Challenges and Trends in Power-Take-Off System Technologies :

Sustainable Lubrication in Offshore Renewables

Lubricant EXPO Europe and The Bearing SHOW Europe – Sept 2024

Juan Guillermo Zapata Tamayo

Reliability and Lubrication in Wind Turbine Applications, 17-19 September 2024
Hall 9, Messe Düsseldorf, Germany

LUBRICANT EXPO EUROPE

THE BEARING SHOW EUROPE

Sustainable Lubrication in Offshore Renewables

Ocean Tribology
Research, discover, and innovate

NoviOcean
Saving the climate with profitable ocean energy

KTH VETENSKAP OCH KONST

In the early years of the development phase of wind turbines, tribology was paid very limited attention. As a result, the failure of components such as bearings and gears in wind turbine nacelles remains one of the top causes of failures even today.

AXEL
AXEL CHRISTIERNSSON

CorPower Ocean™

We aim to prevent this strategic error from being repeated for emerging offshore energy generation technologies.

Swedish Energy Agency

This work has been funded by the Swedish Energy Agency - Energimyndigheten

NEW TECHNOLOGIES IN WAVE ENERGY AND TIDAL POWER GENERATION DEVICES

7th century A.D – Babylonia – Earliest Windmills for grinding corn.

1100 – 1200s

Spread of Horizontal axis windmills in Europe.

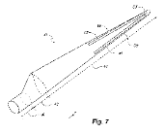
1452 – 1519s

Windmill with six sails **Leonardo DaVinci**

1700 – 1800s

Development of self controlling system, fantail use

1857s



Paddle Shaped Blades **Daniel Holladey**

1980 - 2020s

Wind rotor size development

1973 - 1980s

Connection of Wind turbines to the electric grind, industrialization

1930s

Wind generator for charging galvanic cells - **Jacobs Wind Electric**

1908s

Developed of wind wheels with speed control - **Poul La Cour**

1870s

Steel blades development

1991s

Horns Rev 3
First Offshore wind farm

2008s

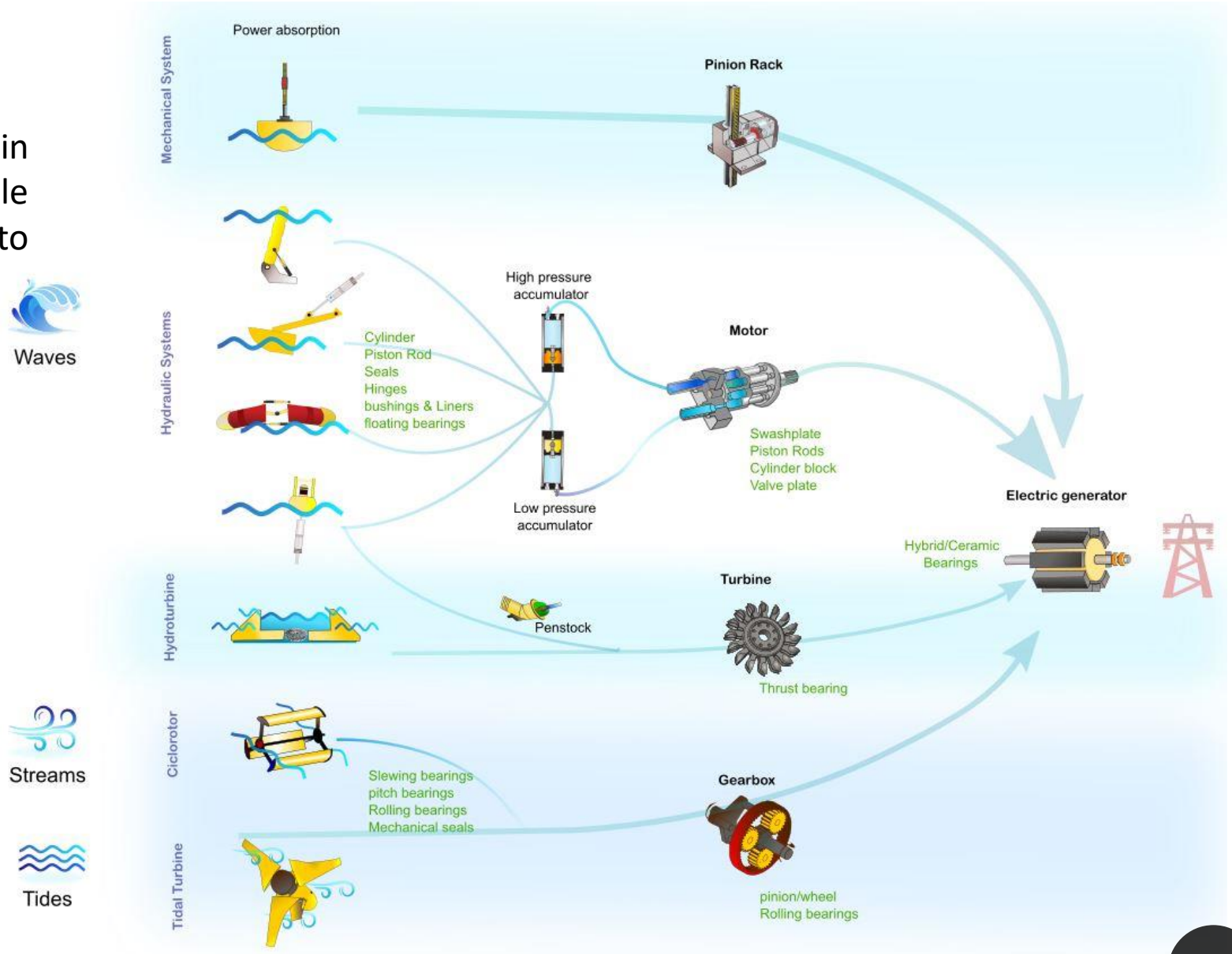
Aguçadoura Wave Farm
Pelamis wave energy converter

Just as wind turbines harness energy from the wind, wave energy converters capture the power of ocean waves, both ultimately driven by the same force of the sun.

