Machinery Lubrication

India *January-February 2017*

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INSIDE

How to Select Right Lubricating Grease for Your Application ?

Storing Grease to Avoid Bleed & Separation

Grease Sampling and Analysis in Wind Turbine Maintenance

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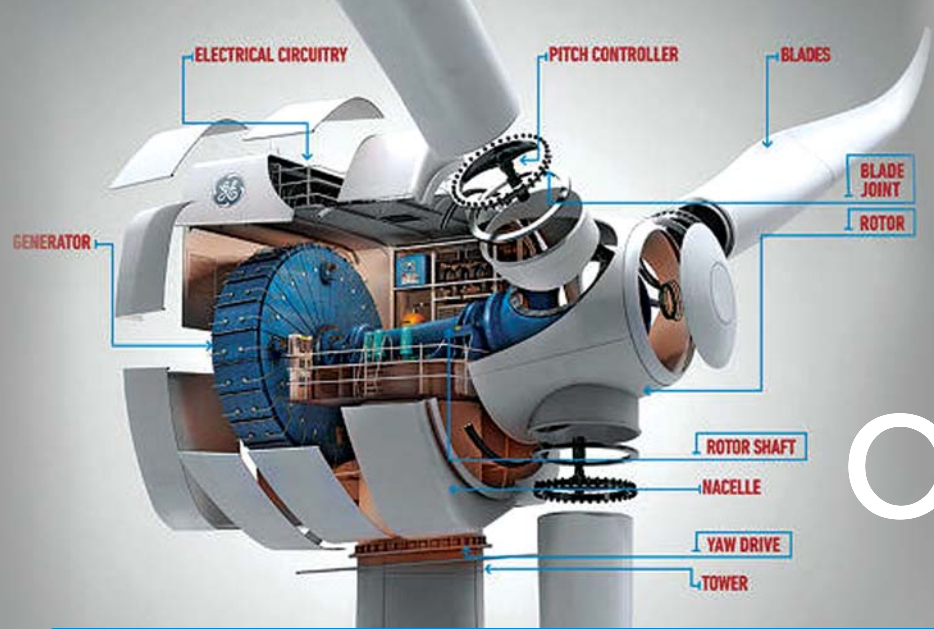

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Publisher's Note

Lubricating Grease is considered a complex subject where in amongst the lubricant professionals. There is something mystic about it, which makes in complex. Significant R&D is being done on the subject to produce more resilient varieties of grease with wider applications. Testing of grease is also a complex subject particularly its integration with the maintenance programme.

The release of the current issue (Jan-Feb 2017) coincides with the NLGI India conference (2-4th Feb) at Varanasi. We are specially carrying a brief write up on NLGI India chapter and its activities and also a few articles on the use and testing of grease, authored by experts in their field.

I had an opportunity to present a paper on "Lubrication Enabled Reliability (LER)" at a conference (MAINTCON) organised by GSMR (Gulf Society of Maintenance & Reliability) in Dec 2016. The four day conference had professionals from the field of reliability from leading companies based the Middle East. During my interaction with the delegates and various authors, I was impressed with the state of art technology being used in this part of the world.

Lubrication-enabled reliability (LER) relates to all activities that improve reliability through tactical changes in the use and application of lubricants. LER offers specific benefits and opportunities that don't exist with alternative reliability strategies. Yet, most companies seem to be in denial when it comes to lubrication. They see themselves as being lubrication responsible — a misguided belief that they are already doing an adequate job with lubrication.

Fundamentally, LER has to be a business decision. Managers face wide-ranging opportunities when it comes to change and investment. Sound business judgment needs to be applied in deciding what to change next. Conversely, the cost of repairing or replacing a failed machine (plus the associated lost production) is not a business decision that is carefully weighed against all options. It is outside of the control and judgment of management. The decision is driven entirely by the machine and its failure. The wisest thing managers can do at that point is to invest in a skilfully performed root cause analysis (RCA) followed by the prescribed changes needed to prevent reoccurrence.

"Tips to help you achieve Lubrication Excellence", which featured as a cover story in the previous edition, evoked an extremely positive response from our readers. We have been inundated with views from the readers on how they have made use of these tips to improve their lubrication practices. As always, we look forward to your valued feedback and comments on our content and presentation.

Warm regards,

Udey Dhir

JIM FITCH NORIA CORPORATION

The BUSINESS CASE for LUBRICATION EXCELLENCE

Machines fail for a reason. They're not supposed to wear out. Humans are at the root of the vast majority of these failures. It's also humans that can intervene and restore plants to healthy and sustained operation. This is not an imaginary concept but rather a living reality in a growing number of companies today.

Machine failure can deliver an important lesson on future prevention and remediation. Fortunately, there have been countless investigations into failure causes across wide-ranging machine types and applications. This learning has enabled organizations to greatly enhance reliability but only when machine and programmatic modifications were applied. Lubrication and reliability training programs are designed to teach this collective knowledge about failure prevention. Still, knowing is not the same thing as doing.

DOES IT MATTER? (Prior to World-Class Lubrication Programs)		
PROBLEM	# OF FINDS	% OF TOTAL
Lubrication	**542**	**53**
Bearing Defect	171	17
Belts	133	13
Base/Mounting	50	5
Resonance	37	3
Misalignment	31	3
Unbalance	19	2
Gear Defects	15	1.5
Coupling	9	1
Others	14	1.5
TOTAL	1,021	

Figure 1

54% of lubrication professionals believe their company is doing an adequate job with lubrication, based on survey results from machinerylubrication.com

The Hard Currency of Lubrication-Enabled Reliability

Lubrication-enabled reliability (LER) relates to all activities that improve reliability through tactical changes in the use and application of lubricants. LER offers specific benefits and opportunities that don't exist with alternative reliability strategies. Yet, most companies seem to be in denial when it comes to lubrication. They see themselves as being lubrication responsible — a misguided belief that they are already doing an adequate job with lubrication. It's like healthy living through a proper diet. It's not a matter of just eating but rather the discipline of eating the right foods every single day.

The same applies to lubrication. It's not about blindly going through the same old tasks of lubricating your machines. This will not enhance reliability. Instead, LER is about reinventing how lubrication is done. This fact is learned from hundreds of published case studies on lubrication. It's very much like an untapped vane of gold that lies just below the surface. It's near at hand but difficult to see.

Fundamentally, LER has to be a business decision. Managers face wide-ranging opportunities when it comes to change and investment. Sound business judgment needs to be applied in deciding what to change next.

Conversely, the cost of repairing or replacing a failed machine (plus the associated lost production) is not a business decision that is carefully weighed against all options. It is outside of the control and judgment of management. The decision is driven entirely by the machine and its failure. The wisest thing managers can do at that point is to invest in a skillfully performed root cause analysis (RCA) followed by the prescribed changes needed to prevent reoccurrence.

Lubrication-enabled reliability is about reinventing how lubrication is done.

LER is an initiative taken prior to failure, ideally when there is considerable remaining useful life. The following are three critical factors that should be considered in making reliability investments such as LER:

1. Find Untapped Opportunities That Yield Deep Benefits

The investment must have the potential to yield deep, rich benefits that outstrip the potential cost and risk. It can't be simply a mild chipping away at maintenance costs but rather a bona-fide homerun opportunity.

The magnitude of the opportunity is influenced by the current state of reliability (or unreliability). For instance, a company's approach may be just to continue reactive maintenance using the 4-R treatment — rapid component replacement, repair, removal or rebuild. In such cases, the opportunity is rich; the worse things are, the better the opportunity for change.

LER doesn't respond to failure but aspires to address the root cause. What is in constant contact with the machine that over time influences the rate of wear and corrosion? It is the lubricant. What, if changed, is best able to slow down that rate of wear and corrosion? Again, it's the lubricant. While there are other influencing factors, lubrication is the greatest common denominator.

As a case in point, see Figure 1. Fifty-three percent of all problems reported by this unnamed company were lubrication related. In addition, those that were not lubrication related (e.g., bearing defects, gear defects, unbalance, misalignment, etc.) would have been revealed by simply analyzing the lubricant (wear debris analysis).

Figure 2 is a plant-wide tabulation of the causes of mechanical failure reported by another company. The incorrect choice and usage of lubricants totaled 43 percent.

The Pareto Principle teaches us that the greatest yield from programmatic changes occurs when we focus on the 20 percent of the causes (critical few) that are responsible for 80 percent of the occurrences of failure.

2. Target Conditions that can be Changed and Controlled

Unarguably, there is much that's outside the realm of control for most reliability and maintenance teams. For instance, we can't inherently know which bearings and gearboxes have design and manufacturing defects. However, we can control the quality of the job we do in mounting, fitting and installing machines/ components. From that point forward, it's about wellness management — careful and continuous nurturing of machine health.

Fortunately, lubrication - enabled reliability is not high science. Any maintenance organization can accomplish it with proper training, planning and deployment. Much of it is behavior based and just good old common sense. It's about making modifications of people, machines, procedures, lubricants and metrics.

In the last issue of *Machinery Lubrication*, I introduced the concept of the Optimum Reference State (ORS). The ORS is a state of preparedness and condition readiness that enables lubrication excellence. It gives the machine and its work environment "reliability DNA" as it relates to lubrication. The enabling attributes of the ORS needed to achieve LER and

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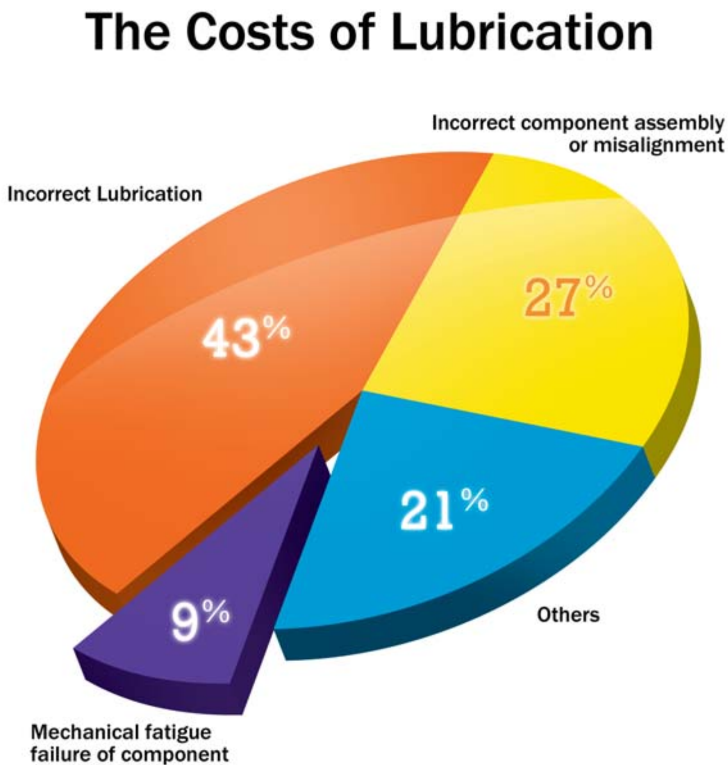


Figure 2

Ref. AIMAN (Italian Association of Maintenance Engineers) and IRI (International Research Institute) in conjunction with SKF

lubrication excellence are:

- **People Preparedness.** People are trained to modern lubrication skill standards and have certified competencies.
- **Machine Preparedness.** Machines have the necessary design and accouterments for quality inspection, lubrication, contamination control, oil sampling, etc.
- **Precision Lubricants.** Lubricants are correctly selected across key physical, chemical and performance properties, including base oil, viscosity, additives, film strength, oxidation stability, etc.
- **Precision Lubrication.** Lubrication procedures, frequencies, amounts, locations, etc., are precisely designed to achieve the reliability objectives.
- **Oil Analysis.** This includes optimal selection of the oil analysis lab, test slate, sampling frequency, alarm limits, troubleshooting rationale, etc.

These ORS attributes are simple, fundamental changes that are within a plant's ability to modify and manage. They are definable, measurable, verifiable and controllable.

3. Choose Strategies that Offer Low, Manageable Risks

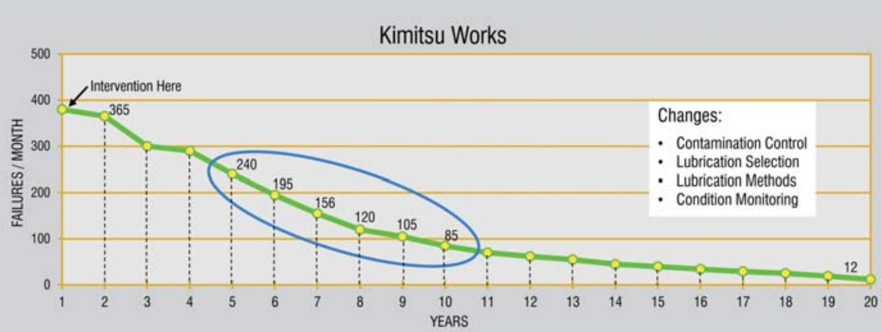
Stop fixing the machine and start fixing what causes the failure. This is proactive maintenance. Of course, it is hard to invest in something that is not yet broken. People are quick to respond to crisis but procrastinate to make changes when plants seem to be running reliably. Lifestyle changes sometimes require the jolt presented by a good health scare. Crisis puts focus on reliability. Change by aspiration alone is far more rare.

