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- Evonik Oil Additives USA, Inc.
- Kao Chemicals
- LANXESS
- MÜNZING
- Nouryon
- The Lubrizol Corporation

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Sustainability and Grease Lubrication in Rolling Bearings

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Article by Frank Berens\textsuperscript{a} and Piet Lugt\textsuperscript{b,c}

\textsuperscript{a}SKF Technology Centers of Expertise, St. Cyr-sur-Loire, France
\textsuperscript{b}SKF Research and Technology Development, Houten, The Netherlands
\textsuperscript{c}University of Twente, Enschede, The Netherlands

Introduction
In the article, Afton Chemical’s Key Driver Seminar guest speakers from SKF discuss how environmental sustainability is important for many companies focusing on their respective CCF (Corporate carbon footprint). SKF has developed a tool for exploring emissions related to the production and use of bearings. It shows the impact of grease lubrication of rolling bearings related to CO$_2$ equivalent (CO$_2$e) emissions.

The grease carbon footprint for factory-fill greases is negligible, while it is the main part of the overall CO$_2$e emissions with relubrication. Grease selection should be based on energy efficiency, reliability, or waste. Standardized and simple test methods or international agreements are currently lacking in the ability to choose a grease based on sustainability concerns.

Background
Over 80\% of all product-related environmental impacts are determined during the design phase of a product\textsuperscript{[1]}. Therefore, choosing the right product is vital for influencing the impact on sustainability.

By far, most rolling bearings (80-90\%)\textsuperscript{[2]} are grease lubricated. Grease use in bearings can be generally divided into two filling regimes: greased for life and greased for relubrication.

Grease selection criteria depend on the application conditions. Many standardized and well-known test methods are used to define the lubricant’s properties, but standards and criteria for sustainability are lacking.

Carbon Footprint Examples
Often, grease has a small contribution to the carbon footprint compared to other components in the bearing. Figure 1 illustrates the example of an SKF wheel bearing where the grease part is less than 1\% of the carbon footprint assessing scope 1, 2, and 3 upstream.

The Carbon Footprint of an SKF Wheel Bearing

![Figure 1: Cradle-to-gate Carbon Footprint of an SKF wheel bearing.\textsuperscript{[3]}](image-url)
To better understand and specifically show the impact of a bearing in the use phase, SKF has developed a CO2e estimator for exploring how emissions related to the production and use of bearings are distributed for different industry applications, visualized on a dashboard [4].

The emissions related to rolling bearings in an application are estimated by considering three main categories: bearing production, including potential replacements; frictional power losses, including seal frictional losses; and grease consumption during the operational lifetime of the bearing. The estimate is based on the EU-31 average conversion factor (source: Greenhouse Gas Protocol).

Looking only from a grease perspective, the grease manufacturing carbon footprint is very important for relubricated bearings, while in greased-for-life bearings, it is significantly less important.

Frictional power loss/energy efficiency is by far the main CO2e emission in many greased-for-life applications. One should aim for a low-friction product to significantly reduce the overall CO2e emission.

The examples are presented below. The first example is a greased-for-life application, showing that frictional power loss is by far the most important contributor to CO2e emission over the service life of the bearing in this application.

In the second example, the bearings in the application are re-lubricated, showing now that the grease itself contributes significantly to the carbon footprint in the application.

### Example 1. Railway, transporting passengers high-speed train, Axle box (see fig. 2)

**CO2 Emission Result**

<table>
<thead>
<tr>
<th>Category</th>
<th>Emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing manufacturing</td>
<td>~1%</td>
</tr>
<tr>
<td>Frictional power loss</td>
<td>~99%</td>
</tr>
<tr>
<td>Grease consumption</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

The values displayed are estimates and may not sum due to rounding. This estimation is based on SKF tapered roller bearing units installed in an axel box application for high speed trains. The bearings are refurbished on a fix maintenance schedule depending on the operating conditions. The combination of the operating conditions and the size of bearings means the main contributor to CO2 emissions is the frictional power losses.

*Figure 2: SKF CO2e dashboard example 1*

### Example 2. Metals, casting machines, slab casters (strand support roller) (see fig. 3)

**CO2 Emission Result**

<table>
<thead>
<tr>
<th>Category</th>
<th>Emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing manufacturing</td>
<td>~26%</td>
</tr>
<tr>
<td>Frictional power loss</td>
<td>~30%</td>
</tr>
<tr>
<td>Grease consumption</td>
<td>~45%</td>
</tr>
</tbody>
</table>

The values displayed are estimates and may not sum due to rounding. This estimation is based on open SKF spherical roller bearings. The bearings are replaced often due to corrosion damages and are regularly relubricated with grease.

*Figure 3: SKF CO2e dashboard example 2*
Importance of Parameters

Depending on the filling regime (greased for life or relubrication), the importance of grease-related parameters can be different (see fig. 4).

Reliability in relation to grease lubrication is – next to fulfilling the application requirements – mainly grease life. As relubrication intervals of a given grease are shorter than the related grease life, a prolonged relubrication interval due to higher performance will nevertheless also decrease the amount of grease used in the application.

The waste is approximately proportional to the amount of grease used over the running time of the application.

Situation of Parameters

The choice of the grease itself is determined in the design phase of the application. This selection is usually based on the results of standardized tests (ASTM, DIN, ISO etc.).

Unfortunately, such tests are not yet available to support a sound decision on which grease to use when focusing on overall grease sustainability factors.

Grease Carbon Footprint: There are ongoing discussions in different organizations to have an agreed method of calculating carbon footprint, e.g., in the ELGI Sustainability Technical Consortium.

Grease Friction (Factor): Even though there are some friction models to calculate bearing friction, there is no standardized test method for this. A clear advantage for the right and fast decision on friction would be the availability of a grease-specific friction factor based on a “simple” standardized test method. Ideas might be drawn from the “Worldwide Harmonised Light Vehicle Test Procedure (WLTP)”[5], which has a test cycle duration of only 30 minutes.

Grease Life (Factor): The grease life factor has been reported and proposed in 2022[6] for greases used in ball bearings. When testing a grease under a given condition, the effect of temperature, speed, axial load, and grease filling is included for calculating a single grease life factor (GLF). This greatly simplifies the choice of a grease based on its grease life performance. The method is independent of the selected test method/rig and can, therefore, be used throughout the industry.

Waste: The amount of grease used in the application is approximately proportional to the waste amount. Recycling or reconditioning of oil is well established; however, similar activities for industrial greases are unknown to the author.

Conclusions

• Carbon footprint for grease, as well as waste, is more important for relubricated bearings. Energy power loss and grease-related reliability are more important for greased-for-life bearings.

