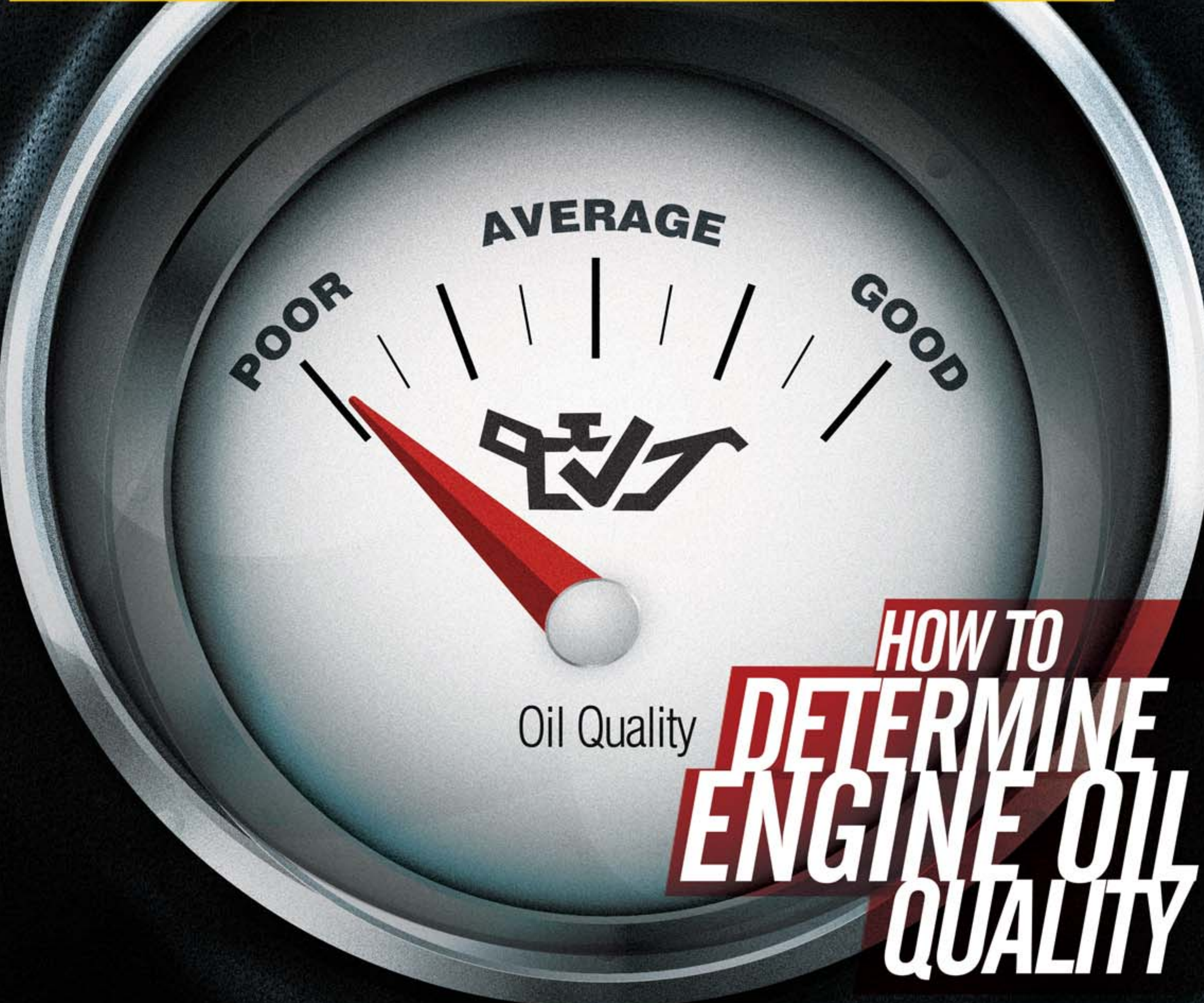
Machinery Lubrication

INDIA January-February 2016
machinerylubricationindia.com



HOW TO DETERMINE ENGINE OIL QUALITY

NORIA

Contents

Machinery Lubrication India
January-February 2016

Publisher's Note

In mid-December 2015 the world agreed to the first universal, legally binding deal to tackle global warming in Paris. Known as the Paris climate deal wrought through UN talks, all countries committed to try to keep global temperature rises "well below" 2 degrees C, as that level would likely herald the worst effects of climate change. The level agreed to was 1.5 degrees C.

The world draws energy from fossil fuel (crude oil, coal etc) classified as hydrocarbon. The hydrogen equates to energy and the carbon is generally a waste product that finds its way into our atmosphere, water and land upon combustion, creating environmental pollution.

The quest for lower energy consumption and cleaner environment has shown a way to the lubricant industry to look for better options by way of "Energy Efficient Lubricants", which claim to be reducing the energy consumption and use better quality fuels in lesser polluting automobiles. This in effect will reduce the consumption of fossil fuels and also carbon footprint.

The latest World Health Organisation report puts 13 Indian cities in the notorious list of 20 cities with most particulate (PM 2.5) pollution. It includes Delhi, Patna, Gwalior, Raipur, Ahmedabad, Lucknow, Firozabad, Kanpur, Amritsar, Ludhiana, Agra, Allahabad and Khanna. PM 2.5 stands for tiny particulate matter, 2.5 microns or smaller, linked with health hazards ranging from mild irritations in eye, nose and lungs to cardiovascular diseases and cancer.

Whilst 50% of this comes from other sources including industrial fuels, the balance 50% PM 2.5 comes from exhaust of diesel vehicles - trucks, buses, SUVs and cars. While vehicles and fuel sold in Delhi has to be BS-4 (Euro 4) compliant, in other parts of India, these are Euro 3 compliant only. The lubricant manufacturers need to gear up R&D to deliver lubes compatible with higher Euro/BS norms, if we want to see less pollution. Keeping this in mind, we are carrying a cover story on Engine Oil Quality.

We look forward to your continuing feedback and suggestions on the content and presentation of the magazine.

Warm Regards,

Udey Dhir

JIM FITCH, NORIA CORPORATION

AVOIDING the Pitfalls of Viscosity-starved MACHINES

Industry rides on a film of oil. The oil's viscosity bears the load and defines the extent of clearance achieved between working surfaces. Sometimes that clearance is thick and bountiful, and other times it is deflated or extinct. Without viscosity, most machines would rapidly self-destruct with mechanical friction and wear.

There is also a well-known penalty and reliability risk from too much viscosity. Like most things, the selection of a lubricant's viscosity must be optimized to enable needed protection and disable the danger from excessive viscosity. For instance, too much viscosity can cause churning losses and excessive heat generation from molecular friction. It can also impede lubricant movement and flow to lubricant-hungry surfaces.

One of the most famous disadvantages of too much viscosity is high energy consumption. In recent years, we've seen automaker-specified viscosity being lowered in crankcase service from 5W40 to 5W30, and now in some cases to 5W20. These changes are all for the sake of energy conservation. Of course, the primary driver for energy conservation is not to save money on fuel or electricity but rather to reduce the consumption of fossil fuels, which emit harmful gases (carbon dioxide, nitric oxides, hydrocarbons, etc.) into the atmosphere as a byproduct of combustion.

While any effort to decrease energy consumption and protect the environment is a noble cause, you should be wise to how excessive viscosity trimming can backfire. Under ideal conditions, lowering viscosity in an engine may result in no harm. However, in worst-case scenarios, dangerously collapsed oil films can accelerate wear and lead to premature failure. Such scenarios in a car engine may occur due to low coolant levels, heavy loads (pulling a trailer), hot ambient temperatures, low oil levels, driving on dirt roads (high particle ingestion), short-trip driving patterns, water contamination and fuel dilution. Excessive wear in the combustion chamber region (rings, cylinder wall, valves and cams/followers) caused by aggressively low viscosity and worst-case scenarios will result in the loss of combustion efficiency, higher fuel consumption and harmful gases being released out the tailpipe.

Too low viscosity can also lead to excessive volatilization and oil consumption in engines, both of which have a negative environmental impact. Low viscosity equates to small molecules that are more prone to vaporization at high temperatures along the piston ring belt, cylinder wall and exhaust valves.

VISCOSITY STARVATION IN WORST-CASE SCENARIOS

Lubrication engineers consider

numerous factors when matching viscosity selection to the needs of the machine. Speed is an important factor, as is load. Both define the viscosity needed to produce hydrodynamic and elastohydrodynamic oil films. These oil films build a clearance between working surfaces to mitigate friction and wear from mechanical contact.

Some machines operate at varying speeds. Without speed, oil films are not producible. This is why it's often said that each time you start your car or truck, you are causing mechanical wear equivalent to 500 miles of driving. Starts, stops, coast-downs, slow speeds and reverse-direction part movements are all oil film/ viscosity starvation events.

Temperature is another critical factor. Usually extreme temperatures are considered first and then normal operating temperatures. At the lowest temperature extreme, the oil must be fluid enough to enable movement and flow. At the highest temperature extreme, the viscosity must not be so low that surfaces are allowed to rub and collide, resulting in excavated working surfaces and failure. Viscosity index also plays a crucial role when temperatures are known to fluctuate widely.

Typically, charts and formulas are used when selecting a lubricant's viscosity. Risk should also be a consideration. What is the likelihood of a viscosity excursion during normal or extreme conditions? What are the consequences? Safety, cost of repair, downtime, energy consumption and environmental factors should all be taken into account.

It is easy to select viscosity for normal and generally constant-load conditions. However, extreme loading puts extreme demands on a lubricant's viscosity. This can come as a result of momentary shock or surge loading, mechanical unbalance and misalignment. Knowing when these conditions occur is essential. In many cases, the solution is not viscosity but rather film-strength additives.

We all know that viscosity produces the working clearance between surfaces in relative motion with respect to speed and load. This clearance defines the machine's sensitivity to three-body abrasion from particle contamination. The particles in the size range of this clearance create the greatest amount of abrasion. For instance, if the working clearance is 10 microns, then the particles around 10 microns cause the most abrasion and pitting. The population of small particles in a lubricant is always much greater compared to large particles. The lower the viscosity, the thinner the working clearance and the more harm done by particle contamination.

OTHER CAUSES OF VISCOSITY STARVATION

As mentioned previously, the conditions that often starve a machine of viscosity can be momentary or temporary. High ambient heat or a defective cooler can drive down viscosity. Sometimes the temperature issue is localized or specific to a transient operating condition. For example, a machine may develop a hot spot for various reasons that can cause viscosity to plunge in that same vicinity. When extreme, these hot spots can also crack the oil's molecules, leading to permanent and severe loss of viscosity.

Viscosity can drop by oil contamination and distress. Fuel dilution in engines and chemical contamination (solvents, refrigerants, natural gas, etc.) can all result in a sudden drop in viscosity. Water contamination can thin many oils that have a high solvency for water. In the case of natural and synthetic esters, water may disassemble the ester molecule to sharply reduce viscosity by a chemical reaction called hydrolysis.

Some lubricants have additive systems

Machinery Lubrication India

Publisher
Udey Dhir - udeydhir@tribologysolutions.com

Creative Director
smassociates@gmail.com

Advertisement Sales (India)
ads@machinerylubricationindia.com

Advertisement Sales (US/Canada)
Tim Davidson - tdavidson@noria.com

Advertisement Sales
(All Other Countries)
ads@machinerylubricationindia.com

CORRESPONDENCE
You may address articles, case studies, special requests and other correspondence to our

Operation office :

Editor
213, Ashiana Centre, Adityapur,
Jamshedpur-831013, India
email : editor@machinerylubricationindia.com
Tel: +91-657-2383238
Tel:(USA): +1-918-960-9738

Marketing Office
Rider House, 136,
Sector 44, Gurgaon-122003, Haryana
National Capital Region, India

Machinery Lubrication India Volume 20 - Issue 1, January-February 2016 is published bi-monthly by VAS Tribology Solutions Pvt. Ltd. Operation Office:213, Ashiana Centre, Adityapur, Jamshedpur-831013, India.

SUBSCRIBER SERVICES: The publisher reserves the right to accept or reject any subscription. Send subscription orders, change of address and all related correspondence to: VAS Tribology Solutions Pvt. Ltd. Operation Office:213, Ashiana Centre, Adityapur, Jamshedpur-831013, India.

RISK-HEDGING STRATEGIES FOR MACHINE VISCOSITY STARVATION	
RISK FACTOR	**STRATEGY**
High temperature from low coolant, high ambient conditions, low oil levels, machine hot spots	Monitor temperature frequently and correct the root cause. Use high VI oil.
High loads and/or slow speeds	Select viscosity to match machine loads and speeds.
Periodic shock loads, frequent stops/starts	Use a lubricant with film-strength additives to protect against two-body abrasion, adhesion and galling. Examples are anti-wear (AW), EP and friction modifiers.
Mechanical unbalance or misalignment	Monitor for these conditions and remediate accordingly. Use additives to mitigate such as AW, EP and friction modifiers.
Fuel dilution or chemical contamination	Use oil analysis to detect and prescribe a remedy.
Hydrolysis of esters from water contamination	Proactively control water contamination. Use oil analysis to detect and prescribe a suitable remedy
VII shear thinning	Use oils resistant to excessive VII shear thinning.
Dirt ingression risk	Employ contaminant exclusion strategies. Use more effective contaminant removal methods (e.g., filters). Monitor particle levels regularly. Consider increasing oil viscosity.

that include viscosity index improvers (VII). VII molecules are extremely large, and when the oil is hot, they unfurl, making them extremely susceptible to rupture by mechanical shearing in the machine's frictional zones (cam/follower contacts, swashplate/slipper contacts, pumps and rolling-element bearings). These ruptures reduce the oil's viscosity over time. Engine oils and most hydraulic fluids are at risk for VII viscosity shear thinning.