So what's the worst that can happen? Clean, dry and cool lubricants don't induce machine failure. The real risk is not in miscalculating the benefits from LER but rather in a botched or incomplete deployment. We've seen many examples of this in the past, and sadly it is a common outcome by those who have pursued LER. This can be the result of:

- Caving into pressure from old-timers who prefer business as usual

Case Study: Nippon Steel

Nippon Steel, which is a past recipient of the Total Productive Maintenance Excellence Award, was the focus of a widely published case study on the benefits gained from lubrication excellence. The company implemented lubrication changes toward achieving the ORS and realized amazing benefits over a period of years in just one area of its plant. Bearing failures dropped from nearly 400 per month to just 12.



- Poor deployment (attempting to save money by cutting corners)
- Incomplete deployment and follow-through (getting halfway done and then becoming distracted by other initiatives)
- Lack of planning and preparation
- Lack of measurement and control (drifting back due to poor sustainability)
- Personnel changes (particularly the revolving door of leadership)

To de-risk implementation, you need leaders to champion the effort, good communication to stakeholders, adequate financial investment, and lots of monitoring and measurement (during and after deployment). Good implementation of LER follows along the lines of good project management. Be methodic and consistent. Rome was not built in a day. If you choose to take the do-it-yourself route, then start by getting the knowledge and help you need. You won't find world-class lubrication in your machine's service manual.

Closing the Knowing/Doing Gap

Sometimes you need an intervention. You can wait for a crisis to get things started, or you can start today. After all, you can't harvest the benefits of LER until sustained implementation is in place. Opportunity knocks today. Open the door.

79%

of lubrication professionals have learned lessons from a machine failure that have led to improved reliability, according to a recent survey at www.machinerylubrication.com

About the Author

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

DR. ANOOP KUMAR, ROYAL MFG CO

HOW TO SELECT RIGHT LUBRICATING GREASE FOR YOUR APPLICATION ?

In this technological savvy world, newer products and technologies are emerging at much faster pace than we actually think and lubricating greases are not far behind. In last few decades, great deal of technological advancement has taken place in the field of lubricating greases and tons of new products can be seen in the market. There have been ever increasing trend to market more and more customized products suiting a specific customer requirements in industries like steel, cement, automotive, off highway, chemical, oil & gas, food processing, mining, marine, agricultural etc . On the other hand, the knowledge of end use customer is limited and decision about what type of grease to be used , is mainly governed by supplier's recommendation which sometime may be biased and possibly misleading. This article is focused around the concept of what one should know about lubricating greases so that end use customer could be smart enough to select right product for right application.

Lubricating Greases :

The idea of using lubricant to reduce friction and wear was perhaps known to the mankind since ancient times perhaps concomitantly with the discovery of wheel. Records indicate that the first lubricant ever used by mankind was probably water in around 3500 BC by Chinese followed by use of animal fat or olive oil mixed with lime, a kind of crude lubricating grease, in 1400 BC by Egyptians in their Chariots. Since then, technologies have progressed remarkably, especially in last 200 years, the developments in field of lubricating greases has been much slower and less scientific. It has been reported that until close to 1800 , the universal lubricants were beef / mutton tallow or a vegetable oil . This drilling of first petroleum crude by Colonel Drake in 1859 had revolutionized the entire industry where most of the lubricants were virtually replaced by mineral oil based products. Since then phenomenal progress has been achieved and countless developments have taken place in the field of lubricants and greases and as a result , a large number of products are available in the market. This sometime confuses the end user and poses challenge in terms of selecting right product for their application

National Lubricating Grease Institute (NLGI) , USA worldwide grease market survey indicates about 2.4 billion lbs of total worldwide grease volume, where mineral oil based greases have dominated by about 92% followed by synthetic and semi-synthetic oil based greases totaling about 7%. Bio-based greases found their entry for the first time in 2010 survey, has now about meager 1 % market share. These greases are being marketed both in auto and industrial applications.

Lubrication: Oil or Greases?

In general, lubrication can either be achieved by lubricating oil (fluid) or grease (semi-solid). Now question arises when to use lubricating oil and where to use lubricating greases? Though there are different school of thoughts, however, there is some applications where lubrication by grease is preferred due to following reasons,

- Lubricating greases acts as sealant preventing ingress of extraneous particles and water
- Stays better on application and due to leak out and minimizes the chances of dry start
- Easy to mix with solid lubricants like moly, graphite and other solid lubricants
- > 90 % roller bearings are grease lubricated

In general, a particular application whether to use lubricating oil or lubricating greases is generally governed by its DmN factor which can be calculated as follows

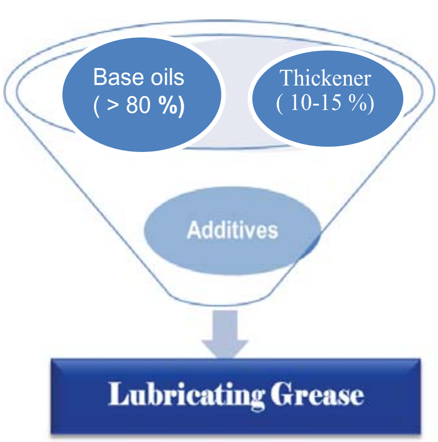
- DmN factor = N x (D + d) /2
- D= Bearing outer diameter, mm, d=Bearing bore diameter, mm
- N=Bearing operating speed, rpm.

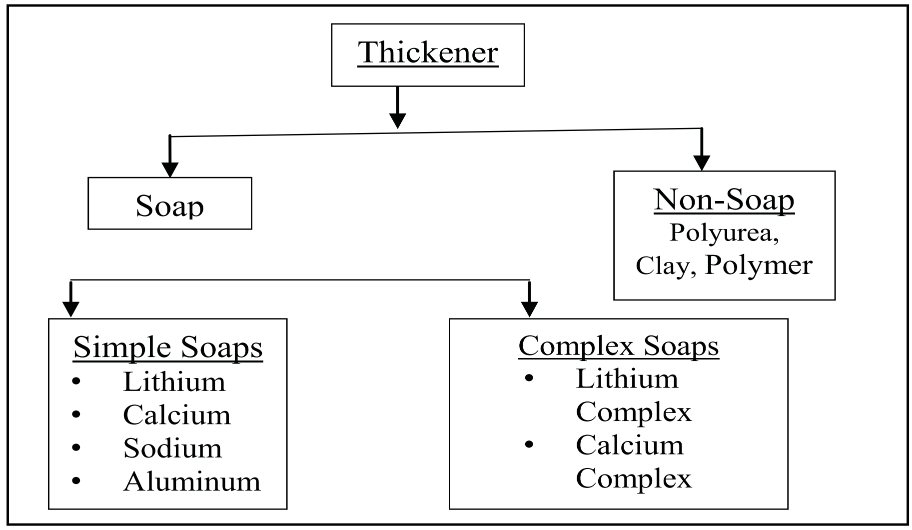
If DmN factor is more than as shown below oil should be used.	
DmN Factor	viscosity, at 40 ·C
<100,000	460
100,000	220
300,000	150
500,000	100
600,000	68

Lubricating greases are generally recommended up to 1 million DmN factor baring few exceptions. For lower DmN factor ranging from 100,000 to 500,000 mineral oil based greases with suitable viscosity may be used however, for higher DmN factor synthetic oil based greases are preferred. DmN factor beyond this, oil lubrication is recommended.

What are Lubricating Greases?

As ASTM (American Society of Testing Materials) defines grease as "a solid to semi-fluid product of the dispersion of a thickening agent in a liquid lubricant". The thickener provides it





non-Newtonian nature by the dispersion of base oil in its gel like structure and acts like sponge. Lubricating greases basically consist of base oil (75-85%), thickener (10-15%) and performance additives (Figure-1&2). Both base oils as well as thickeners influence properties of lubricating greases. Performance additives are added to boost the certain desired performance label of lubricating greases. For examples, extreme pressure (EP) additives are added to boost EP characteristics of particular grease and anti-oxidants are added to control thermal degradation of oil.

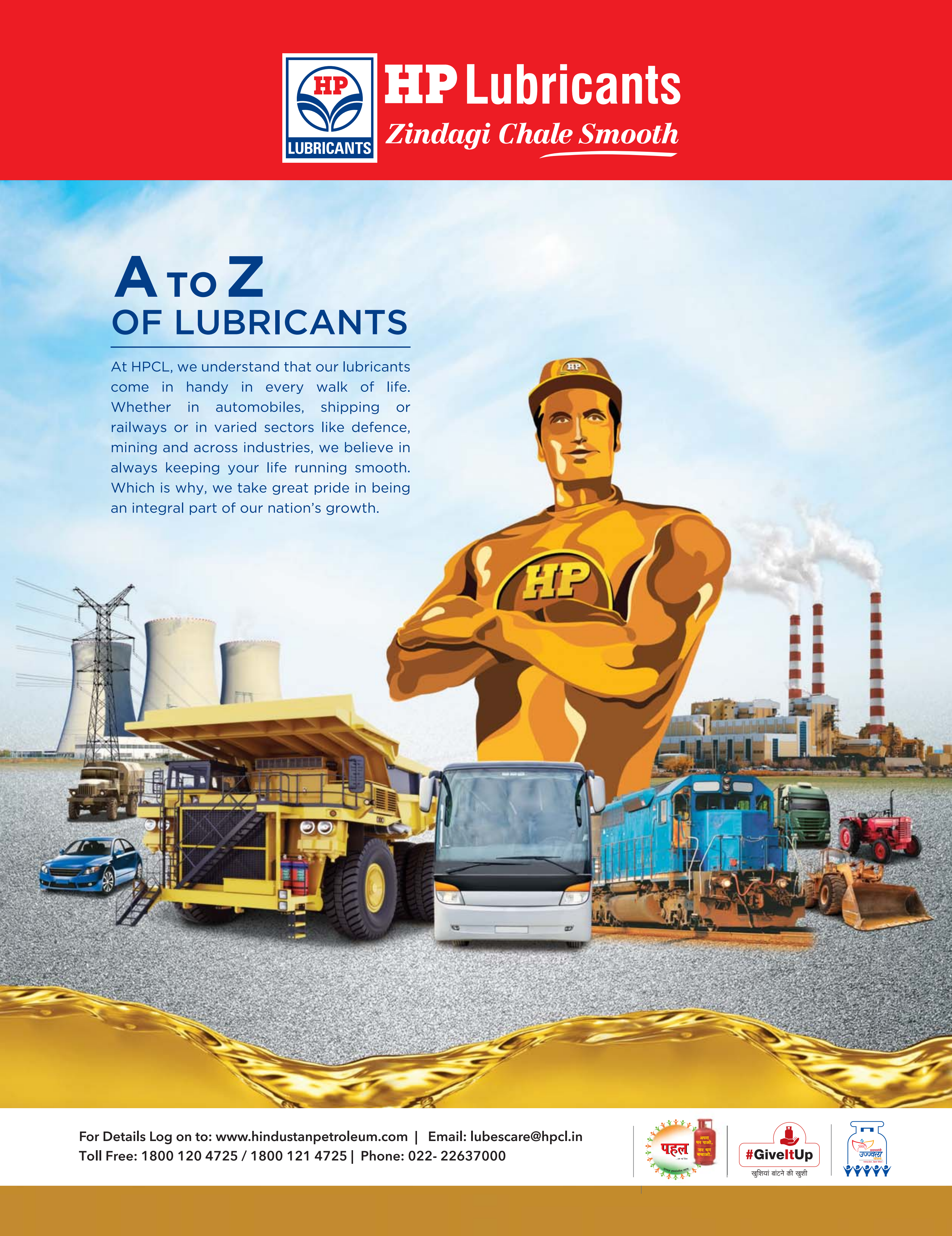
The ability of lubricating grease to perform in a particular application depends on its physico-chemical and performance characteristics which are generally measured by standard ASTM /IP/DIN etc. methods as described below.

What Does Base Oil Do in Lubricating Greases?

Base oils in lubricating greases are present in majority (> 80 %) and main function of lubrication is taken care by base oil, thickeners acts as carrier of oil and act like sponge where it releases oil at point of application. Base oils influence pumping and flow-ability of lubricating greases. High viscosity oil based greases flow / pump slowly compared to low viscosity oil based greases. This is the reason, where ever application speeds are low and bearing diameters are comparatively large, high viscosity oil based greases (e.g., VG 460) are preferred. On the other hand, in applications where bearing run under high speed, low viscosity oil based greases (VG 32 –VG 68) oil based greases may be recommended . Base oil also greatly influences the low temperature characteristics of greases; mineral oil based greases are generally recommended up to -18 0C with appropriate viscosity adjustment. The choice of a viscosity depend on intended service, for higher DmN factor, low viscosity is preferred while for higher loads and low DmN factor heavier oils are more suitable.

What Does Thickener Do in Lubricating Greases?

Thickeners on the other hand, are considered backbone of the greases. The thickener system may be a simple metal soap, a complex soap, a synthetic organic thickener, or inorganic gelling agents. Whatever the thickener type be, many of the important properties and performance characteristics of the fully formulated grease comes from the actual thickener system. High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खुशियां बांटने की खुशी

Consistency	the extent to which the grease resist deformation under the influence of force
Shear Stability	the ability of the grease to resist changes in consistency during mechanical shearing
Oxidation Stability	the ability of the grease to resist chemical deterioration
High Temp. Stability	the ability of the grease to retain consistency at elevated temperatures
Water Resistance	the ability of the grease to withstand against water ingress
Rust/Corrosion Resistance	the ability of the grease to protect metal surfaces against rust and corrosion

temperature capabilities of grease are function of thickener though base oil does play some role. Water resistance characteristics of grease are also controlled by type of thickener, like soda base greases are poor in water resistance whereas aluminum complex and sulfonate base greases are known for its superior water resistance properties.

