Machinery Lubrication

India November - December 2014

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How to Manage LUBRICANT WASTE & DISPOSAL

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NORIA

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Machinery Lubrication India
November-December 2014

Publisher's Note

In the last issue we discussed how Sinclair Wyoming Refinery recognized the need to change its current lubrication practices in order to remain profitable and maintain its position as an industry leader. The task seemed daunting at first, but with guidance from Noria Corporation, great strides have been made in a short amount of time. The refinery is now approaching world-class status..

We also learnt about the steps of managing change of a lubrication program, the basic steps involved are assessing, designing, implementing and managing. Many organizations struggle when implementing a lubrication program because they have a partial vision of the program's scope or because they have no formal change-management plan. However, an effective program administration with a systematic view and an appropriate change-management strategy can help you achieve the goal of lubrication excellence.

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

As industry continues to become more eco-friendly, there will be an added emphasis on waste oil disposal and reclamation in the near future. By reviewing your current procedures and implementing some of the ideas in the article, you can put your facility ahead of the curve and realize the benefits of managing your waste oil with a best-practice mentality.

As usual we welcome our readers' comments and suggestions which enable us to provide you with cutting edge articles. So please keep these suggestions/views coming in to help us serve you better.

Your feedback is very important to us.

We would also like to take this opportunity to wish our readers and advertisers a Merry Christmas & Happy New Year.

Warm Regards,

Udey Dhir

JIM FITCH NORIA CORPORATION

Don't Forget LUBRICANT CRITICALITY When Designing Oil Analysis Programs

I have discussed the concept of Overall Machine Criticality (OMC) and its importance on a wide range of decisions relating to machinery lubrication and oil analysis. These decisions, when optimized, define the Optimum Reference State (ORS) needed to achieve the desired level of machine reliability. It is intuitively obvious that smart maintenance decisions require a heightened sense of both the probability and consequences of machine failure.

However, when lubricants fail, there are consequences that are, at least initially, independent of machine failure. These include the lubricant replacement cost (material, labor, flushing, etc.) and associated downtime. These costs can exist in the presence of a perfectly healthy and operating machine. Of course, lack of timely replacement of a defective lubricant will invariably lead to dire machine failure consequences. For some machines, these cascading events can produce enormous collateral damage and financial hardship to an organization.

In the future issue of *Machinery Lubrication India*, I will explain how nearly all decisions related to lubricant analysis and inspection depend on four factors: Overall Machine Criticality, Overall Lubricant Criticality, Machine Failure Modes Effects Analysis (M-FMEA) and Lubricant Failure Modes Effects Analysis (L-FMEA).

For instance, regarding inspections, these factors influence what to inspect, when to inspect and how to inspect. In relation to oil analysis, these factors affect where to sample, how often to sample, which tests to conduct, which alarms to set and the general data-interpretation strategy.

Machine Criticality vs. Lubricant Criticality

Figure 1 shows the relationship between machine and lubricant failure. On the left are common causes of lubricant failure and machine failure. For example, heat, aeration and contaminants are known to be highly destructive to lubricants. In a similar sense, overloading, misalignment and contamination can abruptly cause a machine to fail. Note how contamination not only can fail a lubricant but also can fail a machine directly without the need to harm the lubricant first. You could say the lubricant is complicit by transporting contaminants to sensitive and critical frictional surfaces. When a lubricant fails, there is imminent danger of machine failure, hence the downward arrow from lubricant failure to machine failure.

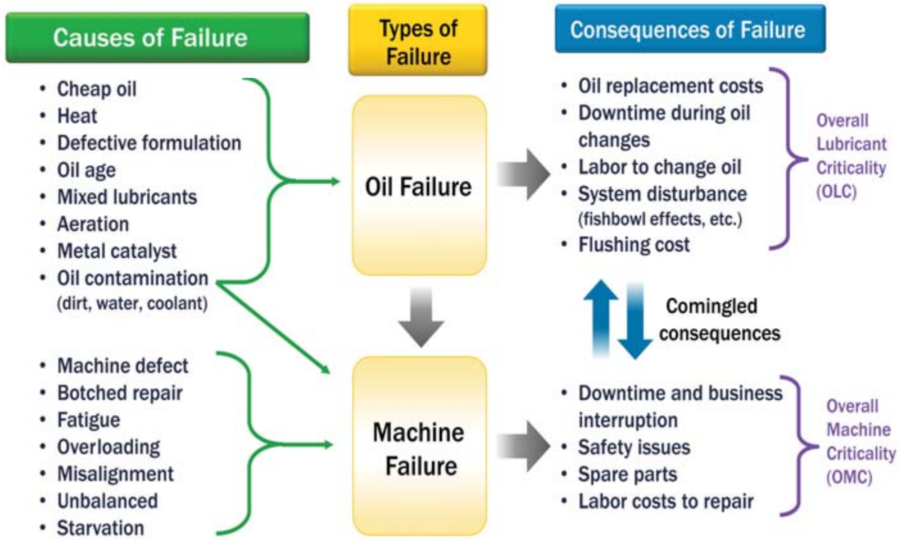
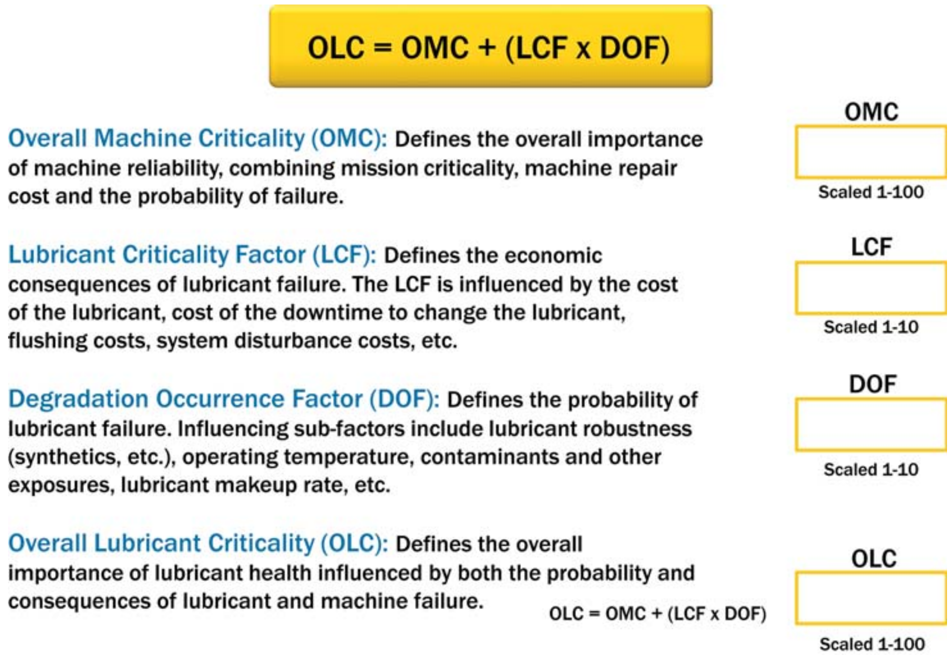


Figure 1. The relationship between machine criticality and lubricant criticality



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

There is slight comingling of these failure consequences. For instance, lubricant failure may cause complete machine failure or only partial machine failure, such as dropping the machine's remaining useful life (RUL) from 80 to 40 percent. Conversely, when a machine (or one of its components) fails due to mechanical causes, the heat and wear debris produced can completely or partially destroy the oil.

Calculating Overall Lubricant Criticality

The Overall Lubricant Criticality (OLC) defines the importance of lubricant health and longevity as influenced by the probability of premature lubricant failure and the likely consequences (for both the lubricant and the machine). The proposed method for calculating the OLC is shown in Figure 2. Like many such methods, the approach is not an exact science but nevertheless is grounded in solid principles in applied tribology and machine reliability.

The calculation is quite simple. Overall Lubricant Criticality equals Overall Machine Criticality plus the multiplied product of the Lubricant Criticality Factor (LCF) and the Degradation Occurrence Factor (DOF). The OLC is scaled from 1 to 100. All calculated values more than 100 are reduced to the default maximum of 100.

As mentioned previously, the OMC was discussed in great detail in the March-April 2013 issue of *Machinery Lubrication*. It is the multiplied product of the Failure Occurrence Factor (likelihood of machine failure) and the Machine Criticality Factor (consequences of machine failure). It is shown again as a matrix in Figure 3.

Because lubricant failures are common causes of machine failures, it is no surprise that the OMC plays a significant

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role in calculating Overall Lubricant Criticality.

Lubricant Criticality Factor

The LCF defines the specific economic consequences of lubricant failure separate from machine failure consequences. The LCF is influenced by the cost of the lubricant, the cost of downtime to change the lubricant, flushing costs and system disturbance costs (e.g., the fishbowl effect). For instance, machines that use large volumes of expensive, premium lubricants will understandably have high LCF values. It is not unusual for main lube oil systems on turbine generators in power plants to have lubricant investments in the range of hundreds of thousands of dollars. In such cases, the cost of premature lubricant failure can be enormous, not to mention the potential impact on the machine's reliability. Studies have shown the true cost of an oil change can far exceed 10 times the apparent cost (labor and oil costs). The LCF is subjectively scaled from 1 to 10, with 10 representing extremely high criticality.

Degradation Occurrence Factor

The DOF defines the probability of premature lubricant failure. The conditions that influence this probability are shown below. Collectively, the DOF is scaled 1 to 10.

Lubricant Robustness — Synthetics and other chemically and thermally robust lubricants lower the DOF.

Operating Temperature — Lubricants exposed to high operating temperatures, including hot spots, can experience accelerated oxidation and degradation. The presence of such conditions will raise the DOF.

Contaminants — Contaminants such as water, dirt, metal particles, glycol, fuel, refrigerants, process gases, etc., can sharply shorten lubricant service life. The presence of such exposures will raise the DOF.

Lubricant Volume and Makeup Rate — Lubricant volume relates to the amount of additives available to fight oil degradation, the estimated runtime to complete additive depletion and the density of contaminants. In normal service, it can take years to burn through the additives in systems containing thousands of gallons of lubricant. The makeup rate refers to the introduction of new additives and base oil. New additives replenish depleted additives, and new base oil dilutes pre-existing contaminants. High oil volume and a high makeup rate will reduce the DOF.

Armed with both the OMC and OLC, lubrication and reliability professionals have the foundational elements needed to better design lubrication and oil analysis condition monitoring programs. While some guesswork may be required, using this method will prevent wild guesses. In turn, extreme waste and poor reliability can be avoided.

The goal is to optimize maintenance and reliability decisions. Understandably, best practice varies considerably from machine to machine. Precision lubrication is another way of saying one size does not fit all. It's time to get it right. In the next issue of *Machinery Lubrication*, this topic will be explored further in the context of oil analysis and inspection.

FAILURE OCCURRENCE FACTOR / MACHINE CRITICALITY FACTOR	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	6	7	8	9	10
2	2	4	6	8	10	12	14	16	18	20
3	3	6	9	12	15	18	21	24	27	30
4	4	8	12	16	20	24	28	32	36	40
5	5	10	15	20	25	30	35	40	45	50
6	6	12	18	24	30	36	42	48	54	60
7	7	14	21	28	35	42	49	56	63	70
8	8	16	24	32	40	48	56	64	72	80
9	9	18	27	36	45	54	63	72	81	90
10	10	20	30	40	50	60	70	80	90	100

Color	Risk	Remediation Required
Red	Extreme Risk	Immediate
Amber	High Risk	High Priority
Yellow	Manageable Risk	As Soon as Possible
Green	Minor Risk	Continuous Improvement
Blue	Low Risk	None

Figure 3. The Overall Machine Criticality (OMC) matrix includes the Machine Criticality Factor on the X-axis, the Failure Occurrence Factor on the Y-axis and five risk zones, each represented by a different color.

How to Manage Lubricant Waste and Disposal

By Wes Cash

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

Waste Oil

Before beginning a discussion on waste oil, it is important to first understand exactly what it is. A common term that is used interchangeably with waste oil is used oil. According to the U.S. Environmental Protection Agency (EPA), the definition of used oil is any oil that has been refined from crude oil, or any synthetic oil that has been used and as a result of such use is contaminated by physical or chemical impurities. This is the technical description for the oil that is drained out of your equipment.

Although most used oil alone is considered non-hazardous, if it has been contaminated by a hazardous substance, then it must be handled as hazardous waste. This encompasses an entirely different set of protocols. Just because most mineral and synthetic fluids by themselves are considered non-hazardous does not mean that all risks associated with handling them have been eliminated.

