INSIDE

Machinery Lubrication

India January -February 2015

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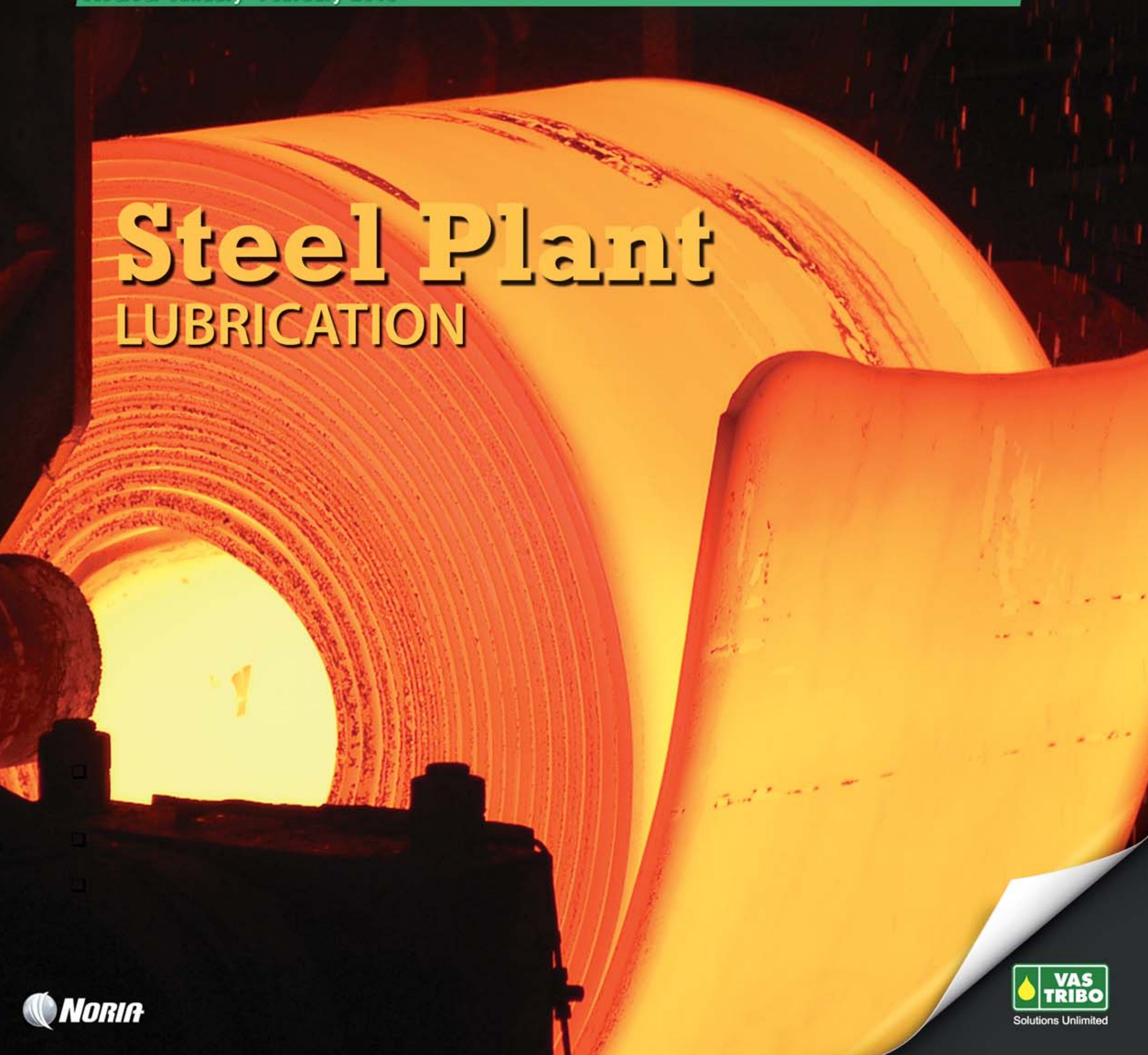

Steel Plant LUBRICATION

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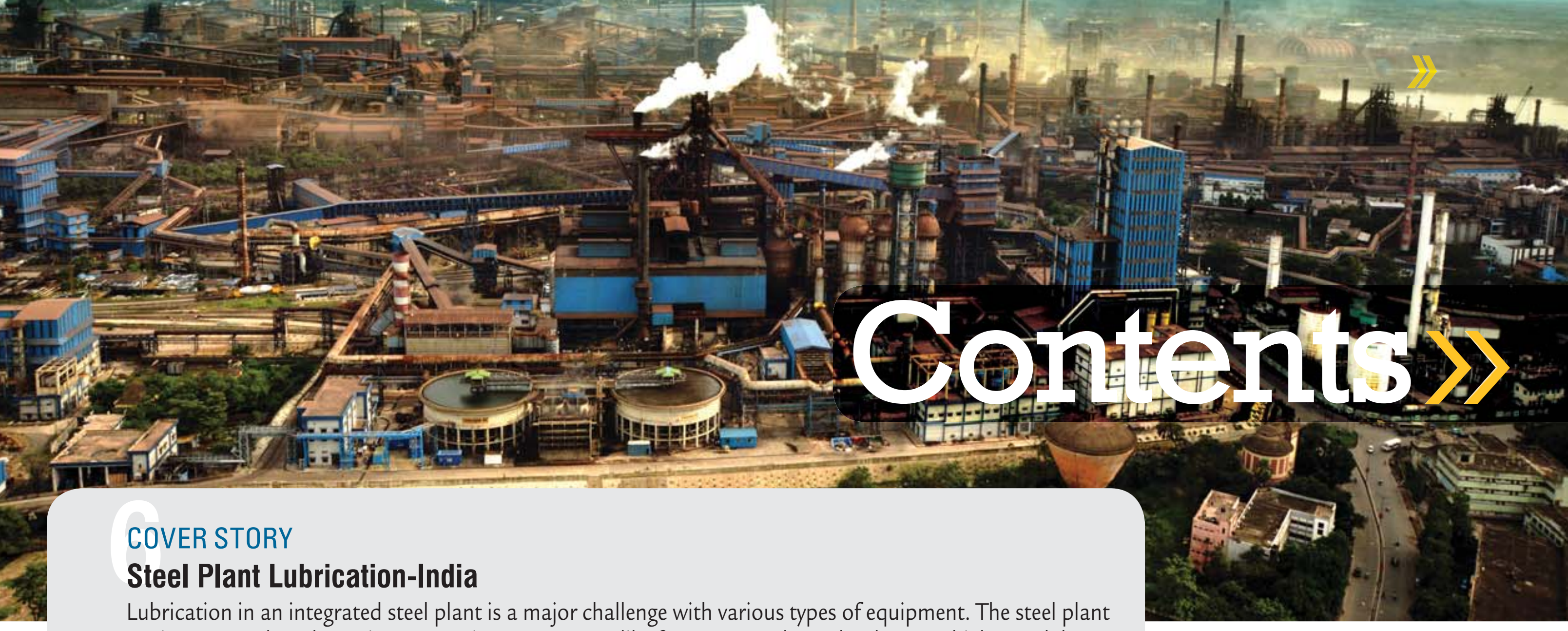

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Publisher's Note

Over the past few months, various world leaders have visited India and pledged their support to India's growth. In the recently concluded Indo-US summit, US President Barak Obama committed US $4 billion to the new initiatives, trade missions and infrastructure in India. The "Make in India" campaign announced by our Prime Minister has come as a shot in the arm and various captains of industry have pledged to support this. Government is trying to remove the bottlenecks in the system for speedy clearance of approvals for Industry.

Crude Oil is at its lowest in many years, which has resulted in cooling of inflation and lowering the cost of energy which is an essential input in today's day to day activities both for domestic, commercial and industrial activity.

All this coupled with the latest IMF report that India will surpass China's growth rate by 2016 indicate that the market is moving in a positive direction.

On the request of our readers, who have been requesting for industry specific articles, our current issue has a cover story on Steel Plant Lubrication, highlighting about the Steel Industry in India, particularly on various techno functional details to be kept in mind while selecting lubricants & implementing a lubrication program. As the quality of lubricants as well as the science behind optimized lubrication is making advancements, it is important to make informed decisions to get the most out of your program. This issue also cover various articles on lubrication and methods for analyzing grease.

In the past issue we discussed about managing lubricant waste and disposal. Across industry, great emphasis is placed on the handling and application of lubricants from the moment they arrive at a facility to the time they are introduced into service. However, proper handling techniques do not end when the oil has been put into service. Once the life of the oil has been exceeded, one must ensure the lubricant is captured and disposed of both safely and in an environmentally friendly manner.

National Lubricating Grease Institute (NLGI) India Chapter will be organizing its 17th Lubricating Grease conference in Mahabalipuram, Tamil Nadu from 12th-14th February 2015 with the theme, "Latest trends in Grease Industry". This event draws strong participation from industry and academia alike. We are proud to be associated as a Media Partner and would be covering the event extensively.

As always, we welcome our reader's comments and suggestions which enable us to provide you with more relevant and cutting edge articles and case studies. So keep the suggestions coming in and help us improve your Machinery Lubrication experience.

Warm Regards,

Udey Dhir

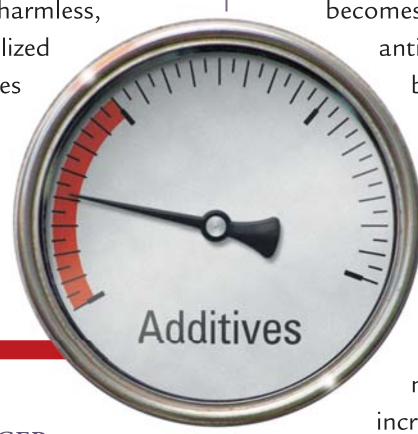
Bennett Fitch | Noria Corporation

The SILENT DANGER of Abrupt Lubricant FAILURE

How fast can your car go with a full tank of gas as opposed to just one gallon of gas? It would be practically the same, right? Not only would the car drive just as fast, but unless you want to consider the weight, there would be no difference in performance. Now imagine driving a car without a fuel tank gauge. After each refueling, you would have an increasing fear that your car could run out of gas at any moment. Your only solution would be to refuel at a frequency that was safely ahead of when you estimate the tank to be empty. Otherwise, you would regularly encounter moments of unexpected inoperability.

Just like a car, lubricants generally perform as expected for extended periods of time without any dramatic signs of degradation. The remaining "fuel" in this case would be reserve additives or inversely related to contamination levels. Unfortunately, you don't have a gauge to display the remaining useful life of key additives.

An antioxidant is an example of an additive that will be expended over its useful life until it becomes empty without warning. The effects of this are exponentially unfavorable. Before antioxidant additives are fully depleted, they act as radical scavengers, coming in contact with and defusing the precursors to oxidation byproducts and metallic catalysts. At the moment of contact, not only are these oxidation precursors rendered harmless, but the localized antioxidant additives become useless. Although this decreases the reserve oxidation stability of the remaining oil, there remains a functioning level of antioxidants in the lubricant.



These types of additives are considered sacrificial because they are consumed as they are used, just like fuel in your car. Their consumption is actually desired, as it means they are doing their job. Typically, the majority of additives in a lubricant will be sacrificial, including antioxidants, detergents, anti-wear additives, rust and corrosion inhibitors, demulsifying agents, and dispersants.

So what happens when an additive becomes depleted? Without antioxidants, oxidation byproducts are allowed to corrode equipment parts, thickening the oil and reducing the base oil's lubricating properties. The rate of lubricant failure, and consequently machine failure, increases rapidly — the same way your car may sputter to a stop as it runs out of fuel.

The most effective way to defend against the silent dangers of impending additive depletion and lubricant failure is to establish persistent oil analysis. Historical information on the lubricant's typical useful life in the given

THE DANGERS OF CONTAMINATION

CONTAMINATION RATES CAN ALSO BE A SILENT DANGER. All lubricants have some level of solid contaminants. Even with new lubricants, complete cleanliness is unattainable. The key is to ensure that there are more contaminants being filtered out than contaminants being generated or ingressed. The problem arises when too many contaminants are allowed to exist in the workings of a machine. These contaminants can generate more contaminants through three-body abrasion. This cyclical act proliferates to a point where the filter cannot keep up. So while oil analysis may show that contaminant levels remain at an acceptable rate, it only takes a moderate increase in contamination to create an exponential spike toward machine failure.

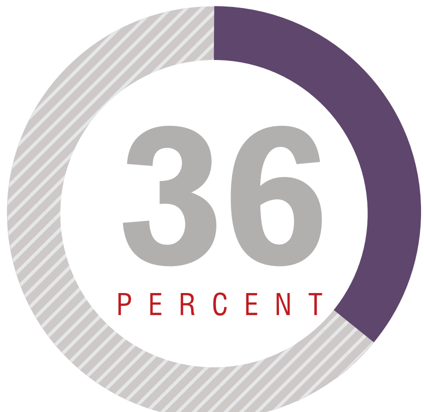
Your lubricant's additives are being consumed rather than progressively exhibiting deteriorating performance.

circumstances will be helpful as well. Although trending additive depletion requires enhanced oil analysis methods and skills, it is now being done with increasing effectiveness. Be sure to monitor each additive in a lubricant, as it's possible to lose one additive well before another. For example, it does no good to have a lubricant with sufficient antioxidants remaining if the anti-wear additive is entirely depleted. In this case, your oil will permit accelerated wear even while antioxidation remains stable.

For lubricants in gasoline or diesel engines, the hours of operation along with the known duty cycle are often the primary gauges for determining the lubricant's remaining useful life (RUL). The engine manufacturer will provide general estimates of the oil change interval, because after a certain point in the lubricant's life, one of the additives likely will become depleted. Although the lubricant may appear healthy (just like the car operating on a single gallon of gas), it's only a matter of time before the effects of the distressed or non-existent additive system become detrimental to the engine.

Even with condition-based oil changes, such as for turbine oil in high-speed applications, it's important to conduct tests to determine the remaining useful life of each additive. Certain tests can give you an indication of residual additives and oxidation stability.