What Does Additives Do in Lubricating Greases :

An additive is any material added to a lubricating oil or grease formulation to improve that product's ability to perform the task called for. In fully formulated grease, the base oil imparts certain characteristics and thickeners also bring certain characteristics to the formulation. The additives doped in the formulation may either add to these characteristics, or may boost desired characteristics already present. These pressure properties, corrosion and rust inhibition, water resistance, low temperature fluidity, color, and odor etc.

Lubricating Greases : General Recommendations:

The application recommendations of a grease depends on the properties of a particular grease which are influenced by type of thickener , base oil present in it and also on the additives. For example lithium grease can be recommended up to + 120^{0}C operating temperatures. Different greases, their operating temperatures formulated in different oils and their general applications are indicated as follows (Table-1and Table-2) .

HOW TO READ/ANALYZE PRODUCT DATA SHEET:

In general one grease can be used for more than one application in the industry and therefore product data sheet of particular grease contain many test. For end users, one need to know what tests are relevant to them, as all the tests listed in the tested may not be as relevant as other. For example for a high temperature application where chances of water ingress are not there, water resistant properties may not be critical. Similarly for application temperature below 100^{0}C, you may not need high temperature grease. Therefore its important to understand your application requirement and then you need to select the appropriate grease for your application. Following are general recommendations for

Lithium soap with suitable oil-viscosity and additives	Operating temperature up to + 120^{0}C max	· Multi purpose · Automotive chassis and wheel bearings · Non-critical Industrial
Li-complex soap with suitable oil – viscosity and additives	Operating temperature up to +150^{0}C max	· High temperatures · High pressure and shock load
Aluminum complex soap with suitable oil – viscosity and additives	Operating temperature up to 150^{0}C max	· Heavy water environments · High temperatures · Food processing and pharma industry · Mining, fertilizers, petrochemicals operations
Poly urea with suitable oil-viscosity and additives	Operating temperature up to +180^{0}C max	· High Temperatures · Oven, conveyor bearings · Electric motors · Refining and petrochemicals · Foundry , metal processing
Clay	Operating temperature up to 150^{0}C	· High temperatures · Food processing
Sulfonate Greases with suitable oil viscosity and additives	Operating temperature up to 180^{0}C	· Water prone · Mining and Marine · Oil & gas , drilling and refining

Table-1: Different Types of Greases and their Applications

Environment	Industry	Recommendation
Moderate Load, Temp (-18⁰C to+120⁰C), High Speed , less water ingress	Agriculture, Farm, Truck & Auto WB, General purpose	Lithium EP (VG 150-220 oil ; NLGI 2)
Heavy Load, Temp (-18⁰C to + 150⁰C), Moderate Speed, some water ingress	Agriculture, mining Construction, Farm, Truck & Auto (NLGI GC-LB), Heavy Duty	Lith. Complex EP (VG 150-220 oil ; NLGI 2)
Extreme Load, Temp (-18⁰C to + 150⁰C), Low Speed, humid and Dusty Environment	Oil & gas , drilling , fertilizer plants, agriculture / Farm, Off Highway, Mining, Heavy Industry	Lithium Complex EP Greases (VG 460 ; NLGI 2) or Sulfonate Complex
High Speed , Moderate Load , Temp (- 40 ⁰C to + 180⁰C), Moderate water	Agriculture / Farm, Off Highway, Mining, Heavy Industry, petrochemicals	Synthetic Greases (Lithium Complex, Polyurea, Sulfonate Complex)
Incidental Food Contact, Hot & Cold Temp, High speeds, Moderate loads	Food & Beverage Industry And pharmaceuticals	H1 Food Grade Greases (Aluminum Complex

Table-2 : Application Conditions and Grease Recommendations

Figure 3 : Water Washout Apparatus

understanding and analyzing the supplier data sheet .

Water Resistance:

Water resistance properties of grease are measured by following tests

i) Water washout test (ASTM D 1264) (Figure 3)

ii) Water spray off test (ASTM D 4049) (Figure 4)

iii) Mechanical / Roll stability in presence of water (ASTM D 217 / D 1831)

Water washout test is more relevant in applications where chances of little water contact or humidity are there. If water is coming direct in contact with grease and with pressure , water spray off test is more relevant as in this test. In conditions where water may get mixed with grease and stability of grease in presence of water may be important , either mechanical or roll stability with 10 / 50 % water . Following table indicate the normal expected limits of these tests

#	Test	Conditions	limits	Remark
1.	Water washout , % wt. washed (ASTM D 1264)	175⁰F , 1 Hrs ,	< 5.0 %	Excellent
			5.0-15.0%	Good
			>15.0 %	Average/poor
2.	Water spray off, % wt. washed (ASTM D 4049)	10 min, 40 PSI	< 10 %	Outstanding
			10-20 %	Very Good
			20-30 %	Good
			30-50	Okay/average
			>50 %	Poor
3.	Mechanical/Roll Stability, w/10% water (ASTM D 217/1831)	10,000 strokes	<10%	Excellent
			10-20%	Good
			>20%	Average/Poor

Table-3: Evaluating Water Resistant Properties

Figure 4 : Water Spray off Apparatus

Extreme Pressure Properties:

Extreme pressures are generally encountered in off high way, mining operations, steel mills, cement / concrete manufacturing etc. Some extreme pressure (EP) properties are provided by thickeners , like sulfonate thickeners possesses inherent EP characteristics however, by and large EP additives are added to meet desired extreme pressure properties . These properties are generally measured by following two tests

Property	Test Property	Data	Remark
Stability/Strength	Pen after 100,000 strokes	< 30	Will not leak during storage/running
	Roll Stability	< 10 %	
	Leakage Tendency	< 6 gm	
High Temp. Property	Drop Point , 0C	< 180	Multi-purpose
		> 260	High Temperature
	High Temperature Life, @ 160 C, hrs.	>80	Good High Temperature life
Heavy Load Capabilities'	Weld Point & Timken	250 kg, 45 lbs	High Load-on road
		>400 kg, 60 lbs	Heavy Duty - off highway, mining

Table – 4: General Recommendations and Test Data Requirements.

i) Four Ball Weld Load (ASTM D 2596)
ii) Timken, OK Load (ASTM D 2509).

For normal EP requirement weld load of 250 kg and over is considered adequate. Similarly Timken OK load of about 45 lbs is sufficient . For heavy duty operations like off high and mining equipment and rolling operations in steel, heavy duty greases with four ball weld load over 400 kg and Timken OK load of 60 lbs might be required. Some other test data requirement and general recommendations are depicted in table 4. These recommendations, though not any set rule, are however based on experience based on trial and product applications.

Do Not Drip Properties:

Stability of grease in application area is an important requirement as if grease do not stay or leak from application, may lead to premature failure of bearings. This property can be tested by studying mechanical , roll stability and leakage tendency tests . If change in penetration after 1 lac strokes is < 30 units , grease is considered very stable . similarly , if roll stability is < 10 % and leakage is < 6 gm tested as per method , grease is likely to be stable in the bearing .

High Temperature Capabilities :

High temperature capabilities of a grease can be indicatively judged by drop point , PDSC , high temperature life by ASTM D 3527 / 3336 and/or FE methods . If the drop point of grease is in the range of 180 C, the application temperatures to could be in the range of 120 C and if the drop point of the grease is around 260 C or more then grease could work at high temperature, however how much will depend on other application factors as well. Life of grease over 80 hrs. as per ASTM D 3527, the grease is considered having good high temperature life (table-4) . There are some other methods like FE and PDSC that also gives good indication of high temperature capabilities of greases

In summary, it is essential to understand your application requirements and then selection of grease depends on your logical and judicious decision as more than one product might be suitable for your application. While making change over from type of product to other, its important to ensure the compatibility of existing grease with new grease .

About the Author

Anoop Kumar, Ph.D. in Chemistry from Indian Institute of Technology, Roorkee, India, is Director of R&D and Business Development at Royal Mfg Co LP. He has over 25 years of experience in formulation, manufacturing and market development of lubricating greases and industrial oils. Dr Kumar has published / presented over 80 technical papers on lubricants and has authored over 25 patents worldwide. Over the years, he has several awards to his credit and currently representing serval technical societies and committees. He played a crucial role in formation of NLGI India Chapter and currently serves in Executive Committee as Treasurer of NLGI.

The Bahrain Society of Engineers and the Gulf Society for Maintenance & Reliability organized the fourth edition of Maintcon during 12 – 15 Dec 2016 held under the patronage of H. E. Shaikh Mohamed bin Khalifa Al Khalifa, Minister of Oil, Kingdom of Bahrain, at the Gulf Intl Convention Center, Gulf Hotel.

The event held under the theme "Value Driven Maintenance & Reliability". The event featured 4 Pre-conference workshops, 6 Keynote Speakers in addition to 54 technical papers presented in 3 tracks over 2 and a half days and concluded with a panel discussion. CMRP certification examination was also part of the event.

21 sponsors supported the event with Saudi Aramco & SABIC being the Diamond Sponsors. The event was also supported by GFMAM & Saudi Council of Engineers. 37 exhibitors showcased the latest technologies and trends in the maintenance & reliability sector. The event was a huge success with over 1000 participants from over 21 countries.

NLGI Serving the grease industry since 1933

FEBRUARY 2-4, 2017

Varanasi (Uttar Pradesh, India)

www.nlgi-india.org

India Chapter of NLGI was founded in 1997 and it has since been very active and is rendering service to Indian grease industry by way of conducting grease education courses on various grease related subjects, organizing round robin tests on various test methods, conducting grease conference, publishing quarterly journal - Greasetech India, advising new grease specifications for the industry, on-line technical help to the industrial customers, etc.

Other major objective of NLGI India Chapter is to educate and train people dealing with grease lubrication viz. manufacturers, marketers, users, input / equipment suppliers, etc. The venues of the education course are generally comprising various industrial areas of the country. NLGI-IC has so far organised 18 education courses covering different aspects of lubrication in number of industries such as Automotive, Steel Plants, Cement Plants, Textile, Mining, Pharmaceutical, engineering, etc.in venues like Mumbai, Jamshedpur, Gurgaon, Baroda, Goa, Silvassa, Faridabad, Coimbatore, Rudrapur, etc. NLGI India chapter promotes research in lubricating greases in India. It sponsors the Best Paper Award winner of its Lubricating Grease Conference every year to attend and present the selected paper in the NLGI, USA AGM. It is considering to fund a research scholarship in any reputed institute in India.

NLGI-India Chapter has chosen Varanasi - "The Ancient City of Civilization" as the 19th conference venue being held during February 2-4, 2017 on the theme 'Latest Trends in Grease Industry'.

The three-day conference has been designed to distinctly identify the current and future trends in the Grease Industry.

LISA WILLIAMS

INTEGRATING GREASE SAMPLING AND ANALYSIS INTO WIND TURBINE MAINTENANCE PROGRAMS

Abstract

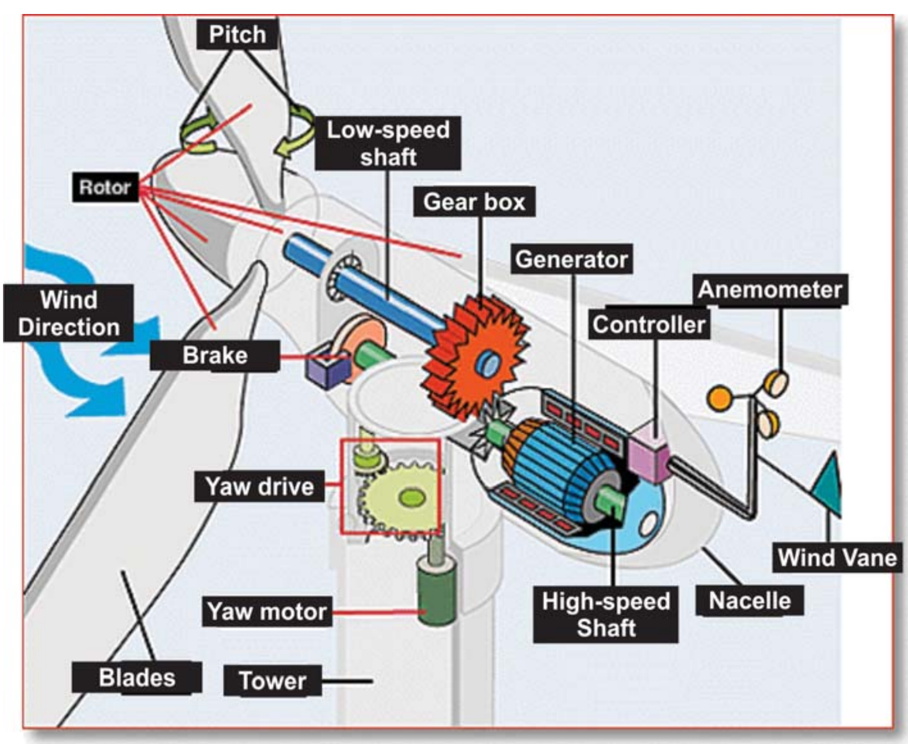
While oil analysis is a well-established part of a condition based monitoring program, the inherent difficulties involved with in-service grease sampling and analysis have long prevented the integration of grease analysis into most CBM programs. Due to this oversight, a sizeable percentage of highly critical machines receive no lubricant analysis and are therefore missing significant reliability data. Wind turbines are especially vulnerable to this omission due to the number of highly critical components that are grease lubricated on each turbine. The main bearing, generator bearings, pitch and yaw bearings are all grease lubricated and are traditionally not subject to lubricant analysis, leaving them vulnerable to undetected wear conditions. Recent advances in grease sampling and analysis techniques are leading an expansion in grease monitoring of wind turbines. This paper will discuss recent grease analysis findings in wind turbine main and pitch bearings utilizing new sampling and analysis techniques outlined in ASTM D7718 and D7918.

