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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Content

• Introduction
• Environmentally Acceptable Lubricants (EALs)
• Why should we use environmentally acceptable lubricants?
• 2013 Vessel General Permit (VGP) – Update
• How to select the right EAL?
• Ports – Should they require EALs?
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

<table>
<thead>
<tr>
<th>Lubricant base oil</th>
<th>Base oil source</th>
<th>Biodegradation</th>
<th>Potential for Bioaccumulation</th>
<th>Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral oil</td>
<td>Petroleum</td>
<td>Persistent / Inherently</td>
<td>Yes</td>
<td>High</td>
</tr>
<tr>
<td>Polyalkylene glycols (PAG)</td>
<td>Petroleum - synthesized hydrocarbon</td>
<td>Readily</td>
<td>No</td>
<td>Low&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Synthetic Ester</td>
<td>Synthesized from biological sources</td>
<td>Readily</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Vegetable Oils</td>
<td>Naturally occurring vegetable oils</td>
<td>Readily</td>
<td>No</td>
<td>Low</td>
</tr>
</tbody>
</table>

Source: Mudge, 2010

<sup>a</sup> Solubility may increase the toxicity of some PAGs
Differences between standard lubricants and EALs
Example – stern tube and thruster gear oil oils

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

++….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

http://www.towingline.com
How to select the right EAL?
Example – stern tube fluid

- 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

Lube chart from SKF Blohm + Voss for SIMPLEX stern tube seals
### Viscosity Shear Stability Test CEC L-45-A-99

#### Test results

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

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.

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**Decrease of kin. viscosity @ 40°C**

- **Klüberbio RM 2-100**
- **Competitor B**
- **Competitor A**
- **Competitor C**

0% to -61.2% over 100 hours (0-100 h)
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