CONSEQUENCES OF INADEQUATE VISCOSITY

Machines starved of viscosity suffer from a range of problems that translate to operational costs and impaired reliability. In certain situations, viscosity deprivation can lead to sudden catastrophic death of machine components such as bearings and gears. In other cases, the effects are milder and may only slightly shorten the life of the machine. The following consequences can occur when viscosity is lower than ideal:

Mechanical Wear

In many circumstances, viscosity is the most important lubricant property that prevents or mitigates wear. When viscosity falls below a critical threshold, mechanical wear is accelerated. This includes abrasive wear (two-body and three-body), adhesive wear (scuffing and galling), surface fatigue (micropitting, etc.), and delamination wear.

Thermal Circle of Despair

Low viscosity causes wear and friction, which generate heat. Heat lowers oil viscosity, leading to more friction and wear as well as more heat. This is the thermal circle of despair. The accelerated wear shortens machine life, and the heat shortens the lubricant life.

Short Lubricant Life

When frictional surfaces are deprived of viscosity, the lubricant's additives are affected in three ways. The first is from heat (as mentioned above). This heat accelerates the depletion of additives such as antioxidants. This results in base oil oxidation. The second is the rupture of VII additives, which leads to more loss of viscosity. The third is the mechanical friction from low viscosity that causes anti-wear and extreme-pressure (EP) additives to sacrificially deplete more rapidly.

Leakage

Low viscosity will increase the rate of leakage. This includes both out-leakage and internal leakage. Out-leakage causes a loss of lubricant, while internal leakage affects machine function (speed and control in the case of hydraulic systems) and energy consumption.

Engine Oil Consumption and Environmental Effects

Low crankcase oil viscosity increases the rate of oil consumption in diesel and gasoline engines, which is an operational cost. The oil that is released to the exhaust path produces hydrocarbon emissions, which endangers human health and leaves a carbon footprint.

RECOGNIZING VISCOSITY-STARVED MACHINES

Don't assume the lubricant in your machine has the right viscosity simply because it is the one specified in the machine's service manual. Challenge conventional recommendations for viscosity. Some machines are operating at conditions far afield from that intended by the machine designer. Machine applications vary sharply due to duty cycle, work environment, temperature, close-proximity contaminants and operating conditions. Many machines run at speeds and loads far below the maximum rated by the manufacturer. Other machines are just the opposite, operating in excess of catalog speeds and loads. All of this has a sharp effect on the machine's viscosity needs.

One way to stay alert to inadequate viscosity (or excessive viscosity) is to "listen" to the machine. This can be done using the following techniques:

Oil Analysis – Test for viscosity/ viscosity index, contamination (fuel, water, dirt, etc.), oxidation stability, thermal stability, wear metals, etc. Look for both root causes (of thin oil) and the effects of viscositystarved machines.

Sound – Bearings, pumps and gears emit sharply different sounds when they are starved of lubricant or viscosity.

Heat Monitoring – Use infrared heat guns and cameras to detect hot spots and unusually high oil and component temperatures. Machines with resistance temperature detectors (RTDs) and temperature gauges can report important temperature excursions on the oil, coolant and bearing metal (thrust, journal, etc.).

Oil Level Change – Contaminants such as fuel, process chemicals and even water can sharply change oil viscosity when they enter the oil. This can often be viewed as a sudden rise in the oil level at gauges and sight glasses.

Stressed Frictional Surfaces – Cylinder walls, journal bearings, gear teeth and cams are examples of machine surfaces that can frequently be inspected periodically for abnormal wear from oil or viscosity starvation.

Out-leakage – A sudden lowering of oil viscosity can sometimes increase leakage across multiple points.

LUBRICANT STARVATION VS. VISCOSITY STARVATION

The dangers of lubricant starvation have been discussed extensively in *Machinery Lubrication*. This condition describes machines and critical surfaces that receive an inadequate supply of oil or grease. Viscosity starvation is different. The amount of lubricant may be adequate, but the load-bearing ability of the lubricant is impaired by thin oil. Keep both forms of starvation in focus with your condition monitoring program. ■

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.

JEREMY WRIGHT | NORIA CORPORATION

Why Your LUBRICATION PROGRAM Needs a CHAMPION

In my years of traveling the globe and assessing lubrication and reliability programs, I have noticed that every successful program has a clearly defined project champion. This person is the individual within a program who takes on the burden of ensuring that everyone involved is on board and behind the ultimate success of the project.

Champions greatly reduce the likelihood of a project's failure. They are on the front lines and in direct communication with the entire team at all times. In essence, they are the guardians of the project. Their passion should be infectious because the tasks often cannot be completed alone. Champions must inspire, rally, encourage and motivate the team to successfully complete the project.

CHAMPION RESPONSIBILITIES

Identify Strategic Objectives

Champions must fully understand all the intricacies of the project so they can easily convey the "why" to others. They should also be able to answer the "what's in it for me?" question for every team member involved.

Convey the Vision

Champions work with the team to ensure the project's vision is successfully conveyed. They need to be able to lead the group to a common goal. Conveying what success looks like and making sure the team members all share the same vision will help increase the project's efficiency.

Implement Best Practices

Change in an organization is difficult. The champion needs to know exactly what the best practices entail and should always be pushing toward those

> *The champion's role is important not only to the success of individual projects but also to the organization as a whole.*

practices. If incorrect practices are implemented, it becomes nearly impossible to initiate change again in a short timeframe.

Identify and Eliminate Obstacles

Champions must identify and eliminate obstacles that may threaten the project's viability within the organization. Knowing the expected roadblocks and being proactive in generating solutions for them when they arise can be extremely valuable and will increase the likelihood of the program's success.

49%

of lubrication programs have a true champion, according to a recent survey at MachineryLubrication.com

Prioritize Project Phases

These programs consume time, money and energy. Understanding where the biggest bang for your buck is and being able to prioritize are important qualities of a champion.

Relay Updates

Communication plays a vital role in a program's success. Keeping the stakeholders well-informed will allow the program implementation to progress much more smoothly.

Allocate Resources

There is nothing more detrimental to a project than having the will and want with no resources. These resources are typically related to time, money or energy. If they are not carefully planned, scoped and allocated, the program will find an early demise.

TRAITS OF A SUCCESSFUL CHAMPION

Having met a number of champions over the years, I have found that they are incredible people who possess a variety of common traits, including the following:

Understanding of Tribology and Reliability

This subject matter takes years to master, and the sheer volume of material requires a champion to be passionate enough to want to continually learn.

Excellent Communication

Being able to bridge the gap in communication between upper management and plant-floor operations is a tough skill to learn. A champion should understand each group's needs and wants as well as have the ability to speak to both in terms of what's important to them.

Organized

Just as a train conductor must keep all the trains running on time, a champion must be able to juggle multiple projects within the program, making sure that efficiency is kept high and waste is minimized.

Motivational

Gaining buy-in is a major contributor to program success. Knowing how to most effectively motivate team members on both sides of the operation (management and skilled labor) is a critical role of a champion.

Negotiation

As with most things in life, there is always a trade-off. Being able to understand the trade-off and negotiate the best possible outcome for the company can be a valuable trait for a champion.

Problem-solving

There will be many obstacles on the path to program success. Possessing the ability and resourcefulness to navigate these obstacles is rare because the obstacles are often broad in scope. They may range from engineering problems to the culture or personnel.

I have witnessed great initiatives with all the proper resources fail because there was no champion. Someone may have been placed in charge, but it wasn't a true champion. These individuals were hired to do a job that had certain tasks. Even though they might have been successful in performing those tasks, the program was ultimately a failure.

On the other hand, I've seen underfunded and understaffed initiatives thrive because there was a proper champion. What's so special about these people that could literally sway companies from one extreme to the other? What they possess has the aura of a "secret sauce." Although I don't know all the ingredients to this secret sauce, I do know that a large part of it is passion. You can tell just by having a simple conversation with these people. You can see it when they describe their role at the company. You can witness it in the way they carry themselves during their day-to-day activities. It becomes infectious. That's how you know you have a true champion for your program.

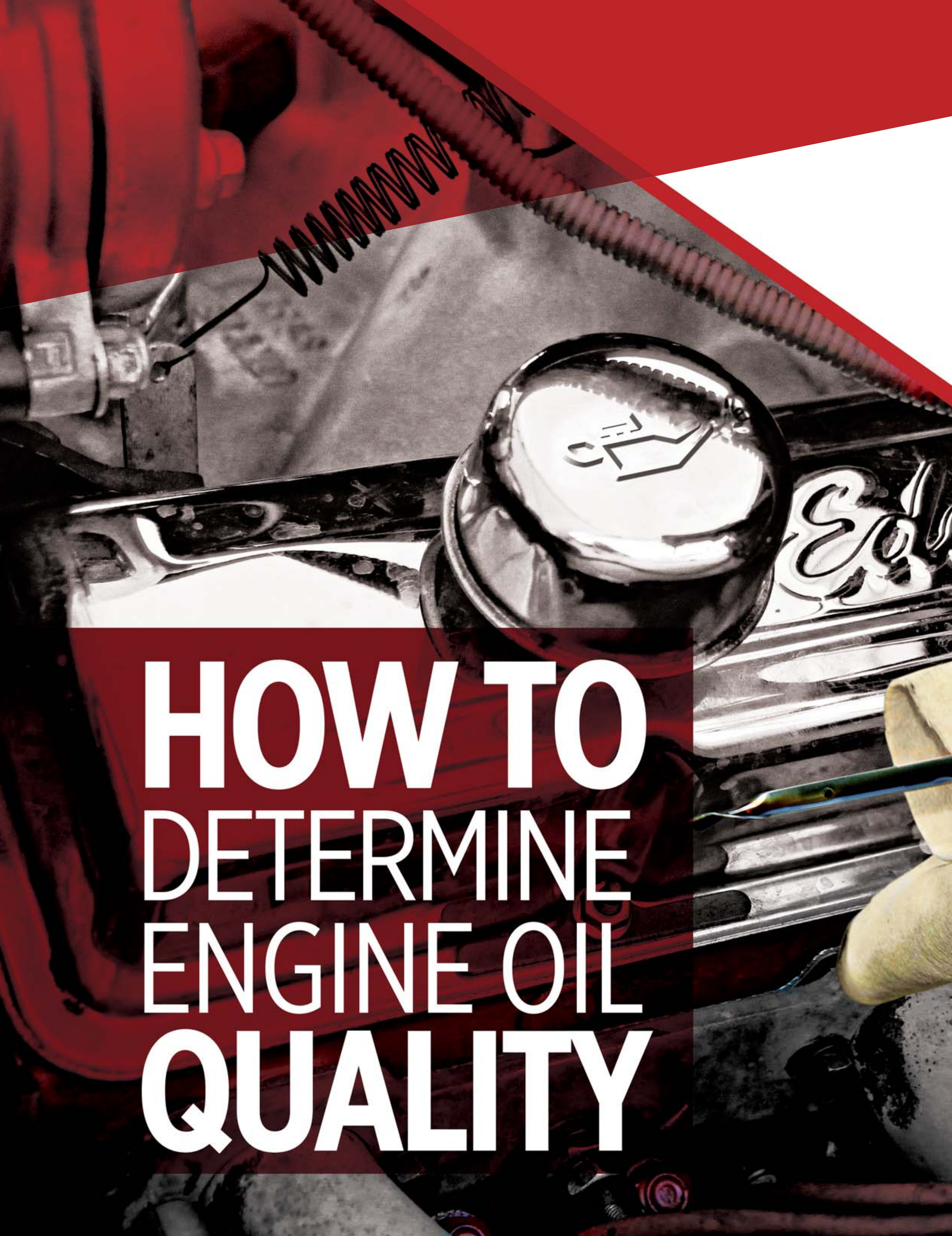
As much as I hate to admit it, consultants can't be your champion. They can be essential contributors, they can show passion, and they can perform all the activities that can help you be successful, but they can't be your champion.

Relying on consultants offers many advantages, including benefiting from their knowledge and experience in implementing a program. More often than not, the program will get up and running almost flawlessly. The problem comes down the road. If no one at the plant buys in or feels that they are part owner of the project, the likelihood of sustaining success will diminish over time.

The solution in these cases has been a champion for hire. These individuals are trained professionals who possess a wealth of knowledge and passion and hold many of the keys to unlocking the path to a successful program. They are transplanted into the program in its infancy stage but are not consultants. They live at the site and become a part of the culture and workforce. I have found that they can increase the probability of success to the point where it can almost be guaranteed.