NEW TECHNOLOGIES IN WAVE ENERGY AND TIDAL POWER GENERATION DEVICES

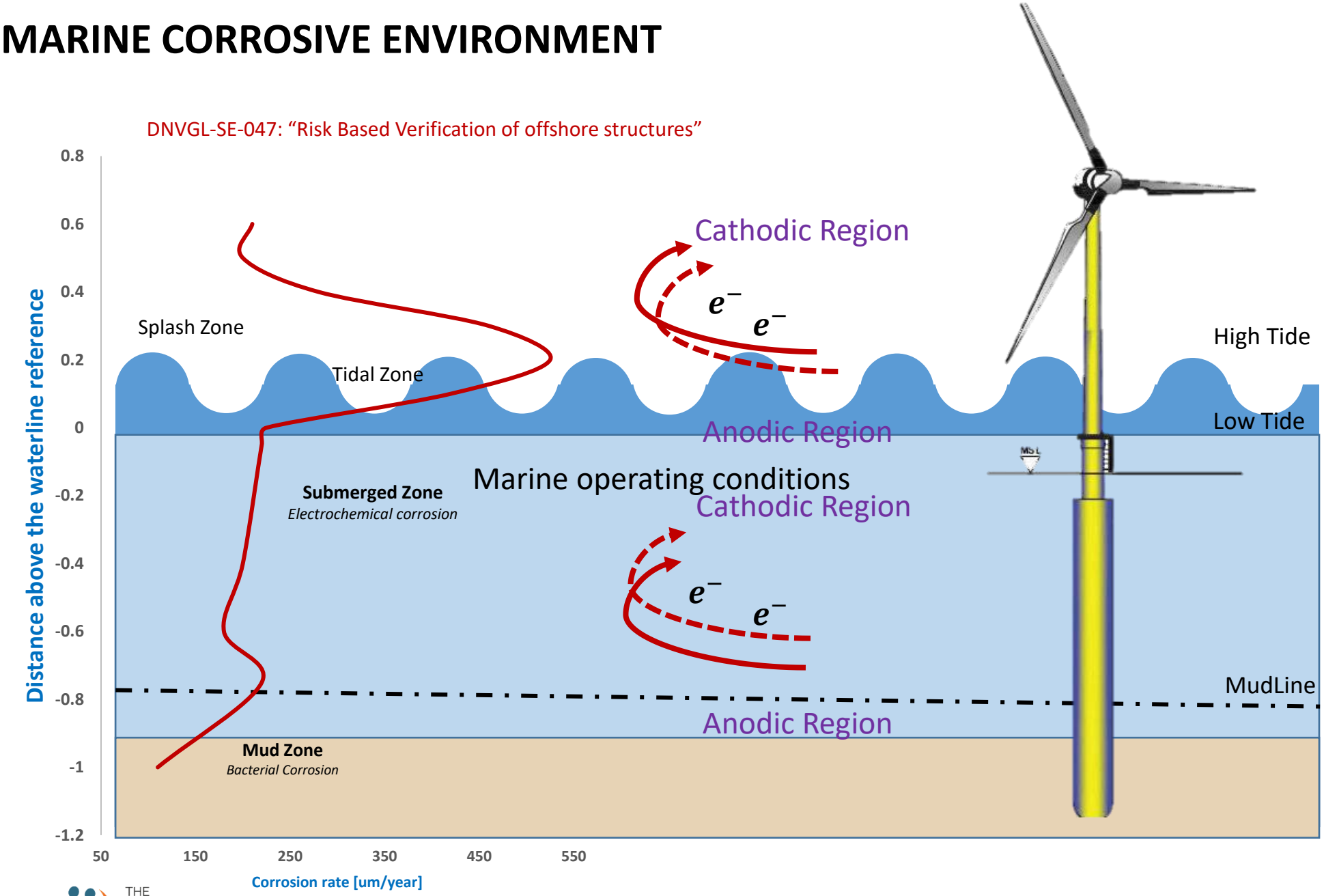
Offshore power-take-off (PTO) systems in ocean power generation devices face multiple environmental challenges that can lead to premature failure:

- **Design against hit by floating bodies**
- **Ice and storm survivability**
- **Control of excessive fouling**
- **Corrosion of the joints and weldings**
- **Lightning strike protection**
- **Fatigue resistance**
- **Enviromental impact and ease of maintenance**



MARINE CORROSIVE ENVIRONMENT

DNVGL-SE-047: “Risk Based Verification of offshore structures”



