White paper

Environmentally acceptable lubricants: Looking beyond the label

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Introduction

The U.S. Environmental Protection Agency's (EPA) Vessel General Permit (VGP) regulation continues to have a significant impact on marine operators' lubricant selection. This paper will address key industry concerns and confusion around **Environmentally Acceptable Lubricants (EALs)** and **provide guidance on the selection of the most appropriate EAL by application.**

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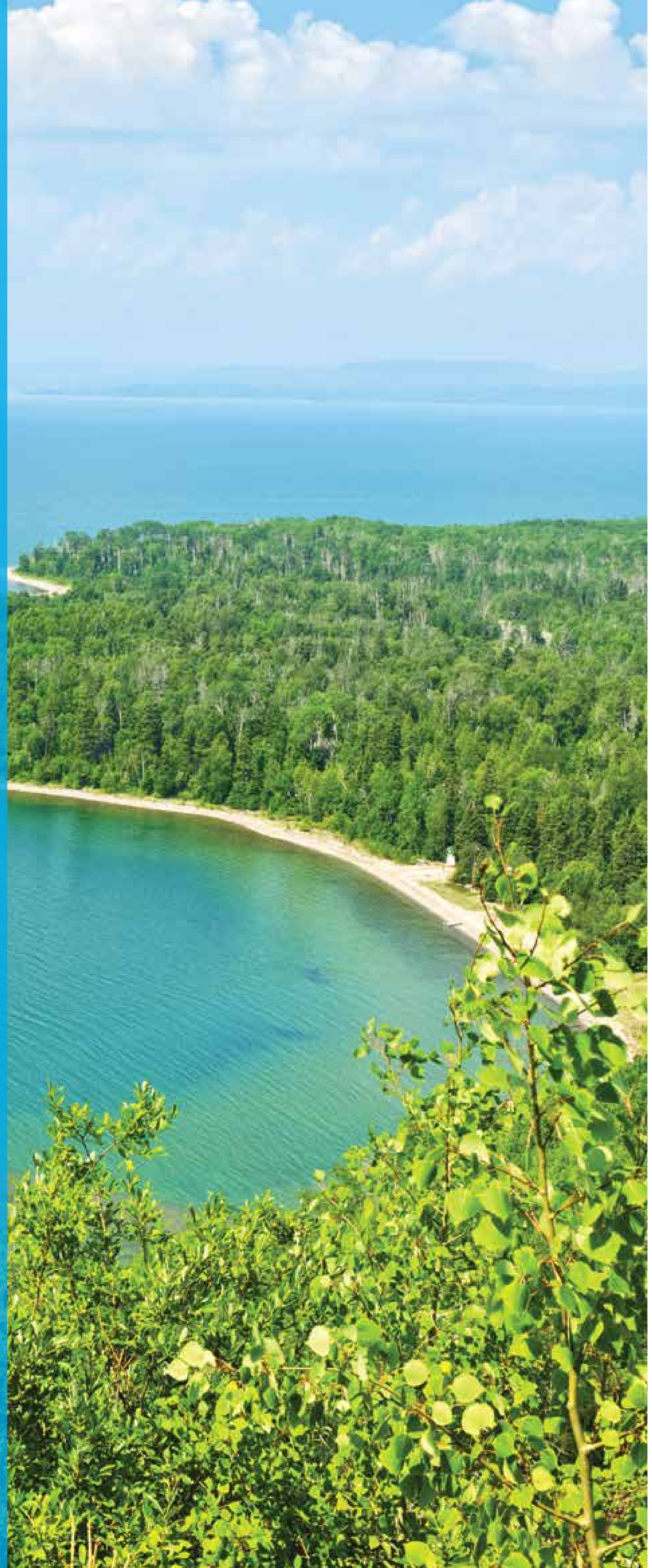
The impact of the Vessel General Permit

The combination of environmental regulations, and pressure from manufacturers and the supply chain for ‘green’ products and services, is having a major impact on the marine industry. Although the majority of the focus is currently on fuel challenges, changes are also affecting a wide range of lubricant applications.



The continued adoption of the VGP affects almost all vessels longer than 79 feet operating within 3 nautical miles of the US coastline and within US jurisdiction in the Great Lakes and inland waters.

It sets out detailed rules for discharges from oil-to-sea interfaces that annually affect around 70,000 vessels. Specifically, it mandates the use of EALs for certain applications. Non-compliance risks a fine of up to $25,000 per day, up to one year of imprisonment or both.

