

THRUSTERS

An Environmentally Preferable Lubricant for Tunnel and Azimuth Thrusters

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Kobelco Eagle Marine, Inc.

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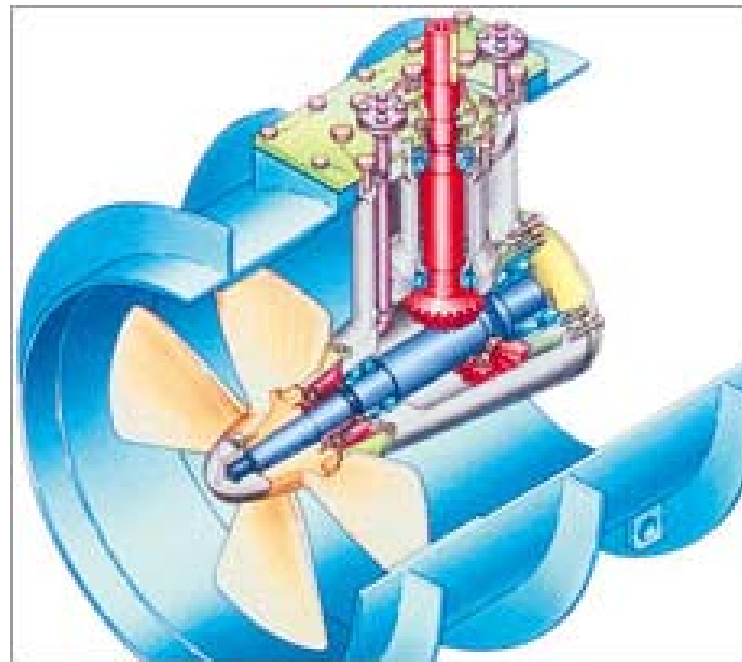
An Environmentally Preferable Lubricant for Tunnel and Azimuth Thrusters

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1. Introduction

- Ocean-going and offshore vessels use oil lubrication in the propulsors.
- Oil leakage from the propulsors is a serious environmental issue for these vessels.
- It is very difficult to seal thruster oil completely.



Typical Thruster

1. Introduction

- In December of 2008 the EPA changed the VGP to include any water to oil interface.
- Existing biodegradable oils do not satisfy all the properties required for propulsor lubricants under the VGP.



Vessel General Permit (VGP)

2.2.9 Controllable Pitch Propeller and Thruster Hydraulic Fluid and other Oil to Sea Interfaces including Lubrication discharges from Paddle Wheel Propulsion, Stern Tubes, Thruster Bearings, Stabilizers, Rudder Bearings, Azimuth Thrusters, Propulsion Pod Lubrication, and Wire Rope and Mechanical Equipment Subject to Immersion.

- **Owner/operators should use an environmentally preferable lubricant**, including vegetable oil, synthetic ester, or polyalkylene glycol as a base for these applications when feasible. Use of an environmentally preferable lubricant does not authorize the discharge of any lubricant in a quantity that may be harmful as defined in **40 CFR part 110**
- This became effective on December 19, 2008.

40 CFR Ch.1 Sec 110.3

- 110.3 Discharge of oil in such quantities as “may be harmful” pursuant to section 311 (b) (4) of the Act.
- (a) Violate applicable water quality standards or
- (b) Cause a film or sheen upon or discoloration of the surface of the water or adjoining shorelines or cause a sludge or emulsion to be deposited beneath the surface of the water or adjoining shorelines

Clean Water Act

- 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 waters and their adjoining shorelines should be reported to the federal government
- Because **the Oil Pollution Act of 1990**, which amended the Clean Water Act broadly defines the term “oil”, **the sheen rule applies to both petroleum and non-petroleum oils** (e.g., vegetable oil).

Other Biodegradable References

IMO Polar Guidelines

- 7.2.3 Stern tube bearings, seals and main propulsion components located outside the hull should not leak pollutants. **Non-toxic, biodegradable lubricants are not considered to be pollutants.**

DNV

- 304 **Non-toxic and biodegradable oil shall be used for stern tube and CP propeller systems.**

2. New Environmentally Compatible Thruster Lubricant

Properties Required for Propulsor Lubricants

- Biodegradability
- Low toxicity
- No sheen or sludge formation
- High viscosity
- Water tolerance
- Shaft seal compatibility

New Lubricant

Comparison of Potential Base Fluids

	No Sheen or Sludge Formation	Water Tolerance	Seal Compatibility
Triglyceride	Poor	Weak, hydrolysis can occur.	Fair
Synthetic Ester	Poor	Weak, hydrolysis can occur.	Fair
Polyalkylene Glycol	Good	Good	Poor, high swelling

- Polyalkylene Glycol is the most suitable base fluid.

1. Stern Tube Lubricant

- An environmentally compatible, water-soluble lubricant was developed for stern tubes.

Sterntube Lubricant **KEMEL ST-77**

- But the new stern tube lubricant did not provide the high lubricity required in thruster applications.

2. New Environmentally Compatible Thruster Lubricant

TH-100

- Based on polyethylene glycol, a type of polyalkylene glycol (similar to ST-77)
- Viscosity grade is the same as that of standard thruster oil.
- Lubrication performance is equivalent to that of standard thruster oil.

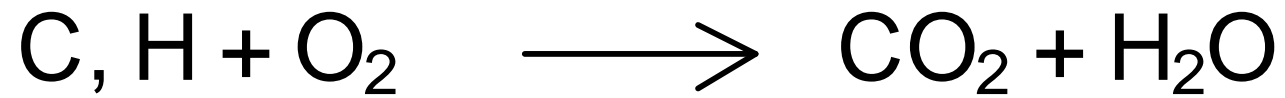
2. New Environmentally Compatible Thruster Lubricant

Tested Lubricants

	Type	Base Fluid	Viscosity @40°C mm ² /s	Specific Gravity @15°C
TH	Thruster Lubricant	Polyethylene Glycol	99	1.12
ST	Sterntube Lubricant	Polyethylene Glycol	76	1.12
MG	Gear Oil (AGMA 3EP)	Mineral Oil	99	0.89
MT	Turbine Oil	Mineral Oil	69	0.88