• The importance of each sustainability parameter depends on the application and if the bearing is greased for life or relubricated.

• The current baseline needs to be known and understood with its importance and impact for being able to potentially reduce environmental impact.

• Unfortunately, no standardized calculation or testing procedure exists for the described parameters. Some are under development or proposed (e.g., Grease carbon footprint or Grease Life Factor (GLF), while others do not exist (e.g., Grease friction factor).

• Commonly accepted simple methods (like the GLF) and calculation agreements (like carbon footprint calculation recipe) are needed for all main sustainability influencing factors to support decisions on grease use in applications.

• The GLF concept makes it possible to use the results from most test rigs in grease specifications.

• The GLF determines reliability and long life and should, therefore, always be part of grease specifications.

The author thanks SKF for the permission to publish this paper.

References

Evonik has recently added two new products, VISCOBASE® 11-532 and VISCOBASE® 11-534, to its portfolio of synthetic high-viscosity base stocks. These products have a wide range of application, including fluids for heavy- or medium-duty truck transmissions. These transmissions include manual, automatic, automated manual, and, with the overall interest in new mobility, transmissions for the electrification of commercial vehicles. Driven by the need to reduce emissions and operating costs, the market continues to explore ways to improve efficiency, lengthen oil drain intervals, and include more sustainable components.

To address these needs, the lubricant market has experienced a shift to lower viscosity grades and higher quality base stocks. Decreasing the viscosity of lubricant formulations provides improvements in efficiency, reduces emissions, and lowers equipment operating temperatures. High quality base stocks, often synthetic, provide excellent oxidative stability and their high viscosity indices and rheological properties further contribute to improvements in efficiency. However, these synthetic base stocks are often based on hydrocarbon chemistries and require energy intensive production routes. Therefore, they lack polarity required for compatibility and have higher product carbon footprints.

In response to these unmet needs, Evonik developed VISCOBASE® 11-532 and 11-534. These novel, high-viscosity base stocks offer unique solvency and low-temperature performance advantages. They work well with a wide range of base oils, providing formulation flexibility, and have low product carbon footprints, allowing for more sustainable formulations. These products take advantage of Evonik’s global supply chain and are available globally. Additionally, they provide high viscosity index, high flash points, and oxidative stability. They are also sulfur-free.

Balanced Polarity

VISCOBASE® 11-532 and 11-534 offer balanced polarity, which is demonstrated by their aniline points. When combined with Group II or Group III base stocks, the aniline point of the mixture is around 110 degrees C. This is lower than the aniline point of typical synthetic base oil mixtures and results in a number of advantages, including additive package compatibility.

The balanced polarity of VISCOBASE® promotes cleanliness. This is exemplified by CEC L-48-1 and L-60-1 oxidation stability tests in which VISCOBASE® improves glassware cleanliness and reduces varnish and sludge on the test gear and pinions. Results suggest that the improved varnish and sludge ratings are accomplished by keeping the byproducts of oxidation in the lubricant through enhanced solvency. Otherwise, the byproducts of oxidation could precipitate from the lubricant resulting in sludge and varnish that could decrease efficiency through insulation and higher operating temperatures.

Compatibility with seals and elastomers is also influenced by the polarity of base oil. Formulators need to achieve a careful bal-
ance of seal swell without extracting chemical compounds from the seals which would result in embrittlement. VISCOBASE®-containing formulations display excellent performance in static and dynamic elastomer compatibility testing. In particular, observations made during dynamic tests indicate that typical failure mechanisms, resulting in shaft wear and lubricant leakage, are eliminated when using VISCOBASE® high viscosity base stocks.

**Dispersancy**

The unique technology used in the synthesis of VISCOBASE® base fluids enables their modification with dispersant functionalities while keeping the other properties unchanged. The dispersancy included in VISCOBASE® 11-534 can further improve oxidative stability performance. In both the CEC L-48-1 and L-60-1 oxidation stability tests, the dispersant version of VISCOBASE® provided additional improvements in glassware cleanliness, as well as varnish and sludge merits. This improvement is achieved through the addition of dispersant functionality that is built into VISCOBASE® 11-534.

**High Viscosity Index**

In addition to the balanced polarity and improved carbon footprint, VISCOBASE® 11-532 and 11-534 contribute to high viscosity index formulations while exhibiting excellent shear stability. This combination provides outstanding temperature-viscosity behavior that remains stable over the lifetime of the fluid. When combined with a 4-centistoke Group III base stock, viscosity indices of about 170 are obtained. This is about 10-20 points higher than other synthetic, high-viscosity base stocks, and translates into broader temperature operating window, superb low temperature performance, and improvements in transmission efficiency.

### SAE J306 Formulation Examples

VISCOBASE® 11-532 and 11-534 can be used to formulate a wide range of automotive gear lubricants from 75W-80 to 75W-140 while meeting the rheological and exceeding the low-temperature requirements of SAE J306. For example, VISCOBASE® 11-532 can be combined with high performance additive packages, Group III base oils, and VISCOPLEX® PPD to achieve SAE 75W-80, -85, and -90 grades. These formulations also meet shear stability requirements, with all staying in-grade following a 20-hour KRL shear stability test.

![Excellent Varnish and Sludge performance in L-60-1 oxidation testing. SAE J306 75W-90 formulations. (Left) VISCOBASE® 11-532 containing formulation with Average Carbon/Varnish, 9.4 merits and Average Sludge, 9.6 merits. (Right) VISCOBASE® 11-534 containing formulation with Average Carbon/Varnish, 10.0 merits and Average Sludge, 9.7 merits.](image-url)
Lower Viscosity E-driveline Examples

As the automotive industry continues to shift towards electric vehicles, there is a growing need for more efficient e-driveline formulations. One way to achieve this is by increasing the viscosity index with high-quality VI improvers. However, as the viscosity index is increased, there is typically a trade-off in shear stability with traditional VI improvers. VISCOBASE® is particularly suitable for formulations demanding low levels of viscosity loss. VISCOBASE® 11-532 and 11-534 have excellent shear stability, and the viscosity loss of these e-driveline examples is less than 5% for a 192-hour KRL.

High viscosity index formulations have lower viscosities at 20 and 40 degrees Celsius which can also have a positive impact on thermal properties. By calculating and comparing Mouromtseff numbers, it can be established that lowering the viscosity improves the fluid’s ability to transfer heat away from the motor, resulting in improved efficiency. Mouromtseff numbers are determined from measured values for density, viscosity, heat capacity, and thermal conductivity and constants for turbulent flow that represent the sensitivity of heat transfer to each property.