The oil-to-sea interface

Oil-to-sea interfaces include any onboard equipment where seals or surfaces have the potential to release oil into the sea. The VGP specifically identifies a range of equipment that has the potential for lubrication discharge from an oil-to-sea interface. These include:

- Controllable pitch propellers
- Thrusters
- Stern tubes
- Thruster bearings
- Stabilisers
- Rudder bearings
- Azimuth thrusters
- Propulsion pods
- Wire ropes and cables
- Equipment subject to immersion

Industry concerns and challenges

The sheen rule

Vessels operating in US inland and coastal waters are also regulated by the Clean Water Act, Discharge of Oil regulation; more generally known as the 'sheen rule.' This commonly used name has given rise to a widespread misperception that oil spills that do not leave a sheen are acceptable. This is not the case. The regulation requires any vessel that discharges oil that could be 'harmful to the public health or welfare' to report the spill.

It also establishes the measures for determining whether an oil spill needs to be reported. The criteria are discharges that:

- Cause a sheen or discoloration on the surface of the water
- Violate applicable water-quality standards
- Cause a sludge or emulsion to form below the water surface or on adjoining shorelines

According to the EPA, the use of EALs does not provide a waiver to the rule, although it may minimise the risk of triggering the reporting requirements.

Sources of lead in used oil

Another common misperception regards the presence of lead in used stern tube oil samples, which has been accredited to the lubricant's formulation. Routine oil analysis has recently revealed that a small percentage of vessels have increased lead content in their used oil, above the International Association of Classification Societies (IACS) guidelines (10mg/kg). Since lead is a heavy metal and is not generated by chemical reaction, the source of the lead could be:

- Stern tube bearing wear, depending on composition
- From paints or coatings within oil circulation systems
- Acidic corrosion of the lead element within the stern tube
- Additives in the EAL

However, a significant number of the vessels that have reported the high lead levels have tin bearings, there have been no reported operational issues, and lubricant analysis had revealed no leaching effect as a result of oil formulation.

If high levels of lead are detected, vessel operators should consult with their OEMs to identify the source of the contamination in order to ensure the most appropriate remedial action is taken.

What characterises an EAL?

EALs are defined in the VGP as lubricants that are biodegradable, **minimally toxic and non-bioaccumulative.**

To meet these environmental standards, an oil must meet all three criteria and there are comprehensive parameters for each classification. What is not specified, however, is an oil's chemistry. As a result, a number of base stocks can be used, including:

- Polyalkylene glycol
- Triglycerides
- Synthetic esters

It is also possible to employ sea water, in selected and limited applications, but this requires the use of bearings made from self-lubricating elastomeric polymer. Practical experience of this type of installation shows cases of rapid wear, or even malfunctions, some of which may be caused by insufficient lubricant flow or a buildup of particulate matter.

Although all these options meet the criteria of the VGP, not all EALs are created equal.

EAL characteristics explained

Biodegradable:
The lubricant must meet a minimum of 60% biodegradation within 28 days for 90% of an oil formulation or 75% of a grease formulation.

Minimally toxic:
The lubricant must pass the Organisation for Economic Co-operation and Development (OECD) 201, 202 and 203 acute toxicity tests, or OECD 210 and OECD 211 for chronic toxicity. As an alternative, an evaluation may be conducted on a constituent basis.

Non-bioaccumulative:
Bioaccumulation occurs when an organism absorbs a toxic substance at a rate greater than the speed at which the substance is lost. Consequently, to qualify as non-bioaccumulative, a substance must not be able to build up to toxic levels.

Base stock benefits

Depending on composition, EALs based on polyalkylene glycol (PAG) offer good lubricity, load-bearing, viscosity indices, oxidation characteristics and hydrolytic stability. They are typically highly incompatible with conventional seals and filters as well as hydrocarbon, vegetable and ester-based oils. This makes switching to a PAG-based EAL complex and costly, as solvent washing of lubricant tanks and associated systems may be necessary and seals may need to be replaced.

Triglycerides, naturally derived vegetable-based lubricants, are readily biodegradable and offer excellent lubricity but are prone to hydrolysis. They also have poor resistance to temperature extremes, low oxidative stability and a short operational life.

The most effective EALs are based on synthetic esters. They perform well across a wide range of temperatures, have a high viscosity index, possess good lubricity, provide excellent corrosion protection and have high oxidative stability. They also offer excellent biodegradability and can have good hydrolytic stability depending on the ester.