Care should be taken during the handling of both new and used oils to avoid any potential risks associated with the fluids. Some oils have been known to cause dermatitis, while others are considered to be toxic. When handling these fluids, exercise caution and avoid prolonged contact with your skin. If you have cuts or sores on your hands, wear gloves to keep the fluid from being introduced into the bloodstream.

Guidelines for Bulk Storage Spill Protection

The Code of Federal Regulations' guideline on overfill prevention instruments (40 CFR 280.20 (C)) states that tanks must:

1. Automatically shut off the supply flow when the tank is 95 percent full,
2. Alert the operator when the tank is more than 90 percent full, or
3. Reduce flow 30 minutes prior to overfilling and alert the operator with a high-level alarm one minute before overfilling.

Containment capacity must equal or exceed maximum volume of the largest tank or 10 percent of the total stored volume, whichever is greater.

As industry increasingly becomes more environmentally conscience, great strides have been made in the area of lubricant management and disposal. Lubricants are now being formulated to meet even the most stringent environmental regulations. Lubricant biodegradability is often tested and referenced when selecting a lubricant for certain environments. For example, the equipment used in open-pit mining is often very large and holds hundreds of gallons of engine oil, hydraulic oil, gear oil and fuel. In the event of a leak, you would want these oils to be environmentally safe. This is where biodegradability or eco-friendly lubricants come into play.

The biodegradability of a lubricant refers to how fast the lubricant can be converted to carbon dioxide and water by naturally occurring micro-organisms. There are a few main tests to determine the biodegradability of a lubricant. The first is the primary biodegradability test (CEC-L-33-A-93). In this test, the candidate oil is contaminated with sewage waste and left for 21 days at 77 degrees F (25 degrees C). At the end of the three-week cycle, the mixture is analyzed. The oil is considered to pass if only 20 percent of the original oil remains intact.

The ultimate biodegradability test is similar to the primary test. For this test, the oil is contaminated with micro-organisms and then left to sit for four weeks at 72 degrees F (22 degrees C). With this test, the amount of carbon dioxide produced is measured and compared against a standard. To pass this test, 70 percent of the candidate fluid must be degraded at the end of the four-week period.

A new biodegradability test method (CEC-L-103-12) was recently developed. It measures the loss of oil and oil-soluble metabolites over 21 days in a nature-like aqueous environment. See the article on page 22 for a more detailed explanation of this new method.

When comparing environmentally friendly lubricants, one must consider that much of a lubricant's biodegradability depends on the base oil with which it is formulated. Higher refined mineral oils (Group III) tend to degrade better than Group I oils. Group IV polyalphaolefins, which are perhaps the most common synthetic oils, score poorly in biodegradability, while polyolesters and diesters are among the best for breaking down naturally. However, if you are looking for the best oil in terms of biodegradability, you would pick a vegetable base oil (natural esters).

Vegetable oils are gaining popularity not only because of their inherent environmentally friendly nature but also because they are able to match the performance characteristics of their mineral counterparts. While governmental agencies focus on what happens to mineral and synthetic lubricants after use, they aren't nearly as concerned with lubricants that are derived from animals or vegetables.

TYPICAL TEST RESULTS FOR LUBRICANTS

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

This can be a benefit in the disposal of vegetable-based lubricants, as expensive reclamation of these oils (due to environmental regulations) may not be required. Of course, this does not mean you can simply pour vegetable oils into a ditch and walk away from them. They just don't fall under the same jurisdiction as used mineral or synthetic oils. Many companies purchase used vegetable oils and recycle these base fluids as bio-diesels and other fluids.

Leakage

Aside from the actual task of draining waste lubricant from a system, there is the risk of oil leakage, which can introduce used oil into the environment. Leakage is common in all industrial facilities, although some plants do a better job of mitigating it than others. Leakage is what causes most facilities to use more oil than what they actually need. Remediating leakage-prone equipment not only can save the company money from wasted oil but also help lessen potential environmental problems.

There are several ways to find the source of leakage, including using ultrasonic equipment. By listening to pipe fittings, valves and pump interfaces on circulating systems, you can often pinpoint internal leaks and fix them. Another common method introduces dye into the system. The dye will bleed through leakage points with the oil and can be identified with the use of an ultraviolet light source.

Once oil leaks from a piece of equipment, the first action must be to control the spill to prevent it from spreading. Several products are available that can help with this problem. Many of the plants I visit use oil “pigs” or super-absorbent mats to quickly soak up and contain the spills. If the oil has any hazardous materials, the area must be isolated and documented before clean-up procedures can begin.

Depending on the severity of the leak and the fluid in question, the reclamation technique may range from simply washing down the leak to full soil reclamation for decontamination. Always consult your company’s environmental policy as well as any local governmental regulations to determine the most appropriate course of action.

Removal

The best practice for the removal of waste oil from a machine is to keep oil from ever being introduced to the environment. The rise in popularity of portable filter carts has made this process even easier. With a waste oil drum nearby and a filter cart hooked to the system’s drain, oil is pulled out of the reservoir and introduced into the waste oil container. For this procedure, it is recommended to bypass the filters on the cart. After all, there is no need to filter the waste oil, which not only would slow down the pump but also cost more money for the purchase of new filters.

The best practice for the removal of waste oil from a machine is to keep oil from ever being introduced to the environment.

If filter carts are not available in your facility, having an appropriate waste oil container is a necessity. The container should be labeled for waste oil only and have adequate volume to hold all of the oil in the system from which it is being drained. Although 5-gallon buckets are often used to capture waste oil and then emptied into used oil drums or totes, this practice offers many opportunities for spills by the constant transfer of oil from one vessel to another.

If waste oil is to be stored in large volumes or for extended periods in a single location, it is best to have spill-containment protocol in place. By using spill-containing pallets or building underground spill-containment reservoirs, you can ensure that leaks or spills are captured and greatly reduce the risk of environmental impact. The rule for spill containment is that it must be able to house the largest volume of oil for the container or 10 percent of the total volume of all oil stored in it, whichever is greater.

There are benefits to housing waste oil and repurposing it for other applications. One popular use for waste oil is to capitalize on the inherent energy contained in the oil. By burning the oil, you can harness the BTUs and use it as a fuel source not only for heat but also for power generation in some instances.

The re-refining of waste oil into a reusable oil source is becoming both increasingly popular and economical. These oils are cleaned of contaminants, re-additized and considered like-new oils. Several automotive oils on the market are re-refined oils.

As industry continues to become more eco-friendly, there will be an added emphasis on waste oil disposal and reclamation in the near future. By reviewing your current procedures and implementing some of the ideas in this article, you can put your facility ahead of the curve and realize the benefits of managing your waste oil with a best-practice mentality.

ALEJANDRO MEZA AND CHRIS CHRISTENSON

Implementing a Training Plan to Support a World-class Lubrication Program

Through the years, Noria has seen many cases in which world-class lubrication practices were implemented successfully as well as unsuccessfully. One of the key factors in determining the success or failure of such an implementation is the training/education of the team. Of course, not all project managers have experience assessing skills and competencies needed for a job. Consequently, they may not have the expertise to tailor a training plan specifically for the maintenance team and other functions involved in the lubrication program implementation.

To be effective, a learning program must be delivered in conjunction with other resources that will allow individuals to absorb this new knowledge and introduce new behaviors into their daily work. These additional resources should include the tools that will make the work more productive, such as new technologies like ultrasound, sampling devices and

	OWNERS	INTERFACES				
	Maintenance/ Engineering	**Purchasing/ Warehouse/Parts Inventory**	**Human Resources**	**Production**	**Safety and Health (S&H)**	**Information Technology (IT)**
Management	Plant director, operations manager, maintenance manager	Plant director/operations manager	HR director	Operations/ production manager	Plant director/ operations manager	IT manager
Coordinators, Supervisors and Group Leaders	Planning and scheduling, field engineering, maintenance supervisors	Procurement manager	HR advisor	Production supervisors	S&H manager/ supervisor	IT support
Plant and Field Personnel	Predictive engineers/ technicians, lube techs, mechanics	Purchasing clerk		Operators	Inspectors	

In this table, three groups of participants are categorized according to their degree of participation in the project. Project owners are displayed in purple, people/functions involved in the project are in yellow, and individuals who must be made aware of the project to provide support are shown in blue.

hardware, a quality lube room, equipment modifications, top-up containers, etc. The methodology should also be provided. This refers to the instructions, work orders, software, etc., that will guide personnel to follow the proper procedures at the appropriate time. Failure to deliver these resources could put the effectiveness of the training initiative at risk, resulting in wasted time, energy and money.

Involved Personnel

The initial step in constructing a good training plan is to determine if the training is for a specific project, part of a broader skill developmental plan or a combination of both. Let's consider an initiative that covers both a specific project and personnel skill development, which is the most complete scenario.

If the decision is made to form a taskforce for implementing best practices within a certain amount of time, it will be useful to identify the personnel involved and the ways in which they will be involved. Questions to ask include will these individuals make strategic decisions on this project, will they need a general understanding or specific technical knowledge, what is the specific technical knowledge needed and will they execute routines, making hands-on training beneficial. These questions should be asked not only for individuals but also for groups with similar functions. Once the questions have been answered, a table for the involved team can be created as shown on page 11.

> A successful plan demands a thorough understanding of the training needs based on the organization's objectives.

Training Needs

The next step is to define what each person should know about the project's objectives and scope, the necessary technical knowledge, and the learning and behavioral needs based on the existing gaps between the current qualification level and the new qualification that is required. Also, determine if the learning needs are basic, general knowledge or advanced. At this point, the learning requirements should be described in great detail.

If there are career-development requirements, now is the time to integrate them into the master training plan. Be sure to verify that the job description and career-development plan are consistent, clear, specific and updated with the learning and developmental objectives. If more than one skill level is required for a specific function, the training requirements should be clearly defined according to the progression of skill competencies.

Another question that should be asked is who needs to be aware of this project and its training requirements in order to support it. A good cultural alignment within the organization is fundamentally important.

Finally, the project leader should have a clear understanding of the training and qualification options that are available and suitable for the project. Research internal training resources as well as options in the marketplace. When required, a partnership with a specialized company that provides an array of training services may be helpful.

After this step, a second table can be created to identify the communication/alignment requirements along with the training needs for each individual and the set timeframe. An example is shown below. In some cases it may be important to include external contractors or outsourcing companies that may be affected by the scope of the project.

Effective Implementation Considerations

When implementing a training solution, you need to look beyond just the knowledge, skills and abilities that are impacted. Many times the success or failure of a training program is not realized until the classes are over and the trainers are long gone. The learning objectives and outcome of the training are typically measured in terms of comprehension of the critical knowledge or skills transferred to the employee. However, a key facet of an effective implementation unfortunately is overlooked and many times results in little change and improvement. This important ingredient is the employee's willingness or motivation. Will the team willingly implement the new skills and knowledge on the job? If the answer is no, then you must investigate the reasons why.

How would your team describe the purpose of the training?

How would they rank the importance of bringing this new knowledge back to their tasks?

How has the expectation of compliance been communicated and how it will be measured?

How has the team been included in the needs analysis?

Answers to these questions will give an indication of how well the training will be embraced or rejected. While the training provides knowledge and should impact skills, it requires a change in behavior.

In the next issue of *Machinery Lubrication*, this discussion on implementing a training plan will be continued with an examination of how organizational culture influences training effectiveness.

Training Plan Design

With a clear number of participants for each training or awareness session, you are now ready to define specific aspects of the training plan. This can be accomplished by answering the following questions:

- How will the training be delivered (in the classroom, online, self-study, on the job or a combination)?
- Will a modular or full program be delivered?
- What is the timeframe to complete the plan?
- How will the learning be assessed (in the classroom, in the field or both)?
- What resources will be needed (considering the budget, location and logistics)?
- Which performance indicators will be used (number of participants per class, percentage of approved, man-hours of training, etc.)?

