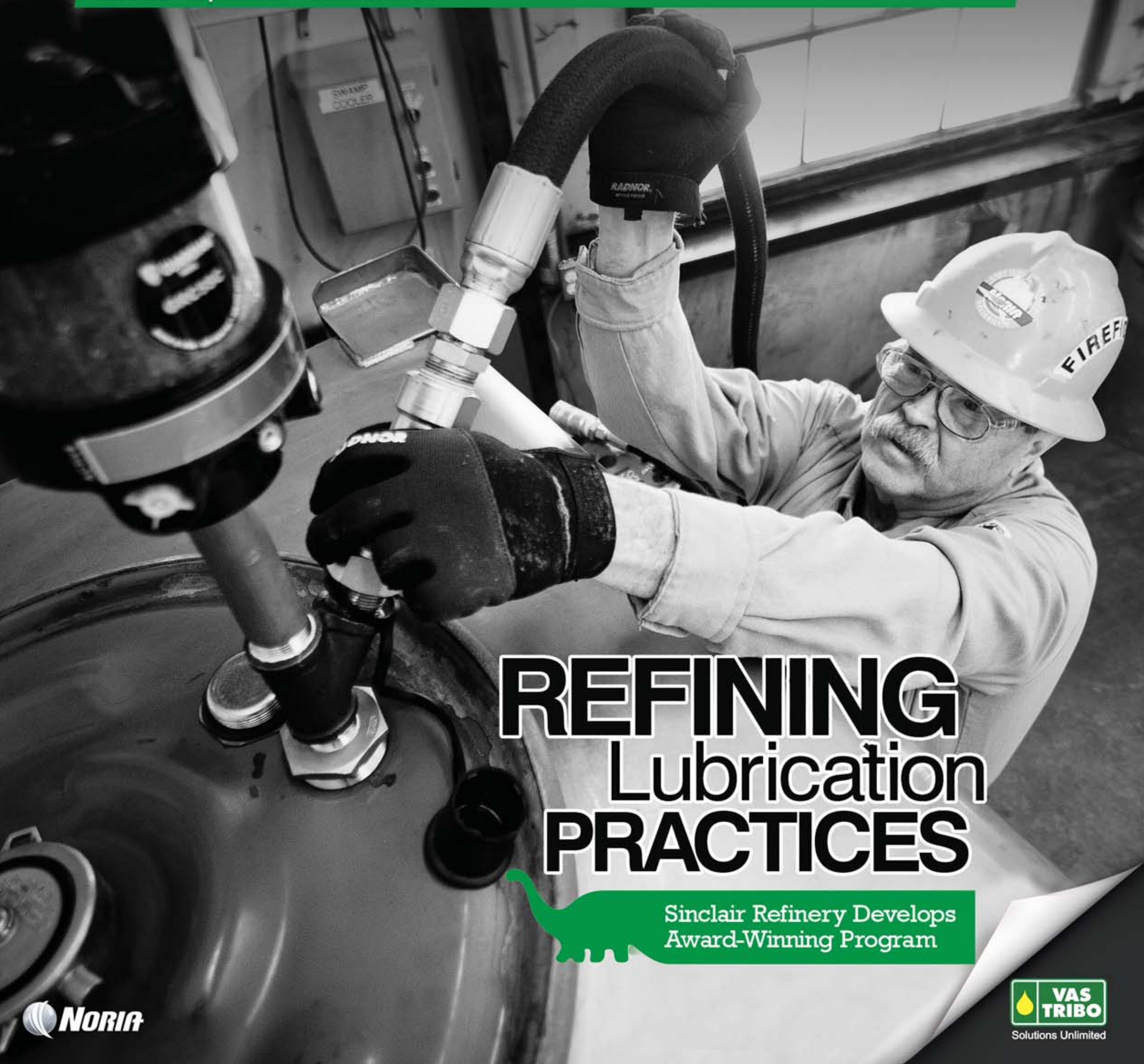

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Publisher's Note

September has seen massive showers, leading to floods in the northern part of the country. While the region is still recovering from this natural disaster, we wish strength to those who have been affected and hope that life restores to normal at the earliest.

In the previous issue we discussed about the secrets of becoming a world class PM facility, where we read about how Cargill's mining operation took significant steps in maintaining its mobile equipment fleet with the development and implementation of a world class preventive maintenance facility. We also gained knowledge about the advantages of proper lubricant storage and no matter whether we use bulk storage, totes or drums. It is important to learn the most effective ways to store and handle lubricants.

On the request of many of our subscribers in the petroleum sector, who had been requesting us for a case study on their sector, we decided to cover one in the current issue. The article writes about how Sinclair Wyoming Refining Co.USA, recognized the need to change its current lubrication practices in order to remain profitable and maintain its position as an industry leader. The task seemed daunting at first, but with guidance, great strides have been made in a short amount of time. The refinery is now approaching world class status. I am sure this case study would give many pointers to our subscribers to achieve a world class lubrication program.

We will also highlight the topic of how to determine the bearing system life where we discuss the Failure modes, Basic bearing life, Bearing system life & Causes for removal.

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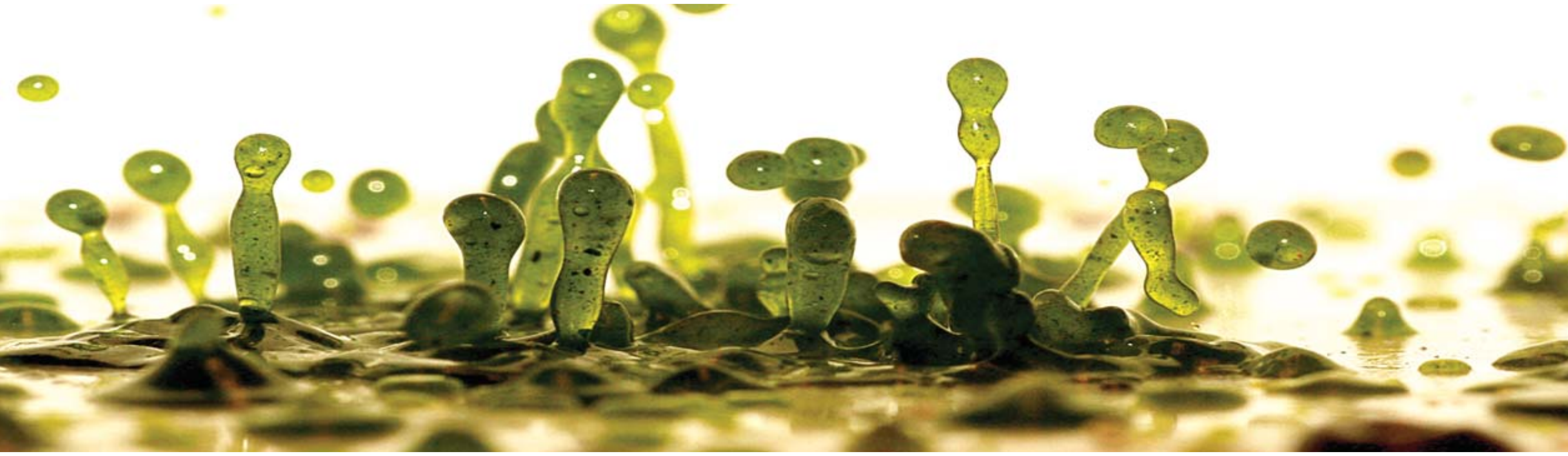

JIM FITCH NORIA CORPORATION

ADVANTAGES of a Unified CONDITION MONITORING Approach

For most plants, condition monitoring consists of multiple technologies that are cobbled together in an attempt to enhance machine reliability. Clearly, these efforts are founded in good intentions, and many such programs enjoy considerable success. Still others languish due to a lack of symmetry and central focus. Money is spent and efforts expended, but results are too often disappointing.

Condition monitoring requires a proper foundation from understanding and aligning criticality and failure mode analysis. Alignment greatly helps to optimize deployment of activities and spending to minimize waste and redundancy. Alignment also keeps the maintenance and reliability professionals on the same page by providing a clear understanding of what's being done and why.

This column is Part 3 on this topic. You can find Parts 1 and 2 at Machinery-Lubrication.com under the archive tab. In Part 1, "A New Look at Criticality Analysis for Machinery Lubrication" (April 2013), I discussed the concept of Overall Machine Criticality (OMC) and its importance on a wide range of decisions relating to machinery lubrication and oil analysis. When optimized, these decisions define the Optimum Reference State (ORS) needed to achieve the desired level of machine reliability. It is intuitively obvious that smart maintenance decisions require a heightened sense of both the probability and consequences of machine failure.

Part 2, "Don't Forget Lubricant Criticality When Designing Oil Analysis Programs" (April 2014), explained how there are consequences when lubricants fail that are, at least initially, independent of machine failure. These include the lubricant replacement costs (material, labor, flushing, etc.) and associated downtime. These costs can exist in the presence of a perfectly healthy and operating machine. Of course, lack of timely replacement of a defective lubricant will invariably lead to dire machine failure consequences. For some machines, these cascading events can produce enormous collateral damage and financial hardship to an organization.

To my knowledge, the method presented in this article is the first truly rationalized and unified approach to condition monitoring based on both machine and lubricant failure mode ranking and criticality analysis. The condition monitoring methods and technologies being integrated include oil analysis (real-time, portable and laboratory), field inspections (advanced methods providing frequent and comprehensive assessments), and other portable and

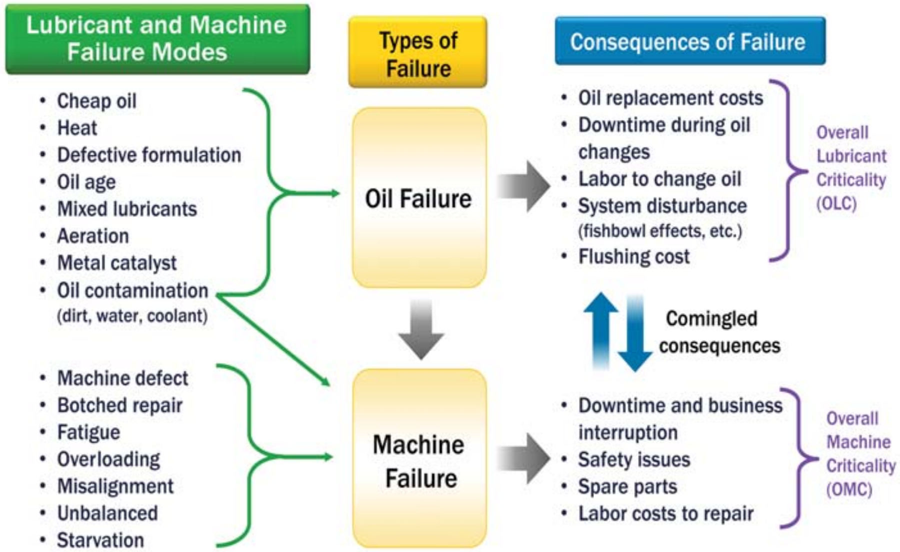

Figure 1. The relationship between machine criticality and lubricant criticality

MACHINE FAILURE MODE (MFM) RANKING (Example below)	Overall Machine Criticality (OMC) Score									
	100	90	80	70	60	50	40	30	20	10
1. Particle Contamination	CM1	CM1	CM1	CM2	CM3	CM3	CM3	CM4	CM4	CM5
2. Water Contamination	CM1	CM1	CM2	CM3	CM3	CM3	CM4	CM4	CM5	CM5
3. Varnish & sludge	CM1	CM2	CM3	CM3	CM3	CM4	CM4	CM4	CM5	CM5
4. Low oil level	CM2	CM2	CM3	CM3	CM4	CM4	CM4	CM5	CM5	CM6
5. Wrong oil	CM2	CM3	CM3	CM4	CM4	CM4	CM5	CM5	CM6	CM6
6. Misalignment	CM3	CM3	CM3	CM4	CM4	CM5	CM5	CM6	CM6	CM6
7. Aeration & foam	CM3	CM3	CM4	CM4	CM4	CM5	CM5	CM6	CM6	CM6

Figure 2. Surveillance Planning Table for the Machine

LUBRICANT FAILURE MODE (LFM) RANKING (Example below)	Overall Lubricant Criticality (OLC) Score									
	100	90	80	70	60	50	40	30	20	10
1. Heat	CM1	CM1	CM1	CM2	CM3	CM3	CM3	CM4	CM4	CM5
2. Water Contamination	CM1	CM1	CM2	CM3	CM3	CM3	CM4	CM4	CM5	CM5
3. Cross Contamination	CM1	CM2	CM3	CM3	CM3	CM4	CM4	CM4	CM5	CM5
4. Aeration	CM2	CM2	CM3	CM3	CM4	CM4	CM4	CM5	CM5	CM6
5. Metal Particles	CM2	CM3	CM3	CM4	CM4	CM4	CM5	CM5	CM6	CM6
6. Wrong or Defective Lubricant	CM3	CM3	CM3	CM4	CM4	CM5	CM5	CM6	CM6	CM6
7. Microdieseling	CM3	CM3	CM4	CM4	CM4	CM5	CM5	CM6	CM6	CM6

Figure 3. Surveillance Planning Table for the Lubricant

TEST AND INSPECTION CATEGORIES

- A = Real-time Sensors
- B = Daily Field Tests or Inspections
- C = Weekly Field Tests or Inspections
- D = Monthly Lab Analysis
- E = Bi-monthly Lab Analysis
- F = Quarterly Lab Analysis

CONDITION MONITORING ZONES	SURVEILLANCE LEVEL
CM1 = A plus D	Real-time Surveillance
CM2 = A or B plus D	Daily Surveillance
CM3 = A, B or C plus E	Weekly Surveillance
CM4 = D	Monthly Surveillance
CM5 = E	Bi-monthly Surveillance
CM6 = F	Quarterly Surveillance
CM7	Never Surveillance

real-time condition monitoring technologies (thermography, vibration, etc.).