Takeaways

VISCOBASE® 11-532 and 11-534 provide shear-stable thickening and high-VI formulations. Unlike other high viscosity base stocks, VISCOBASE® is polar and exhibits a balanced solvency which promotes compatibility with elastomers and seals. These features make VISCOBASE® a versatile formulation tool for heavy- and medium-duty truck transmission lubricants with high-efficiency and long drain interval targets. Additionally, VISCOBASE® 11-532 and 11-534 are suitable for low-viscosity e-driveline fluids and rheological testing indicates that they should improve the heat transfer capability.

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Today's Metalworking and Cleaning Challenges: Mastering Formulation Challenges for Sustainable Solutions

By Dr. Sabine Wohlfahrt, KAO Chemicals GmbH, Emmerich, Germany

KAO Chemicals is a supplier of surfactant technology for high-end technical applications, particularly in the field of metalworking. With its global metalworking competence center, the company focuses on developing emulsifiers, co-emulsifiers, and solubilizers. Kao’s unparalleled expertise in metalworking stems from its production of specialty surfactants, primarily managed through the global metalworking competence center located at Kao Chemicals Germany, a division of Kao Chemicals Europe.

Metalworking and Cleaning Formulations Hurdles Demand Effective Solutions

Metalworking and cleaning fluids play a vital role in various industrial processes, and as technology and regulations evolve, formulators face a multitude of challenges in achieving optimal performance, sustainability, and safety.

The main challenges are the following:

• Foam control: Excessive foam in metalworking fluids can lead to operational issues, reducing process efficiency and causing potential damage to equipment.

• Fluid stability and longevity: The stability and longevity of metalworking fluids are essential for consistent performance and reducing maintenance efforts.

• Water quality and hardness tolerance: The presence of hard water and dissolved salts can affect fluid performance and stability.

• Enhanced performance: Industries continually seek improved performance to meet higher machining demands and achieve superior results.

• One fluid fits all alloys and operations: Creating a universal fluid that works effectively across different alloys and machining operations is a complex challenge.

• Increasingly severe and diverse machining conditions: As machining processes become more rigorous and diversified, fluids must adapt to varying conditions.

• Corrosion & staining protection: Preventing corrosion and staining is crucial for extending the lifespan of equipment and maintaining product quality.


• Sustainability and safe handling requirements: Environmentally friendly and safe-to-handle formulations are becoming essential due to regulatory pressures and environmental concerns.

• Stable global availability and usability: Consistency in the availability and usability of additives is vital for smooth operations on a global scale.

• Shrinking additive toolbox: The restriction on certain additives due to regulatory or supply chain challenges limits the formulation options.

Facing the Challenges: KAO Chemicals’ Metalworking Toolbox

Kao Chemicals’ Metalworking Toolbox offers innovative solutions to the several critical hurdles that demand effective solutions within the metalworking industry. The toolbox comprises multifunctional surfactants designed to boost performance, effectiveness, and sustainability. Furthermore, the solutions presented consider prevailing global regulations and limitations.

Global regulatory pressure on alcohol ethoxylates, limitation of raw materials, foaming behavior, and the need for corrosion protection are key challenges faced with main emulsifiers. To address these issues, Kao Chemicals presents two non-ionic main emulsifier solutions:

• KAO FINDET MB & AKYPO® ROX: A low-foaming emulsifier with high efficiency, excellent environmental profile, and global registration. It offers improved hard water stability and compatibility with various base oils. Three polarity (HLB) grades available:
Challenges with Stability and Solutions with AKYPO®

Addressing issues such as short fluid longevity, water hardness, foaming behavior, corrosion, tramp oil rejection, and microbial growth is necessary for fluid stability. Kao Chemicals introduces AKYPO® LF, a long-term emulsion stabilizer that enhances foam control and tramp oil rejection in metalworking fluids. Additionally, AKYPO® multifunctional co-emulsifiers, such as AKYPO® RO and AKYPO® LF, improve emulsion stability, fluid cleanliness, and corrosion protection. In detail:

- **AKYPO® RO and TEC AM VG** enhances foam control of metalworking fluids by limited foam formation tendency and fastest foam collapse rates when combined with fatty acids.
- **AKYPO® LF** has a positive effect on the self emulsification of the formulation.
- **AKYPO® LF** is beneficial for the tramp oil rejection behavior of metalworking fluids because of its hydrophilic and anionic structure.

Apart from its significant advantages in metalworking formulations, AKYPO® also offers notable benefits in metal cleaning. It enables increased active cleaner content, leading to reduced water consumption and lower CO₂ emissions during transport. Moreover, it facilitates the formulation of more efficient and longer-lasting cleaner solutions, minimizing waste generation. Especially in the presence of particles the cleaning efficiency will be significantly improved.
In the dynamic landscape of metalworking and cleaning fluid formulation, the challenges presented are indeed multifaceted. However, the comprehensive solutions provided by the Kao Metalworking Toolbox meet the challenge. As the metalworking industry deals with foam control, fluid stability, enhanced performance, and the pursuit of eco-friendly formulations, Kao Chemical’s multifunctional additives stand as reliable partners.

Designed with a deep understanding of the intricacies of global regulations and constraints, these solutions show Kao Chemical’s dedication to quality. Efficiently becoming part of the changing industry, they improve how emulsions work, make it easier to handle hard water and electrolytes, and bring in a new era of formulations with less foam. The toolbox’s offerings go beyond just operational advantages, also protecting equipment and product quality by preventing corrosion and staining.

Also, Kao Chemicals’ dedication to worldwide availability is significant. With products spanning the globe and rooted in renewable sources, the brand not only enhances operational efficiency but also helps conserve resources, particularly by extending the life of fluids and saving water.

In a world that thrives on innovation, the Kao Metalworking Toolbox stands as an exemplar, leading the path to advanced and eco-friendly metalworking fluids. Its versatile additives represent both progress and responsibility, balancing operational excellence with environmental awareness. As the industrial scene evolves, Kao Chemical’s solutions stand as a crucial partner, working towards efficiency, longevity, and a greener future.
LANXESS is commercializing a new generation of calcium sulfonate complex (CSC) thickened greases. LANXESS started commercial production of their first generation of CSC greases in 1984. In comparisons with lithium, lithium complex and polyurea greases in laboratory tests and field trials, they provided superior overall performance and service life under wet, hot, and high shock load conditions such as those in steel, pulp and paper mills. In 2001, LANXESS introduced their second generation of CSC greases, which were formulated to meet all the requirements for incidental contact food grade (FG) lubricants. The new generation of FG CSC greases is formulated with improved, safer antioxidants. All of their performance properties are as good or better than those of the previous generation of CSC FG greases. (see Fig. 1)

LANXESS AG (Cologne, Germany) is a leading global supplier of more than 660 synthetic base stocks, additives and fully-formulated lubricants to over 800 customers worldwide. The lubricant additive portfolio includes antioxidants, detergents (sulfonates), anti-wear compounds, extreme pressure additives, corrosion inhibitors, friction modifiers and industrial additive packages. The base stock portfolio includes high viscosity polyalphaolefins (PAOs), synthetic esters, and phosphate esters.