Training Requirements

	Maintenance/ Engineering	Purchasing	Human Resources	Production	Safety and Health
Managerial Opportunity Awareness	Plant director, operations manager, maintenance manager, project leader	Procurement manager	HR director	Production manager	Environmental health and safety (EHS) manager
General Awareness			HR advisor	Production supervisors	
Introduction to Machinery Lubrication and Lubricant Storage and Handling	Planning and scheduling	Purchasing clerk, warehouse personnel			EHS engineers and inspectors
Machinery Lubrication	Plant and field engineering, maintenance supervisors				
Introduction to Machinery Lubrication and Best Field Practices	Lube techs, mechanics, millwrights			Operators	
Oil Analysis	Condition-based maintenance technicians				

Plan Execution

Once the budget has been approved and the necessary resources identified and aligned with the involved personnel, it is time to execute the plan. Participants should be notified in advance. Conduct an initial general awareness session to explain the program's goals, content and timeframe. This will dissipate doubts and concerns while motivating the stakeholders to participate and support the program. Emphasize why the program is being implemented as well as the benefits for the individuals involved. Rewarding participation with certificates and a symbolic gift of the new status may help to create a positive environment.

Training Feedback and Competency

The effectiveness of the training may be assessed using a variety of methods. One simple way is with a course evaluation provided by the participant. This can be used to express the degree of satisfaction with the training, its usefulness and improvement opportunities.

Another approach is to give an exam on the topics presented in the training. The exam could be conducted before and after the training to compare the learning acquired, and may include case studies and exercises. This can be an excellent tool to measure how much information was retained at the end of the training.

A certification exam provided by a recognized organization like the International Council for Machinery Lubrication (ICML) can be very beneficial. This will motivate and demand a greater commitment from participants as a result of the new status achieved. It can even be used for career development.

The new knowledge or skills should also be verified in the field to ensure procedures are being followed properly. Not only should the new practices be confirmed, but also whether the objectives or improvements have been achieved.

Key performance indicators can be implemented to track the program's development and success. These might include the average result and the number of certified professionals.

A successful plan demands a thorough understanding of the training needs based on the organization's objectives. Planning, budgeting and consistent follow-up will also be necessary. While an investment of time and energy will be required, the plan will pay off with better performance, motivation and ultimately improved plant reliability. ■

A SNEAK PEEK INTO

NORIA'S TRAINING PROGRAMME

Lubrication-Institute recently accomplished its 4th Series of Noria Public Trainings and In-house Trainings in India. The trainings were organized across Kolkata, Mumbai, Vadodara and Vapi, with Mr. Andrew Jr. Sitton from the United States and Mr. Michael Hooper from New Zealand as the lead faculty and Mr. KNV Subrahmanyam as supporting faculty

The Public Training programmes conducted were on three subjects which were

1. Essentials of Machinery Lubrication,
2. Advanced Machinery Lubrication
3. Advanced Oil Analysis.

Besides these, two In House Trainings on Lubrication & Oil Analysis were conducted for Reliance Industries Ltd at their Learning Centre at Vadodara and Hard Castle Petrofer at Vapi.

Each programme was spread across three days of an interactive classroom discussion with the participants and the trainer discussing a variety of issues they experienced and possible corrective measures they would take away from this programme.

"Do not take oil analysis reports at face value. Look beyond the analysis report for possible answers. Helped dispel various myths which were taken as gospel truth." (S. Biswas, Indian Oil Corporation)

There was a total participation of 96 professionals across the 5 programs. Participants received a Noria course manual as a future go to book and a certificate.

The programmes were followed by an optional ICML (International Council of Machinery Lubrication) organized certification test. The council offered level 1, 2 & 3 certifications in MLA/MLT/MLE.

"I am working as a maintenance engineer in Petrochemical industry, looking after rotary equipment. After this training program, my perception regarding lubricating oil is completely changed. I would take oil sampling methods, sampling points, analysis techniques in my day to day work." (Anurag Chopra Reliance Industries)

1) Chief guest Mr. R R Kulkarni (Chief Manager, Lubes TS) addressing the participants

2) Mr R R Kularni (Chief Manager, Lubes TS) handing over certificate to Mr G R Khunte (Gas Co, UAE)

3) Mr R R Sudheendranath (GM Lubes, HPCL) being welcomed

4) Mr Andrew JR Lewis Sitton (Lead faculty) welcoming Mr S Jeyakrishnan, ED (Direct Sales) HPCL at the valedictory function on 15th Nov. 2014.

5) Training at Reliance Learning Centre Vadodara.

6) Mr S Jeyakrishnan, Chief Guest (ED-DS, HPCL) with participants of "Advanced Machinery Lubrication" in Mumbai.

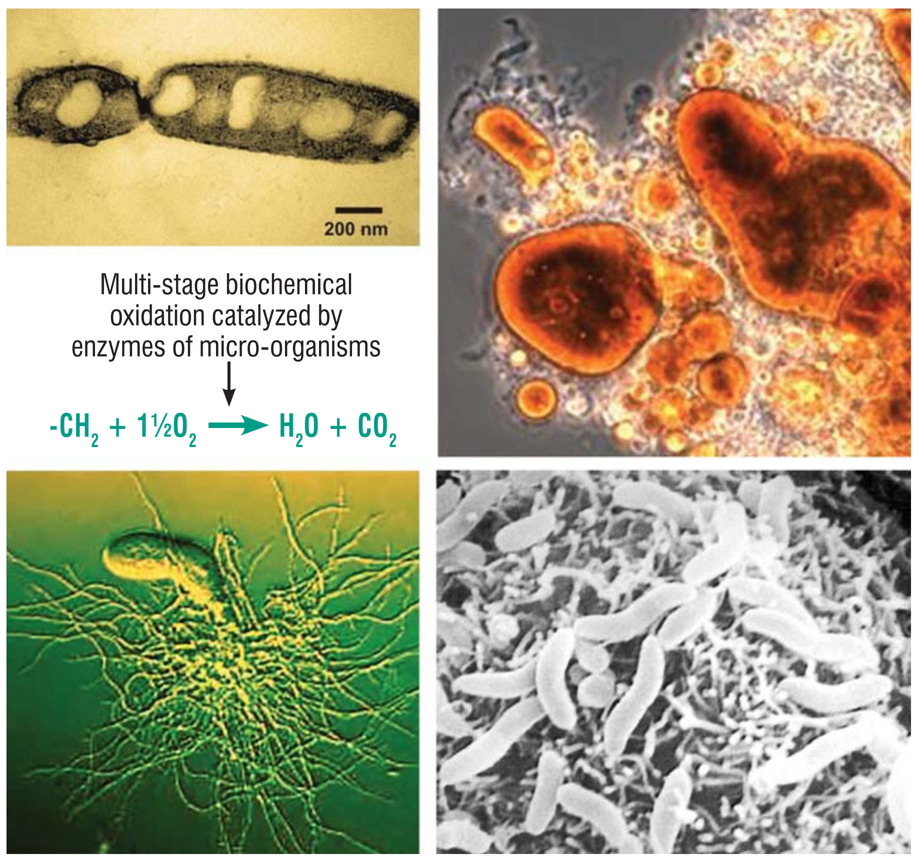
7) Participants of in house training held at Hard Castle Petrofer Vapi from 24-26th Nov. 2014.

DR. MARTIN VÖLTZ

New Test Method for Lubricant Biodegradability

Following criticism of the Coordinating European Council's well-known biodegradability test (CEC-L-33-A-93) for its use of hazardous solvents, and with alternative tests not designed for testing lubricants, a technical development group (TDG-L-103) was formed to establish a replacement test method. After 3½ years, a new biodegradability test procedure has been developed, thoroughly tested and approved. It essentially measures the loss of oil and oil-soluble metabolites over 21 days in a nature-like aqueous environment.

Before presenting the new test method, an understanding of biodegradation may be useful.



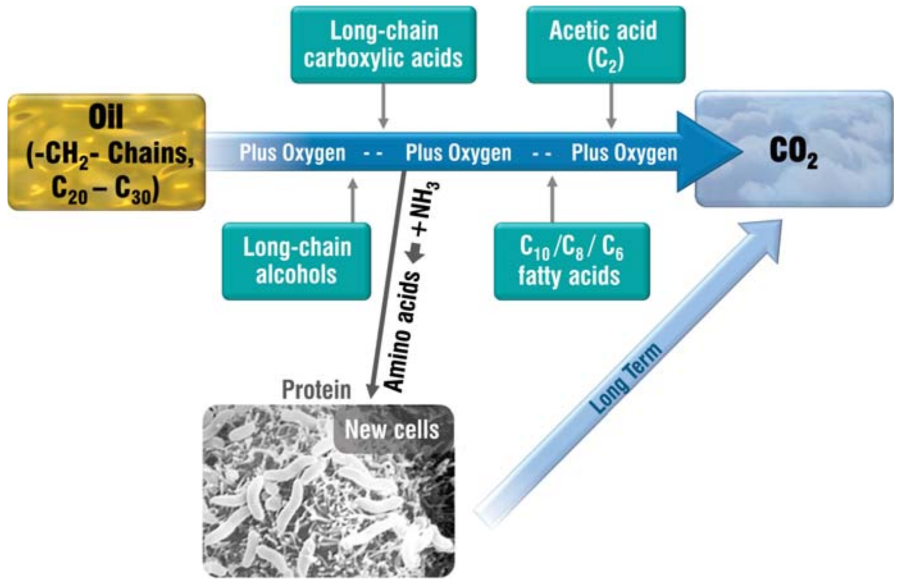
Biodegradation of hydrocarbon compounds

Biodegradation

Biodegradation of organic material (natural or synthetic hydrocarbon compounds) is actually biochemical oxidation. It is initiated and performed by the enzymes of micro-organisms such as algae and microfungi. Although similar to combustion, this biochemical process is much longer, comprising several small bio-oxidation steps via long-chain alcohols and carboxylic acids, as well as shorter chain acids down to acetic acid and carbon dioxide. This process delivers energy to the micro-organisms. There is also another side reaction inside these "microbugs" that uses long-chain carboxylic acids for the formation of amino acids and proteins. This reaction makes the micro-organisms grow in size and number.

When oil or other organic material is spilled into natural water containing the usual micro-organisms, the initial speed of biodegradation is very slow, as not all "bugs" present will accept this material as "food." Those that do will eat and grow in number and size, thus producing a faster biodegradation speed until this food (the added substrate) is fully consumed.

The resulting degradation/time curve of any organic material usually has



three stages: the lag (or adaptation) phase, the degradation (or exponential) phase and the stationary phase, where the new biomass will die away if no additional food is added. This type of degradation curve is found whenever the concentration of added organic material is observed. However, when the resulting carbon dioxide is measured, the shape will be somewhat different due to the side reaction into proteins and the time-consuming dying-off process of the biomass produced. This should be noted when comparing the results of oil removal tests with other methods measuring carbon-dioxide production.

Test Development

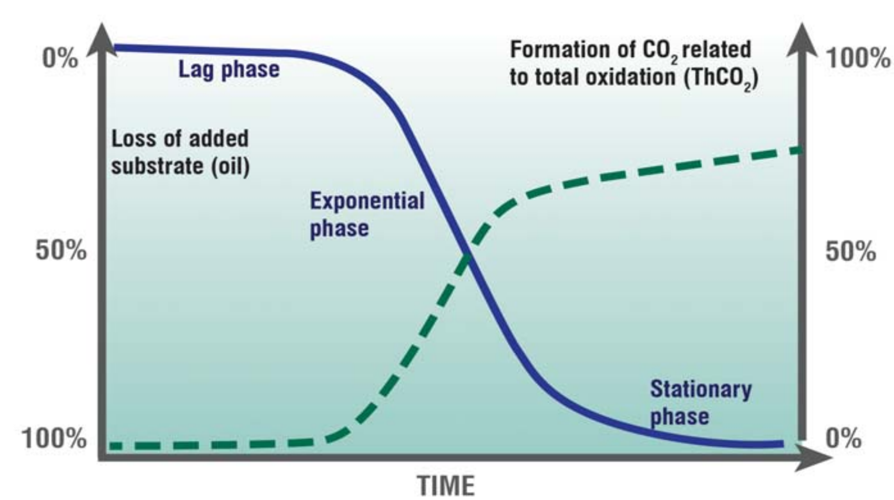
The establishment of a new test method for biodegradability began in late 2008 with the formation of the CEC Technical Development Group L-103. It was comprised of three active laboratories and a few industry experts. The group was charged with keeping the basic principles and advantages of the CEC-L-33-A-93 test, such as having a clearly defined oil incorporation procedure, using reference oils, and being suitable and proven for all types and chemistries of oils on the market, especially all types of bio-lubes. In addition, the group was to avoid hazardous solvents, exceed the L-33 test in repeatability and reproducibility, and match the test quality and surveillance criteria of the 2001 guidelines set by the CEC.