This approach is important enough that it deserves a name: Unified Condition Monitoring (UCM). What makes UCM different from other strategies is the following:

1. Periodic condition monitoring technologies and methods for each machine are integrated and optimized.
2. Periodicity for each technology and method is optimized.
3. The method of optimization is based on criticality analysis and failure mode ranking.

Failure Mode Ranking

Ranking failure modes helps customize and optimize the condition monitoring strategy. This is another way to say gaining the greatest benefit for the least possible cost and risk. According to the Pareto principle, the top 20 percent of failure causes are responsible for roughly 80 percent of the failure occurrences. It only makes sense to focus resources and condition monitoring on the top 20 percent.

Failure modes and failure root causes are closely associated and are often the same. For instance, abrasive wear may be the

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failure mode, but particle contamination is the root cause. Ignorance, culture, insufficient maintenance and poor machine design are all possible pre-existing conditions that individually or collectively lead to contamination. Because you can always search for deeper levels of "cause," for simplicity, the terms "failure mode" and "root cause" are used interchangeably.

Figure 1 shows the relationship between machine and lubricant failure. On page 3 are common causes (failure modes) of lubricant failure (LFM) and machine failure (MFM). For example, heat, aeration and contaminants are known to be highly destructive to lubricants. In a similar sense, overloading, misalignment and contamination can abruptly cause a machine to fail. Note how contamination not only can fail a lubricant but also can fail a machine directly without the need to harm the lubricant first.

It is best to not only list failure causes but also to rank them in terms of probability and severity. This helps allocate resources by priority. From lubricant and machine failure come specific consequences, which are listed on the right in Figure 1. Again, these consequences are mutually exclusive. Lubricant failure consequences include oil replacement costs, downtime during the oil change, labor to change the oil and flushing costs. Machine failure consequences relate to safety, spare parts, labor to repair and downtime (e.g., production losses).

The Overall Lubricant Criticality (OLC) defines the importance of lubricant health and longevity as influenced by the probability of premature lubricant failure and the likely consequences (for both the lubricant and the machine). The Overall Machine Criticality (OMC) defines the likelihood and consequences of machine failure alone. The methods for calculating OLC and OMC were previously discussed. Like many such

Oil Analysis Tests and Inspections	OMC OR OLC SCORE	PARTICLE CONTAMINATION	WATER CONTAMINATION	VARNISH AND SLUDGE	LOW OIL LEVEL	WRONG/ DEFECTIVE OIL	MISALIGNMENT	AERATION AND FOAM	HEAT	CROSS-CONTAMINATION	METAL PARTICLES	MICRODIESELING
MFM	80	CM1	CM2	CM3	CM3	CM3	CM3	CM4				
LFM	70		CM3			CM4		CM3	CM2	CM3	CM4	CM4
Viscosity						L4				L4		
Acid Number				L4		L4						
FTIR-Ox				L4								
FTIR-Nitr				L4								L4
FTIR-Phenolic Inhibitor				L4		L4				L4	L4	
Linear Sweep Voltam.				L4		L4						
RPVOT				E		E						
MPC				L6								L4
Particle Count		R & L4									L4	
Water - KF			L4									
Elemental Spectroscopy						L4	L4			L4	L4	
Ferrous Density							L3				L4	
Wear Particle I.D.							E					
Inspection/Field Test: - Oil Color/Clarity - Oil Level - Oil Aeration & Foam - Magnetic Plug			F2	F3	F2	F2	F3	F3		F2		F2
Real-time Sensors									R			
Vibration Analysis							F3					

LEGEND

E = Exception lab test (e.g., analytical ferrography)
R = Real-time monitoring (e.g., an online particle counter)
L = Routine lab testing (either onsite lab or offsite commercial lab)
F = Field inspection (e.g., oil level inspection) or field instrument (e.g., portable patch test kit, portable vibration tools)
2 = Daily monitoring
3 = Weekly monitoring
4 = Monthly monitoring
5 = Bi-monthly monitoring
6 = Quarterly monitoring

Figure 4. Combined Surveillance Planning Table for the Machine and Lubricant

methods, the approach is not an exact science but nevertheless is grounded in solid principles in applied tribology and machine reliability.

Building the Surveillance Planning Table

Figure 2 shows an example of a Surveillance Planning Table (SPT) for a given machine, e.g., a reciprocating compressor. The SPT is used to define the degree of surveillance (oil analysis and inspection, for instance) for each of the ranked failure modes. These failure modes are ranked from one to seven on the left of the SPT. Tribo-analysts and reliability professionals are best suited to assign this ranking for individual machines. The list shown in Figure 2 is hypothetical for the compressor example to illustrate how to build an SPT.

Across the top is the OMC range (see Part 1 for calculating the OMC score) from 10 to 100. A score of 100 represents high criticality from the standpoint of probability of failure and consequences of failure. In this example, the arrow shows the compressor to have an OMC score of 80. There are seven color-coded condition monitoring zones corresponding to time-based surveillance levels. These are also represented by the designations CM1 to CM7. The surveillance levels range from CM1 (real-time) to CM4 (monthly) to CM7 (never). For an OMC of 80, the condition monitoring zones range from CM1 to CM4.

The only things that change from machine to machine using the SPT are the failure mode rankings and the placement of the arrow corresponding to the OMC score. Otherwise, all SPTs look exactly the same. For instance, the compressor has particle contamination assigned to the highest ranked failure mode. With an OMC of 80, the intersecting box shows a CM1 condition

	ORS FINAL TESTING AND INSPECTION PLAN			
	REAL-TIME MONITORING	FIELD INSPECTION TEST	ONSITE LAB TESTING	FULL-SERVICE LAB TESTING
Viscosity				L4
Acid Number				L4
FTIR-Ox				L4
FTIR-Nitr				L4
FTIR-Phenolic Inhibitor				L4
Linear Sweep Voltam.				L4
RPVOT				E
MPC				L6
Particle Count	R			L4
Water - KF				L4
Elemental Spectroscopy				L4
Ferrous Density			L3	L4
Wear Particle I.D.				E
Inspection/Field Test:				
- Oil Color/Clarity		F2		
- Oil Level		F2		
- Oil Aeration & Foam		F3		
- Magnetic Plug		F3		
Real-time Sensors	R			
Vibration Analysis		F3		

Figure 5. Condition Monitoring Work Plan

monitoring zone. This relates to real-time surveillance. You can see in Figure 2 that "real time" refers to the use of real-time sensors (A) and monthly oil analysis (D) from the test and inspection categories list. There are numerous online particle counters on the market that could be conveniently used for CM1 surveillance. On the other hand, water contamination merits a CM2 surveillance level. This can be done using daily inspections and monthly oil analysis.

Figure 3 presents a similar SPT but specifically for the lubricant. The Lubricant Failure Mode ranking is on the left, and the Overall Lubricant Criticality is across the top. In this case, the OLC score is 70, which has condition monitoring zones ranging from CM2 to CM4.

Combining Machine and Lubricant SPTs

Figure 4 shows the SPTs for both the machine and lubricant in a single unified table. The failure modes for both MFM and LFM are listed across the top with the corresponding condition monitoring surveillance zones just below. Down the left are various oil analysis tests and inspections that satisfy the condition monitoring requirements for each failure mode. This list was developed based on the available and required technologies and methods. The legend lists specific surveillance types (e.g., lab testing or inspection) and periodicity (frequency of use).

By referring to the condition monitoring zones under each failure mode, the surveillance type(s) and periodicity can be properly selected and optimized. For instance, under particle contamination is the R designation (for real-time) and L4 (for monthly laboratory analysis). Under aeration and foam is the F3 designation for weekly field inspections of the compressor's sight glass.

Misalignment is monitored using multiple methods including elemental analysis of wear metals (monthly laboratory analysis), ferrous density analysis (also monthly), wear particle identification (on exception based on elemental analysis and ferrous density), magnetic plug inspections (weekly) and vibration analysis (weekly). These tests and inspections can easily be rationalized and streamlined to improve efficiency and reduce costs.

All of the tests and inspections can be condensed into a single condition monitoring work plan for the compressor, as seen in Figure 5. The tests and methods needed are clearly shown as well as the frequency for the four main monitoring categories: real-time sensors, field inspections/tests, onsite lab testing and full-service lab testing. This work plan is the final product of the UCM strategy.

Using the Unified Condition Monitoring Model

From the preceding discussion, you can see how nearly all decisions related to periodic condition monitoring depend on four factors: Overall Machine Criticality, Overall Lubricant Criticality, Machine Failure Modes and Lubricant Failure Modes. These factors influence what to test, when to test and how to test. In relation to oil analysis, these factors affect where to sample, how often to sample, which tests to conduct, which alarms to set and the general data-interpretation strategy.

UCM is an overarching principle that can be adapted for many applications and uses in the reliability field. The more you know about machine-specific failure modes and criticality, the better you can plan and optimize condition maintenance across multiple technologies within both predictive and proactive schemes. On the surface, these foundation pieces can seem time-consuming and arduous, but in the long run you gain by reducing costs and optimizing the benefits. These are solid and wise reliability investments indeed.

About the Author

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

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WHY CLEAR and Bright OIL SAMPLES are NOT Good Enough

Before joining Noria as a technical consultant, I served in the U.S. Navy where I was stationed aboard the USS Saratoga and assigned to the oil lab. Prior to placing equipment into operation onboard the ship, we would draw an oil sample and conduct a visual analysis. If the sample was "clear and bright," it was considered acceptable, and the equipment was placed into service. I now know that using the "clear and bright" standard is not nearly good enough. Particles that cause the majority of damage in equipment are smaller than can be seen with the naked eye, and lube oils can contain up to 0.1 percent water and still be "bright." Keep in mind that at 0.1 percent water, 75 percent of the bearing's life may have been lost.

Oil Analysis in the Navy

The following excerpt is from the Navy's *Machinist Mate 3 & 2*, which is the advancement training guide for steam plant operators, heating and air conditioning technicians, and ship oil kings:

"Lubricants must be maintained at specified standards of purity and at designed pressures and temperatures. Without proper lubrication, many units of shipboard machinery would grind to a screeching halt."

Note the phrase "specified standards of purity." Prior to starting a piece of equipment, one of the requirements is to draw an oil sample. This sample is sent to the shipboard oil lab for analysis. According to the *Machinist Mate 1 & C*, the procedure is as follows:

"The visual test must meet the clear and bright criteria. Clear refers to the lack of particulate matter in the sample. Particulate matter cannot cover more than one-quarter of the bottom of the sample bottle. The bright criteria refer to the lack of free water in the sample. Entrained water can dull the lube oil sample. If the sample is dull, try to read a PMS card through the sample. If you can read the PMS card, it passes this test. If it does not pass the visual test, you need to run a BS&W test. Be careful of entrained air that may dull the sample. If you are unsure whether air or

OIL TYPE / APPLICATION	TEST PERFORMED	LIMITS ALLOWED
MIL-L-9000/Lube Oil (MS 9250) Diesel Engine Oil	• Viscosity at 100ºF • Water Content • Acidity Test • Fuel Dilution • *Spectrometric Analysis Performed	100-225 Centistokes Pass/Fail 0-2% Satisfactory 2-5% Notify Customer 5% Abnormal: Secure Machinery
MIL-L-17331/Lube Oil (MS 2190TEP) Marine Turbine Oil	• Acid Number • Water Content • *Spectrometric Analysis Performed	0.5 Mg KOH/g max. 0.1% max.
MIL-L-23699/Lube Oil Aircraft Engine Oil	• Viscosity at 100ºF • Acid Number • *Spectrometric Analysis Performed	25-37 Centistokes 1.0 Mg KOH/g max.
VV-L-825/Lube Oil Refrigerant Oil	• Water Content • Acid Number • *Spectrometric Analysis Performed	0.01% Max. 0.1 Mg KOH/g Max.
MIL-L-17331/Hydraulic MIL-H-17672/Hydraulic MIL-H-5605/Hydraulic MIL-F17111/Hydraulic	• Water Content • Particle Count	0.05% Max. NAS Class 9 Max.
MIL-H-83282/Hydraulic	• Water Content • Particle Count	0.05% Max. NAS Class 7 Max.
MIL-H-19457/Hydraulic	• Water Content • Acid Number • Flash Point • Particle Count	0.3% Max. 0.3 Mg KOH/g Max. 475ºF Min. NAS Class 12 Max.
MIL-H-22072/Hydraulic	• Viscosity at 100ºF • pH • Particle Count	41-51 Centistokes 8.2-10.0 NAS Class 9 Max.