Keywords:
Wind; Grease Analysis; Maintenance

1 WIND TURBINE LUBRICATION MAINTENANCE

Wind turbines are part of a growing industry of renewable energy. Certain regions of the globe are particularly suited to deploy wind turbines to capture this energy source, and are appearing in ever growing numbers. Much of the maintenance focus on wind turbines to date has been on the transmission gearbox, an oil lubricated speed increaser that takes the relatively slow rotational speed of the turbine blades and converts it to a sufficiently higher speed for the generator. While it is appropriate to focus on the transmission, it is by no means the only lubricated component where reliability is a concern. There are no fewer than 6 major grease lubricated components in the majority of large wind turbine designs currently dominating the market. They include the main bearing, generator bearings, pitch and yaw bearings.

For each of these grease lubricated components, failure to function can either interrupt completely, or



significantly impact the efficiency and capacity for electric generation. However, getting a reliable grease sample from these bearings can be a challenge. Finding a solution to grease sampling and analysis challenges can have a significant financial impact through the early detection of abnormal wear, or the identification of degraded or contaminated grease. Obtaining representative samples with useful, low-costs grease analysis solutions is critical to properly maintaining these assets. New grease sampling and analysis techniques have recently been developed in ASTM D7718 and ASTM D7918.

2 OBTAINING SAMPLES

In most circumstances, procedures for obtaining grease samples from the bearing housing and gears are not consistent and likely do not represent the true condition of the "active" grease near the lubricated surface. The grease may also contain particulate and other contamination picked up during the sampling process.

For open gears or rollers, the collection of a sample is best accomplished with a kit that utilizes a spatula-like tool to enable the sampler to gather the grease from between the rollers or open gears. The spatula is used to scrape the grease from the rollers and the grease is placed into a syringe. The filled syringe is injected into the passive grease sampling device [Figure 2]. Because of the non-newtonian nature of grease, it can be difficult for it to move under vacuum (may be insufficient to reach the yield stress for flow), therefore during the sampling process the syringe plunger is removed from the body by completely pulling the handle back and out, and the open body is packed with grease using the spatula. The plunger is re-inserted, and the grease can be easily moved while under pressure, to fill the grease sampler [Figure 3].

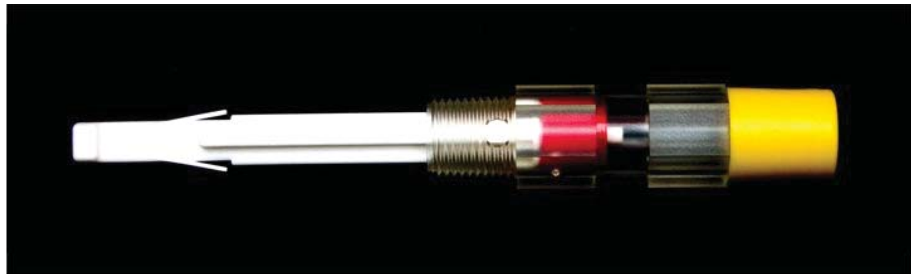


Figure 2: Passive Grease Sampling Device (ASTM D7718)

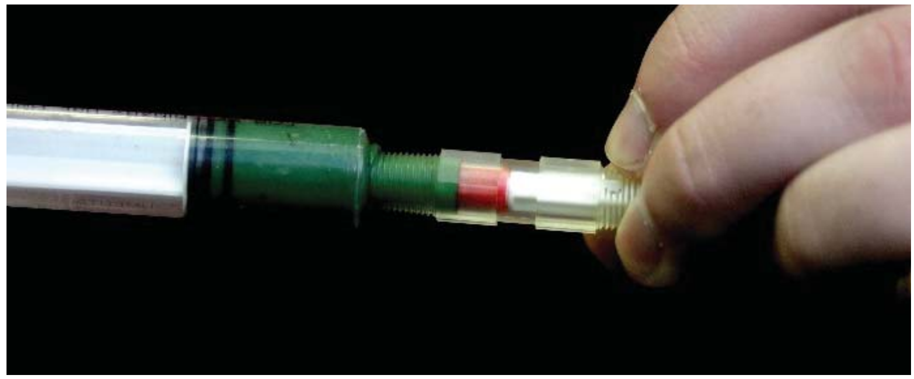


Figure 3: Filled syringe injecting grease into the Passive Grease Sampling Device

The passive grease sampler design is also optimized for subsequent laboratory analysis. By providing a sealing surface in the fitting cylinder, the entire volume of grease is available for analysis. Extraction of the grease is done under variable pressure and force conditions, and the response of the grease can be measured and related to the grease consistency and flow characteristics of a brand new grease. As the grease is extruded for analysis, it is also delivered on to a thin film substrate for accurate analysis by FTIR, RULER, spectral analysis, and other tests giving detailed information about grease oxidation, contamination, mixing and wear.

2.1 T-Handle Extension

For bearings that must be accessed through a drain port, other sampling tools have been developed. Similar to the principle of a liquid sample "thief", the device must be able to travel from the access hole to the active lubrication location, near the bearing or gear mating area, and bypass the non-representative grease along the way.

The grease sampler is inserted with t-handle extension to permit remote actuation and capture of the sample at the site of active grease use and wear

Figure 4: Grease sampler in T-handle extension

generation, adjacent to the mating gears or bearing surface.

2.2 Slim Handle

Typical bearing drain port sizes in a wind turbine are around 0.60“ in diameter, but in some main and pitch bearing applications the drain port is smaller and requires a smaller tool for coring the grease sample. The slim tool

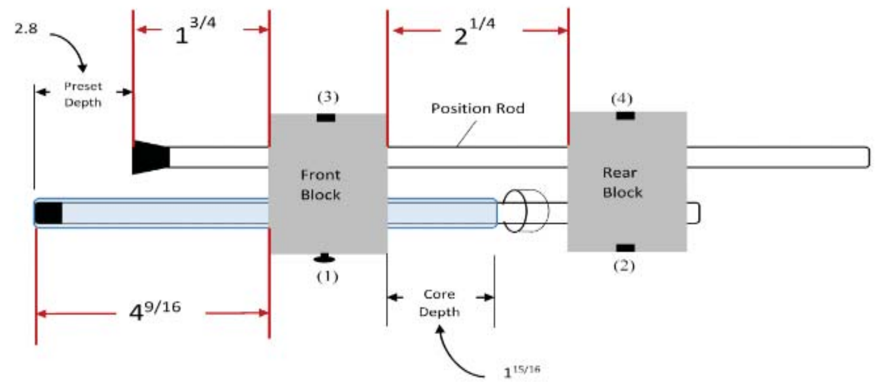


Figure 5: Slim Handle Design

was designed for drain port sizes ranging from 0.28“ to 0.60“ in diameter.

Pocket Slim

The Pocket slim design was created to overcome pitch bearing sampling challenges. Two of the most common sampling challenges with pitch bearings are access to the drain port and clearance at the drain port. The pocket slim design is designed to be used with drain port clearances less than 2 feet. The small design can be used with one hand, allowing the operator to reach if necessary to access the port and core the grease sample. The grease sample is cored with a straw and then transferred into a grease sampler and shipped to the laboratory for subsequent analysis.

3 BASIC ANALYSIS OPTIONS FOR GREASE

The following tests make up a streamlined grease analysis process that uses the passive grease sampling device outlined in ASTM D7718. This allows the first two tests to be performed as part of the preparation of the sample for the subsequent tests listed. This reduces the amount of sample handling and preparation required, thus reducing the potential costs of performing meaningful and routine grease analysis for critical equipment [3].

3.1 Ferrous Debris Monitoring per ASTM D7918

A difficulty in evaluating wear particulate in grease exists because of the inability to agitate a sample to evenly distribute particulate, as is done with oils. This non-uniformity of distribution can lead to misleading results because the portion of the sample selected for dissolution and analysis may be skewed higher or lower with respect to wear particle content. One way to compensate for that condition is to measure the ferromagnetic effects of the grease by inserting the passive grease sampling device into the center of a magnetic field generated by a coil. This method minimizes data scatter due to particle distribution issues and improves trendability and sensitivity of results.

3.2 Grease Consistency per ASTM D7918

By measuring the load under varying conditions during the extraction of the grease through the extrusion die, the consistency of the grease can be compared to the new grease consistency. Changes in this value, whether indicating a thinning or thickening of the grease, can be used to flag this property. Subsequently, the grease is distributed on to a thin film substrate in 0.25 gram sections that can easily be distributed to other instruments in the laboratory for further testing. Follow up detailed analysis with a rheometer can further classify the condition of the grease and gives detailed insight into the flow and shear behavior of greases under dynamic conditions.

3.3 Comparative FTIR Spectroscopy

FTIR spectra are created from new grease samples for all greases in a facility’s program. Using a horizontal attenuated transverse reflectance (HATR) rig, a thin film of grease is applied across the crystal. The in-service greases are tested and compared to a new grease spectrum. In particular, for different families of greases, the FTIR spectra are quite different and can be compared to see if significant mixing has occurred. In other cases, similar greases (two different polyurea greases) might not have significant differences in their spectra, but there is less likelihood of compatibility issues in that case. Still, many greases within the same family from different manufacturers can be differentiated with FTIR analysis. Also this test is valuable in monitoring for grease oxidation and the presence of certain organic additives.

3.4 Anti-Oxidants

The RULER instrument works on the principle of linear sweep voltammetry. By applying this test method, in which a variable voltage is applied to the sample while measuring the current flow, the presence and concentration of various antioxidant additives (including, but not limited to ZDDP) can be determined based on their unique electrochemical oxidation potential and the magnitude of the induced current. Monitoring residual anti-oxidants in purge greases can provide feedback on the effectiveness of grease relubrication frequencies. For example, a grease sample that has been purged from a bearing on the established relubrication interval, when analyzed and determined to have a large amount (perhaps 70% or more) of residual anti-oxidants, and also shows good consistency characteristics, may be a candidate for extension of relubrication interval. Conversely, a purge grease sample that shows no or minimal (less than 25%) residual anti-oxidants may not be completely protected from oxidative stressors during the grease life-cycle, and may appropriately be adjusted to a shorter relubrication interval.

3.5 Metals Spectroscopy

The grease is weighed out or distributed onto the thin film substrate and added to a glass vial where it is diluted and dissolved with a filtered mixture of grease solvent. This liquid mixture is then analyzed by RDE (Rotating Disc Electrode) or ICP (Inductively Coupled Plasma) spectroscopy, and the results are ppm normalized to 1 gram of grease based on the measured weight of grease that was dissolved. The concentration of metals in the grease can be compared to the new grease for the purpose of identifying significant differences in additive metals that could point toward grease mixing. Also, the presence of wear metals can be deduced.

3.6 Grease Colorimetry per ASTM D7918

Visual observations of grease appearance are a common assessment tool for field evaluation of lubricated components. Appearance changes, including darkening and unexpected or mixed colors, are often the first condition noted that may indicate unusual lubrication conditions or mixing. A desire to empirically evaluate and substantiate such observations led to the development of an optical cell, used to present a grease sample in a uniform manner for subsequent visible light spectral analysis. This grease colorimetry optical cell is designed to create an optical path for the visible light spectrometer, and includes a sliding drawer that presents the extruded grease thin-film on substrate produced from the Die Extrusion Method. The resulting 0.040" (1.0 mm) pathlength is backed by a polished stainless steel mirror, which allows testing of the grease in a uniform manner without interference from ambient light and without contacting the grease sample.

It has been suggested that grease colorimetry may have value in the manufacture of greases. Current commercial greases typically are dyed, for differentiation and marketing purposes. The specific color of a grease becomes closely identified with the brand, and maintaining consistency in the color of the product, while not affecting performance, may be important from a perception standpoint. Batch testing of greases by comparing an in-process batch with a colorimetric profile may enable grease manufacturers to quantitatively evaluate color and include a quality control step on appearance as part of the process.

4 DATA INTEGRATION AND ADVANCED ANALYSIS

Together these tests can be used to evaluate the condition of the grease, determine the extent of mixing with an incorrect grease, detect oxidation, measure the depletion of anti-oxidant additives, and categorize the extent of wear present in the sample. These tests can be done cost effectively because the consistency measuring instrument prepares the grease as a thin-film substrate for weight normalization and easy dissolution of the grease thickener, so the liquid sample can be analyzed with typical oil analysis equipment.

4.1 Additional Testing

If concerns arise during the above analysis test slate, follow-up analysis can be performed using the following tests:

Analytical Ferrography

This test can also be performed on the dissolved grease (prepared as for metals spectroscopy) to visually identify the amount, shape, composition, and wear severity of the particulate in the sample. This method and its benefits are well documented for oil analysis, and have similar benefits for properly obtained grease samples. The key difference for greases is that it is necessary to understand that wear levels are cumulative during the operating life of the grease, and that relative quantities of observed particulate can be misleading, if comparing samples with significant differences in service time for the grease.

Patch Microscopy

When the particles of interest are non-metals or non-ferrous metals, there may be some advantage to preparing a Millipore patch by drawing a diluted sample under vacuum through the patch and microscopically analyzing the particulate content to identify the presence of wear or contaminant particles, and relatively quantifying their presence. Often, this test is more difficult with greases than oils, because of the difficulty in completely dissolving grease thickeners sufficiently to pass through the patch. Solvent selection is critical, and some grease thickener types do not perform well in this test, with the presence of thickener fibers dominating the filter patch and obscuring other particulate.