Just like the CEC-L-33-A-93 test, the new test's basic principle involves preparing a "mineral medium" (similar to natural surface water) that contains some mineral salts and natural micro-organisms. A small volume of oil and a carrier are added to prepare the test flasks, with biocide used for poisoned flasks and no addition made to neutral flasks. The oil contents of these flasks are analyzed and compared on the starting day and after 21 days of incubation in the dark with mild shaking at 25 degrees C. In all, 15 flasks are prepared for each candidate and reference oil — five for instant analysis and 10 for analysis after 21 days of degradation.

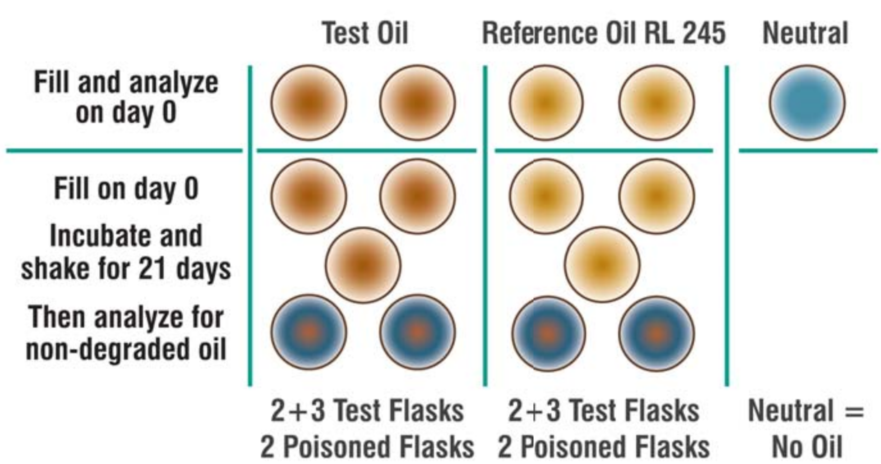
In the initial version of the CEC-L-33 test, the carrier material used to introduce the test oil into the aqueous medium was carbon tetra-chloride. Ethylene tetra-chloride or Freon was prescribed after 1993. The same hazardous solvents were also used to extract the non-degraded oil portion for quantitative infrared spectroscopy analysis after three weeks. Excluding the use of such solvents was found to be a significant challenge in the L-103 test development. Eventually, high-temperature gas chromatography was employed for the analytical evaluation of oil concentrations instead of infrared spectroscopy.

Gas Chromatography

Conventional gas chromatography (GC) is a good tool for qualitative and quantitative analysis as well as for



Kinetics of biodegradation



Preparation of test flasks for the new biodegradability test

producing simulated boiling curves of organic material with a minimum volatility. Lubricants of low and medium viscosity are also suitable for GC analysis but not heavy materials and esters.

High-temperature GC is a development of the last 10 years that has widely overcome these limitations and works well with all types of lubricating oils. Even polymeric components can be analyzed with good precision. Modern high-temperature GC analyzers are highly automated and can offer amazing precision, which enables test flask volumes to be reduced.

CEC-L-103: Repeatability Exercise

GC	
RL110	**RL245**
36%	71%
36%	75%
34%	74%
36%	72%
36%	72%
38%	72%
35%	69%
34%	71%
34%	74%
41%	72%
38%	70%
38%	74%
39%	74%
37%	74%
39%	75%

Data from one lab: 5 repeat tests with both reference oils	
Results	
35%	73%
37%	72%
34%	71%
39%	72%
37%	74%
Standard Deviation	
1.7%	1.3%

Overall TDG-L-103 Results	
Repeatability	
Low Ref. Oil RL 110	High Ref. Oil RL 245
5.6%	3.2%
Average: 4.6%	
CEC-L-33:	
6.7%	4.5%
Average: 5.6%	

Results of the repeatability exercise in phase one of the test-development process

Another advantage of GC analysis is that it allows the extraction of residual oil at the end of the test through the use of ordinary, non-toxic hydrocarbon solvents. However, such solvents are not helpful for introducing the oil sample into the aqueous test medium.

An effective biodegradation test must provide equally good dispersion conditions for all types of materials and products. The identification of such a "co-solvent" was an important step in the development of the new test method. This was followed by the exchange of mercury chloride in the abiotic (non-biological) "poisoned flasks" in favor of a mild but efficient organic biocide.

As prescribed for every CEC test-development process, the new procedure had to prove sufficient repeatability and discrimination with two reference oils. In the first phase of development, five repeat tests with two reference oils were conducted in each of the participating laboratories. Very good repeatability was seen in one of the cooperating labs, and clear discrimination of the two tested products was evident in all three laboratories. The average repeatability of all three labs was better than in the CEC-L-33 test.

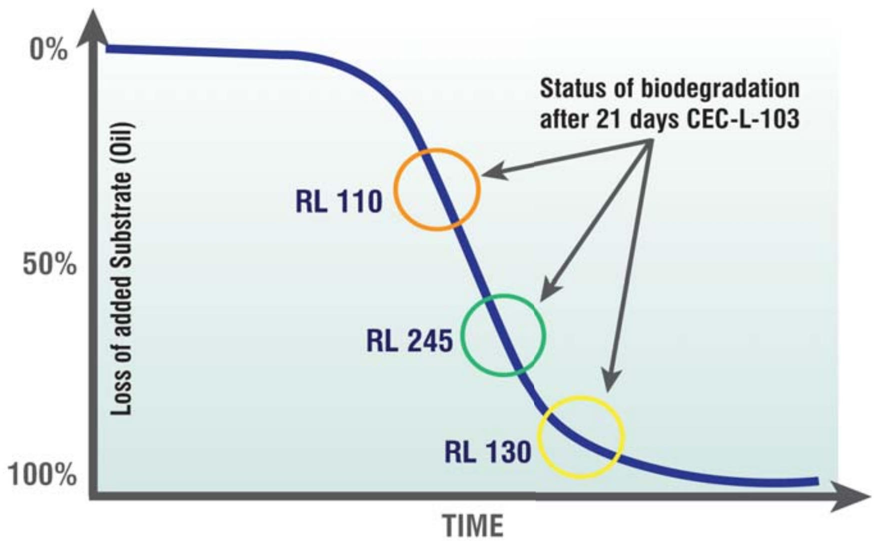
Round-robin Exercise

The second phase of the CEC test-development process involved the demonstration of the method's reproducibility in a minimum of five test laboratories. Three additional labs with suitable equipment and skills were located. The active labs in this phase included three independent commercial test labs, one additive supplier, one oil supplier and one governmental lab.

A round-robin exercise was then conducted according to the guidelines set by the CEC with guidance from the Statistical Development Group (SDG). Each lab tested four oils in parallel. One month later, the same oils were tested again using fresh inoculum. This would provide a final judgment on the new test method's discrimination, repeatability with the same inoculum (batch of micro-organisms), repeatability with another inoculum in the same lab and reproducibility in six different labs using six different inocula.

The average biodegradability results of the six labs were in the range of 35 to 40 percent with mineral base oils and formulations, 70 to 90 percent with synthetic base stocks and oils, and 90 to 100 percent with vegetable oil products. These results showed clear discrimination of high and low

Nevertheless, the precision data of the new test marked a big step forward in comparison to existing tests, as the reproducibility of the CEC-L-33 test had been 19 to 38 percent in 1991, and the reproducibility of the Organization for Economic Cooperation and Development's test (OECD-301) using



Biodegradation of oils after 21 days

biodegradability, with ranges similar to many results associated with the CEC-L-33 test.

The repeatability of the four samples was calculated at 4 to 7 percent using identical inoculum and 7 to 14 percent using different inocula, with 12 to 19 percent reproducibility. The best figures were seen at high degradation, and the worst at lower degradability. This was not surprising considering the degradation/time curve in which the daily degradation rate is low above 80 percent but high in the 30- to 70-percent range. This led the technical development group in an earlier stage to switch from the "high" reference oil (RL 130) used in the L-33 test with 80- to 90-percent degradation to an alternative synthetic (RL 245) with degradation values near 70 percent.

only water-soluble chemicals had been 19 to 40 percent in 1988.

The round-robin exercise made the effect of the individual inocula (bacterial batches) quite obvious. Using two different inocula in the same lab brought the repeatability figures up into the range of the reproducibility. Thus, the relative activity of the micro-organisms was a factor with equal importance as the individual lab and operator.

Two options were found to minimize or remove this undesired variation through microbial activity. First, each candidate test result must be achieved consecutively with a test of RL 245. In addition, the test result is valid only if the RL result is within the 10-percent range of the last round-robin test's average. Second, inoculum preconditioning, which involves

Summary of the New Lubricant Biodegradability Test Procedure

The new test method (CEC-L-103-12) provides a procedure to evaluate the biodegradability of lubricants in natural water. It is performed in direct comparison with at least one reference oil. Lubricants tested may be base oils or contain usual additives. Base oils can be conventional mineral, hydrogenated/hydrocracked oils, PAOs, synthetics, natural (vegetable) esters or mixtures thereof.

The required hardware for the test includes standard glassware, a shaker tablet and a high-temperature gas-chromatographic column and analyzer. The test medium is natural water from a defined source (comprising a defined level of micro-organisms) enriched with defined nutrient mineral salts.

The test is set up to simulate biodegradation in natural water, i.e., ground water or open rivers, lakes or sea. There is also good correlation with biodegradation in wet soil with the presence of sufficient air/oxygen as well as in biological sewage plants.

The lubricants tested are introduced by pre-dilution with a special solvent. After a 21-day degradation period, the oil content of the test flasks is compared with the original oil concentration and with poisoned (abiotic) reference flasks using oil extraction and a high-temperature GC analyzer. This procedure ensures all original oil and the products of primary biodegradation (long- and medium-chain hydrocarbons, esters, alcohols and fatty acids) are counted as "non-degraded" in the final test evaluation.

Test results provide the percentage of biodegradation over three weeks. For example, a result of 70 percent would indicate that 70 percent of the test material has been degraded biologically over 21 days down to carbon dioxide, protein (cell material) or metabolites that are readily soluble in water and are on a direct biochemical path to ultimate degradation.

putting each inoculum into a well-defined environment of standard nutrients before the oil test, was shown to reduce the number of individual species and the individual behavior of the inoculum.

Benefits of the New Test Method

The new test procedure is equally suitable for all types of lubricating oils, base stocks and formulations except water-soluble products. It avoids the use of toxic or harmful chemicals, reduces the overall consumption of chemicals and biomass, and increases test precision. It also offers a good way to simulate the fate of lubricating oil spilled in small quantities within the environment, such as during the operation of chainsaws or two-stroke engines.

Laboratories beginning to perform this new test procedure will need training and experience until they are able to produce valid results. However, the test description contains a number of hurdles and checkpoints that help make insufficient accuracy obvious and grant a high degree of reliability for all valid results.

Of course, there remain several issues that are not sufficiently covered by this or other test methods. For instance, no standard test method exists for simulating biodegradation of severe oil spills in a limited volume of water or soil, as in the cases of accidents with tank cars or mobile hydraulic systems. The main problem in such accidents is oxygen starvation that can lead to severe environmental damage. More research and possibly new test methods may be required to rate products for these real-world conditions.

In addition, during the technical development group's work, a few tests were conducted with lubricating greases, which produced reasonable results. However, these tests were performed only with low NLGI grades and in a limited number, so the new test procedure cannot be recommended for lubricating greases in general. This may be the subject of further investigation and possibly an optimized test procedure.

Please note that CEC test methods do not define limits for "good" or "acceptable" behavior of candidate oils. This is generally left to those who use CEC test procedures to set specifications, such as the DEKRA product-specific rules guideline for sustainable hydraulic fluids, which was the first specification using the new CEC-L-103 test. ■

SHANKAR KARNIK, ASIA PACIFIC MOBIL SHC
BRAND MANAGER & ENERGY ADVISOR

Mobil SHC 634 helps APOLLO TYRES increase gearbox efficiency by 2.6%;

In today's globally competitive business landscape, manufacturers feel constantly challenged to get the most out of their equipment. Even incremental increases in machine productivity can alter a profit/loss scenario – often the primary, if not the only consideration in many businesses. Also, in a world increasingly conditioned by a heightened awareness of environmental impact, concerns with the latter demand focus on sustainable business practices and energy efficient systems. In response, industrial and mobile equipment hydraulic systems have become smaller and lighter, and utilize higher pressures to achieve maximum system efficiency.

For instance, while gear lubrication has been commonly considered elementary, it is in fact, a dynamic process requiring sophisticated technology interventions. The differentials that house the gears

are out of sight, and therefore, out of mind–a neglected process. But differentials are just as important to the operation of a vehicle as the engine is. An engine without a functioning differential will not move the vehicle. This is why advanced hydraulic fluids are now available, contributing to the overall hydraulic system and energy efficiency.