The main lesson here is that your lubricant's additives are being consumed rather than progressively exhibiting deteriorating performance. Many people have the misconception that lubricants fail in a linear fashion. Instead, performance can drop off suddenly and catastrophically, just like a car sputtering on its last drop of gas. If you are actively monitoring your lubricant's RUL, you should be aware of the individual additive depletion probabilities and be able to predict the end of their useful life.



of lubrication professionals do not use oil analysis to monitor additive health, according to a recent survey at MachineryLubrication.com

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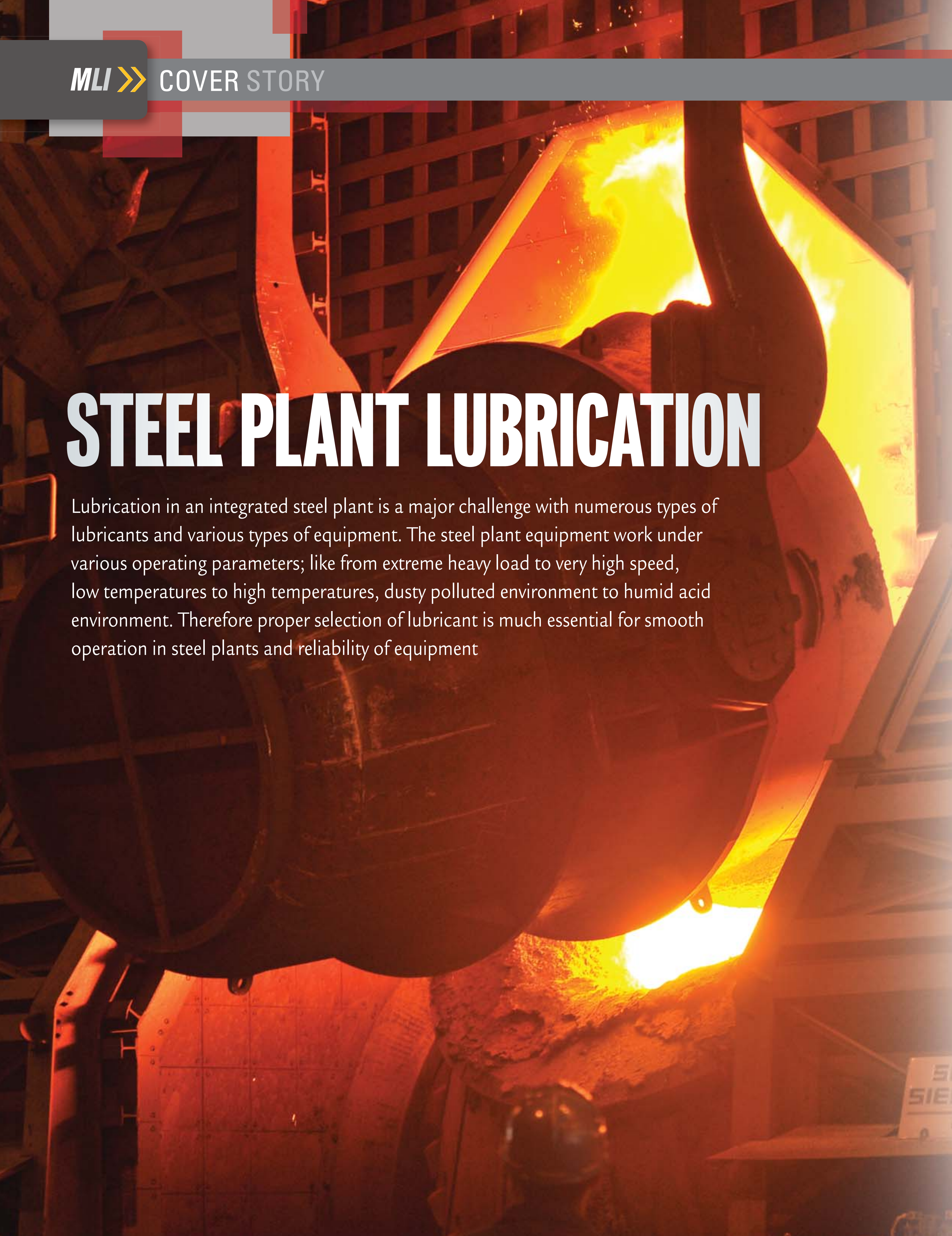
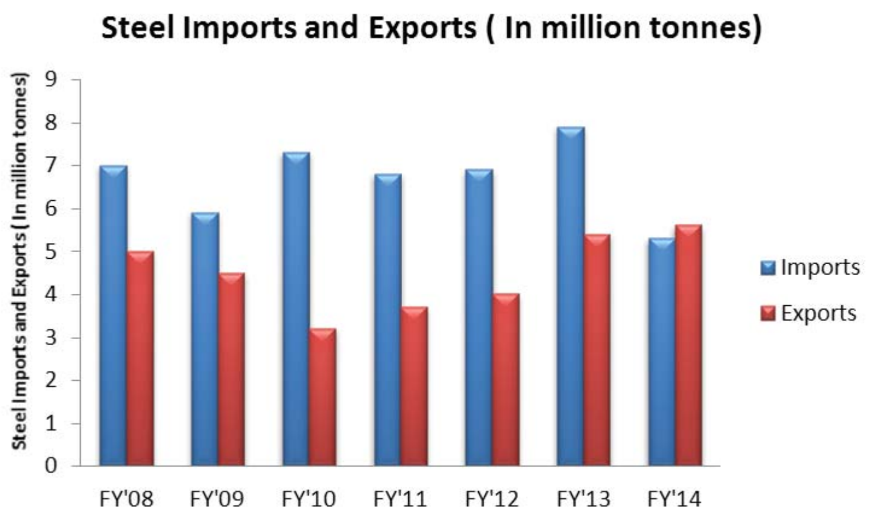


STEEL PLANT LUBRICATION

Lubrication in an integrated steel plant is a major challenge with numerous types of lubricants and various types of equipment. The steel plant equipment work under various operating parameters; like from extreme heavy load to very high speed, low temperatures to high temperatures, dusty polluted environment to humid acid environment. Therefore proper selection of lubricant is much essential for smooth operation in steel plants and reliability of equipment

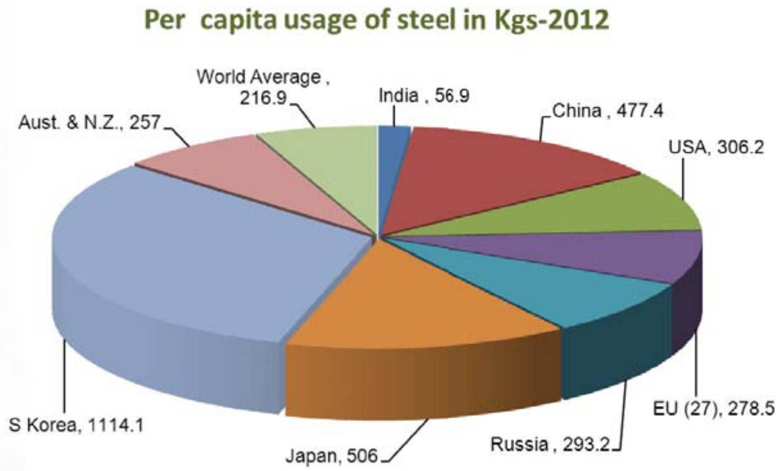
Kuldeep Pradhan & Ashok Kumar, Indian Oil Corporation Limtied

India at present with 77 MMT is the 4th largest steel producer globally. In 2012, India became a net importer of steel, mainly special grades. By 2016, India is expected to become world's 2nd largest crude steel producer. Fast urbanization will be the driving force for India's steel industry growth. Total crude steel production rose at a CAGR of 7.9 percent over the last five years to reach 81.54 MT in FY14 where as finished steel production increased 4.1 percent to 85.0 MT in FY14. By 2020, Indian steel sector will witness emergence of 5-6 players controlling 65~70% of total production and will emerge as one of the leading exporter of steel globally along with China. Over the last few years, import dependency has decreased due to growth in domestic production. However the per capita consumption of steel in India remains low which suggests that there is still a high potential for growth. Over FY08–FY14, consumption has of steel has expanded at a CAGR of 6 percent. Steel consumption is expected to grow at an average rate of 6.8 per cent, reaching 113.3 MTPA by FY17. Infrastructure is India's largest steel consumer, accounting for 63 percent of total consumption in FY12. Engineering and fabrication is the next largest consumer, with 22 percent of total consumption.



An integrated steel plant comprises of four major groups such as Iron Making, Steel Making, Rolling and Finishing and Auxiliary Units. The equipment and the working environment in each of these groups differ significantly and hence the requirements of the lubricants used are also different.

The Iron making group includes plants like raw material blending & blending yard, beneficial plant, sinter plant, coke ovens and blast furnaces etc. The equipment in general are required to work under high temperature dusty (abrasive) and corrosive environment. The equipment used for crushing and screening application are subjected to high impact as well. The speeds are lower. The steel making group includes plant like LD Furnaces, continuous casters as well as lime plant etc. The equipment are subjected to very high temperature, dusty (abrasive) and corrosive environment. The other working conditions in this group are similar to those in the iron making group. The rolling and finishing group includes Hot Strip Mill, Cold Rolling Mill, Primary Boom Bar Mill, Bar and Wire Rod Mill and Merchant Mill. The equipment in rolling and finishing group are subjected to high impact loads , water and scale ingress, high temperature near reheating furnaces and higher speed and unit loads.

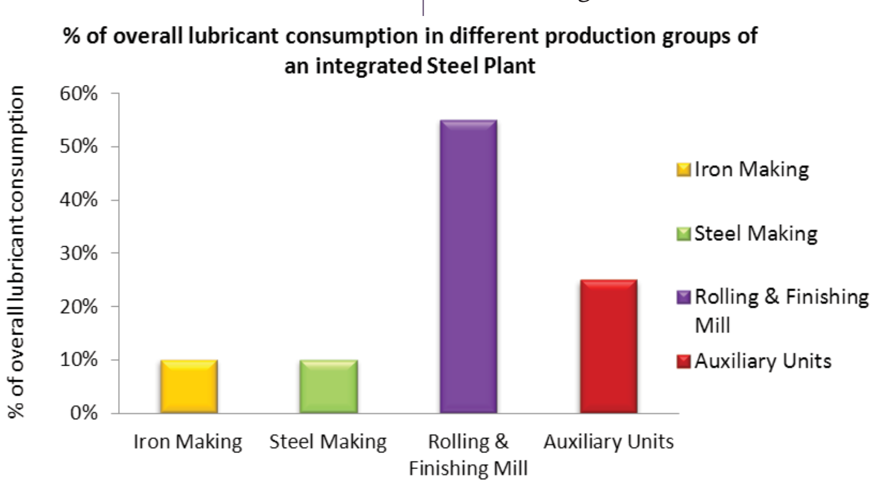


In Steel plants equipment reliability & better maintenance practices are very important which directly affects the productivity & equipment Health. Specific Maintenance cost is to the tune of roughly around Rs 1500 per tonnes of crude steel. This is about 10-15 % of the total production cost. Proper lubrication can obviate various maintenance problems leading to smooth operation of steel plants. Cost of Lubricants is only a tiny fraction of maintenance cost. But improper lubrication can cause more than 30 % of the breakdowns. Procuring superior quality of lubricant may slightly increase the spare cost however this will be rewarding in terms of trouble free working, reduced spares and optimum cost of maintenance.

While selecting lubricant for steel plants equipment these factors must be taken into consideration. Generally OEMs recommend the type and grade of the lubricant based on the design, speed and load parameters of the equipment. However in the absence of OEM recommendation or in case the recommended grade is not performing, a set of codes are to be made as guidelines by considering the afore-mentioned operational factors and select the lubricants accordingly. While selecting lubricant for an application, two very important aspects are to be looked at, namely, the factors concerning engineering requirements and the factors concerning requirements pertaining to the service condition. The majority of engineering requirements are met by selecting proper viscosity of the oil (called lubricant grade) while the service condition requirements are met by selecting proper additive package for the lubricant (called lubricant type).

PROCESS GROUP	% OF TOTAL MAINTENANCE COST IN THE PROCESS PLANT	% OF TOTAL LUBRICANT CONSUMED IN THE PLANT
IRON MAKING	11%	10%
STEEL MAKING	15%	10%
ROLLING MILLS	52%	55%
AUXILIARY UNIT	22%	25%

The factors concerning engineering requirement includes load, speed, surface finish of the interacting surfaces and rise in temperature etc. The problems posed by the service condition of the application are addressed by selecting a suitable additive system and appropriate base oil for the lubricant. Different additive combinations are used for providing protection against rusting, oxidation, scuffing, corrosion and foaming etc. Various categories of base oils available are mentioned as below:



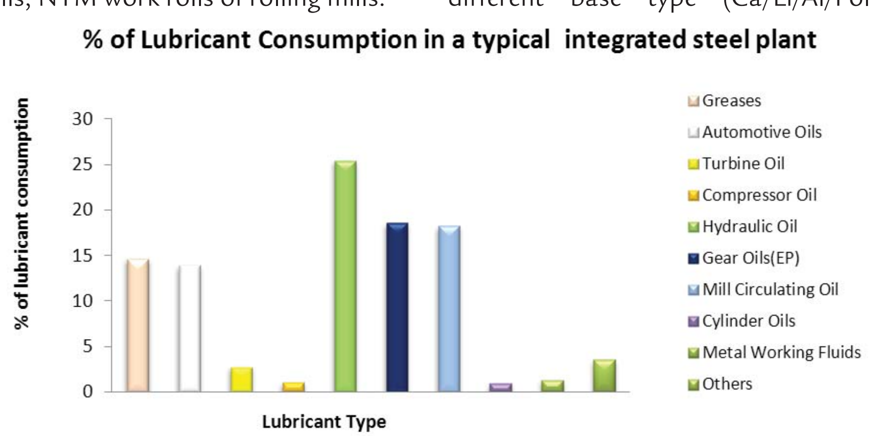
The base oil trend in steel plants is currently shifting from Group I to II due to the higher oxidation stability, thermal stability and high Viscosity Index and lower sulphur content of Group II base oil compared to Group I. Further Group II formulated oils have excellent demulsibility properties which is an essential parameter for steel mill bearing oils. Most of the lubricants such as hydraulic oil, gear oil, circulating oil and turbine oil used in a steel plant are now being formulated with Group II base oil. The use of synthetic oil in steel plants is limited to certain compressor oil and few gear oils (critical gear box with severe shock load and high temperature).

Some of the major suppliers of lubricants in Indian steel plants are IOCL, HPCL, BPCL, Shell, Mobil and Quaker Chemicals. Various types of lubricant grades are used in a steel plant. Those grades are hydraulic oil, industrial gear oils, compressor oils, film bearing oils, compounded oils, high demulsibility circulating oils(With and without EP), turbine oils, metal working fluids (mineral based, semi-synthetic and synthetics- heat type & emulsion type), wire rope and open gear compounds , automotive crankcase oils, process oils like cold

API Base Oil Categories					
Base Oil Category	Sulfur (%)		Saturates (%)	2007 Global Basestock Distribution	Viscosity Index (VI)
Group I (solvent refined)	>0.03	and/or	<90	66%	80 to 120
Group II (hydrotreated)	<0.03	and	>90	20%	80 to 120
Group III (hydrocracked)	<0.03	and	>90	5%	>120
Group IV	PAO Synthetic Lubricants				
Group V	All other base oils not included in Groups I, II, III or IV				

and hot rolling oils, rust preventive oils, mill greases ,high temperature greases, multipurpose greases and speciality lubricants doped with MoS2 or graphite.

