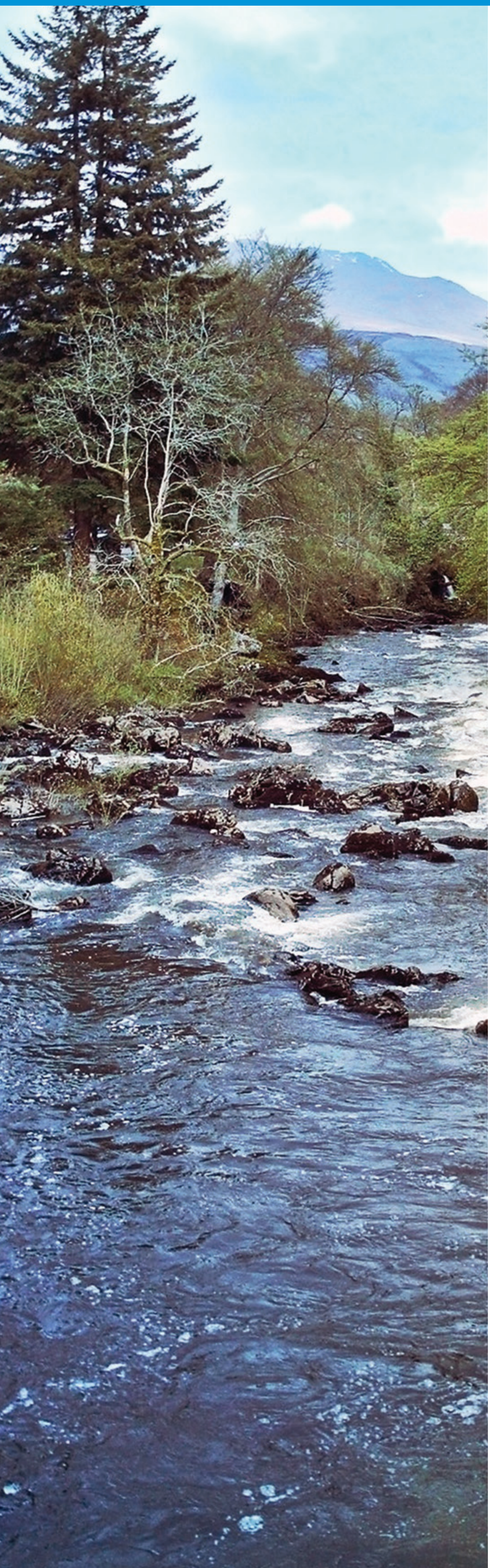
LUBRICANTS AND THE ENVIRONMENT

The demand for lubricants and other petroleum specialty products has grown exponentially in the last few decades as a consequence of the revolutionary development in various sectors (e.g. the automotive, industrial, railroad, marine and aviation). As a result, petroleum resources have been depleting the world over. Very recently the lubes market has been flat and may continue that way, especially in developed markets.



The main change has also been a slight shift toward synthetic lubes, which does use less petroleum products. These moves are in the right direction. However, the usage pattern of lubricants and fuels has not always been prudent. It is also a fact that lubricants, both fresh and used, can be quite deleterious to the environment due to wrong application, improper usage, incorrect disposal and simple spillage. When used properly petroleum products are certainly a boon, but improper use can cause long-lasting effects to our environment The base oils and additives employed in making various lubricants and greases and their oxidation products can prove toxic to plants, aquatic animals and human and other living beings. While there may only be a tangential effect of these pollutants on human beings, in the short term, they are still pernicious to those subjected to prolonged exposure.

Due to the availability of petroleum-based lubricants in large supply, in many countries, where environmental regulations and legislations are not as stringent, lubricants are disposed of in sewage and streams to avoid collection and bypass recycling. While this may seem unheard of in certain countries it is quite common practice in certain parts of the world. A small amount of contaminant can spoil a large quantity of water; thus, endangering aquatic animals and plants. These infected animals serve as a food supply for other large animals, in and around the sea, as well as human beings who consume seafood. These contaminated food sources will pose a high risk of diseases in other animals and human beings in the long term.