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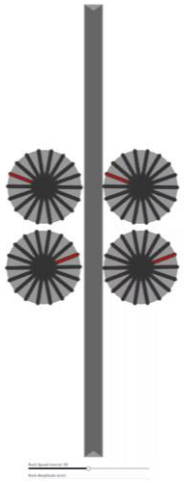
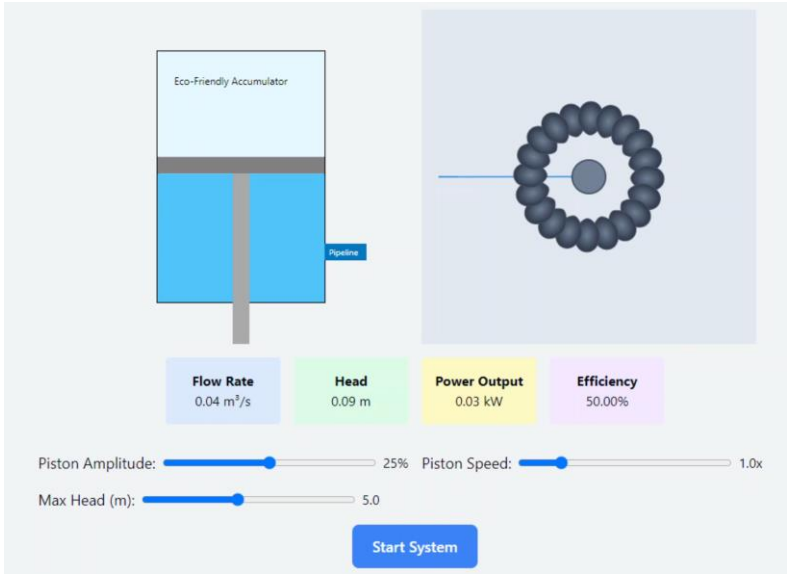
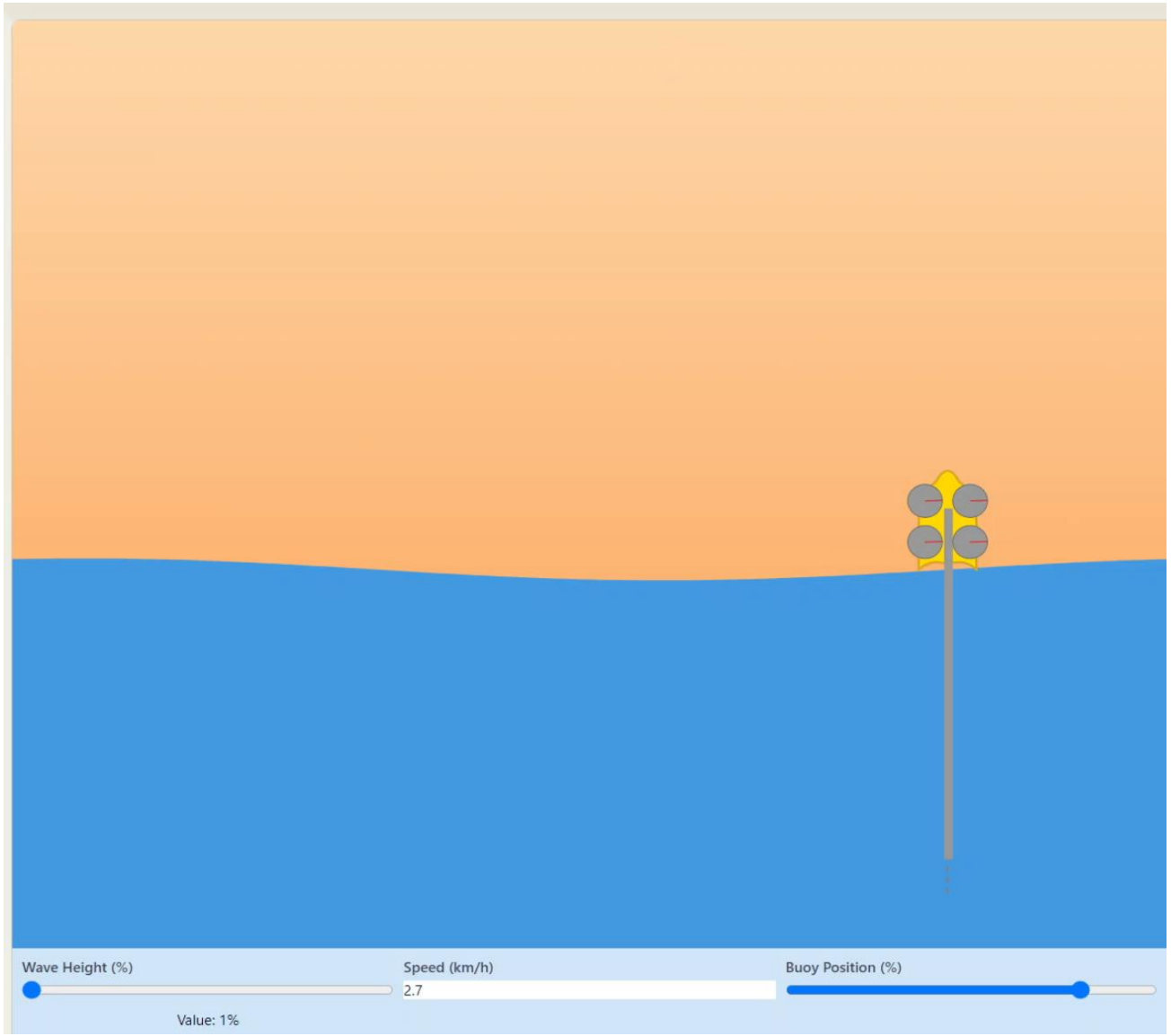
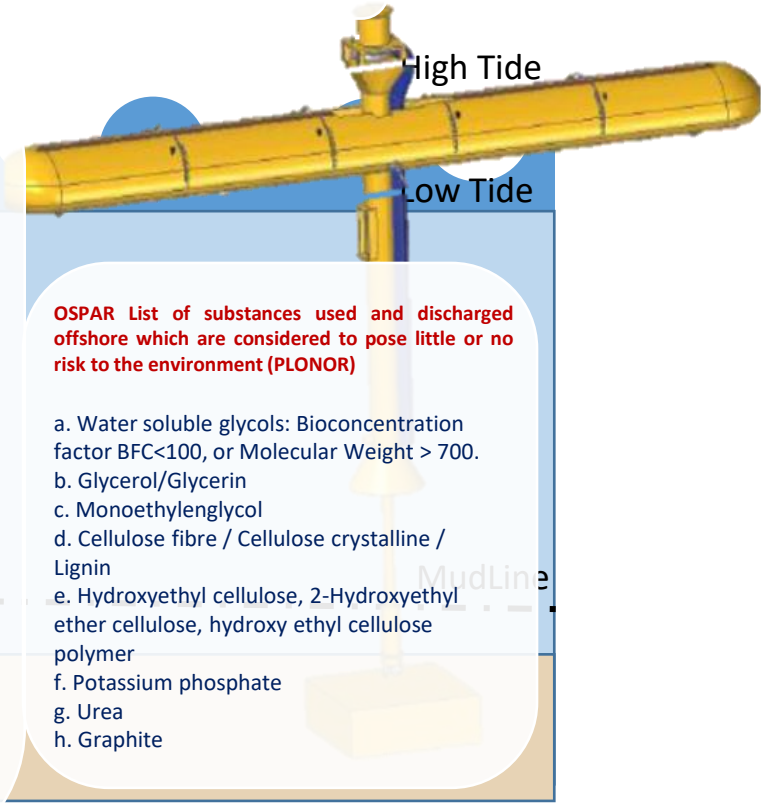