Apollo Tyres has been in the business of manufacture and sale of tyres since its inception in 1972. The company has a manufacturing presence in Asia, Europe and Africa, with nine modern tyre facilities and exports to over 118 countries. The company offers a comprehensive product portfolio spread across passenger car, light truck, truck-bus, off highway and bicycle tyres, retreading material and retreaded tyres. The company firmly believes that to truly move up the value chain, it is critical to use fewer natural resources while optimizing its manufacturing output. For a growing organization with a long-term focus and commitment, it is critical to safeguard resources for the future even as it creates value today. This is why Apollo is committed to the cautious and careful use of natural resources.

In 2012, Apollo Tyres experienced the benefits of using Mobil premium mineral lubricants in one of their Feed Mill Gearboxes which resulted in a steep drop in temperature, seal life enhancement and significant overall lubrication cost reduction. Thus, Apollo Tyres was satisfied with the services provided by ExxonMobil. But then, Mobil Industrial Lubricants had much more in store for its treasured customer. Keeping "Sustainability in Motion" and as a result of ExxonMobil's technical approach to Apollo Tyres, they wanted to experience energy conservation by using Mobil synthetic lubricants in their critical applications.

Cracker Mill Gearbox(202) was chosen to demonstrate "Energy Efficiency" by using Mobil SHC 600 Series, a fully synthetic gear lubricant offering following key benefits;

- Increased reliability of the equipment with less wear of internal components
- Reduced "Total Cost of Ownership"
- Increased "Energy Efficiency", all leading to "Advancing Productivity" of Apollo Tyres Ltd.

ExxonMobil Engineers recommended Apollo Tyres to replace the cracker mill gearbox with Mobil SHC 634 a fully synthetic gear lubricant with energy efficient benefits to customers and provided series of technical services such as thermal imaging of the gearbox and incorporate power logger to measure energy consumption during operation. The gearbox was registered under SIGNUM program to monitor condition of the equipment and Mobil SHC 634.

To achieve above stated objectives, the Cracker Mill gearbox was first charged with fresh competitor ISO VG 460 Gear oil (Conventional) and run for approximately 40 days with energy meter installed from Apollo Tyres Electrical division. The gearbox was flushed and then replaced with Mobil SHC 634 and run for another 40 days with same measurement device and energy readings were compared. During the process the gearbox output as a parameter of production was also measured to ascertain the actual load on the gearbox. The treading process started with Cracker Mill and completed after extruder through a Feed Mill. The production output was measured as number of treads produced per shift (8 hrs duty) after extruder. Only the cracker mill gearbox was charged with Mobil SHC 634 to evaluate energy efficiency.

A 5oC drop in average temperature of gearbox was observed after changeover to Mobil SHC 634

With changeover to Mobil SHC 634 alongside SIGNUM Oil Analysis, Apollo Tyres were able to experience an overall 2.6% energy savings calculated through energy meter readings. This was also substantiated by a temperature drop of 5oC through thermal imaging.

Benefits:

By changing over to Mobil SHC 634, Apollo Tyres Perambara site achieved following key benefits,

- Extended Oil life and reduction in equipment wear
- Increased reliability of the equipment with reduced overall lubrication cost
- Reduced power consumption by 2.6 % (through Energy meter) and 3.7 % (through Temperature profile measurement)
- Energy savings calculated using energy meter is recorded below,
- Motor rating with 80% efficiency, 200 kW
- Energy saved per year in units 200 x 0.026 x 8000 = 41600 units
- At an average of Rs 5/- as unit cost of energy, annual savings of INR 2,08,000(USD 3,525.42) is recorded

In conclusion, superior product performance of Mobil SHC 634 supported by Signum Oil Analysis based on recommendation by Mobil engineers helped the customer improve energy efficiency of 2.6% in their gearboxes.

About ExxonMobil Lubricants Private Limited

Customers have relied on ExxonMobil lubricants for more than 120 years. Marketed in nearly 200 countries and territories worldwide, ExxonMobil products stand for performance, innovation and expertise. As an industry leader in synthetic lubricants, a full range of ExxonMobil products is available in the automotive, commercial and industrial business sectors. ExxonMobil recognises that business success and social responsibility go hand in hand. To that end, ExxonMobil works closely to support the communities where they operate and pledges to maintain the highest ethical standards, comply with local laws and respect local and national cultures. The term “ExxonMobil” is used for convenience only, and may include Exxon Mobil Corporation or any of its affiliates.

Mobil Industrial Lubricants is a business of Exxon Mobil Corporation. Today, Mobil Industrial Lubricants are used extensively in many industrial market sectors - including power generation, general manufacturing, metal working, food and beverage processing, pulp and paper, cement, construction, metals and mining. Every day, Mobil-branded lubricants help enable industrial companies to successfully boost productivity, enhance the performance and life of their equipment, increase profitability and reduce downtime.

For more information on Mobil Industrial’s range of lubricants and services, visit mobilindustrial.com

BRENT MILEY, JOHN SHINN JR. AND JACK R. NICHOLAS JR.

Establishing an In-house Predictive Maintenance Program

While many companies are perfectly satisfied with the performance of their outsourced predictive maintenance (PdM) programs, some do not get the desired results for the time and money expended. Others recognize that they have a pool of in-house talent that could do the job given enough time and training, or are facing budget cuts and pressures that force limiting, reducing or defunding PdM contracts.

Whether your organization has an established contractor-provided PdM program that you want to bring in-house or is starting a program from scratch, it should be done only after careful analysis of the expected benefits and problems that are likely to be encountered. For example, it takes a considerable amount of time for PdM technicians to become proficient in some technologies, particularly vibration analysis and infrared thermography.

Having a competent PdM contractor already engaged with your assets will make the transition to an in-house program easier and quicker if the contractor is willing and able to train your personnel in the technologies already being applied. Most attempts to bring a PdM program in-house fail not because of the contractor but because of internal factors such as personnel turnover and failure to select workers suited to the practice of predictive maintenance. Related issues include but are not limited to:

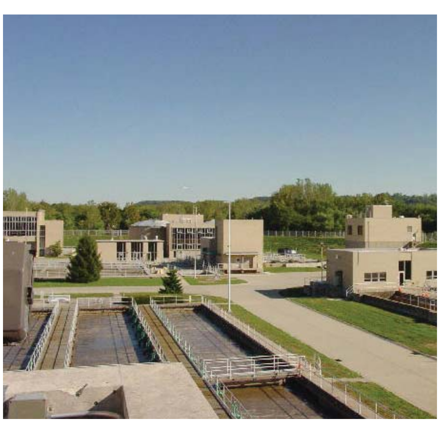
- Lack of computer literacy among those who would like to be PdM candidates;
- Inability to learn complex PdM technologies;
- Lack of appreciation by managers, supervisors, team candidates and co-workers for the difficulty of achieving competency in a complex PdM technology;
- Failure of managers and co-workers to appreciate that a PdM technician's work is every bit as demanding as that of maintenance crew personnel;
- Failure to create and maintain a current PdM program master plan;
- Failure to establish and defend an adequate budget for all aspects of a PdM program;
- Failure to educate management, supervisors and co-workers on the benefits of a PdM program;
- Failure to continuously calculate the return on investment and

It can take a considerable amount of time for predictive maintenance technicians to become proficient in some PdM technologies.

document other benefits of a PdM program;

- Failure to provide for retention of PdM technicians after they become competent in assigned technologies; and
- Failure to establish a succession scheme for PdM team personnel who retire or move on to jobs with greater responsibility.

The last item above is particularly important. When ideal candidates are selected for a PdM team, management must expect that sooner or later at least some of them will move to better-paying, higher-level positions. Preferably, this will be within the current organization where they should become "champions of PdM." The worst-case scenario is that they leave with only a two-week notice and go elsewhere. It then may take months to identify novice candidates or to hire partially experienced or even certified replacements and get them up to speed. In the meantime, monitoring languishes, reliability decreases and the PdM program may even be abandoned if its true worth hasn't been documented. This can result in a decline in availability while the maintenance strategy reverts to more costly approaches such as reactive maintenance. To mitigate this risk, it is a good idea to continue a relationship with the PdM contractor to support the program when required.



The Metropolitan Sewer District Wastewater Treatment Division operates seven major treatment plants and more than 100 smaller treatment facilities that process an average of 180 million gallons of raw sewage each day.

In a two-tiered predictive maintenance program, a skilled PdM team with sophisticated data-collection hardware and analysis software supports and collaborates with maintenance crews equipped with simpler tools for detecting problems in their plants.

Another pitfall to avoid is deciding that a PdM program can be done cheaply. With this strategy, simpler, easy-to-learn PdM tools are acquired, but more sophisticated suites are never applied, even with contractor support. In these cases, the diagnostic and long-term analysis capabilities of advanced PdM software and the full potential of a comprehensive PdM program are never realized.

The opposite situation can also create problems. Sophisticated and costly PdM tools are purchased and put into the hands of maintenance crew personnel who are given training they either don't apply soon after the classes or have too few opportunities to learn how to apply them on the job.

Benefits of a Two-tiered PdM Program

A two-tiered PdM program that applies multiple technologies can be beneficial for many organizations, especially those with plants dispersed over a wide geographic area and/or where semi-autonomous maintenance crews are employed. These benefits are over and above those of a traditional team-only or decentralized, non-integrated approach.

Under this two-tiered arrangement, a skilled PdM team with sophisticated data-collection hardware and analysis software supports and collaborates with maintenance crews equipped with simpler but sufficiently sensitive tools for detecting and confirming problems in their plants. With this type of program, local maintenance crew personnel are empowered to declare an asset ready for return to operational service.

The PdM capability provides maintenance personnel with their own quality-assurance tools. This is done by having the local maintenance crews responsible for post-maintenance testing, which is performed to determine if a restorative or mitigating task has been successful in fixing a reported problem, as well as to ensure that new problems weren't introduced in the course of maintenance. In the event post-maintenance testing reveals an abnormal condition, help from the PdM team can be requested to define what may have gone wrong during maintenance so it can be remedied.

There is also a division of labor and responsibilities in the employment of predictive technologies between the PdM specialists on the PdM team and the PdM practitioners on the maintenance crews. This can pay dividends in three ways:

1. The maintenance crews, which are equipped with simple but effective tools, can perform post-maintenance testing and make the "go/no-go" calls with a reasonable level of assurance. This boosts their confidence and self-esteem.
2. It enables staff through involvement in PdM technology to determine if they are interested in becoming future PdM team member candidates.
3. The PdM team is relieved of having to perform post-maintenance testing under time constraints and pressures to return the asset to service as soon as possible.

Another advantage of a two-tiered PdM program is that it offers added opportunities for cooperation between the PdM team and local maintenance crew members. For example, when baseline testing by PdM team members is being conducted, maintenance crew PdM practitioners should be present with their PdM tools to take readings at the same time. This allows the maintenance crew members to compare readings from their simpler tools to those taken by the PdM team members on their more sophisticated equipment. This will educate both groups on each other's capabilities and limitations, and enhance future cooperation.

Case Study: The Metropolitan Sewer District of Greater Cincinnati

The Metropolitan Sewer District of Greater Cincinnati (MSDGC) serves 800,000 customers and has approximately 600 employees who work at facilities located throughout Ohio's Hamilton County. The MSD Wastewater Treatment Division operates and maintains seven major treatment plants and more than 100 smaller treatment facilities that process an average of 180 million gallons of raw sewage per day. Most of the major treatment facilities were built in the 1950s and contain more than 16,000 total discrete assets that are critical to meeting MSD's mission of protecting public health and the environment through water reclamation and water-shed management.

When the Wastewater Treatment Division decided to establish an in-house PdM program, one of its strategic goals was to build internal PdM core competencies aligned with the mission and vision of the organization. This required alleviating problems associated with data collection and correlation, communications (particularly feedback and follow-up on PdM-initiated work orders), and planning and scheduling. For several years, the organization had been using local maintenance personnel to perform ultrasonic analysis as well as online and offline motor testing to help complement its contractor-managed vibration and infrared (IR) thermography program.

MSD's contractor had no access to its in-house technology or computerized maintenance management system (CMMS) databases due to strict firewall maintenance. This made correlating data very difficult or impossible for those outside the firewalls. All in-house technology databases were managed by MSD planners who issued work orders based on the results of the in-house testing but without much internal analyzing. The planners also wrote work orders from the quarterly PdM report provided by the contractor. Opportunities for data correlation were often overlooked or too difficult for those not trained or dedicated to doing so.