3. Environmental Compatibility

Biodegradation Process

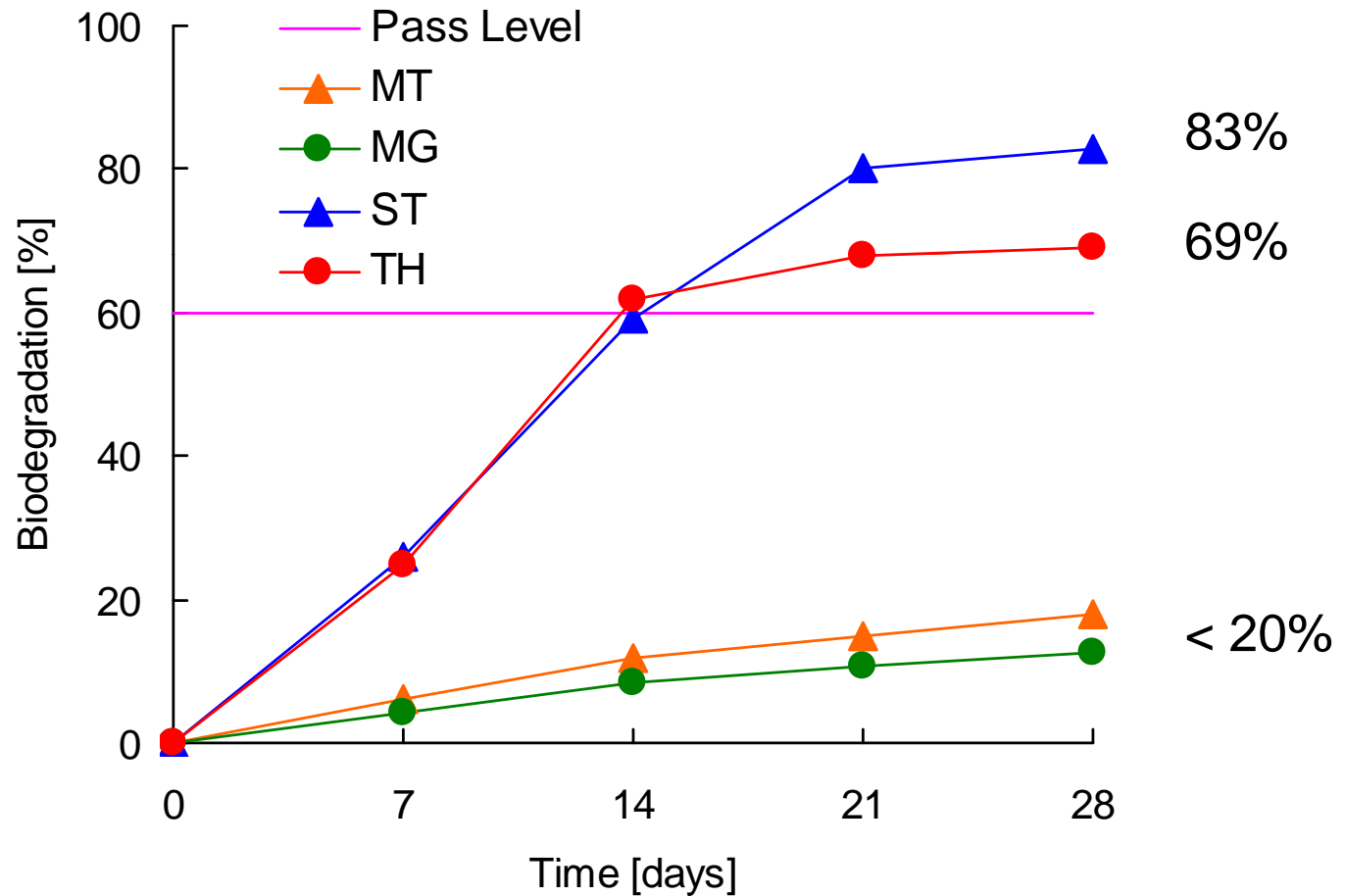


Bacteria

Water

3. Environmental Compatibility

Biodegradation vs. Time [OECD 301C]



3. Environmental Compatibility

Acute Toxicity to Fish [OECD 201]

	96h-LC50 ppm
TH	> 100
ST	> 100

3. Environmental Compatibility

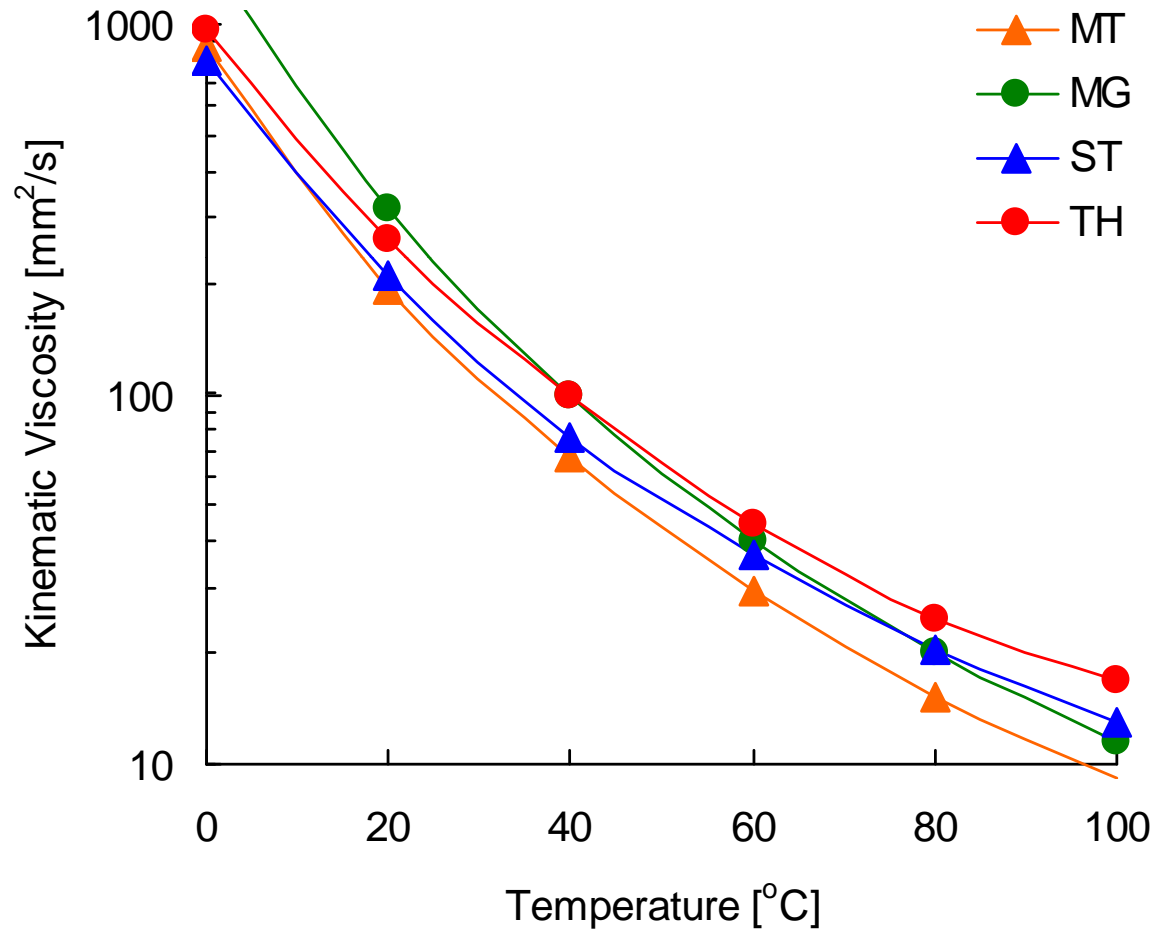
No Sheen or Sludge Formation

- TH and ST are completely water-soluble, since both base fluid and additives are water-soluble.
- TH and ST form no sheen on seawater surface or sludge under seawater surface.