Looking over to our oceans now, it would be fair to say that the maritime environment is more challenging in this regard: Long hours, heavy loads, extreme weather and the constant risk of contamination contribute to difficult operating conditions. The National Oceanic and Atmospheric Administration (NOAA) estimates more than 2653,000 KL of petroleum products enter the environment each year, more than half of which is through irresponsible and illegal disposal. It is estimated that 70% - 80% of hydraulic fluids leave systems through leaks, spills, line breakage and fitting failure. Base oils and additives used in marine applications should be selected for their environmental performance in the marine environment. There is growing concern regarding the environmental impact and associated costs of lost petroleum-based fluids.

In comparison to the concern of liquid lubricants, usage and disposal of lubricating grease is also more complicated, since the collection of used grease is very labor intensive and basically unfeasible. In an effort to decrease the consumption, associated cost of labor for relubrication and disposal issues, the grease is required to perform for a longer life; therefore, the life of bearings and equipment can be enhanced and disposal can be minimised. Similarly, in steel plants, paper mining, cement, etc. there is also a great demand for high performance long-life grease, since in places where water ingress is very high, grease gets washed away from the system thus passing into the sewage.

Lubricant manufacturing, storage, transportation, application, and disposal of lubricants all need to be considered for possible protection of living beings, their habitat and natural surroundings. Furthermore, a variety of lubricants such as engine oils, gear oil, process oils, coolants, metal working fluids, industrial specialties lubricants, greases and even biodegradable lubricants are primary factors contributing to environmental pollution if they are mishandled or result in leakage from vehicles. Improper application and wrong practices of disposal are also major culprits of detriment to the environment.

Another way of protecting our environment and preserving our petroleum resources over the long run is by focusing on and developing an eco-friendly process of re-refining used lubricating oils, particularly used crankcase engine oils. This is because the usage of crankcase oil easily makes up more than 50% of all lubricating oils. Crankcase oils pose more of a threat whether via automobile engine oils, stationary engine oils or marine engine oils. These engine oils contain a high percentage of additives like detergents, and other metallic constituents such as extreme pressure additives. Marine

engine oils contain an even greater percentage of additives, and a poor quality of fuel is used in marine engines. Therefore, re-refining and recycling is the most efficient and economical way of managing the used oil. This re-refining saves money by preventing the costly cleanups and the liabilities that are associated with management of the used oil necessary to protect the environment. Due to inadequate and unsafe technology of reclaiming and recycling of used oils, tons of used oil is being wasted or burnt.

In the automobile manufacturing sector, the original equipment manufacturers (OEMs) across the globe are continuously working on redesigning or modernising their technology with respect to reduction of engine weight by replacing heavy metal parts with lighter metals and adding various after-treatment devices to get better fuel economy and achieve a reduction in harmful pollutants to the environment. Again, this is posing difficult challenges to additive fuel as well as lubricant manufacturers. To reduce internal drag, lighter viscosity-grade engine oils are required to fulfill this demand. Accordingly, a lot of research and work is being focused on achieving this goal. Lowering tailpipe emissions, increasing fuel economy, and increasing the usage of low sulfur or zero sulphur fuel are some ways by which the environment can be protected and pollution can be reduced. In order to meet the challenges of emission norms, fuel economy and energy efficiency many OEM's like Mazda, Daimler, Honda, Nissan etc. are coming up with development of Spark-Controlled compression-ignition (SPCCI) engines which embody the well-known technology of homogenous composition compression ignition for gasoline engines. By this HCCI, new engine technology as well as excellent fuel economy can be achieved by the very lean air-to-fuel ratio. In addition to this, emissions are also reduced and energy efficiency is achieved.

Therefore, lubricant manufacturers will uphold a critical position in preserving the earth by fostering good manufacturing practices and developing long-life high performance lubricants to meet specified applications for greater longevity of vehicles and equipment. Additionally, increased use of biodegradable lubricants will also aid in maintaining the environment, as these lubricants are manufactured from renewable sources and biodegrade faster, they will not harm living beings or the environment.

Ever-broadening legislation has made it imperative for lubricant manufacturers to adopt salubrious manufacturing practices for developing high performance long-life lubricants which adhere to adequate storage and handling management as well as correct recommendation for lubricants for longer life of vehicles and equipment. China is developing even more stringent legislation, with respect to emission norms and lubricant specification, than the U.S. and European Union, to reduce carbon and protect the environment. Similar strict legislation and regulations will eventually need to be followed by all developed countries jointly.

Simultaneously, manufacturing of electric vehicles is growing faster by many OEM's in an attempt to reduce pollution by exhaust gases; however, many drawbacks are associated with these EVs. But this effort will not be much of a contributing factor in curbing reduction in pollution regarding environmental protection. Increased usage of oxygenated fuels like ethanol and biodiesel will also help in reduction of emission to a certain extent.