About the Author

Jeremy Wright is the vice president of technical services for Noria Corporation. He serves as a senior technical consultant for Lubrication Program Development projects and as a senior instructor for Noria's Machinery Lubrication I and II training courses. He is a certified maintenance reliability professional through the Society for Maintenance and Reliability Professionals, and holds Machine Lubricant Analyst Level III and Machine Lubrication Technician Level II certifications through the International Council for Machinery Lubrication. Contact Jeremy at jwright@noria.com to learn how Noria can help you find a champion for your lubrication program.



HOW TO DETERMINE ENGINE OIL QUALITY

By Tina Dasbach and Theodore W. Selby

While most engine oils are made to acceptable standards, their general and specific qualities can vary widely. Poor-quality engine oils are often put on the market due to ignorance or greed. Unfortunately, for the uninformed automobile owner, a high-quality engine oil and one of poor quality will look and feel the same.

Engine and Bench Tests

The engine has always been the ultimate platform for identifying the required quality of its oil. Even as engine design has changed to meet performance, fuel efficiency and environmental standards, the engine continues to be the ultimate arbiter of oil quality. However, using the engine to measure oil quality in dynamometer tests can be an expensive proposition. Even so, to help control warranty costs, the development and use of engine tests is unavoidable for engine manufacturers when determining the oil quality needed for a particular design or component.

Although necessary, generating repeatable dynamometer tests for an engine can be challenging. As engine design has progressively increased power from smaller engines, the difficulty of establishing repeatable dynamometer tests has grown even more rapidly. Fortunately, once the quality level has been determined on the dynamometer or in the field, there is a much less expensive approach that can be applied to more precisely appraise the oil quality. This involves using laboratory bench tests designed to correlate closely with engine dynamometer tests or field experience. These bench tests have the capability of providing a relatively inexpensive measure of oil quality. However, the value and significance of this type of test is dependent on a number of factors, including identification of the engine's specific needs, clear and consistent information from the engine either Newtonian in flow characteristics, as the viscosity was found to decrease with increasing shear rate. This was considered important in lubricating engines that operated at high shear rates (as measured in millions of reciprocal

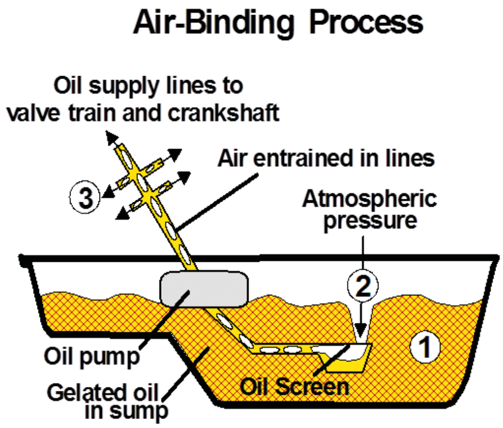


Figure 1. This graphic shows (1) structured oil, (2) a "hole" pulled in gelated oil to an operating oil pump by atmospheric pressure, and (3) air being pumped to the engine's lubrication sites.

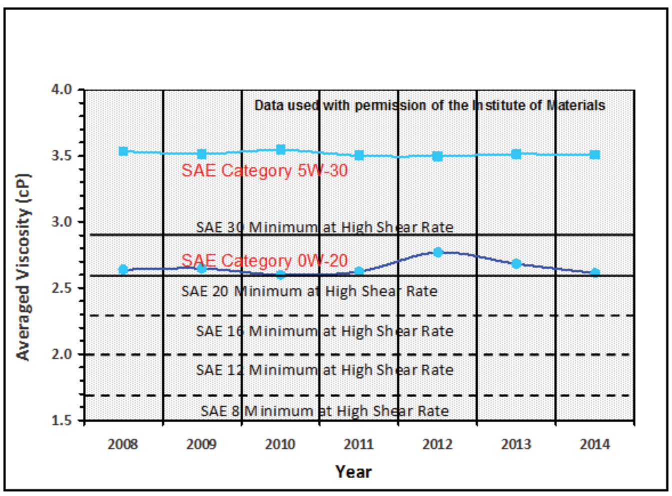


Figure 2. Engine oils at high shear rate and 150 degrees C

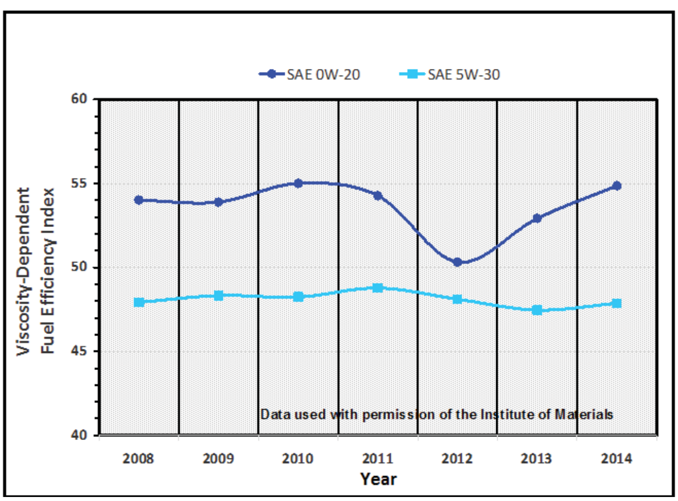


Figure 3. Engine oil viscosity's effect on fuel efficiency

seconds), in contrast to the several hundred reciprocal seconds of the low-shear viscometers then being used to characterize engine oils.

High Shear Rate Viscometry

Consequently, the need arose to develop a high shear rate viscometer to reflect the viscosity in engines under operating temperatures. In the early 1980s, an instrument and a technique were developed that could reach several million reciprocal seconds at 150 degrees C as well as exert high shear rates at other temperatures on both fresh and used engine oils. The instrument was called the tapered bearing simulator viscometer. The technique was accepted by ASTM as test method D4683 for use at 150 degrees C (and more recently as D6616 for use at 100 degrees C). This critical bench test of engine oil quality became known as high temperature, high shear rate (HTHS) viscosity. Minimum limits were then imposed for various grades in the SAE viscosity classification system.

Interestingly, it was later shown that this instrument was unique and basically absolute in providing measures of both shearing torque or shear stress and shear rate while operating. It is the only known viscometer capable of doing this.

Viscosity and Oil Gelation at Low Temperatures

Multigrade engine oils were originally introduced to reduce oil viscosity at low temperatures to aid in engine startup. This important benefit was immediately apparent, and multigrade oils have since become the most popular form of engine lubricant around the world.

With easier engine startability at low temperatures, another problem became evident — oil pumpability. This was a considerably more serious issue, as lack of oil pumpability could destroy the engine. In cold-room dynamometer tests, it was determined that there were two forms of the pumpability problem. The first was simply related to high viscosity and called flow-limited behavior. The second was less obvious and involved the gelling of the oil under a long, deep cooling cycle. This was labeled "air-binding," since the oil pump became air-bound as the result of a column of oil being pulled from the sump and the oil not filling this void, as shown in Figure 1.

This knowledge and bench test, which initially seemed to predict both forms of failure, were not enough. In the winter of 1979-80 in Sioux Falls, South Dakota, a cooling cycle showed that air-binding could occur under relatively mild cooling conditions. Over a 24-hour period, a number of engines containing oil were ruined. The cooling cycle had produced a condition in which the oil became air-bound. The costly incident revealed the need for a more sensitive bench test that would accurately predict the tendency of air-binding pumpability failures.

Gelation Index

The air-binding engine oil that caused the Sioux Falls failures provided a solid case study. A new bench test instrument and technique were developed to indicate any tendency of the test oil to gelate. The technique, which involved continuous low-speed operation of a cylindrical rotor in a loosely surrounding stator, was immediately incorporated into engine oil specifications and later became ASTM D5133. This not only showed the oil's tendency to become flow-limited but also specified the degree of gelation that might occur over the measured temperature range (typically minus 5 to minus 40 degrees C). The parameter was called the gelation index. Today, engine oil specifications for multigrade oils require a maximum gelation index of 12.

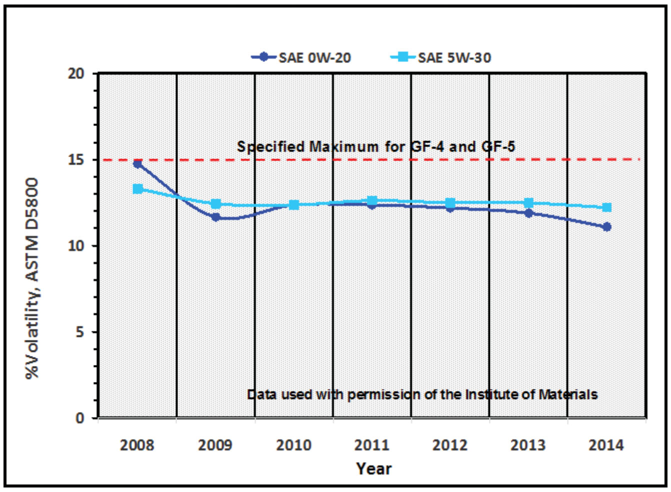


Figure 4. Volatility of SAE 0W-20 and 5W-30 engine oils

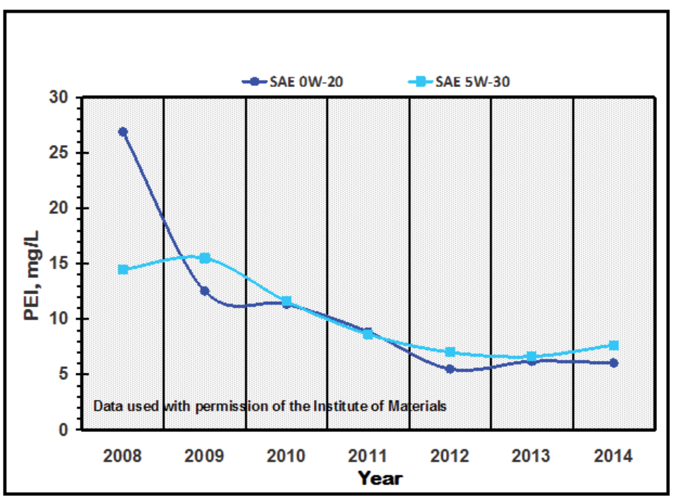


Figure 5. Phosphorus emission index generated in Selby-Noack volatility bench test

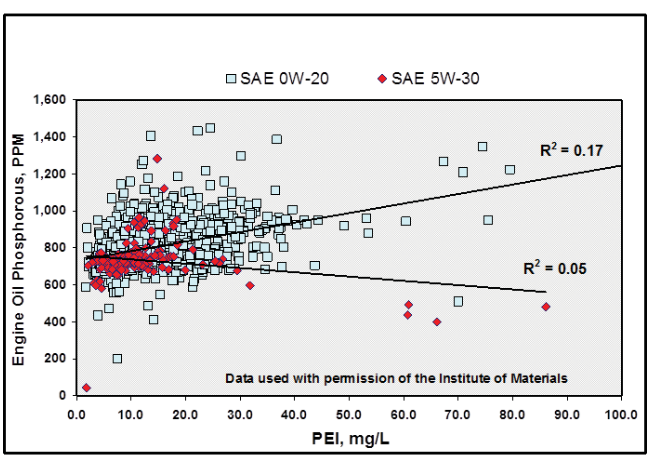


Figure 6. Phosphorus content of engine oil and PEI

Viscosity and Energy Absorption

As beneficial as viscosity is to the engine in preventing wear through hydrodynamic lubrication, it also has some negative aspects that can affect the engine's operating efficiency. The oil's molecular friction, which separates two surfaces in relative motion, requires energy to overcome it. This is a significant amount of energy from the engine in exchange for the provided wear protection. Therefore, careful formulation of the oil viscosity is critical to vehicle owners and to governments mandating fuel economy limits. Lowering oil viscosity can be an important step in reducing viscous friction to improve fuel efficiency. Interestingly, over the last several years, there has been an increase in the number of automobiles operating with engine oils that have lower viscosity levels, thus markedly improving their engine efficiencies.

A decade ago, the lowest SAE viscosity grades were SAE 0W-20 and 5W-20 oils, with SAE 20 carrying the minimum high shear rate viscosity of 2.6 centipoise (cP) to simulate engine operation at 150 degrees C. Figure 2 shows data from engine oils sold in North and South America as well as for SAE 5W-30 engine oils.

Japanese automakers have recently called for even lower viscosity grades. As a consequence, the SAE has introduced three new operating grades identified as SAE 16 (2.3 cP minimum at 150 degrees C), SAE 12 (2.0 cP minimum at 150 degrees C) and SAE 8 (1.7 cP minimum at 150 degrees C). These grade requirements are also shown in Figure 2 for comparison. None of these lower grade oils has yet to reach the market for analysis. Since viscosity is directly related to the amount of energy expended by the engine for wear protection through hydrodynamic lubrication, such a decrease in viscosity would be expected to have important benefits in fuel efficiency but only in engines designed for their use.

Viscosity-dependent Fuel Efficiency Index

Given the influence that oil viscosity has on the engine, a technique was developed to calculate the effects of engine

Engine Oil Database

Thirty years ago, based on concerns expressed by engine manufacturers about the quality of some oils, the Institute of Materials (IOM) began to compile an engine oil database. Engine oils were collected directly from the market and analyzed by selected laboratories through a series of bench tests. The results were then published. The database, which is available at www.instituteofmaterials.com, now covers more than 14,000 engine oils worldwide.