Lubrication solutions tailored to the unique demands of Power Take-Off systems

- OSPAR Guidance on the use of lubricants in offshore Oil and Gas operations
- International convention for the prevention of pollution from ships (MARPOL).
- Baltic Sea and North Sea Action Plan
- Swedish Standard **SS 15 54 34** Category V, includes environmental requirements for hydraulic fluids and among other things stipulates the need for high biodegradability low acute and chronic toxicity of the additives toward water organisms.



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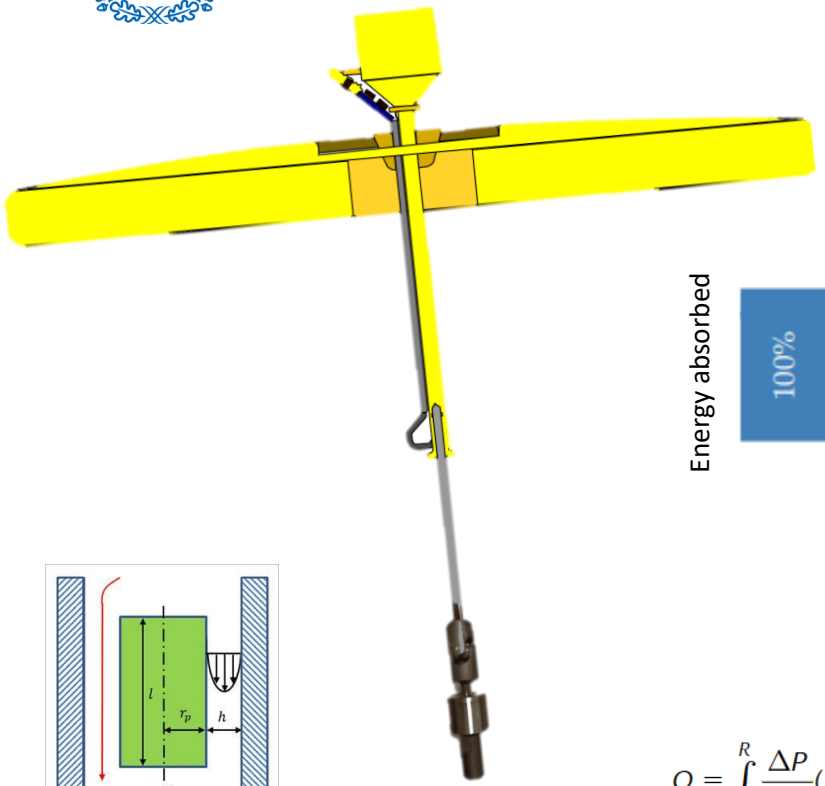


$$\frac{\Delta p}{L} = \frac{8\lambda\rho Q^2}{D^5\pi^2} \qquad Re = \frac{\rho VD}{\mu} \qquad \lambda = \frac{64}{Re}$$