Importantly, they have a history of **proven performance, long operational life and compatibility with mineral oils, making changeovers straightforward.**

Synthetic esters: Specific properties

Volatility: The polarity of ester molecules causes them to be attracted to one another, and because of this, more energy (heat) is required to get them to move from a liquid to a gaseous state. As a result, the synthetic ester lubricants have a high flash point and a low rate of evaporation.

Lubricity: Polarity also causes the ester molecules to be attracted to positively charged metal surfaces. As a result, the molecules tend to create a film that requires additional energy (load) to wipe it off. The result is high lubricity and low energy consumption in lubricant applications.

Detergency/Dispersancy: The polar nature of esters makes them good solvents and dispersants. This allows the esters to dissolve or disperse oil degradation byproducts that might otherwise be deposited as varnish or sludge.

Biodegradability: The character of ester linkage provides vulnerability for microbes to biodegrade the ester molecule. This results in high biodegradability rates for ester lubricants, which enables the formulation of environmentally friendly products.

Although base stock is important, the lubricant's additive package also plays an important part in an EAL's overall performance. For example, the demands placed on hydraulic and gear oils are quite different. Gear oils often have to deal with below-the-waterline applications, such as thrusters and pitch propellers. Hydraulic oils are most commonly found in deck equipment, such as cranes, ramps and hatches.

Vessel operators are therefore advised to select lubricants best suited for individual tasks. This will not only ensure optimum operation; it can also help maintain lubricant performance, which can help reduce maintenance costs and enhance overall efficiencies.

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A global drive to minimise marine pollution

The VGP's ruling is part of a wider ongoing trend driven by a growing awareness of environmental issues and the demand from business for "sustainable" supply chains. For example, the International Maritime Organization (IMO) Polar Code, which entered into force 1 January 2017, recommends the use of EALs in polar waters.

There are also national and regional schemes that impose environmental standards for marine lubricants, including the European Union's Ecolabel, Germany's Blue Angel scheme, Sweden's SS 155434 ruling on hydraulic fluids and greases, and the Nordic Swan, which was jointly developed by Norway, Sweden, Iceland, Finland and Denmark. This is generally considered to be the most demanding and comprehensive programme as it sets out criteria for biodegradability, toxicity, renewability and technical performance.

These types of regulations are an everyday reality for vessel operators, and their scope and frequency is likely to increase. China, for instance, is incrementally toughening its maritime emissions regulations, and the IMO has signalled further changes.

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ExxonMobil's EAL offering

In order to ensure that vessel operators have access to lubricants and greases that not only comply with the VGP but also help to extend equipment life (compared with industry-standard mineral products),

ExxonMobil has developed the Mobil SHC™ Aware™ family of high-performance synthetic ester-based EALs. These include hydraulic oils, synthetic gear oils, greases and stern tube oils.

With the exception of the stern tube oil, all are made with saturated esters. This helps ensure they have good resistance to temperature-related degradation and are stable in the presence of water, therefore protecting against hydrolytic breakdown.

The presence of water in stern tubes is, however, unavoidable, so unsaturated esters are used in the formulation of Mobil SHC™ Aware™ ST Series lubricants. This ensures that the stern tube oils readily emulsify with water while providing outstanding lubrication and rust/corrosion protection, even with up to 20% water content.

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Compliance is just the start

When it comes to EAL selection, compliance is just the starting point; vessel operators should also look for lubricants that are most suitable for the application and can help to enhance operation efficiencies.

Conversion from existing mineral oils to EALs requires time in dry dock for some applications. It is therefore essential that the changeover process is as easy to manage as possible. Vessel operators will want to avoid the need for solvent flushing, as required for PAGs, while also ensuring that their EALs are up to the job. The optimal solution is an EAL based on synthetic esters, coupled with EAL-compliant performance additive technology.

Used oil analysis

A condition-based maintenance approach, such as used oil analysis, offers a range of benefits. Properly implemented, it can help vessel operators:

- **Improve equipment reliability**
- **Cut lubricant consumption/ expenditure**
- **Reduce maintenance costs**
- **Enhance equipment life**

ExxonMobil's Mobil Serv™ Lubricant Analysis simplifies this process by producing reliable results and clear guidance that help vessel operators identify issues before they become problems. Its insights into the condition of equipment and lubricants are backed by ExxonMobil's extensive marine industry experience and expertise.

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