All these grade of lubricants used in steel plants can be categorized in to five classes such as machinery lubricants, hydraulic oils, metal working fluids, automotive lubricants and process oils. Machinery Lubricants include spindle oil, way oil, cylinder oil, straight mineral oil, turbine oil, mist oils, gear oil, mill bearing circulating oil, black oils and greases. Spindle oils are low viscosity oil for machine toll bearings working at very high speeds. Way oils are heavy duty EP oil with oiliness additive which are used in machine tool way. These oils have good stick slip property, for Cylinder oil are high viscous fluids used for application in worm gears and steam cylinders. Black oils are dark, heavy, tacky oils which are meant for open gears, skids and chains lubrication. Circulating oils are used for the lubrication of back up rolls, NTM work rolls of rolling mills.



** The figure excludes various process oils such as rolling oils, rust preventive oils, caster moulding oil

Inhibited type highly refined (Group II base) are used for the turbines and blowers of steel plants. These oils are fortified with antioxidant, antirust, antifoam additives and possess very high thermal stability with, oxidation stability etc. Industrial gear oils are highly refined mineral oils fortified with EP additive and are used for lubrication

of gearboxes, mill drives and pinions. Mist oils are lubricants which possess good misting properties, low stray mist, no gumming properties, which are used in rolling element bearing and slippers of universal spindle. Greases of different base type (Ca/Li/Al/Poly Urea/Clay base) with or without additive/filler are used for the lubrication of antifriction bearings and couplings of steel plants.

In Steel plants various types of hydraulic fluid such as antiwear hydraulic fluid, fire resistant fluids and high water based fluids are used. Antiwear hydraulic oils are low viscosity refined oil with friction modifier for the fluid power system, with antirust, antifoam, antiwear additives, etc. Fire resistant fluids are water in oil emulsions having made of water glycols, organic esters and phosphate ester for protection against fire. High water based fluids (95/5) are also used for fire resistant application.

Process Lubricants in steel plants include slushing oil, rolling oils, pickler oils, mould oil and wire drawing compounds. Slushing oils are antirust, inhibited, light oil for sheet protection .Rolling oils are made of synthetic oil, semi-synthetic oil, fatty oil which is used for roll bite lubrication . Pickler oils are light mineral oil with rust inhibitor for sheet protection after pickling. Wire drawing compound are soaps with fillers for wire drawing application. Metal Working Fluids include soluble oils and neat cutting oils. Soluble oils are lubricating oil with emulsifiers which are used in water hydraulics and light machine tool operations. Cutting oils are chemical and petroleum base products for use in cutting, grinding and drawing, etc. Automotive grades are used in locos, mobile equipments, IC engines and HEV equipments.

Designation of service parameters:

Before selection of a lubricant for a specific application in a steel plant various process parameters like speed, load, temperature and moisture content must be designated. The load in steel plant equipment can be classified into five categories as per recommended % of c-ratings of AFMBA chart (Cn) which are as follows:

Load W: Normal (1), Medium (2), Heavy (3), Very Heavy (4), Impact (5)

- (1): It the actual load , W is as per recommended % of c-ratings as per AFMBA chart(Cn), i.e W<=Cn
- (2): Cn<= W<=1.2 Cn
- (3): 1.2Cn <=W <= 1.3 Cn
- (4): 1.3 Cn <=W <= 1.4 Cn
- (5): W >= 1.4 Cn

Example:

(1): Centrifugal pump, fan and blower (2): Transfer table rolls, Vibratory screens (3): Rod Mill and Bal Mills, gearboxes (4): Mill drive gearboxes, sheet straightening machine (5): Roughing and Finishing mill work rolls, Hammer mills and crushers.

Likewise the speed (N- RPM) can be categorized into Very Low (6), Low (7), Normal (8), High (9), Very High (10) the classification of which is given below:

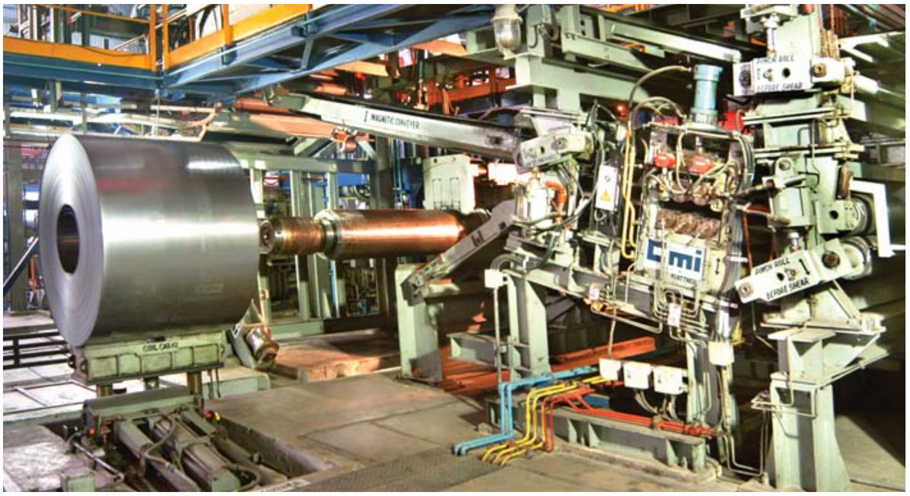
- (6): N<= 25
- (7): 25 <= N<=100
- (8): 100 <=N <= 1.3 500
- (9): 500 <=N <= 1500
- (10): N:>= 1500

Type of equipment	Load & Speed	Type of equipment	Load & Speed
Centrifugal pumps, fans and blowers	1,9	Vibrator screen	2,6
Transfer table rolls	2,8	Gearboxes	3,8
Rod and ball mills	3,6	Mill drive gearboxes	4,8
Finishing mill work roll, ROT rolls	5,8	NTM drive system	1,8
Roughing mill work rolls	5,7	Mixing drum, kiln	4,6
Hammer mill and crusher	5,9	Hydraulic pumps	1,9
Turbine journal bearings			1,10

Temperature ranges in various bearings and gears can be classified into Normal (T<60), High (60≤T≤120), Very High (T>120), Low (T<10), Very Low (T<0). Rolling Mills and Finishing lines in steel plants work under severe moisture condition, therefore rating the moisture level in steel plant equipment become much essential at steel plants. The moisture level (M in ppm) in equipment can be categorized into Normal (M≤ 100), High (100 ≤N≤500), Very High (M> 500).As various operational groups of a steel plants have distinct operating conditions, a proper lubricant is to be selected taking consideration of not only design parameters but also the operating condition such as the moisture level, dust ingress and acidity/alkalinity of the environment.

Lubrication challenges in a steel plants

From a lubrication perspective equipment under severe working condition poses serious threat to lubrication failure. Critical parameters of such equipment are

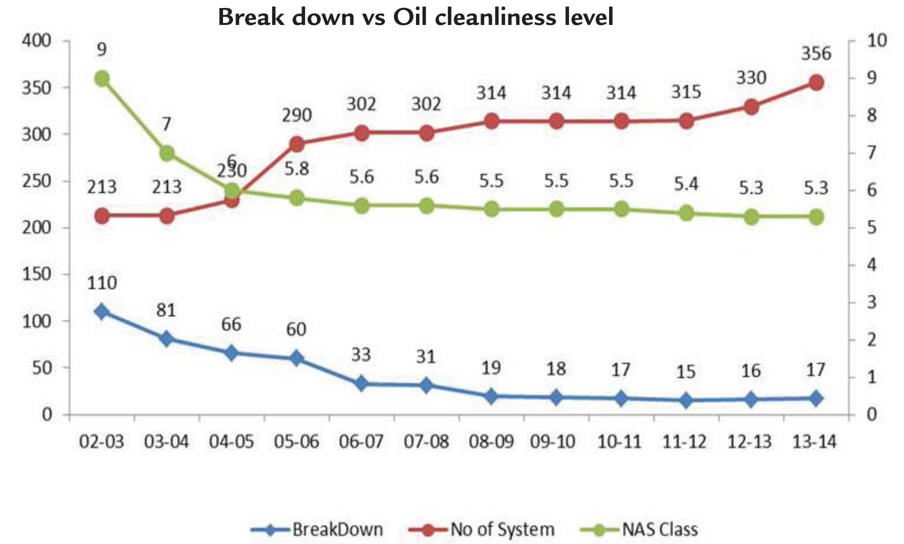


- High speed
- High impact loads
- High temperature
- Ingress of cooling water and scale in the lubricant
- Pumpability problem (Pumping of grease to long distances in CGS systems)
- Ever increasing speeds and loads to improve production rates

For high temperature application a thermally stable highly refined mineral oil with high VI shall be used for temperature range below 100 deg C. For temperature more than 100 deg C synthetic oils shall be used. Mineral oil & synthetic oil for such application may or may not be doped with MoS2 OR PTFE filler. Clay base grease with MoS2 filler can operate up to 150O C where as Li base/poly urea/Li, Al-complex grease can be used when operating temperature is below 130O C. For high temperature application i.e. temperature up to 200O C Ca-Sulfonate greases are suitable. For high impact forces application, high viscosity oil with / without MoS2, graphite, PTFE fillers, EP additive is used. Similarly greases with high viscosity oil (ISO - VG - 320/460/680/1000) are used for high load operation.

Equipment with very high speed requires improved application method as working temperatures tend to rise. Oil mist lubrication helps high speed application. Lubricating oil with low viscosity and inherent heat stability

For water and scale ingress application,



installation of water deflectors and application of better polymer sealants shall be done. In oil lubrication system oil with super demulsibility property shall be chosen for such application. In grease lubricating system, the area where maximum water ingress is present especially in mills; Li-Ca mixed base grease can be used to eliminate bearing failure. Li-Ca mixed base greases possess excellent water washout and water spray-off properties which resists washing out of greases from the surface due to ingress of moisture. Greases with high viscosity base oil poses serious problem of pumpability especially at low temperatures. Such applications need to be isolated into separate small systems to cater to short distance pumping. Also multiline grease system can be adopted to obviate such pumpability problem in the grease system.

The life of the lubricant and the life of equipment in steel plants are directly proportional to how clean the oil is initially and how effective the procedures are to maintain its cleanliness level. Simply by using cleaner oil equipment life can be enhanced. When the cleanliness of hydraulic fluid in a hydraulic system where servo valves are used for zero tolerance and consistent dimensional parameters is increased by a factor of 10; it has been observed through maintenance practices that pump life can be extended by a factor of 50. Up to 90% reduction in bearing failures can be achieved by a contamination control program. Hydraulic fluid system shall be maintained with cleanliness level of NAS 4 or 5 that to particle of 2-5 Q & 5-15 Q should be below 1500 and 1000 respectively. Filters of beta ratio 1000 are available with dirt holding capacity of 99.9. % can be used now –a- days to contain contamination. Apart from contamination control, condition monitoring program for lubricant can enhance the reliability factor in equipment. It also optimizes the usage of a lubricant in the equipment without compromising the quality. Condition monitoring program for lubricants includes performance parameters analysis of lubricants and wear debris analysis.

Lubrication in an integrated steel plant is a major challenge with numerous types of lubricants and various types of equipment. The steel plant equipment work under various operating parameters; like from extreme heavy load to very high speed, low temperatures to high temperatures, dusty polluted environment to humid acid environment. Therefore proper selection of lubricant is much essential for smooth operation in steel plants and reliability of equipment. A good lubricant can be of slightly higher cost. However, its benefits in terms of equipment reliability, productivity, reduction in down time are substantial.

About the Author

Kuldeep Pradhan is BE (Chemical) from NIT Rourkela. Presently he is working with Indian Oil Corporation Ltd. as a Technical Service Engineer in Marketing Division. In his three years of working experience in technical services, he has wide exposure to lubrication aspects of various types of industries like steel, automobiles, engineering, power & mining.

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By STEFFEN BOTS, OELCHECK

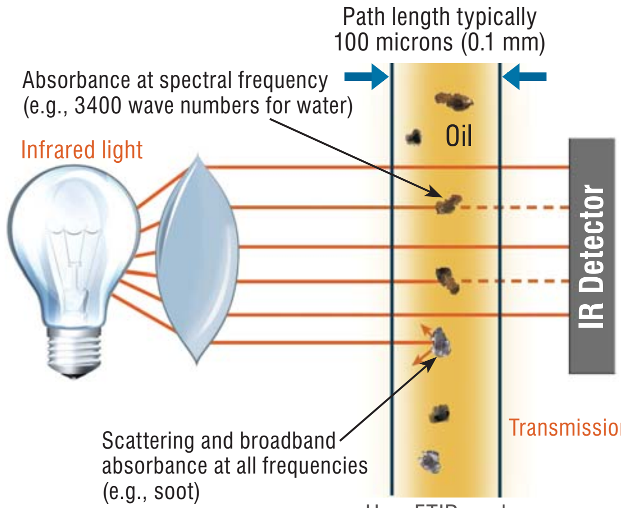
Best Methods for Analyzing Grease

What lubricates more efficiently, oil or grease? More than 95 percent of all components are lubricated with oil, not because it lubricates better but because it has a wider variety of properties. Grease generally is used only if oils cannot be utilized because sealing the lubrication point is problematic or expensive. Typically, grease is applied on rolling bearings, with nearly 80 percent of these bearings lubricated with grease.

During analysis, oils and grease behave similarly. Although both contain important information, it is more difficult to interpret the results for grease. The following methods represent the most important ways to analyze lubricating grease.

Atomic Emission Spectroscopy

Atomic emission spectroscopy (AES) by the Rotrode method can be used to provide information about wear, impurities, thickeners and additive levels in a grease sample. Increased iron and chromium values may indicate that a rolling bearing has been subject to wear, while copper, lead and tin show corrosion or abrasive wear from bearing cages. Possible impurities such as silicon (dust), calcium (lime) or hard-water deposits help to identify the causes of wear. Deviations between fresh and used grease in terms of the content and composition of the additive package or the thickener reveal that another grease is being used.



How FTIR works

Particle Quantifier Index

The particle quantifier (PQ) index specializes in determining magnetizable iron particles. Unlike AES, which cannot easily detect iron particles greater than 5 microns, the PQ index records all the wear particles that are magnetizable regardless of their size. The height of the PQ index is then measured in conjunction with the AES iron content.

An extreme PQ index (more than 500) indicates that acute wear has taken place regardless of the AES iron values. Often there has been pitting or material fatigue. A high PQ level (more than 200) with a low AES iron value (less than 100) signifies that acute wear is occurring and causing relatively large wear particles. An increased PQ index (more than 100) in combination with a correspondingly high AES iron value is a sign of typical material fatigue during which "normal" wear occurs. A low PQ index (less than 50) accompanied by a high AES iron value (more than 100) is always a sign of corrosion and rust formation. Rust is barely magnetizable, so it produces a low PQ index.