CLASS	Maximum Particles/100mL in Specified Size Ranges (μm)				
	5-15	15-25	25-50	50-100	>100
00	125	22	4	1	0
0	250	44	8	2	0
1	500	89	16	3	1
2	1,000	178	32	6	1
3	2,000	356	63	11	2
4	4,000	712	126	22	4
5	8,000	1,425	253	45	8
6	16,000	2,850	506	90	16
7	32,000	5,700	1,012	180	32
8	64,000	11,400	2,025	360	64
9	128,000	22,800	4,050	720	128
10	256,000	45,600	8,100	1,440	256
11	512,000	91,200	16,200	2,880	512
12	1,024,000	182,400	32,400	5,760	1,024

The NAS 1638 Contamination Classification System, which has been discontinued and replaced with SAE AS4059E

water is the cause of the dullness, let the sample settle a few minutes. Air will clear to the top of the sample; water will settle to the bottom."

If the oil sample contains particles longer than 1/8 inch along any axis or if visible sediment is noted, the procedure is to let the sample bottle sit for 10 minutes and then lay it on its side for 10 minutes or until all visible sediment has settled to the bottom. If this results in a solid line, a bottom sediment and water (BS&W) test is required. The BS&W test involves spinning 100 milliliters of the oil sample at 1,500 revolutions per minute for 30 minutes and then recording the results. Generally, results of less than 0.1 percent by volume are acceptable.

Samples are sent periodically to a Navy oil analysis program laboratory for testing. The test slate will be dependent on the type of oil and the associated equipment class. The table on page 8 shows the test slate based on fluid and application types.

For oils designated for equipment lubrication, a spectrometric analysis is conducted to track wear metal concentrations for trending and troubleshooting. Among the metals that are tested for include iron, nickel, sodium, lead, silver, phosphorus, copper, tin, zinc, chromium, silicon, calcium, aluminum, boron and barium. The National Aerospace Standard (NAS) classification reference is to the NAS 1638 standard, which was used to indicate particle counts. It has been discontinued and replaced with SAE AS4059E.

Inherent Problems

The problems associated with using clear and bright as acceptance criteria for lubricants in operating machinery should be fairly obvious. "Clear" refers to the lack of particles, which are generally measured in microns. One micron is 39 millionths of an inch. The human eye can see particles down to the 40-micron range. A human hair is between 30 and 120 microns. The oil film on a journal bearing runs from 5 to 200 microns, but on rolling-element bearings, it is usually less than 1 micron. The table on page 10 offers a comparison of clearances for various components.

Suffice it to say, it would be nearly impossible to see the particles that are doing the damage. Particles in the size range of the working clearance cause the most damage. Several of the larger pieces of marine equipment use journal bearings, so to a certain degree they are designed to be more forgiving of the smaller, submicron particles. However, in the case of rolling-element bearings, it is a different story. As previously stated, the lubricant film in rolling-element bearings is usually less than 1 micron.

According to SKF, the cleaner the lubricant, the longer bearings will last. In fact, the bearing company has gone so far as to state, "Bearings can have an infinite life when particles larger than the lubricant film are removed."

SKF has conducted case studies and determined that roughly 70 percent of bearing failures are due in part to contamination. Similar studies show the benefits of controlling particle contamination. For instance, Nippon Steel was rewarded for its contamination control efforts with a nearly 76-percent reduction in pump replacement frequency, a 75-percent reduction in oil consumption, an 80-percent reduction in hydraulic repairs and a 50-percent reduction in bearing purchases. Likewise, after BHP Billiton improved filtration at one of its mills, production increased nearly 3.5 times. These are just a few examples of the benefits to be gained from controlling particle contamination.

"Bright" refers to the presence of water. Whoever made the statement that oil and water do not mix was just plain wrong. Nearly all oils have a certain quantity of dissolved water, and this dissolved water will not be evident by conducting a visual test. Oil will contain a quantity of water up to the saturation point and still appear clear.

According to SKF, "The presence of water in lubricating oils can shorten bearing life down to 1 percent or less, depending on the quantity present."

Oil can actually carry up to 2,000 parts per million of dissolved water before reaching its saturation point and beginning to appear cloudy.

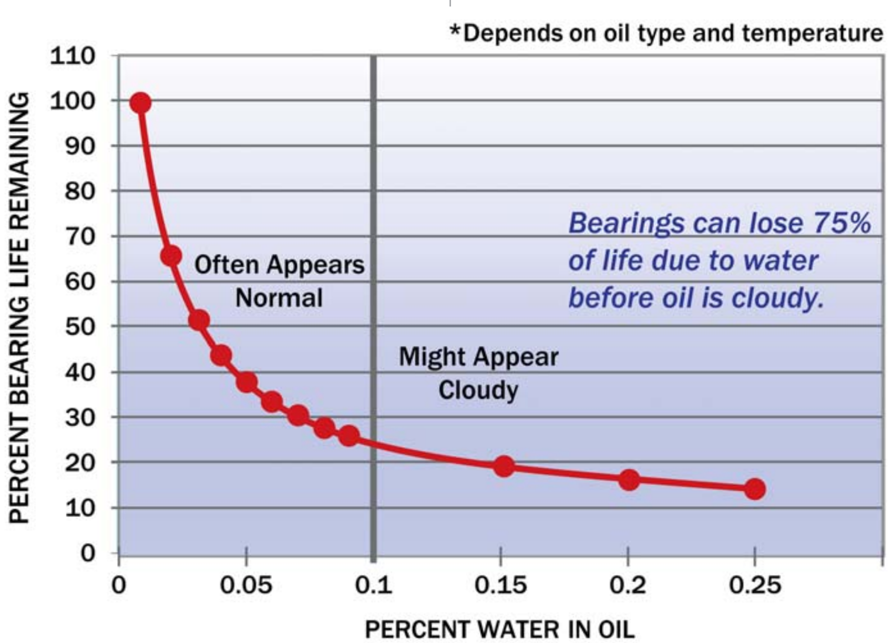
In his *Machinery Lubrication* article on how water causes bearing failure, Jim Fitch explained several modes of failure caused by water in oil. Among these are hydrogen-induced fractures, corrosion, oxidation, additive depletion, oil flow restrictions, aeration and foam, impaired film strength, and microbial contamination. A few of these modes are less obvious as to how they operate than others.

COMPONENT	CLEARANCE microns
Rolling-element Bearings	0.1 to 3
Journal Bearings	0.5 to 100
Gears	0.1 to 1
Engines	
• **Ring/Cylinder**	0.3 to 7
• **Rod Bearing**	0.5 to 20
• **Main Bearings**	0.8 to 50
• **Piston Pin Bushing**	0.5 to 15
• **Valve Train**	0.0 to 1.0
• **Gearing**	0.0 to 1.5
Pump, Gear	
• **Tooth to Side Plate**	0.5 to 5
• **Tooth Tip to Case**	0.5 to 5

In regard to impaired film strength, lubricating oils have a unique property known as the pressure-viscosity coefficient. Simply put, the higher the pressure, the higher the viscosity. The pressure in the load zones for rolling-element bearings is often in excess of 500,000 psi. This causes oil to almost become a solid, and it will maintain the separation between the rolling element and the raceway. The viscosity of water is one centistoke, and regardless of pressure, it stays essentially at one centistoke. Therefore, water will not be sufficient for maintaining the separation between the rolling element and the raceway.

It should now be readily apparent that it is not a sound practice to simply utilize the clear and bright criteria for determining whether oil is acceptable to use or for deciding whether equipment can be placed into service.

As far as I know, the Navy currently has no means of tracking the number of bearing failures it experiences over the course of a year. It would be interesting to see these statistics and the associated costs. If your organization is using the same methodology as the U.S. Navy, you likely are losing a large amount of money every year.



Case Study: USS San Antonio

The USS San Antonio was commissioned on Jan. 14, 2006. Shortly after being placed into service, the ship began to develop serious mechanical issues with its main propulsion diesel engines. The failures were the result of several factors, which were not all contamination-related.

The Navy conducted an investigation into the causes of the engine failures. Several issues were discovered, with a good number of them resulting from poor contamination control. In the investigation's report, it was noted that the lube oil service system design used muslin bags and that particles smaller than 25 microns would pass through the filters.

During inspections of the engine oil sumps, welding slag, paint chips, inorganic fibers and free water were found. It was also reported that the system configuration allowed contaminants to recirculate through the pump. These contaminants would be macerated until they were able to pass through the filter.

About the Author

Loren Green is a technical consultant with Noria Corporation, focusing on machinery lubrication and maintenance in support of Noria's Lubrication Program Development (LPD). He is a mechanical engineer who holds a Machine Lubrication Technician (MLT) Level I certification and a Machine Lubricant Analyst (MLA) Level III certification through the International Council for Machinery Lubrication (ICML). Contact Loren at lgreen@noria.com.

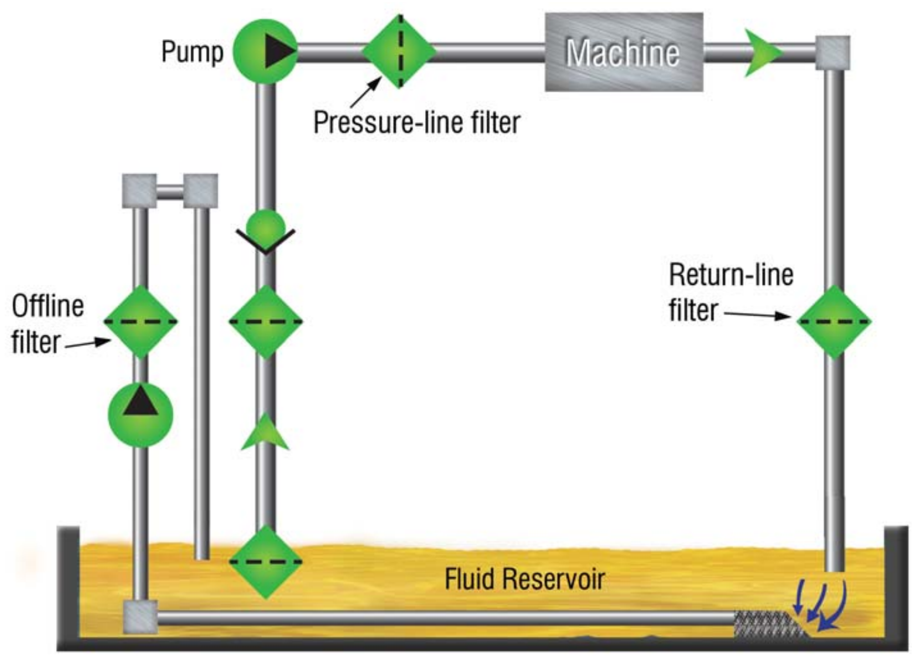
WES CASH | NORIA CORPORATION

Choosing the RIGHT OIL FILTER Location

Great emphasis has been placed on contamination control within lubricating systems. By limiting the amount of contaminants entering the lubricant, you can effectively extend the life of the equipment and the oil. Reducing the ingression rate is one part of achieving maximum machinery reliability; the other part is removing contaminants as quickly as they are introduced.

Perhaps the most common method of removing contaminants is utilizing filtration. Filters come in a variety of shapes and sizes and can be installed in multiple locations. A filter is the best line of defense to remove contaminants once they have entered the machine. With filtration systems, there are many options that must be considered to make sure the system is as efficient as possible.

One of the first considerations is the filter material. The construction material can make a difference in the filter's ability to do its job well. For instance, fiberglass filters have more pores and thus generally have a higher dirt-holding capacity. Fiberglass also holds up to acidic environments better than traditional cellulose-type media. One of the benefits of cellulose is that it can absorb some water from the oil being filtered.



Filter location options

For each filter media decision, there are also filter elements that must be considered as well. Two common types of filter elements are surface-type and depth-type elements. With surface-type elements, the majority of particles are trapped on the filter's surface. These are typically constructed of a single layer of material that oil flows through and that traps particles as they pass by.

As their name suggests, depth-type media have more depth than surface-type elements. In depth filters, oil flows in a tortuous path throughout the media, and particles are trapped throughout the depth of the filter. Since these filters require the oil to remain in contact with the media for a longer period of time, they also tend to have a higher differential pressure or pressure drop across the elements. Care must be taken when using these types of filters in a supply-line application, as they can reduce oil flow to lubricated components downstream and lead to equipment failures.

Both media and filter materials can be designed to work in a variety of applications and are regularly used in tandem with each other in different locations throughout a system. Depending on the system design and overall machine criticality, several filtration options must be considered to achieve the system's target ISO cleanliness codes. The filter's physical location in the lube system will make a difference in some of the decisions such as media type and construction material.

