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The Case for Environmentally Acceptable Lubricants: Reducing Operational Discharges of Lubricants into Oceans and other Water Bodies

Green Boats and Ports for Blue Waters III Workshop

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Environmentally Acceptable Lubricants

United States Environmental Protection Agency
Office of Wastewater Management
Washington, DC 20460

Environmentally Acceptable Lubricants

- ‘Environmentally Acceptable Lubricants’ means lubricants that are ‘**biodegradable**’ and ‘**minimally-toxic**’ and are ‘**not bio accumulative**’
- Environmentally Acceptable Lubricants include those labeled by the following **labeling programs**:
  - Blue Angel
  - European Ecolabel
  - Nordic Swan
  - the Swedish Standards SS 155434 and 155470
  - Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) requirements
  - EPA’s Design for the Environment (DfE)

Environmentally Acceptable Lubricant Types

Lubricant base oil	Base oil source	Biodegradation	Potential for Bioaccumulation	Toxicity
Mineral oil	Petroleum	Persistent / Inherently	Yes	High
Polyalkylene glycols (PAG)	Petroleum - synthesized hydrocarbon	Readily	No	Low[a]
Synthetic Ester	Synthesized from biological sources	Readily	No	Low
Vegetable Oils	Naturally occurring vegetable oils	Readily	No	Low

Source: Mudge, 2010

a. Solubility may increase the toxicity of some PAGs

Differences between standard lubricants and EALs
Example – stern tube and thruster gear oil oils

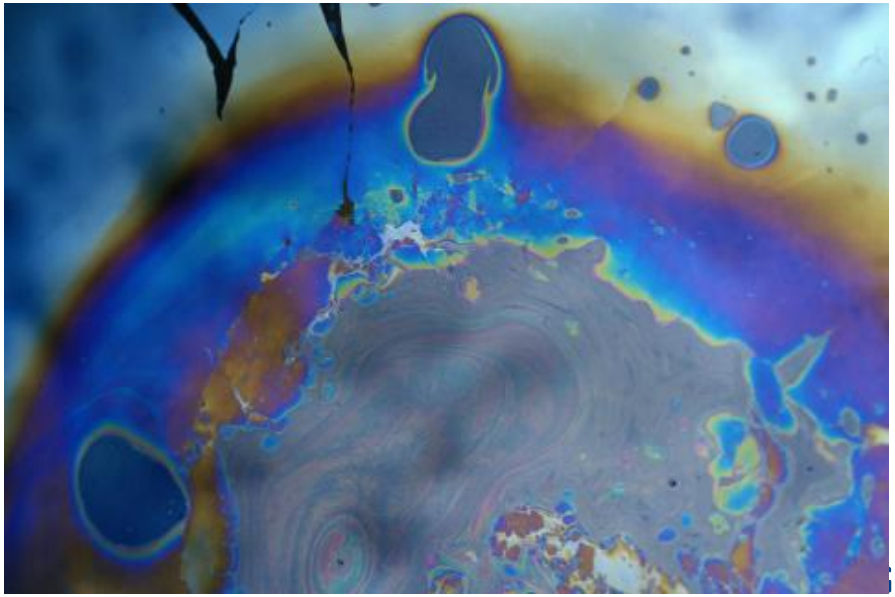
Properties	Mineral oil	Ester oil Native or synthetic
Rapidly biodegradable according to OECD 301 B	≤ 20% –	≤ 90% ++
Wear protection	o	+
Friction coefficient	o	++
Ageing resistance	o	– ….+
Viscosity-temperature behavior	o	+
Water in oil	+	–
Seal compatibility	++	– with NBR ++ with selected FKM
Hydrolytic stability	Not relevant	– ….+
Lifetime	1	3 – 4 (no water)

++….very good +….good o….satisfactory –….poor

Why should we use environmentally friendly lubricants?

Why should we use environmentally friendly lubricants?

- Several million liters of petroleum lubricants leaked annually into our rivers and oceans from operational discharges (Etkin, 2010)
- Oil leakage rate through a new propeller shaft seal can be as high as 5 l / day.
- Leakage rates of older seals could be even higher.



Motivation for vessel owners and operators

Mandatory by law in the US

- Requested by the **2013 Vessel General Permit Vessel (VGP)** vessels larger than 79 feet must use Environmentally Acceptable Lubricants (EALs) in all water-to-sea interfaces when entering waters of the United States

Other - Polar Code

- Non-toxic biodegradable lubricants or water-based systems should be considered in lubricated components located outside the underwater hull with direct seawater interfaces, like shaft seals and slewing seals.