Fourier Transform Infrared Spectroscopy

The principle of Fourier transform infrared (FTIR) spectroscopy is based on there being molecules present in a lubricant that absorb infrared light to different degrees because of their chemical structure. Changes to the used lubricant can be compared to the fresh grease reference spectrum and then depicted, calculated and interpreted as typical "peaks" for certain wave numbers. In addition to identity controls, oxidation can also be proven with FTIR spectroscopy, for instance. As they age, molecular compounds alter and absorb more infrared light than fresh grease. Through the process of Fourier transformation, these values can be read and the molecular vibrations represented in an FTIR diagram.

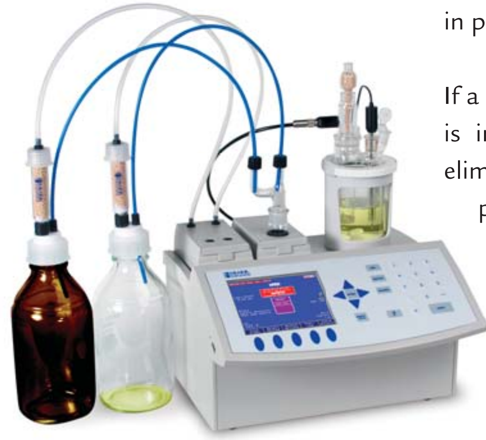
Depending on the molecular compounds, the peaks develop as corresponding wave numbers. Synthetic lubricants frequently contain ester-based components. Because of the oxygen molecules contained within them, they absorb infrared light in almost the same wavelength range as the double oxygen bonds that arise through oxidation. This is why oxidative changes to a synthetic oil cannot be calculated accurately using FTIR alone. The RULER test is needed for this.

Through comparison with the deposited fresh grease spectra, the process provides quick and reliable information on whether greases have been mixed together or a completely different type of grease has been used. The process can also determine whether the grease contains a base oil that is synthetic or mineral oil based.

For base oils that are mineral oil based, FTIR establishes whether oxidation has taken place because of a lack of relubrication or because of damage caused by high temperatures. If the grease contains high-pressure additives, additive deterioration may be detected. A fresh grease comparison can also prove whether there is too much water.

Karl Fischer Titration

Too much water in grease may cause corrosion and bearing damage. In places with high relative movement, cavitation can occur. If too much water is present or water penetrates continuously, relubrication must be performed more frequently. If the grease cannot withstand water, it may become soft or watery, and the quality will decrease.



Karl Fischer titrator (Ref. Hanna Instruments)

Just as with oil, the amount of water in a grease sample is calculated using the Karl Fischer (KF) method. It requires that water is "driven out" of the sample. With oil, the water from the sealed sample is steamed away by heating it to temperatures of up to 140 degrees C. However, it is much more difficult to boil water out of grease. In this case, the water must be extracted slowly at a temperature of 120 degrees C. The water is channeled into a titration vessel using a hollow needle and nitrogen. An electrochemical reaction then takes place with a special KF solution. Once the transition point of the titration curve has been reached, the exact water content can be stated in parts per million.

NLGI CLASS	PENETRATION NUMBER	CONSISTENCY AT ROOM TEMPERATURE
000	445-475	Very liquid
00	400-430	Liquid
0	355-385	Semi-liquid
1	310-340	Very soft
2	265-295	Soft
3	220-250	Semi-solid
4	175-205	Solid
5	130-160	Very solid
6	85-115	Extremely solid

The National Lubricating Grease Institute (NLGI) divides greases into classification groups based on their consistency.

If a grease contains too much water, it is important to find the origin and eliminate it. The Karl Fischer method provides quantitative information about water content. The elements investigated by atomic emission spectroscopy help to distinguish between condensate and tap water. If the used grease sample is unlike the fresh grease sample and is polluted with sodium, calcium, potassium or magnesium, this points to "hard" water, which may have penetrated the grease during high-pressure cleaning. If these minerals are not present, it may be "soft" rain or condensed water.

If water was not removed effectively during the production of the grease, it may be found in the fresh grease sample. An analysis of fresh and used grease will clarify this matter.

Bleeding Test

The sponge-like structure of the thickener or soap used in grease holds the base oil firm and allows it to transfer slowly to the lubrication point. However, if the oil flows too quickly and uncontrollably from the thickener, the grease "bleeds" away. If the remaining thickener contains too little oil for the lubrication tasks, the remaining grease dries out. If the residual oil content of a grease falls too quickly, either the grease is unsuitable or must be reapplied more frequently or in larger quantities. Determining the residual oil content provides the necessary information to decide which is the case. This test shows the percentage of base oil that the soap structure has lost over the course of six hours at a temperature of 60 degrees C. The residual oil content of used grease should then be compared with the fresh grease sample.

If the values are between 5 and 25 percent, and the difference between the used and fresh grease is plus or minus 15 percent or less, the grease can still be used without changing the relubrication intervals. If the used grease loses considerably more oil than the fresh oil, the thickener is no longer able to maintain the base oil in its sponge-like structure. If significantly less oil is released from the used grease, it has already begun to dry out. The bearing surface is "hungry" for lubrication and must be lubricated again.

Residual oil content levels that are too low may be the result of too much time in use and insufficient relubrication; strong vibrations, loads or rotation speeds; mixing of greases that have been saponified differently; impurities caused by water, acids or lyes; inadequate temperature resistance; or oxidation and aging (acetifying) of the base oil.

Penetration Test

While viscosity describes the ability of a lubricating oil or hydraulic fluid to flow, consistency refers to the extent to which a lubricating oil is stiff. However, the consistency of a grease is not directly linked to the viscosity of its base oil or the kind of thickener used. The National Lubricating Grease Institute (NLGI) divides lubricating greases into classification groups based on their consistency. Along with the base oil's type and viscosity, the consistency category to which it belongs provides another important value to classify the firmness of the grease. The consistency shows whether the grease is feedable or has become too firm as a result of bleeding.

Consistency is measured using a standardized cone. Grease is spread into a small pot. The tip of the cone touches the grease. The penetration depth is reached in 5 seconds and measured in 0.1 millimeters. This produces the grease penetration number used to determine the NLGI class. The softer the grease, the deeper the cone penetrates. This indicates a high penetration number and a low NLGI class.

Comparing fresh and used grease penetration allows certain conclusions to be drawn. For example, if the used grease has become softer and therefore has a higher penetration number than the fresh grease, it may have mixed with another grease or been contaminated by water or another liquid. The grease may also have been mechanically sheared and loaded.

A significant drop in the penetration number indicates that the grease may have been bled by excessively strong vibrations or that high temperatures may have resulted in oil separation. High levels of pressure in the central lubrication system may have also disturbed the balance between the base oil and the thickener.

Sulfate Ash

Investigating sulfate ash is a process used to identify inorganic levels in organic samples. This is achieved by heating the sample to temperatures of 775 degrees C. At this temperature, the organic elements in the samples "combust." All that remains are ashes consisting of metallic oxides (soap, additives, etc.) and impurities. By smoking this with concentrated sulfuric acid, the oxides in the ashes are transformed into sulfates. The weight of the remains is then recorded.

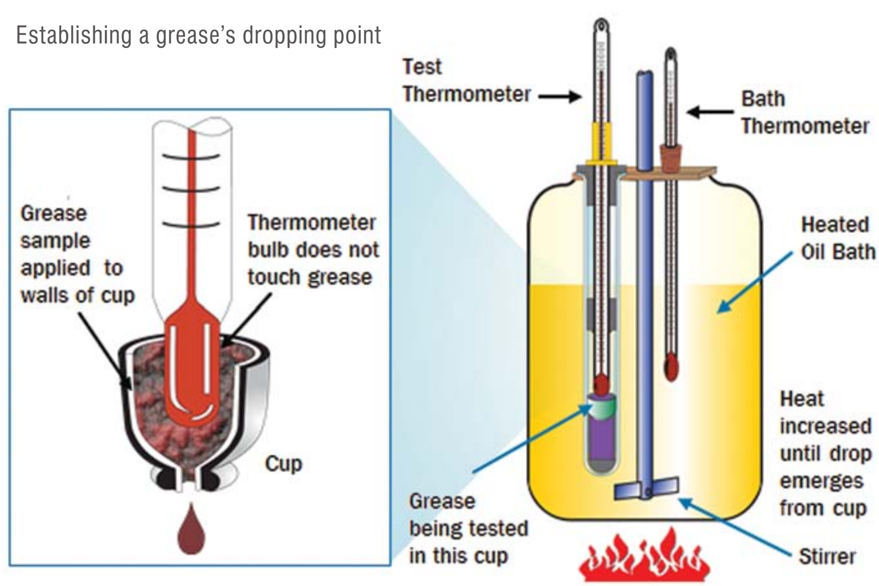
If the proportion of sulfate ashes in the used grease has increased in comparison to the fresh grease, this is a clear indication of impurities and/or wear. If the metal values established by AES are consulted at this stage, the cause of the weight increase can be clarified. High levels of iron and chromium point to wear, while increased proportions of silicon and calcium hint at impurities.

The weight of the sulfate ash is affected by metallic abrasion from bearing wear, hard impurities such as silicon (dust), levels of solid lubricants like molybdenum disulfide, metal organic extreme-pressure additives, and other metal soaps and inorganic thickeners from other greases with which they have mixed.

Shear Stress, Visible Viscosity

A rheometer is used to measure a grease's visible viscosity at different

Establishing a grease's dropping point



temperatures. For this purpose, a small amount of grease is placed on a temperature-controlled plate. The plate-based testing cone, which develops a gap between the upper and the lower plates, moves onto the film of grease. The force between the plates and the cone is measured as dynamic viscosity, which for grease is also called "shear viscosity."

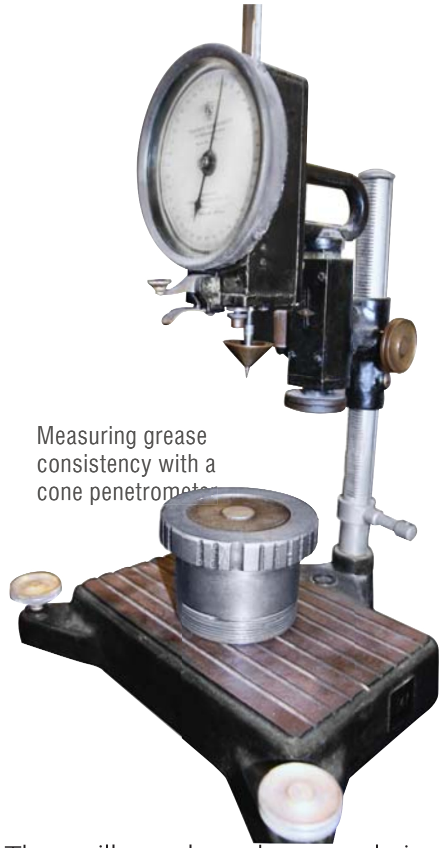
The stability after the shearing, which assesses characteristics such as a grease's deformability, can be described in terms of apparent viscosity. The rheometer provides the shear viscosity at the beginning and end of the testing procedure and displays the shear viscosity decrease in terms of percentage.

By using the index and comparing with different fresh greases or through trend analyses, you can determine the lower temperature limit at which the grease can be used, whether the grease is suitable for high rotation speeds and whether it is acceptable for specific types of bearings.

Dropping Point

As temperatures rise, greases behave differently than edible fats. They do not melt like butter or coconut oil when warmed but hardly change at all as the temperature rises because the thickener holds the base oil firm. Only when the thickener's critical temperature has been reached does the soap structure dissolve.

To establish the dropping point, a grease sample is warmed in the testing device until liquid drops fall to the bottom of the test tube through an opening in a nipple. Gel- or powder-based greases, which are measured at temperatures of more than 300 degrees C, are considered as not having a dropping point.



Measuring grease consistency with a cone penetrometer

There will not always be a correlation between a grease's dropping point and its maximum operating temperature. Of course, the permissible temperature is always less than the dropping point value. Along with the thickener, the oil type will dictate a grease's maximum operating temperature.

A lower dropping point of a used grease in comparison to a fresh grease may be caused by greases with different thickeners mixing together, the grease containing water or other foreign fluids, or the grease shearing into small particles under extreme loads.

Linear Sweep Voltammetry

Linear sweep voltammetry, which is also known as the RULER test, establishes the amount of amino and phenol oxidation inhibitors in a grease sample. Because lubricating greases are affected by factors such as time and temperature, they usually contain antioxidants along with extreme-pressure and anti-wear additives. These additives can break down. Therefore, the relubrication intervals and amounts must be adapted to the decreasing additive levels.

Infrared spectroscopy can identify the development of oxidation in mineral-oil-based greases but not for synthetic base oils. The RULER test is used for these types of greases. By comparing the curves of fresh and used greases, the remaining lifespan of a grease can be determined as well as the best time for the next relubrication.

Soxhlet Extraction

Since base oil viscosity is a key factor in calculating bearing lifespans, most grease manufacturers provide this essential information about the base oil. However, no regulations currently exist regarding this issue. Generally, high viscosity is considered better.

In order to demonstrate high viscosity, all of a fluid's components including the oil, additives and viscosity index (VI) improvers must be mixed. The viscosity is stated based on this mixture. This viscosity value has little in common with the way viscosity is calculated for oil used in roller bearings because the grease no longer releases some parts of the thickener onto the bearing track.

A Soxhlet extractor can separate the liquid grease component from the thickener. Oil that is extracted in this process only contains liquid components. Polymer or adhesive supplements, VI improvers and even solid lubricants remain in the thickener.

After the oil-based components have been extracted from the soap, information can be provided about the grease's oil and thickener levels. Separating the components into solids and oil makes it possible to carry out a detailed analysis of the base oil with respect to its viscosity, composition and proportion of additives

Neutralization Number

Even greases can turn "sour." Oxidation of the base oil, breakdown of anti-wear additives or entry of salted fluids will result in the development of acids in the grease. These acids can destroy alkaline thickeners, causing the grease to have a soup-like consistency and the base oil and soap residue to separate. The grease then will run off the bearing surface, and bearing failure may occur.

Various reactions can lead to the fat becoming acidic. When this happens, relubrication should take place at more regular intervals.

The neutralization number can help determine when a grease is not suitable for use and if the base oil or thickener should be improved.

Water Resistance

Although it is easier to seal lubrication points with grease than with oil, grease should be resistant to water. Hydrophobic grease will provide a seal against splash water. If a grease can emulsify water, there is a risk of corrosion and hydrogen embrittlement.

A simple test for water resistance involves placing a thin layer of grease on a strip of glass. If the layer of grease turns a cloudy, milky color or dissolves from the glass strip entirely, the grease will absorb moisture when stored in water. If water runs off the layer of grease, the grease can be considered water-resistant.

Copper Corrosion

For this test, a copper strip is covered with grease on all sides and placed in a specimen container with the same grease. The sealed sample container is stored for a certain amount of time in a warming bath. After the test period, the copper strip is removed, cleaned with solvent and carefully dried. The level of corrosion is established by using a color scale to compare the copper strip's discoloration.