The quality of engine oils will play a much greater role in the smaller, more powerful turbocharged engines that are entering the automotive market.

oils on fuel efficiency. To be meaningful, the viscosity values had to be obtained at the high shear rates associated with operation in specific sections of the engine.

Earlier dynamometer work had identified the percentage of friction and operating temperature of the five main lubricating sites in a reciprocating gas-fueled engine responsible for nearly all efficiency loss. This information was used to develop the viscous fuel efficiency index (V-FEI) parameter. With this value, which ranges from 0 to 100, the higher the V-FEI of a given engine oil, the less energy is lost to viscosity, and consequently, the more fuel efficient the engine is. Although different engine designs may have different levels of friction in the essential lubricating areas, use of this friction data provides a comparative value for engine oils.

Figure 3 shows the average value of SAE 0W-20 and 5W-30 engine oils from the North and South American markets from 2008 to 2014. For comparison, the average V-FEI for SAE 0W-20 and 5W-30 in an earlier study was 46 and 47 respectively.

As expected, it was determined that the yearly averaged multigrade SAE 0W-20 oils contributed more fuel efficiency to the engine than did the averaged multigrade SAE 5W-30 oils because of the viscosity differences shown in Figure 2. With the exception of 2012, the increase in V-FEI is equivalent to nearly 7 to 8 percent in viscosity-dependent fuel efficiency. The decrease shown in the average fuel efficiency of SAE 0W-20 engine oils collected in 2012 may indicate the development of formulations meeting automakers' concerns that the benefits of hydrodynamic lubrication will not be lost in efforts to improve fuel efficiency.

Engine Oil Volatility

Another aspect to consider when reducing the viscosity in engine oil formulations is that such a reduction is most frequently obtained by using base oils with higher volatility. Volatized oil reduces the amount of lubricant serving the engine and may carry exhaust catalyst-contaminating components, negatively affecting the catalyst's smog-reducing ability. The oil remaining after the loss of the more volatile components will also be more viscous and energy-absorbing.

Figure 4 shows the response of two of the most volatile multigrade engine oil classifications. Also shown is the specified maximum volatility set by the International Lubricant Standardization and Approval Committee (ILSAC). In the last few years, it is evident that the SAE 0W-20 and 5W-30 classification categories were designed to meet the ILSAC volatility specification by a comfortable margin. These results suggest that volatility control may be less demanding with the more recently classified multigrade oils identified as SAE 0W-16, 0W-12 and 0W-8.

Phosphorus Emissions and Volatility

Soluble phosphorus compounds such as zinc dialkyldithiophosphate (ZDDP) have been used in formulating engine oils for many years. These anti-wear and antioxidation compounds have provided considerable support to the design of modern engines.

In the mid-1900s, the reciprocating engine was identified as a major contributor of air pollution. Unburned or partially burned hydrocarbons from the engine exhaust were modified by sunlight into noxious gaseous hydrocarbons, which produced smog in some large cities. As a consequence, exhaust catalytic converters were developed in the 1970s to treat the exhaust gas and convert it into carbon dioxide and water. Unfortunately, in the years following the catalytic converter's development, it was discovered that certain elements in gasoline or engine oil, including phosphorus and sulfur, would deactivate the catalyst by coating it. This ultimately led to restrictions on the quantity of these chemicals in engine oil and fuel.

Phosphorus Emission Index

The Selby-Noack volatility test was developed in the early 1990s as a better and safer approach for determining engine oil volatility. It collected the volatile component of the volatility test for further analysis, which was helpful in detecting phosphorus and sulfur. In the first analyses of volatiles collected from the bench test, it was apparent that the phosphorus additives in the engine oils were also producing phosphorus through additive decomposition. On the basis of these findings, a parameter related to the amount of phosphorus released during the test was developed called the phosphorus emission index (PEI).

Figure 5 shows the change in PEI over the last eight years. It is evident that considerable progress has been made in reducing the phosphorus decomposition and/or volatility of these two multigrade SAE classifications. The reduction of the PEI to 6 to 10 milligrams per liter of engine oil is a significant change in protecting the catalytic converter from the effects of phosphorus.

With the trend toward smaller, fuel-efficient and turbocharger-equipped engines generating higher temperatures during operation, a bench test that can reveal an oil formulation's phosphorus emission tendencies would be useful in designing lubricants best suited to the engine and the environment.

Phosphorus Content and Volatility

How much influence the phosphorus in an engine oil has on the amount of phosphorus volatilized during engine operation is an important question affecting the choice of additives in oil formulation. Figure 6 shows the phosphorus content in a number of SAE 0W-20 and 5W-30 engine oils vs. the PEI values obtained. The data reveals that phosphorus volatility generated by the Selby-Noack test is virtually unrelated to the amount of phosphorus present in the oil as an additive. The lack of correlation between the phosphorus in the engine oil and the amount of phosphorus volatilized is evident in the low correlation coefficient (R^2) values. This parameter would be near a value of one if phosphorus concentration affected its volatility. As shown in Figure 6, the values obtained from the data are much lower, with R^2 at 0.05 for SAE 0W-20 and 0.17 for SAE 5W-30 engine oils.

The PEI data are primarily clustered at values from 2 milligrams per liter to about 30 milligrams per liter. However, a small number of PEI values exceed 40 milligrams per liter. These engine oils are likely to be more harmful to the exhaust catalyst. However, as has been shown in Figure 5, PEI levels have been decreasing markedly over the last few years.

Without question, the quality of engine oils will play a much greater role in the smaller, more powerful turbocharged engines that are entering the automotive market. However, it is essentially impossible to establish the quality of an engine oil by appearance. This determination can only be made by using the oil or pre-testing it. Obviously, the latter is the much preferred option for automobile owners, who have a significant investment in and need for a well-functioning and durable engine.

BY AL SMILEY, GPM HYDRAULIC CONSULTING

The Safety Dangers of Hydraulic Accumulators

What do you normally cover in your plant's safety meetings? Personal protective equipment, chain guards, safety harnesses and lockout-tagout procedures are common topics. When was the last time hydraulic accumulators were discussed? If your plant is like most, the answer is never. Why? In most plants, maintenance, production and safety managers are not aware of the dangers. Nevertheless, accumulators can present a safety hazard if the potential risks are not understood.

Accumulator Function and Pre-Charging

An accumulator is a storage device in a hydraulic circuit. It is the hydraulic equivalent of a capacitor in an electrical circuit. The two most common kinds of accumulators are the bladder and piston types. The bladder (Figure 1) is nothing more than a rubber balloon that separates the hydraulic oil from the dry nitrogen. Dry nitrogen is used to fill the inside of the bladder to a pre-charge level. The nitrogen pre-charge is usually half to two-thirds the maximum pressure in the system.

When the pump is turned on, the nitrogen is compressed to the maximum pressure in the system. The setting on the pump compensator spring will determine the maximum pressure when a pressure-compensating pump is used. The relief-valve setting controls the pressure in a fixed-displacement pump circuit.

In Figure 2, the bladder accumulator has been pressurized to 2,000 pounds per square inch (psi).

The piston in a piston-type accumulator (Figure 3) separates the nitrogen from the hydraulic oil. When oil is ported into the accumulator, the piston will rise until the maximum pressure is reached. The hydraulic and nitrogen pressures will be equal at that time.

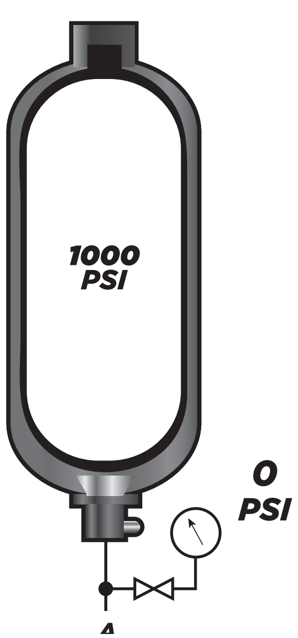


Figure 1. Bladder accumulator

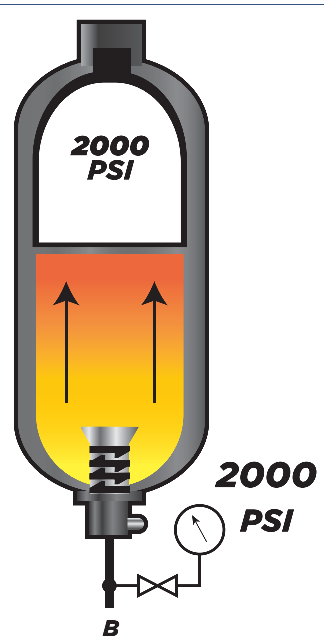


Figure 2. Bladder accumulator pressurized to 2,000 psi

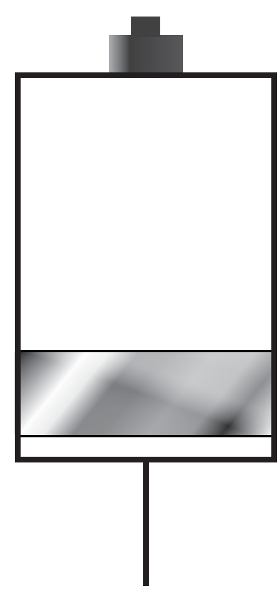


Figure 3. Piston-type accumulator

When the pump is turned off, the pressurized fluid in the accumulator must be released back to the tank. This is accomplished by an automatic or manual dump valve. If this pressurized fluid is not bled back to the tank through the dump valve, the accumulator will remain pressurized. The accumulator then becomes a one-shot hydraulic pump. If a valve were to inadvertently shift, then the pressurized fluid would be directed to operate the cylinder or hydraulic motor. This results in the load moving, which can be hazardous or deadly to maintenance or operations personnel.

Automatic Accumulator Dump Valves

Many systems incorporate automatic dump valves. These valves are operated either hydraulically or electrically. A common type of electrical dump valve is illustrated in Figure 4. When there is no electrical power to the solenoid, the valve spring shifts the spool to the open position as shown. This allows any pressurized oil in the accumulator to return to the tank. The solenoid on the valve is usually wired into the electric motor starter. When the motor is started, voltage is applied to the valve solenoid, causing the valve spool to shift closed. Flow from the pump and accumulator is then blocked back to the tank.

So if your systems incorporate automatic dump valves, why should you be concerned? Because like any other hydraulic component, these valves can fail. The valve may fail open, causing a loss of speed, or fail closed, maintaining the accumulator in a pressurized condition.

Consider what happened at one plant several years ago. This system had an electrically controlled dump valve that opened once the pump was turned off. Two cylinders were mounted on the machine to extend and retract two large chipping heads. When the machine was shut down, the operator would frequently change the knives on the chipping heads. The operator followed all the mill's safety procedures for locking and tagging out the machine. There was no written procedure for checking the gauge at the accumulator to verify that the pressure inside the accumulator had been released back to the tank through the dump valve. If the operator would have looked at the gauge in this particular instance, he would have seen that 1,500 psi were still locked in the hydraulic lines. What he did not know was that the accumulator dump valve had failed closed.

While the knives were being changed, a co-worker crawled over the in-feed conveyor, making a photo eye. An electrical signal was then sent to the programmable logic controller (PLC), indicating that a log was on the conveyor. The PLC then sent a current signal out for the chipping head valves to shift. The accumulator discharged oil to the cylinders, which extended the chipping heads, crushing the operator. Had the operator been instructed to verify that the hydraulic pressure had bled down to zero psi when the machine was turned off, he might be alive today.

Figure 5. A mislabeled accumulator

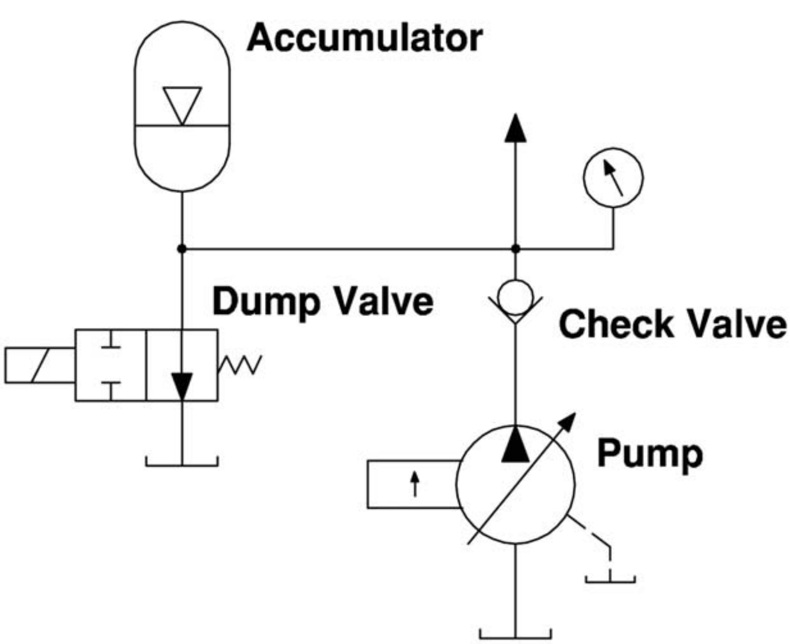


Figure 4. An electrical dump valve

Manual Dump Valves

Other systems have only a manual valve that must be opened to bleed the pressurized fluid in the accumulator back to the tank. In this case, all individuals working on or around the machine must know where the valve is located and that it should be opened. How much training does a new millwright or electrician get in your plant regarding hydraulic safety? Normally, little or nothing is said about releasing pressure in hydraulic accumulators.