With full-flow filters or when filters are installed in the supply line, they offer direct protection to components downstream of the filtration system. Since these filters are in the path of the oil before it lubricates any components, they must be monitored for any signs of filter plugging or the filter going into a bypassed state. The term "bypass" is a reference to an internal valve that opens when pressure becomes too great. If the filter's bypass valve is opened, the oil flows around the filter and continues through the system unfiltered. When installing full-flow filters, ensure you have differential pressure gauges to monitor the health of the filters and to confirm oil is still flowing through the system.

Return-line filters are common in most hydraulic systems. They are installed in the line after all lubricated components and before the main reservoir. While these filters don't offer direct component protection like supply-line filters, they are often oversized, which can lead to longer filter life. Typically, these filters are installed in tandem, so if one becomes plugged, the line can be switched over to allow the plugged filter to be changed without disrupting lubricant flow. Aside from being oversized, return-line filters usually have high beta ratios. The beta ratio refers to the filter's capture efficiency. The higher the beta ratio, the more efficient the filter is in capturing particles at the rated micron size.

Kidney-loop systems offer the best option for reaching total system cleanliness targets. Since they don't require the system to be working in order for the filters to be active, they provide a more economical method of removing dirt. With kidney-loop systems, it is also easy to add additional lubricant conditioning and monitoring accessories, such as heat exchangers, temperature gauges, online water meters, etc. These accessories can help ensure that the health and life of the oil are monitored and controlled as much as possible.

Filter carts and other portable filtration devices can be used as a kidney-loop filtration system on most machines. These allow you to decontaminate the in-service lubricant as well as clean the oil as it is transferred from the drum into the system. An added benefit of portable systems is that they can be moved from one system to the next. Care should be taken to make certain that they are dedicated to a single lubricant to avoid any potential problems with cross-compatibility between different lubricant types.

To maintain and improve system cleanliness, a balance must be established to remove particles as quickly as they are ingressed. For this to be achieved, the correct filtration system must be employed. In most cases, utilizing multiple filter locations offers the best way to hit the cleanliness targets that the machine requires to operate at optimum reliability. By reducing the number of particles in the oil, you can extend the life of the machine and make your facility more profitable.

About the Author

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Benefits of Offline Filtration

Off-line filters are a relatively modern alternative or addition to conventional full-flow filters. These filters sit off the main operating system as a side loop from the reservoir. A necessary supplemental component to the off-line filter is a pump and motor. Because it does not depend on the hydraulic system, it can run independently, even when the main system is off. The following are a few additional benefits of off-line filtration:

- Constant flow optimizes dirt-holding capacity and capture efficiency for a given type of filter
- Easy to service "on the run" (filter changes, repairs, etc.)
- Heat exchanges can be built in the loop
- Sample ports can be installed for sampling on the run
- Lowest cost to remove a gram of dirt (expensive pressure-line and surge-resistant filters are required)
- Can double for an oil transfer system for adding makeup oil

ALEJANDRO MEZA | NORIA CORPORATION

Managing CHANGE For a SUCCESSFUL Lubrication Program

Many organizations struggle when implementing a lubrication program because they have a partial vision of the program's scope or because they have no formal change-management plan. However, an effective program administration with a systematic view and an appropriate change-management strategy can help you achieve the goal of lubrication excellence.

Successful implementations of lubrication best practices consider several technical, organizational and human factors related to a lubrication project. These principles are not only suitable for lubrication programs but also for other maintenance strategies.

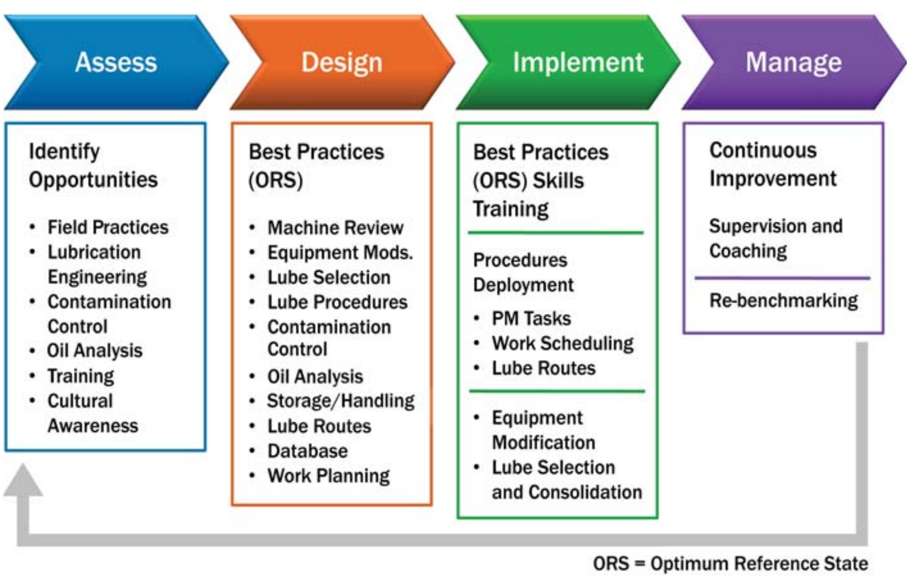
A Holistic Approach

The fundamentals of lubrication excellence are well-known: use the right lubricant in the right amount at the right time and keep your lubricants clean, cool and dry. Your lubrication strategy should be implemented in a way that ensures all of these require ments are fulfilled on a continuous basis. This implies not only knowing the content and importance of each individual requirement but also the value of coordinating the actions in a methodical manner. Thus, to be successful, it is necessary to understand lubrication excellence from a holistic or systemic standpoint. Otherwise, there is a risk of implementing isolated actions that may improve lubrication reliability but not necessarily to the optimum level.

For example, a manager may have detected the need to improve the lubrication practices at his plant and decided to send his lube technicians or mechanics for training. Upon their return, the participants should have a good understanding of the best practices for handling, storing and applying lubricants. They may also be able to identify opportunities to improve and be ready to change. The challenge is that they do not have the tools or hardware to work under the new vision of excellence. There also is not a proper lube room to organize their equipment or formal procedures aligned with the training. Frustration may occur in this scenario, and the effectiveness of the implementation likely will be very poor.

A holistic vision of lubrication excellence has several categories. The first is the technical scope, which includes three factors: training and qualification, infrastr-ucture and tools, and methodology.

Training and qualification will be fundamental to ensure appropriate attitudes, behaviors and reliable work. The infrastructure and tools involve the physical resources that will provide the environment and suitable



4 Phases of Lubrication Program Development

hardware to execute the job in a consistent, safe, effective and ergonomic manner. The methodology refers to the systems, policies, procedures, instructions and records that guide the work to be performed following the best available practices.

If only one of these three elements is implemented, some improvements may occur, but the chances of overall program success are low. For instance, new procedures may be written and distributed, but if poor or no training is made available to involved personnel and no new tools or hardware are provided, the result will be a less than desirable outcome.

These three factors work together as a system and should be embraced by the improvement strategy. The same concepts apply to other functions and processes in the maintenance organization and operation.

8 Steps of Change Management

In their book, *The Heart of Change*, John Kotter and Dan Cohen state that change management should include a sequence of eight steps from the moment the need of change is identified until the new culture and practices are implemented and consolidated. Below is an example of how their model may be adapted to the implementation of a lubrication excellence program.

1. **Create urgency.** When the need for change or the opportunities for gains with lubrication excellence have been identified, it is time to start the process of change. The leader takes the initiative to communicate and sell the project to the decision-making team.
2. **Build a guiding team.** Once the idea is accepted, all participants must be identified (including external consulting/engineering support).
3. **Develop a vision and a strategy.** A project is defined with the steps to follow along with the expected results.
4. **Communicate the vision for buy-in.** The vision and benefits are communicated to the entire maintenance team and other involved personnel.
5. **Empower others to act.** The project is executed, and everyone participates in the design and implementation of the new practices. Newer technologies, hardware and software are acquired at this time.
6. **Produce short-term wins.** The first benefits of the lubrication program are seen, such as a reduction in oil consumption.
7. **Consolidate gains and produce more change.** The most valuable benefits of a reliability program come with time, so it is necessary to stay focused and maintain the new practices.
8. **Create the new culture.** The new lubrication culture is implemented, but it is important to monitor through indicators, records, meetings, etc., so it becomes permanent.

Project Management

For effective management of a lubrication program implementation, consider a formal project with systematic steps to be followed, moving from the identification of needs and the design of new procedures and technical requirements to implementation and management. The diagram on page 16 illustrates the approach Noria has used successfully with numerous customers.

Assess

The process should begin with an assessment to identify opportunities for improvement. How does the current state of the lubrication program compare to the desired one? Detailed elements relating to the three categories mentioned previously (methodology, training and resources) should be benchmarked against best practices. Noria utilizes a questionnaire of nearly 230 questions to assess 12 areas related to lubrication excellence.

Design

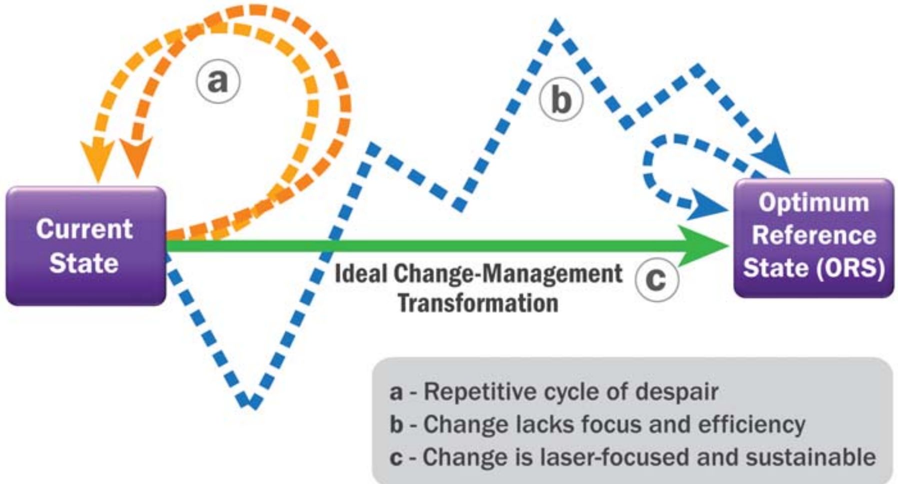
After the improvement opportunities have been determined, the next step is to define the desired engineering (lubrication) specifications. The practices to be implemented must be described in sufficient detail so they can be put into effect properly. These may include equipment modifications, the lube room design, procedures for handling and applying lubricants, training/certification requirements, etc. The formal definition of a best practice to be implemented is called the Optimum Reference State (ORS). This can be defined as the prescribed optimum state of machine configuration, conditions and maintenance activities required to achieve and sustain reliability objectives. Lubrication excellence is achieved when the current state of lubrication approaches that of the Optimum Reference State. The ORS consists of numerous individual attributes. These attributes should be measurable, verifiable and aligned with specific reliability goals, and collectively serve as an engineering specification for lubrication excellence.

Implement

The third stage is implementing what was technically defined in the second stage. This is a more hands-on step supported by the selection and acquisition of monitoring technology, installation of hardware, and deployment of the necessary training.

Manage

The fourth stage is managing the new system. It will be successful if the previous three stages were properly managed. It requires the use of appropriate key performance indicators (KPIs) to monitor the system.



The challenges of programmatic change

Is Change Management Necessary?

During the implemen-tation stage, which requires more intense field work, companies often struggle to select and purchase the proper hardware and technology that will be compatible with existing equipment and other technolo-gies to be integrated. Obtaining external support from an experienced party will save time and be very helpful in this process.

> Definition: The Optimum Reference State is the prescribed optimum state of machine configuration, conditions and maintenance activities required to achieve and sustain reliability objectives.

> Definition: Lubrication Excellence is achieved when the current state of lubrication approaches that of the Optimum Reference State.

The project can also suffer from a slow implementation pace or incomplete implementation and even return to old practices after supposedly being fully implemented. These possibilities may be the result of not involving all affected parties at the right time, a lack of communication and alignment among the implementation team, or insufficient managerial support. These symptoms also indicate the absence of a good change-management strategy and a holistic vision for the project.