Grease Rheology

Use of a rheometer and evaluation of such parameters as normal force measurement and apparent viscosity can be significant in the characterization of grease properties. Prior research [1,2] has indicated the value of applying rheological measurements to both new and used greases, and research is ongoing to optimize this analysis and relate measured parameters to changing physical properties. Rheological measurements provide insight on changes due to incompatible grease mixing, excessive grease working, and severe oxidation. One of the capabilities of this testing is the ability to evaluate the compatibility of mixed greases. The data results of this test provide insight into grease pumpability, shear characteristics, and the tendency for a given grease or grease mixture to undergo "channelling" or "tunnelling" in bearing and gear applications.

5 GREASE SAMPLING AND ANALYSIS IN WIND TURBINE APPLICATIONS

5.1 Pitch Bearing Grease Sampling and Analysis

Recently grease sampling and analysis was performed on a series of failed pitch bearings where it was thought the incorrect grease was originally packed in the bearing by the manufacturer. Grease samples utilizing the slim handle technology were taken from the failed bearing , and returned for lab analysis. In addition, grease samples were taken from other similar bearings removed from service at the same time as well as broken pieces of the cage. Samples were taken from the supply holes on the outside of the outer race as well as through the seal for a comparison of the results and an evaluation of candidate locations for sampling moving forward. The elemental comparison and FTIR analysis showed there was a significant residual concentration of Grease A in the supply hole samples, even after the recent product change over to Grease B. The significant differences observed between the area below the seal near the rolling elements and the samples taken from the supply hole indicated the grease from the supply hole is part of the non-active region, and was likely not a good indicator of the bearing condition. The seal samples showed much higher wear levels in addition to a better comparison to Grease B, which would indicate these samples were in a region actively participating in the lubrication of the bearing. It was determined moving forward samples from the seal would likely give a better indication of the condition of the bearing.

Additionally, physical inspection of the broken cage piece showed dark grooves on the surface of the cage facing the rolling elements. Advanced ferrographic analysis of the grease seal samples confirmed the presence of black oxides indicating high localized temperatures due to skidding and loss of lubricant film condition. In a low speed high load application, such as this, it is possible full film conditions are never established in the bearing, in which case an anti-wear or extreme pressure additive is critical to provide protection for the contact surfaces. The presence of white solids in the formulation of Grease B were intended to provide this protection against boundary lubrication damage. The continued presence of Grease A; however, raises concern about the effectiveness of the product changeover from Grease A to Grease B. A continued purge and replacement with Grease B was suggested.

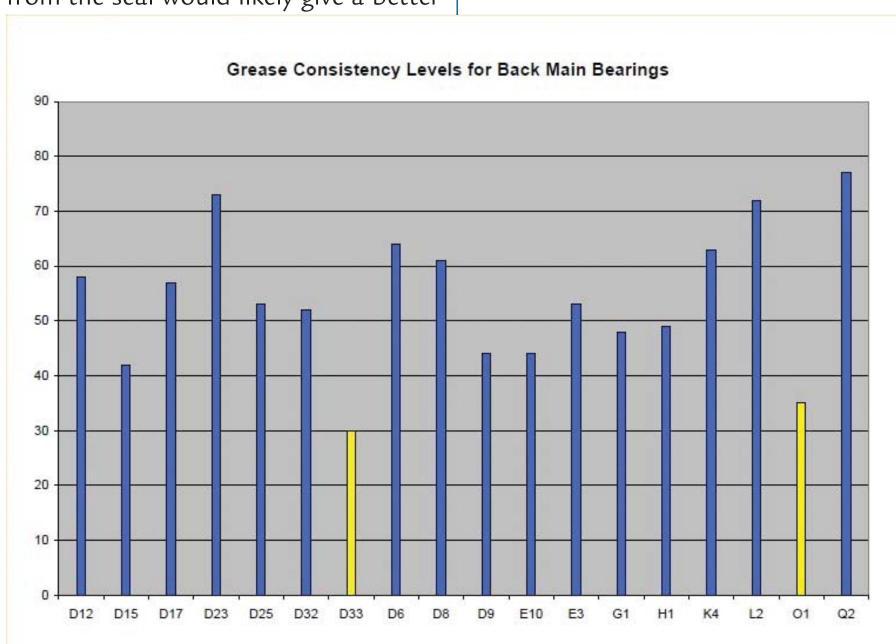


Figure 6 shows a series of grease samples that were analyzed using the Die Extrusion test outlined in ASTM D7918. The Die Extrusion Test is indicating a couple of the bearings (yellow) are showing low consistency (GTI).

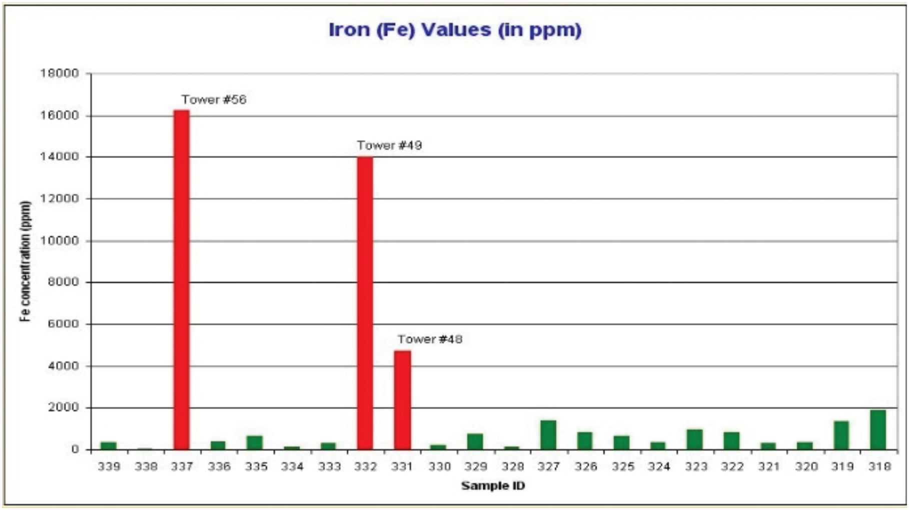


Figure 7 shows a series of grease samples that were analyzed using the fdm+ device outlined in ASTM D7918. Several of the towers showed elevated wear levels much higher than the average.

5.2 End of Warranty Fleet Testing

US wind turbine owners used grease analysis to evaluate their fleet of turbines nation-wide coming off of warranty. Full grease analysis of one wind turbine is approximately $500-$750 per year. When these problems are encountered early with grease analysis, the problems can typically be fixed uptower for less than $2,000. If a bearing failure occurs, the cost for replacement can be $350,000 or more (for off-shore). Grease analysis is an excellent tool for early indications of wear and grease consistency problems. It can also be used to optimize relubrication frequency and save on grease changeouts.

Figures 6 and 7 shows some examples of how grease analysis is used to detect consistency and wear levels in a fleet of samples. Consistency changes are often indicative of other problems occuring with the grease. Grease mixing is the most common reason for changes in consistency. Other reasons can include excessive load or even excessive wear particulate.

Trending wear levels is also extremely important. Changes in the wear values can indicate excessive surface or cage wear. The fdm+ technology is a useful tool for screening grease samples for further wear testing such as metal spectroscopy or analytical ferrography to understand the nature and origin of the wear particulate. The fdm+ technology paired with the passive grease sampling device is an excellent way to trend the wear levels and ensure a representative sample is being taken from the same location on the bearing each time.

6 CONCLUSION

Grease analysis presents a significant opportunity to expand machinery diagnostic capabilities. The historical challenges of obtaining representative and trendable samples are being addressed through technological developments outlined in ASTM D7718. The further development of repeatable analysis methods outlined in ASTM D7918 utilize smaller quantities of grease; which produces greater value in the analysis results and encourages the sampling of greases from locations where reliability is important. By designing grease sampling equipment appropriately, the matter of optimal grease replenishment may also be addressed through the establishment of sampling programs. Wherever there is a critical machine, regardless of lubricant type, the demand for reliability drives the development of improved sampling methods and analysis techniques to produce the valuable information present in lubricant analysis.

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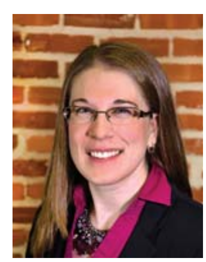
About the author



Lisa Williams has been with MRG Labs since 2007 working both in the lubricant laboratory and on-site with clients to manage lubrication programs. She is certified by STLE as a Certified Lubrication Specialist (CLS) and also holds ICML MLA I and LLA II certifications. Ms. Williams serves as Co-Vice Chair of ASTM D02.96 Committee for In-service Lubricant Testing and Practices. During her time at MRG, Ms. Williams has developed three patents and successfully balloted two ASTM standards (ASTM D7918 and ASTM D7718) related to in-service grease sampling and analysis.

SLIGHT CHANGES Can Mean BIG PROBLEMS

Copper readings can be particularly alarming when increases are in the hundreds of parts per million. However, huge increases are typically insignificant in terms of component wear. Ironically, small subtle increases in copper are of greater concern and should be examined closely. Copper alloy component wear is generally accompanied by lock-step increases in alloy metals such as lead, tin, aluminum and zinc. The amount of alloy metal present in brass/bronze components is only a small percentage of the total copper content. Changes in these alloys may be only a few parts per million but should be taken seriously when present with copper increases.

Controlling Contamination

Portable transfer/filter carts are versatile and can be used for more than just transferring fluids. Other possible uses include offline filtration, cleaning stored lubes, flushing after machine repair and rebuild, flushing during equipment commissioning and draining a reservoir or sump.

Greasing Gearbox Bearings

Does your gearbox have a sealed or open input shaft bearing? This bearing is often above the gearbox oil level and must be greased if it is an open bearing. Manufacturers may ship the gearbox with a plug where the grease fitting is needed to prevent damage during shipping.

In addition, the manufacturer may change the input shaft bearing design from open to sealed and back to open without notification. Small changes such as no longer receiving an attached plastic bag with a grease fitting included with the replacement gearbox may be a clue to a change in design.

Always check the manual included with the new gearbox to see if the lubrication needs have changed.

Advice for Coupling Grease Application

When changing the lubricating grease in a geared motor coupling, always apply a full coating of grease to the teeth of the coupling. Never fill the coupling housing completely with a grease gun due to expansion of the grease as the motor comes up to running temperature.

This expansion of the grease will apply internal coupling pressure, pushing the motor shaft off magnetic center and onto the thrust surface of your bearing, causing bearings to overheat and leading to early bearing failure.

Even after hand-packing the coupling, the motor should be run up to operating temperature, then shut down and the grease plug removed to allow excess grease and pressure to be released.

Inspect Your Level Gauges

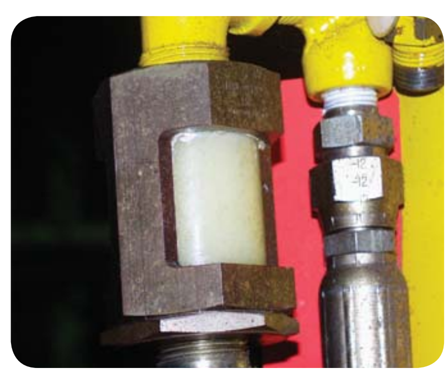
Routinely inspect the vent hole in column-type vented level gauges. In dirty environments, the vent hole can become easily plugged, causing an air lock in the gauge headspace. This will result in a false oil level (higher than reality) in the gauge. Many prefer dual-port gauges instead (unvented).

'Handy' Sampling Tip

During regular weekly or monthly oil sampling, use a tube of "handy wipes" to keep your hands cleaner while handling sample equipment. This practice may not show directly in the cleanliness of the samples, but it feels cleaner, looks very professional and sends a message about the importance of contamination control.

Keeping Hydraulics Healthy

Baffles are an important component in a hydraulic reservoir. They allow the fluid time to cool, deaerate and to settle out water and dirt. A good rule of thumb for residence time in a reservoir is three to five times the pump output. If the system is highly contaminated, residence time may be 10 times the gallons per minute of the pump.

