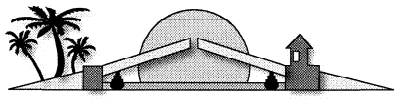
HEAVY MOVABLE STRUCTURES, INC.



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ENVIRONMENTALLY PREFERABLE LUBRICANTS AND FUELS IN MOVABLE STRUCTURES

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SYNOPSIS

Environmentally preferable fuels, lubricants and hydraulic fluids can save operators and contractors tens or hundreds of thousands of dollars in fines and clean up costs in the event of a fluid leak or spill. When properly selected, applied, maintained and monitored, a biodegradable fluid will have a long useful life and will protect equipment as well as or better than conventional petroleum based fluids and have no long term negative impact on the environment upon discharge.

INTRODUCTION

There is broad use of lubricants and fuels in the movable structure industries. Applications include; bastilles, hydraulic power tools, two-cycle engine oils, spillways, drawbridges, fuels and others. Fluids and lubricants have multiple ways to enter the environment. For example hydraulic fluids circulate through systems and are exposed to the environment. Through routine wear, hoses and fittings can leak or break and release the lubricant to the environment. Chain saws and outboard motors expel oil into the environment through their design.

There is growing concern regarding the environmental impact and associated costs of lost petroleum based fluids. The National Oceanic and Atmospheric Administration (NOAA) estimates over 700 million gallons of petroleum enter the environment each year, over half of which is through irresponsible and illegal disposal. Industry experts estimate that 70% to 80% of hydraulic fluids leave systems through leaks, spills, line breakage and fitting failure. Petroleum is persistent and toxic. It damages living organisms including plants, animals and marine life for many years. In addition, the Coast Guard, EPA and local governments are increasing the range of responsibility of lubricant releases including significant fines and clean up costs.

"Environmentally friendly" or "green" lubricants are being developed to utilize renewable resources that will degrade rapidly upon contact with the environment. There is a range of definitions being utilized to determine environmental preferability, however, there remains no universal definition. It is important to know not only the manufacturers definition of environmental safety or biodegradability, but also the performance limitations of the product. The product must be considered in a total life cycle assessment "from cradle to grave" which includes the performance chemistry, base fluids, manufacturing conditions, ability to be recycled, disposal and packaging.

LUBRICANT FUNDAMENTALS

Wherever movement or power transfer takes place, lubricants are used to; protect components from wear, protect equipment from corrosion, transfer heat and remove wear debris. Since hydraulic fluids that primarily provide fluid power, afford similar performance and are similar in formulation to lubricants, a clear differentiation in not always made.

There are two main classes of lubricants defined by usage, total loss lubricant (TLL) and continuous application lubricants (CAL). TLLs, by design of the equipment, end up virtually entirely in the environment. For example chain lubricant, greases and two cycle oil pass entirely through their system and wind up in the environment. CALs, in contrast, are designed to stay contained within the equipment. Automotive engine oils and hydraulic fluids best exemplify CALs. While, they should be disposed of by environmentally sound methods, they can inadvertently end up in the environment.

Lubricants are also classified by their use or function. Differentiation is made between engine oils, hydraulic fluids, gear oils, transmission fluids and others. Their characteristics and performance vary with their base oil and performance additives combinations. Base fluids make up the majority of the formulation and can include petroleum, various synthetics, vegetable oil and newly developed high performance XBO. Different base fluids impart different characteristics as outlined in Table 1 below.

Table 1

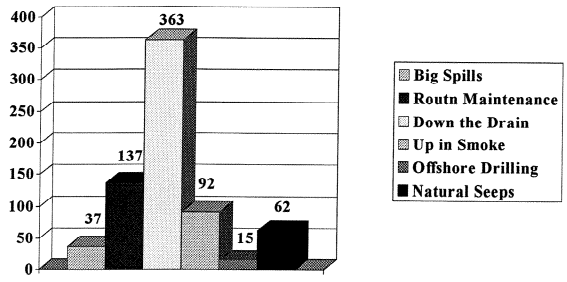
Characteristic	Petroleum Oil	Vegetable Oil	Synthetic	XBO
Biodegradability	Very Low	Very High	Moderate	High
Oxidative Stability	Good	Moderate	High	High
Temperature Range	Wide	Moderate	Very Wide	Wide
Thermal Stability	Good	Moderate	Very Good	Very Good
Mineral Oil Compatibility	Very Good	Good	Moderate	Very Good

Performance additives impart characteristics not found in the base oil. These characteristics include, oxidation protection, wear protection, corrosion resistance, viscosity and others. By balancing the additives with the base oil, lubricants can be developed that meet the needs of various equipment, operating temperatures, operating pressures, change-out intervals and price.