This technique is utilized to investigate a grease's corrosive characteristics in the presence of copper, as the sulfur level alone does not provide enough information on the expected corrosion of metallic machine parts. The test can reveal whether the additives that are supposed to reduce the effect of sulfur compounds still work and how the grease will behave in terms of non-ferrous metal corrosion when used in bearing cages.

Of course, all of these methods will depend on the ability to obtain a representative grease sample. Without this essential element, qualified grease analysis and a reliable diagnosis will be impossible. ■

Jeremy Wright | Noria Corporation

How to MEASURE Lubrication PROGRAM SUCCESS

Many companies thrive on financial performance metrics. Share price, earnings per share and return on net assets are taught religiously in every business school. This information is used to assess an organization's financial health and drive current and future decisions. Even if you are not a CEO or investor, you probably are familiar with these metrics.

Just as important are the metrics for safety coordinators, production managers and site managers. Unfortunately, few people understand lubrication and reliability metrics, much less use them. These metrics are not typically taught in engineering or management schools. This leads to a serious failure in recognizing the impact that lubrication has on a plant's production, profit and safety.

For many plants, lubrication remains a challenge even to this day. According to numerous case studies, when a machine fails, the likelihood that the failure was in some way related to lubrication is greater than 70 percent. Lubrication key performance indicators (KPIs) can go a long way to help identify not only these issues but also others that affect production, profit and safety. They are all related and integral to a facility's overall success.

Why have maintenance KPIs failed to become mainstream? Is it because they are not being taught? When was the last time you read about lubrication KPIs in a textbook or worked for a company that used them? As part of my role with Noria, I travel around the world and help companies get their lubrication programs on the right track. One observation that I have made over the years is that if your company is using lubrication metrics, you are in the top 2.5 percent of the industrial world.

The foundation for lubrication KPIs starts with a few simple questions. Have you analyzed your mission as a company or group? Write down your three main objectives. The KPIs will need to relate to this mission in some way.

Have you identified the stakeholders? When you complete your mission, who benefits? These are the people or companies that would be most interested in the results of your KPIs.

Have you defined your goals? The majority of KPIs should be tied directly to achieving your goals.

Next, let's set a few ground rules for these KPIs. No single KPI can adequately measure all aspects of a lubrication program. This means you must have multiple KPIs to make sure the data is reinforced.

Each area of interest should have a limited number of KPIs (maximum of four to six) that will drive the desired behavior. If too many are selected, you may get lost in the data and data collection and lose sight of your objectives.

KPIs must be relevant and specific to the particular program aspect they are designed to measure and preferably prepared from data that is available from existing systems. This makes the data collection much easier.

KPIs should also have an associated target figure or finite goal. This could be dollars, a percentage, cleanliness level, etc., but it must be measurable in

OIL ANALYSIS ALARMS

Frequency	Data Source	Target
Monthly/ Quarterly	Oil Analysis Software	100% Green

Definition

Similar Measure to Asset Health - Broken Out:

- Machine Health Alarms
- Lubricant Health Alarms
- Cleanliness Alarms

	Machine Health	Lubricant Health	Cleanliness
Percent in Green Condition	98.75%	98.75%	97.28%
Percent in Yellow Condition			
Percent in Red Condition	1.25%	1.25%	2.72%
Total Locations Assessed	479	479	479

some way.

Finally, the KPI must be presented in a clear, summarized format that shows present and historical performance, targets, benchmarks, etc.

Now that you have a foundation and some ground rules, I'd like to offer a few examples of KPIs that can help you achieve your lubrication program objectives. There are five categories for these key indicators.

Oil Analysis KPIs

Oil analysis KPIs are meant to verify the quality of the lubrication being applied to equipment by monitoring relevant machine condition indicators. For oil analysis data to be used as a meaningful KPI, it is vital that targeted alarms and limits are set appropriately. While loose limits may result in compliance with lube condition and contamination targets, their meaning may diminish to such an extent that they become irrelevant as a KPI. When setting targets, don't consider where the plant is today but rather what targets need to be established to attain the plant's stated reliability goals.

Once appropriate targets have been set, logging exception results becomes relatively easy given the availability of commercial oil analysis software packages.

New oil deliveries can be treated in much the same way as assets in the field. They should be tested for cleanliness, dryness and fluid properties.

You can also use oil analysis data to get an idea of machine health, lubricant health and contamination levels.

Work Management KPIs

These KPIs are required to evaluate the efficiency and effectiveness of routine and ad-hoc lubrication task planning, scheduling, execution and review. While a number of lubrication KPIs can be generated using data from a computerized maintenance management system (CMMS) or other generalized predictive and preventive maintenance management tools, some of the most valuable KPIs require data gathered at individual lubrication points.

LUBRICATION TASK COMPLETION

Frequency	Data Source	Target
Monthly	CMMS/LMS	>90%

DEFINITION

$$\frac{\text{\# of Lubrication Tasks Completed (LTC)}}{\text{\# of Lubrication Tasks Due (LTD)}}$$

LTC=523, LTD=600 → LTComp=87%

LUBRICATION TASKS OVERDUE

Frequency	Data Source	Target
Monthly	CMMS	<10%

DEFINITION

$$\frac{\text{\# of Lubrication Tasks Past Due (LTPD)}}{\text{\# of Lubrication Tasks that were Due (LTD)}}$$

LTPD=77, LTD=600 → LTComp=13%

The lubrication task completion KPI gives managers a clear picture of the overall efficiency of lubrication practices at the task level. It is a measure of the total number of completed lubrication tasks divided by the total number of scheduled lubrication tasks over a certain timeframe. A low number may reveal inefficiencies in areas such as lubrication routes, workload balancing, resource allocation or equipment access.

The lubrication tasks overdue KPI reflects the total number of lubrication tasks not yet completed versus the total number scheduled. A high number here reveals similar concerns as a low task completion score. More importantly, this KPI, along with the lubrication task completion KPI, tells maintenance organizations how often and to what degree lubrication goals are being met.

Storage and Handling KPIs

Storage and handling of lubricants and associated consumables in the appropriate types, amounts and condition is an important enabling factor in the provision of quality lubrication.

Health, Safety and Environmental KPIs

These metrics and targets should reflect

LUBRICANT STOCK LEVELS

Frequency	Data Source	Target
Monthly	Inventory Management System	Minimum

DEFINITION

Total lubricant and consumable stocks held.

Approach "just in time" inventory practice where feasible.

LUBRICANT STOCK OUTS

Frequency	Data Source	Target
Monthly	Inventory Management System	0

DEFINITION

Number of times that lubricants or consumables are unavailable from the store when required.

Approach "just in time" inventory practice where feasible.

WASTE OIL COLLECTION RATE

Frequency	Data Source	Target
Quarterly	Inventory Management & Waste Oil Removal	95%

DEFINITION

$$\frac{\text{Total Volume of Waste Oil Removed (WOR)}}{\text{Total Volume of New Oil Issued (NOI)}}$$

WOR=123, NOI=125 → CR=98%

WOR=109, NOI=125 → CR=87%

OVERALL ASSET HEALTH

	Oil Analysis	Vibration	Motor Current Analysis	Infrared Mechanical	Infrared Electrical	Ultrasonic Mechanical	Ultrasonic Electrical	Overall
Assets in Healthy Condition	85.38%	70.83%	93.07%	97.86%	94.00%	74.00%	90.50%	86.52%
Assets in Deteriorating Condition	10.56%	16.32%	4.93%	1.89%	4.43%	17.10%	6.30%	8.79%
Assets in Critical Condition	4.06%	12.85%	2.00%	0.25%	1.57%	8.90%	3.20%	4.69%
Total Assets Assessed	360	448	525	923	329	283	911	1273

- *A "healthy" asset is one that has no identifiable defects.*
- *One of the best "leading" indicators of maintenance effectiveness and costs*
- *The higher the overall asset health, the lower the maintenance cost will be for any given plant.*
  - » *Fewer equipment will require maintenance*
  - » *Fewer parts purchased*
  - » *Fewer emergencies*
  - » *Less overtime*

the overall site health, safety and environmental system with a particular focus on lubrication. They provide valuable insight to help engineers and technicians rapidly spot potential problems and trends. The waste oil collection rate KPI can be a broad measure of the amount of lubricant used over time across different facilities or a more tightly focused view of lubricant consumption within a given department or area of the plant. Irregular levels of consumption may indicate leakage, poor lubrication practices, issues with lubricant quality or other concerns.

Macro Level KPIs

Some high-level lubrication KPIs provide a snapshot across entire operations. These are indicative of overall equipment condition. One of these is overall asset health, which is a useful gauge of plant readiness. It shows the percentage of all equipment in a facility with no known issues or defects. Another helpful KPI is lubrication-related failures, which is often a simple calculation of the monetary cost, number of incidents or other measures of equipment failures that can be traced to lubrication over a given period of time.

LUBRICATION-RELATED FAILURES

Frequency	Data Source	Target
Quarterly	RCA Reporting System	0

Definition

Number (or dollar value) of equipment failures or reduced life directly or predominantly caused by some failing of the lubricant or lubrication

Any failure related to lubrication indicates room for improvement.

Keep in mind that achieving lubrication success is difficult, and all but the best will struggle. Setting goals and putting procedures into place to guarantee that proper lubrication practices are followed will greatly increase the likelihood of program success. Only then should KPIs be established for continued improvement. After all, what use is it to spend time, money and energy to measure something that you already know needs improvement, other than to look back and remind yourself how far you have come? As always, if you need assistance or someone to point you in the right direction, I'd love to help. ■

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 get your lubrication program on the right track.

By Victor D. Manriquez, IPEMAN

The Importance of Integrating Knowledge Management with Maintenance

Many organizations manually collect and store data relating to equipment inspections and repairs. This data is frequently stored in the most accessible place for maintenance personnel — their personal notebooks. These "little black books" contain large volumes of maintenance experience that unfortunately will disappear when the employee retires.

In 2006, a study published by the Hudson Institute on the U.S. workforce found that 30 to 40 percent of maintenance personnel would be retiring in the next five years. Considering it is now 2014 and three years beyond the year projected in the study, the scarcity of maintenance employees has become a reality.

The retiring workforce is exerting a pressure that most organizations have never had to face. A high percentage of these professionals have 20 to 30 years of experience, and little has been done to document what they know, what they do and how they do it. As businesses continue to make their operations "lean," some of these retired maintenance personnel are not being replaced. Even if organizations could afford to replace them, it is becoming hard to find suitable replacements.

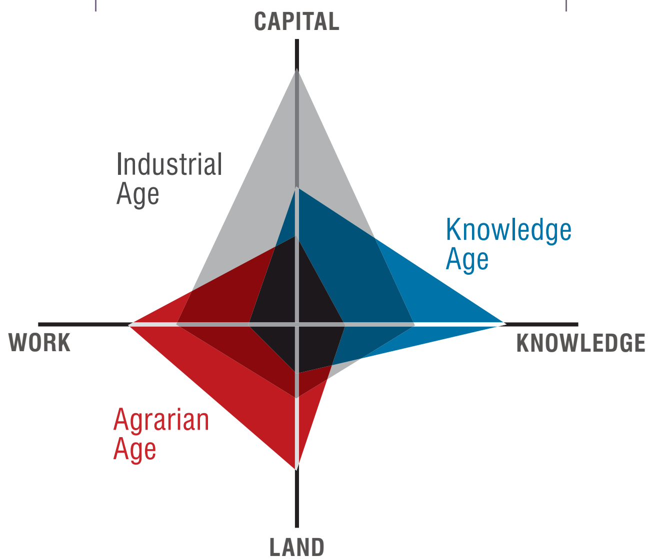
Compounding this problem is the fact that fewer people are entering into the maintenance field. There are several reasons for this trend, but they all lead to the same conclusion — more must be accomplished with fewer resources. To achieve this goal, organizations need to integrate knowledge management with maintenance.

The Knowledge Age

In our contemporary economy, knowledge is a crucial resource because it is inexhaustible and can be used by many organizations and people to generate even more knowledge. We live in the knowledge age, and individuals and organizations who can adapt to the inevitable changes are the ones who will be able to face the future challenges. Those who don't will be part of the past.

Three criteria must be met before information can be considered knowledge:

- Knowledge is connected. It exists in a collection of multiple experiences and perspectives.
- Knowledge is an action. Information that does not precipitate some type of action is not knowledge.
- Knowledge is applicable in new and unique situations. Information becomes knowledge when it is used to address circumstances for which no direct precedent exists.



Evolution of society

Knowledge Management

What does the term "knowledge management" (KM) mean? Typically, three concepts are combined: intellectual capital, which consists of a company's know-how, patents and trademarks; organizational culture, which includes the willingness to share knowledge and cooperative work within an organization; and information technology, which involves implementing devices that make it easier to access the knowledge produced inside an organization.

In addition to knowing what KM is, it is also important to understand what it is not. KM is not technology. It is not a directive, and it is not a business strategy. KM is a dynamic management system for a viable business strategy, not just a storage capacity for accumulated knowledge. KM is also the ability to act on that knowledge. Organizations are no longer valued just for what they have done but for the potential of what they might be able to do.

Remember, knowledge is connected. For information to be transformed into knowledge, you must recognize, support and manage the connections, and most importantly the people, who are the ultimate owners of all knowledge.

KM Concepts

Understanding KM begins with two basic characteristics: knowledge complexity and knowledge applications. The former refers to the physical manifestations and depth of knowledge available, while the latter is the approach to connecting knowledge to people and processes.

Knowledge Complexity

All knowledge can be classified according to its complexity in a continuum from explicit to tacit. Explicit knowledge is articulated in formal language and easily transmitted among individuals. Tacit knowledge is personal knowledge embedded in individual experiences and involving such intangible factors as personal beliefs, perspectives, instincts and values.

Implicit knowledge is another common term that refers to knowledge derived from the careful and deliberate decomposing of tacit knowledge into a quantifiable and codifiable series of explicit knowledge. In other words, it is tacit knowledge in the process of becoming explicit knowledge.

An iceberg is frequently used as an analogy to represent the relationship between explicit and tacit knowledge, with explicit knowledge as the visible top of the iceberg and tacit knowledge as the iceberg's unseen, underlying portion.

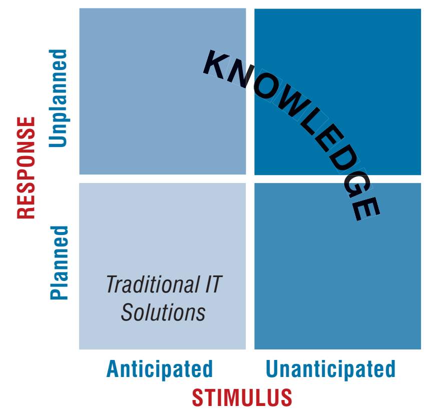
Knowledge Chain

In their book *Corporate Instinct*, Thomas Koulopoulos, Richard Spinello and Wayne Toms developed the concept of the knowledge chain. This chain has four links that determine the uniqueness and longevity of any organization: internal awareness, internal responsiveness, external responsiveness and external awareness.