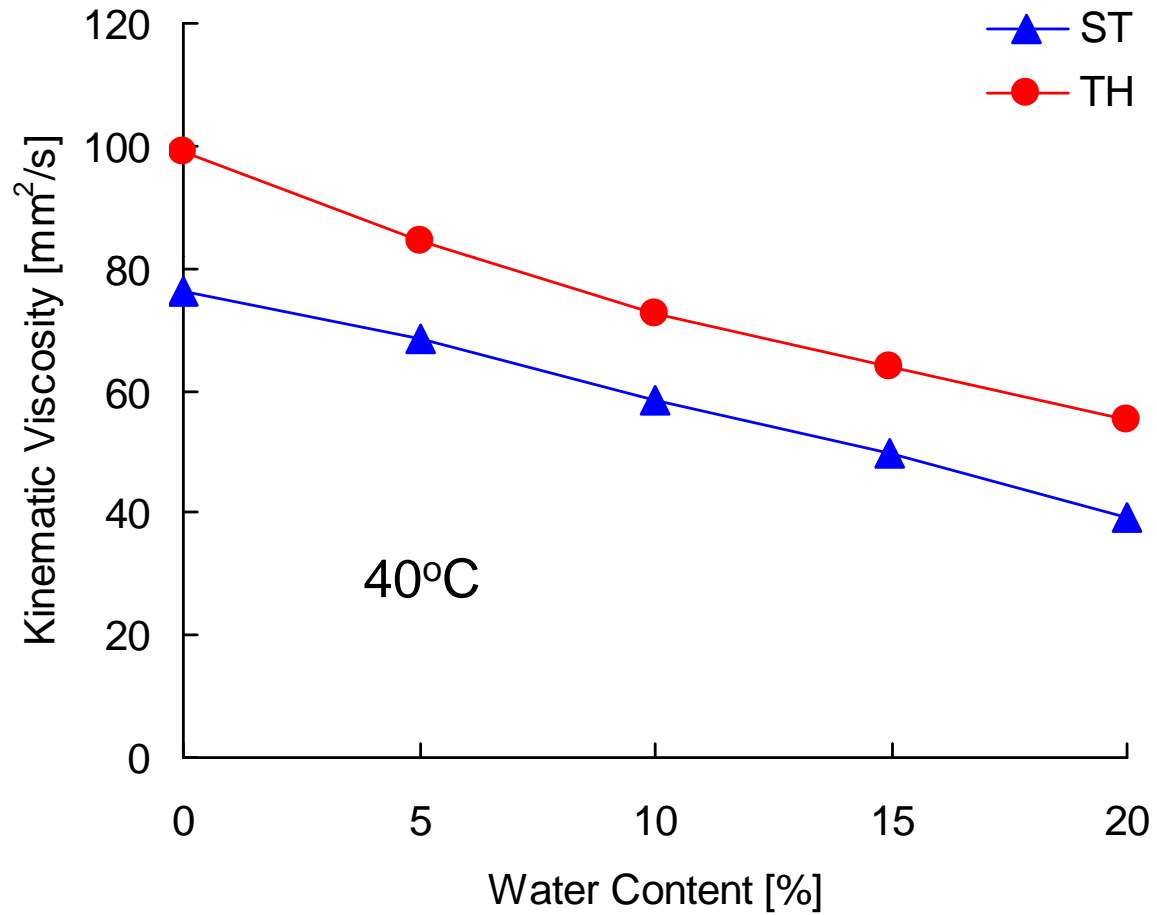
4. Viscosity

Viscosity vs. Temperature



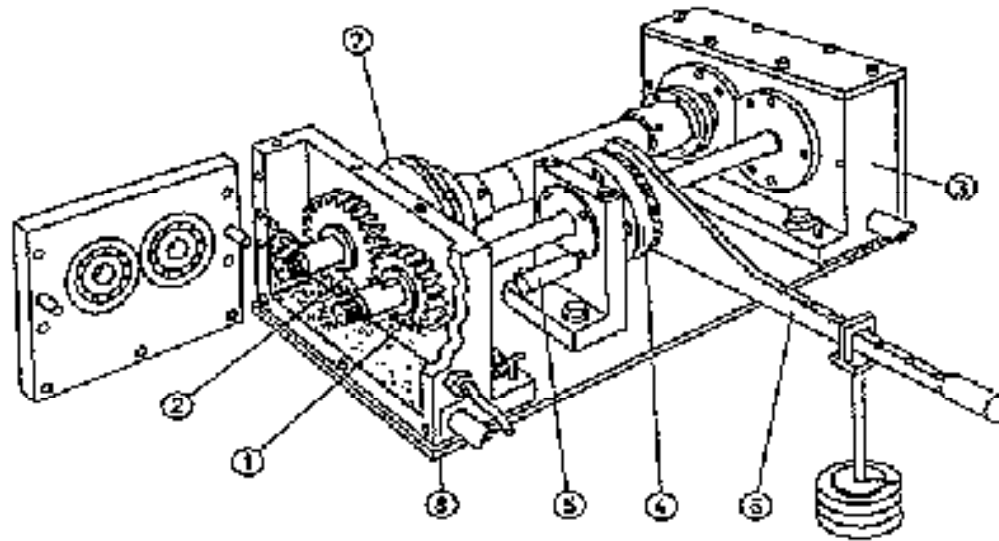
4. Viscosity

Viscosity vs. Water Content



5. Lubricity

FZG Gear Test [DIN 51354]