A successful change-management initiative will include the following:

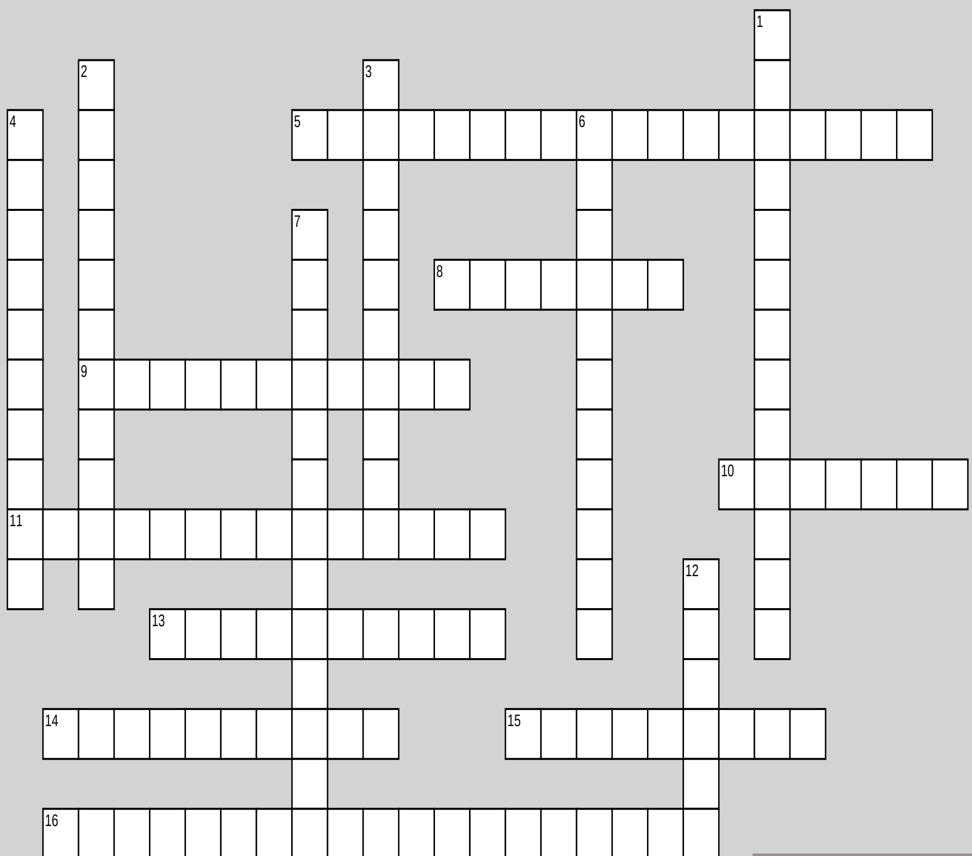
- Segmentation of the project scope in terms of personnel and areas involved within the organization as well as external parties
- Effective team communication, awareness and training
- Understanding the perceptions and motivation of the involved personnel
- Aligning the vision, developing teamwork, promoting change and consolidating gains
- Continuous measurement
- Unwaivering management support.

Of course, your lubrication or maintenance strategy will depend on the scope of the project, the size of your company and the cultural maturity of your organization, including not only the maintenance group but also top management and other areas that will be affected by the change. The bigger the organization and the project, the more relevant a good change-management initiative becomes, and the more resources will be needed for a seamless and faster implementation. ■

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 manage change to support a world-class lubrication program.

Crossword Puzzler»



Get the solution on page 34

Across

5 The time required for a fixed amount of an oil to flow through a capillary tube under the force of gravity.

8 A soft, white, non – ferrous alloy bearing material composed principally of copper, antimony, tin and lead.

9 A container in which fluid is stored under pressure as a source of fluid power.

10 A fluid used to remove heat.

11 A group of synthetic lubricants with superior fire resistance.

13 Engineering science pertaining to liquid pressure and flow.

14 A unit of absolute viscosity.

15 The release of a contaminant that was initially captured by the filter medium.

16 A black, lustrous powder that serves as a dry-film lubricants in certain high–temperature and high–vacuum applications.

Down

1 The temperature at which a grease passes from a semisolid to a liquid state.

2 The control of friction and wear by the introduction of a friction-reducing film between moving surfaces in contact.

3 Engineering science pertaining to gaseous pressure and flow.

4 Property of a lubricating grease manifested by a softening in consistency as a result of shearing.

6 A property of a solid-liquid system manifested by the tendency of the liquid in contact with the solid to rise above or fall below the level of the surrounding liquid.

7 The potential of a system for particle attraction and adhesion.

12 Insoluble material formed as a result of deterioration reactions in an oil or of contamination of an oil, or both.

JEREMY WRIGHT | NORIA CORPORATION

Use EDUCATION and Training to Overcome RESISTANCE to Change

What is the biggest hurdle when trying to implement a reliability or lubrication program? Is it funding or obtaining approval from upper management? Or maybe it's that you have no idea where to even start?

> *With the amount of training available today, there is no longer a valid reason to be unconsciously incompetent.*

Having designed and implemented world-class lubrication programs for many years, I know the answers to these questions. It has become easy for me to walk into a facility and compile a report of strengths, weaknesses, opportunities and threats. Within three days, I will have written more than 100 pages spelling out the current conditions, the optimum conditions and a gap analysis of how to bring the two more in line with one another. These exercises have become almost second nature to me. But why do some facilities that receive this information put it into practice, while others allow their programs to wither and die?

When I become part of a program, I like to share in its successes and failures, and I don't like to fail. If there is a failure, I want to know why so I can prevent it from happening again. After a few investigations, I've come to the realization that almost all the failures (those that have not yet approached world-class status) had something in common — the stakeholders were not on the same page. They lacked a common goal and were pulling the program in different directions.

Upon further investigation, I found the root cause of the problem — people do not like change. There are many reasons for this apprehensiveness to change, including fear of the unknown, lack of trust, unconscious incompetence, ties to the old way of doing things and failure to communicate the project's benefits. See the sidebar on page 19 for a more detailed list of the reasons why people resist change.

To combat this resistance, the first thing you should do is to expect it because it will happen. Of course, the pushback you receive can come in different levels of severity. It may feel like opposition is coming from the

entire company at once or only from a select few individuals. However, if you are expecting it, it can be handled easily.

Now that you are anticipating resistance, plan how you will manage the objections. Take a proactive approach. Noria preaches proactive maintenance, but what about proactive objection management? A great way to start is to focus on the list of reasons for apprehensiveness to change. What can you do to ease this apprehension? Education and communication offer the best solution.

Before changes come flying down the organizational hierarchy, you must show those who will be most affected why the change is needed. The likelihood of success is severely diminished when the change comes in the form of an order. I've found that pushback and apprehension decrease to almost nothing if you take the time to sit down with those affected and educate them. Once they thoroughly understand the situation along with the nuances of the decision, they will either get onboard with the project or at least know enough about it to be able to make suggestions. Either of these situations is beneficial to the overall outcome of the project.

Change management is the single most important aspect of implementing a lubrication or reliability program.

6 Reasons for Resistance to Change

1. **Fear of the Unknown** – People will only take steps toward the unknown if they believe that the risk of standing still is greater than that of moving in a new direction.
2. **Competency** – Change in an organization often necessitates a change in skills, and some people fear they won't be able to make that transition.
3. **Trust** – If your organization has tried unsuccessfully to implement programs in the past, why should employees trust that this one will be successful?
4. **Unconscious Incompetence** – If there is no understanding of why a change is needed, the change rarely happens.
5. **Ties to the Old Way** – People are hard-wired and emotionally connected to a certain way of doing things. The longer they have been doing them that way, the harder it is to break that tie.
6. **Failure to Communicate the Benefits** – If you cannot easily help an individual or group see the benefits of change, they are much more likely to be resistant.

Frequently, I'll spend a few hours on basic lubrication fundamentals and then begin discussions with the group about their particular plant. I like to use real-world examples and discuss opportunities that center around change. I also ask lots of leading questions to steer the conversation. When I hear, "Why haven't we always been doing it like that?" I know I've won them over. Through education and communication, I have shown them that the new way is better and has less risk than the old way.

If you really want to increase the likelihood of success, put their new knowledge to use. Ask for input based on what they have learned from past experiences as well as their new awareness. When they start contributing, they will feel ownership in the cause. This is the ultimate goal. When others have contributed their ideas, time and effort to the decision for change, how can they oppose it?

Change management is the single most important aspect of implementing a lubrication or reliability program. You may have the best plan, equipment and backing and still fail if the people charged with making the change on the plant floor are not 100-percent onboard. Training and education are key to this onboarding process. With the amount of training available today, there is no longer a valid reason to be unconsciously incompetent. Make training a priority before the implementation of any program and you will see the likelihood of success skyrocket.

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 to learn how Noria can help you implement a world-class lubrication program.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REFINING LUBRICATION PRACTICES

How the Sinclair Refinery Developed an Award-Winning Lubrication Program

BY JONATHAN MCNEES, SINCLAIR WYOMING REFINING CO.

A little more than a year ago, the Sinclair Wyoming Refining Co. recognized the need to change its current lubrication practices in order to remain profitable and maintain its position as an industry leader. The task seemed daunting at first, but with guidance from Noria Corporation, great strides have been made in a short amount of time. The refinery is now approaching world-class status.

One of the first hurdles Sinclair faced was ensuring the proper lubricant was being applied to each specific component of a machine. Prior to implementing program changes, the refinery had experienced catastrophic failures of machines due to cross-contamination of grease and oils. By evaluating each machine and its lubricant requirements, Sinclair is more able to provide the exact lubricant for each lube point.

The refinery also began to carefully review its current lubricants, looking for areas of overlap or for one or more lubricants with the same performance characteristics. This consolidation effort reduced the facility's inventory from 34 total lubricants to 19. Not only did this help mitigate the risk of cross-contamination, but it also improved the quality of lubricants in storage by reducing storage time.

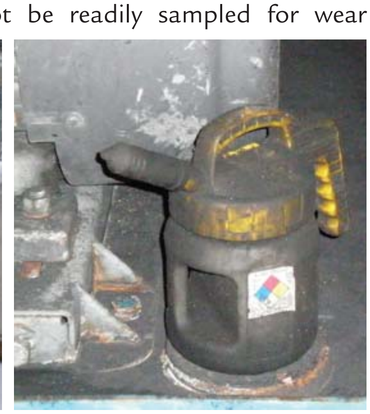
Now if the need for a new lubricant arises, equipment specifications are checked against all lubricants on hand. Lubricants are designated to ISO 6743 in order to quickly classify the oil type and additive package. By matching these ISO classifications, Sinclair is able to maintain its consolidation efforts, and the total number of lubricants can be kept as low as possible.

Among its future plans, the Sinclair team intends to procure a new field-services lubricant truck to maximize the efficiency of its lube staff.

Lubrication Program Design

In designing a new lubrication program and developing thousands of new procedures, the refinery had to determine the types of tasks that would be performed for each machine type onsite. To avoid the one-size-fits-all approach of maintaining equipment, Sinclair looked at a matrix of machine criticality, lubricant volume and environmental severity to systematically decide which machines should be included in its oil analysis program (predictive maintenance) and which ones should be maintained in more of a preventive manner.

Every machine deemed critical enough to be included in the oil analysis program had to be reviewed to ensure that samples could be taken from the correct zone. To do this, the refinery had to retrofit sample valves into each system so the maximum data density could be achieved, thus providing a consistent best-practice sample location. For some machines, this involved the addition of a valve on existing piping. For others, it meant installing a valve with a rigid tube assembly to allow the tube to be bent into the turbulent area of the oil. Oil analysis data from these sample valves is used in tandem with vibration data to ensure as many predictive tools as possible are utilized to draw conclusions about the equipment's life cycle.



From Top: Previously, grease guns and cabinets were unorganized and dirty. Oil totes were stored outside with no protection. Top-up containers were left by the equipment and were highly contaminated.

Some predictive maintenance methods are still performed on machines not included in the oil analysis program to obtain feedback on equipment health. For example, vibration analysis is used on some greased components that cannot be readily sampled for wear debris. In addition, the vast majority of equipment has external sight glasses and bottom sediment and water bowls to allow for visual oil inspections. These predictive visual inspections are completed by operators with reports of the findings triggering actions by the lube team or mechanics, based on the severity of the issue discovered.

Every piece of equipment in the facility benefits from proactive maintenance strategies. Prior to any oil being placed into service, it is tested to ensure it meets performance criteria as well as cleanliness and moisture target levels. Countless studies have shown that cleaner oil leads to longer machine life, and Sinclair has taken this to heart with its current practices. Decontaminating incoming oil and outfitting machines with upgraded contamination control accessories provide the machines with everything needed to operate at peak efficiency while running more reliably. Other proactive practices deployed at Sinclair include laser alignment, balancing and optimal lubricant selection.

Preventive maintenance (PM) is used to round out the rest of the program. Some examples of these tasks include periodic oil changes based upon equipment runtime and the routine

SINCLAIR WYOMING REFINERY

Location : South-central Wyoming in the town of Sinclair

Year Started: 1923

Size: One of the largest high-conversion refineries in the Rocky Mountain region

Crude Processing Capabilities: In excess of 80,000 barrels per day

Awards: Received the 2013 John R. Battle Award for excellence in the application of machinery lubrication from the International Council for Machinery Lubrication and the 2005 Gold Award for achievement in safety from the National Petrochemical and Refiners Association

regreasing of bearings and motors. Most of the machines being maintained with preventive methods are less critical and contain less lubricant. Therefore, it is more cost effective to change the lubricant than to analyze the current state of the lubricant and the machine to guide the schedule of events.

As the refinery's machines continue to age and new machines are installed, Sinclair updates its records and procedures to ensure each machine receives proper maintenance. By continually reviewing its procedures and practices and staying current with the most up-to-date technology, the facility is poised to carry the lubrication program into the future.

Tracking the current status of the lubrication program is done on two fronts. Day-to-day operations, including sampling and installing tracking hardware, are performed using a spreadsheet developed by Noria. With this spreadsheet, the refinery is able to plot lubrication routes and look up individual tasks.