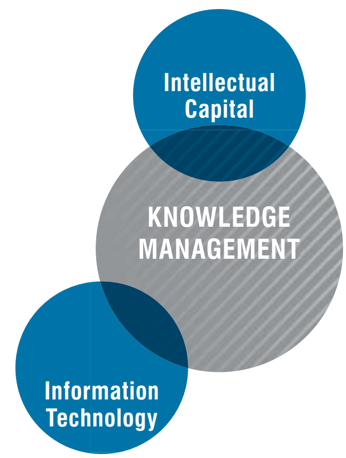
Internal awareness is the ability of an organization to quickly assess its inventory of skills and core competency. Internal responsiveness is the ability to exploit internal awareness. External responsiveness is the ability to best meet the requirements of the market. External awareness is the mirror image of internal awareness.

KM Applications

The four applications of KM are intermediation, externalization, internalization and cognition. Intermediation is the connection between knowledge and people. Externalization is the connection of the knowledge to other knowledge. There are two fundamental components of externalization: the capture and storage, and the classification or organization of the knowledge. Internalization is the connection of



Focus of knowledge-based solutions in a dynamic work environment



Elements of knowledge management

knowledge to query. Cognition is the linking of knowledge to process. It is the process of making or mapping decisions based on available knowledge.

Impact of KM

KM has demonstrated an impact on business. In an economy based on knowledge, KM is the critical element of a business strategy that will allow an organization to accelerate the rate at which it handles new market challenges and opportunities. It does so by leveraging its most precious resources — collective know-how, talent and experience (intellectual capital).

Implementing a KM system offers several benefits, including:

- Reducing the dependency on tacit knowledge
- Minimizing the loss of intellectual capital

- Promoting creativity and innovation
- Providing more flexibility
- Increasing the response capacity and quality before changes occur
- Improving management quality and efficiency
- Improving integration with linked external parts (customers, suppliers, partners)
- Making organizational learning easier
- Reducing risks
- Facilitating decision-making

Maintenance and KM

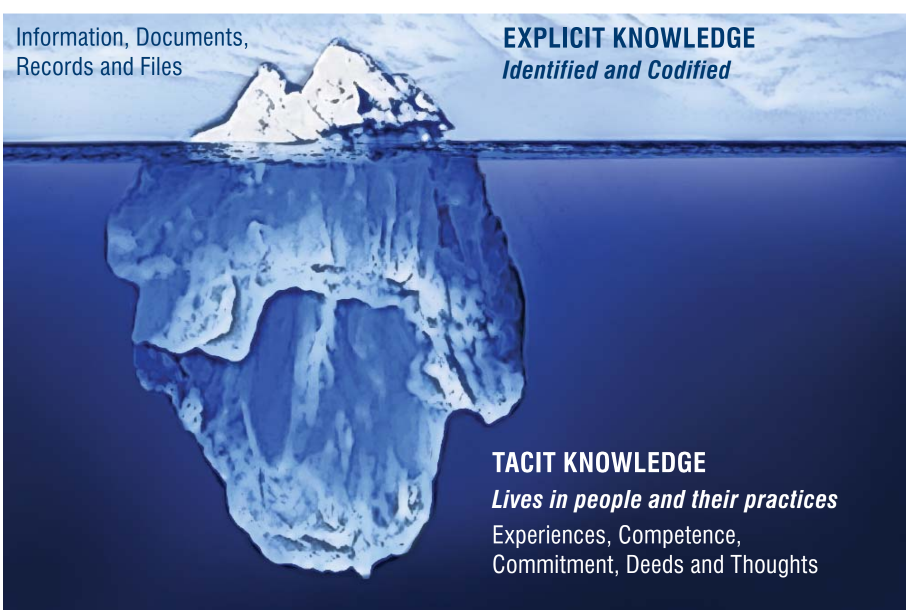
Maintenance is one of the most prolific areas in an organization for producing knowledge, both explicit and tacit. For example, this would include handbooks for equipment installation and operation, procedures, checklists, asset records, periodical reports, technical books, reference tables, technical knowledge, etc.

Explicit maintenance knowledge should not be of great concern, as it is more of an issue of organization and classification. Tacit maintenance knowledge must be internalized. It coexists with intelligence and experience, and affects how decisions are made. For this reason, the primary repository for knowledge is in the heads of individuals. Electronic and paper-based knowledge repositories are merely intermediate storage points for information en route between people's minds. Therefore, technical personnel should be considered as the repositories of an organization's know-how (and often the know-why, too). This is particularly true for maintenance processes and tasks.

These raw goods of intellectual capital — experience and know-how — must be channeled and made available. Otherwise, innovation can be restricted. How and where this intellectual capital is being captured must also be evaluated. The goal is to capture and monitor this continuously developing intellectual capital and promote its leverage.

Procedures

To transfer knowledge about equipment and related maintenance tasks, a combination of accurate information, complete records and numerous photos will be needed. This knowledge transfer may be made between personnel inside the plant, such as operators or new employees, and/or to outside contractors through effective job-specific training and documentation. The key is to ensure the knowledge is transferred properly. This work must be performed consistently and in a quality manner each time. Documenting work processes and capturing the knowledge possessed by maintenance professionals should be a priority. Whether the organization refers to these as PMs, standard operating procedures or work processes, they must be documented properly.



The knowledge iceberg analogy

Using CMMS

Most maintenance operations today employ computerized maintenance management systems (CMMS) to drive their maintenance tasks. Each work document can be tied to the CMMS so that when a PM is generated, a copy of the documented work tasks can go with it. However, the reality is that the information in these systems often has not been updated through the years, and there may be more tasks than personnel to perform them. The work tasks may also be poorly documented and offer little instruction. In this scenario, when maintenance professionals retire, their replacements (assuming there are replacements) will not have the same resident knowledge to perform the tasks adequately.

Documenting work tasks in the appropriate manner will help to prevent this situation from occurring and allow the organization to retain and transfer knowledge, improve/update historical practices, and enjoy greater flexibility. Indeed, the company must learn to manage knowledge in order for it to remain viable long term.

Apprenticeship Training Programs

An apprenticeship training program is a common method used to replace maintenance workers. The benefit of this type of program is that it can incorporate existing workers who understand the production processes and have good discipline and attendance records. The disadvantages of these programs are that they may take three to four years and are expensive to conduct.

Before beginning a training program, you should be assured that the candidates for training have the necessary skills to learn what is being presented. This can be accomplished by requiring specific qualifications or certifications. Of course, you must use caution, as these credentials are only as good as the curriculum at the institution granting them.

Mentors/Coaches

Another option when replacing workers is to train veteran maintenance personnel to be mentors or coaches and share their knowledge with new employees. For this approach to be sustainable, you must carefully select individuals who not only have experience but also the competency to serve as a mentor. Potential candidates should be able to perform several key functions, such as:

- Present issues in an understandable way
- Build collaboration and rapport
- Be respectful
- Be a good time manager
- Ask questions, formulate hypotheses and offer examples that promote knowledge transfer
- Balance individual and group activities
- Help apprentices achieve autonomy and confidence in the learning process
- Provide positive feedback
- Possess emotional intelligence

Keep in mind when implementing a KM system that you must record and update the existing knowledge of personnel who are close to retirement while also managing the knowledge transfer to new employees through procedures, training or mentoring. Maintenance operations especially should develop mechanisms to preserve their intellectual capital. Otherwise, this valuable experience and know-how will disappear when personnel quit or retire and take their knowledge with them.

Wes Cash | Noria Corporation

Creating BEST-PRACTICE LUBRICATION Procedures

Most facilities utilize some type of platform from which lubrication tasks are performed and documented. The most common documentation for lubrication tasks is that of the PM. Unfortunately, many of these PMs fall short of fully describing the work that needs to be done or outlining the step-by-step instructions to be followed.

Manufacturer Recommendations

When asked how to maintain a piece of equipment, technicians usually reach for the equipment's operating manual. These original equipment manufacturer (OEM) recommendations provide a foundation for the lubrication requirements needed to maintain the machine, including oil change or regreasing intervals, a list of lube points, recommended lubricants, a cross-reference of brands and types of lubricants, storage practices and seal compatibility information.

OEM recommendations are a good place to start when developing a new procedure. They offer a baseline for which lubricant to put into the machine as well as how much and how often. The frequency may need to be adjusted slightly to meet unique operating conditions or to match the lubricant to the ambient conditions i.e., lower viscosity for colder temperatures.

Once this information is gathered from the maintenance manuals, the next step is to realize what it will take to complete the task. This should include the tools, items and detailed step-by-step instructions.

Lubrication Accessories

Contamination is the scourge of any lubricated system. Great strides have been made in the realm of equipment reliability through the advancement of contamination control accessories. Sold as aftermarket accessories for virtually all pieces of equipment, these devices should be taken into account during a procedure's design phase. For instance, consider a desiccant breather. If you have a pump operating in a high-humidity environment with a history of water problems in the oil, it would be a good idea to install a desiccant breather to dry the air entering the system.

Once the breather is installed, you not only will have to maintain the pump but also the breather. In creating procedures for this pump, there will need to be instructions for checking the pump's oil level, topping up the oil in the pump, changing the pump's oil, sampling the oil in the pump (if it is to be included in the plant's oil analysis program), inspecting the desiccant breather's condition and changing the breather (if warranted based on the inspection results).

What may have started out as a single line in the pump's operation manual as, "Change the oil after every 2,000 hours of operation," has now grown to a list of six different procedures for the same pump.

> It isn't enough to develop **procedures** based only on what the OEM recommends. The **targets and goals** of the plant must also be incorporated.

Keep in mind that it isn't enough to develop procedures based only on what the OEM recommends. The targets and goals of the plant must also be incorporated. If a facility has target cleanliness goals for lubricants or internal processes that require the use of contamination control devices, it is imperative that the lubrication procedures be created with their use in mind. Documenting the procedure is paramount, as it provides the basis from which all lubrication technicians will be working. This is why the procedure must represent best practices.

Documenting the Procedure

Perhaps the biggest stumbling block when developing procedures is failing to document when lubrication tasks are performed. You also must be sure to document the correct procedure. This will be the most efficient procedure that allows you to maintain the equipment in the best manner possible. Some generic procedure types are as follows:

Oil Changes

Depending on the machine's criticality, an oil change may consist of simply unthreading a drain plug and refilling the reservoir from a sealed container of oil. Conversely, it may entail using a filter cart with quick-connect fittings to attach the cart to the machine and removing the oil without opening the machine to the atmosphere. Regardless of the method used, each step should be detailed for the equipment in use so there can be uniformity in the completion of these tasks by every individual.

Oil Sampling

Again, the hardware installed will make a tremendous difference in how this task is performed. For true best-practice procedures, each machine should have a unique sample port installed to allow for consistent sampling by all professionals.

Regreasing

Often overlooked as a complicated task, using a grease gun incorrectly can harm not only the machine but also the user. Each regreasing procedure should highlight the safety concerns of using a grease gun as well as the proper way to apply grease, including the grease volume for each lube point.

Once the correct procedure has been documented, all maintenance and lubrication professionals must be trained on the proper way to perform the task and follow the new procedure. This serves as a great proving ground for the new procedures and a training opportunity for all parties involved.
Of course, having the best procedures means little if they aren't being followed or you don't have the necessary equipment to perform them. If the procedure requires drawing a sample from an installed sample port, there must be a sample port installed. If you will design procedures based upon how the program should be run and follow through with equipment modifications, your lubrication program will be well on its way to becoming world class.

49%

of lubrication professionals have written lubrication procedures for equipment at their plant, based on a recent survey at MachineryLubrication.com

About the Author

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By Mark A. Tarbet, Luminant Power

Babbitt: The Other Bearing Lubrication

Journal bearings play a critical role in equipment with large and high-speed rotating components. They primarily are used in machines with more than 500 horsepower and that operate at speeds of more than 3,000 revolutions per minute (rpm). Previously, their most important job was to reduce friction between two surfaces in relative motion. Now, journal bearings not only reduce friction but also provide the means to remove heat and debris while offering protection to more expensive components such as shafts and rotors.

Most journal bearings found in modern industrial equipment are built with a surface of Babbitt material. This material has a smooth, slick surface that is easily wetted by liquids. The soft material is resistant to galling but easily wears away, protecting the harder surface of the typically steel shaft. The bearing surface is sacrificed, with Babbitt actually becoming the lubricant, and the shaft surface is preserved in case there is a loss of lubrication or other operating anomaly.

In the 17th century, Robert Hooke began utilizing "bell" metal as a bearing surface material. Bells were often formed with a bronze alloy that usually included a 4-to-1 mix of copper and tin. In 1839, Isaac Babbitt patented a bearing alloy similar to the material used today. These alloy formulations became so popular that the name "Babbitt" has become synonymous with the material.

The standard Babbitt alloy is comprised primarily of a solid matrix of tin with various amounts of antimony cuboids and/or copper threads. Table 1 shows some of the physical properties of the most common forms of Babbitt classifications in industry.

Although tin enters the liquid phase near 450 degrees F, the liquid phase for the Babbitt alloy microstructure does not occur until temperatures exceed 600 degrees F. This allows for machine operation at higher temperatures, which often result from heavier loads and faster speeds. Journal bearings are quite strong and can carry heavy loads as long as they are lubricated properly. The lubrication forms a protective barrier between the shaft and Babbitt surface while also removing friction-generated heat and debris from the bearing.

Theoretically, a journal bearing may have an infinite life since there is no contact between the bearing surface and journal. This lubrication barrier also provides damping characteristics when passing through rotor-critical speeds, allowing for stable equipment operation. A journal bearing is easier to remove and repair given the split design. It typically produces less noise than anti-friction bearings and has natural electrical isolation properties.