“At LANXESS, innovation means constant learning and improving our lubricants and additives to deliver the highest value,” notes Ross Dworet, Global Product Manager for Detergents (Sulfonates) within the Lubricant Additives Business (Shelton, Connecticut). “The cost-benefit ratios of the new food grade greases are a significant advantage for our customers and end users. These greases are based on a technology platform that was perfected at our Application Technology Centre (West Hill, Canada). We view these greases as the best choice for our customers looking to market food grade compliant greases.”

Wayne Mackwood, Global Head of Detergent and Grease Technology, leads a highly skilled, dynamic and dedicated team of chemists at the West Hill Technology Centre. He explains, “We built upon our deep experience with CSC greases as a starting point for the reformulation of three core food grade greases to comply with new standards for health and safety. The properties of these three updated formulations are equivalent to or better than those of the previous generation.”

CSC Greases
The unique structure and properties of CSC thickeners provide many advantages. (see Fig. 2)

Mackwood explained, “We make greases thickened with CSC from optimized combinations of raw materials and processing conditions. We are back integrated into the

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**Figure 1. Food Grade Grease History – 20 years on**

- **2001-2002**
  - First H1 CSC grease with Halal and Kosher certification
  - Introduction of this next generation Food Machinery Grease at NLGI ELGIN NLGI India Meetings

- **2011**
  - NLGI “10 years on” review of H1 CSC greases with extreme environment H1 grease range performance against A1X greases
  - “Lack of performance is no longer a reason for not using a food grade certified grease”

- **2022 – 2023 (Now)**
  - New challenges in REACH regarding reproductive toxicity of commonly used antioxidants
  - Although H1 compliance not affected by EU regulatory changes, initiated successful development

- **Beyond**
  - Alternative formulations proven above and beyond performance in product operating life in all FG grease range
  - Utilize backward integration to develop next generation food grade greases
production of overbased calcium sulfonate and control its composition. During production, the ingredients react and arrange to form micelles. Each microscopic micelle has a core that contains stacks of calcite calcium carbonate (CaCO₃) crystals and a stable oil-soluble shell. The calcite crystals serve as barriers to water to improve corrosion resistance and control the release of oil under applied shear stress. No other grease thickener has this unique structure and combination of outstanding tolerance to heat, water and high loads.”

Global production of calcium sulfonate greases increased from 26,063 MT (2.2% of global production by volume) in 2013 to 55,770 MT (4.8%) in 2022 according to NLGI surveys. Commercial production is surging at 8.8% CAGR (2013-2022). CSC grease is replacing lithium grease in certain applications.

**Food Grade Greases**

Chemists at LANXESS have developed more than a dozen high performance H1 CSC grease formulations covering an extensive range of oil viscosities and types. These greases comply with US Food and Drug Administration (FDA) 21 CFR 178.3570 while exceeding the performance of other lubricating greases in the food processing market.

H1 FG lubricants are certified for safe use in applications where incidental food contact may occur. Incidental food contact is defined as unintentional contact by minimal amounts such as accidental drips or splashes of lubricant. The end user, at least in North America, is required to ensure that less than 10 ppm of the finished lubricant is transferred to the foodstuff. Ideally, H1 FG lubricants should be used in all stages of food production, processing, manufacturing, packaging (including its manufacture) and possibly agriculture.

Food grade lubricants are registered as H1 by a number of third-party organizations including NSF (US/EU), 2Probity (EU), CFIA (Canada), and AQIS (Australia). A newer system, ISO 21469, has been gaining popularity as a true certification method that encompasses chemistry and manufacturing processes. It has become common-place to evaluate and certify H1 compliant FG lubricants as pareve Kosher and permissible Halal products. Any food processor using the HACCP (Hazard analysis and critical control points) system for food safety management must use an appropriate level of food grade lubricant to meet standard practices.

LANXESS commercialized the first H1 CSC grease in 2001. After a decade of R&D and field trials, Mackwood recognized, “Performance is no longer a reason to not use FG greases. Calcium sulfonate grease brings industrial level performance to the food grade market. Our CSC FG greases have outstanding tolerance of heat, water and high-pressure conditions like those common in agriculture and processing of food and beverages, and they meet all requirements for H1 registration. Most if not all of LANXESS’ portfolio of H1 FG compliant CSC greases meet the new core specification for NLGI High-Performance Multiuse (HPM) grease, and several qualify for additional HPM tags.” (see Fig. 2)

Dworet observed, “Markets for FG greases are expanding worldwide. There is increased understanding of their benefits, and there are more regulations to control risks associated with production of food and beverages. The FG grease market is well established in the Americas and Europe while continuing to emerge in Asia. Food processing and handling safety are key to securing a safe, healthy, and sustainable food supply. FG lubricants are even used in upstream applications such as handling lines for produce and pellet mills.”

**New CSC FG Greases**

The European Chemicals Agency (ECHA) recently re-classified certain oil-soluble antioxidants (AOs) as H361f Reproductive Toxicants, i.e., substances suspected of damaging fertility. This change included AOs used in FG CSC greases in the LANXESS portfolio.

Dworet explained, “These antioxidants remain classified as HX-1 on the 21 CFR 178.3570 list and still meet FDA requirements for use at historic treat rates in H1 lubricants. However, it became necessary to add H361f classification to the labels of our products. Instead, LANXESS was proactive and replaced these AOs.”

Mackwood agreed, “We took advantage of our 20 years of experience formulating CSC greases to replace the AOs and optimize new formulations for three FG CSC H1 compliant greases. We maintained their performance properties and raised the bar for FG grease longevity. The 4-ball test results were even better for our new products.”

The NLGI 2 grades of the first three updated greases, G-2233-2, G-2234-2 and G-2235-2, are smooth and tan with 605°F dropping points (ASTM D2265). They are ideal for use in humid environments, have excellent water resistance (<3% removed,
water washout at 80°C, D 1264) and can withstand processing line washes and flushes. As CSC greases, they have an inherent high tolerance to acidic conditions such as citrus fruits and tomatoes. Test results for all three greases are excellent:

- Manage heavy loads (weld points 400 and 500 kg, 4-Ball EP, D 2596)
- Good wear performance (wear scars 0.38 and 0.39 mm, 4-Ball Wear, D 2266)
- High mechanical stability (3%, 5% and -6% change, Mechanical Worked Stability, D 217, 10,000 strokes) for long service life.