The facility is also in discussions to fully integrate its lubrication program database into a computerized maintenance management system (CMMS). Once the integration is completed, Sinclair will have the capability to track lube-tech work orders, route compliance, lubricant consolidation, lubricant consumption, lubricant costs and overall lubricant effectiveness.

Lubricant Storage and Handling

Lubricant storage and handling techniques, which previously had been a problem for the facility, have improved drastically in the past year. When new lubricants arrive onsite, they now are quarantined until deemed ready for service by oil analysis testing. This ensures the lubricants that reach the equipment meet the guidelines for cleanliness, performance and water content. This part of the handling program has expanded to include satellite lubricant storage, proper lubricant-dispensing equipment and the reduction of contaminant ingression during relubrication tasks.

In the past, lubricant handling had not been considered. Small oil containers were taken from the warehouse, filled with oil from whatever source was available and then left next to the machine and open to the environment until they were empty or oil was needed elsewhere. The same was true for grease guns. Storage was an afterthought, and most of these tools were found hanging from pipes or lying under equipment.

By educating its maintenance and operations personnel on the need for cleanliness and by purchasing weather-proof cabinets, the refinery was able to greatly improve its lubricant handling practices. Oil containers and grease guns are now stored in a clean cabinet that is sealed to keep out dirt and water. All equipment has also been labeled and color-coded to prevent cross-contamination.

Bulk oil storage has been moved indoors with proper stock rotation principles observed. Previously, oil totes were staged across the refinery with no method or reason. Now oil comes to a central location before it is distributed throughout the plant. This enables better tracking of inventory levels and ensures that oil gets placed into service before its performance characteristics become impaired. These new practices have had a marked effect on equipment operation as well as the refinery staff. Personnel take better care of lubrication-related tools, and contamination is controlled more effectively.

This new satellite storage cabinet is designed for storage of small oil containers and grease devices.

Proper reclamation techniques are also in use at Sinclair. Small volumes of oil are captured in pails and then emptied into larger waste oil containers for disposal. For larger sumps and reservoirs, specially equipped vacuum trucks are utilized to pull oil into onboard reservoirs. This reduces the risk of high-volume leaks and permits large quantities of oil to be removed without workers ever having to touch the fluid with their bare skin. Plant personnel have been informed of the lubricant-related risks and have access to material safety data sheets in the event accidental contact occurs.

All lubrication PMs are housed in the CMMS system, which can be accessed by key personnel. The new detailed procedures have also been moved into this platform to allow access to everyone. Scheduling is based upon the calendar date as well as on-condition requirements. All lubrication tasks are documented and stored for review in case issues arise at a later date.

Monthly samples are taken from the critical machines and equipment recommended by Noria in its Lubrication Program Development. The results are reviewed by the maintenance engineer, and a failure report is created for each work order. Work orders are generated if the sample is deemed "condemned."

Oil Analysis

Initially one of the strongest parts of its lubrication program, Sinclair's oil analysis program is now even more robust. During the implementation stages of the new program, the refinery was able to add to its onsite laboratory equipment arsenal. The in-house lab can perform a wide array of screening tests for new oils and provide information on in-service oils. Onsite capabilities include testing for viscosity, elemental analysis, particle counts, water content, acid number and analytical ferrography.

Laboratory personnel are trained on all lab equipment and can accommodate urgent samples with quicker turnaround times than shipping a sample to an offsite lab. Since the lab currently is unable to handle all samples, Polaris Laboratories is employed for exception testing and less critical applications. By using both onsite and offsite labs, Sinclair is able to check both labs for accuracy and ensure the results mirror each other.

Similar to the test slates, the alarms and limits for the testing methods have also been customized. There are alarms and limits for all three sides of the oil analysis triangle: physical properties, contamination and wear debris. By monitoring all three factors, the refinery is able to ensure lubricant and machine health and that all contamination control devices are working properly.

Of course, the best lab equipment and testing strategies are wasted if you aren't able to obtain a good, consistent sample. This is why Sinclair installed sample valves on all the equipment in

The renovated lube room offers better lubricant storage.

All machines and oils do not undergo the same array of tests. Each oil and machine has its own customized test slate and target levels for contamination and moisture. The test slate takes into consideration the contaminant severity and failure modes for each machine type. For instance, the target cleanliness level for the main gear oil is 17/15/12. However, the target for turbine oils is 15/13/10. This is due to gearboxes being able to handle higher amounts of contamination before excess wear is generated. The same methodology is used for routine oil analysis test slates for each machine type.

its oil analysis program. These sample valves enable the refinery to take clean samples from turbulent zones within the machinery. Lube techs have been trained in the operation of these valves and the proper way to extract a sample from machinery. This has increased the value of the oil analysis data and allowed values to be trended much more easily.

Each sampling tactic has its own detailed procedure that breaks down step by step how to attach the sampling device, flush the tubing and take the sample to ensure the maximum amount of data with the minimum amount of

Achieving a Culture Change

Education is a vital part of making lasting change in any organization. The Sinclair refinery identified this as a key area of focus early in its lubrication program development. The training it offers is based on an individual's role within the program. Operators and mechanics are expected to complete half-day lubrication awareness training that outlines the fundamentals of lubrication, lubricant health, lubricant application and contamination control. These courses are provided in-house and based upon the shift schedule. Currently, 10 courses are offered with more planned in the future.

Lubrication technicians, laboratory personnel and engineers are required to attend a three-day seminar relating to their function in the program, such as oil analysis, lubricant application or machine-specific oil sampling. The lubrication program manager must complete advanced machinery lubrication and oil analysis courses. This advanced training is provided by Noria.

Certification through the International Council for Machinery Lubrication (ICML) is highly encouraged. The refinery also subscribes to magazines and newsletters to stay up to date on industry best practices and technologies.

This emphasis on education has helped the facility successfully achieve a culture change. Although changes initially were met with skepticism and opposition, by providing training and demonstrating the benefits of the new equipment, accessories and practices, this skepticism was eroded and opponents were won over for continued support of the program.

data disturbance from outside sources. These procedures are housed in the master lube program file and are provided in paper form to accompany lube techs during their sampling rounds.

Sampling rounds are performed monthly on critical machines and quarterly on other equipment. If any alarms or limits are tripped on the test slate, secondary samples are obtained to confirm the results. Once the results are verified, action is taken to correct the issue. The correcting action can range from changing the oil to simply filtering the oil using a filter cart. Once an action has been taken, another sample is obtained to ensure the issue has been corrected.

Contamination Control

Contamination control at the refinery had been a weakness, but now contaminant ingression is in check. By modifying machines and training its personnel, Sinclair has greatly reduced the amount of contamination entering its lubricants through lubricant application or normal equipment operation.

Operators and mechanics have learned the importance of contamination control and how they can affect a machine's life by something as simple as leaving the breather plug off a machine during operation. The need for change was recognized and well-received. New devices have been implemented to aid in the exclusion of contaminants, including desiccant breathers, quick-connect fittings and external level gauges.

These devices work hand-in-hand with filter carts to decontaminate new oils being delivered as well as oils that are in use. The filter carts are designated for a single lubricant in order to reduce the risk of cross-contamination between dissimilar fluids. They also employ different size fittings on the cart's inlet and outlet. This ensures lube techs hook up the cart correctly every time to avoid damaging the cart or machine due to backward oil flow. The same quick-connects are found on some top-up containers for adding small volumes of oil without opening up the equipment. This enables the refinery to have completely sealed equipment and still maintain it properly.

Filters in the filter carts are matched to target cleanliness goals as well as to the fluid type. Higher viscosity fluids utilize a 6-micron filter with a beta rating of 1,000. This guarantees that the maximum amount of particles is captured in a single pass. For lower viscosity fluids, a tandem filter setup is used consisting of a 6-micron beta-200 filter and a 3-micron beta-200 filter. The tandem filters permit oil polishing and cleaning down to the cleanest of targets.

An ideal asset would include all the devices mentioned previously in order to service the machine without ever having to expose it to the atmosphere. This ensures the machine is operating to the best of its ability while reducing the amount of contaminants entering the system from the environment. To decrease the amount of wear debris

Viscosity testing can be conducted onsite.

produced in the machine, cleaner oil is delivered to the system, and the machine's needs are matched to the oil's performance characteristics. This results in the machine generating less wear and lasting much longer.

By utilizing sealable and refillable containers, the refinery is able to store small volumes of oil in satellite cabinets without the risk of them becoming contaminated. This further enhances

Sealable and refillable containers are now the plant standard for all oil top-ups.

Assets are completely sealed against all contaminants and are properly labeled as to which lubricant goes into the reservoir.

the ability to provide clean oil to equipment. With these containers, operators and mechanics can top-up small volumes of oil without introducing large volumes of contaminants as they did previously. The containers are color-coded and labeled to match the equipment's lube tags. Hoses attached to the pumps on the containers have reduced the facility's dependency on funnels and have won over personnel with their ease of use and cleanliness.

Sinclair also replaced all of its grease guns. The old grease guns had varying output amounts, which made proper greasing difficult. The new color-coded grease guns have clear barrels, which allow the installed grease cartridge to be seen. The refinery also standardized on a single grease gun type to accurately dispense the proper volume of grease to bearings and electric motors. Understanding how much grease volume per stroke is being applied has reduced overgreasing issues, and bearings now run at a lower temperature.

Automatic lubricant - dispensing systems are now utilized as well. Currently, four processing units employ oil-mist systems on pump and turbine bearings. The mist systems are the preferred oil application systems because they are low maintenance and provide longer bearing life than traditional oil baths. As the refinery continues to improve its lubrication processes, it will look to further expand the use of these mist systems.

In applications that are hard to reach or where manual greasing could potentially cause bodily harm, the facility uses automatic grease applicators. These systems are set to dispense the calculated volume of grease required by the bearings and are monitored to ensure they are working properly.

Training Personnel

As new hardware was deployed at the refinery, training individuals who would be using these devices became increasingly important. By hosting lubrication awareness training onsite, Sinclair was able to instruct all personnel on the function and maintenance of oil and grease application systems. This training has proven invaluable.

To avoid slipping back into mediocrity, the facility developed a plan for continuous improvement of its lubrication program. Training is an ongoing task to ensure all workers in the plant stay current with their understanding of lubrication fundamentals and techniques. Key members of the lubrication program further their education with advanced lubrication and oil analysis courses as well as advanced lubrication certifications.

The refinery soon realized a need for more lube techs and began to fill these roles to reduce the demand on operations and maintenance for lubrication-related tasks. It is also exploring the possibility of more laboratory personnel to enhance the capabilities of the in-house lab and to eliminate shipping samples offsite.

Future Plans

With the current lube storage building filling up with equipment, a new facility is being planned for lubricant storage. Sinclair also intends to procure a field-services lubricant truck to maximize the efficiency of its lube staff while maintaining strict cleanliness targets.

As it ventures into the future, the refinery is constantly looking for areas of improvement within its own processes and through new technologies. By being vigilant with its lubrication practices, the plant not only will become more profitable but also serve as a model for the rest of the refining industry.

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How to Determine Bearing System Life

When the topic of rolling bearing life arises, engineers often ask questions such as:

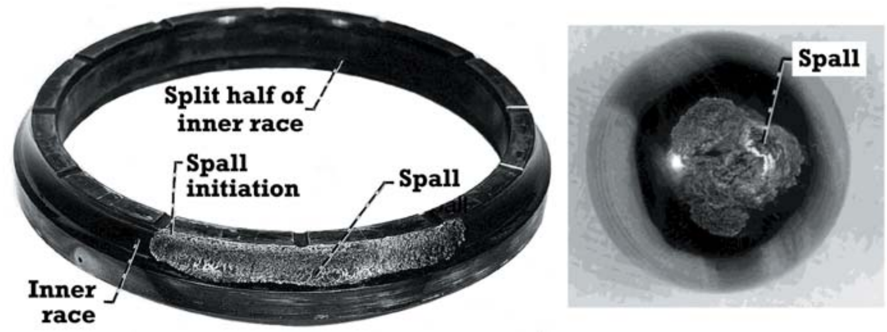
- "What do you mean by rolling bearing life?"
- "How do you know when you come to the end of bearing life?"
- "Is it when the bearing stops rotating?"
- "Is it when the machine within which the bearing resides reaches a specific operating time?"

Typically, answers to these questions might include: "The end of life comes when the bearing or bearings are no longer fit for their intended purpose," or "When it stops rotating." Unfortunately, these answers are neither specific nor adequate.

In bearing manufacturers' catalogs and most engineering design books, the phenomenon that limits bearing longevity and reliability is termed rolling - element fatigue. This phenomenon has been studied for more than 120 years beginning in the 1890s with the pioneering work of Richard Stribeck in Germany, as well as the early part of the 20th century with John Goodman in Great Britain and Arvid Palmgren in Sweden.

Palmgren's contributions probably were the most significant to rolling-element bearing technology. In 1924 he provided the foundation for rolling-bearing life calculation. He articulated that bearing life was not deterministic but rather distributive. He meant that no two bearings in a group run under the same conditions or will fail at the same time. He proposed the concept of an L10 life or a time at which 90 percent of a population of bearings will survive and where 10 percent have failed. He was perhaps the first person to propose a plausible approach to calculating the life of a machine element.