Gear type: A

Pitch line velocity: 8.3 m/s

Temperature: 90°C

Test period: 15 min

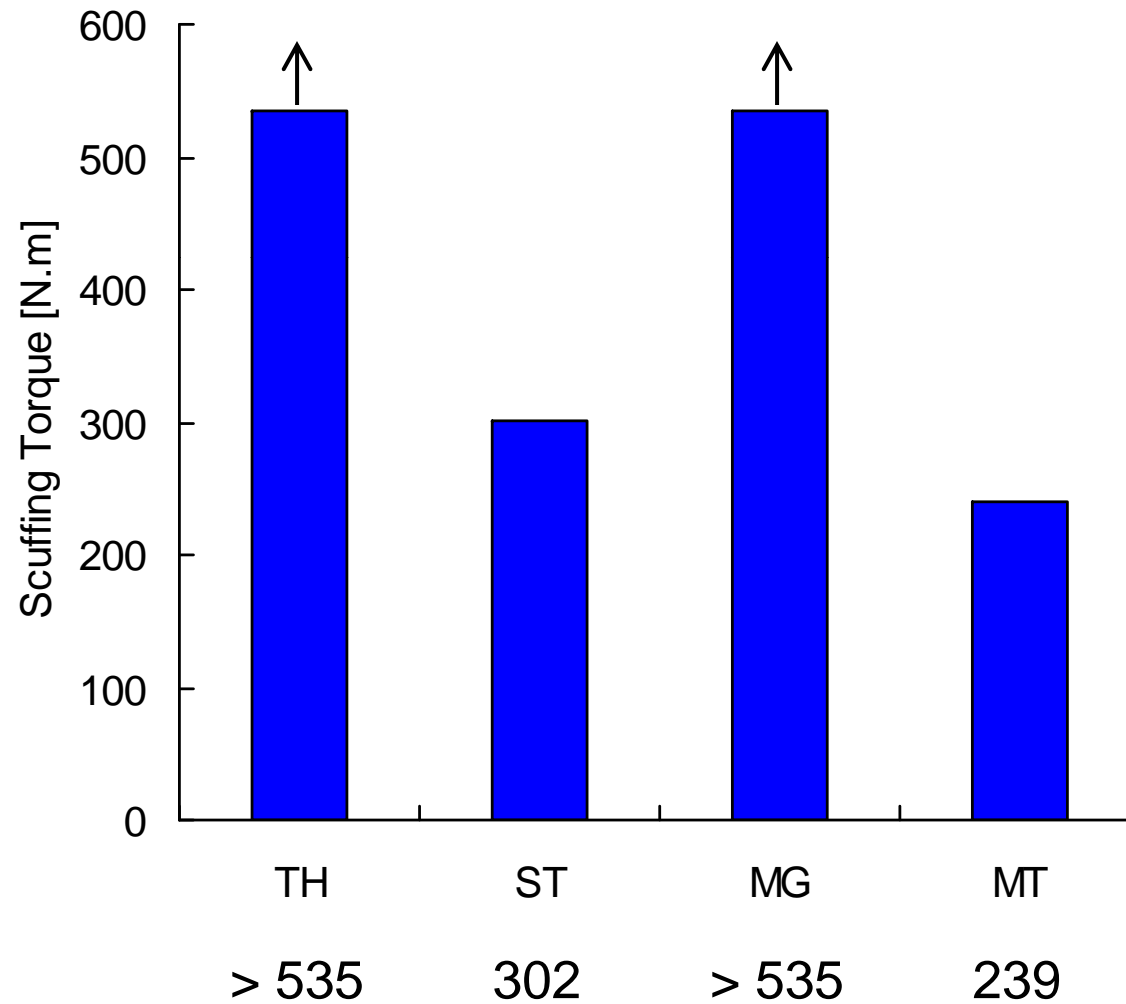
5. Lubricity

Scuffing Load Capacity

	TH	ST	MG	MT
Scuffing Load Stage (A/8.3/90)	12+	9	12+	8

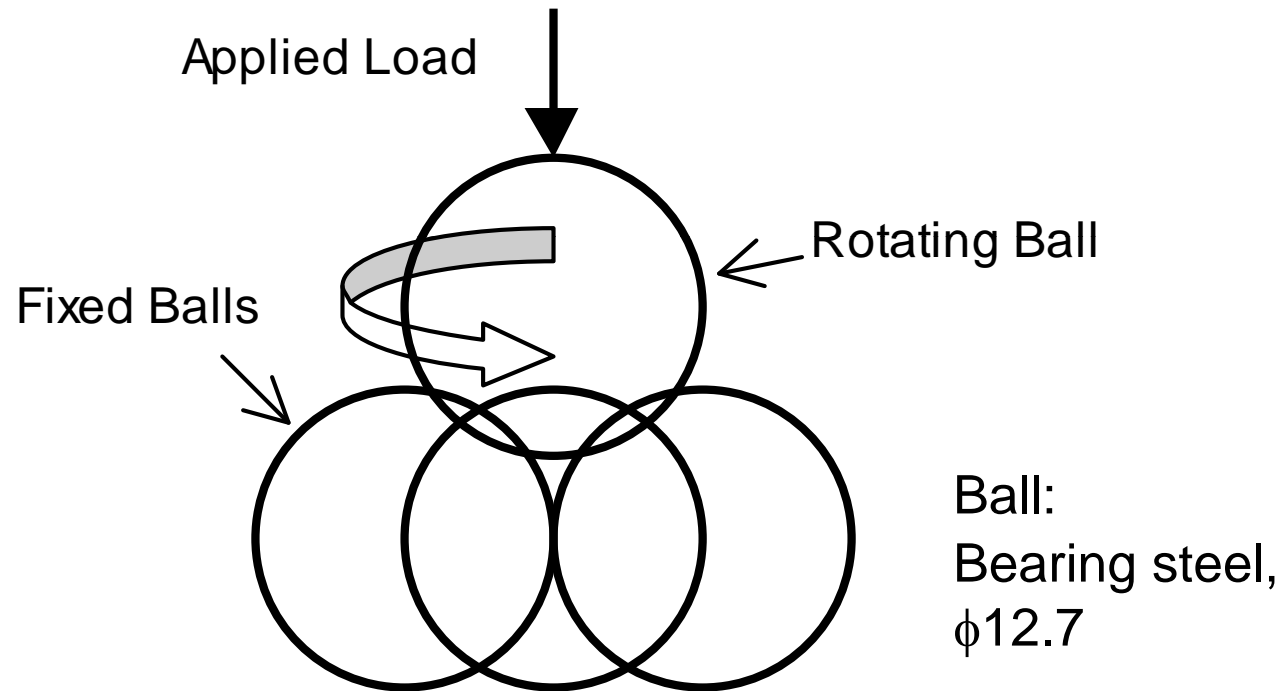
5. Lubricity

Scuffing Torque



5. Lubricity

Four-Ball EP Test [ASTM D2783]