The previous program operated under a basic plan. On a quarterly basis, the contractor performed vibration analysis and IR thermography on assets deemed critical to the wastewater treatment process. An asset list was sent out the week before the contractor's quarterly visits. The week of the visit, the contractor would collect data on all operating equipment during the first day or two. On the second or third day, the operations department was required to switch "missed" equipment so it would be running during the last days of the data-collection week.

While this may seem to be an adequate plan, there were inherent flaws that took years to correct and required work-arounds to be devised. Not having in-house PdM technicians skilled in even basic vibration analysis and infrared thermography became problematic almost immediately after the start of the contractor-based PdM program. If critical equipment could not be switched by operations (for any number of reasons), that piece of equipment was missed until the next quarterly contractor visit (or longer).

Delays in post-maintenance testing (PMT) were another issue. When the contractor identified a problem, the in-house maintenance crew would make the repair but had no way to tell if the reported defect had been corrected. Since MSD could not allow a machine that wasn't repaired properly to operate (or remain idle) for a full quarter before PdM readings were taken, the organization decided to call in the contractor to perform PMT. If satisfactory conditions were found, new baseline readings would be obtained before being turned over to operations. However, getting the contractor to the asset to be tested and having the results analyzed and reported might take several days.

In developing this process, MSD discovered that it was calling in the contractor several times a month for PMT on only one item, which was expensive. A work-around was designed to minimize cost. The contractor would only be called in when more than one asset was ready for PMT. Unfortunately, this put the organization back in the same sinking boat; now they just had to use a bigger bucket to bail.

After several years of trial-and-error and countless meetings to improve the program, MSD decided it needed an effective in-house PdM program. In late 2011, through a series of workshops with operations, maintenance and engineering, MSD refreshed its shared vision, mission and core values. To support the mission and accomplish its vision, MSD developed a strategic maintenance and reliability plan that had six goals and objectives. One of the goals was to reduce downtime through a centralized and decentralized predictive maintenance program. An expert with more than 40 years of PdM experience was chosen to guide the organization in the program development. A five-year plan was created outlining tools, training, software, workflows and budgets. The result was a two-tiered system of low-end and high-end PdM technology tools and users serving all seven plants.

High-level tools such as vibration analysis suites, IR thermography analysis software, ultrasonic analysis devices, and online and offline motor-circuit analysis suites were placed in the hands of PdM team members selected from the in-house maintenance crews based on their past experience and aptitudes. Previously, motor-circuit testing had been carried out by maintenance crews but with highly variable results across the division. This was due to personnel turnover and the need for substantial training and field experience to become proficient in the use of the equipment and in performing proper data interpretation after testing.

Following some research by crew leaders, vibration meters, simple infrared "guns," laser alignment tools and ultrasonic detection devices were purchased based on their suitability for wastewater treatment assets and the maintenance personnel who would be assigned as PdM practitioners.

The PdM contractor supported a training, mentoring and certification program with appropriate milestones, number of hours and courses needed for the team to become capable in vibration analysis and infrared thermography. Quarterly contractor visits for monitoring became "shadowing" sessions where the PdM team would observe the data-collection process and learn the basics of the technologies. The contractor also conducted training and certification examinations in visual inspection for both the PdM team and maintenance crew personnel.

After one or two quarters, the PdM team started collecting the data. Reaching this point was a huge milestone in the program. Instead of missing equipment each quarter, the team began collecting data on equipment throughout the quarter and sending it to the contractor for analysis. As proficiency was gained in analysis, team members progressively assumed this responsibility also. The PdM team now initiates work orders in the CMMS for crews to repair and conduct PMT. This more complete approach to data collection has been well-received by operations.

Ultrasonic sensor-aided grease guns, which had been acquired earlier and used by local maintenance crews for some time, would continue to be utilized by them. Sophisticated ultrasonic analysis devices that had previously been issued to the maintenance crews but not used much because of their complexity and crew member turnover were transferred to the PdM team. Maintenance crew PdM practitioners who received and were trained on the simple-to-learn tools began using them to conduct PMT.

An existing laboratory-supported lubricant and wear particle analysis program remained in the capable hands of local maintenance crews and their planners. Another key was having personnel both within the PdM team and the local maintenance crews with the desire and drive to make the PdM program work.

Annual alignment PMs and workflows were developed to obtain baseline readings on newly installed equipment and rebuilds or major repairs. Once alignment is completed, a task is created for the PdM team to acquire new baseline readings.

After the newly formed team was in place, a predictive maintenance management software (PDMMS) contract was established to allow personnel to manage and correlate PdM data from all the efforts of the team, the outside contractor and the maintenance crews. The PDMMS is Web-based and operates outside of network firewalls, which requires some manual transfer of data (such as work-order numbers, etc.) between the CMMS and PDMMS.

Classroom training by the contractor and technology vendor instructors along with in-the-field training and mentoring has proven invaluable. Once hours of on-the-job practice are met, certification in the assigned technologies is required. This is overseen by a PdM specialist from the outside contractor, who provides vibration analysis and infrared thermography services until the PdM team takes over. After two years, all PdM team members are expected to be certified in at least two technologies.

The most important part of the two-tiered PdM system is the involvement of the local maintenance crews. Instead of a PdM team coming out and telling them what to fix and whether they did their job correctly, it's more of a unified approach.

The hard-working staff at MSD along with the senior and executive leadership have been essential in promoting a culture that is striving toward world-class maintenance reliability. While their simple approach of fostering a proactive culture based on proven best practices works, it requires time and energy. A commitment to follow-through at all levels is delivering results, and efforts to continuously improve are being rewarded by a noticeable culture change and success stories.

The vast improvement in the overall program is evident by the increase in proactive labor from 46 percent in 2011 to 70 percent today. The monthly emergency failure rate has also decreased by 55 percent, and documented cost avoidance has reached more than $650,000 due to proactive maintenance activities. Thus, assets are more reliable, and downtime has decreased as a result. Less than halfway into its five-year PdM plan, MSD is excited to see what the future holds.

ExxonMobil
Fuels & Lubricants

Launch of Report on ENHANCED ENERGY EFFICIENCY in Industrial Lubrication

ExxonMobil Lubricants Private Limited, a subsidiary of Exxon Mobil Corporation, was present at the launch of an independent study by the Confederation of Indian Industries (CII) on “Enhanced Energy Efficiency in Industrial Lubrication.” The report launched by Dr. Ajay Mathur, Director General, Bureau of Energy Efficiency contained findings of the importance of using efficient lubricants & lubrication practices for conserving energy.

From(L to R) _ Ms. Soma Banarjee, Dr. Ajay Mathur(Director General BEE), Mr. Rajiv Mishra and Mr. Ramani Iyer

The report highlighted an online survey to 461 experts across all sectors comprising of power, cement, iron & steel, chloralkali, pulp & paper, fertilizer, textiles, aluminums.

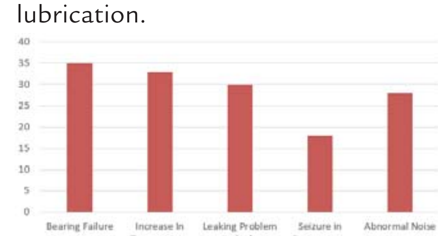
Mr Chima Eze, Global Industrial Brand Manager, ExxonMobil Fuels & Lubricants said, “The industrial sector is a major consumer of energy, accounting for about half of all the electricity consumed around the world. One opportunity for energy conservation that is often overlooked in industrial facilities is the technology behind the lubricant used.” He further added, “Using energy efficient lubricants will enable manufacturing facilities to operate at maximum efficiency at optimal cost. Typically companies that upgrade their lubricants and reliability practices have been able to document a significant reduction in power requirements along with achieving productivity improvement and reduction in carbon emissions across various applications in the industrial sector.”

From(LtoR) Mr. Shankar Karnik, Mr. Glen Sharkowicz, Mr. Chima Eze and Mr. Sachin Mahehwari

Mobil Industrial Lubricants is geared to meet and exceed industry requirements through a suite of step-up technology lubricants which include the next-generation Mobil SHC 600 series, Mobil SHC Gear series, Mobil SHC Pegasus, Mobil SHC Cibus series, Mobil SHC 500 series and Mobil DTE 10 Excel series.

According to Mr. Shankar Karnik, Mobil SHC Brand Manager & Energy Advisor, ExxonMobil Lubricatns Pvt. ltrd., "There is a need for companies across industries to perceive energy efficiency through a strategic lens and align it to their core business objectives."

Typical problems obseved in the rotating equipment due to improper lubrication.



TYLER HOUSEL, INOLEX CHEMICAL CO.

Synthetic Esters: Engineered to Perform

The lubricant industry generally treats synthetic esters as a monolithic class of Group V base oils with well-defined properties. It is not difficult to find a chart that lists esters as having "fair" hydrolytic stability, "good" biodegradability, "very good" lubricity, "excellent" oxidative stability and so on. Sometimes diesters and polyol esters are listed separately, but there is seldom further differentiation. However, the nature of esters defies such oversimplification. There are endless varieties of esters that can be built from commonly available acids and alcohols, so almost anything is possible.

Modern synthetic esters can be "tuned" to perform in nearly any environment and application. Whether you seek excellent hydrolytic stability, oxidative stability, biodegradability, lubricity, high viscosity index or low-temperature properties, all of these are possible with the right synthetic ester. Synthetic esters are manufactured from carboxylic acids and alcohols, which are very common chemical building blocks. They provide almost unlimited structural and performance possibilities.

The Ester Reaction

Figure 1 shows the basic chemical reaction used to synthesize all esters — a carboxylic acid and an alcohol react to form an ester and water. Organic chemists call this a reversible reaction because water can react with ester groups and break the ester into its components. This is known as hydrolysis.

The raw materials used to make esters can be linear, branched, saturated, unsaturated, monofunctional, difunctional or polyfunctional. There are hundreds of potential acid and alcohol building blocks, and the number of combinations is almost limitless. Attempts have been made to classify esters in categories such as diesters and polyol esters or simple and complex esters, but the technology is far ahead of the terminology.

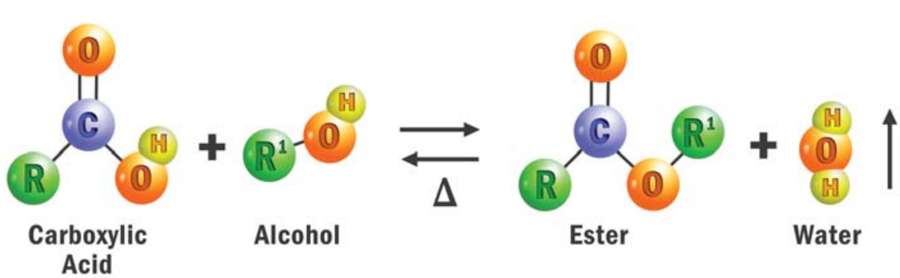


Figure 1. The esterification reaction

The building blocks often define the maximum performance potential of an ester, while the manufacturing savvy determines whether the ester reaches its potential. For example, a synthetic neopolyol (alcohol) can produce an ester with outstanding oxidative stability, yet the oxidative stability of the ester may be diminished with inferior ingredients, contaminants or poor processing techniques.

Thermo-oxidative Stability

Oxidation is a degradation process that occurs when atmospheric oxygen reacts with organic molecules. For synthetic esters, this normally occurs at high temperatures, but it is possible to find esters that oxidize without heating. It has been known for centuries that linseed oils form a solid coating when exposed to air at ambient temperatures. These are called drying oils because they can be painted on wood and cured to a hard, protective varnish. Room-temperature polymerization relies on oxidative cross-linking of polyunsaturated fatty acids.

While varnish enhances the appearance of antique furniture, it is not beneficial on industrial equipment. Synthetic esters are the best choice to provide clean, varnish-free lubrication at temperatures up to 600 degrees F (300 degrees C). The only way to engineer a superior high-temperature lubricant is to understand and eliminate structures that are oxidatively unstable.

It has already been established that polyunsaturated fatty acid components must be eliminated, but unsaturated fatty acids such as oleates are commonly used in lubricants. In fact, oleates have many good properties including lubricity, low volatility, cold flow, biodegradability, renewability and a low price. The oxidative stability is also much better than that of drying oils. However, unsaturated esters, including vegetable oils, are still limited to lower temperature applications.