G-2234-2 is a cost-effective high-performance H1 CSC grease based on white oil (95 cSt at 100°C, D 445) with operating range from approximately -18°C~29°C to 170°C.

G-2233-2 is formulated with low viscosity PAO (53 cSt at 100°C, D 445). It has a wide temperature range for good performance (from -40°C to 170°C~200°C), and is especially useful at lower temperatures.

G-2235-2 is formulated with high viscosity PAO (400 cSt at 100°C, D 445). Mackwood recommends it for applications where the lubricant is exposed to elevated temperatures for extended periods of time. The higher viscosity enhances the formation of tribo-films, and the lower volatility and better thermal stability of the higher viscosity PAO raise the operating temperature of G-2235-2 above that of G-2233-2.

As this upgrade involved replacement of the current AO, the oxidation properties of the reformulated greases were examined carefully. The West Hill team employed three new instruments in addition to ASTM D942 and D3527.

A RapidOxy 100 Oxidation Stability Tester was used to measure oxygen absorption in a sealed system (D 2206). Results were significantly better for the reformulated greases. (see Fig. 3)

Pressure differential scanning calorimetry (PDSC, D 6186) was applied to evaluate thermo-oxidative stability. At 210°C, the time for a sample to equilibrate (per unit mass) was substantially better (longer) for the new greases. (see Fig. 4)

An FE9 test rig was used to perform mechanical-dynamic tests for greases in ball and roller bearings between 100°C and 200°C (DIN 51821). At 6000 rpm with 1500 N load until failure, the benefits of reformulation were clear. (see Fig. 5)

"Reformulating these CSC FG greases is an excellent example of how LANXESS continues to do more than maintain compliance. We raise the bar on the performance of our products and continue to demonstrate our capabilities as a leader in performance for private label H1 CSC greases," Dworet concluded.
Tank side defoamers have some of the same attributes as in-concentrate defoamers, such as fast foam break, persistence to filtration, and being washable and paintable. But there are also other attributes that can play a role in their performance, such as spreading quickly on the surface, easy handling and short-term dilution stability.

There are five main properties to consider when choosing a tank side defoamer:

1. **Foam break** – how quickly the foam knocks down upon addition of defoamer
2. **Foam Control Persistence** – amount of defoamer required to maintain low foam levels
3. **Dilution stability** – level of kick out visible in the field
4. **Filterability** – how easily the defoamer is filtered out
5. **Dosage Control** – understanding the dosing system during the operation

Depending on which properties are most important in the specific application, there are several different classes of tank side defoamers to consider. Cost-effective 3D Siloxane emulsions, high-performance 3D Siloxane defoamers, or the non-Si based defoamers (Figure 1).

**Tank Side Defoamer Testing and Results**

Many defoamers were evaluated in tank side recirculation with many MWFs. The test method involved using a peristaltic pump and 1000mL cylinder to run the blank MWF dilution in a recirculating test. Every time the total volume reaches 800mL, tank side defoamer is added, the foam collapse is then recorded. At the end of the test, the total number of drops required to maintain a level lower than 800mL is recorded along with a rating based on the appearance of the glass walls indicating defoamer kickout.

The first property to consider is the foam collapse as shown in Figure 2. Higher collapse volumes indicate better foam collapse. The high-performance 3D Siloxane and the non-Si oil based defoamers both provide significant foam collapse in all three fluid types. Specifically, FOAM BAN MS-5E provides better foam collapse compared to FOAM BAN MS-5A. The main difference between these two defoamers is the FOAM BAN MS-5E is more emulsifiable allowing the active to spread more quickly.
on the surface. The cost-effective 3D Siloxane defoamers provide less foam collapse compared to the other two categories.

The second property to consider is the foam control persistence (Figure 3). Lower number of additions required indicates better persistence to shear. The high-performance 3D Siloxane products provide significant improvement in foam control persistence as compared to the other two categories. Within the non-Si group, it is observed that the less emulsifiable defoamer is more persistent. The cost-effective defoamers varied in performance depending on the fluid type, specifically they worked well in semi-synthetic and soluble oil formulations.

The third property is the dilution stabil-
ity (Figure 4). Lower ratings indicate better stability in the dilution. All of the 3D Siloxane based defoamers provide good stability in the dilutions, while the non-Si based defoamers showed more kick-out after the test.

A further filtration test comparing a 3D Siloxane defoamer vs a non-Si oil based defoamer was completed. It was concluded that the non-Si oil based defoamers may have a tendency to clog filters more easily as compared to both cost-effective and high performance 3D Siloxane based defoamers.

The fifth property to consider is the dosage control, and depending on the dosing system at the end user, different defoamer types may be more optimal.

- **Good dosing system** = high performance 3D Siloxane defoamers are most effective
- **No defined dosing system** = over-dosing can be a risk when using high-performance 3D Siloxane defoamers, cost effective or non-Si defoamers are more optimal
- **Lower viscosity of the FOAM BAN® tank side defoamers compared to in-concentrate defoamers**, leads to easier handling and spreading of the actives in the field

As shown in Figure 5, the cost-effective 3D Siloxane FOAM BAN® defoamers provide good dilution stability, average knockdown and foam control persistence and would be optimal for operations with high risk of over-dosing. The high-performance 3D Siloxane FOAM BAN® defoamers have optimal compatibility, knockdown and foam control persistence for operations with well defined dosing systems. The non-Si FOAM BAN® defoamers have good knock down and are low-cost but tend to show poor persistence, stability and filterability.

The conclusion is, the most optimal tank side defoamer choice depends significantly on the specific application, system type and desired performance features that are required.
NOURYON is a leading global customer solutions business that provides essential, specialty chemicals for diverse end-markets, customers, and geographies. Our customer-centric business model is focused on providing tailored solutions that improve the performance, quality, and sustainability of our customers’ products across a variety of end markets, such as lubricants, fuels, oilfield, mining, packaging, paper, cleaning goods, personal care, crop protection and nutrition, paints, coatings, and more.

- Operations in more than 80 countries
- 13 strategically located Innovation and Application Centers worldwide
- 60 geographically distributed manufacturing sites
- 77% of R&D product pipeline focused on solutions with sustainability benefits
- EcoVadis Platinum rating (2022)

Growing Together with Our Customers

For more than 40 years, we have been innovating lubricant solutions that play an essential role in powering people around the world, one molecule at a time. We believe that collaboration is a key enabler to success, so we devote ourselves to understanding your needs.

When what’s inside matters to you, we pave the way for you to create solutions that perform.