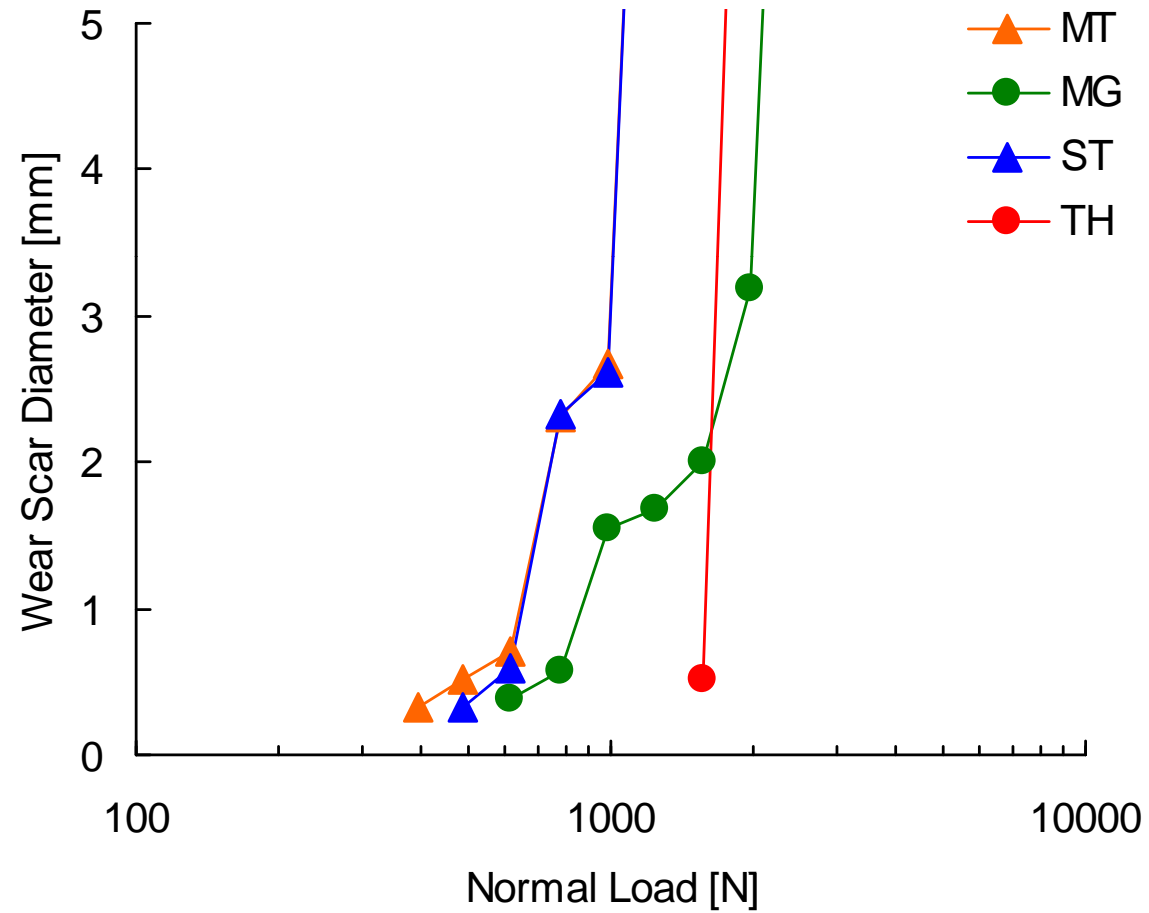
Rotation speed: 1760 rpm

Temperature: 25°C

Test period: 10 s

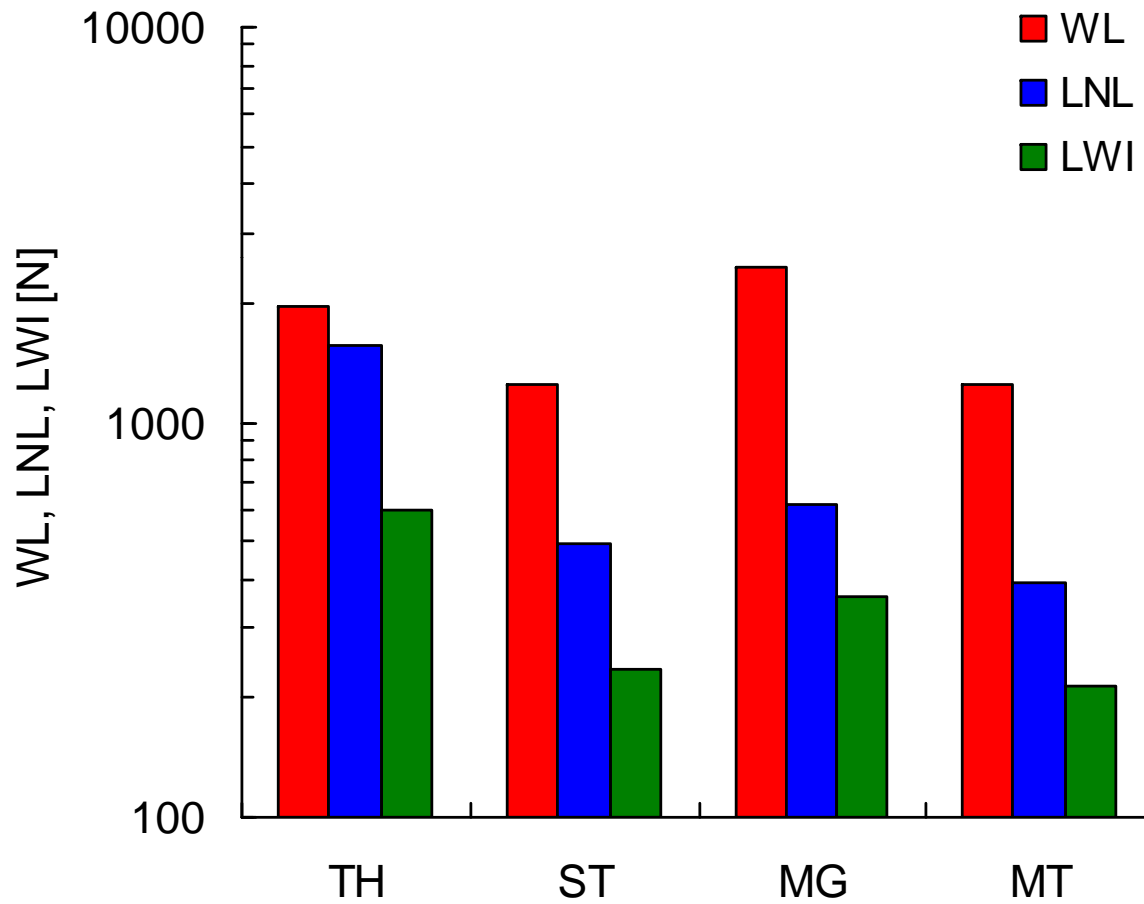
5. Lubricity

Wear Scar Diameter vs. Normal Load



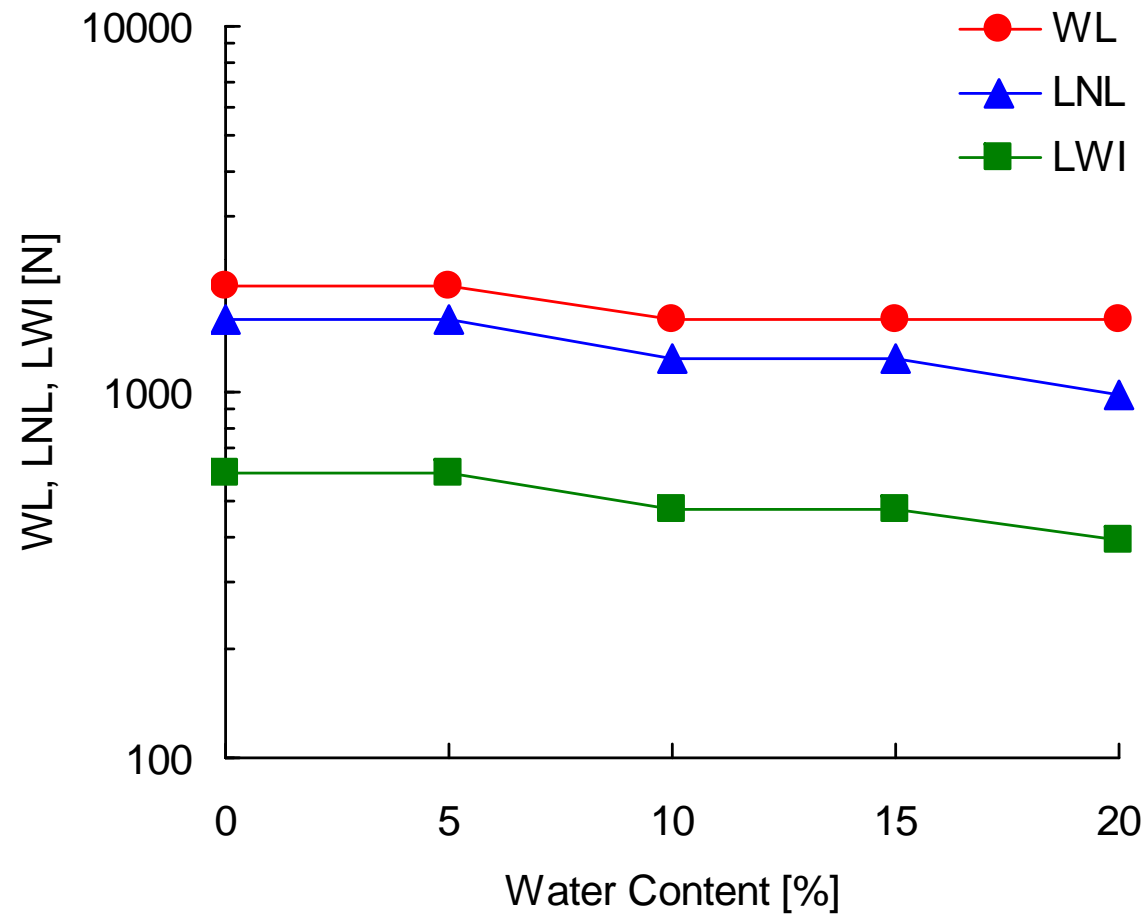
5. Lubricity

EP Performance



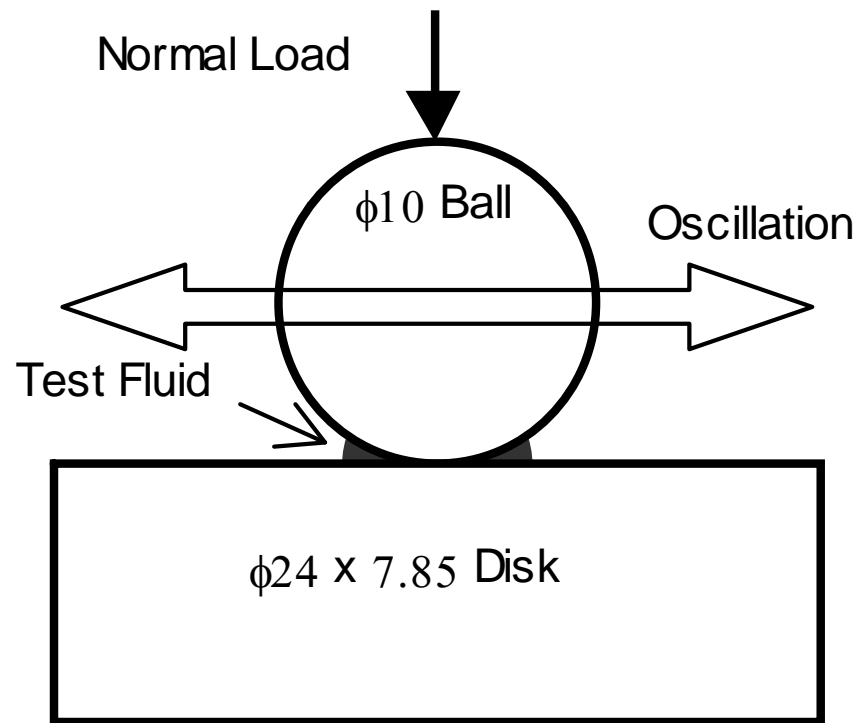
5. Lubricity

EP Parameters vs. Water Content



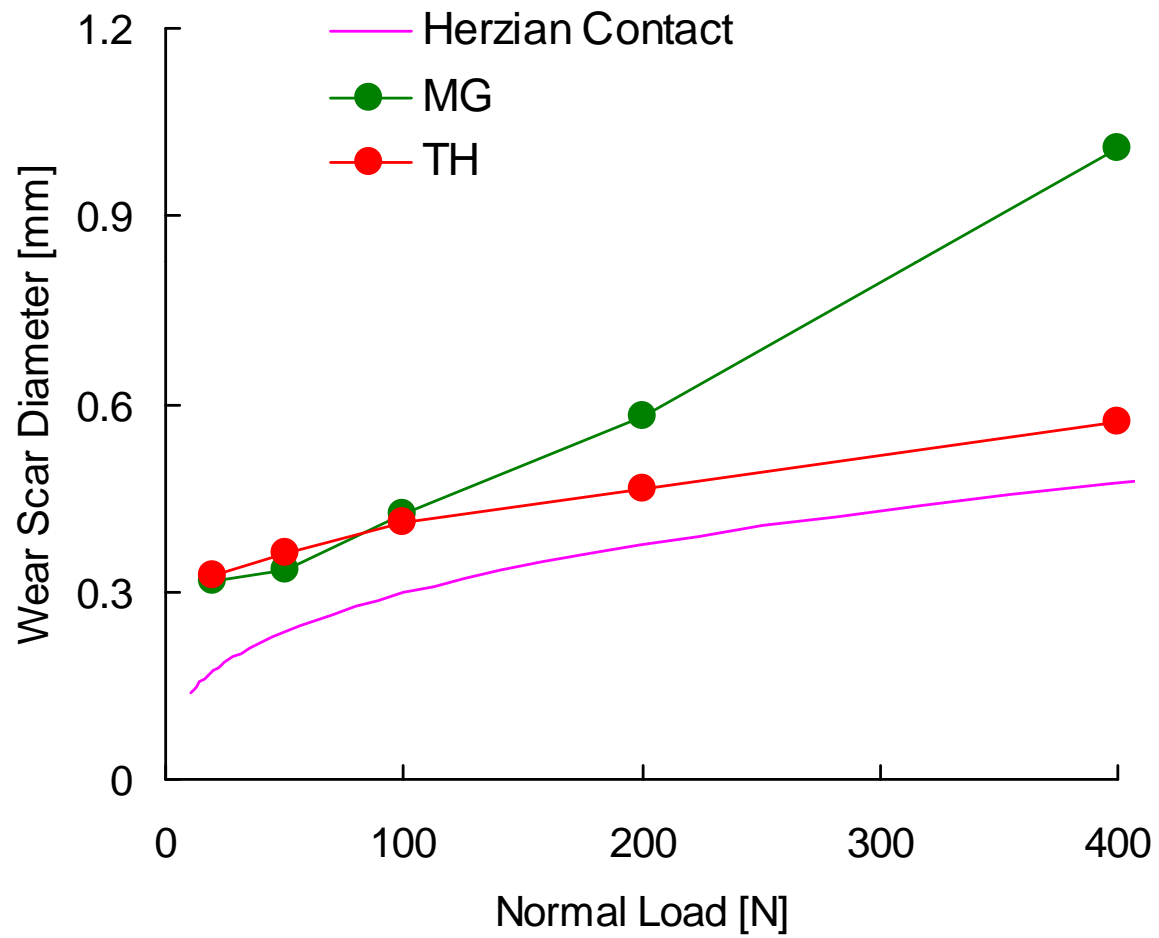
5. Lubricity

Translatory Oscillation Wear Test [DIN 51834]