One company hired a new mechanic who was being trained on the job by a Class I mechanic. The Class I mechanic

Figure 6. A breakdown of the accumulator minus the bladder

failed to tell the trainee about opening a manual dump valve prior to working on a particular machine. When the Class I mechanic was on vacation, the trainee had to change a cylinder on the machine. After he loosened the fitting on the hose at the cylinder, 2,800 psi discharged from the line. His safety glasses were knocked off, and oil was injected into his eye. As a result of the accident, he now wears a special lens due to the 40-percent vision loss. If a written procedure to achieve a zero-energy state had been in existence, this accident would not have occurred.

Dry Nitrogen or Air?

Accumulators should always be charged with dry nitrogen, never oxygen or compressed air. While technically not an "inert" gas, dry nitrogen does not react readily with other chemicals. Oxygen and compressed air aid combustion. Most accumulators have a safety sticker on the shell warning that only nitrogen should be used for pre-charging.

A few years ago, one of our consultants was working with a plant and located an accumulator labeled "Danger: Compressed Air," as shown in Figure 5. This was discovered only two days after an inspection of the plant by the Occupational Safety and Health Administration (OSHA). Why would anyone put this sign on an accumulator? Could it be because many people have a well at their homes with an accumulator that is pre-charged with air? The person who placed this sticker on the accumulator most likely thought that the Schrader valve used to refill with nitrogen looked very much like the accumulator in his well system, bicycle or car tire.

Also, notice that the actual warning sticker applied by the accumulator manufacturer is covered up by the piece of wood underneath the chain clamp. Fortunately, compressed air had never actually been used in the accumulator. If someone had ever filled it with compressed air, as the sticker suggests, the bladder could have ruptured, and the result would have been an explosion or possibly a fire at this plant. Needless to say, our consultant had this sticker removed immediately.

Mounting and Removal

An accumulator should be properly clamped to the mounting fixture. Figure 6 shows a breakdown of the accumulator minus the bladder. When assembling the accumulator after bladder replacement, the retainer ring is fitted around the outside of the poppet valve, and both are inserted into the accumulator shell. If the accumulator shell is not properly clamped, then failure of the retainer ring can cause the poppet valve to disconnect from the accumulator. This can result in the shell taking off like a rocket. Figure 7 shows a properly clamped accumulator.

Prior to removing and storing an accumulator, the nitrogen pressure should be released and the protective cap installed over the Schrader valve. One plant only had a single accumulator. Every time the accumulator needed pre-charging, it was removed, placed in a pickup truck and driven to the nearest shop. If the Schrader valve had broken off or the retaining ring failed during transport, the accumulator could have acted as an unguided missile.

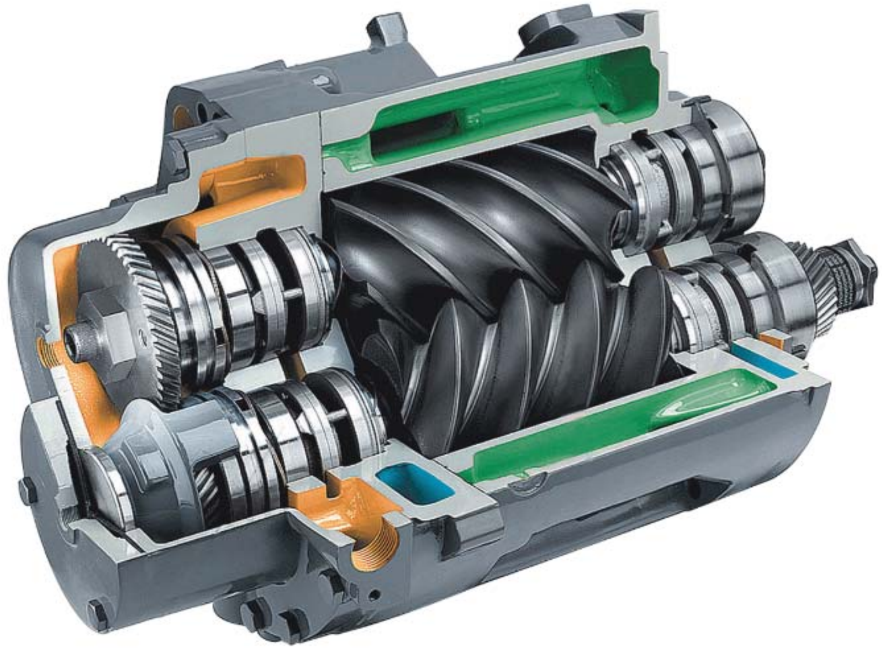
Most workers are not aware of the dangers of accumulators. Don't wait until someone is injured or killed in your plant to educate your personnel.

Figure 7. A properly clamped accumulator

WES CASH | NORIA CORPORATION

SECRETS FOR REFRIGERATION COMPRESSOR LUBRICATION

Compressors are very sensitive components that must be properly lubricated in order for them to achieve a long service life. The lubricant not only must be able to lubricate all the parts inside the compressor but also handle the refrigerant with which it is in contact (in the case of refrigeration and air-conditioning compressors). Some lubricants work better with certain refrigerants, and this must be balanced with the needs of the compressor in order to select the proper base oil and additive properties. By understanding how lubricants flow with refrigerants, as well as the requirements of the lubricant, you can ensure your compressors will run as efficiently and effectively as possible.



How Compressors Work

The function of a compressor is fairly simple. A gas enters the compressor at a low pressure, where it is compressed, and then leaves at a higher pressure. There are several byproducts to this compression, with the most common being heat and moisture. These byproducts are very detrimental not only to the health of the machine but also to the health of the lubricant.

With proper care and attention, the compressors in your refrigeration systems can provide years of trouble-free service.

While compressors can be used in a number of different applications, this article will focus primarily on compressors in refrigeration or heating, ventilation and air-conditioning (HVAC) systems. Within these applications, the refrigerant system is typically sealed and closed loop. The majority of these systems require the loop to be vacuumed prior to being charged with a refrigerant. By pulling these lines into a deep vacuum, the moisture inside the lines is boiled out and removed, keeping the system as dry as possible. This helps reduce the amount of water that is produced as a result of the compression process.

Compressor Types

As with most machines, compressors come in a variety of types based on the application. Generally, the refrigerant or the required volume of cooling capacity will determine the kind of compressor that is needed. There are three main types of compressors used with refrigerants: reciprocating, rotary and centrifugal.

Reciprocating compressors function in a similar manner as a car engine. A piston slides back and forth in a cylinder, which draws in and compresses the low-pressure refrigerant, sending it downstream at a higher pressure. Frequently, reciprocating compressors are multiple-stage systems, which means that one cylinder's discharge will lead into the input side of the next cylinder. This allows for more compression than a single stage. These compressors have many lubricated parts, such as cylinders, valves and bearings.

Rotary compressors normally use a set of screws or vanes to draw in the gas and compress it in the compression chamber. This could be compared to the function of a vane pump. Like reciprocating compressors, these systems have a variety of lubricated components, including gears, bearings, valves, etc.

Centrifugal compressors utilize the rotational motion of the drive to rotate a series of impellers, which will provide the compression action. These systems often are rotating at several thousand revolutions per minute. The lubricant must be thin enough to lubricate properly at these speeds but also thick enough to handle the heat and refrigerant contamination that can occur.

With all of these compressor systems, the lubricant's base oil, additives and viscosity grade must be carefully selected. Compatibility with the refrigerant being compressed is perhaps the most important factor in choosing a base oil, as not all lubricants can handle this type of contamination. The additive package usually must have some anti-wear properties as well as demulsibility in the event of moisture contamination. The viscosity is variable depending on the load, speed and temperature at which the compressor will operate.

Understanding Refrigeration

Refrigeration has revolutionized many industries. Nearly every plant uses some sort of refrigeration, whether to help remove heat or simply for the comfort of the employees. How the cooling cycle works is quite simple. It involves the ideal gas law and how gases undergo a change in temperature when they are subjected to a change in pressure. The compressor acts as a pump to circulate the refrigerant. The refrigerant leaves the compressor as a high-pressure gas and moves into a condenser. Here, the gas is condensed into a liquid, which will then flow through a pipe until it reaches a metering device. This metering device is often referred to as a thermal expansion valve, piston or orifice. Basically, it necks down the opening in the line and causes a large pressure drop on the back side. As the pressure drops, so too does the refrigerant's temperature.

Immediately after the metering device is the evaporator. This is where the heat transfer occurs. The air passing over the evaporator is warmer than desired. The heat in the air is absorbed by the refrigerant in the evaporator and then transported back to the condenser where it is removed. The compressor is what causes this movement.

Perhaps you've heard the expression that air conditioners or refrigerators don't cool but actually move heat. This is exactly how the cycle works. Heat is moved from an area where it is not wanted to an area where it can be released. You can experience this effect on a hot summer day by walking to your outside air-conditioning unit (the condenser). The air coming out of the condenser's top will be hotter than the ambient air.

Types of Refrigerants

Refrigerants must be able to absorb and transfer heat. There are several types of refrigerants, which are selected based on the desired temperature. Refrigerants must be able to readily change states from a liquid to a gas. This change of state is what allows for the sudden temperature drop after moving through the metering device. Depending on the refrigerant used, you can achieve very low temperature refrigeration or simply basic cooling capacity.

Perhaps the most prominent types of refrigerants are the hydrocarbon-based series. These are similar to what you

The History of Refrigeration

The refrigeration process dates back to the mid-1700s when experiments were conducted on how ice could be produced. The technology was perfected in the 1800s, and modern refrigeration was born. This allowed for the cooling or freezing of liquids and foods, which enabled them to be preserved longer. With some adaptation, these small refrigeration systems could be used to cool rooms in hospitals and homes to help the sick be more comfortable. This also had a huge impact on food and beverage companies, which previously had relied on tons of ice to provide the same cooling function.

would purchase for your house or car. They are often referred to by names such as R-22, R-134a, etc. Ammonia is another common refrigerant employed primarily in industrial facilities. It performs well and can achieve low temperatures for cooling or freezing. All told, there are dozens of different refrigerants composed of chlorofluorocarbons (CFC), hydrogen-containing CFC (HCFC), and hydrogen fluorine and carbon compounds (HFC), as well as combinations of each.

Compressor Lubricants

Lubricants perform several functions in a compressor system. Of course, they must be able to lubricate the machine. In some systems, the lubricant is required to act as a cooling fluid as well as a sealant. This is why it's important to select the proper lubricant for your compressor. When in doubt, check with the manufacturer about the correct oil for the system.

Compressor lubricants are often a specialized blend of additives and base oils in order to provide the necessary lubricating properties while still being compatible with the refrigerant. Any incompatibility of the base oil and the refrigerant could have disastrous results for the equipment.

The majority of compressor lubricants are synthetic. This allows them to have a longer service life and handle the rigors of the system better than mineral-based fluids. Most home air conditioners now use a blended refrigerant known as R-410a. A polyolester (POE) base oil is employed to help lubricate the system, but this oil can also separate from the refrigerant.

Although the compatibility between the refrigerant and the lubricant is perhaps the most pressing issue in terms of lubrication, there are many others as well. For instance, moisture contamination can be very detrimental to some synthetic base oils that are hydrolytically unstable. Moisture reacts with the base oil to form acids, change the viscosity and impair the oil's lubricating properties. This can lead to premature compressor failure as well as improper system cooling.

Lubricant problems are common in any system. One way to avoid having issues with the gases being compressed is to simply remove the lubricant from the equation. This is a frequent occurrence with the "dry" compressors becoming more widely used. "Dry" refers to the lack of oil in the compression chamber. If the lubricant is not in the compression chamber, it is much less likely to mix with the refrigerant and cause problems. However, in wet or flooded compressors, the oil is present in the compression chamber and mixes intimately with the refrigerant. In these systems, the lubricant's compatibility with the refrigerant is paramount.

67%

of lubrication professionals say oil samples are taken periodically from the compressors at their plant, based on a recent poll at MachineryLubrication.com

Many large compressors utilize a forced lubrication system, which features an oil reservoir, piping and a pump. The pump forces the oil through the piping and into the compressor where it lubricates and cools and then returns back to the reservoir. These systems enable you to filter, cool and separate gases and water from the oil while it is in service.

Smaller compressors typically are static-housed lubricant systems in which the compressor holds the oil and the system is completely sealed. Provided it is cleaned and sealed before being put into use, this type of system has a low likelihood of lubricant failure. Most often these systems will run for years without needing an oil change. The oil sits in the compressor to lubricate it, but some of the oil will flow through the refrigerant lines. In certain cases, an oil trap or knockout must be employed to keep oil from clogging the lines and reducing the system's cooling capacity.

Oil Sampling

In industrial plants, compressor systems tend to be among the most critical machines. Therefore, it is important to obtain oil samples periodically to check the health of the lubricant and the machine. Among the oil analysis tests performed on these fluids include elemental analysis, viscosity analysis and wear debris analysis. The viscosity must be monitored because refrigerant dilution can lead to a decrease in viscosity and an increase in machine wear.