The source of most engineers' practical knowledge of ball and roller bearings comes from bearing manufacturers' catalogs. For about 90 to 95 percent of machine design applications, the equations and recommendations in the bearing manufacturers' catalogs provide for safe and reliable design. Usually, the remaining 5 to 10 percent of the applications require specialized knowledge and analysis to avoid problems.



These images show representative rolling-element fatigue failure of an inner race (left) and ball (right) from 120-millimeter-bore ball bearings made of AISI M-50 steel.

Failure Modes

The ultimate failure mode limiting bearing life is rolling-element fatigue of either a bearing race or a rolling element. Rolling-element fatigue is extremely variable but is statistically predictable depending on the steel type, steel processing, heat treatment, bearing manufacturing and type, lubricant used and operating conditions.

The failure manifests itself as a spall that is limited to the width of the running track and the depth of the maximum shearing stress below the contact surface. The spall can be of surface or subsurface origin. A spall originating at the surface usually begins as a crack at a surface defect or at a debris dent that propagates into a crack

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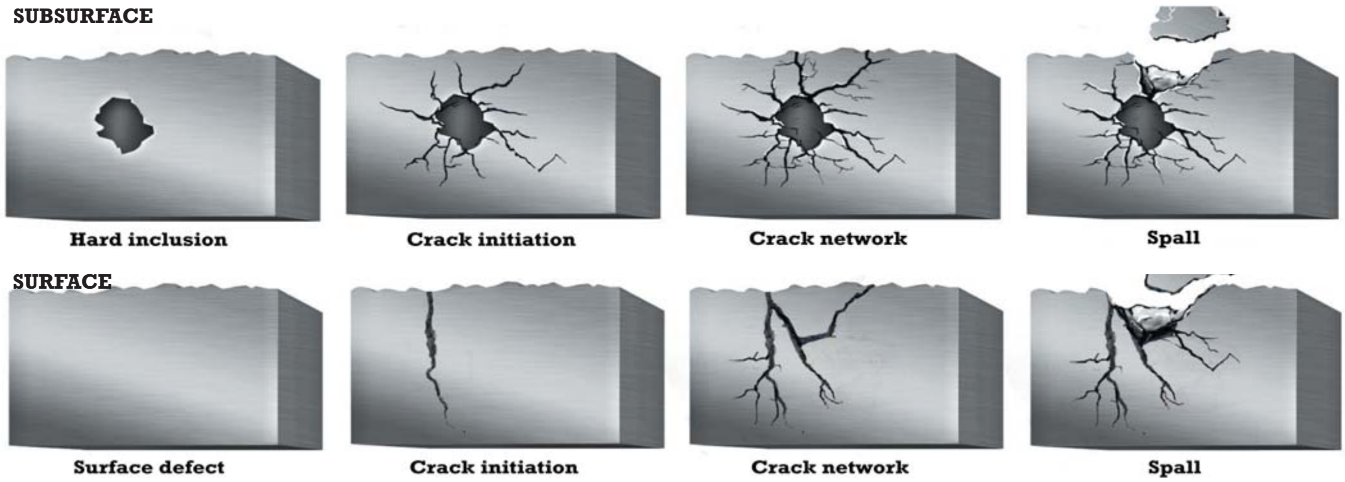


These illustrations depict a subsurface-initiated spall at a hard inclusion (top) and a surface-initiated crack network from a surface defect.

network to form a spall. A crack that begins at a stress riser, such as a hard inclusion below the running track in the region of the maximum shearing stress, also propagates into a crack network to form a spall.

Fatigue failures that originate below the contacting surface are referred to as classical rolling-element fatigue. Failure by classical rolling-element fatigue is analogous to death caused by old age in humans. Most bearings, however, are removed from service for other reasons.

Failures other than those caused by classical rolling-element fatigue are considered avoidable if the bearing is not overloaded and is properly designed, handled, installed and lubricated. With improved bearing manufacturing and steel processing along with advanced lubrication technology, the potential improvements in bearing life can be as much as 80 times that attainable in the late 1950s or as much as 400 times that attainable in 1940.

Basic Bearing Life

As mentioned previously, the L10 life, in millions of inner-race revolutions, is the theoretical life that 90 percent of a bearing population should equal or exceed without failure at their operating load. It is based on classical rolling-element fatigue. The "basic bearing life" often referred to in bearing manufacturers' catalogs is the L10 life without life factors, which are dependent upon the bearing type, bearing steel, steel processing, heat treatment, lubricant and operating conditions.

Most bearings are selected and sized based on the "basic bearing life" calculated with and, at times, without life factors. The caveat is that on or before this calculated time, 10 percent of the bearings operating under this load and speed can be expected to fail. Many engineers do not realize that the life they have calculated is based not on the time before which no failures will occur but on the time before which 10 percent of the bearings can be expected to fail. This mistake can result in warranty and product liability claims for the equipment manufacturer.

Bearing System Life

Since it can be assumed with reasonable certainty that any rotating machinery will have two or more bearings comprising the system, you must also determine the bearing system life in addition to individual bearing life. This can be achieved by combining the individual bearing lives into a single life for the system.

To establish system life, an understanding of strict series reliability is required. Remember, the life of the bearings as a system is always equal to or less than the life of the shortest lived bearing in the system. For example, say you have a simple speed-reducer gearbox with two bearings supporting the input gear running at 3,600 rpm and an output gear supported by the same two types of bearings running at 900 rpm. At full (100-percent) load or torque, the lives of each of the input bearings are 2,500 hours, and the lives of each of the output bearings are 10,000 hours. The 10-percent life of the system would be calculated to be 1,124 hours. This means if you distributed 1,000 gearboxes and they were all operated at maximum torque for 1,124 hours, 100 gearboxes would have at least one bearing failure. The question then becomes how long could you operate the gearbox at this condition without a failure.

If the life of the shortest lived bearing in the system is 2,500 hours, it can be reasonably expected that for the first 133 hours of operation for each gearbox there will be no bearing failure. However, the gearboxes may not be operated at full output torque at all times. Assume that the gearboxes operate at full torque for 50 percent of the time, one-half torque for 30 percent of the time and one-quarter torque for 20 percent of the time. In order to

Table 1

PROBABLE CAUSE FOR BEARING FAILURE	PER-CENT
Fatigue (surface and subsurface origin)	3%
Cage wear	3%
Wear	6%
Handling damage	7%
Dimensional discrepancies	17%
Debris denting/contamination	20%
Corrosion pitting	27%
Other	17%

calculate the total system life, you would need to calculate the L10 system life at each condition.

At an L10 system life equal to 2,671 hours, 10 percent of all the gearboxes in service would theoretically have one or more failed bearings. If, as in the previous example, you have 1,000 gearboxes in service and have 100 failed gearboxes, you would have 100 failed bearings out of the 4,000 bearings in service. In other words, 2.5 percent of the bearings in service that have failed account for 10 percent of the failed gearboxes. The other 97.5 percent of the bearings in service can reasonably be assumed to be undamaged and usable.

This is why the vast majority of undamaged bearings removed from service have never reached their calculated L10 life. Therefore, it becomes practical and cost-effective to inspect, rework and place back into service those undamaged bearings that were removed before reaching their L10 life.

Causes for Removal

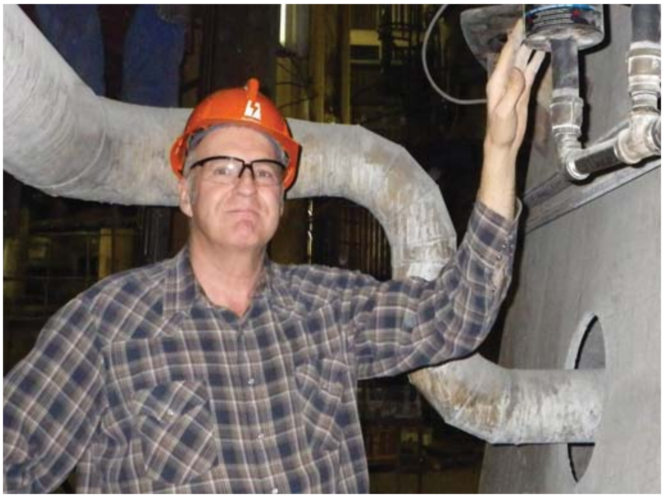
So far this discussion has been based on classical rolling-element fatigue as the sole mode of failure and bearing removal. However, probably less than 5 percent of bearings are removed from service because of rolling-element fatigue, whether of subsurface or surface origin.

Table 1 features a list of probable causes for bearing removal and an estimated percentage related to each respective cause. In addition to this list of causes for bearing removal, related failure modes categorized under "other" would include bearing misalignment, true and false brinelling, excessive thrust/bearing overload, lubrication, heat and thermal preload, roller edge stress, cage fracture, element or ring fracture, skidding damage, and electric arc discharge.

These causes for bearing removal and failure can be minimized and/or mitigated by good bearing design, proper bearing installation, timely maintenance and good lubrication practices. However, they cannot be eliminated entirely, which makes understanding and determining bearing life even more important.

Passion for Improvement Leads Crooks to Successful Oil Analysis Program

Four years ago, a change in management at SaskPower's Poplar River Power Station (PRPS) in Saskatchewan, Canada, led to a new way of thinking. Mechanical foreman Mark Crooks was asked to initiate and implement a lubrication program and improve on anything that was already in place. When Crooks asked, "Why me?" he was told, "You have a passion for improving the lubrication problems in the plant." Over the past three years, Crooks has been in the lead support role for the company's oil analysis program and has been educating employees on the importance of clean oil, proper oil handling and keeping oil reservoirs and gearboxes as clean as possible. He knows that once these ideas become common practice and the routines become a habit, everything will start to flow more smoothly.



Name: Mark Crooks
Age: 59
Title: Mechanical Foreman
Years of Service: 34 years
Company: SaskPower
Location: Saskatchewan, Canada

Q: How did you get your start in machinery lubrication?

A: I started my career with SaskPower in 1979 as a dragline oiler. At the time, the company ran draglines with 400-foot booms and 90-yard buckets. I graduated to dragline operator and held the position for five years. I then moved to a coal-fired power plant in Saskatchewan and worked as a coal handler until I was appointed to an apprentice millwright position. I worked as a journeyman millwright and then as a mechanical foreman. This included working with and supervising welders, machinists and millwrights, as well as various contractors. I have been in the oil analysis business for three years.

Q: What types of training have you taken to get to your current position?

A: As a dragline oiler and operator, I took a basic lubrication principles course. I also have my supervisor's certificate for open-pit mining. As a journeyman millwright, I completed an introduction to vibration technology course as well as a reliability-centered maintenance program. I have taken courses for steam turbine generator maintenance and oil analysis for proactive maintenance.

Q: What professional certifications have you attained?

A: In 1992 I received my industrial mechanic (millwright) provincial trade certification, and in 2011 I earned my Machine Lubricant Analyst (MLA) Level I certification from the International Council for Machinery Lubrication (ICML).

Q: Are you planning to obtain additional training or achieve higher certifications?

A: I plan on obtaining my MLA Level II and III certifications in the future. It is my goal to have our oilers also earn Machine Lubrication Technician (MLT) Level I and II certifications.

Q: What's a normal work day like for you?

A: Our team is made up of one oiler, one millwright and me. In the morning, we meet in the oil room and discuss the plans for the day. We talk about equipment permits, safety issues and the day's work. I check any oil issues that may have been written up the night before and put them in the schedule according to priority. Any oil additions or breather changes would be done that day. Following the crew meeting, I check certain pieces of equipment that may have concerns. I also check the oil analysis reports and schedule work orders to remedy any problems. I research our equipment to find out what oils the manufacturer recommends. This will allow me to see if we can consolidate the oils. I also research breathers, filters and oil-related equipment so we can improve maintenance, make our jobs easier and extend the life of our equipment. We wrap up the day with a short meeting about what happened that day and what needs to be done the next day.

Q: What is the amount and range of equipment that you help service through lubrication/oil analysis tasks?

A: We are kept busy with sampling and monitoring our two turbine generator sets, 12 bowl mills, three large compressors, 12 large fans, 14 conveyor systems and a host of smaller equipment. We sample about 100 pieces of equipment. Depending on the equipment, these samples are taken in a range from once a month to once a year. We have another 175 gearboxes that are not sampled but are set up for regular oil changes.

Q: What lubrication-related projects are you currently working on?

A: Our team is now working on installing breathers. We are systematically changing our breathers over to an acceptable type. At the same time, we are moving the piping to a cleaner and more accessible spot. We will be setting up a preventive maintenance program for checking and replacing these breathers. On our major equipment gearboxes, we are piping in suction and discharge lines and adding quick couplers. We will locate these at convenient locations so that we can hook up our filter carts quickly and safely. This will eliminate the use of hoses that could be damaged or cause tripping hazards.

Q: What have been some of the biggest project successes in which you've played a part?

A: Our first big challenge was to clean 30 years of grease off the oil room floor, get rid of the barrels, replace them with totes, and then keep the room clean and neat. The oilers do not go home at quitting time until the oil room is cleaned up from the day's work. This includes washing the floor every day at the end of the shift. The oil room must be as clean as or cleaner than it was in the morning. The oilers do this as part of their daily routine.