Local laws, customs and preferences

- High demand for environmentally friendly operation of ships from customers, e.g. cruise passengers

2013 Vessel General Permit – game changing regulation

- Result of the Clean Water Act (mid 1970's) and environmental law suit 2008 in the United States
- Requires Environmentally Acceptable Lubricants (EALs) in all oil-to-sea interfaces
- Focus is on reducing "Operational discharges and leakages"
- 1st version in 2009, updated in 2013, next version in 2018

Case Study - ATB units

Lost in use grease

- More than 150 vessels are operating in US Waters
- 200 tons of grease annually
- More than 50% discharged into waters

How to select the right EAL?
Example – stern tube fluid

All listed EALs can be used for oil lubricated SIMPLEX sterntube bushes and seal systems.

Company name / Product name	Viscosity cSt. 40°C	Appli-cation	Company name / Product name	Viscosity cSt. 40°C	Appli-cation
BP / Castrol			Klüberbio RM 2-100	100	S
BioStat 68 *	68	M	Klüberbio RM 2-150	150	S
BioStat 100 *	100	M	Klüberbio LR9-68	68	H
Chevron			**MAN Diesel & Turbo SE**		
Clarity Synthetic EA Hydraulic Oil 68	68	H	PrimeServLube Bio P 1000 **	100	S
Clarity Synthetic EA Stern Tube Oil 100	100	S	**TOTAL LUBMARINE (ex Elf Marine)**		
Clarity Synthetic EA Gear Oil 100*	100	G	Bioneptan 100	100	S
Clarity Synthetic EA Gear Oil 150*	150	G	**TOTAL INDUSTRIE**		
ExxonMobil			Biohydran TMP 100	100	H
Mobil SHC Aware ST 100 **	100	S	**Terresolve / RSC Bio Solutions**		
Mobil SHC Aware ST 220 **	220	S	EnviroLogic 3068	68	H
Fuchs / Lukoil			EnviroLogic 3100	100	H
Plantogear 100 S	100	M	EnviroLogic 210 *	100	G
Gulf Oil Marine Ltd.			EnviroLogic 215 *	150	G
GulfSea BD Sterntube Oil 68 **	68	S	**Vickers Leeds**		
GulfSea BD Sterntube Oil 100 **	100	S	Hydrox Bio 68 **	68	S
Klüber			Hydrox Bio 100 **	100	S
Klüberbio EG 2-100	100	G	Hydrox Bio 220 **	220	S
Klüberbio EG 2-150	150	G			

* *Oils with general limited application temperature, 60° C*

** *Oils not suitable for SIMPLEX Airspace seals.*

Oil application: G =Gear, H = Hydraulic, M = Multipurpose, S = Sterntube

Lube chart from SKF Blohm + Voss for SIMPLEX stern tube seals

- EAL approval list from propeller seal OEM
- Several stern tube oils are approved
- No ranking in regards to performance is given by OEMs

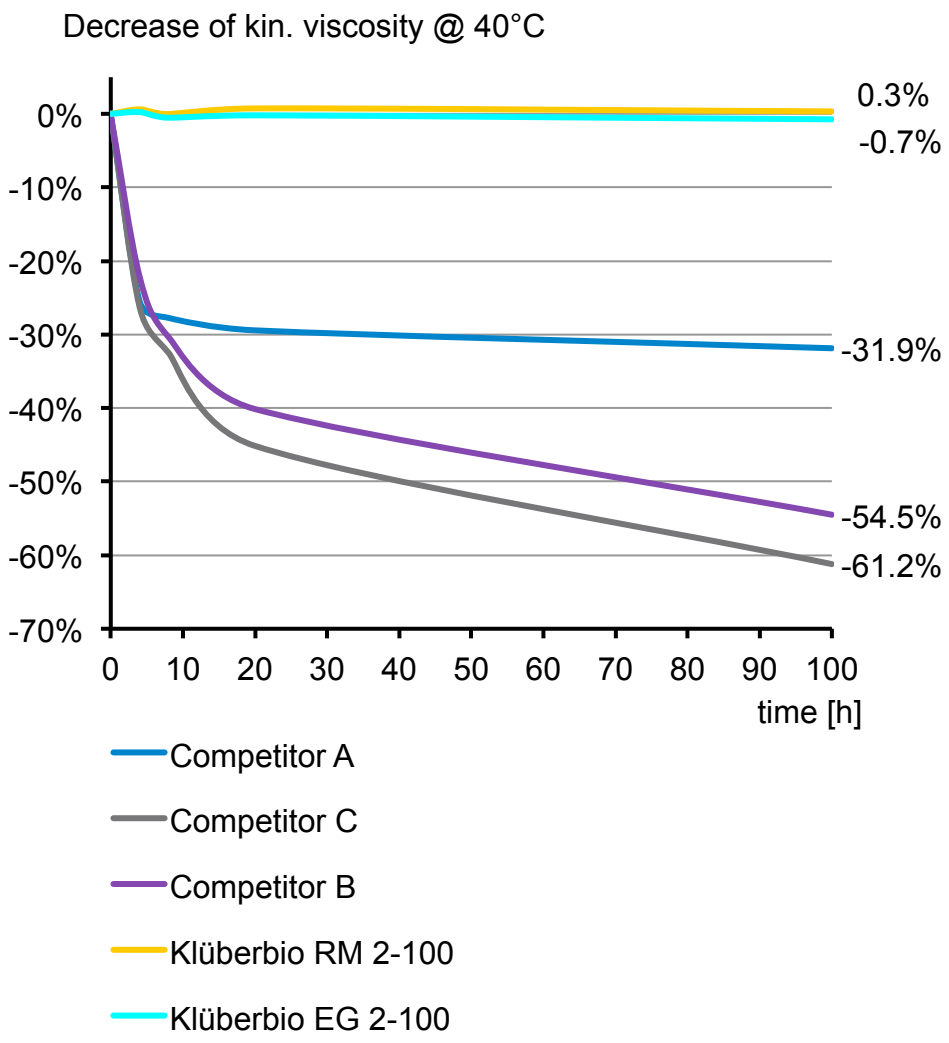
There are huge differences in performance of different EALs :