In some cases, oil samples must be degassed before they can be shipped to the laboratory or analyzed. Since the gas expands with temperature, it can result in a pressure increase in the bottle, causing a leak or the oil to erupt upon opening the bottle. While pressure-relieving caps can be used with these bottles, remember that every time you open the bottle, you expose it to contamination, which can affect your particle count results.

With proper care and attention, the compressors in your refrigeration systems can provide years of trouble-free service. When changing the oil in these systems, keep in mind that it must be compatible with the refrigerant and the fluid previously used in the system. Finally, try to keep each compressor sealed, clean, cool and dry. If you are able to achieve this, you will stay cool even when the temperature outside gets hot.

About the Author

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

Loren Green | Noria Corporation

WHEN AND HOW TO USE FRICTION MODIFIERS

The purpose of a lubricant is to reduce the amount of friction between two surfaces. In some cases, the base oil in the oil or grease may not have enough lubricity to perform this function sufficiently. The component metallurgy may also require special chemistry. For example, with worm gears, traditional extreme-pressure or anti-wear additives often are too chemically aggressive for the softer yellow metals. In this situation, friction modifiers are added to increase the oil's lubricity.

Conversely, in an automatic transmission, one fluid is used to provide lubrication, hydraulic power transfer and many other functions. The clutches and friction bands within the transmission need friction to function properly. In this instance, friction modifiers are required to smooth the transition from one speed to another. Otherwise, the clutches and bands would "chatter," causing damage and an irritating condition for the driver.

As fuel economy standards become more stringent, more will be required of engine oils.

ORGANIC FRICTION MODIFIERS

Mode of Action	Friction Modifier Products
Formation of reacted layers	Saturated fatty acids, phosphoric and thiophosphoric acids, sulfur-containing fatty acids
Formation of adsorbed layers	Long-chain carboxylic acids, esters, ethers, amines, amides, imides
Formation of polymers	Partial complex esters, methacrylates, unsaturated fatty acids, sulfurized olefins
Mechanical types	Organic polymers

OTHER FRICTION MODIFIERS

Type of Friction Modifier	Products
Metallo-organic compounds	Molybdenum and copper compounds
Mechanical types	Molybdenum disulfide, graphite, PTFE

A number of compounds are used to modify a lubricant's coefficient of friction. These are known collectively as friction modifiers. They are designed to change the amount of energy needed to cause two surfaces to move past one another. The different types of friction modifiers are shown in the table above.

The purpose of a friction modifier varies based on the application. In a combustion engine, the goal is to lower the amount of friction, thereby gaining fuel economy. In clutches, automatic transmissions and industrial applications, the aim is not simply to control friction in order to maximize efficiency but to reduce slippage. To a degree, this seems a bit counterintuitive, since a lubricant's objective is to reduce friction and wear. However, there are many situations in which a certain amount of traction friction is required for equipment to operate properly. The friction modifiers used in these applications are not intended to increase or decrease friction but to act differently under specific shear conditions. This essentially smooths the transition from a dynamic condition to a static condition, such as during a gear change in a transmission or the engagement of a clutch.

The vast majority of friction modifiers in use today are designed to reduce

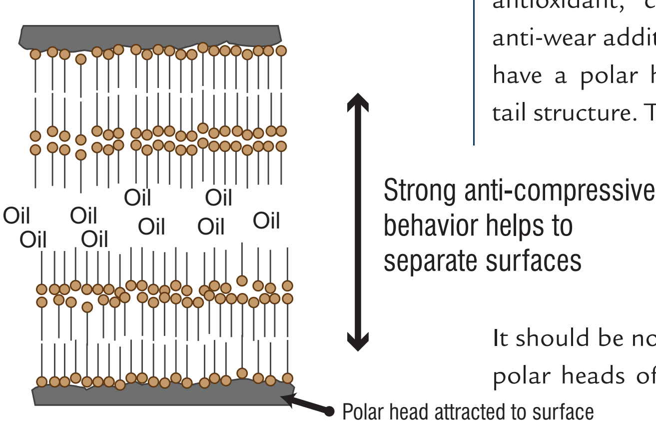
The Progression of Friction Modifiers

Friction modifiers in engine oils can be traced back to 1915. They were used first in differentials, wet-clutch applications and transmissions. Their use escalated considerably in the late 1970s. Fuel economy became very important during the oil embargo at that time, which triggered a significant shift in the automotive industry. This led to the introduction of friction modifiers in passenger car motor oils.

friction or increase lubricity for better fuel economy. Recently, the U.S. government increased fuel economy standards with the goal of raising the Corporate Average Fuel Economy (CAFE) to 54.5 miles per gallon. This number, which is double the current standard, is for gasoline engines only, but there is a similar push for diesel engines as well. One way to achieve this goal would be to reduce the viscosity of the engine oils in use. The challenge is lowering the viscosity while maintaining a sufficient lubricant film to reduce wear and friction.

Great strides have been made in engineering to lower the friction generated in an engine. This has increased fuel economy. There have also been many advances in lubricant technology, including in the development of friction modifiers.

Friction Modifiers



Friction modifiers are most efficient under boundary conditions or where metal-to-metal contact occurs. Organic friction modifiers have long, soluble chains and a polar head. The polar head attaches to the metal surfaces. The soluble chains line up beside each other much like fibers in a carpet. The polar heads may be comprised of phosphoric or phosphonic acids, amines, amides or carboxylic acids. The soluble chains form dense mono layers or thick, reacted viscous layers. These layers shear easily and create a relatively slippery surface.

Organic Friction Modifiers

Mechanical types of friction modifiers form layers of platelets that align with one another, providing a reduction in friction. The most common of these is molybdenum dithiocarbamate (MoDTC). These additives reduce friction by forming nano-sized single sheets dispersed in either a carbon or pyrite matrix. These nano-sized sheets are oriented in layers and slide against one another, reducing the generated friction.

Organic molybdenum compounds have been shown to work well in conjunction with zinc dialkyldithiophosphate (ZDDP). Used in engine oils for the better part of 80 years, ZDDP has been one of the most successful additives developed for oils. It has many functions, such as serving as an antioxidant, corrosion inhibitor and anti-wear additive. These additives also have a polar head and an oil-soluble tail structure. They form relatively thick, sacrificial boundary films that are much softer than steel or iron surfaces.

It should be noted that not only do the polar heads of friction modifiers need to be able to attach to ferrous metals, but they also must be able to attach to the zinc layers that will be present due to the ZDDP. These thick films formed by ZDDP are dependent on temperature and consist primarily of zinc, orthophosphate and polyphosphate glass, with an increasing proportion of polyphosphate chains closer to the surface.

As fuel economy standards become more stringent, more will be required of engine oils. While the technology for friction modifiers continues to evolve, the most effective way to improve fuel economy or energy consumption is to lower the viscosity of the lubricant. However, you can only go so far before losing the hydrodynamic film and operating in either mixed-film lubrication or boundary lubrication. It is in these two lubrication regimes that the use of friction modifiers becomes critical for reducing friction. ■

51%

of lubrication professionals use lubricants in which friction modifiers have been added, according to a recent poll at MachineryLubrication.com

About the Author

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

TEST your KNOWLEDGE

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

1. The lubricant formulation most commonly used for industrial, heavily loaded gear systems is:

A) R&O gear oil
B) Zinc-phosphorus anti-wear (AW)
C) Sulfur-phosphorus extreme pressure (EP)
D) 000 EP grease
E) Compounded gear oils

2. Depth filters:

A) Involve a torturous path between fibers with high dirt-holding capacity
B) Are made using square-weave wire cloth
C) Have pores of inconsistent sizes
D) Answers A and C
E) All of the above

3. What is the prime advantage to newer "complex" soap thickeners vs. older simple soap thickeners?

A) Higher cost
B) More appealing color
C) Harder grease
D) Higher dropping point and thus higher operating temperature
E) Better low-temperature pumping

Answers

1. C
Sulfur-phosphorus extreme pressure (EP) additive systems are chemically aggressive and work at high temperatures generated from high loading. Under high loads and associated high temperatures, sulfur-phosphorus EP additives form an adherent surface film that transforms to a ductile, metal soap sacrificial film to help protect gear components from wear.

2. D
Because of the non-woven media structure, depth filters generally have inconsistent pore sizes and high dirt-holding capacity. Thus, the correct answer is D.

3. D
Both simple and complex soaps consist of long-chain fatty acids and metal hydroxide. The main difference between simple and complex soaps is the presence of short-chain fatty acids in complex soaps. This improves the thermal stability of the thickener and leads to higher dropping points and thus higher operating temperatures. The dropping point of a grease is the temperature at which it passes from a semi-solid to a liquid state under specific test conditions.

THE "LUBE-TIPS" SECTION OF *MACHINERY LUBRICATION* MAGAZINE FEATURES INNOVATIVE ideas submitted by our readers. Additional tips can be found in our Lube-Tips email newsletter. If you have a tip to share, email it to us at editor@noria.com. To receive the Lube-Tips newsletter, subscribe now at www.MachineryLubrication.com/page/subscriptions.

Advice for Automatic Lubricators

When using automatic grease lubricators set for several months, draw a line and date at the level of lube with each weekly inspection. This allows you

to instantly spot a plugged or faulty lubricator.

Modify Oil Containers to Reduce Contamination

You can reduce contamination when refilling oil top-up containers by adding male quick-disconnects to the lids and female quick-disconnects to the hoses coming from all bulk oil drums. This also helps with housekeeping, since you will not have to take the lid off the top-up container to refill, and there is no oil dripping from the lid or pump. In addition, you won't have the problem of figuring out where to place the lid and pump while refilling. For improved oil cleanliness, consider adding filtration to the hoses.

Handle Bearings with Care

Anything that may come into contact with bearings should be kept clean, including workers' hands, benches, tools, solvents and rags. Any type of moisture, such as perspiration or condensation, should be kept away from bearings. Always handle bearings with a clean, lint-free cloth. Also, be sure to protect bearings with an oil film and make every effort not to break that film.

Tips for Applying Anti-Seize Compound

When placing high-speed, oil-filled bearing housings back together, be extra careful not to apply too much anti-seize compound for the bolts. If an excessive amount is applied, it can enter the housing faces during torquing and make its way into the oil bath. This, in turn, can bring about early bearing failure due to the incompatibility of the oil and anti-seize compound mixing and moving into the load zone.

Monitor Fire-Resistant Fluids

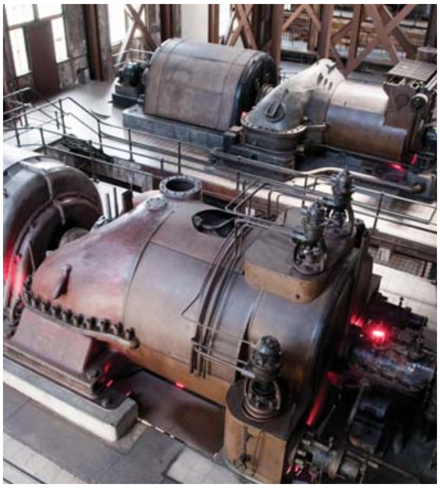
When using a water-glycol fire-resistant hydraulic fluid, always monitor the water level to ensure the required percentage of water is maintained (typically around 50 percent). Naturally, if this type of product is used in an application where the fluid normally runs hot, the water will more rapidly evaporate, so weekly monitoring may be necessary.

The Risks of Grease Separation

Grease-lubricated equipment should not be kept idle for long periods. The base oil in the grease could separate out and get drained from the thickener, which does not have any lubrication properties. Consider all of your equipment to evaluate the potential risks with grease separation.

Preventing Oil Contamination in Gearboxes

Replacing flat washers with crush washers is an excellent way to prevent oil contamination in gearboxes. The crush washers provide a much better seal than regular flat washers for not much more expense. This is a cheap improvement that can go a long way.



"What is the preferred method for minimizing the content of unwanted debris in lube oil? We are talking about diesel engines with up to 2,000 liters of oil in the sump.

"The oil is monitored regularly by the oil supplier, which tells us when to change. However, the manufacturer recommends an oil change every 1,000 hours. We installed an offline filter, and the oil company report said the oil was useable up to 3,000 hours.