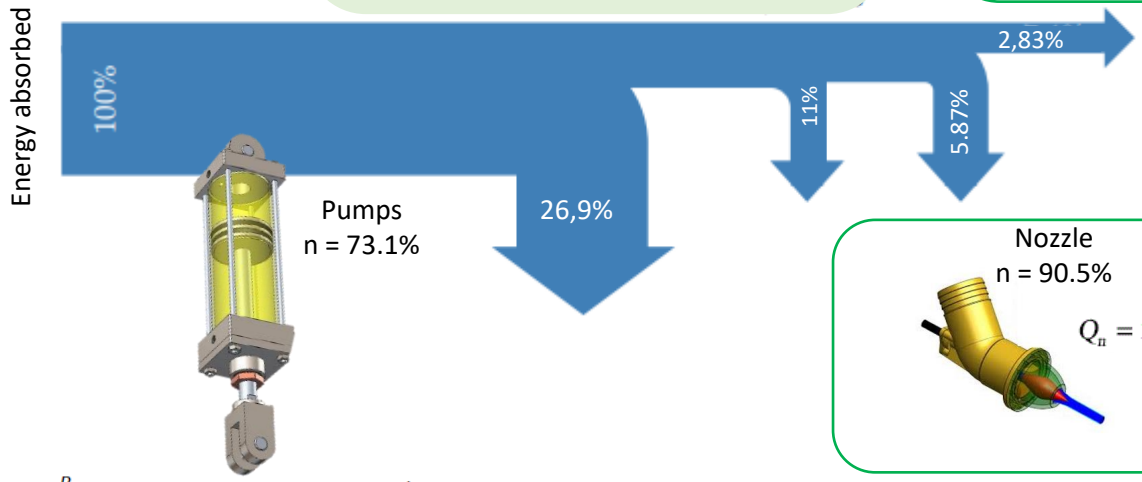
Penstock
n = 85%

Pelton
n = 95%

$$P_{loss} = P_{input} \cdot (1 - \eta_{total})$$

$$P = 0.00981 q_m (H - h) e$$

$$Work/second = \rho gQH$$

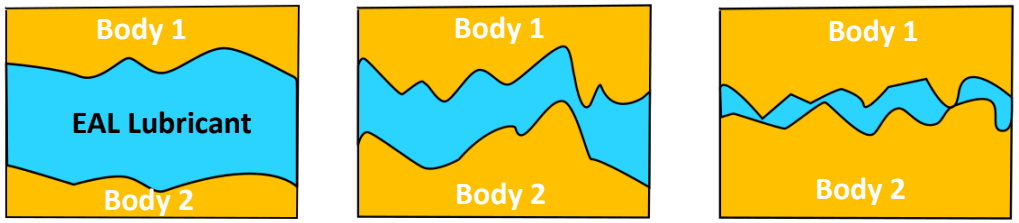


Nozzle
n = 90.5%

$$Q_n = 28.9 \times D^2 \times \sqrt{P}$$

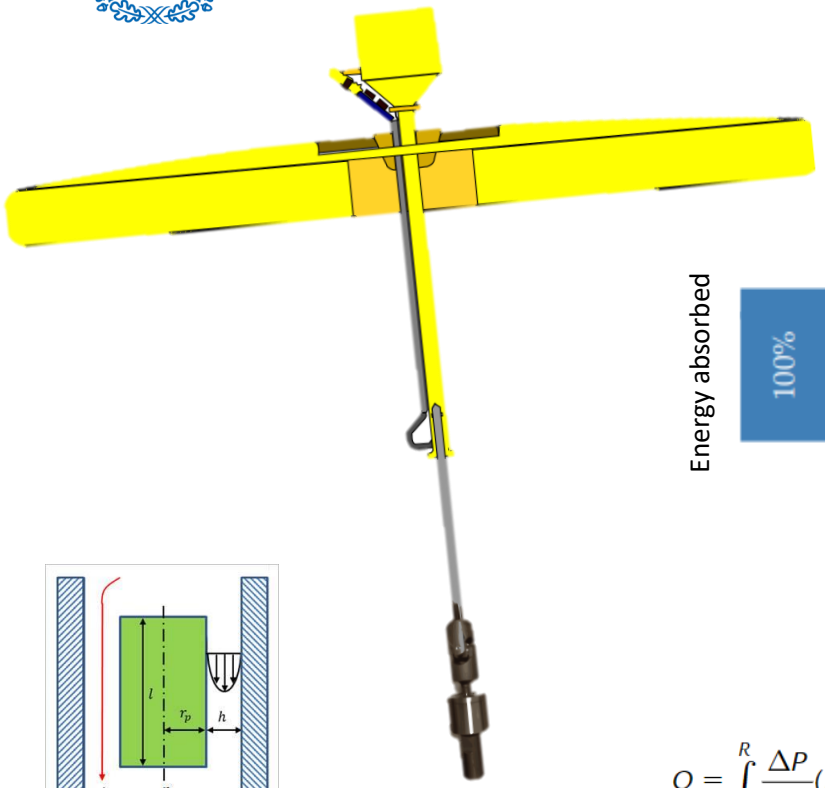
$$Q = \int_0^R \frac{\Delta P}{4L\mu}(R^2 - r^2)2\pi r\, dr = \frac{\pi R^4 \Delta P}{8L\mu}$$

PTO efficiency = $\eta_{cylinder} * \eta_{penstock} * \eta_{nozzle} * \eta_{pelton}$



$$h_{min} = 3.63 R_x \left(\frac{u_e n_0}{E' R_x}\right)^{0.68} (\alpha E')^{0.49} W_2^{-0.072} \left(1 - e^{-0.68k}\right)$$