Today, catchphrases and buzzwords such as biodegradable, bio-based, eco-friendly, non-toxic, renewable and green are virtually synonymous with the lubrication industry. In today's ecologically-conscious milieu, these keywords have become powerful tools and selling points for lubricant manufacturers and marketers. However, they can often be misnomers. One of the main impetuses for this green initiative of late, in tandem with legislative compliance, is the burgeoning awareness and consumer demand to make available more environmentally-friendly products.

Biodegradable lubricants are recommended in equipment used for particular industries like forestry, mining, petroleum exploration or wherever the lubricants might come into direct contact with the environment. Before switching over to a biodegradable lubricant, and away from a conventional mineral oil lubrication system, the compatibility of biodegradable lubricant with mineral oil must be established. Furthermore, various other parameters like the lubricating system's operating and design characteristics, (e.g. the operating temperature, pressures and compatibility of sealing materials with bio-based products) should be familiarised. Also, disposal method must be taken into consideration.

However, in most developing countries, customers are unable to pay the high price for these biodegradable, bio-based products. Customers in these regions are cost conscious rather than quality conscious. This is likely due, in part, to lack of awareness and lenient environmental legislation and regulations. The governments of these countries need to enforce strict environmental legislation and regulations to encourage and promote these lubricants in industries and other probable applications. The petroleum industry is especially challenged by this, considering the finite resources inherent in it. This furthers a need to scour for alternative and renewable sources.

As health, safety and environmental regulations in industrial end-use markets are becoming more stringent, there still remain a lot of shortcomings with regard to usage of conventional lubricants like oil disposal, recycling/disposal regulations and driving extension of drain interval; thus, requiring the usage of synthetic lubricants. In order to use lubricants for longer periods, demand for high performance lubricants is increasing. The downside of conventional lubricants can be sometimes offset by use of synthetic lubricants. Though the initial cost of these lubricants is very high compared to conventional lubricants, the longevity is three to four times greater than conventional lubricants and the lifespan of machinery can also be increased by employing synthetic lubricants.

No single unified definition is accepted across the board, when it comes to what constitutes environmental safety; however, factors such as eco-toxicity, bio-accumulations, renewability, biodegradability and bio-accumulations must all factor into the equation when being held accountable for the protection of the environment. Being petroleum-based, lubricants are inevitably categorised as an environmental danger. A vast amount of industrial lubricants was, in the past, disposed of irresponsibly into the environment via used oils and spills or by accident leading to serious environmental concern demanding to be immediately rectified.

First, there are dual means of grappling with lubricants and their impact on environmental safety when it comes to lubricants: One is using means to eliminate the disposal of lubricants into the environment. The other is to use environmentally-safe or green products in environmentally precarious applications such as forestry, mining, agriculture, mining and marine life.

Making the situation of how the environment is affected by the lubrication industry even more opaque, is the vagueness surrounding the terminology of what it means to measure or analyse environmentally safe products. In an effort for better understanding, here are a few of the issue's most common terms: Firstly, 'biodegradable' simply refers to the chemicals of a substance (such as a lubricant) degrading, when in contact with microorganisms. While there are various ways to define biodegradability, industry wide, probably one of the most notable can be found in ASTM D6064, which describes biodegradability as 'a function of degree of degradation, time and test methodology.'

Fluids that are defined as 'readily biodegradable' should exhibit a minimum biodegradability of 60% over 28 days. Laboratory test methods are used by industry laboratories to determine biodegradability, an important parameter for the evaluation of the ecological behavior of substances. Biodegradability has a key role due to the simple fact that a degradable substance will cause no long-term risk in the environment. To guarantee the acceptance of the test results by authorities and customers internationally standardised methods (ISO, OECD) and established quality criteria (GLP, EN 45000, ISO 9000) are used.

Knowing the ecological behavior of substances and products is one of the responsibilities of the manufacturing industry. Substances which pass into the environment must not constitute a danger there. Unlike local emissions from the production process, which can be controlled by technical measures, substances and products which are marketed worldwide are no longer under the direct control of the manufacturer and therefore have to be adequately investigated and characterised.