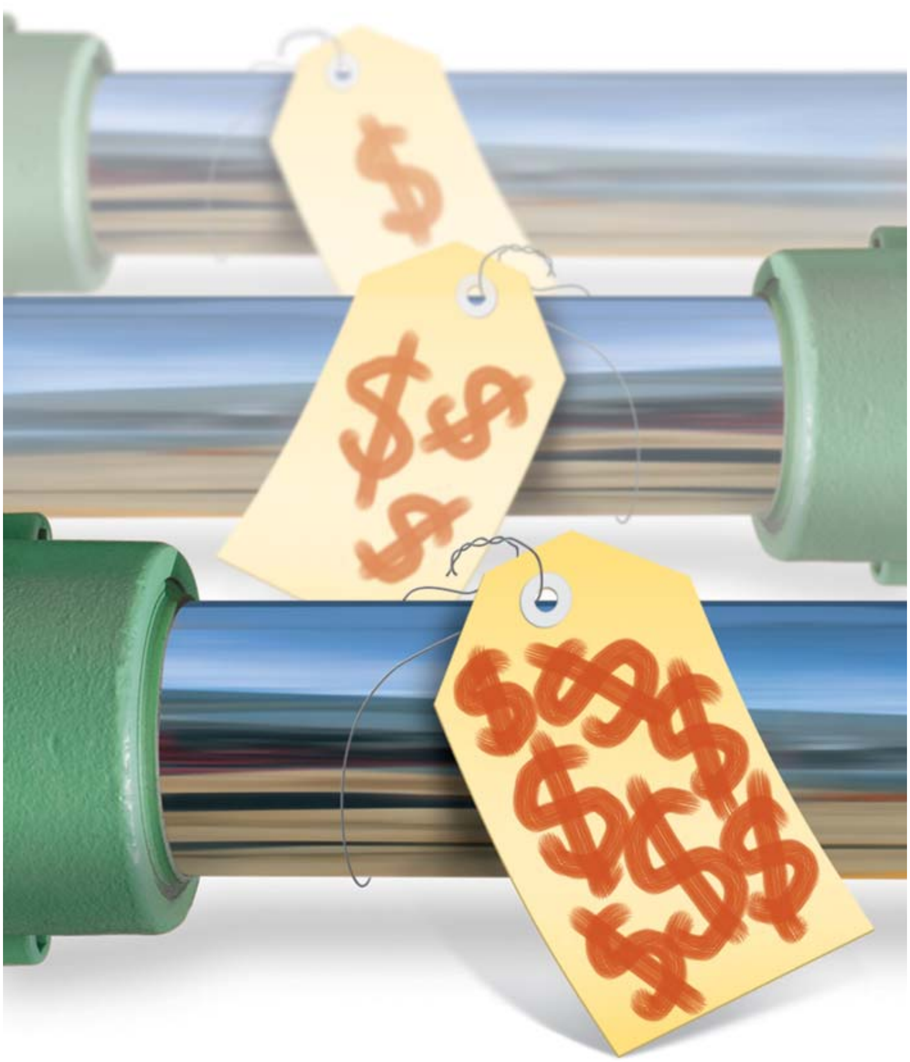


Brendan Casey

CONSIDER the LIFETIME OPERATING COST of HYDRAULIC MACHINES

My son Benjamin turned 9 last month. For his birthday, we bought him a new mountain bike with all the bells and whistles: front shocks, rear mono-shock, front disc brake and 21-speed derailleur. I still can't get over the price. It was only $149, and that was the regular ticket price. Of course, it was made in China.

When you look at the finished product, you wonder how it could be so cheap.



> *It's just not realistic to pay a quarter or even half the price and expect the same performance or service life.*

The retailer has his margin in there, and there's also shipping costs to consider. My guess is the ex-factory cost could be as little as $20 to $30.

While the bike looks like a top-quality product, only time will tell. But even if much did go wrong with it, for this sort of money, it would likely be cheaper to buy another one and cannibalize the original for spare parts. It is hard to argue with the economics.

As we all know, this is not just happening with bicycles. Whether we like it or not, China is currently the world's leader in low-cost manufacturing, which includes hydraulics.

Hydraulic machines and most of their components are big-ticket items, so upfront savings are always seductive. But as I discuss in detail in *Insider Secrets to Hydraulics*, when considering a cheaper alternative, it's important to weigh what you will save if it lives up to expectations versus what it could cost you if it doesn't — and whether you're willing to carry the risk to find out.

This is another way of saying that the initial or upfront cost isn't necessarily the most important consideration. Instead, it's the life-of-ownership cost that counts the most. This involves thinking beyond the here and now. Superficially at least, the math is fairly simple. Just add the initial capital cost of the machine or component with the cost of keeping it running over the course of its useful life.

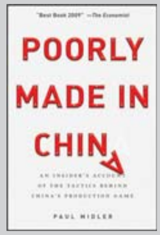
While the capital cost is easy to quantify, the lifetime operating cost is more difficult to calculate because it is usually dependent on the first variable.

Regular readers of this magazine are well aware of the importance of proactive maintenance and the influence it has on the life-of-ownership cost of any asset, including a hydraulic one. Of course, maintenance tasks consume time and resources, and therefore the need for maintenance should be designed out rather than designed in. However, this almost always means a higher initial investment, at which the majority of hydraulic equipment buyers baulk.

This is why we are likely to see Chinese hydraulic manufacturers make fairly rapid inroads into Western markets. Their entry strategy will be based on price, and a lower initial capital outlay will prove irresistible for a large number of potential owners. It's happening already. Most of us can probably think of an example.

But the Chinese are copiers, and they're not always good at it. Obviously, the quality of individual components affects the reliability of the machine as a whole. For instance, if the entire machine was built in China, which factory did the machine's hydraulic filters come from? Did they come from a reputable filter manufacturer's facility in China or a "me-too" outfit? If from the latter, how well will they perform?

Beware of Quality Fade



In his book, *Poorly Made in China*, Paul Midler reveals that a common mode of operation for Chinese manufacturers is to bid low to get the business and then once production is under way substitute high-grade raw materials with low-grade alternatives. They do this to reshape the deal for maximum profit. Midler calls this "quality fade."

Imagine sourcing hydraulic hoses or seals from China. The quality is perfectly satisfactory in the beginning, but then "quality fade" creeps in. The results could be disastrous.

Also, where was the design of the hydraulic system borrowed? As pointed out previously, with most established equipment manufacturers in the Western world designing with one eye on initial capital cost and the other (blind) eye on reliability, the Chinese won't be taking the lead in this area anytime soon.

So by copying hydraulic designs that are less than ideal from a maintenance and reliability perspective, and then building these machines with components that may not be up to snuff, the learning curve for Chinese manufacturers and their customers could be long and at times painful.

As far as machines go, my son's new bicycle is about as unsophisticated as it gets. Provided the brakes don't fail and the wheels or handlebars don't snap off, its safe operation is not too much of a concern. Of course, I checked that everything was secure and correctly adjusted, and rode it around the block myself before I put him on it.

I'm sure my son will grow out of his new mountain bike long before he wears it out. But in the case of a Chinese-made hydraulic machine, if it's half the price of a locally made unit and lasts better than half as long without any safety incidents, the economics may be OK.

On the other hand, if it's half the price and only lasts a quarter as long, the economics don't stack up. So how do you know? The reality is that you don't. The same goes for Chinese-made hydraulic replacement parts or components. It's just not realistic to pay a quarter or even half the price and expect the same performance or service life.

This is not to say that such economics can never be a good deal for the end user of the hydraulic equipment. It may indeed have a happy ending, but only if the user knows the devil he's dealing with, has considered the possible safety implications and has a large enough economic margin of safety built in. These are the only reasons why my son is riding around on a new mountain bike made in China.

About the Author

Brendan Casey is the founder of Hydraulic-Supermarket.com and the author of *Insider Secrets to Hydraulics, Preventing Hydraulic Failures, Hydraulics Made Easy* and *Advanced Hydraulic Control*. A fluid power specialist with an MBA, he has more than 20 years of experience in the design, maintenance and repair of mobile and industrial hydraulic equipment. Visit his Web site at www.HydraulicSupermarket.com.

BY SUZY HITCHCOCK, ICML

Survey Results Confirm VALUE of CERTIFICATION

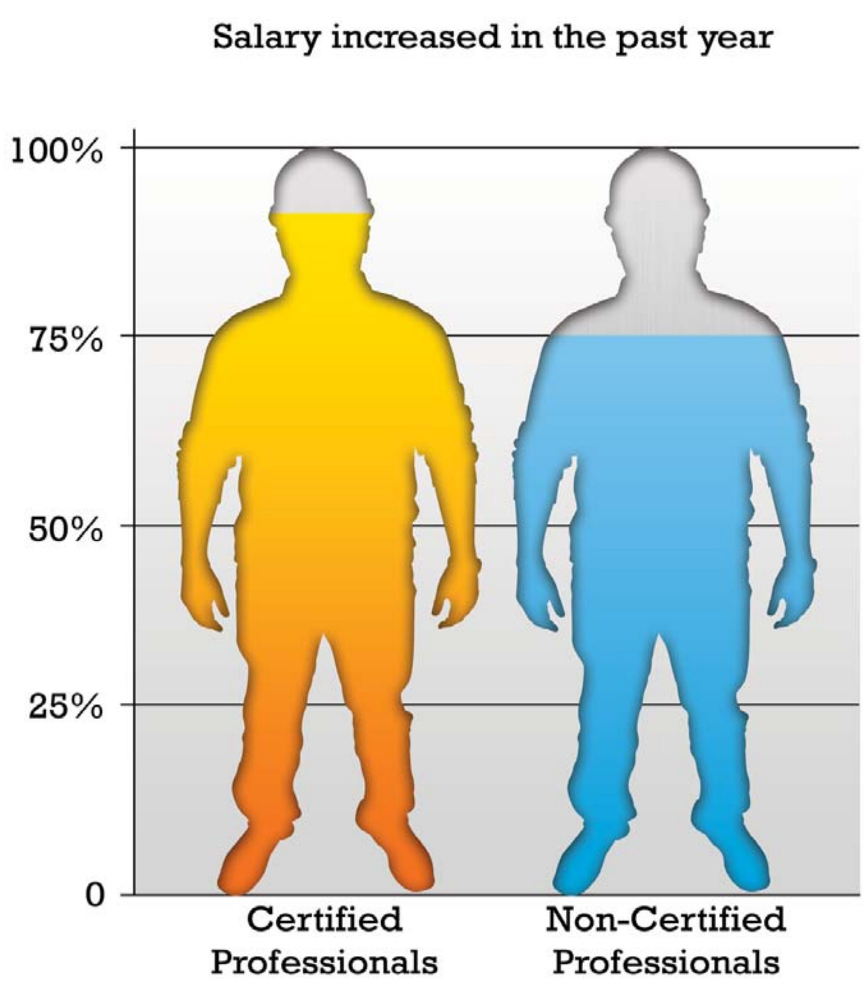
A recent *Machinery Lubrication* survey of lubrication professionals in the United States revealed some interesting trends and also shed light on just who is taking care of our lubricated equipment.

Many of the survey's respondents reported being employed by well-known and respected companies in industry that have had lubrication personnel certified by the International Council for Machinery Lubrication, with some of the companies being founding members of ICML.

According to the results, professional certification has become a requirement for career and earnings advancement in several cases, which is confirmation of skill-based pay (over seniority) as a trend. Survey respondents holding some type of professional certification reported 10 percent higher salaries than their non-certified peers, were among the most likely to have received a raise in 2011 and also were more likely to serve as a supervisor than those without a certification.

While it was gratifying to see the survey quantify the benefits of certification to ICML members in terms of remuneration, career advancement, supervisory positions and even the number of hours worked per week, it was equally exciting to see the personalities and work ethic of these workers shine through.

Easily noted in the respondents' comments provided in the survey were their commitment to quality and their desire for recognition of the criticality of their function within their company and industry. Many expressed concerns regarding apathy of peers resistant to change and the lack of management's awareness of not only the criticality of their role but also the resources needed to deliver high-quality results.



The highlight of the survey may have been in the job satisfaction area, where the responses matched the profile of many ICML members and industry practitioners, demonstrating passion for what they do, being moved by the challenge and not giving up on "the cause" despite such low recognition across industry.

Most characteristic of who these workers are could be seen in their rating of "challenge and stimulation of the job" at the top of the list of reasons for job satisfaction, which was almost three times as high as salary and benefits. Because these individuals are dedicated and proud of their roles, naturally "lack of recognition" was the factor most frequently given for dissatisfaction with their jobs.

What can be learned from this survey is that lubrication professionals should be valued and recognized for the worth they possess and for the direct criticality of their function to the success of operations. These individuals should be empowered with the needed resources, including knowledge through accountability of training followed by certification and fair compensation. The result will be loyal, hard-working, dedicated, in-house experts who value being part of a team more than even the possible monetary rewards.

These are true professionals who take pride and responsibility in the success of their roles. They are machine lovers who are the key to reliability-centered, best-in-class lubrication. These front-line men and women are the walking, talking human factor of reliability. They are where your asset-management journey begins if you run a business heavily dependent on lubricated equipment. They are driven by passion, a love for challenge and a focus on doing things right.

When your company achieves a world-class lubrication program, be sure to give them extra support for recognition by encouraging them to apply for ICML's John R. Battle Award for Excellence in Machinery Lubrication.

For the complete survey results, visit www.machinerylubrication.com. For more information on the John R. Battle Award and ICML certification credentials, visit www.lubecouncil.org or e-mail info@lubecouncil.org.

MATT SPURLOCK

USING CRITICALITY to DRIVE OIL ANALYSIS STRATEGY

Oil analysis provides a huge payback when deployed through a proper strategy. While an extremely valuable tool in today's reliability programs, it is sometimes applied in an ad-hoc manner. This is a dangerous approach, as the program can quickly become quite costly due to overtesting or even show little value due to inadequate testing. Let's take a look at both situations.

Overtesting

A recently visited paper mill had a rather robust oil analysis program. This program was further optimized by the corporate reliability manager. The maintenance manager had a positive feeling about the benefits of predictive technologies and was supportive of the oil analysis program. While this was all seemingly positive data, the drawback was that the manager decided he wanted all equipment to be incorporated in the oil analysis program, including small centrifugal pumps containing less than even a quart of oil.

79%

of Lube-Tips subscribers believe their plant's oil analysis testing is inadequate.

Taking this approach would have meant that the mill would run hundreds of oil samples on at least a quarterly basis. Adding to this, when following proper sampling procedures, we understand that the sampling hardware must first be flushed. When sampling small reservoirs, such as those in small centrifugal pumps, following the flush portion and then sampling, a complete oil change would have occurred on every pump each quarter. Considering the increased lubricant consumption coupled with the additional cost of testing the oil samples, you can see how the overall costs would add up quickly.

