NEW LAWS GOVERNING BIOBASED, ENVIRONMENTALLY PREFERABLE LUBRICANTS AND FUELS

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ABSTRACT

As environmental enforcement agencies increase pressures and costs for petroleum lubricant spills, many offshore operators are using or considering environmentally safer products. These types of fluids can protect the users against fines, cleanup costs and downtime, but care must be given in selecting the right product for a specific application.

This paper will review the definitions of environmentally preferable products and strengths and limitations of each type. It will also review the various definitions of "biodegradable" and the maintenance practices required to prolong the life of the fluid and the equipment.

INTRODUCTION

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 SAFE OIL

More and more owners, operators, leaseholders and regulatory agencies are recognizing the benefits of environmentally preferable fluids. Using these lubricants can potentially save an operator thousands of dollars in terms of fines, clean-up costs and down time.

As in any emerging industry, companies are offering a variety of products that have a range of environmental benefits and performance attributes. There are a variety of names used by oil suppliers; environmentally safe, biodegradable, readily biodegradable, food grade. They can also be described as triglyceride (vegetable) based, ester based, food grade, synthetic. Table 1 below outlines the performance of various fluids. The reader will note that triglyceride or vegetable based products and some synthetics are most environmentally preferable. The so-called "Environmentally Safe" products tend to be petroleum based and not biodegradable in the truest sense. Glycols and synthetic esters offer very poor elastomer and seal compatibility.

Type	Base Fluid	Biodegradation Time	Toxicity	Typical Performance	Elastomer Compatibility	Water Tolerance
Triglyceride (Vegetable)						
Biobased	**Vegetable**	**Days**	**Low**	**Varies**	**Mixed**	**Medium**
High Oleic	**Vegetable**	**Days**	**Low**	**Mixed**	**Mixed**	**Medium**
XBO	**Modified Vegetable**	**Days**	**Low**	**Very Good**	**Excellent**	**Excellent**
Petroleum						
"Environmentally Friendly"	**Petroleum**	**Years**	**Low**	**Good**	**Good**	**Good**
Petroleum	**Petroleum**	**Years**	**High**	**Good**	**Excellent**	**Good**
Inherently Biodegradable	**Petroleum**	**Years**	**Varies**	**Good**	**Excellent**	**Good**
Food Grade	**Petroleum**	**Years**	**Low**	**Weak**	**Excellent**	**Weak**
Glycol (PAG)						
Poly glycol	**Glycol**	**Years**	**Medium**	**Weak**	**Very Poor**	**Good**
Synthetic						
Synthetic Ester	**Synthetic**	**Days**	**Low**	**Mixed**	**Very Poor**	**Very Weak**
BioPolyOlefin	**Synthetic**	**Days**	**Low**	**Excellent**	**Excellent**	**Excellent**

Table 1. Fluid Performance

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.

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.

OIL SPILLS

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 "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 "biobased 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 statute 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". In fact, the Coast Guard also relies on the guidelines as outlined by equipment manufacturers and highly favors the use of biobased 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.

The Aerobic Biodegradation Process

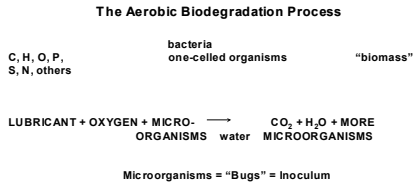


Figure 1. Aerobic Biodegradation

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.

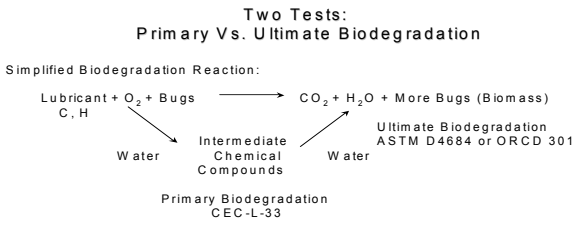


Figure 2. Primary vs. Secondary Biodegradation

BIODEGRADABILITY DEFINED

There is no single definition of biodegradability. Throughout the United States and internationally there is a wide range of environmentally preferable definitions. The ASTM 6064 has defined biodegradable as a function of degree of degradation, time, and test methodology. See Table 2 below.

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

Table 2. ASTM Biodegradation Classification

Readily Biodegradable

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.

"Environmentally Safe" Inherently Biodegradable

There are several petroleum-based lubricants that claim "inherent biodegradability". These are typically referred to as "Environmentally Safe". 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. The chart below illustrates the difference in degradation timing of a readily biodegradable product compared to an inherently biodegradable product.

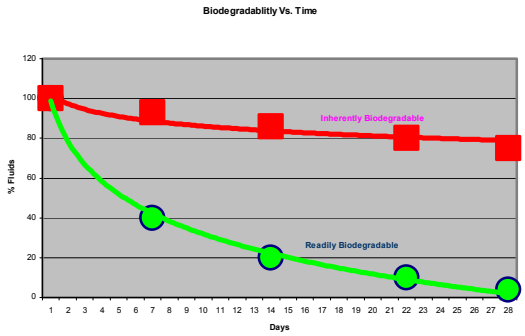


Chart 1. Readily Biodegradation

Looking at Chart 1 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.