- Versatile chemistry portfolio, including nitrogen derivatives, anionic and non-ionic surfactants, and performance polymers
- Extensive synthesis capabilities, offering a broad spectrum of design possibilities to research, test, and formulate the most optimal solutions for your specific need
- Reliable global manufacturing footprint, placing us close to customer operations and facilitating your better access to our products and expertise

Our range of Armolube® lubricant solutions has a proven track record of driving quality and performance across various functionalities and applications (see chart below).

Armolube® Anti-wear Additives

Our robust phosphate ester and amine portfolio delivers ash-free, anti-wear additives made from natural raw materials. Exhibiting strong wear performance at a comparatively low treatment rate and excellent oil solubility, these additives also offer friction modification, TBN, and detergent, among other functions.

Nouryon Armolube® Lubricant Solutions

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RENEWABLE SYNTHETIC BASE STOCKS

- Synthetic esters

INTERMEDIATES

- Functionalized polymers

Powering People Around the World – One Molecule at a Time

By Alvaro Jose Ortiz, Global Strategic Marketing Manager – Lubricants & Fuels, Nouryon
In a recent study, our phosphate ester amine salts outperformed ZDDP and competitor phosphate amine-based anti-wear products. They achieved both low friction and low wear conditions while exhibiting an ability to balance friction and wear properties based on application needs.

4-ball wear test results indicated lower wear scar diameter (WSD) values than the Competitor anti-wear product (AW) and the ZDDP, while also offering a considerably lower friction coefficient.

A wear performance test across different base stocks showed consistent favorable anti-wear functionality with minor variability being attributed to solubility differences between the base stocks.

**Armolube® Friction Modifiers**

Fuel economy improvement remains a major challenge facing the automotive market, but having the right ingredients can help. Our strong amine derivative design capabilities equip you with the ability to tailor friction properties to meet diverse application and performance demands as well as sustainable options (Fig. 5).

- Ash- and metal-free components derived from natural raw materials
- Numerous primary, secondary, and tertiary fatty amines
- Ethoxylated fatty amines with multifunctional properties
- Neutralized fatty amine salts that allow for tailored friction and wear performance
- Esters of fatty acids, polyacids, and/or alkanol amines that can deliver superior friction performance, film-forming characteristics, and synergistic benefits when used with MoDTC and/or ZDDP
- Functionalized fatty amides to provide a combination of better product properties and friction performance

**MTM data on selected Nouryon organic friction modifiers in Yubase 6**

Figure 5: MTM Film forming: 120 °C; 20N; 0,1 m/s; SRR: 50%. MTM Stribeck curve: 120 °C; 20N; 3 to 0,005 m/s; SRR: 50%.
Our latest polymeric friction modifiers are able to deliver competitive performance in the boundary regime at a comparatively low treat rate of 0.2 wt% (Fig. 6, top) and across all friction regimes at a comparatively low treat rate of 0.1 wt% (Fig. 6, bottom).

**Armolube® Thickener Precursors**
We offer various precursors for the manufacture of polyurea grease thickeners, including three made from sustainable feed sources – Armolube® TM 97, Armolube® 18D, and Armolube® 12D.

**Where Performance Meets Sustainability**
To help meet the growing demands for increasingly sustainable products, we create innovative tailored solutions in close partnership with our customers. Our design process (Fig. 8) is focused on:

- Developing natural-derived, ash-free, and zinc-free solutions that meet or surpass customers’ performance objectives
- Using partly or fully bio-based and renewable raw materials to allow flexibility and stability (e.g., tallow/vegetable-based)
- Aligning with global and regional health/safety regulations
- Allowing reliable access to our products and expertise in every region across the globe
- Continuing reductions of our carbon footprint, waste, and water use, aspiring to be a net-zero organization by 2050

See our full sustainability report at nouryon.com/sustainability

Learn more by contacting us at lubes.fuels@nouryon.com or visit nouryon.com/markets/fuels-and-lubricants.
Formulating for Longer Drain Intervals—and Lower Total Cost of Ownership

Hydraulic equipment manufacturers, as well as end users, are seeking new ways to lower the total cost of ownership of their equipment. One way to make an impact is by extending the oil drain interval for hydraulic fluids—but it must be done with some important considerations.

By Shubhamita Basu, Ph.D., North American Product Manager, The Lubrizol Corporation

However, expanding service interval is not easy considering the trends that are shaping modern hydraulic equipment. New machines are achieving increased power densities with higher pressure pumps, finer filtration, while reducing sump sizes and downsizing or outright eliminating coolers—all of which can create more challenging conditions for hydraulic fluids.

So, how can ODI be reliably extended? This article will explore the factors impacting fluid life, the complexities associated with accurately measuring anticipated oil life, and why maintaining necessary levels of performance is critical, irrespective of the length of service.

What Factors Impact Hydraulic Fluid Life?

Before determining ODI, it is important to understand the components that make up a hydraulic fluid.

A typical hydraulic fluid is made up primarily of a base oil, 0.6 wt.%–1.5 wt.% performance additives along with a pour point depressant (optional), and a viscosity modifier for multigrade fluids. The additive components of a fluid are formulated carefully to balance the levels of antiwear additives, oxidation inhibitors, metal deactivators, rust inhibitors, demulsifiers and antifoam agents to offer optimum performance.

A good hydraulic fluid must deliver the targeted levels of wear and corrosion protection as well as oxidation and thermal stability for reliable performance. In addition, elastomer compatibility and filterability are increasingly gaining more importance with the advent of newer elastomer materials and finer filtration in modern hydraulic systems. Ultimately, maintaining a robust tribofilm with optimized performance is the key for durable performance.

While in use, the components that are crucial for the performance and protection of the equipment can undergo thermal and oxidative degradation leading to sludge and varnish formation, impacting oil life. Harsh operating conditions and water ingress only aggravate the situation further. Smaller reservoir size can increase aeration leading to microdiéseling which can be explained as a rapid pressure induced compression of an air bubble as it travels from a low pressure to a high pressure zone within the hydraulic system. As a result, localized heat is generated which leads to darkening of oil and oxidative degradation leading to sludge and varnish. Additionally, contaminants can block filters and ineffective filtration can impact oil life further. All these factors in varying degrees can limit the ODI of a hydraulic fluid in service.
Predicting Fluid Life: A Testing Challenge

The operational challenges that have the potential to impact the service life of a hydraulic fluid can be complex and make establishing standard ODI difficult. In fact, there is no accepted industry standard for determining the service life of hydraulic fluids.