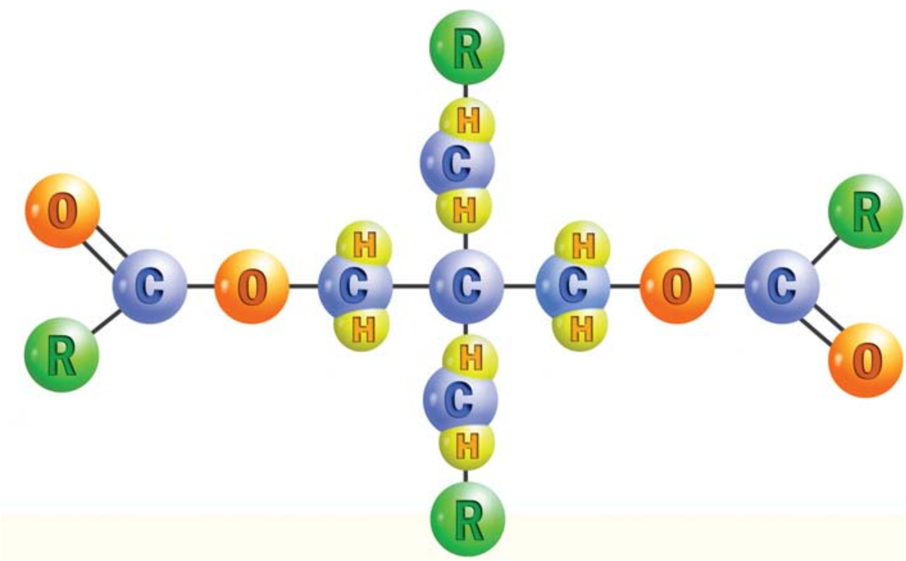


Figure 2. Polyol ester

Saturated esters are required for use at higher temperatures, but there is more to consider. High-temperature oxidative stability depends heavily on the amount and configuration of hydrogen on the beta-carbons in the molecule. The beta-carbon is the second one from the carbon-oxygen bond of the ester group. The beta-hydrogen is very reactive toward oxygen, so esters with no beta-hydrogen are more thermally stable. These are known as neopolyol esters, with their name derived from their structural similarity to neopentane. Neopolyol is shortened to polyol esters and abbreviated as POE. All POEs have good oxidative stability because they have no beta-hydrogens (see Figure 2).

Although unsaturated fatty acids cannot perform at high temperatures, it is not enough to simply substitute saturated fatty acids such as stearic acid. Synthetic short-chain carboxylic acids offer a greater degree of oxidative stability and are much better at low temperatures than saturated fatty acids. Shorter branched fatty acids are used when exceptional thermal stability is required. By eliminating the oxidative weak points, synthetic esters can be designed to operate at high temperatures and will tend to evaporate cleanly before undergoing oxidative polymerization so they will not form deposits and varnish.

Viscosity

Chemists find many examples of the link between viscosity and molecular weight. From linear alkanes to polymers, bigger molecules are expected to be more viscous. However, this simple rule of thumb does not always apply to synthetic esters. The viscosity is strongly dependent on the amount of branching, aromaticity, functionality and ease of rotation of the bonds that make up the molecule. As the structure becomes more branched, it is more difficult for the molecule to bend around and flow over itself.

Aromatic esters are extremely viscous because of the rigid aromatic ring. So while it's true that molecular weight is related to viscosity, there are also ways to break this relationship when desired. This is particularly useful when the volatility profile requires a specific molecular weight and the application demands a certain viscosity.

Molecular weight is not the only factor that determines the viscosity of a synthetic ester, but it can certainly be used to increase viscosity when necessary. If the component acids and alcohols each have more than one reactive group, esters can be polymerized to any length. Although the lubricant industry doesn't employ rigid polyesters that are made into bottles, the same principle can be used to build molecular weight and therefore increase viscosity. These are called complex esters or CPE.

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HIGHLIGHTS

- PLENARY SESSION – "Scenario of Steel & Lubricant Industry"
- PANEL DISCUSSION I – "Lubrication challenges of Hydraulics & Gears in a modern steel plant"
- PANEL DISCUSSION II – "Lubrication needs of BUR Bearings, Turbines & Compressors"
- PANEL DISCUSSION III – "Rolling lubricants"
- PANEL DISCUSSION IV – "Best lubrication operating & maintenance practices"

CHIEF GUEST

Mr. Anand Sen, President (TQM & Steel), Tata Steel

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Biodegradability and Hydrolytic Stability

The rate of the hydrolysis reaction is highly dependent on both the chemistry of the ester bond and the environmental conditions. Synthetic esters can be stable for a few hours or thousands of years, so it is impossible to classify them using words such as "fair" or "good." To manage hydrolysis, it is important to understand the type and purity of the reactants as well as the manufacturing process.

Remember that esters are made from alcohols and carboxylic acids, and that water is a byproduct of the esterification reaction. All ester reactions are reversible, so water can break ester back into the acid and alcohol components. Once ester is broken into the alcohols and acids, bacteria can complete the digestion of the components. Typically, increasing the amount of natural components such as vegetable-based fatty acids helps biodegradability. When synthetic acids and neopolyol alcohols are used, the ester becomes more inert and the rate of biodegradation is reduced.

It is possible to chemically block the hydrolysis pathway using branched carboxylic acids. These esters are extremely stable in water and act like mineral oils in typical hydrolysis tests. In fact, a computer simulation shows that the rate of hydrolytic degradation is measured in hundreds of years.

Smoke Point, Flash Point, Fire Point and Volatility

Synthetic esters are prized for their ability to lubricate at high temperatures. One of the main reasons for this is that they have a much lower volatility than other lubricant base oils at a given viscosity. Volatility is strongly related to smoke point, flash point and fire point, which are part of ASTM D-92. As the temperature rises, the amount of evaporation increases until there is visible smoke and eventually enough smoke to support a flash or fire in the presence of a flame. The table on page 40 shows the relationship between flash point and viscosity for several common types of synthetic lubricants.

SYNTHETIC BASE OIL	VISCOSITY AT 40°C	FLASH POINT
PAO	19 cSt	220°C
PAG	34 cSt	218°C
Alkylated Naphthalene	29 cSt	222°C
Diester	14 cSt	231°C
Polyol ester (POE)	19 cSt	257°C

Volatility is also dependent on the distribution of molecular weight in a lubricant. It has been proven that a small amount of flammable solvent will still be flammable even if mixed with other inert components. The mixture will ignite as long as there is enough flammable vapor in the air. Likewise, the most volatile components of a lubricant base oil determine flash point. Esters can be designed to have a very pure composition so there are few small molecules to smoke and flash. An added benefit is that viscosity stays in grade because no light ends evaporate from the lubricant.

Volatility and Deposits

From a chemical standpoint, volatility is related to molecular weight, polarity and chemical stability. While molecular weight and polarity are well-known effects, chemical stability is often overlooked because it considers only small organic molecules. However, a high-temperature lubricant is made from larger molecules that do not evaporate readily, so stability becomes important.

Oxidative and thermal degradation begin to occur between 200 to 300 degrees C. At these temperatures, base oil evaporation is a slow process. However, oxidation can break the molecule into small, volatile fractions. A large percentage of the weight loss in evaporation tests such as ASTM D-2595 comes from oxidation. Not only does oxidation cause weight loss, but it also causes varnish. The decomposition products in the vapor phase are often free radicals or reactive molecules. Deposits and varnish can form as the radical groups in the vapor condense and create a polymer varnish on metal surfaces. These polymers can also form sludge if they reach a high enough concentration to be insoluble in the bulk oil.

Synthetic esters reduce varnish and other deposits because they have outstanding oxidative stability and do not form many radical decomposition products. Furthermore, they are good high-temperature solvents and tend to dissolve the varnish back into the liquid phase so it can be filtered out.

Lubricity, Polarity and Additives

The key property of a lubricant is that it is expected to lubricate. Lubricity has to do with how easily the molecule flows over itself and how well it competes for and coats the metal surface. Esters are generally considered good boundary lubricants because they associate with metal surfaces and reduce the amount of metal-to-metal contact during sliding motion. Structural factors that impact lubricity include the chain length, the amount of branching and the location of linkages within the molecule.

Longer carbon chains, less branching and good polarity all favor boundary lubrication. Ester linkages are polar but can be less surface active if they are shielded by carbon chains. Synthetic esters are designed from different acid and alcohol feed stocks, so the location of ester groups and type of carbon chains can be selected independently. The lubricity of the ester base stock depends on the interaction of the ester with the metal surface. Esters have good lubricity, but under severe conditions, anti-wear and extreme-pressure additives are used to carry the bulk of the load. Some say esters compete so vigorously for the metal surfaces that they crowd out necessary additives. However, many additives are active enough to displace an ester from a surface. Expertise and experience are important here, as some additives do not work well with synthetic esters.

It is also important to choose an ester that is appropriate for the application. If the application involves boundary lubrication where metal surfaces grind together under pressure, lubricity is a key concern. But if the application involves only hydrodynamic lubrication where there's no metal-to-metal contact, lubricity is less important. Esters are great for high-temperature hydrodynamic applications because they can survive in extreme environments where no other lubricant can.

Manufacturing, Chemical Stability and Application Suitability

To this point, the role that chemical structure plays in ester properties has been discussed. However, a second factor is equally important: the manufacturing process and the residuals it can leave behind.

Residual Acid Value

Ester manufacturing always starts with an acid and an alcohol, both of which may be volatile. It is impossible to achieve 100-percent conversion in any chemical reaction, so there is always some residual carboxylic acid or alcohol in the final product. If this is not properly controlled, it can alter the initial properties of the ester and can also cause the lubricant's properties to change during storage and use.

Carboxylic acids are the primary concern because they can accelerate hydrolytic breakdown of the lubricant. This is especially problematic in metalworking fluids where water is a main component.

Figure 3 shows the effect of residual acid on hydrolytic stability. This is an accelerated hydrolysis test that holds an ester and water in a sealed tube at 125 degrees C. Ester 1 (blue) has an acid number of 0.03 milligrams of potassium hydroxide per gram (mg KOH/g) and shows almost no degradation over the duration of the test. Ester 2 (purple) starts with an acid number of 1, while Ester 3 (red) begins with an acid number of 3. Esters 2 and 3 are highly degraded by the end of the test.

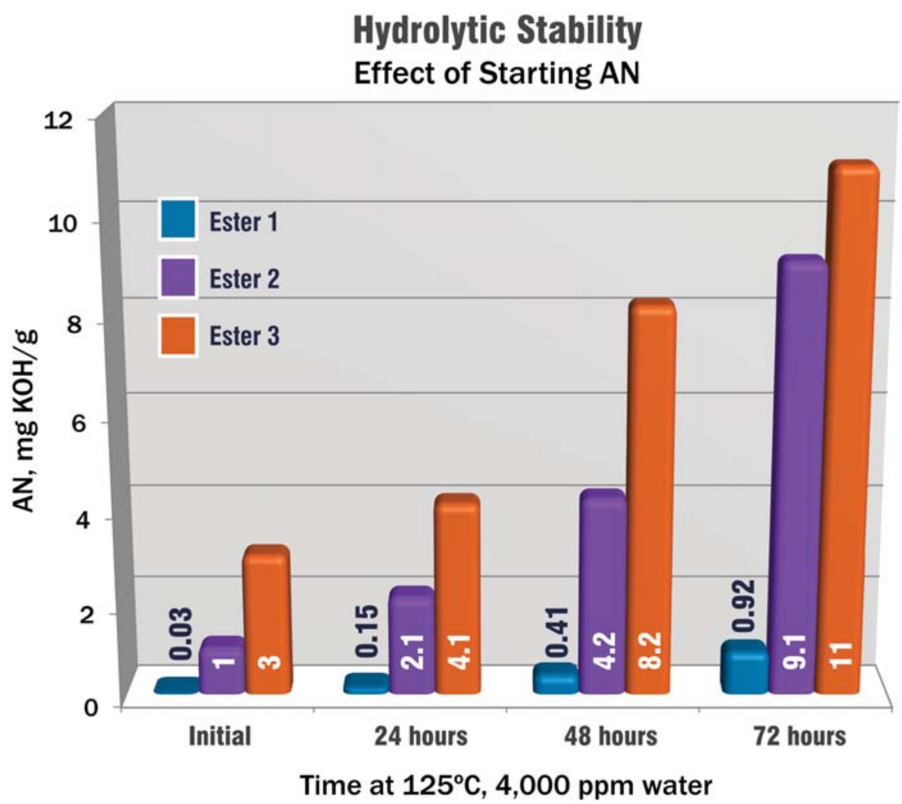


Figure 3. Residual acid left after manufacturing shortens ester life dramatically.