ECO-TOXICITY

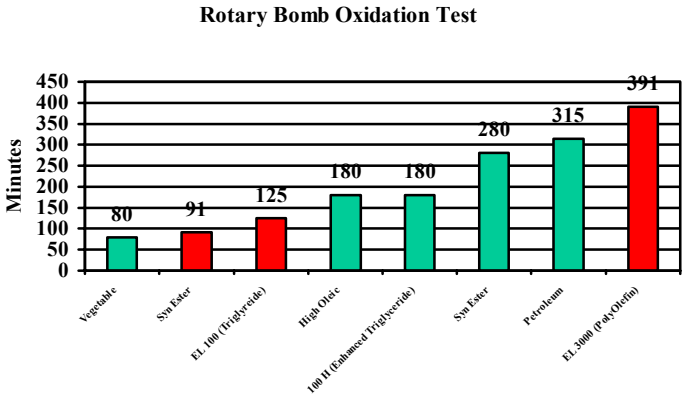
Another measurement to determine environmental effect of a lubricant is "eco-toxicity". Historically, tests for eco-toxicity have concentrated on the aquatic environment with a number of standard test procedures. Most typically, the tests are for "acute toxicity". This is a measurement of the concentration 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.

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

Table 2. ASTM Ecotoxicty Classification

PERFORMANCE OF BIOFLUIDS

There are a wide variety of performance levels among biodegradable products. 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 temperatures in excess of 400° F and still offer long fluid life. As would be expected, these products are significantly more expensive. Below is a graph that illustrates the comparative oxidative stability of various readily biodegradable hydraulic fluids as compared to petroleum oil.



Graph 2. Oxidative Stability

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 claims 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.

PRODUCT DEMONSTRATION

Since there is no standard for environmentally preferable fluids, many different types of products claim to be environmentally safe. For the most part they fall into four major classes of products:

1. Inherently Biodegradable products are those that will break down "some day" and the time to do so is usually measured in years. The environmentally safe aspect is that they are made from either food grade oil or highly refined petroleum base fluids and contain no heavy metals in the additives. While not truly biodegradable, they can have reduced toxicity.
2. USDA H1 "food grade" lubricants that are designated for use in food processing plants. They are designed for light duty applications where the fluid does not come in contact with food. Food grade oils are typically impractical for severe marine applications. In addition, they are toxic; in fact an entire batch of food must be discarded in the event of contact with the lubricant. Finally, they are petroleum-based and therefore environmentally persistent (inherently biodegradable or non-biodegradable) meaning they will be toxic to marine life for long periods of time.
3. Readily biodegradable products such as vegetable based break down into safe, environmentally compatible components (CO_2 and H_2O) by over 90% in 28 days or less. They are also non-toxic, so they don't kill marine life. They typically are designed for low operating temperatures (less that 220°F).
4. Synthetic products usually offer enhanced performance as compared to vegetable or petroleum products. Some can be readily biodegradable and non-toxic and can withstand operating temperatures over 400°F.

HISTORY

While readily biodegradable products have a long history of successful performance in a wide range of applications, they are relatively new to the marine industry.

Historically vegetable based fluids have not exhibited sufficient performance for offshore applications. There were several reasons for this.

1) Fluid formulations
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.

2) Fluid Choice
Even the highest performing biobased fluids have operating limitations in terms of temperature and life expectancy. Using a biobased fluid in an application over 220°F (and as low as 160°F for some fluids) will cause premature and possibly catastrophic equipment failure. There are numerable cases in which using a vegetable based fluid in the wrong application was a major contributor to the failure. In extreme, high temperature, environmentally sensitive applications readily biodegradable synthetic fluids should be utilized.

3) Fluid Care
Traditional biobased fluids offer unique performance characteristics however they require special care to maximize their useful life. While water is the enemy of all lubricants, most biobased fluids are more susceptible to hydrolytic breakdown, the result of which can be acid formation. These acids can attack seals, increase wear and accelerate fluid aging. Proper filtering will prolong the useful life of these fluids.

DRIVING FORCES

Regulatory Leniency

While significant spills with readily biodegradable fluids are still reportable events, the resultant costs associated with the incident are usually minimized. Good industrial hygiene should be utilized to contain any spill, however these are usually "non-events". Since the fluids were biodegradable and non-toxic, there was no long-term negative effect to the ecosystem.

Regulatory agencies including the MMS, Coast Guard, EPA, Marpol are increasingly recognizing the environmental benefits of readily biodegradable products. They are aware that in less than 30 days spilled fluid will be reduced to safe, environmentally benign components specifically, carbon dioxide and water. There is no long-term negative impact to the environment and therefore no need for punitive fines. Frequently, an operator can continue working while rectifying the situation.

Another key aspect in assessing a spill related fine is negligence. When an operator is using a readily biodegradable product, regulatory agencies know that they are taking every precaution to not only protect the environment in the event of a spill but also to avoid spills in the first place. Readily biodegradable hydraulic fluids can cost three to five times as much as conventional petroleum based fluids. Obviously, an operator spending this difference is doing everything possible to prevent spills.