Although the maintenance manager should be commended for his

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Understanding Operational Criticality

The oil analyst should know a machine's operational criticality. This can be broken down into two basic elements. The first is mission criticality, which considers the consequences of failure (production losses, safety, etc.) in relation to the machine's intended mission. The second is functional restoration, which basically asks in the event of failure, what would it cost to replace, repair and rebuild the broken machine.

These two elements of operational criticality don't always go hand-in-hand. Because of redundancy and standby equipment in some processes, an expensive repair may not always result in costly downtime. Likewise, in other cases, huge production losses may be triggered by small throw-away machine components.

Operational criticality is best defined by the asset owner, not by outside oil analysts or other non-stakeholders. For instance, consider using a scale from one to five for both mission criticality and functional restoration. A rating of one might mean failure is inconsequential, while a rating of five alerts that failure could have devastating consequences. The cost, frequency and quality of oil analysis will likely vary in accordance to how the machine is rated for operational criticality.

aggressive drive toward equipment reliability, moving forward with the initially desired approach would have been costly, significantly reducing the program's overall return on investment (ROI).

Inadequate Testing

During a recent oil analysis program benchmarking exercise, it was asked how machines were selected for inclusion in the testing program. The initial response was, "We use criticality." When the process used for criticality assessment was investigated, it was revealed that there was no real process. The machines were selected based on what I like to call "perceived criticality." This resulted in a very small group of components initially being tested, although the program was growing in a methodical manner. When a machine component failed that was not part of the analysis program, the replacement component was then put on the program. So there was no real methodology at all.

This plant was experiencing a significant number of failures that could have been avoided had the program been put together properly in the first place. By taking this approach, the total cost of program development and optimization was incredibly high once the costs of missed opportunities were included into the equation.

Moving Forward

Oil analysis comes in three basic forms:

1) **Commercial Lab Testing** — Samples are collected and sent to a third-party laboratory for testing and analysis. This can take place on a routine basis or to confirm screening data from select on-site testing.
2) **On-site Testing** — Samples are collected and tested at the plant site using a number of potential on-site test equipment. Many advances have occurred in on-site test equipment that will be explored in a later issue of *Machinery Lubrication*.
3) **Online Testing** — Specialty meters (usually particle counters), moisture meters and dielectric testers are installed in a circulating system in order to capture "live" lubricant conditions. As with on-site testing equipment, this technology has grown significantly over the past 5 years.

Each of the basic types of oil analysis has an intended function and can offer significant benefit to the end user if deployed properly. For companies with a large number of lubricated components included in the oil analysis program, it is vital to incorporate some level of each of these categories for a well-rounded program.

Utilizing the criticality of machines that has been assigned through a documented method provides the best starting point in the decision-making process regarding which form, or combination of forms, is best for each component.

A plant with a well-developed criticality system already has the foundation for establishing an equally well-developed oil analysis program. Some of the primary decisions related to oil analysis that criticality can assist with include:

- Machine selection
- Reliability objectives
- Test slate selection
- Sample frequency

The days of the common test slate and frequency are over. The largest ROI will be achieved by using criticality to fine-tune an existing program and to get a new program off to an optimized starting point. The plant that does not have an established criticality assigned to machines should consider this foundational element. Without it, the entire predictive program is at risk of supplying less than the desired effect on overall reliability and ROI. ■

About the Author

Matt Spurlock was the director of oil analysis services and technologies for Noria Corporation. For the past 20 years, Matt has helped companies develop world-class lubrication and oil analysis programs.

JOSH PICKLE NORIA CORPORATION

The ADVANTAGES and DISADVANTAGES of BIODEGRADABLE LUBRICANTS

Vegetable oils can be used as lubricants in their natural forms. They have several advantages and disadvantages when considered for industrial and machinery lubrication. On the positive side, vegetable oils can have excellent lubricity, far superior to that of mineral oil. In fact, their lubricity is so potent that in some applications, such as tractor transmissions, friction materials must be added to reduce clutch slippage.

Vegetable oils also have a very high viscosity index (VI). For example, a VI of 223 is common for vegetable oil, compared to 90 to 100 for most mineral oils, about 126 for polyalphaolefin (PAO) and 150 for polyglycol. Viscosity index can be

62%

of lubrication professionals do not use any biodegradable lubricants at their plant, according to a recent survey at machinerylubrication.com

defined as a frequently used measure of a fluid's change of viscosity with temperature. The higher the viscosity index, the smaller the relative change in viscosity with temperature. In other words, oil with a high VI changes less with temperature than oil with a low VI.

Another important property of vegetable oils is their high flash points. Typically, this might be 326 degrees C (610 degrees F) for a vegetable oil, compared to a flash point of 200 degrees C (392 degrees F) for most mineral oils, 221 degrees C for polyalphaolefin (PAO) and 177 degrees C for polyglycol. Flash point can be defined as the temperature to which a combustible liquid must be heated to give off sufficient vapor to momentarily form a flammable mixture with air when a small flame is applied under specified conditions, according to ASTM D92.

More importantly, vegetable oils are biodegradable, generally less toxic, renewable and reduce dependency on imported petroleum oils.

On the negative side, vegetable oils in their natural form lack sufficient oxidative stability for lubricant use. Low oxidative stability means the oil will oxidize rather quickly during use if untreated, becoming thick and polymerizing to a plastic-like consistency. Chemical modification of vegetable oils and/or the use of antioxidants can address this problem, but it will increase the cost. Chemical modification may involve partial hydrogenation of the vegetable oil and a shifting of its fatty acids.

The challenge with hydrogenation is determining at what point the process should cease. Depending on the required liquidity and pour point of the oil, optimum hydrogenation is established. Recent advances in biotechnology have led to the development of genetically enhanced oil seeds that are naturally stable and do not require chemical modification and/or use of antioxidants.

Did You Know? *Biodegradable oils currently make up less than 1 percent of all lubricants.*

Employing tests developed by the American Society for Testing and Materials (ASTM) and the Organization for Economic Cooperation and Development (OECD), oil is inoculated with bacteria and kept under controlled conditions for 28 days. The percentage of oxygen consumption or carbon-dioxide evolution is monitored to determine the degree of biodegradability. Most vegetable oils have shown to biodegrade more than 70 percent within that period, as compared to petroleum oils biodegrading at nearly 15 to 35 percent. For a test to be considered readily biodegradable, there must be more than 60-percent degradation in 28 days.

TYPICAL TEST RESULTS FOR LUBRICANTS

LUBRICANT TYPE	PRIMARY BIODE-GRADED QUANTITY
Vegetable Oils	70 - 100 %
Polyols and Diesters	55 - 100 %
White Oils	25 - 45 %
Mineral	15 - 35 %
PAG	10 - 20 %
PAO	5 - 30 %
Polyether	0 - 25 %

Similarly, by using a variety of tests involving fish, daphnia and other organisms, the toxicity of vegetable oils can be measured. In this case, both mineral oil and vegetable oil in their pure forms show little toxicity, but when additives are included, the toxicity increases.

Another disadvantage of using vegetable oils is their high pour point. Pour point is defined as the lowest temperature at which an oil or distillate fuel is observed to flow when cooled under conditions prescribed by test method ASTM D97. The pour point is 3 degrees C (5 degrees F) above the temperature at which the oil in a test vessel shows no movement when the container is held horizontally for 5 seconds. This problem also can be addressed by winterization, the addition of chemical additives (pour point suppressants) and/or blending with other fluids possessing lower pour points. Various synthetic oils can be used for this purpose.

If a high degree of biodegradability is required, then biodegradable synthetic esters are added to improve cold-temperature properties. On the other hand, if the goal is to maintain the so-called biobased property, where at least 51 percent of the lubricant is made of natural biomaterials, then a portion of the blend could be light mineral oil with low pour points. The latter will show a higher degree of toxicity and a lower degree of biodegradability.

Why Use Biodegradable Lubricants?

Approximately 2.5 billion gallons of lubricants are sold annually in North America. Studies show that much of this fluid (60 percent) is not accounted for and ends up in ground water, rivers, lakes and on the ground itself, causing untold harm to the environment, fish and wildlife. Marine, forestry and agriculture industries in particular, along with citizen groups and governments, are becoming more and more concerned about our responsibility to the protection of the environment. The use of biodegradable fluids can help to maintain the environment and relieve some of the demand on mineral oils in the future.

About the Author

Josh Pickle is a technical consultant with Noria Corporation, focusing on machinery lubrication and maintenance in support of Noria's Lubrication Process Design (LPD). He is a mechanical engineer who holds a Machine Lubrication Technician (MLT) Level I certification through the International Council for Machinery Lubrication (ICML). Contact Josh at jpickle@noria.com.

BY LAWRENCE G. LUDWIG JR., SCHAEFFER MANUFACTURING

Storing Grease to Avoid Bleed and Separation

When storing grease and even during use, a certain amount of oil bleed will develop. Although it is common, the rate at which this bleeding occurs can be controlled through proper storage and usage techniques. Before looking at these strategies, it is important to understand the make-up of grease and the types of oil release that can take place.

Grease Composition

Grease = 70 to 95 percent base oil + 3 to 30 percent thickener system + 0 to 10 percent additives.

In general, a grease is a solid to semifluid product that consists of a dispersion of a thickening agent in a liquid lubricant. This thickener system can be made up of either simple or complex metal soaps of lithium, calcium, aluminum, barium or sodium, or non-soap such as clay (bentone) or polyurea. The thickener system can be thought of as a sponge that contains a matrix of fibers or platelets with a high surface area forming a dense network of micro-asperities (voids) or fibers. It is in these voids or fiber structure where the base oil and additives are stored until they are needed for lubrication.

Just like a sponge that releases water when it is squeezed, the grease releases its base oils from the thickener system when it is squeezed or stressed. The stresses a grease encounters can be generated either mechanically or thermally during application or storage.

In an application, a grease gradually releases oil into the working areas of the machine surfaces in order to lubricate them. The greater the amount of sheer stress encountered, the faster the grease's thickener system releases its hold on the base oils. The thickener system matrix imparts little or no lubricating characteristics. If the thickener system matrix did not release the base oils, the grease would be unable to perform its lubricating properties.

By the same token, a grease also should have the ability to exhibit some type of reversibility characteristics after the stresses are relaxed. Reversibility is defined as a grease's ability to recapture its base oils in order to return to its original consistency and continue functioning as intended. When a machine is shut off or when the conditions of mechanical or thermal stress are relaxed, the grease must have the ability to recapture its base oils to return to its original consistency. A grease's reversibility characteristics are dictated by the type and amount of thickener used. Generally, the higher

Tests for Oil Bleeding

There are a number of different tests that can measure a grease's bleeding and oil separation characteristics. These tests can be categorized into two groups: static and dynamic bleed tests. The most common tests used to evaluate oil separation and bleeding are:

Static Tests

ASTM D-1742 Oil Separation from Lubricating Grease During Storage – This test predicts the tendency of a grease to separate oil during storage when stored at room temperature.

ASTM D-6184 Test Method for Oil Separation from Lubricating Grease (Conical Sieve Method) – This method determines the tendency of the oil in a lubricating grease to separate at elevated temperatures.

Dynamic Tests

U.S. Steel Pressure Oil Separation Test – This test is used to measure the oil separating and caking characteristics of a grease under fixed conditions that indicate the stability of a grease under high pressures and small clearances in a centralized grease pumping system.

ASTM D-4425 Oil Separation from Grease by Centrifuge – This method evaluates the oil separation tendency of a grease when subjected to high centrifugal forces.

Trabon Method 905A – This test is used to predict the tendency of a grease to separate oil while under pressure in a centralized lubrication system.

Although a grease may exhibit good resistance to oil bleed and separation in these static and dynamic tests, proper storage and handling of the grease are still key components to ensure that it is able to perform its job.

the thickener content, the less the grease's reversibility.

Types of Oil Release

Although a grease's thickener system is not soluble in the base oil that it thickens, it does have an attraction to the base oil. Depending upon the amount of thickener system used in the grease's formulation, this attraction can be strong. The higher the proportion of thickener used, the greater its attraction to the base oil. As the base oil content is increased and the amount of thickener system is decreased, the forces of attraction also decrease, thus resulting in the base oil being loosely held in the thickener system matrix and easily separated.

From these statements, you might think a higher thickener content is better. However, as mentioned previously, a thickener system matrix that does not release its base oils would be unable to perform its lubricating properties. Therefore, it is important for a grease to have the proper balance of base oil and thickener system content to function properly.

Oil release or separation from greases can be found in two distinct modes: static bleed and dynamic bleed. Static bleed is the release of the grease's base oil from the thickener system in the container in which it has been placed or in a non-moving part into which it has been introduced. Static bleed, which can also be referred to as oil puddling, occurs naturally for all types of greases and at a rate dependent on their composition.

Static oil bleeding can be affected by storage conditions, including the storage temperature, the length of storage, any vibrations the containers may be exposed to during transport or storage, an uneven grease surface in the container or the natural force of gravity. These factors can cause extremely weak stresses to be placed on the grease, resulting in the release of small amounts of base oil. Over time, a puddle of oil can form on top of the grease.

Static bleeding is more pronounced if the grease is soft in consistency (NLGI grades 00, 0 and 1) and/or if the grease's base oil viscosity is low (ISO 68 and lighter). It does not result in the grease being unsuitable for use.

Any base oil that has puddled or is lying on top of the grease can be either removed by decanting the free oil from the surface or by manually stirring it back into the grease. The quantity of oil that has separated from the grease is generally insignificant and represents a mere fraction of the total quantity of base oil that is held in the thickener system matrix. This small amount of oil will not adversely affect the consistency of the remaining product and will have little or no effect on the performance of the product.