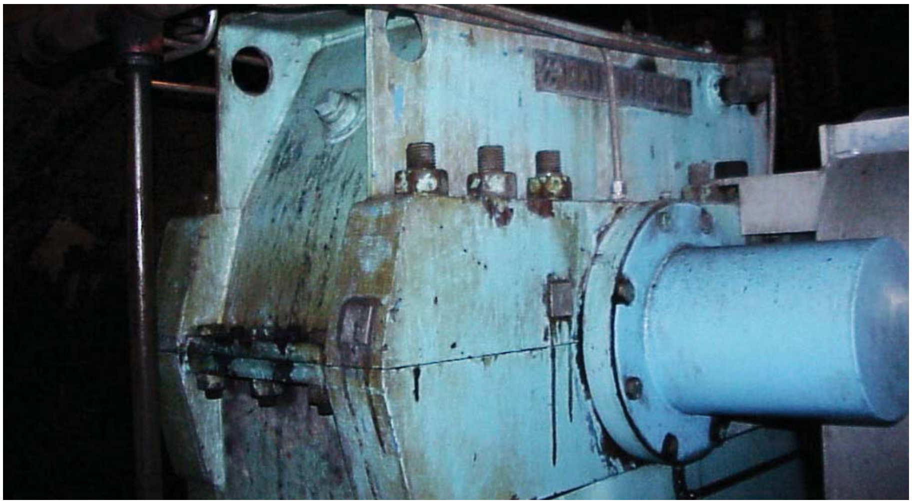
"For a long time, we have used centrifugal purifiers, which have done a good job, but we also know they have their limitations when it comes to removing smaller and lighter particles from the oil. We are now looking into substituting the purifiers with offline filtration, which would be able to take out smaller particles along with water. Then we have glycol and fuel dilution to consider as well. We know we have to maintain the engines regarding these matters, but our main issue is to find out what is the best purification method of diesel engine lube oil? Is it a purifier or bypass filtration?"

First, you shouldn't allow oil suppliers to conduct the analysis and tell you when to change the oil. It is in their best interest for you to perform more frequent oil changes than may be required. Instead, use an independent lab test and change the oil based on the results. You may find that you are able to get more life from the oil. Remember, world-class lubrication programs use a condition-based approach rather than a time-based approach for lubricant change-outs.

Secondly, there's no mention of testing the oil upon receipt or prior to transfer. Studies have shown it is 10 times more expensive to remove contaminants once they are in the oil. Your oil should be tested upon receipt to ensure you are receiving clean oil from your supplier. In addition, every time the oil is transferred from one container to another it should pass through a filter. Use quick-connect fittings and a product-dedicated filter cart to fill and drain oil from sumps to stop particle ingression.

If you have issues with either fuel or glycol in your oil, removing these contaminants should not be your focus. Having fuel or glycol in the oil is only a symptom, so you must fix the problem. Once these fluids find their way into your oil, they are very difficult and expensive to remove. Check the system for coolant leaks and fix them. In the case of fuel, look for problems with injectors or air filters, which will affect the fuel/air ratio and can cause soot loading.

"One of our customers recently found some waxy material in an **enclosed gearbox after using a synthetic gear oil for approximately 61 hours.**



The best method of purification would be to use a combination of both purifiers and bypass filtration, since each has its limitations. Centrifugal purifiers are good at removing larger particles and water but not for removing the smaller organo-metallic particles, which a filter will remove. If you already have purifiers, keep them and add bypass filtration.*"My initial thought was that this could possibly be the residue from a rust-preventive fluid. However, this gearbox has been used for a period of time. Is it possible that this is seal material or a sealant? If not, what could be causing this waxy residue and how can it be prevented?"*

Waxy residuals are not as prevalent as sludge or solid sediment but can be generated by several sources depending on the fluids used, the contaminants present in the gearbox and the operating temperatures.

A common source is present in some mineral oils. When operating at low temperatures (0 to 30 degrees F), waxes existing in these lubricants may precipitate. Water contamination can also intensify this effect.

Other precipitations may be produced by a variety of causes such as cross-contamination of different lubricants (including synthetics), the use of assembly oils, employing certain types of additives or even contaminants from the environment.

In order to determine the root cause of the waxy material, you may wish to analyze it using Fourier transform infrared (FTIR) or X-ray fluorescence (XRF) spectroscopy and identify its properties. This information along with the machine's maintenance/operation history can help you pinpoint the origin. Also, you can filter the oil for patch tests and observe it under a microscope.

Regardless of the waxy material's origin, there are ways to help prevent it. You should try to minimize cross-contamination among lubricants, assembly oils and additives used in the machine. Take steps to control contaminants in the oil that come from the environment or production processes. Before using an additive or assembly oil, or switching to a synthetic lubricant, ask the lubricant supplier about the potential effects of mixing different products. Also, be sure to limit lubricant contamination with water or process emulsions.

In addition, if the equipment must work at low temperatures, verify that the lubricant formulation is appropriate for these operating conditions.

Most likely the waxy residue did not come from a sealant. When a seal or gasket is incompatible with a lubricant, the typical effects are gasket swelling or shrinking but not the generation of wax products. ■

If you have a question for one of Noria's experts, email it to editor@noria.com.

OIL LUBRICATION FLOWMETERS AND FLOW MONITORING SYSTEMS

Kytola make Oval gear flowmeters measures correct oil flow irrespective of viscosity change and hence ensured required oil flow to bearings or lube points. Along with local display unit, it gives flow values on site and also equipped with 4-20 mA analog signals, relay output and Modbus communication. Local display unit gives choice to select alarms for low, high and other user defined flow rates. Kytola Oval Flow technology is quite proven and reliable solution for metering of Lube or Hydraulic oil. Flowmeter blocks with 2, 4, 6 nos. are also available.

KonFluid Engineers
kytola.com

OIL SAFE LUBRICATION SYSTEMS

The OilSafe Lubrication Management System is visually intuitive, removing risk from your maintenance process at every step along the way. It prevents the machine failures and downtime you thought were unavoidable. And it keeps your entire manufacturing environment running better, safer, cleaner, longer—so your business will, too. OilSafe. Think. Work. Flow.

Gulf Oil Lubricants India Limited
gulfoilindia.com
whitmores.com

By Suzy Hitchcock, ICML

Is Your LUBE TECH Costing You MONEY?

The impact of improper lubrication in equipment failure should be of no surprise to *Machinery Lubrication* readers, yet lubrication departments are not always highly regarded within a maintenance organization. Why? Many personnel do not understand the risks associated with the different jobs. People still do not realize that the lubrication technician is more likely to cause equipment failure when compared to others working with the machine. Certain mistakes may lead to failure, but incorrect lubrication will cause failure sooner or later.

For the value of a lube tech to be recognized, it is important to understand the cost of failure, because cost is the ultimate voice for buy-in. From operators to managers, everyone understands and speaks dollars and cents. Unless there is broad spectrum buy-in, change can never be successful.

After analyzing the cause of each failure, it is possible to segregate the failures into groups and identify the criticality of each activity. You must also consider the impact of the human role in each failure group before determining the cost and worth of the human elements of reliability.

Cost of Poor Lubrication

A plant in New Zealand recently estimated its cost of failures to be $5 million. Some 80 percent of the failing assets had lubricant-related issues, meaning poor lubrication was a contributing factor to potentially $4 million of the estimate. Realizing the direct and significant impact of human failure in improper lubrication, virtually 100 percent of this potential $4 million could be attributed to mistakes made by lube techs, such as incorrect lubes, leaks, empty lubricators, blocked filters and contamination.

This is why it's critical for everyone in the organization to understand the role each technician plays in causing failures. It is also essential to consider that the human cause for failure was more than likely due to a lack of proper processes, procedures, systems and, most of all, technical knowledge.

After the plant determined that lube techs could contribute to costs of $4 million in a year, how much do you think the maintenance engineer cost the plant in failures? Close to zero is a good estimate. Now think in terms of investing in these two individuals. Would you think the lube tech is being trained and educated at a ratio of four million to zero when compared to the maintenance engineer?

Training is normally viewed as a cost to the organization. Therefore, perceived role criticality determines who gets trained. If considering the budget in most organizations, it is likely that analysis of the cost of failure vs. job title will point to the technicians having a more direct impact (criticality) in total cost of failures than other (more highly regarded) positions.

Importance of Training

When you don't know how much the lack of knowledge costs your company, training will be viewed as a cost. Once you realize that it was likely the lube tech's lack of knowledge that caused the improper lubrication, which was potentially responsible for 80 percent of the costs related to failures, training improves from a cost to an investment.

ICML Certifications

MLA I
Machine Lubricant Analyst Level I

MLA II
Machine Lubricant Analyst Level II

MLA III
Machine Lubricant Analyst Level III

MLT I
Machine Lubrication Technician Level I

MLT II
Machine Lubrication Technician Level II

LLA I
Laboratory Lubricant Analyst Level I

It also becomes clear who should receive this training.

Without any harm intended toward maintenance engineers or managers, if reliability relates to avoiding failure, and failure has been proven to be caused by the technician, wouldn't it make more sense in terms of the return on investment to allocate more money to training and qualifying the people who actually cause the failures?

Of course, the road to improvement doesn't stop there. After training and qualifying lube techs, organizations still have many changes to make before they can happily say their lube techs are no longer taken for granted or "walking liabilities" to the equipment.

CERTIFICATION NEWS

RECENT RECIPIENTS OF ICML CERTIFICATIONS

LUBRICATION INSTITUTE (lubrication-institute.com) WOULD LIKE TO CONGRATULATE PROFESSIONALS in our region who have recently achieved certified status through ICML's certification programs. ICML offers certification in the areas of oil analysis and machinery lubrication. The following is a list of recently certified professionals in the area of machinery lubrication & oil analysis who have attained their status as a certified Machine Lubricant Analyst (MLA), Machine Lubrication Technician (MLT).

BANGLADESH

Chevron
Minhaj Uddin Ahmad, MLA I, MLA II
Md. Feroje Alam, MLA I, MLA II
Mohammad Baktier Uddin Chowdhury, MLA I, MLA II
Md. Sadeaque Ul Islam, MLA I, MLA II

MH Energies & Distribution Co. (MEDCO)
Mosaddek Hossain, MLT I

INDIA

AIMIL
K.N.V Subrahmanyam, MLA I, MLA II, MLA III

Atlas
Pradeep Nair, MLA I, MLA II

Balmer Lawrie
Mukesh Agarwal, MLA I
Sujay Kumar Baisya, MLA I
Sharmila Barman, MLA I
Sandip Ranjan Dasgupta, MLA I
Somnath Dey, MLA I
Projjwal Ghorai, MLA I
Dipak Ghosh, MLA I
Mahesh Chandra Gupta, MLA I
Barunav Kundu, MLA I
A. Mohankumar, MLA I
Mahendra Singh Negi, MLA I
Ramachandran Padmanaban, MLA I
Narbdeshwar Pandey, MLA I
Kedar Panse, MLA I
Chandrashekhar Yadaw Rade, MLA I
V. Ramanamurthy, MLA I
N. Ramesh, MLA I
Malay Kanti Saha, MLA I
Sanjay Sanfui, MLA I
Nilesh Mahadeorao Sapate, MLA I
Manoj Sardana, MLA I
Rajeshwar Singh, MLA I
Arijit Das Thakur, MLA I

Capron Oil
Chandra Sekhar Kartik, MLA I, MLA II, MLA III
Rajeeb Kumar Rath, MLA I

Chem-Tech Laboratories
Vedang Ghanashyam Bhagwat, MLT I, MLA I, MLA II, MLA III,
Smita Subandh, MLA I, MLA II

Cirra Consultants Pvt Ltd.
Charly George, MLA I, MLA II

Croda Chemicals
Shantanu Das, MLT I, MLT II, MLA I, MLA II, MLA III

EKS Filter Technik (I) Pvt. Ltd.
Nishil Bhatt, MLA I, MLA II

Electro Kleen Systems
Ashvin S., MLA I

Excell B Enterprises
Palanisamy Duraisaamy, MLT I, MLT II, MLA I, MLA II, MLA III

Gulf Oil Corporation Ltd
Pooja Gropalkrishna Joshi, MLT I
Somesh Sabhani, MLT I

Hindustan Petroleum Corporation Ltd
Abhijit Sarkar, MLT I

Indian Oil Corporation Ltd
Yavnish Garg, MLA I
Abhinav Jogi, MLA I
Darshan Keshari, MLT I
Nitish Mittal, MLA I, MLA II
Kuldeep Pradhan, MLT I
Pramod Kumar Prasad, MLT I
Raben Chandra Roy, MLA I, MLA II
Chaitanya Vvssgrk Tummala, MLT I

JSW Steel Ltd.
Vinaya Suvarna, MLA I, MLA II

Kinetics Commercial Company
Koustuv Mohanty, MLA I

Maersk Oil Trading Lubricants
Sandip R. Jarode, MLT I

One Stop Solutions
Samir Chandrakant Bhagwat, MLT I, MLA I

Pall
Gonal Lakshmikanth, MLA I, MLA II

Petrolabs
S. Janakiram, MLT I
Rajinder Negi, MLT I
Shailender Prashad, MLA I, MLA II

Petronet LNG Ltd.
Pawan Kumar Chaturvedi, MLT I

Petronum Trading
M. Hussam Adeni, MLA I

Praxair
Alv Avinash, MLA I, MLA II

Predict Technologies India CP Ltd
S. Ravi Kiran, MLA I, MLA II
Ayub Pasha Shaik, MLA I, MLA II

Raj Petro Specialities Pvt. Ltd.
Mohammad Sayeed Ansari, MLT I
Tapas Chakrabortym, MLT I
R. Ramesh Raja, MLA I

Schaeffler Group
Seemant Shripad Joshi, MLA I

Tata Steel
Ajit Kumar Verma, MLT I

Tractors India Pvt Ltd
Saugata Roy, MLA I, MLA II

VAS Tribology Solutions
Md Aatif, MLT I
L. Viraraghavan, MLT I, MLA I

Vedanta Aluminum Ltd
Ipsita Hota, MLA I

Vestas Wind Systems
Pattabiraman Trichy Ramakrishnan, MLA I, MLA II

SAUDI ARABIA

Petromin Corporation
Emad Hamed Alahmadi, MLT I
Zeshan Ashraf, MLT I
Salman M Bajwa, MLT I
Ali Hyari, MLT I
Tariq Javed, MLT I
Bilal Samad Khan, MLT I
Mohammed Imran Khan, MLT I
Asif Ali Khan, MLT I
Muhammad Naeem, MLT I
Abdul Majid Osmani, MLT I
Syed Mahmood Quadri, MLT I
Pir Shujahat Ali Shah, MLT I
Cherif Talibi, MLT I
Engr. Faisal Yasin, MLT I
Essan M Saleh, MLT I

SRI LANKA

Loadstar (Pvt) Ltd.
Arambegoda Loku Gamage, MLA I
Yasith Chandrasiri, MLA I
S.A.P.R. Jayathissa, MLT I, MLA I
Sattambiralalge Don Ishanth Sameera, MLT I, MLA I

UAE

Abu Dhabi Gas Industries, Ltd. (GASCO)
Lala Gulabrao Khunte, MLA I, MLA II

Enoc Lubricants & Grease Manufacturing Plant
Lingesan Chinnamuni Mohanan, MLA I
Nitin. Prabhakar Desai, MLA I

Eppco Lubricants
Yousef Hasan Mallouh, MLT I
Porus Noshir, MLT I
Ammar Abdul Latif Mohd Said, MLT I
Fuad Mustafa Yaseen, MLT I

Tribocare FZC
Venkata Suresh Pedasingu, MLT I, MLA I, MLA II

YEMEN

Yemen LNG Company Ltd.
Venkatesan Narayanan, MLA I, MLA II

SERVO 100% PERFORMANCE. EVERYTIME.