Long-term remediation and monitoring is usually very expensive. Since readily biodegradable products will dissipate within a 28-day window, there is no long-term clean up. Moreover, some of these fluids are vegetable-based and nontoxic and can provide a food source to the ecosystem.

As previously mentioned, 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 statute 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 highly favors the use of biobased and biodegradable fluids and in this writer's experience, there has never been a fine levied on a vegetable oil spill.

Legislation

There is mounting pressure from the Federal Government to utilize environmentally preferable products.

The Farm Security and Rural Investment Act of 2002, otherwise known as the "Farm Bill", passed and was signed into law in May of 2002. It requires all federal agencies to give ***procurement preference*** to biobased products. The language in Title IX, Section 9002 states, "…each Federal agency which procures any items designated in such guidelines shall, in making procurement decisions, give preference to such items composed of the highest percentage of biobased products practicable, consistent with maintaining a satisfactory level of competition, considering such guidelines."

A major piece of legislation is Executive Order 13101 (The Greening of the Government) signed by President Clinton in 1998. E.O. 13101 calls for Federal agencies and federally funded state agencies to purchase Environmentally Preferable, and specifically, biobased "products and or services that have reduced effect on human health and the environment when compared with competing products or services. The comparison may consider any or all phases of the products life cycle". It charges the head of each executive agency to "develop and implement affirmative procurement programs in accordance with section 6002 of RCRA (42 U.S.C. 6962) and this order and consider use of the procurement tools and methods."

Another Executive Order, E.O. 12852, provides for "sustainable development". In the order, sustainable development is broadly defined as "economic growth that will benefit present and future generations without detrimentally affecting the resources or biological systems of the planet".

While not specifically promoting biobased products, Public Law 104-55 "The Edible Oil Regulatory Reform Act" requires "the head of any Federal Agency to differentiate between fats, oils and greases of animal, marine or vegetable origin, and other oils and greases in issuing certain regulations and for other purposes.

The Clean Water Act of 1972 is the principal federal statute protecting navigable waters and adjoining shorelines from pollution. Since its enactment, the CWA has formed the foundation for regulations detailing specific requirements for pollution prevention and response measures. Section 311 of the CWA addresses pollution from oil and hazardous substance releases, providing EPA and the U.S. Coast Guard with the authority to establish a program for preventing, preparing for, and responding to oil spills that occur in navigable waters of the United States. EPA implements provisions of the Clean Water Act through a variety of regulations, including the National Contingency Plan and the Oil Pollution Prevention regulations.

Under the legal authority of the Clean Water Act, the Discharge of Oil regulation, more commonly known as the "sheen rule", provides the framework for determining whether an oil spill to inland and coastal waters and/or their adjoining shorelines should be reported to the federal government. In particular, the regulation requires the person in charge of a facility or vessel responsible for discharging oil that may be "**harmful to the public health or welfare**" to report the spill to the federal government. The regulation establishes the criteria for determining whether an oil spill may be harmful to public health or welfare, thereby triggering the reporting requirements, as follows:

- Discharges that cause a sheen or discoloration on the surface of a body of water;
- Discharges that violate applicable water quality standards; and
- Discharges that cause a sludge or emulsion to be deposited beneath the surface of the water or on adjoining shorelines.

Petroleum lubricants clearly meet these requirements.

CONCLUSIONS

True proof of performance is found in the field. Any fluid supplier should support their customers with routine oil monitoring and interpretation of the results. Since biodegradable products behave differently than conventional petroleum products, one should not count exclusively on the conventional oil analyst's interpretation of test lab results.

It is important to partner with a biofluid supplier, with enough field and technical experience to support an oil-monitoring program and to be willing and able to support product changes.

Many factors should be considered when choosing a biodegradable fluid. The key considerations to be evaluated prior to selecting any fluid include:

- Temperature
- Pressure
- Seals and elastomers
- Water intervention
- Fluid life
- Spill potential
- Client choice

Readily biodegradable lubricants can save time, money and protect the environment, however, they must be properly maintained. Since the key to long fluid life and top tier performance is keeping the fluid clean and dry, proper filtration is essential.

One must do their homework to determine that using a readily biodegradable hydraulic fluid is the "right thing to do". It's the right thing for their clients, the right thing for the environment and right thing for you.

ABOUT THE AUTHOR

Mark Miller is the Head of Sales and Chief Executive Officer of Terresolve Technologies. Mr. Miller has a B.S. in Chemical Engineering from Tufts University and an M.B.A. from Manhattan College. He has engineered, sold and marketed lubricants and lubricant additives for over 20 years.
Terresolve Technologies, a Cleveland-based company, is dedicated to providing non-toxic, biodegradable lubricating products that deliver exceptional performance. Terresolve's biobased fluids are renewable, support the agrarian community, and meet federal guidelines for environmentally preferable purchasing. Their performance has been proven in the lab and in the field. There has never been a reported case of a fine relating from an accidental discharge of these readily biodegradable environmentally safe products.
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.