Lubrication solutions tailored to the unique demands of Power Take-Off systems



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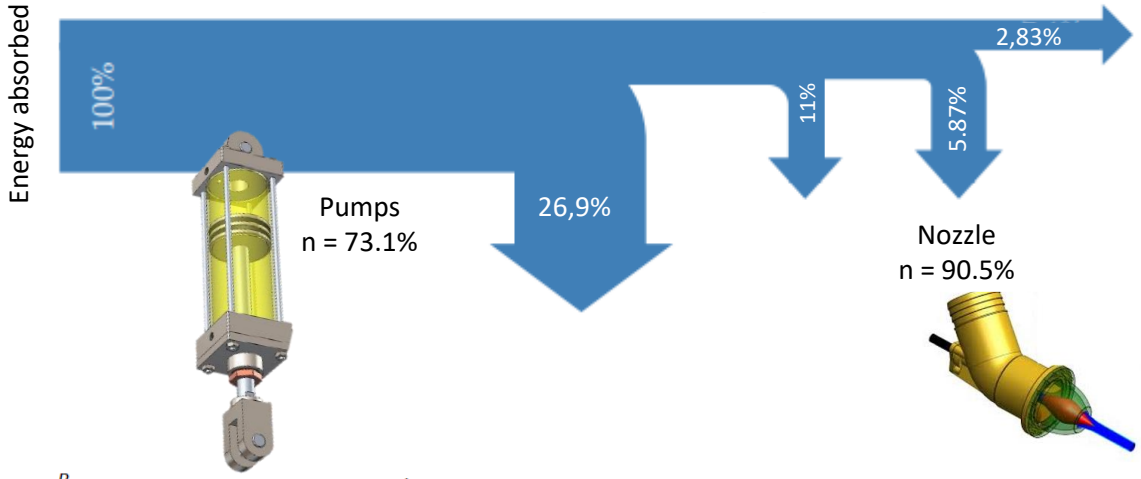

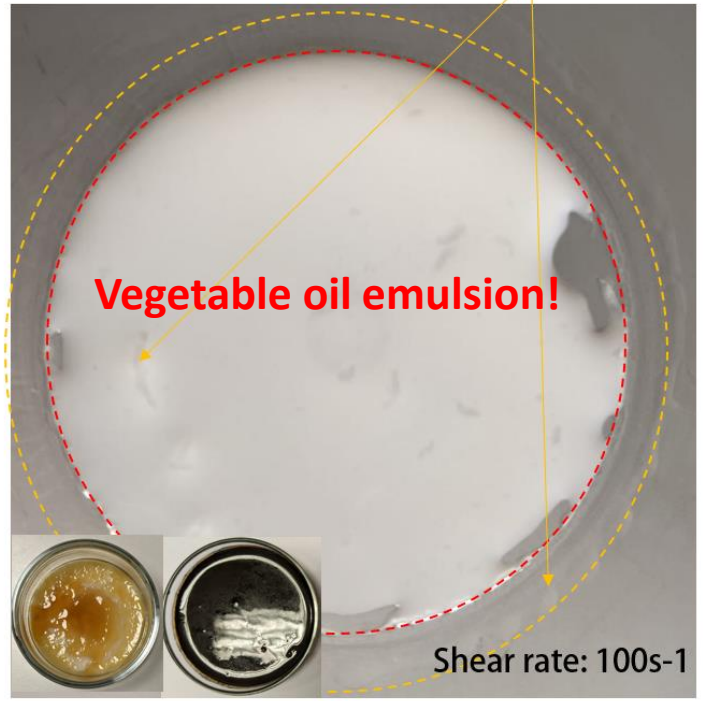

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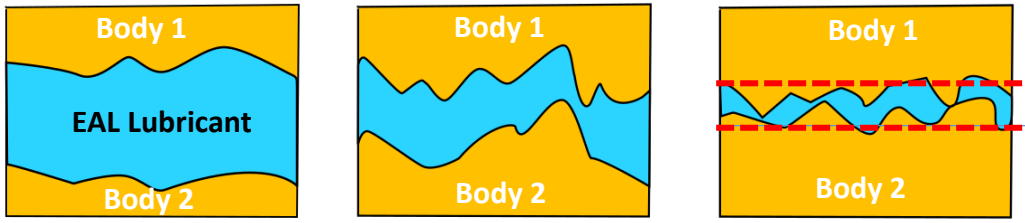