In the absence of a standard to determine ODI, two test methods – ASTM D943 and D4310 – are often used as predictors of oil life. In ASTM D943 or turbine oil oxidation stability test (TOST), the sample is treated with 17% water and iron/copper catalyst and heated to 95 °C under air flow for an extended period, and the change in acid number is measured over the duration of the test. The test is continued until the change in acid number exceeds 2 mg KOH/g or the test reaches 10,000 hours—whichever comes first. The precision of this test was determined using steam turbine oils and has poor repeatability and reproducibility. ASTM D4310, a modified version of the D943 test, uses the same test conditions but measures sludge after 1,000 hours. Since neither of these test methods mimic operating conditions of hydraulic fluids in the field and are not correlated to oxidation of hydraulic fluids in service, they are not suitable to predict oil life.

Unfortunately, in many instances TOST test is given a lot more importance as a predictor of oil life and fluids with high TOST numbers (above 7,000 hours) are considered better than those with lower TOST hours. However, TOST results by itself can be misleading. While formulators can easily influence TOST results the question becomes whether improving TOST result is necessary. It is important to note that TOST tests are impacted by base oil quality and base oils with higher levels of unsaturation and sulfur can hurt TOST results. For example, Group II base oils are expected to outperform Group I base oils in TOST tests and lower viscosity base oils can help attain higher TOST results than higher viscosity base oils. Additionally, ZDDPs or zinc dialkyldithiophosphates, one of the most ubiquitous and effective antiwear additive chemistries, tend to impact TOST results negatively; however, many leading OEMs prefer higher ZDDP treat rates for increased durability. Furthermore, a hydraulic fluid with a high TOST number doesn’t guarantee good pump performance which is the most important predictor of fluid performance in real world applications. Most leading OEMs put limited importance on the TOST test and consider it only as a screening tool and not a performance indicator. Bosch Rexroth RDE90235 specification, considered the most stringent hydraulic specification, requires fluids to meet only 1,500 hours in the TOST test while emphasizing on the extremely high pressure RFT-APU-CL pump-motor test.

The Piston Pump Test: A Better Service Lifetime Indicator

While TOST is not the best method, it does not mean there are not reliable methods that can show better correlation to ODI. The Rexroth A2F10 piston pump test has demonstrated immense potential to indicate hydraulic fluid service lifetime under field conditions. Unlike other pump tests that measure wear performance,
the A2F10 test was developed by the Standardization Committee of Japan Construction Mechanization Association (JCMA) to measure sludging, oxidation and corrosion performance at elevated temperature and pressure using a 5,000-psi axial piston pump. Per the JCMAS P045 specification, fluids must be evaluated for 500 hours, with samples taken every 100 hours and measured for the parameters in the table above. The sample is considered to have failed the test if the limits have exceeded at any point during the test.

A passing 500-hour A2F10 test is correlated to about 2,000 hours of service life for a piece of construction machinery with a medium sump size and duty cycle. Test duration can be extended to indicate the potential robustness of ODI. However, it is important to note that actual ODIs may vary based on the size of the reservoir, as well as operating conditions, duty cycle and maintenance practices.

**The Key to ODI: Performance Retention**

Irrespective of the test method, it is critical to remember that establishing ODI for any hydraulic fluid must be based on its ability to retain critical performance characteristics over time.

It is important for OEMs and end users to be cautious when a fluid emphasizes only high TOST test performance. A high performing fluid should demonstrate strong all-round performance credentials, including broad OEM approvals and industry specifications. Passing results from service life tests like the A2F10 is also a good indicator that the fluid will deliver a long ODI while maintaining the optimum performance with minimal downtime. Proof of field performance can offer further confirmation of robust performance, and the TOST number needs to be considered with caution. For fluids in service, regular condition monitoring should check for maintained filterability, foam performance retention, robust water separation and antiwear levels so that measures can be taken before any catastrophic failures.

Lubrizol offers a breadth of products and solutions that can help maximize performance retention for longer ODI—helping to satisfy OEM and end user performance requirements and lower TCO. These include:

- **Lubrizol® 5703**, a mainline zinc based hydraulic additive package with top-tier OEM credentials and proven field performance
- **Lubrizol® AH921ZF**, a mainline ashless hydraulic additive package with OEM credentials
- **Lubrizol® 5687, Lubrizol® 5685, and Lubrizol® 5689**, are a complete suite of ashless, biodegradable hydraulic finished fluids for applications in environmentally sensitive areas combining both environmental and performance credentials.

It is anticipated that OEMs will continue to seek ways to lower the TCO for new and evolving hydraulic machinery. Extending ODIs is important and possible only when the hydraulic fluid can retain its performance level over time and the right additive chemistry is essential to get there.

Lubrizol is continuously working to develop premium hydraulic additive and finished fluid solutions for worry free performance. We also apply our expertise to identify the most effective methods of evaluating critical performance characteristics. To learn more, visit [www.Lubrizol.com](http://www.Lubrizol.com) or contact your Lubrizol representative.
Examining the Rising Importance of Environmentally Acceptable Lubricants

Ecological impact is a growing and important concern in marine, forestry and construction applications—and the right lubricant technology can help equipment in these industries optimize environmental friendliness.

By Joshua Dickstein, Ph.D., Technology Development Manager, Lubrizol

Global Bio-Lubricant Consumption by Region


Around the world, no matter the market, there is a growing need for environmentally benign lubricants.

Why? Every year, considerable volumes of industrial fluids make their way into the environment via machine leakage, accidental spills, and improper disposal. As the global society grows increasingly environmentally conscious, minimizing the impact of escaped fluids like hydraulic fluids, greases, metalworking fluids, industrial gear oils, and other fluids into the environment has become even more important. Biodegradability—a lubricant’s ability to be decomposed by microorganisms over time into simpler byproducts—has become a sought-after trait. Low toxicity and bioaccumulation potential have likewise become more important to better protect the environment. Not only do such spills and leaks have an impact on ecosystems, but they can lead to other consequences for companies including negative attention and publicity, and poor business results.

For these reasons and more, there is rising demand for environmentally acceptable lubricants (EALs) and for lubricant marketers, there is sizable opportunity in developing EALs in a marketplace that is becoming more and more eco-conscious. The market for bio-based lubricants has a projected compound annual growth rate (GAGR) of ~3.5%-5.6% through 2024, with the largest markets existing in Europe and the Americas, according to recent studies by the market research firm Kline & Company and Lubrizol’s analysis.

Defining Environmental Friendliness

As demand for EALs grows, it can be useful to define how they are situated within the broader context of sustainability. In the context of lubricants, sustainability has been defined as follows by the Union of the European Lubricants Industry (UEIL): “Lubricants created by innovative businesses enabling the use of safe, resource-saving technologies and processes which reduce the burden on the planet, local environments and benefit people and society.”