RELEASE TO THE ENVIRONMENT

According to NOAA, 706 million gallons of petroleum are released into the ocean each year. Over half of that, 363 million gallons, are because of irresponsible maintenance practices and routine leaks and spills. Chart 1 below shows the various contributors to oil released into the ocean.

Chart 1



As demands on lubricant systems increase, the likelihood of accidental release of fluids increases. Increased operating temperatures, pressures and working cycles shorten the life of circuit components. The single best approach to protecting the environment, the equipment and the operation is to prevent leaks and spills through good routine maintenance. A good preventative maintenance program will:

- increase productivity since equipment is utilized more,
- better utilize in-shop maintenance since there is less emergency work,
- improve control of spare part inventory and reduce parts usage,
- reduce equipment down time,

- reduce safety hazards,
- increase equipment life,
- reduce fines and clean-up costs due to environmental release, and
- reduce down time related to environmental release.

There are increasing regulatory pressures from the EPA, Coast Guard and other environmental organizations. While small releases will not result in a Resource Conservation and Recovery Act (RCRA) clean up, large spills will. All petroleum hydraulic fluid spills are a "reportable events". These events involve a great deal of clean-up cost, administrative procedures and punitive fines that can range from tens of thousands to hundred of thousands of dollars.

While spilling large quantities of biodegradable hydraulic fluid is still considered under RCRA to be a reportable event, agencies are required to evaluate "bio-based oils" differently than petroleum-based oils. As awareness of biodegradable fluid increases, state and federal agencies become more lenient regarding fines and clean-up costs. In fact there are several case studies of equipment releasing several hundred gallons of vegetable-based hydraulic fluid into environmentally sensitive areas with no fines and minimal clean-up expense. In most instances, the operator was able to continue working while clean-up efforts were underway. Since the fluids were biodegradable and non-toxic, there was no long-term negative effect to the ecosystem.

There is a common misperception that the Coast Guard approves oils based on the oil not leaving a sheen. This is not true. The Coast Guard does not approve, recommend or endorse any fluids. Furthermore, the Coast Guard does not approve or recommend any test procedures, but rather, follows United States statue laws. The oil sheen that is frequently referenced is inferred from the Clean Water Act as defining "any substance that leaves a sheen, emulsification, or discoloration, as a pollutant and be subject to appropriate fines and regulations governing pollutants". The Coast Guard also relies on the guidelines as outlined by equipment manufacturers and highly favors the use of bio-based and biodegradable fluids.

BIODEGRADABILITY

Biodegradation is the process of chemical breakdown or transformation of a material caused by organisms or their enzymes. Figure 1 defines it.

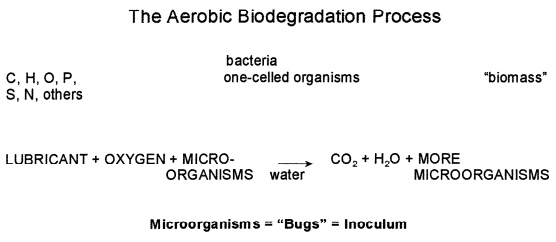


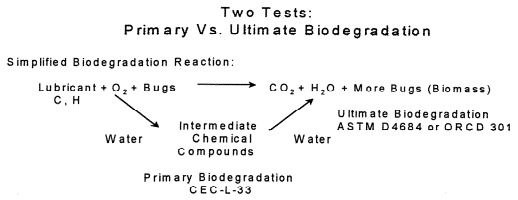
Figure 1. The Aerobic Biodegradation Process

BIODEGRADATION MEASUREMENT

There are two commonly used measurements for biodegradation. The first is "primary degradation" which measures reduction of the Carbon and Hydrogen bonds (C-H) in the initial solution; this is the reduction of the amount of the lubricant. The most widely used test that measures this decrease is the CEC-L-33-A-93.

The second measurement of biodegradation is "secondary degradation" or "ultimate degradation". This measures the evolution of CO_2 through the biodegradation. The usual test for this is the OECD 301or the ASTM D4684.

Figure 2, below, shows the process.