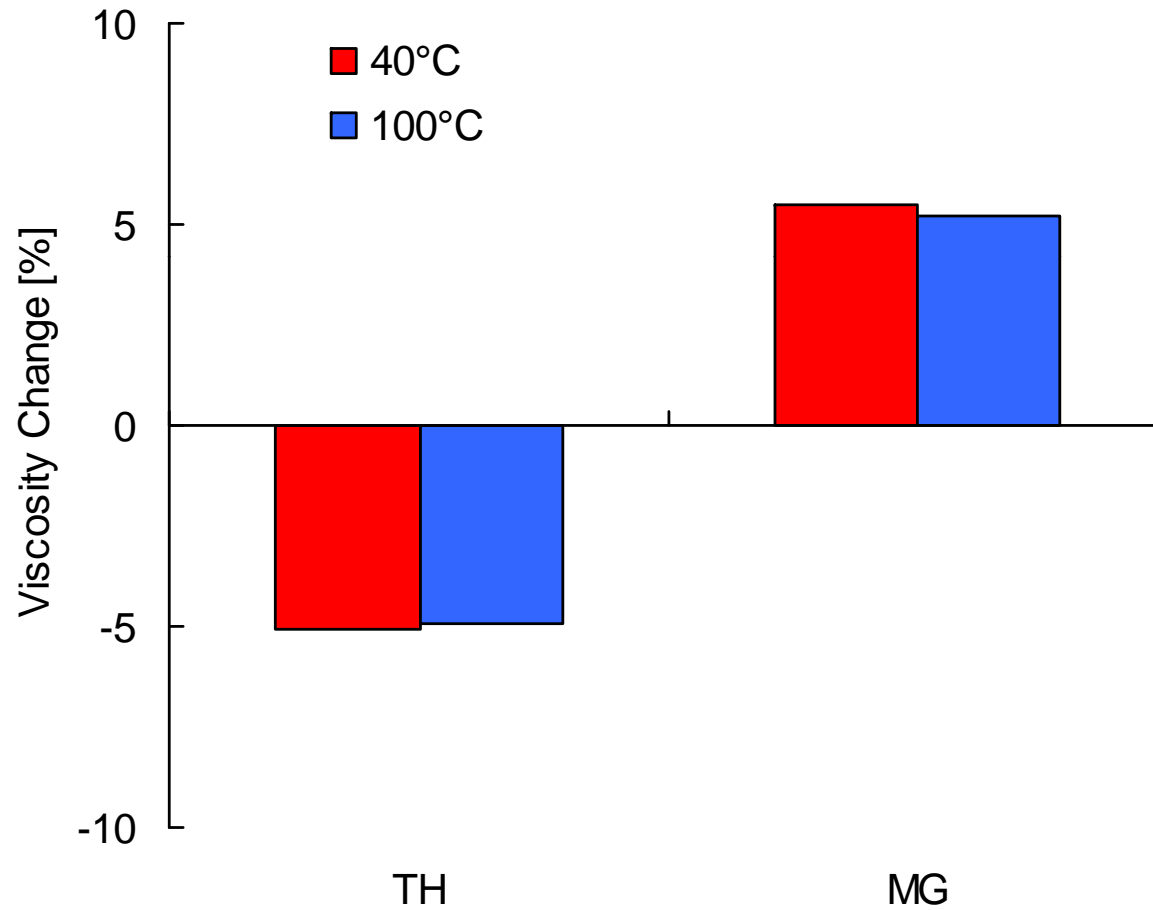
5. Lubricity

Anti-Wear Performance



6. Oxidation Stability

Anti-Oxidation Performance [ASTM D2893]



7. Rust Prevention

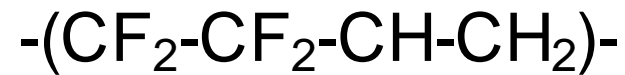
Anti-Rust Performance [JIS K2510]

Seawater %	TH	ST	MG	MT
5	rust-free	rust-free	rust-free	rust-free
10	rust-free	rust-free	rust-free	ru st ed
15	rust-free	rust-free	rust-free	ru st ed
20	rust-free	ru st ed	ru st ed	ru st ed