This is helpful for understanding how EALs can minimize environmental impact. Specifically, according to standards set by the

The Lubrizol Corporation
U.S. Environmental Protection Agency (EPA), EALs by definition must meet strict criteria set for:

- **Biodegradability**: The capacity of lubricants to be decomposed by microorganisms over time into:
  - A combination of simpler byproducts (primary biodegradation)
  - Carbon dioxide and water (ultimate biodegradation)
- **Minimal Aquatic Toxicity**: Low toxicity to aquatic organisms according to tests defined by the Organization for Economic Co-operation and Development (OECD) and EPA test guidelines.
- **Bioaccumulative potential**: The buildup of chemicals within the tissues of an organism over time.

Meanwhile, in recent years, the lubricants industry has seen increasing stringency of several widely recognized standards and labels that certify varying levels of eco-friendliness. Many of them require that fluids bearing the label definitionally meet the requirements of EALs. Some of these include:

- **The European (EU) EcoLabel**, which certifies products with a guaranteed, independently verified low environmental impact. The label places limits on the amount of hazardous ingredients formulators can include in formulations, how biodegradable the formulation is, and whether it contains components that are persistent and bioaccumulative.
- **Blue Angel**, the German Ecolabel, which the country awards to a wide variety of environmentally friendly products. Blue Angel is similar in stringency to the EU EcoLabel, but places additional requirements on how to properly dispose of labeled formulations.
- **EPA’s Vessel General Permit (VGP)** which will soon be replaced with the Vessel Incidental Discharge Act (VIDA), establishes a framework for the regulation of discharges incidental to the normal operation of a vessel under a new Clean Water Act.

**Major Opportunities for EALs**

Inland water, forestry, marine and construction applications represent the areas where EALs can make the most impact.

Take the marine industry as a critical example. Massive, complex cargo ships are home to dozens of applications where EALs can help improve environmental impact. Hydraulic fluids, gear oils, stern tube lubricants, greases, and other lubricating fluids can be found throughout a broad range of important equipment, including:

- Steering and propulsion equipment, including rudders, controllable pitch propellers, stern tubes, fin stabilizers, thrusters and more.
- Ship engines, responsible for powering the ship across vast distances.
- Operational equipment, including deck cranes and winches and cables for maneuvering cargo pods from place to place, along with davits, responsible for lowering and retrieving dinghies and other smaller vessels.

At any of these points, critical fluids can escape into the environment, whether via user error, machine damage, or another event. It’s also worth considering that many such applications are below the waterline, meaning leakages would necessarily infiltrate the marine ecosystem. Given the scale of these ships and the sheer volume of fluids required to keep them operational, loss of such fluids can make a major impact on oceanic and marine life. Minimizing the harm resulting from such losses is increasingly critical.

**Maintaining Optimal Performance in EAL Formulations**

Importantly, EALs must maintain the same critical performance characteristics as conventional lubricants in order to deliver the required levels of equipment protection and functionality. But original equipment manufacturers (OEMs) and fluid formulators do face some challenges when it comes to developing EALs that reliably deliver the kinds of performance required in critical marine applications.

For example, a priority for any industrial fluid is the protection of equipment. Preventing the premature wear of metal surfaces as they come into contact with each other is the core function of a lubricant—for EALs and conventional formulations alike. But some
of the most reliable classes of anti-wear additives do not meet EAL criteria for biodegradability—meaning they must be excluded from any formulation to be an EAL.

The same holds true for many other important performance requirements industrial fluids must demonstrate. An industrial gear oil (IGO), for instance, typically incorporates extreme pressure additives. Sulfurized olefins are a reliable solution for these needs, but do not display the biodegradability required in accordance with EAL standards. A variety of conventional chemistries frequently used as antiwear agents, demulsifiers, antifoam agents, corrosion inhibitors, friction and viscosity modifiers cannot be used in the composition of an EAL.

For lubricant marketers looking to capitalize on these needs, working collaboratively with the right partner can be beneficial to develop environmentally certified and performance-validated fluids. A true partner should be able to offer reliable chemistry expertise and EAL-compatible solutions, enabling lubricant marketers to expand EAL marine offerings quickly.

**Case Study: EAL Solutions from Lubrizol**

The Lubrizol Corporation has committed its formulation expertise to bringing robust EAL solutions to market, offering industrial lubricant marketers an ideal solution to meet growing demand for EALs.

For example, the **Lubrizol® IG22EL EAL IGO Series**—a high-performance chemical additive package and related finished fluids—delivers all of the performance characteristics required in demanding industrial gear applications for an all-around solution with environmental protection. Benefits include:

- **Excellent Wear Protection.** Lubrizol IG22EL solutions offer strong FE-8 bearing protection, exceptional micropitting performance, and outstanding FZG load carrying capabilities.

- **Robust Demulsibility and Foam Control.** Along with its robust demulsibility performance, Lubrizol IG22EL offers superior foam control and air release properties required in industrial gear applications.

- **EAL Compliance.** The Lubrizol IG22EL EAL IGO finished fluids are highly biodegradable, demonstrate low toxicity, and are formulated with bio-derived synthetic ester base oils. The solution is compliant with VGF, VIDA and EU EcoLabel requirements.

Lubrizol IG22EL has demonstrated these characteristics through a robust series of bench and mechanical testing and is well-suited for the most demanding industrial applications. The Lubrizol IG22EL EAL IGO finished fluids have also achieved broad industrial and environmental specification coverage.

The Lubrizol IG22EL EAL IGO Series is a part of the company’s EcoAssurant™ Portfolio, a broad offering designed to elevate the environmentally protective qualities of EAL lubricants in industrial applications, worldwide. Solutions include:

- A complete suite of components and additives listed on the Lubricant Substance Classification (LuSC) list for worry-free formulating.

- Fully formulated solutions that eliminate the costs and complexities associated with formulating and blending.

For the industrial lubricant marketer, selecting the right additives partner allows you to enhance your eco-conscious reputation and lead the way with products that have been tested and certified as biodegradable, non-bioaccumulative and minimally toxic to aquatic life. Further, environmentally certified and performance-validated additive solutions can give you a competitive edge by enabling your business to speed its EAL offerings to market with confidence. Working with the right supplier can allow your business to expand its offering of highly valued products, gain greater share of market and enter new markets.

Lubrizol is committed to providing the global lubricants industry with the right solutions needed to lessen our impact on the environment while enabling next-generation machinery and equipment for a greener future.

To learn more, contact your Lubrizol representative, or visit [www.Lubrizol.com](http://www.Lubrizol.com) to learn more about EcoAssurant.