PARAMETER	TYPE 2	TYPE 3
Tin	89%	84%
Antimony	7.5%	8%
Copper	3.5%	8%
Liquidus Point	669°F	792°F
Brinell Hardness	24	27
Tensile Strength	12,600 psi at 68°F	10,000 psi at 68°F
% Strength at 212°F	52	52

TABLE 1. Common ASTM B-23 Babbitt classifications

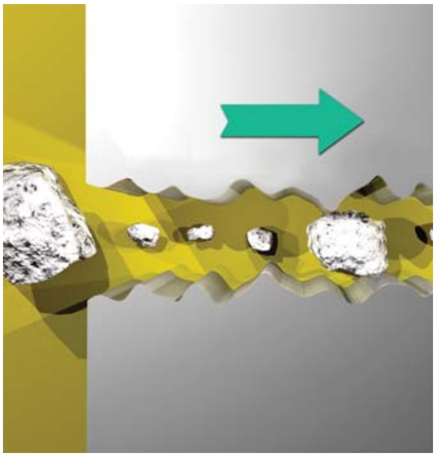
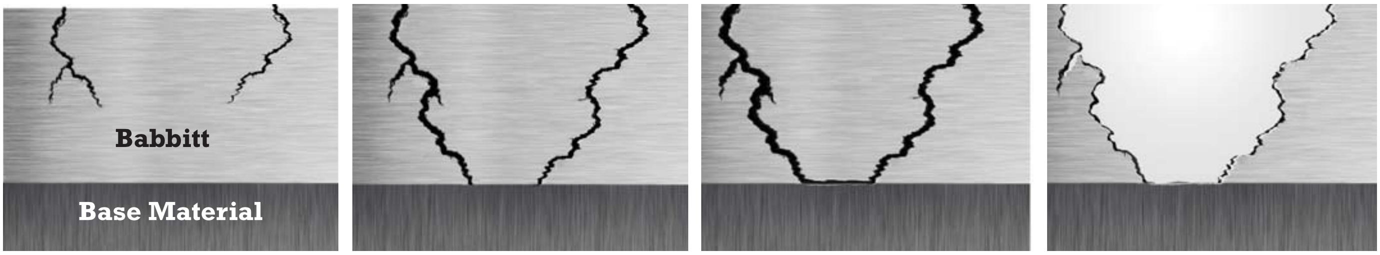


FIGURE 1. Illustration of possible bearing damage from debris



Fatigue Cracks | Cracks Propagate | Cracks to Base Metal | Material Loss

FIGURE 2. Fatigue cracking caused by excessive hydrodynamic forces

One of the main issues with journal bearings is the requirement of continuous lubrication that is clean and cooled. Contamination is a primary contributor to many bearing failures in industry. The soft characteristics of the Babbitt material make it susceptible to damage during installation. This also means the Babbitt can be easily destroyed if subjected to significant dynamic loading for long periods of time. The Babbitt will eventually crack and break off, leaving voids, as shown in Figure 2.

Another common cause of bearing failures is the machine operating at slow speeds either during startup or shutdown. For a bearing to work properly, the shaft surface must be moving at a sufficient speed to draw in the cool lubricant, pressurize it to form a hydrodynamic layer and expel it with any debris formed during the process. Figure 1 illustrates how hard particles can lead to bearing damage. This can occur with small particles at slow roll when the shaft and bearing surfaces are close together or with larger particles during normal operation. Figure 3 shows a journal bearing that was damaged during shutdown as the speed slowed to less than 200 rpm.

For Babbitt to work properly, a small portion of the tin is expected to melt and be washed away by the lubricant. This creates channels around the harder particles of antimony and copper, which actually support the shaft and carry the load. These channels allow oil to pass through them, cooling the surfaces and washing away any debris that was formed during normal operation.

Case Study #1: Steam-turbine-driven Boiler Feed Pump

A large pump experienced a bearing failure during normal operation. The shaft journal was 5.75 inches, and the typical bearing clearance was 7 to 9 mils. A post-mortem test was conducted to determine the possible cause of the failure. Figure 4 shows the bearing when it was removed from the pump. The bearing suffered from significant loss of overlay material, as seen in Figure 5.

Melting along the edges of the overlay material can be seen in Figure 6. This likely was due to significant heating, although there was no thermal data indicating an event had occurred. This picture also shows the redeposition of melted material on the bearing surface.

A highly magnified image of the bearing surface (Figure 7) from a scanning electron microscope (SEM) shows the surface microstructure of the Babbitt alloy. It includes copper needles and antimony cuboids embedded in the tin alloy. The shaft surface actually rides on the harder needles and cuboids, while the lubrication flows around them in channels within the tin. This allows for cooling of the bearing surface and the removal of any debris that might enter the bearing.

FIGURE 3. Bearing damage incurred during low-speed operation

FIGURE 4. Failed pump bearing

FIGURE 5. Loss of overlay (Babbitt) material down to the base metal

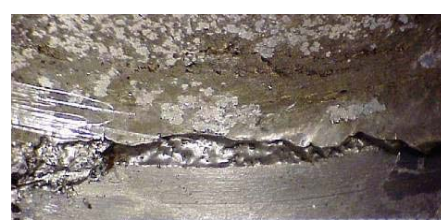


FIGURE 6. Melted Babbitt and material redeposition

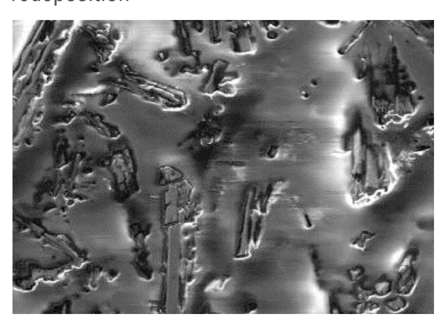


FIGURE 7. A highly magnified view of the Babbitt surface

FIGURE 8. A large centrifugal fan

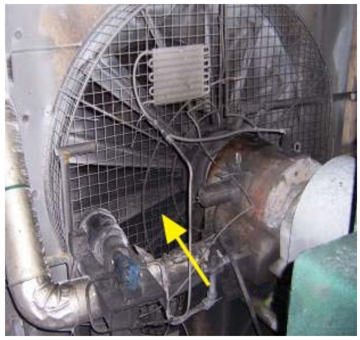


FIGURE 9. A lube oil pump and radiator (note the dark area where oil and dirt collected during operation)

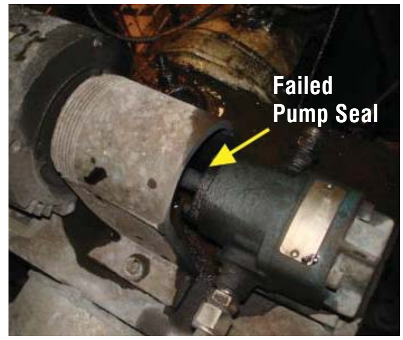


FIGURE 10. A leaking pump seal

FIGURE 11. Previously melted Babbitt reformed after restoring lubrication

Plant personnel believed electrical arcing was the root cause of failure. The study results found no evidence of electrical arcing but pointed toward overheating (likely from a loss of lubrication) as the primary cause. Since the bearing was severely damaged, an accurate diagnosis was difficult. This allowed for the possibility of a simple failure in the bond between the base metal and the Babbitt material as the root cause.

Case Study #2: Fan Bearing Failure

A large centrifugal fan (shown in Figure 8) was operating normally when the bearing metal temperature spiked to 212 degrees F. This was captured by the instrumentation and monitoring systems, initiating a critical alarm condition.

Checks of the fan indicated that the bearing metal temperature spike occurred after a general upward trend in temperature beginning almost five days before the failure. The temperature spike resulted in a sudden increase in vibration and elevated bearing temperatures on both ends of the fan. The lubricating oil level in the system reservoir had also dropped to very low levels.

Figure 9 shows the lubrication cooling pump used to move oil through a radiator attached to the fan inlet. A seal on the pump had failed, and oil was leaking out during operation. The location of the pump caused the leaking oil to be sucked into the fan. Therefore, routine visual inspections by operating personnel did not detect a pool forming. This allowed the oil reservoir level to drop at a steady rate with no visual cues of a problem.

The failure occurred during an operating period with record cold temperatures. The unit needed to be available for full-load operation and had to run regardless of the suspected bearing condition. In order to accomplish this, the reservoir was refilled with new oil. Lube oil filtration carts were placed directly on both bearing drains and monitored continuously.

To determine if the bearing condition was stable or deteriorating, lube oil contamination parameters were monitored and tracked regularly, as shown in Figure 12. This allowed the unit to operate until after the severe weather had passed.

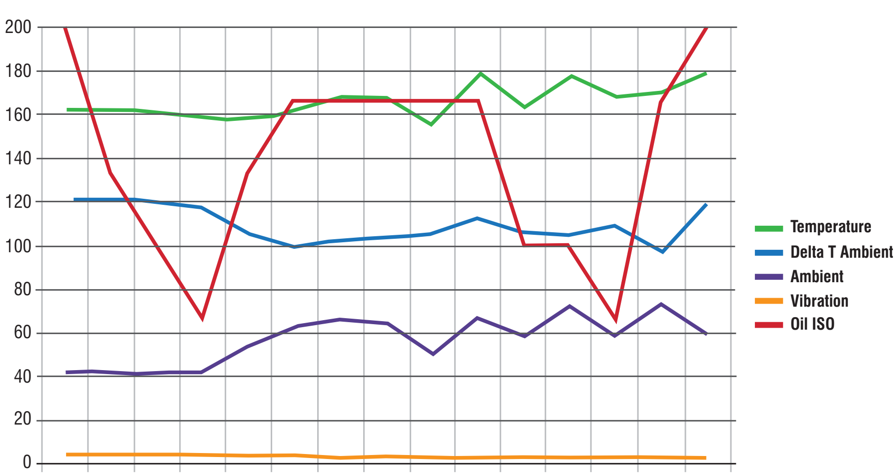


FIGURE 12. Lube oil contamination trend plot for a fan bearing

Once the unit was taken down for repair and the top half of the bearing removed, the damage was evident, as seen in Figure 11. The Babbitt material worked as designed, melting in the absence of lubrication to protect the shaft. After oil was restored to the bearing, the Babbitt cooled and reformed, enabling the machine to continue to operate until an outage could be scheduled. The bearings were replaced during a brief scheduled outage, and the machine returned to normal operation. ■

References

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How to SELECT the RIGHT Oil ANALYSIS TESTS

Oil analysis is an excellent tool that can be used to direct maintenance decisions. However, if you have not chosen the proper test slate, it is wasted time and money. Therefore, one of the first steps toward a successful oil analysis program is determining the right tests to perform.

Test slate selection can be a bit daunting. Some mistakenly believe that it is too technical or too involved for an untrained individual. It may help to break the selection into smaller segments. For example, first decide whether you want to examine the fluid properties, the contamination or the wear debris.

As shown in the chart on page 56, particle counting can be a great indicator of the effectiveness of your contamination control program, but if you are looking for a test to tell you about the health of your lubricant, the acid/base number and viscosity tests would be much better. You can narrow your focus even further by considering tests based on equipment type.

> "Having the ability to conduct onsite particle counts can save you money by providing quick information on the effectiveness of your contamination control program."

Qualification testing, quality assurance testing, user acceptance testing and monitoring of new oils in storage are some of the other important categories of oil analysis. Typically, lubricant manufacturers or blenders will use qualification testing to make sure the lubricant blend meets the stated minimum criteria. Among the tests usually conducted include:

- Oil viscosity and lubricity
- Oxidation stability
- Acidity and/or alkalinity
- Pour, flash and fire point
- Soluble and insoluble contaminants
- Air release and foaming characteristics
- Anti-corrosion and anti-rust characteristics
- Anti-wear and extreme-pressure characteristics
- Water separability and emulsibility characteristics
- Relative cold-weather operating characteristics

A number of other organizations may conduct additional testing to verify performance for specific machine classes. For example, the Society of Automotive Engineers (SAE) and the American Petroleum Institute (API) perform tests for gasoline and diesel engine oils, while the International Organization for Standardization (ISO) and the American Gear Manufacturers Association (AGMA) run tests on gear oils and for viscosity, anti-wear, extreme-pressure and other performance specifications.

Quality assurance testing is conducted by lubricant manufacturers during

46% of lubrication professionals use onsite oil analysis testing at their plant, based on a recent poll at MachineryLubrication.com refining and blending to confirm product quality and consistency. These tests are generally limited to oil viscosity and/or viscosity index, sulfated ash, acidity and/or alkalinity, and additive concentration.

Acceptance testing is often some of the first testing performed by end users. It helps ensure that the lubricants delivered match those that were ordered and that deliveries meet acceptance quality standards. Typical tests include oil viscosity, viscosity index, atomic emission spectroscopy, Fourier transform infrared (FTIR) spectroscopy, water contamination and particle counts.

Finally, there is testing used to monitor new oils in storage. Many are unaware that lubricants in storage have a shelf life. Over time, lubricants suffer the effects of contamination, biological growth, oxidation and degradation byproducts. If oils are stored for an extended period of time, they should be tested to verify that they have not deteriorated to the point of becoming useless.

The table below provides component-specific routine and exception test

SELECTING OIL ANALYSIS TESTS BY APPLICATION

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

*** Gas compressors only ** Air compressors only *** For phosphate ester fluids, consult your fluid supplier and/or turbine manufacturer**
R = Routine testing
E = Exception test keyed to a positive result from the test in parenthesis

Component-specific routine and exception test slates

What is analyzed	1. Fluid Properties Physical and chemical properties of used oil (aging process)	2. Contamination Fluid and machine destructive contaminants	3. Wear Debris Presence and identification of wear particles
Possible Tests:			
Particle counting	No benefit	Primary benefit	Minor benefit
Moisture analysis	No benefit	Primary benefit	No benefit
Viscosity analysis	Primary benefit	Minor benefit	No benefit
Ferrous density	No benefit	No benefit	Primary benefit
Analytical ferrography	No benefit	Minor benefit	Primary benefit
AN/BN	Primary benefit	Minor benefit	Minor benefit
FTIR	Primary benefit	Minor benefit	No benefit
Patch test	No benefit	Primary benefit	Minor benefit
Flash point	Minor benefit	Primary benefit	No benefit
Elemental analysis	Primary benefit	Minor benefit	Primary benefit
	Proactive	Proactive	Predictive

Primary benefit — Minor benefit — No benefit

slates for the majority of equipment used in plants today. Several of the tests listed as routine are fairly simple and can be performed in-house. At minimum, I would recommend that you have a particle counter and viscosity comparator to make certain that the lubricants you are receiving are labeled correctly. Having the ability to conduct onsite particle counts can save you money by providing quick information on the effectiveness of your contamination control program.

Of course, there are many reputable oil analysis laboratories that will work with you to select test slates targeted to your equipment and processes, but you must educate yourself to guarantee that you are getting your money's worth and that your oil analysis program is aligned with your reliability goals. Besides the name of the test, be sure to ask which test method is utilized. If the lab is not able to identify the ASTM method being used, this would be a good indication to terminate the partnership. ■

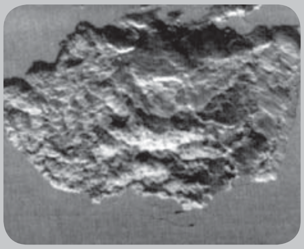
About the Author

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.