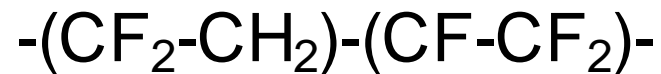
8. Shaft Seal Compatibility

Fluoro-Elastomers

FEPM

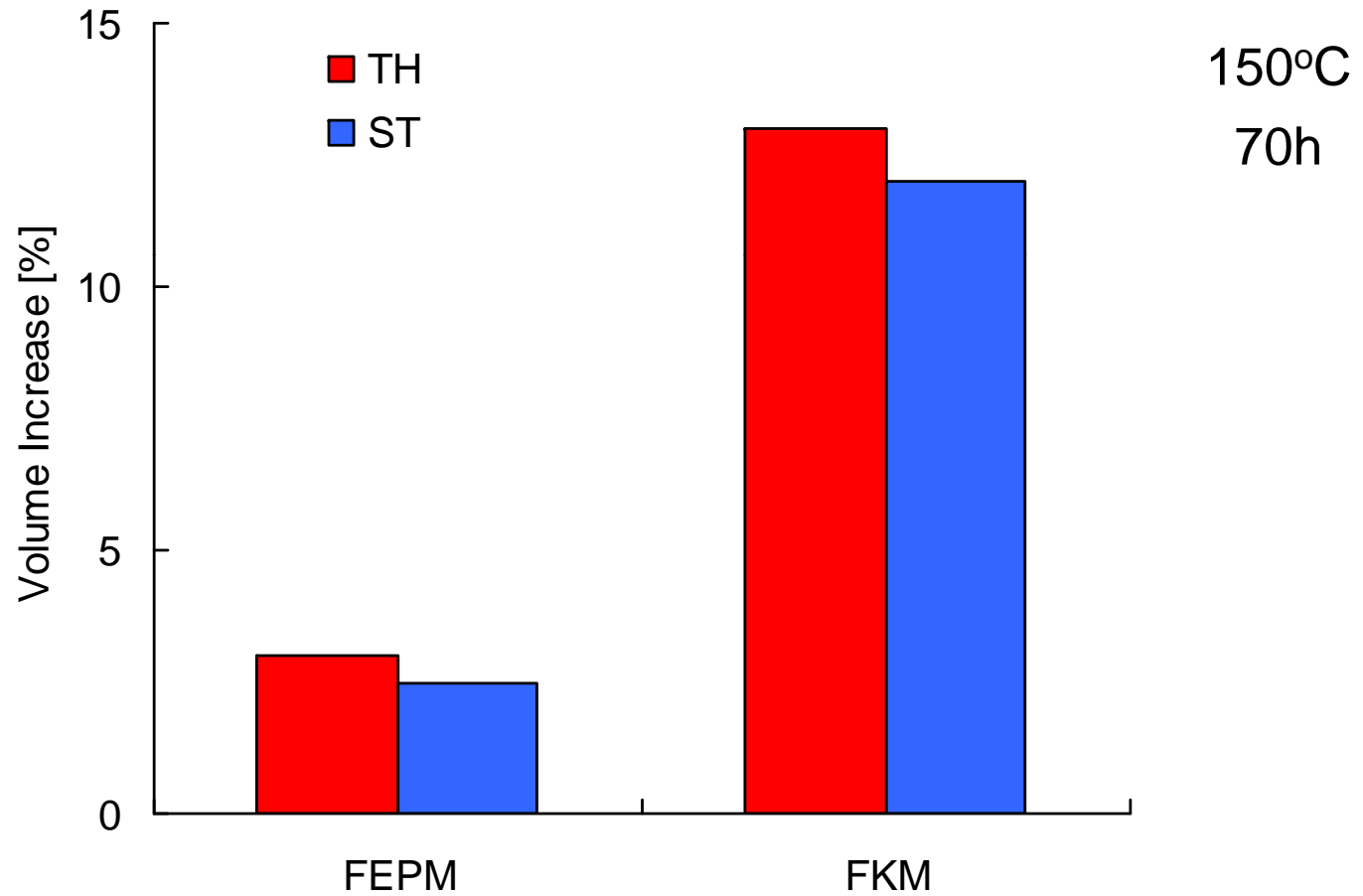


FKM



8. Shaft Seal Compatibility

Swelling of Fluoro-Elastomers



9. Field Experience

New Stern tube Lubricant **ST-77**

- The first trial in stern tube application began in November 2005.
- Totally the lubricant has been applied to 47 vessels end of August 2009.
- This has included 21 large container carriers.

9. Field Experience

New Stern tube Lubricant **ST-77**

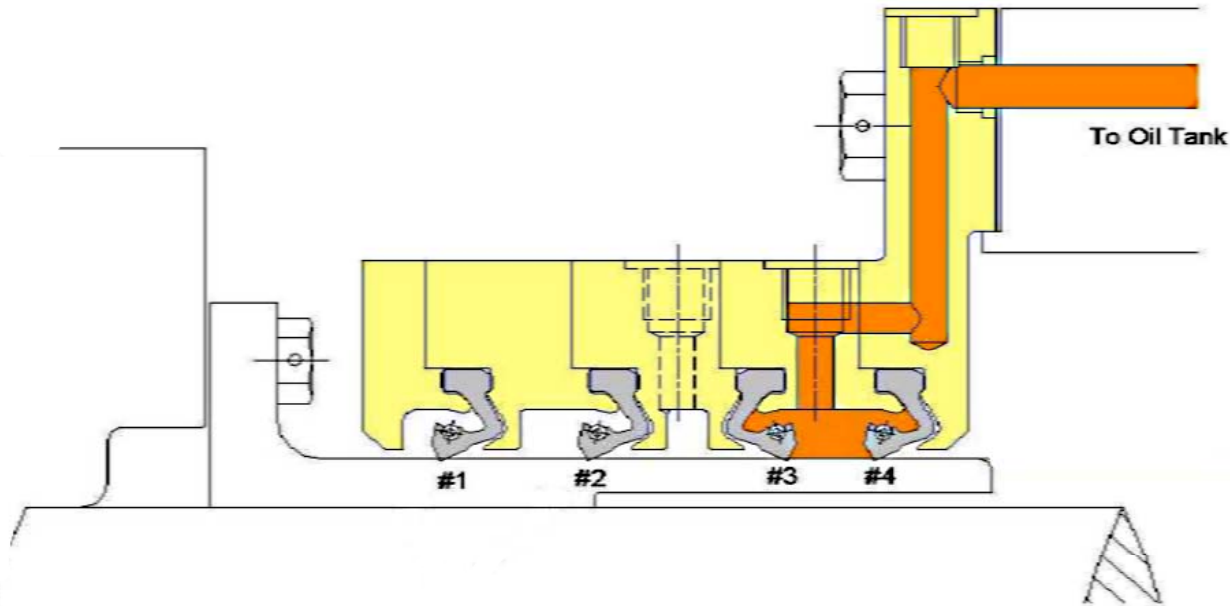
- The lubricant has also been applied to CPP system of three vessels.
- Application in marine hydraulic systems is another promising area for the lubricant.



9. Field Experience

New Thruster Lubricant TH-100

- Firstly the lubricant had been applied to propeller shaft seals of azimuth thrusters of a tugboat in October 2008.



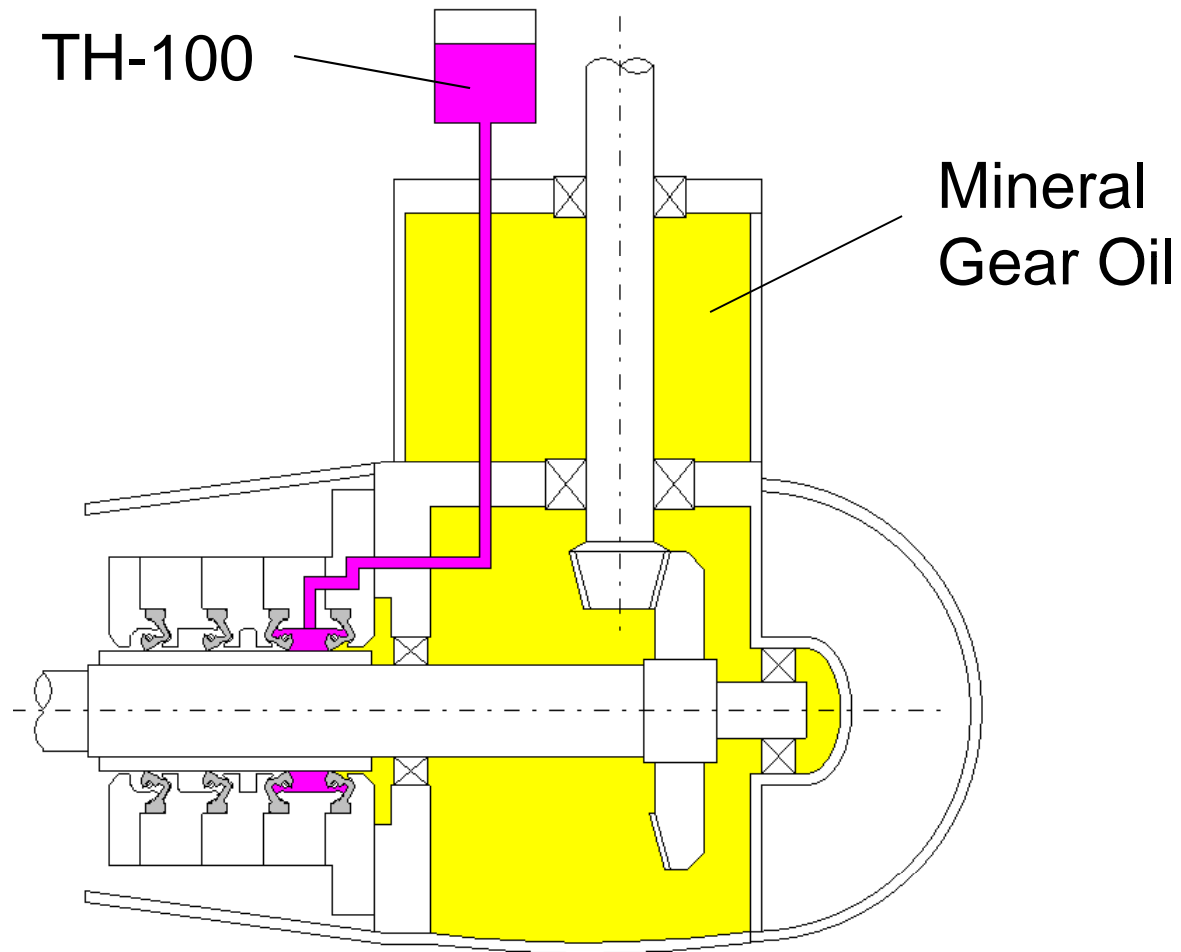
9. Field Experience

New Thruster Lubricant TH-100



9. Field Experience

Barrier Thruster Seal



10. Conclusions

- A water-soluble, environmentally preferable lubricant for tunnel and azimuth thrusters was developed.
- The lubricant has excellent environmental compatibility and high lubricity equivalent to industrial gear oil.
- The lubricant provides good water contamination lubrication.
- The lubricant conforms to the new NPDES in the VGP as updated by the EPA.