SERVO Steel Meet 2016 Kolkata

India has become the 3rd largest producer of crude steel in 2015 and continues to be the largest producer of sponge iron in the world. World Steel Association has projected Indian steel demand to grow by 6.2% in 2015 and by 7.3% in 2016 as compared to global steel use growth of 0.5% and 1.4% respectively.

The growth of Indian Steel Industry is a reflection of the growth of the Indian Economy which grew at 7.3% in 2014-15. The World Bank has forecasted a growth of 7.5% in 2015-16, followed by a further acceleration to 7.8% in 2016-17 and 7.9% in 2017-18.

The above growth projections augur well for the future Indian Industrial Climate. This implies new industries, addition of new facilities and revamp of old units in existing industries. New machineries will be installed and there will be a spurt in initial fill lubricant requirements and top ups as they enter in the production mode. There will be new requirements of lubricants encompassing efficiency, reliability and environment friendliness.

An integrated steel plant provides the ultimate challenge to lubricants because it encompasses all the lubrication regimes, worst possible lubrication environment, complexity of processes and very high safety considerations.

Indian Oil Corporation Ltd -West Bengal State office organized the Servo Steel Meet 2016 at Kolkata with the theme:"Lubrication – A tool to reduce your plant's operational cost" at Kolkata on 8th January 2016.

Ranjan Kumar Mohapatra, GM, WBSO welcomed the participants in the presence of R Suresh, ED (LT), R&D, T S R Gopalarao, GM (ILS) HO and SR Sarkar, GM (LC), Kolkata. The representation from customers were more than 100 with distinguished presence from SAIL, JSW, TATA, ESSAR, RINL, JSPL, BHUSHAN and important project consultants and OEMs like VAS TRIBOLOGY, PRIMETALS, DANIELI, PAULWURTH ,Tata Consulting Engineers Ltd etc.

There were 17 presentations from customers and 5 presentations from IOC. A technical booklet covering the high performance lubricants for steel plants was also shared with customers.

Reliance Industries engineers train with Lubrication Instititute

Reliance Industries Ltd conducted its second in-house training program on "Advanced Machinery Lubrication" at Reliance Manufacturing Academy situated at Vadodara. 25 reliability engineers drawn from 6 manufacturing sites were trained in a 3 day training program. A few months back another set of engineers undertook 3 day training in "Essentials of Machinery Lubrication".

The training was conducted by Lubrication Institute (an associate of VAS Tribology Solutions).

Mr Andrew Monk (UK) and Mr Michael Hooper (NZ) were the lead faculty.

Noria Public Training in Mumbai

Noria Skill Training on Oil Analysis and Machinery Lubrication was conducted by Lubrication Institute at its public training program recently. Amongst the participating companies were Dow Chemicals, Indian Oil Corporation Ltd, Bharat Petroleum Corporation Ltd, Tractors India Ltd, Intertek Laboratories, SKF Ltd, Predict Laboratories, Castrol BP, Pall India, Raj Petro, University of Hissar, besides participants from Bangladesh, UAE and Srilanka .

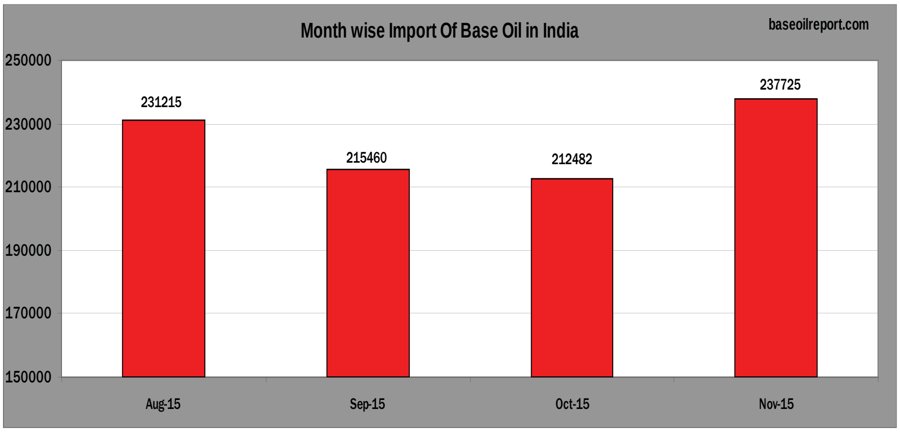
The training was followed by ICML Certification Exams. The next trainings are scheduled for April/May 2016.

DHIREN SHAH

BASE OIL REPORT

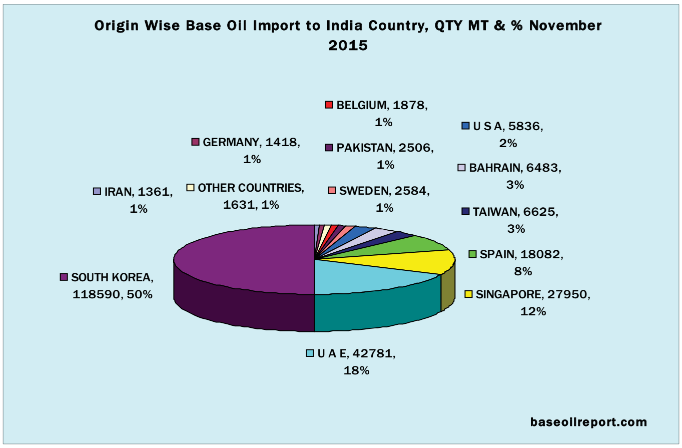
With price of Brent crude already hitting a 11-year low, any upward movement in the price looks unlikely in the coming quarters as the Organization of the Petroleum Exporting Countries (Opec) refused to restrain its production. As oil analysts believe that the recent hike in interest rate by the US Fed and OPEC decision in its last meeting not to put a cap on its production will create a scenario of oversupply and weakening demand. International Energy Agency has warned that global oversupply could worsen in 2016. Also, OPEC production has moved up from 30 million barrels per day (bpd) to 31 million bpd. Of them, Saudi Arabia, the largest producer, had registered an output of 9.7 million bpd. The outlook for crude oil remains bleak. With the crude oil from Iran coming into the market, prices can further ease in a month's time. The short term looks like the WTI crude will touch $30-32 per barrel and will hover around for a while. However, analysts believe that every crude oil producing country seems to be concerned about cash flows and their own fiscal deficit and no one has cut production due to falling prices. Between June and October, a surplus of 2.1 million barrels has already been recorded. Part of the weakness is also due to currency fluctuations.

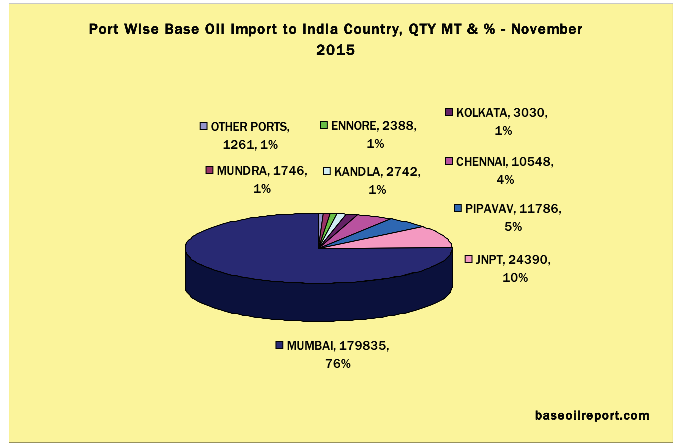
During the period August 2015 to November 2015, India imported 924568 MT of Base Oil. The country imported 231215 MT in August, 215460 MT in September, 212482 MT in October and 237725 MT in



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

Month	Group I - SN 500 Iran Origin Base Oil CFR India Prices	N-70 Korean Origin Base Oil CFR India Prices	J- 150 Singapore Origin Base Oil CFR India Prices	Bright Stock - 150
October 2015	USD 505 – 515 PMT	USD 570 – 575 PMT	USD 600 - 605 PMT	USD 850 - 860 PMT
November 2015	USD 465 – 475 PMT	USD 525 - 530 PMT	USD 560 - 565 PMT	USD 810 - 820 PMT
December 2015	USD 475 – 480 PMT	USD 510 - 515 PMT	USD 535 - 545 PMT	USD 810 - 820 PMT
	Since October 2015, prices have dripped down by USD 30 PMT (6%) in December 2015.	Since October 2015, prices have marked down by USD 60 PMT (10%) in December 2015.	Since October 2015, prices have dipped down by USD 60 PMT (10%) in December 2015.	Since October 2015, prices have fallen down by USD 40 PMT (5%) in December 2015.





November 2015. Compared to the previous month i.e. October 2015 Base Oil import of the country has surged up by 12% in November 2015. Compared to the same month last year.

The Indian domestic market Korean origin Group II plus N-6070/150/500 prices at the current level have been marginally down. As per conversation with domestic importers and traders prices reflects minimal changes for N 60/ N- 150/ N - 500 grades and at the current level are quoted in the range of Rs. 31.25 31. 30/32.25 32.35/34.30 35.35 per liter in bulk respectively with an additional 14 percent excise duty and VAT as applicable, no Sales tax/ Vat if products are offered Ex-Silvassa a tax free zone. Discounts are offered for lifting sizeable quantity. The above mentioned prices are offered by a manufacturer who also offers the grades in the domestic market, while another importer trader is offering the grades cheaper by Rs.0.35 0.45 per liter on basic prices. Light Liquid Paraffin (IP) is priced at Rs. 33.10 33.20 per liter in bulk and Heavy Liquid paraffin (IP) is Rs.37.00 37.15 per liter in bulk respectively plus taxes extra.

Approximately 10141 MT of Light & Heavy White Oil has been exported in the month of November 2015 from Chennai, JNPT, Mundra and Ahmedabad. Compared to last month i.e. October 2015; exports of the country have gone down by 3% in the month of November 2015.

Petrosil Base Oil Report (www.baseoilreport.com) offers solutions to the entire base oil value chain, from refiners, suppliers, buyers, traders, agents, consultants, lubricant

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

Approximately 10141 MT of Light & Heavy White Oil has been exported in the month of November 2015 from Chennai, JNPT, Mundra and Ahmedabad. Compared to last month i.e. October 2015; exports of the country have gone down by 3% in the month of November 2015.

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

Approximately 2923 MT of Transformer Oil has been exported in the month of November 2015.

companies, professionals and logistic providers as well as any other entity of the base oil value chain. Base Oil Report is a comprehensive marketplace for global base oil reporting and trading.

Our subscribers can use this exclusive and unique base oil gateway to access information from the different sections and post and reply to international base oil offers. The gateway offers integrated solutions and is an essential tool for members that want to enhance their trading opportunities and access timely base oil news, prices and analysis.

About the Author

Dhiren Shah

(Editor – In – Chief of Petrosil Group)

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

HOWELL PETROLEUM
Shanghai Howell Petroleum Additives Co.,Ltd

A worldwide professional lubricant additives manufacturer with full range of components and DI packages.
www.howelladditives.com

More Than Solutions

T321A

Sulfurized Isobutylene
EP Antiwear Agent
Without Chlorine
Excellent protection

T3234

Engine Oil DI Package
for API SN/CI-4
Lower Cost
Higher Efficiency

T4216

Gear Oil DI Package
for API GL-5
Higher performance
Eco-friendly

Shanghai Howell Petroleum Additives Co.,Ltd.
549,No.11,Wuhua Road,Shanghai,China 200086
E-mail： info@howelladditives.com