Q: How does your company view machinery lubrication in terms of importance and overall business strategy?

A: The SaskPower management team has supported our undertaking at PRPS. They feel that clean oil, oil analysis and vibration analysis will pay for itself over and over in the future. Just think of the satisfaction of knowing which equipment needs attention and which ones are going to fail. We can plan to repair equipment when we want to schedule it instead of when it breaks down in the middle of the night. It is hard to put a cost savings to this kind of reliability program. It can really cut down the financial burden of emergency repairs.

Q: What do you see as some of the more important trends taking place in the lubrication and oil analysis field?

A: I am very excited about the clean oil and oil analysis movement. It seems to me that the time is here. Companies are now realizing the benefit of these programs due to many major breakdowns and the unnecessary costs of plant downtime. Plant reliability is finally receiving the attention it deserves. At Poplar River, instead of ignoring the oil analysis data, we study it, take the findings and act on it before we run to fail. We now have more knowledge and support equipment than ever before. We are moving from the dark ages and starting to use the new technology that is available today.

Q: What has made your company decide to put more emphasis on machinery lubrication?

A: At Poplar River, this need for change became very apparent with far too many unnecessary equipment failures. The management team started to listen to the people on the floor. As tighter budgets and plant reliability became more important, we were left with no choice but to improve equipment reliability and develop a strong oil maintenance plan. This was the best way to achieve this at a reasonable cost. As our oil maintenance program expands, our plant will continue to reap more benefits that will in turn last for years to come.

Be Featured in the Next 'Get to Know' Section

Would you like to be featured in the next "Get to Know" section or know someone who should be profiled in an upcoming issue of *Machinery Lubrication India* magazine? Nominate yourself or fellow lubrication professionals by emailing a photo and contact information to editor@noria.com.

TEST your KNOWLEDGE

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

1. Which governing body is responsible for the designation of food-grade lubricants?

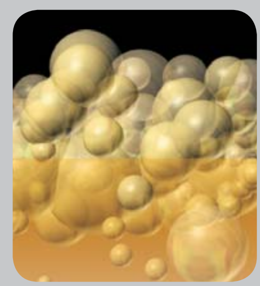
A) USDA
B) ISO
C) NSF
D) NLGI
E) ASTM

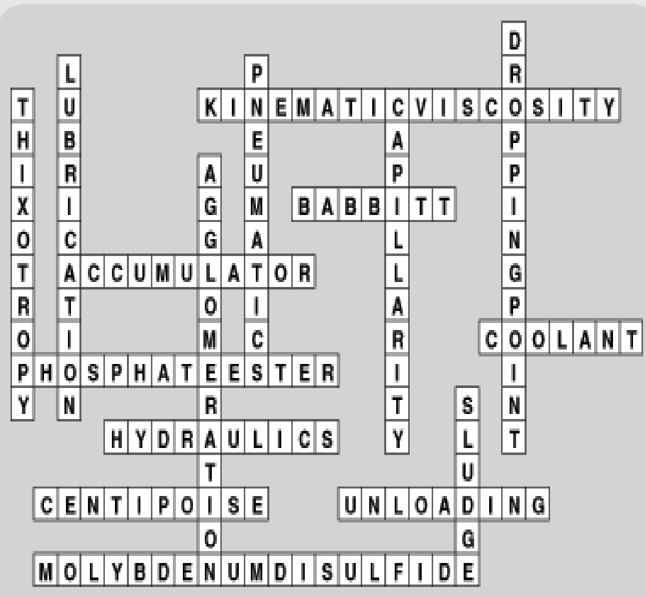
2. Human sensory (no instrumentation) inspection of machinery can indicate:

A) Excessive water and foaming
B) Excessive heat
C) Highly oxidized, burnt oil
D) Neither A, B or C
E) Answers A, B and C

3. Foam and air entrainment:

A) Are generally not a lubrication problem
B) Can result in oil starvation and/or impair film strength
C) Can result in a change in air pressure in the reservoir
D) Can usually be eliminated by adding more anti-foam additive
E) Are the same thing





From Page 17

Answers:

1. C

The organization is NSF, which was founded in 1944 as the National Sanitation Foundation. The name was changed to NSF International in 1990 when the National Sanitation Foundation and NSF Testing Labs merged.

2. E

For some oils, excessive water content results in an emulsion where the oil looks turbid or milky. For other oils, it is easy to see free water in the bottom of the reservoir. Foaming can also be easily seen by inspecting sight glasses. Excessive heat can be sensed by touching surfaces. Oxidized oil looks dark and has an unpleasant odor. Burnt oil smells like burned food.

3. B

Foam and air entrainment can result in oil starvation due to impaired oil flow/movement, and the lubricated part will see foam and air bubbles instead of viscous fluid to carry the load and prevent metal-to-metal contact.

DHIREN SHAH

BASE OIL REPORT

Crude oil prices rebounded in Asia on Monday Sept 8 2014 with last week's sharp fall providing room for bargain hunters. On the New York Mercantile Exchange, crude oil for delivery in October traded at $93.48 a barrel, up 0.20%, after tumbling last week to end down 1.23% at $93.29 a barrel. Last week, crude oil futures declined following the release of disappointing U.S. employment data and as Ukraine and pro-Russian separatists agreed to a ceasefire. Elsewhere, on the ICE Futures Exchange in London, Brent oil for October delivery slumped 0.99%, or $1.01, to settle at $100.82 a barrel by close of trade on Friday. For the week, the October Brent contract lost 2.29%, or $2.37 after Ukraine signed a ceasefire deal with pro-Russia rebels, taking the first step toward ending the five-month old conflict in eastern Ukraine.

India's Import of Base Oil in June 2014		
Country	QTY in MT	%
Korea	90223	52
Singapore	20645	12
Bahrain	11290	6
Russia	8855	5
Taiwan	7756	4
USA	6437	4
UAE	6349	4
Italy	4669	3
Iran	3194	2
Brazil	2826	2
Saudi Arabia	2380	1
Spain	2184	1
Sweden	1578	1
Malaysia	1197	1
Qatar	1180	1
Other Countries	3358	2

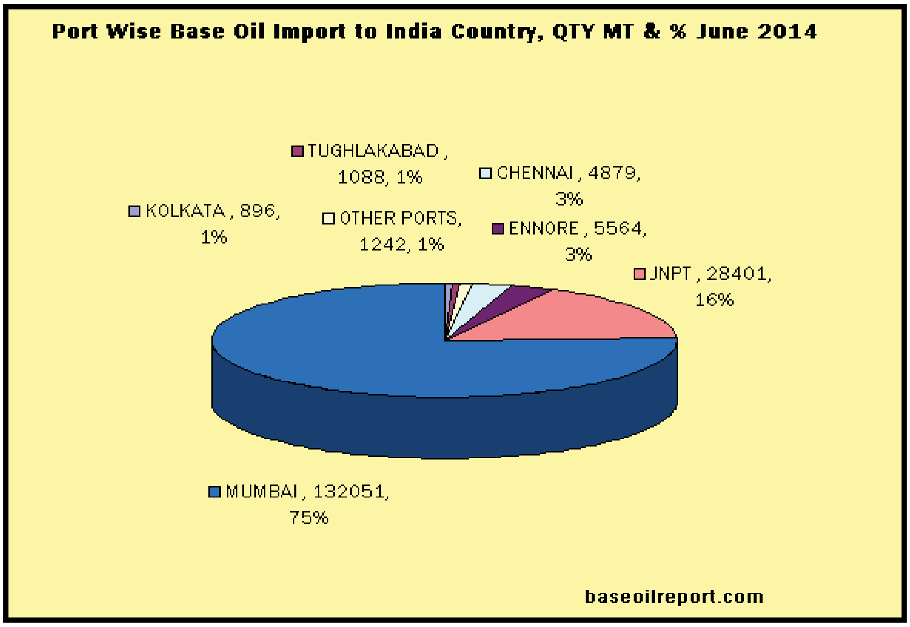
The Indian base oil market remains steady with inventories at optimum levels with surplus of imported grades. During the month of July 2014, approximately 220621 which are 27 % up as compared to June 2014 have been procured at Indian Ports of all the grades The rates variance applicable effective Sept 01 , 2014. by PSU's are as follows:

1. SN – 70/N – 70/N-65/SN – 150/N -150/N – 150 : Rs 0.50 per Liter ↑
2. SN - 500/N - 500/MakBase - 500 Rs. 0.40 per liter ↑
3. Bright stock - Rs. 0.70 per Liter ↑

Hefty Discounts are offered by refiners which are in the range of Rs. 10.00 – 13.00 per liter for buyers who commit to lift above 1500 MT. Group I Base Oil prices for neutrals SN -150/500 (Russian and Iranian origin) are offered in the domestic market at Rs. 60.80 – 61.15/61.10 – 61.40 per liter, excise duty and VAT as applicable Ex Silvassa in bulk for one tanker load. 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 is steady. As per conversation with domestic importers and traders prices reflects marginal changes for N – 60/ N- 150/

Month	Group II - N 500 Korea Origin Base Oil CFR India Prices	SN-150 Iran Origin Base Oil CFR India Prices	SN -500 Russia Origin Base Oil CFR India Prices	Napthenic Base Oil HYGOLD L 500
July 2014	USD 1130 – 1150 PMT	USD 1020 – 1025 PMT	USD 1050 – 1055 PMT	USD 1070 - 1075 PMT
August 2014	USD 1145 – 1150 PMT	USD 1025 – 1035 PMT	USD 1050 – 1060 PMT	USD 1080 - 1090 PMT
September 2014	USD 1145 – 1150 PMT	USD 1025 – 1035 PMT	USD 1050 – 1060 PMT	USD 1075 – 1085 PMT
	USD 1080 – 1090 PMT	USD 1025 - 1035	USD 1060 - 1070	USD 1130 - 1150
	Since July 2014, prices jumped up by USD 20 PMT (1%) in September 2014	**Since July 2014, prices has marked up by USD 15 PMT (1%) in September 2014**	**Since July 2014, prices has gone up by USD 10 PMT (1%) in September 2014**	**Since July 2014, prices has increased by USD 20 PMT (2%) in September 2014**



N - 500 grades and at the current level are quoted in the range of Rs. 60.50 – 60.70/61.50 – 61.90/64.30 - 64.55 per liter in bulk respectively with an additional 14 percent excise duty and VAT as applicable, no Sales tax/Vat if products are offered Ex-Silvassa a tax free zone. The above mentioned prices are offered by a manufacturer who also offers the grades in the domestic market, while another importer trader is offering the grades cheaper by Rs.0.25 – 0.35 per liter on basic prices. Light Liquid Paraffin (IP) is priced at Rs. 61.50 – 61.70 per liter in bulk and Heavy Liquid paraffin (IP) is Rs. 65.75 – 66.00 per liter in bulk respectively plus taxes extra.

Approximately 9204 MT of Light & Heavy White Oil has been exported in the month of June 2014 from JNPT, Mundra, Raxaul LCS, and Chennai port. Compared to last month i.e. May 2014, exports of the country have gone up by 11% in the month of June 2014.

Approximately 2516 MT of Transformer Oil has been exported in the month of June 2014 from JNPT and Chennai port. It has been exported to Bangladesh, Brazil, Malaysia, Iran, New Zealand, Oman, Paraguay, Morocco, Indonesia, South Africa, Sri Lanka, Saudi, Philippines, Thailand, Vietnam, and UAE, Turkey.

Indian lubricants industry growth is highly correlated to GDP growth. The per capita lubricant consumption in India is quite low compared to developed countries. However, even a comparison with other developing countries like China and Indonesia reveals that there is a significant potential for growth in lubricant consumption in India. If the economy improves further with the required investments then the entire lubricants industry is expected to witness a much positive growth in the coming years. As per the Reports, A big challenge which the industry currently facing is the awareness about available lubricants and right lubricant for right application. We expect increase in awareness and use of condition monitoring equipment in coming years. We will continue to see new technologies that assist in refining programs from testing lubricant properties to determining how the lubricant gets to the equipment. In India, users will continue to stress on product performance. We believe these technologies enable lubricant manufacturing companies and independent lubricant consultants to stress lubricant performance rather than price. Hence, due to increase demand for high performance products, condition monitoring and knowledge of product performance both will increase. There have been cultural challenges as well. Some OEMs and customers still perceive that thicker lubricants are better as they have grown with this old perception.

About the Author

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

Countries Where Light & Heavy White Oil Has Been Exported									
Argentina	Australia	Bangladesh	Bulgaria	Cambodia	Chile	Domincian Re	Djibouti	Ecuador	Egypt
Eritrea	Germany	Indonesia	Ivory Coast	Iran	Israel	Italy	Morocco	Kenya	Malaysia
Myanmar	Nepal	Newzealand	Nigeria	Pakistan	Peru	Philippines	Poland	Russia	S. Africa
Senegal	Spain	Srilanka	Sudan	Taiwan	USA	Tanzania	Turkey	UAE	UK
Ukraine	Vietnam	Yemen	Zaire						