Catalyst Residue

Esters are usually made with a catalyst to accelerate the synthesis, but ester catalysts also accelerate the degradation of ester in the presence of water. Therefore, it is essential to remove or deactivate the ester catalyst at the end of the manufacturing process to ensure that the ester will maintain its quality during storage, formulation and use. Moreover, mineral acids and certain

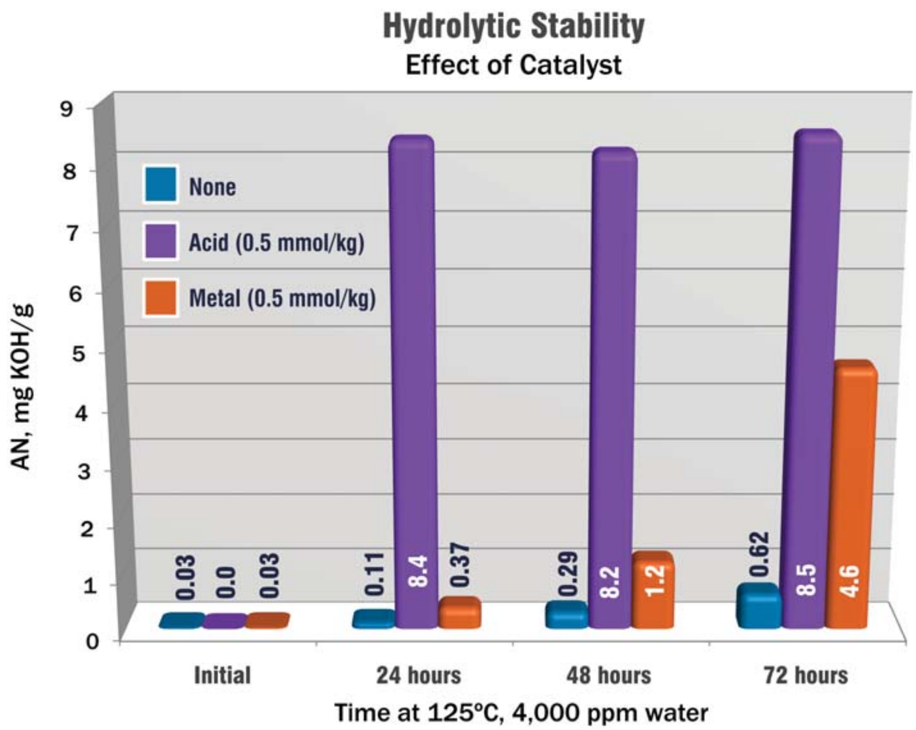


Figure 4. Residual catalyst significantly reduces hydrolytic stability.

active metals must be avoided because they can break down any type of ester. Most ester lubricants are not recommended for applications in which they will come in contact with strong acids and bases.

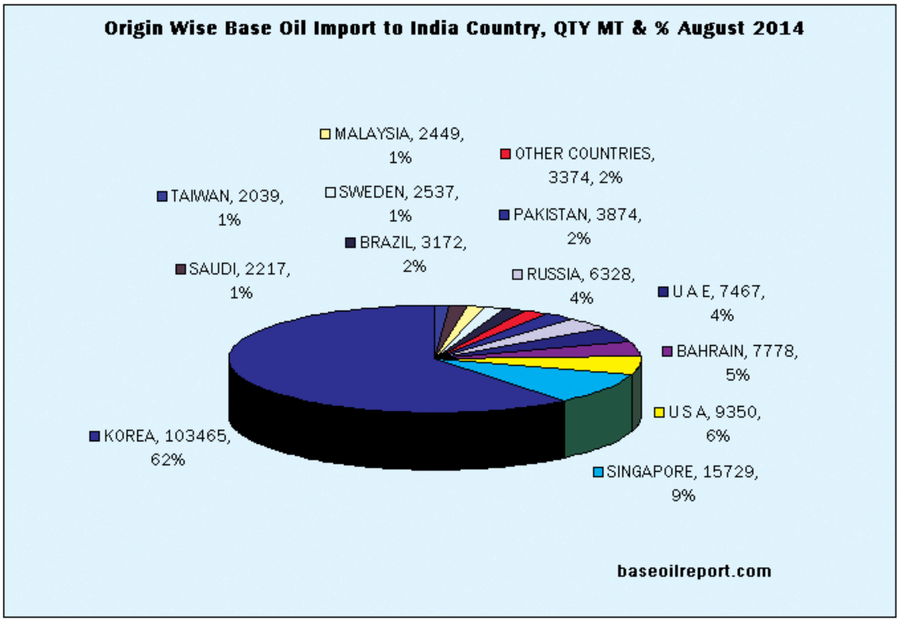
Figure 4 shows the effect of mineral acids and metals on hydrolytic stability. The three samples all started with virtually no acid present. One sample (purple) was treated with a mineral acid, while metal fines were added to another (red). As shown on the left, the strong mineral acid completely hydrolyzed the sample within 24 hours. Metal fines were not as fast but had the same effect. The untreated sample (blue) retained its integrity.

In conclusion, it is a good idea to consider the expertise and experience of your ester supplier. Esters can be designed and manufactured to work in almost any environment, but this means the selection process is critical. Work with someone who knows the science and technology of esters and is willing to take the time to understand your requirements. This is the only way to ensure you are getting the right product for your lubrication needs.

DHIREN SHAH

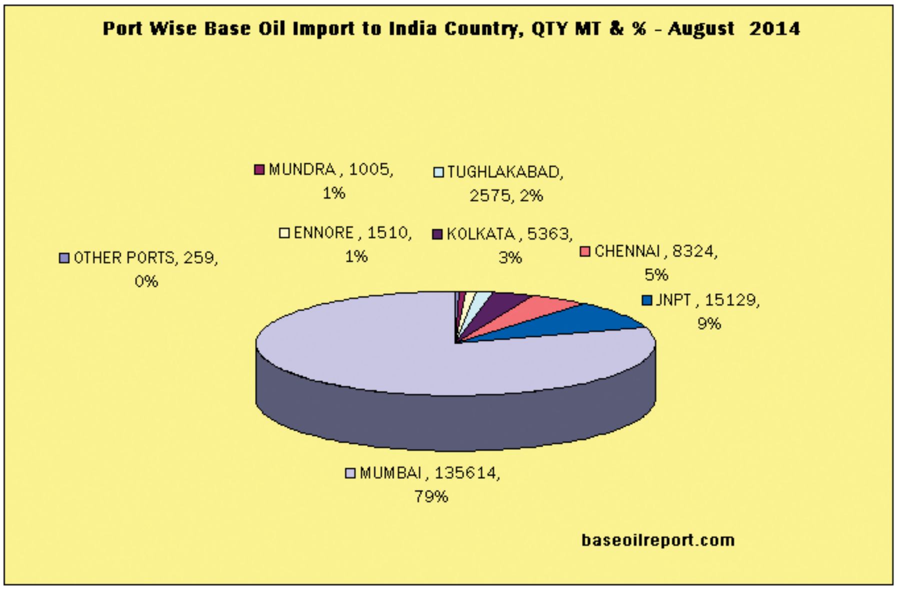
BASE OIL REPORT

Crude-oil futures has seen a fall after the Organization of the Petroleum Exporting Countries cut demand forecasts for its oil and investors worried about the health of the eurozone's economy. On the New York Mercantile Exchange, light, sweet crude futures for delivery in December CLZ4, -0.37% fell 77 cents, or 1%, to settle at $77.91 a barrel. December Brent crude LCOZ4, -0.66% on London's ICE Futures exchange fell 9 cents, or 0.1%, to $82.86 a barrel. Both benchmarks are down for five out of the past six sessions and off nearly 30% from a June peak. OPEC said demand for its crude oil would fall to 28.2 million barrels a day by the end of 2017, as output from producers outside the cartel, such as the U.S. and Canada, Latin American countries, and Russia, continue to rise. Demand for OPEC crude will pick up again in 2018, but a year later it will still



be lower than demand for 2013, OPEC said. Earlier in the week, futures had fallen to fresh multiyear lows. Investors remain worried about the combination of plentiful supplies and diminished demand, with all eyes on the coming OPEC meeting in two weeks. Investors will be parsing any signs that the cartel will cut its production — a move that would push prices higher. Saudi Arabia, the world's No. 1 crude exporter and a key OPEC member, has not indicated it wants to follow that route. It recently cut prices for its oil sold to the U.S.

Month	Group II - N 70 Korea Origin Base Oil CFR India Prices	SN-500 Iran Origin Base Oil CFR India Prices	Bright Stock - CFR India Prices	Base Oil HYGOLD L -2000
July 2014	USD 1065 – 1075 PMT	USD 1040 – 1045 PMT	USD 1220 – 1230 PMT	USD 1075 - 1085 PMT
August 2014	USD 1055 – 1060 PMT	USD 1045 – 1055 PMT	USD 1235 – 1245 PMT	USD 1070 - 1085 PMT
September 2014	USD 1015 – 1020 PMT	USD 1015 – 1020 PMT	USD 1200 – 1210 PMT	USD 1055 – 1060 PMT
	Since July 2014, prices down by USD 50 PMT (5%) in September 2014	**Since July 2014, prices has marked down by USD 25 PMT (2%) in September 2014**	**Since July 2014, prices has gone down by USD 20 PMT (2%) in September 2014**	**Since July 2014, prices has decreased by USD 20 PMT (2%) in September 2014**



Port Wise Base Oil Import to India Country, QTY MT & % - August 2014

and elsewhere, in a bid to preserve its market share rather than provide a floor to crude prices.

The Indian base oil market remains steady with inventories at optimum levels with surplus of imported grades. During the month of September 2014, approximately 205219 MT have been procured at Indian Ports of all the grades, which is 21 % up as compared to August 2014, Major imports are from Korea, Singapore, USA, UAE, Iran, Taiwan, France, UK, Netherlands, Japan, Italy, Belgium, etc. Indian State Oil PSU's IOC/HPCL/BPCL basic prices for SN – 70/N – 70/N-65/SN – 150/N -150/N – 150 marked down by Rs. 1.90 per liter, while SN - 500/N - 500/ MakBase – 500 is down by Rs, 2.20 per liter. Bright Stock price is down by Rs. 0.30 per liter. Hefty Discounts are offered by refiners which are in the range of Rs. 13.00 – 15.00 per liter for buyers who commit to lift above 1500 MT. Group I Base Oil prices for neutrals SN -150/500 (Russian and Iranian origin) are offered in the domestic market at Rs. 57.00 – 57.45/57.50 – 57.75 per liter, excise duty and VAT as applicable Ex Silvassa in bulk for one tanker load. At current level availability is not a concern.

The Indian domestic market Korean origin Group II plus N-60–70/150/500 prices at the current level have been marked down due to higher inventories level. As per conversation with domestic importers and traders prices reflects marginal changes for N – 60/ N- 150/ N - 500 grades and at the current level are quoted in the range of Rs. 55.25 – 55.30/57.10 – 57.30/58.10 - 58.55 per liter in bulk respectively with an additional 14 percent excise duty and VAT as applicable, no Sales tax/Vat if products are offered Ex-Silvassa a tax free zone. The above mentioned prices are offered by a manufacturer who also offers the grades in the domestic market, while another importer trader is offering the grades cheaper by Rs.0.25 – 0.35 per liter on basic prices. Light Liquid Paraffin (IP) is priced at Rs. 55.75 – 55.95 per liter in bulk and Heavy Liquid paraffin (IP) is Rs. 60.75 – 61.80 per liter in bulk respectively plus taxes extra.

About the Author

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

Countries Where Transformer Oil Has Been Exported	
Bangladesh	South Africa
Brazil	Srilanka
Malaysia	Saudi
Djibouti	Philippines,
Myanmar	Thailand
Iran	Vietnam
Newzealand	UAE
Oman	Indonesia
Paraguay	

Countries Where Light & Heavy White Oil Has Been Exported										
Algeria	Australia	Argentina	Bangla desh	Brazil	Bulgaria	Cambo dia	Chile	Colombia	Dominican Re	Djibouti
Ecuador	Egypt	Germany	Guatem ala	Ghana	Greece	Indon esia	Ivory Coast	Iran	Israel	Italy
Jordan	Kenya	Malaysia	Myanmar	Nepal	Newzea land	Nigeria	Pakistan	Peru	Philippines	Poland
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