There is no single definition of biodegradability. Throughout the United States and internationally there are a wide range of environmentally preferable definitions. The ASTM has defined biodegradable as a function of degree of degradation, time, and test methodology. Table 2 outlines the ASTM definition.

Table 2

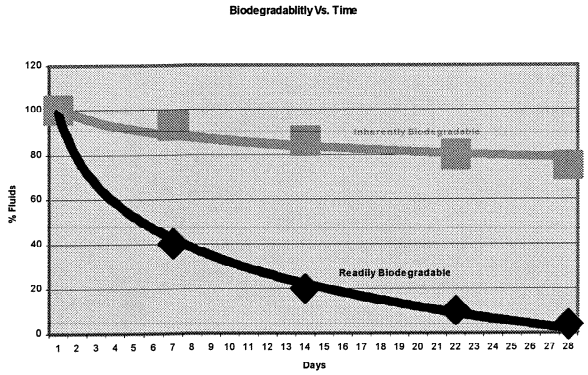
Persistence Designation	Test Method	% Degradation	Days
Pw1	Ultimate	60	28
Pw2	Ultimate	60	84
Pw3	Ultimate	40	84
Pw4	Ultimate	<40	84
PwC	Primary	80	21
Pw4	Primary	<80	21

Despite these definitions, there are two widely used designations for biodegradability, readily and inherently. Readily biodegradable is defined as degrading 80% within 21 days as measured by the decrease of a test sample. This type of degradation is preferable because in most cases, the fluid will degrade long before environmental damage has occurred. Because of this, they require little in terms of long-term bio-remediation. Vegetable-based lubricants and some synthetic ester-based products exhibit ready biodegradation.

There are several petroleum-based lubricants that claim "inherent biodegradability". Inherent biodegradation is defined as having the propensity to biodegrade, with no indication of timing or degree. These types of products can persist in the environment for years, continuing to cause substantial damage. They require long-term remediation due to the environmental persistence. Typically, these products are

petroleum-based, like conventional lubricants. Chart 2 illustrates the difference in degradation timing of a readily biodegradable product compared to an inherently biodegradable product.

Chart 2



Looking at Chart 2, it is easy to see the difference between a readily biodegradable product and an inherently biodegradable one. The EPA and Coast Guard utilize this differentiation when evaluating an oil release.

TOXICITY

Another measurement to determine environmental effect of a lubricant is "eco-toxicity". Historically, tests for eco-toxicity have concentrated on the aquatic environment with a number of standard test procedures. Most typically, the tests are for "acute toxicity". This is a measurement of the concentration required to kill various organisms over a short period of time ranging 24-96 hours. Depending on the tests and its end points, the toxicity of a fluid is described by a loading rate that has a 50% effect (EL50) or causes 50% mortality (LL50) after the stated time. That is, at what concentration of fluid one half of the sample organisms die. Most of the systems in Table 3 accept values of >100 parts per million (ppm) to 1000 ppm EL50/LL50 in acute toxicity tests as low or no aquatic toxicity.

ASTM D 6064 has utilized a tiered approach as defined in Table 3.

Table 3

Ecotoxicity in Soil	Ecotoxicity in Water	Loading Rate wppm ll50
Ts1	Tw1	>1000
Ts2	Tw2	1000-100
Ts3	Tw3	100-10
Ts4	Tw4	<10

Attempts have been made using "food grade" lubricants to protect the environment. While food grade oils seem like a good idea, it is highly impractical for demanding applications. First, food grade products are designed for equipment in food processing plants. They are toxic; in fact an entire batch of food must be discarded in the event of contact with the lubricant. Secondly, they are environmentally persistent (non-biodegradable) so they are toxic to marine life for long periods of time. Lastly, they are designed for very light duty usage and under break down quickly under typical movable structure applications temperatures and pressures.

PERFORMANCE

There are a wide variety of performance levels among biodegradable products. Traditionally, a lubricant is compounded from base oil and a variety of performance chemistries. Early pioneers in the vegetable-based lubricant market used the same chemistry that was used for petroleum lubricants in vegetable base-oils. It was a great idea, but it didn't work. The characteristics of vegetable oils are vastly different than those of petroleum oils. Vegetable oils had to be formulated for their individual strengths and limitations. Today, there are several vegetable-based products on the market. They offer good performance and a fair price. While all vegetable-based lubricants have temperature limitations, there are some that are better than others. One should check with their lubricant supplier to determine their maximum and minimum operating temperatures. While most vegetable-based lubricants have a maximum operating temperature of 140° F, there are some that offer protection as high a 220° F. Similarly, most vegetable-based lubricants offer good performance to 30° F, yet there are some that flow below –30° F.