A knowledge of the biodegradability of chemicals is one of the most important aspects of their environmental behavior because a biodegradable substance is expected to cause less ecological problems in the long term than a persistent one. Degradation processes are constantly taking place on a large scale in the natural environment, especially in the aquatic sphere. Water is the most important transportation and distribution medium for many substances and an absolute prerequisite for all biological processes.

As in the natural environment, or in technical facilities, test systems too have a number of parameters which crucially affect the level of biodegradation. The biodegradability of substances depends primarily, but not only, on their molecular structure. The degradation result is generally stated as a degradation level in percent.

This brings us to a pair of generally agreed upon measures for biodegradability: The first is primary degradation, which is measured as the reduction of the carbon-hydrogen bond. This is ascertained with infrared spectroscopy (IR) and correlates to the direct measure of the percentage of lubricant breakdown. The Coordinating European Council (CEC) created the most widespread means to measure this degradation, the L-33-93 test method which runs for 21 days.

In addition, secondary degradation is the other type of biodegradability. More commonly referred to as ultimate biodegradability, this measures the evolution of carbon dioxide through the degradation process over a 28-day span. The Organisation for Economic Cooperation and Development (OECD) came up with the most used method to determine this, 301B/ASTM D5864. The criterion of what stamps a lubricant as biodegradable is more than 80 percent by the CEC L-33-93 method or more than 60 percent by the OECD 301B methodology. Although, the actual biodegradability of mineral oil-based products or vegetable based products will vary according to geographical region. This is due to temperature fluctuation from place to place. For instance, one product may show low biodegradability in North America or in Europe as temperature is very low. Meanwhile, the same product can show high biodegradability in tropical countries like South East Asian countries. As the maximum biodegradability can be achieved at around 35 to $38^{\circ}C$, laboratory testing conditions will be ideal everywhere. Thus, the biodegradability of any product cannot be predicted based on any standard established test method.

Another often touted, yet rarely understood, term is 'bio-based'. This is a term mostly used in the United States and buttressed by the need to produce renewable products from vegetable, plant and animal-derived materials. The industry or regulatory body (USDA) did not mean for bio-based to suggest a 100% vegetable oil-based formula, as other bio-based components might be called upon to meet industry performance benchmarks. The USDA and other regulatory organisations have agreed that the use of 50% or greater bio-based material in a formulation could allow a product to be considered bio-based. Therefore, an acceptable definition of bio-based lubricants would be

those products formulated with a majority of renewable and biodegradable base stocks.

'Green' is another ambiguous umbrella term bandied about when it comes to the environment. It is simply another word for being environmentally-sound. It can also be the most misleading due to its imprecise meaning. Certain products that are not even vegetable-based may still be advertised as 'green' environmentally-conscious alternative lubricants. Even if these types of lubricants are devoid of heavy metals and other possibly noxious ingredients, they are not biodegradable; thus, it is critical for consumers to be mindful when purchasing such products and to be cognizant of the fact that green does not necessarily equate to biodegradable.

The general consensus is that environmentally-safe products are those which degrade expediently and naturally with non-toxic decomposed fractions based on renewable sources. In addition, these lubricants must be primarily comprised of renewable/vegetable oils, easily biodegradable and devoid of heavy metals and other virulent ingredients and byproducts. Environmentally-safe products can offer unique performance advantages: When lubricants are composed of vegetable oil, they sometimes demonstrate superior lubricity, this translates to reduced friction and wear, a high viscosity index and high flash points for an improved safety profile.

Conversely, there are sometimes downsides inherent in these types of products such as limited high-temperature abilities due to subpar oxidation of thermal stability, limited low-temperature applicability, due to higher pour points, and poor pumpability at below-zero temperatures. Since these lubricants are obviously supposed to degrade over time in the presence of oxygen, their longevity is, of course, sometimes limited as well. Also when considering making the switch to vegetable oil-based greases, another facet which must be considered is their compatibility with mineral oil or synthetic oil-based greases.

Information regarding environmental safety is still in its embryonic stages, therefore, more research and experimentation is necessary to elucidate exactly what that phrase means, in addition to fully comprehending its related terms, applications and overarching implications. It must always be kept at the fore that there are joint objectives to meet: One being environmental safety and the other being the need to search for alternatives to petroleum-base stocks. The future of sustainable or environmentally-friendly lubricants will rely on how well the disadvantages can be surmounted while maintaining a competitive price.

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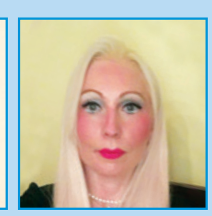

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