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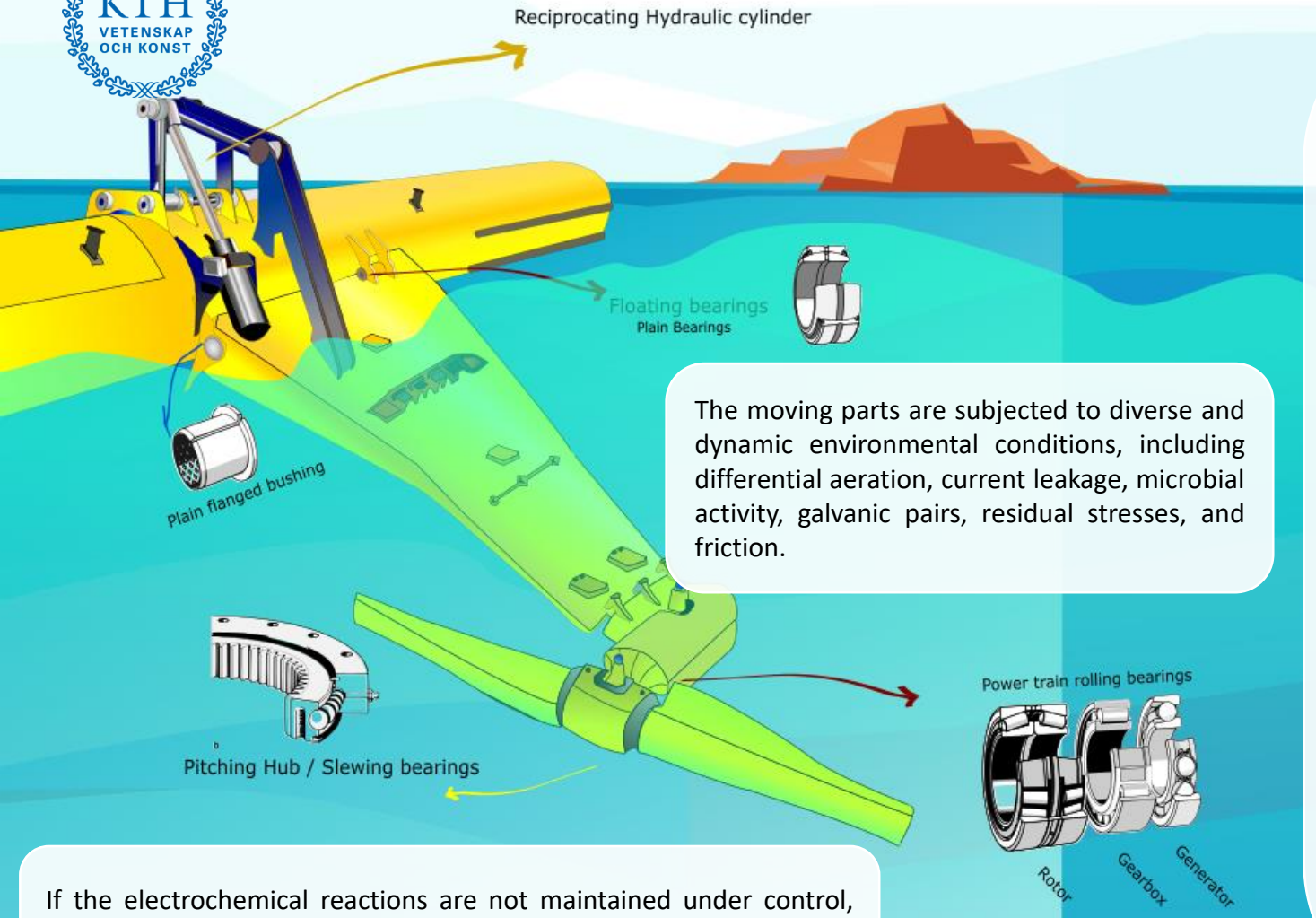
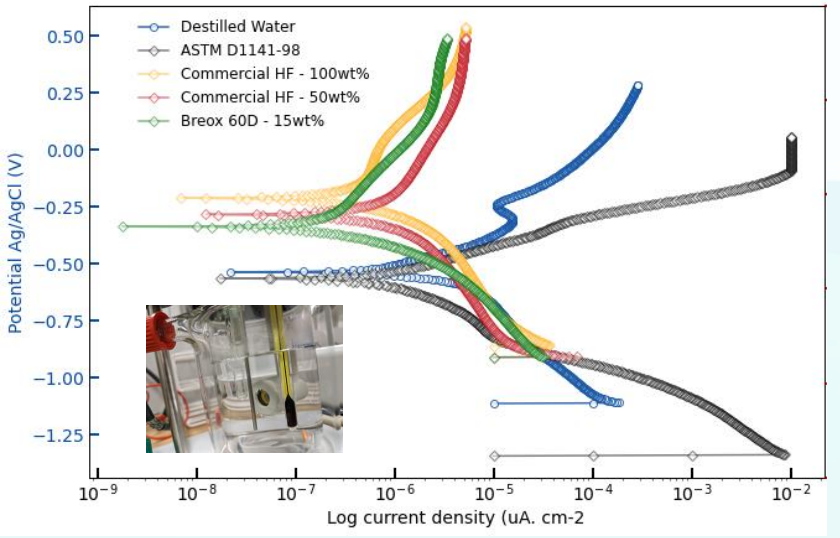
Friction, wear, and corrosion behavior of eco-friendly lubricants

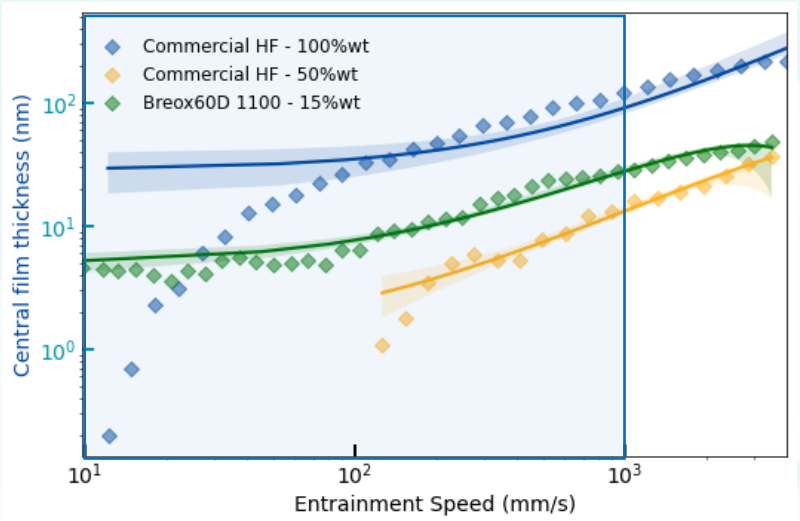


The moving parts are subjected to diverse and dynamic environmental conditions, including differential aeration, current leakage, microbial activity, galvanic pairs, residual stresses, and friction.

If the electrochemical reactions are not maintained under control, the moving parts can experience premature failure due to the synergistic effect between fatigue and tribocorrosive processes.