- Oil film thickness in a bearing
- **Shear stability of the oil**
- Oxidation stability
- Emulsifying or non-emulsifying oil
- Can water be removed from the oil and how

Viscosity Shear Stability Test CEC L-45-A-99
Test results

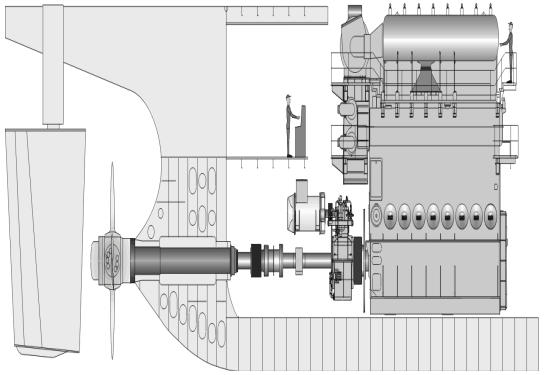
Product	Running time; [h]	V 40 [mm²/s]	Change [%]
Klüberbio EG 2-100	0	97.4	-
	20	97.2	-0.2
	100	96.7	-0.7
Klüberbio RM 2-100	0	99.9	-
	20	99.5	0.8
	100	96.7	0.3
Competitor A	0	99.8	-
	20	70.4	-29.4
	100	68.0	-31.9
Competitor B	0	106.1	-
	20	63.5	-40.1
	100	48.3	-54.5
Competitor C	0	105.0	-
	20	57.6	-45.1
	100	40.7	-61.2

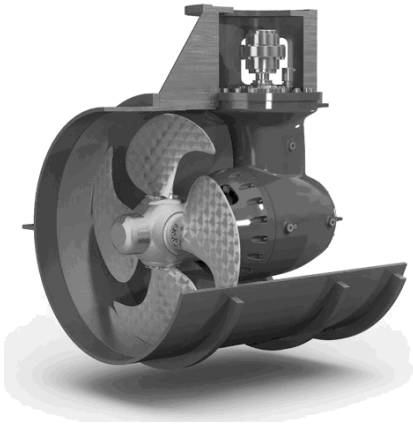
These values are results from one-time measurement and serve for information only. No assurance of values/properties of the series-produced product. They are not part of the specification and can not be used for.



EAL Results to Date

- The VGP went into effect 12/13
- Some exemptions available
- Vessels covered by the permit must submit an annual report to the EPA
- 41,980 reports submitted in 2015
- 9,313 reported oil to sea interfaces
  - 18,270 applications
  - 9,949 using EALs
- Global impact on vessels trading in US waters
- EALs are successfully protecting marine equipment





Ports – Should they require EALs?

- Oil and grease discharge limits are specified in NPDES permits and are generally included in SWPPP.
- Sources of oil and grease include wire rope, chains, wheel axles, engines (non-point pollution)
- Limits in storm water runoff 10 – 15 mg/l per day (not including accidental spills)
- 360 ocean and river ports in the US
- Green Port initiatives to date do not require EALs
- Many applications could be effectively changed over.

EALs – Protect marine equipment and the environment