Dynamic bleed is the actual controlled release of the base oils and additives during use due to temperature or mechanical stresses. It is important for the grease being used to have a controlled rate of bleeding in order for it to do its job properly.

Dynamic bleed conditions can also be caused or aggravated by the following conditions:

Overgreasing – Overgreasing can cause high temperatures, which result in oxidation of the grease and rapid separation of the base oils from the thickener due to churning.

Thermal Runaway – Too much grease in a bearing, mechanical conditions (misalignment, excess preload, etc.)

and starvation can lead to higher running temperatures, which cause the base oils to be readily released from the thickener system matrix, leaving the thickener system behind to lubricate.

Cake Locks in an Overgreased Bearing — These cake locks can act as microscopic logjams. They are immobile and block flow paths and even mechanical motion of the bearing. When fresh grease is applied, the grease's base oils are separated and flow through the built-up thickener due to hydrostatic extrusion, leaving the thickener system behind. Additional build-up of this logjam can lead to elevated operating temperatures, resulting in increased bleeding of the base oils from the grease's thickener system.

Contamination — Gross contamination by dust, dirt, fly ash and dry powder contaminants can draw out the base oils from the thickener system over time, resulting in the thickening of the grease.

Mixing of Incompatible Thickener Systems — This accelerates de-gelling and oil separation.

Hydrostatic Extrusion — Grease subjected to constant pressure can separate by hydrostatic forces, just like water flowing through a sand filter. The base oils are literally squeezed from the thickener system.

Vibration and Centrifugal Forces — Prolonged vibration and/or centrifugal forces can cause grease separation.

A grease's oil bleed rate can be affected by a number of factors, including its composition, the type of manufacturing process used to produce the grease and distribute the thickener system within the base oil, and how the grease is stored once it reaches the customer. The ability of the grease to retain or release the oil depends upon all of these factors.

Without exhibiting some bleeding, whether static or dynamic, a grease will not provide lubrication for the application in which it is being used. The balance between these two modes of bleeding is the key to the grease's performance.

Storage and Handling Techniques

Like most materials, lubricating grease gradually will deteriorate with time. The rate and degree of deterioration depends on the storage and handling conditions to which the grease is exposed.

Grease may change its characteristics during storage. The product may oxidize, bleed, change in appearance, pick up contaminants or become firmer or softer. The amount of change varies with the length of storage, temperature and nature of the product.

Depending on the storage conditions, some greases can undergo age hardening, which results in the product becoming firmer and increasing in consistency or even softening. These changes in consistency can cause the grease to slip out of its original consistency grade. This behavior can be further aggravated by prolonged storage conditions. Because of this aspect, extended storage periods should be avoided.

If a grease is more than a year old, the National Lubricating Grease Institute (NLGI) recommends that it be inspected and the worked penetration tested to ensure that the grease is still within its intended NLGI grade.

Another recommended industry practice specifies that whenever any type of lubricant is received, the usage and storage methods must follow the first-in/first-out inventory system. This simply requires the user of the lubricating grease to use the grease that was put into the storage system first. In addition, grease manufacturers place a date code or bath number on the individual packages or cartons that can help determine the month, day and year the grease was made.

As previously mentioned, greases tend to bleed and release their base oils during storage. The rate of oil released from the grease will increase with time and vary based on the temperature at which it is stored. Ideally, grease should be stored in a cool, dry indoor area that does not exceed 86 degrees F (30 degrees C) and remains above 32 degrees F (0 degrees C).

It is not unusual to find grease containers in storage areas that have temperatures as high as 130 degrees F (54 degrees C). These storage areas also can be exposed to contaminants such as dust, dirt, moisture or rainwater, which can severely deteriorate the quality of the grease.

A grease container should never be exposed to direct sunlight or be stored in an area directly near a heat source such as a steam pipe, furnace, cab of a truck in hot weather, etc. This will only aggravate the rate of oil release that can occur.

Always store grease in its original packaging and keep the container closed until it is time for it to be used. Wipe the lid or cover of the container before opening and always use clean tools and dispensing equipment when handling or pumping the grease. After use, the container should be closed immediately and kept closed. Before placing the lid back onto the container, wipe off any dust, dirt or excess grease that may have accumulated.

Cartridge tubes of grease should be stored upright at all times. If a cartridge tube is left in a grease gun, the grease gun should be depressurized, wiped with a clean cloth to remove any contaminants and stored in a horizontal position inside a clean, cool, dry area to keep the oil from bleeding out of the grease.

To further ensure a grease's original quality and cleanliness, as well as to prevent excessive oil separation, the following storage and handling techniques are recommended:

- ✓ Do not use lubricating greases that have been stored for long periods of time unless their condition and cleanliness can be verified by a laboratory analysis.
- ✓ If accidental mixing is suspected or has occurred, consult the lubricant supplier or conduct compatibility tests.
- ✓ The storage room should be separated from areas of contamination such as metal debris, dust, dirt, chemical fumes or moisture. The room should be heated, well-ventilated and contain clean accessories, dispensing equipment and other necessities. Personnel also should be properly trained in storage techniques and inventory control to prevent contamination.
- ✓ Grease containers should be clearly labeled with the date they were received, the type and brand of grease, etc. These markings should be kept in a position where they can be easily read.
- ✓ Store grease in its original container until it is used. Drums, pails, kegs and boxes should be kept off the floor and supported by a rack, platform or blocks at least several inches high.
- ✓ Never leave grease containers improperly covered, uncovered or open. Keep them tightly sealed between uses. If the containers are stored outside, a heavy canvas tarpaulin, plastic sheet or lean-to can be used to keep off water or dirt. Drums, kegs and pails should be raised off the ground and stored either on their sides or tilted at a 45-degree angle to prevent any moisture or dirt from being drawn into the product.
- ✓ Any tools used to handle or dispense grease should be cleaned before they are used.
- ✓ Never use wooden paddles or spatulas to remove or transfer grease from containers to grease guns or other types of dispensing systems. This practice poses a high risk of contamination.
- ✓ If a barrel warmer is used, it should have some type of temperature-regulating mechanism. The grease should never be heated above 75 degrees F, and the barrel warmer should not be left on overnight or unattended. This can cause the grease to readily release its base oils or even thicken in consistency due to oxidation and thermal stress.
- ✓ Never use a torch or open flame to warm a grease container. This poses a fire hazard.
- ✓ Maintain a separate inventory and utilization record for each product. Tracking how much grease is used and on which machine or piece of equipment will help you keep an accurate inventory of lubricants.
- ✓ Use the oldest container received first.
- ✓ Before storing or using a grease, inspect the received containers for any damage such as severe dents, corrosion or moisture.
- ✓ Some type of coding and tagging system should be used to identify the contents of different lubricant containers, transfer/pumping systems, tools and pipes that carry grease throughout the plant. Make sure all transfer valves, hoses and dispensing equipment are kept clean. Seals and gaskets also should be maintained in proper condition.
- ✓ All transfer containers should be filled under clean conditions.
- ✓ Grease containers should be completely emptied before being discarded. ■

About the Author

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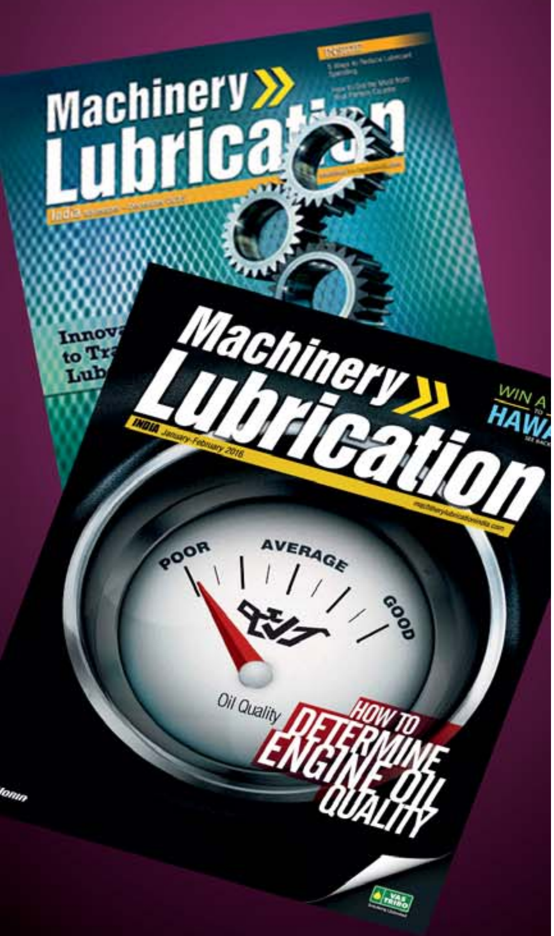


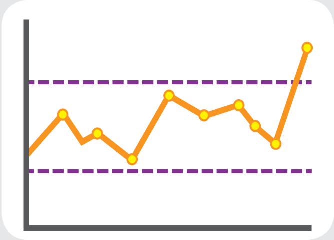
TEST your KNOWLEDGE

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.

1. The primary reason that machinery is replaced is due to:

A) Erosion
B) Accidents
C) Obsolescence
D) Surface degradation of the metal
E) Corrosion

2. Upper and lower alarm limits are generally needed on which oil analysis test results?



A) Acid number
B) Base number
C) Viscosity
D) Flash point
E) RPVOT

3. Which is the most common type of grease thickener?

A) Lithium
B) Barium
C) Polyurea
D) Calcium
E) Aluminum

4. Elastohydrodynamic lubrication (EHL) is considered to occur primarily in:

A) Piston rings and liners
B) Journal bearings
C) Rolling bearings, gears and cams
D) Slow-moving pins and bushings
E) Worm gears

5. Sampling crankcase oil from an engine should be done:

A) Through the dipstick hole with a drop-tube
B) From a valve mounted after the pump and after the filter with the engine running
C) From a valve mounted after the pump, before the filter with the engine running
D) From a valve mounted after the pump, before the filter with the engine shut off
E) From the drain plug

Answers: 1-D, 2-C, 3-A, 4-C, 5-C

WES CASH NORIA CORPORATION

HOW DESICCANT BREATHERS CONTROL CONTAMINATION

To combat the ingression of particles into oil systems, breathers are often attached to reservoirs and other oil storage components. Whether they are connected to an expensive piece of machinery or a drum of oil, breathers offer the peace of mind that as the oil level fluctuates, the air filling the space will be properly cleaned and mostly free of contaminants. Desiccant breathers provide a wide range of benefits and are becoming more common. However, you may wonder how a plastic cup full of what looks like plastic beads actually filters incoming air and removes not only harmful particles but also water vapor, which is so dreaded in lubrication systems. The answer involves chemistry.

These breathers use the inherent qualities of two of nature's most absorbent materials — silica and carbon. Everyone likely has opened a package and found little packets marked "Do not eat." This is the same silica in desiccant breathers. How it works is quite simple. Silica is a very porous material that can trap and hold nearly 40 percent of its weight in water. As water vapor passes around these beads, it is trapped in the pores of the silica. Any water vapor that isn't trapped by the silica goes through a layer of activated carbon. Electronegativity is a chemistry term used to describe an element's attractive force toward other elements. Carbon and oxygen both have high values and are attracted to each other to form new gases, such as carbon dioxide. Water vapor attaches to carbon by this force. The oxygen in the water binds with the activated carbon in the breather, thus preventing it from going any farther.

Most breathers also have a color-change indicator that shows when their useful life is up. This is accomplished with a water-reactive reagent embedded into the body of the silica. As water vapor attaches, it reacts inertly with the reagent, making it change its color. Desiccant breathers generally have a synthetic fiber filter at the top to trap larger solid particles such as dust or organic material in the atmosphere. Next, there is a device called a diffuser, which takes incoming air and forces it through the entire volume of silica evenly. After the diffuser is the activated carbon, which serves to remove anything left after the initial filtration. As the container exhales, this process takes place in reverse, with the activated carbon absorbing the oil mist so as not to allow it back into the mass of oil after being in contact with other contaminants.

It is recommended that these breathers be installed in tandem with a vacuum gauge. In the case of dry environments, there may not be enough moisture ingression to cause a color change of the silica beads before the top layer of the synthetic filter is clogged with dust and other contaminants. A vacuum gauge will provide a visual signal as to when this occurs, since the air will not be able to pass through the entire breather. As with most spin-on breathers, desiccant breathers often have a beta rating associated with them. This is a mark of how well the filter removes incoming contaminants. Among the other criteria to keep in mind when selecting a filter is the cleanliness of the environment, which can affect its life expectancy. Obviously, the dirtier the air, the more particles the breather will trap. The amount of moisture or humidity in the air will determine how long you can go between filter changes. The criticality of the machinery the breather is attached to is important to consider as well. If the machine operates on close tolerances with little room for particle ingression, you may need to get a high-quality breather and change it more regularly. To maximize a breather's efficiency, ensure the headspace of the oil level is sealed tightly. The volume being protected should breathe only through the filter installed. A loose seal will defeat the purpose and allow a straight path for outside particles to enter the system. Although breathers are relatively easy to install, the process of how they work is quite involved. Pairing science with real-world need provides the advantage required to tackle the challenges of particle ingression and maintaining the small fluid film on which this industry rides. ■

3 Key Properties of a Breather

Desiccant breathers can help control both moisture and dirt ingression. A good desiccant breather system is one that:

1) achieves the target level for cleanliness and dryness,
2) has the capacity to enable a sufficient service interval between change-outs,
3) is easily visible for routine inspection during preventive maintenance.