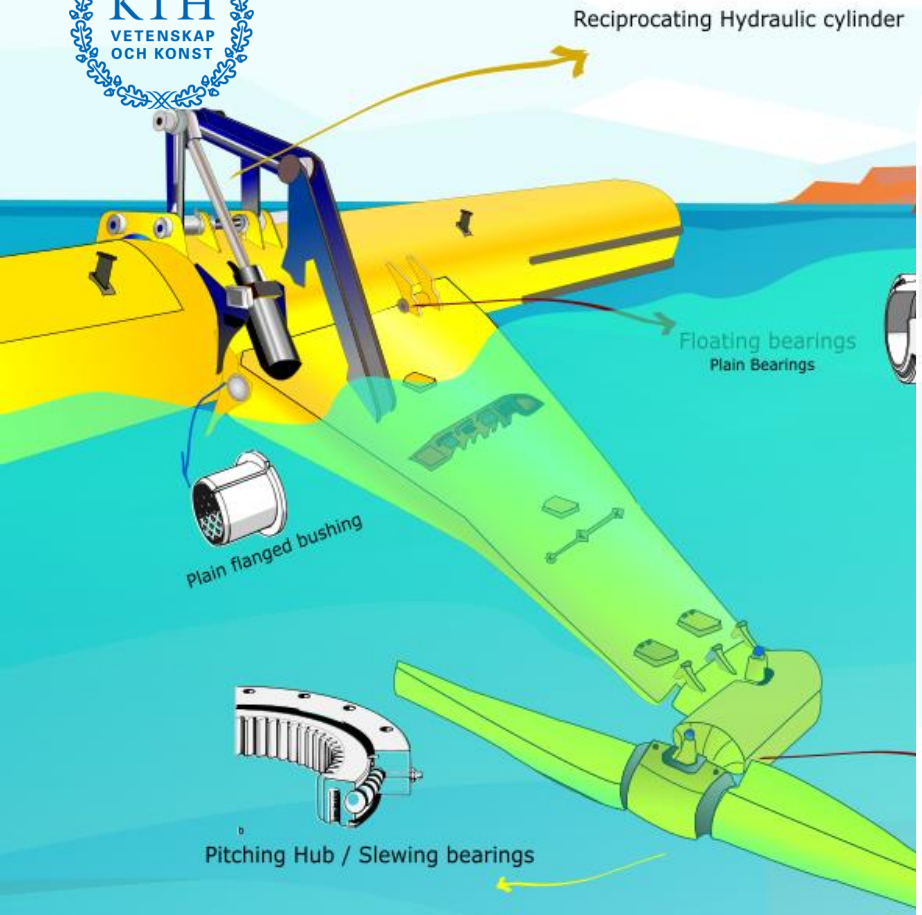


Electrochemical response of 52100 bearing steel exposed to EAL lubricants.



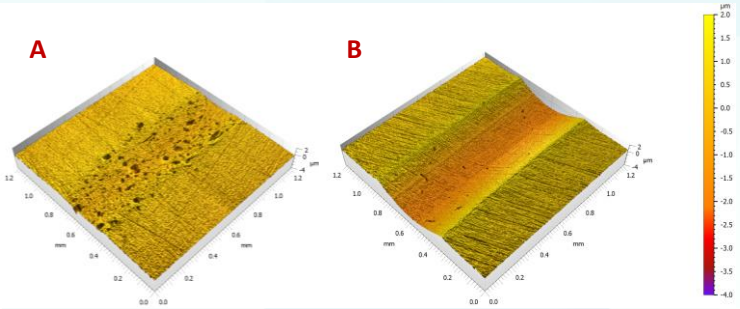
Film formation capabilities EAL lubricants

Friction, wear, and corrosion behavior of eco-friendly lubricants



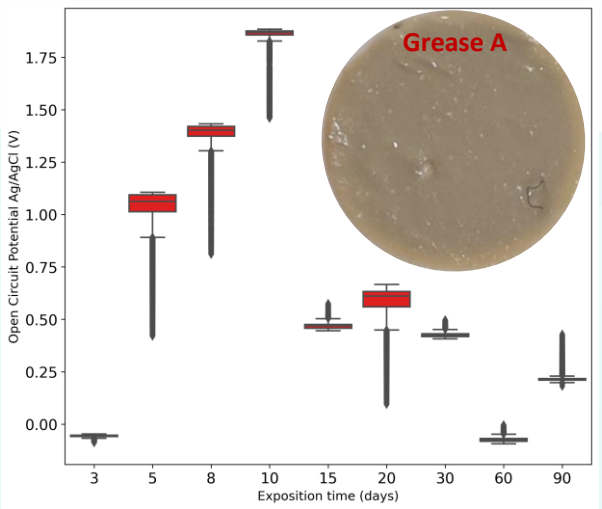
EAL Greases

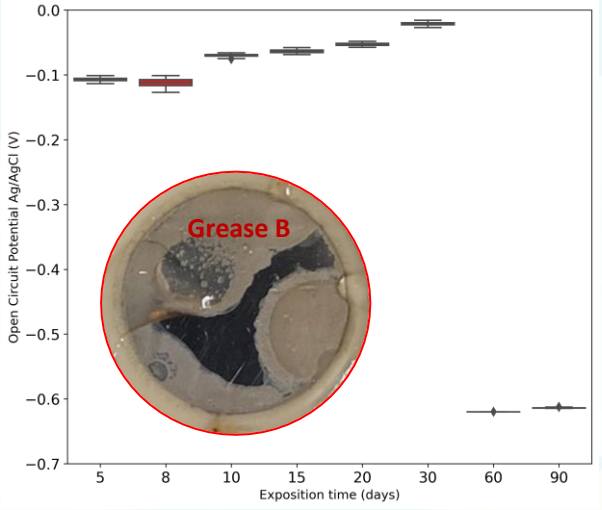
- An homogeneous and dense grease layer can effectively protect a steel surface from corrosion when directly exposed to seawater. However, if the layer is damaged, water can find its way to the interface, promoting corrosion.



Wear behaviour – rolling-sliding contact.

Grease barrier properties





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Thanks for your Attention

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