When an environmentally preferable product is required outside the common temperatures range, a biodegradable synthetic is usually required. While offering biodegradation, these products can operate in temperature in excess of 400° F and still offer long fluid life. As would be expected, these products are significantly more expensive.

Synthetic oils fall into three categories:
Polyalphaolefins (PAOS) – which have excellent low temperature properties but tends to shrink seals
Diester – which have good anti-oxidation characteristics and good seal compatibility
Polyalkylene glycols (PAG) – which are water soluble, have good fire resistance, but can cause foaming.

Combining the performance of a synthetic with the vegetable oil are XBO oils. These are a new type of enhanced vegetable oils, developed by Terresolve Technologies, Ltd. in conjunction with the U.S. Department of Energy and the United Soybean Board. XBO oil allows a vegetable based lubricant to meet the performance of a synthetic. The cost structure is slightly higher than conventional vegetable oils and about half of synthetic oils. XBO's have longer useful life than petroleum oils, handle temperatures over 400° F and below – 40° F and offer no seal incompatibility.

PRODUCTS

There are wide ranges of commercially available environmentally preferable lubricants on the market. Some of the products include; hydraulic fluids, gear oils, greases, diesel fuels, two-cycle oils and others. Care must be taken in choosing the appropriate product for the specific application. Responsible environmentally preferable product (EPP) suppliers can clearly indicate their definition of "environmentally preferable". The Federal Trade Commission has been very specific in their requirements for environmental claims and state "look for claims that give some substance to the claim, the additional information that explains why the product is environmentally friendly". Many "would be" EPP suppliers use misleading environmental claim such as "inherently biodegradable" or "food grade". Suppliers should be able to support performance claims with testing data. These data can include standard industry tests (ASTM), field-testing, and equipment manufacturer tests. Unless an EPP supplier specializes in environmentally preferable products, they are probably not expert in the field.

MAINTENANCE OF BIOFLUIDS

All lubricants, both biodegradable and petroleum-based, will afford better equipment life when the fluid is properly maintained. Fluid maintenance should initiate in the design of the equipment and hydraulic

system. Good filtration, dewatering, temperature control and adequate sump size should all be considered early in the development of the system. Lubricants must be considered a component of the equipment it works in, therefore it should be monitored and maintained like the machine itself. Frequently the oil is ignored and abused until a problem arises. One cause of this is arbitrary oil change intervals and, in particular, extending oil drains. This is particularly important in bio-fluids, which can be more expensive than conventional fluids, and the tendency is to increase their change interval to recoup their investment.

Lubricant maintenance incorporates all aspects that are necessary to keep the lubricant and the entire system in good condition. Preventative periodic maintenance of oil will maximize its useful life by only changing it when it is required rather than on a set period of time or hour on a machine. Key elements to monitor and key indications of useful life decreases are as follows in Table 4:

Table 4

Test	Veg.Oil	Syn.	XBO
Viscosity Change			
Increase @ 40 C %	20	20	20
Decrease @ 40 C %	10	10	10
Decrease @ 100 C %	10	10	10
Free Water Content PPM	500	1000	1500
TAN mg KOH/g	2	3	3
Contamination Level	16/13	16/13	16/13

CONCLUSION

Growing concern over the cost and environmental impact of lubricant spills in all movable structures has lead to increased interest in environmentally safer fluids. These fluids can be biodegradable and non-toxic so that they will have no long-term negative impact in the environment in the event of an accidental discharge.

Biodegradable hydraulic fluids have other unique characteristics that must be taken into consideration when selecting the appropriate fluid. Care must be taken to utilize the correct fluid in the proposed application.

With proper maintenance and routine monitoring, biodegradable fluids will provide a long useful life for the fluid and the equipment. Lastly, no one wants lubricant spill, but they are a fact of life. In this circumstance, a biodegradable lubricants will more than pay for themselves in terms of reduced clean up costs, fines, downtime and administrative costs.

ABOUT THE AUTHOR:
Shari Miller is the director of marketing for Terresolve Technologies, Ltd. Terresolve, a Cleveland-based company, is dedicated to providing non-toxic, biodegradable lubricating products that deliver exceptional performance. For more information about Terresolve, field test results and all of its environmentally friendly products, visit their web site at www.Terresolve.com or call (800) 661-3558.