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. Glycol antifreeze field test kits:



A) Determine glycol by density
B) Determine glycol by a chemical color change
C) Determine glycol by FTIR
D) Determine glycol by viscosity
E) Determine glycol by a change in smell

2. Silt-size particles (5 microns and smaller) influence reliability by:

A) Causing erosion, valve sticking and abrasion
B) Causing surface softening
C) Silt is too small and does not affect machine reliability
D) Doesn't affect reliability because silt will always be removed by the filter system
E) Doesn't affect reliability because silt particles will settle out in the reservoir

3. Best practices for top-up oil containers could include:

A) Closeable galvanized containers
B) Dedicated and sealable containers by oil type
C) Any available container will be satisfactory
D) Lubricants should be stored at the machinery location regardless of the cleanliness
E) Use a funnel that contains a screen in the bottom to catch contaminants

Answers:

1. B
This procedure involves mixing toluene solvent with oil and then adding sulfuric acid and a reagent. The glycol is converted to formaldehyde, and the concentration is estimated by colorimetry.

2. A
Although silt particles are very small, they are more harmful to system components than particles that are larger than the components' internal clearances. This is because silt particles are abrasive. When built up over time, they cause erosion, abrasion and valve sticking.

3. B
Dedicated containers can prevent cross-contamination that may result from using different oil types. Using sealable containers helps stop foreign particles from entering the oil system.

"New age STEEL PLANTS LUBRICANTS"

- All India Meet at Jamshedpur

An all India steel plant meet: "Servo® Steel Meet -2014" was organized by Indian Oil Corporation Limited on 4th Dec 2014 at Jamshedpur; the birth place of Indian Steel Industries. The theme of the event was "New Age Steel Plant Lubricants". The program shared the latest Steel Making & Rolling Technology and the consequent tribological challenges imposed on the lubricant developments.

The growth and expansion of steel sectors is contingent upon modernization of steel plants embedded with technology up gradation and latest scientific adoption for quality products and improving productivity & economy. Consequently significant development in the field of lubricant and tribology is required to meet the need of such modernized steel plants. Therefore it was felt essential to organize such a meet for sharing the advanced lubrication and tribology technology for modern day steel plants.

More than 100 participants from various steel plants across the country like Tata Steel, SAIL (six plants), Essar, JSPL, JSW, JSL, RINL, Electrosteel, Tata Tinplate, ISWP, Tata Bluescope, Tata Tubes, Salem Steel Plant, Uttam Valve and Usha Martin attended the meet. Shri Anand Sen, President (TQM & Steel Business) Tata Steel, was the chief guest of the event. Many senior executives of Indian Oil were also present in the meet including Shri P. Rajendran – ED (Lubes), Executive Director (Lubes) Marketing, Shri R Suresh – ED (LT) R&D , Dr. S.K. Majumdar – GM (IL& Tribology)R&D ,Dr. E Sayanna– GM (MWO & Grease)R&D, Shri K L Murty- GM(LS).

Shri P. Rajendran in his inaugural speech mentioned that this meet would generate great many inputs for development of modern steel plant lubricants which will not only improve equipment reliability but also enhance productivity and quality. Shri Anand Sen in his key note address stressed upon the significant modernization in technology that steel plants had witnessed in recent times which had resulted in complexities to lubricant supplier as the lubricant is expected to deliver a critical function while withstanding extreme operating conditions.

This program was designed to have various talks and presentations covering the following areas:

1) Plenary Session – "Scenario of Steel & Lubricant Industry"
2) Panel Discussion I – "Lubrication challenges of Hydraulics & Gears in a modern steel plant"
3) Panel Discussion II – "Lubrication needs of BUR Bearings, Turbines & Compressors"
4) Panel Discussion III – "Rolling lubricants"
5) Panel Discussion IV – "Best lubrication operating & maintenance practices"

22 technical presentation and talks were deliberated on the event by faculties from various steel industries and Indian Oil. The program covered wide aspects of lubrication, lubricant technology, rolling

oil technology and tribology & best maintenance practices.

Representatives of various steel plants appreciated the effort for organizing such an event where people of various steel industries could get the chance to share their knowledge and experience in the field of lubrication and at the same time could avail several new inputs pertinent to tribology and best maintenance practices.

PLENARY SESSION – "Scenario of Steel & Lubricant Industry"

The Indian Steel Industry in today's globalized world - By Shri V K Nirala, Chief Mechanical (IM)Tata Steel, JSR

Modernization & Upgradation of SAIL steel plants - By Shri M Ravi Varma – ED (Projects), SAIL, BSL, Bokaro

Trends in development of lubricants for new age steel industry - By Shri R Suresh – ED (LT) R&D Center, Faridabad, IOCL

PANEL DISCUSSION I – "Lubrication challenges of Hydraulics & Gears in a modern steel plant"

Changes in hydraulics of rolling mills - By Shri P.K. Dash -DGM (Maint.), HSM : JSW Bellary

New generation gearboxes for modern steel plants - By Shri M.K.Jha & Shri M Sathyanarayana Tata Steel KPO

Criticality of Gear Lubrication System - Crop Shear of Heavy Plate Mill - By Shri Manoj Badekar GM Plate Mill :Essar Steel, Surat

Indigenization of High performance Gear oil – Servomesh XP 320 - By Shri Shamir Imam - AM (Bar Mill) : JSPL Patratu

Challenges of lubrication in NTM blocks - By Shri A. Ravishankar– AGM (Mech. WRM), RINL Vizag

Lubrication of guide roll in Bar mill – Servosteel EP 100 Plus - By Shri P.J.Ravi - DGM (Rolling Mills), Electrosteel Bokaro

PANEL DISCUSSION II – "Lubrication challenges of BUR Bearings, Turbines & Compressors"

Lubrication challenges of new back up roll bearings - By Shri Anuj Kumar & Kashyap Adury Tata Steel , JSR

Critical issues with compressor & turbine lubrication - By Shri Dasri Raj Sekhar – Sr. Manager(CPP Operation): Usha Martin, JSR

High performance Morgoil bearing oils ; Compressor & Turbine Oils - By Shri Nitish Mittal -Manager(TS),HO, IOCL

PANEL DISCUSSION III – "Rolling lubricants"

Expectations from a good hot rolling oil & RBL system - By Shri Jagjit Singh - Head Rolling(LD3 TSCR): Tata Steel

Development of Role Bite Lubrication Servosteerol H2 for SAIL Bokaro - By Shri P.Pathak - AGM, Flat Rolling : SAIL RDCIS, Ranchi

Benefits achieved by use of Servo Steerol H3 in HSM of JSL Jajpur - By Shri Kedarinath – AM (Mech. Maint.) HSM : JSL Jajpur

Use of hot rolling oil Servosteerol H4 for longer roll life at SAIL-BSP - By Shri S.K.Jain – DGM (Lub.): SAIL Bhilai

Roll coolant and cold rolling - By Shri Jafar Ghori &Abhishek Kumar Tata Tinplate, JSR

Performance of Servosteerol SS C 28 in Tandem Mill & Reversible mill, RSP - By Shri P.Govindrajan – DGM (CRM): SAIL RSP, Rourkela

PANEL DISCUSSION IV – "Best lubrication operating & maintenance practices"

Condition monitoring practices in steel plants - Shri Amitabha Guha & P K Mahato ,TATA Steel, JSR

Possibility of TFM in steel plants - Shri Rakesh – DGM (Mech.), CRM: SAIL BSL Bokaro

Interdependence of quality of lubricants and maintenance costs - Shri KCK Jyothi - AGM (MTB): SAIL DSP

Green Tribology-Oil Patch Test in conjunction with Ferrography and WDA - Shri Pradeep Agarwal - DGM (CS): JSPL, Raigarh

DHIREN SHAH

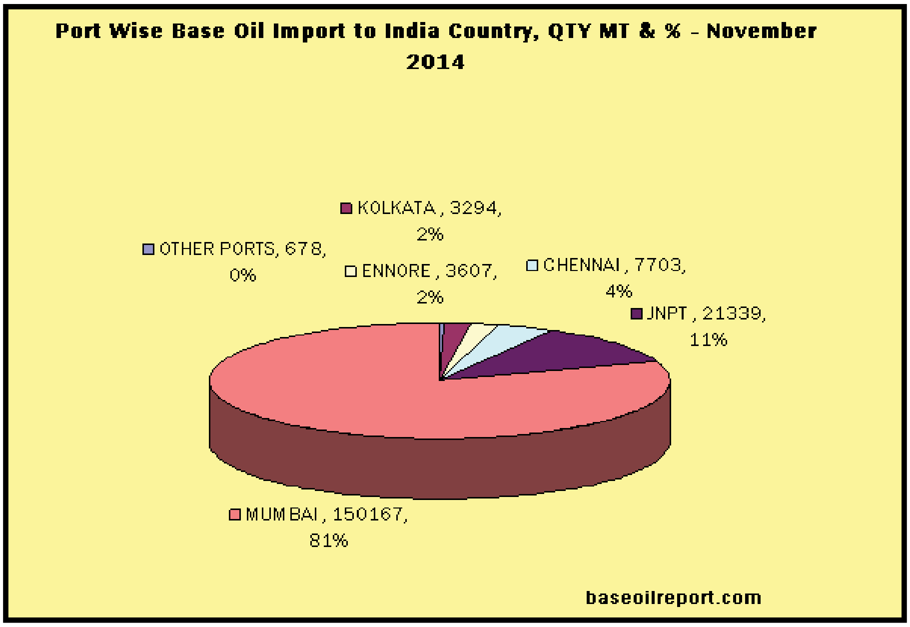
BASE OIL REPORT

Brent crude oil has seen a new low of almost 60 per cent in the past two quarters, currently around $51 a barrel, a level not seen in five and a half years .While many see the fall as a blessing for the macro economy, the decline is not so good for all businesses and markets. The real benefits can be seen when prices stabilise, preferably at levels acceptable to both consumers and producers. A lower crude oil price for a country like India (a third of our import bill is crude oil) is certainly beneficial, as it helps macroeconomic management." It results in lower inflation, gives comfort to the Reserve Bank of India in cutting interest rates and flexibilities in budget and fiscal management. Crude oil import in 2013- ¬14 was $165 billion, about 36 per cent of the total import bill. In April¬- November 2014, it was $90.3 billion, about 28.3 per cent of the total import. India also exports petroleum products and in FY14- ¬15 till November, these were $42.6 billion or a fifth of total exports. Thus, India saves on foreign exchange. A 10 per cent reduction in crude oil prices could reduce Consumer Price Index-based inflation by around 20 basis points (bps) and bring about a 30 bps rise in gross domestic product (GDP) growth. A $10 a barrel fall in oil prices reduces the country's import bill and, hence, the current account deficit by $10 bn or 0.48 per cent of GDP. However, on the flip side, the sharp and immediate fall in crude oil prices has deeper implications on markets and the way businesses and companies operate. For example, $2 trillion of bank funding is involved in oil exploration and production activities, including in shale gas. With crude oil falling to around $50 a barrel, many projects are facing viability issues. When unviable for a long period, there will be either production cuts or the company might declare bankruptcy. It would be wrong to ignore the potential downside risks associated with lower oil prices. Many oil producers, both companies and countries, are dependent upon high prices, and we should therefore expect to see an increase in bankruptcies and sovereign defaults as a result. As a country, India for sure stands to gain from lower crude oil prices. However, currency volatility and global economic

Base Oil Import In November 2014

Country	MT	%
Korea	114000	61%
Singapore	20540	11%
USA	12388	7%
UAE	11527	6%
Saudi	10211	5%
Pakistan	3176	2%
Bahrain	2547	1%
Brazil	2529	1%
Russia	1730	1%
Taiwan	1618	1%
Italy	950	1%
Other countries,	3486	2%

Month	TOBS Korea Origin Base Oil CFR India Prices	SN-150 Iran Origin Base Oil CFR India Prices	Group II N - 500 CFR India Prices	Base Oil Bright Stock
October 2014	USD 995 – 1000 PMT	USD 1005 – 1010 PMT	USD 1070 – 1080 PMT	USD 1180 - 1200 PMT
November 2014	USD 955 – 965 PMT	USD 930 – 940 PMT	USD 985 – 990 PMT	USD 1140 - 1160 PMT
December 2014	USD 860 – 870 PMT	USD 870 – 880 PMT	USD 880 – 895 PMT	USD 1080 – 1090 PMT
	Since October 2014, prices down by USD 135 PMT (13%) in December 2014	**Since October 2014, prices has marked down by USD 135 PMT (13%) in December 2014**	**Since October 2014, prices has gone down by USD 185 PMT (17%) in December 2014**	**Since October 2014, prices has decreased by USD 105 PMT (9%) in December 2014**



slowdown might impact exports.

The Indian base oil market remains steady with inventories at optimum levels with surplus of imported grades. During the month of November 2014, approximately 186788 MT have been procured at Indian Ports of all the grades, which is 17% down as compared to October 2014,Major imports are from Korea, Singapore, USA, UAE, Iran, Taiwan, France, UK, Netherlands, Japan, Italy, Belgium, etc. Indian State Oil PSU's IOC/HPCL/BPCL basic prices for SN – 70/N – 70/N-65/SN – 150/N -150/N – 150 marked down by Rs. 4.00 per liter, while SN -500/N - 500/MakBase – 500 is down by Rs, 3.80 per liter. Bright Stock price is down by Rs. 2.60 per liter. The prices are effective January 01, 2015. Hefty Discounts are offered by refiners which are in the range of Rs. 15.00 – 17.00 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. 47.50 – 47.80/47.85 – 47.90 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 have been marked down due to higher inventories level. As per conversation with domestic importers and traders prices reflects minimal changes for N – 60/N- 150/ N - 500 grades and at the current level are quoted in the range of Rs. 47.10 – 47.30/48.10 – 48.25/47.90 – 48.30 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. Prices may decline further by another Rs,1.50 – 2.00 per liter due to lack of demand and high inventories. Light Liquid Paraffin (IP) is priced at Rs. 47.75 – 48.00 per liter in bulk and Heavy Liquid paraffin (IP) is Rs. 51.75 – 52.25 per liter in bulk respectively plus taxes extra.

Approximately 9547 MT of Light & Heavy White Oil has been exported in the month of November 2014 from JNPT, Raxaul LCS, Village Poneri and Chennai port. Compared to last month i.e. October 2014, exports of the country have gone down by 9% in the month of November 2014

Approximately 5997 MT of Transformer Oil has been exported in the month of November 2014 from JNPT, Village Ponneri and Chennai port.

About The Author - Dhiren Shah is a Chemical Engineer and Editor – In – Chief of Petrosil Group. He is instrumental in developing the various Petrosil brands

Countries Where Light & Heavy White Oil Has Been Exported

Australia	Algeria	Argentina	Bangladesh	Brazil	Bulgaria	Cambodia	Chile	Colombia	Cuba
Djibouti	Ecuador	Egypt	Germany	Guatemala	Greece	Hong Kong	Indonesia	Ivory Coast	Iran
Israel	Italy	Jordan	Kenya	Malaysia	Myanmar	Nepal	New Zealand	Nigeria	Pakistan
Peru	Philippines	Poland	South Africa	Senegal	Spain	Srilanka	Taiwan	USA	Tanzania
Thailand	Turkey	UAE	UK	Ukraine	Vietnam	Yemen	Zaire		