Q&A

Typical Characteristics TH-100

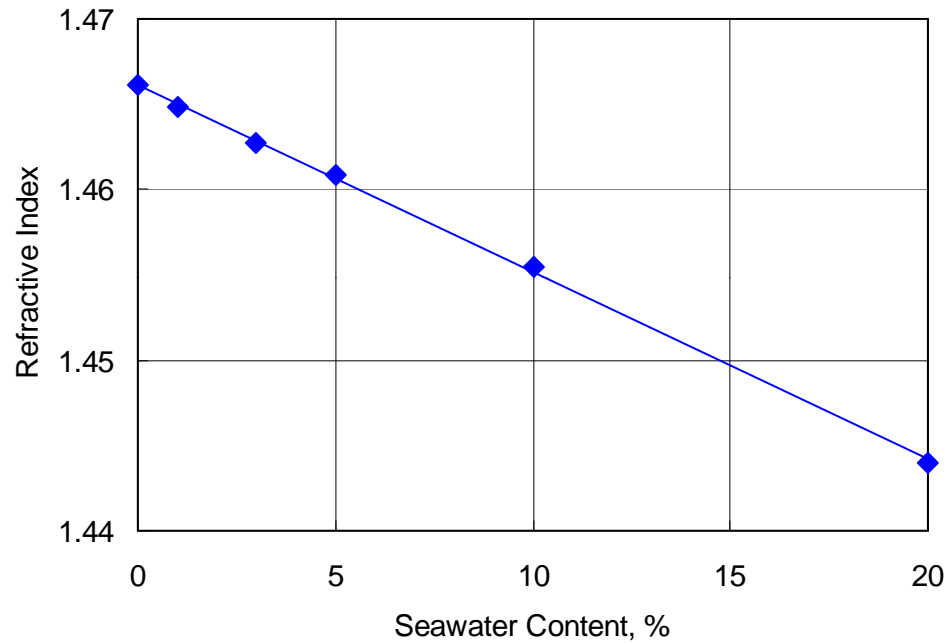
Appearance	Pale yellow liquid
Viscosity at 40 °C	100 mm ² /s
Viscosity at 100 °C	17 mm ² /s
Density at 15 °C	1.12 g/cm ³
Pour Point	-5 °C
Flash Point	225 °C
pH	9

9. Field Experience

Anti-Scuffing Performance [DIN 51354]

	Scuffing Load Stage (A/8.3/90)
Neat MG	12+
MG + 10% TH	12+

Onboard Check for Seawater Content



Refractive Index vs. Seawater Content



Portable Refractometer

Rubber Compatibility

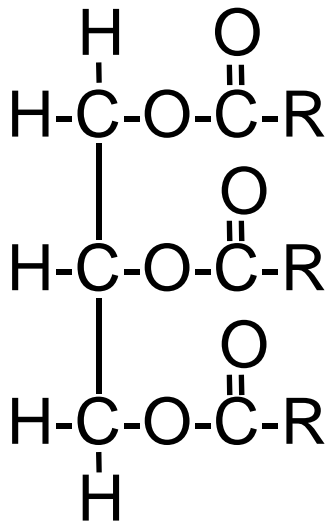
Material	Compatibility
NBR	OK
HNBR	OK
ACM	Poor

NBR: Nitrile Rubber

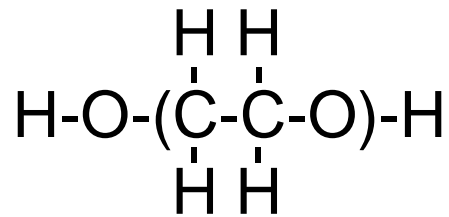
HNBR: Hydrogenated Nitrile Rubber

ACM: Acrylic Rubber

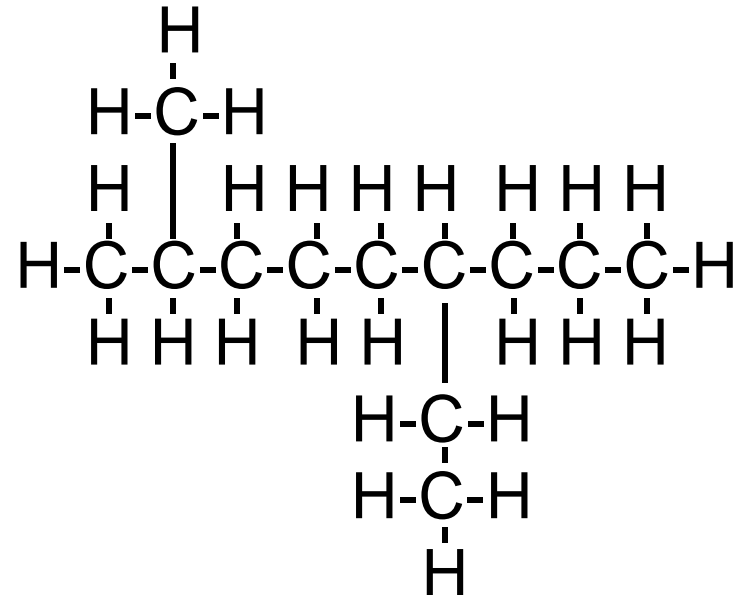
Base Fluids



Vegetable Oil



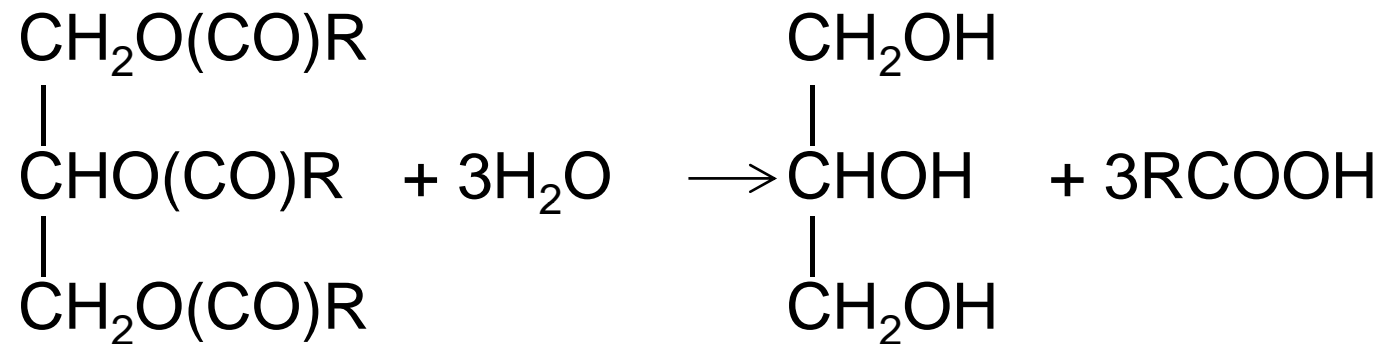
Polyethylene Glycol (PEG)



Mineral Oil

Ester

Hydrolysis



High emulsibility is needed for propulsor lubricants.

➡ Water contained cannot be separated.