

Lubricant Expo - September 2024

Enhancing wind-turbine gear oil durability with high-performance base stock technology

ExxonMobil

Agenda

High-viscosity PAO market view

Metallocene PAO (mPAO): molecular structure

Blend study mPAO/conventional PAO (cPAO)

Summary

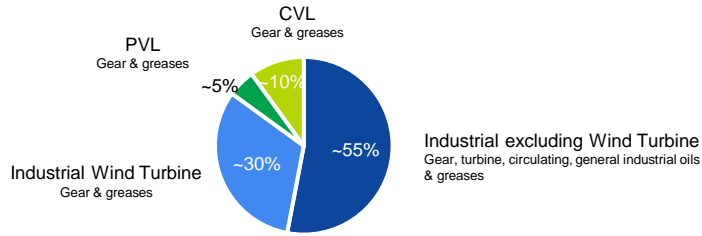
High-viscosity PAO demand is strong

Key trends

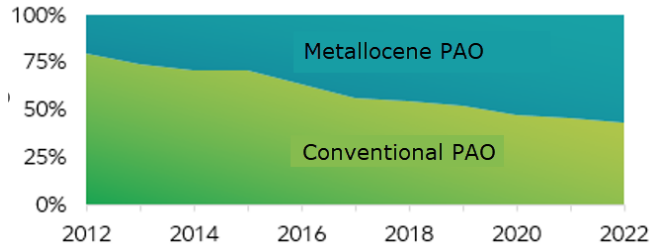
Strong historic demand growth; very strong demand growth in 2023

Optimism about future demand growth driven by emerging applications such as Wind

Global HiVis PAO demand by market segment

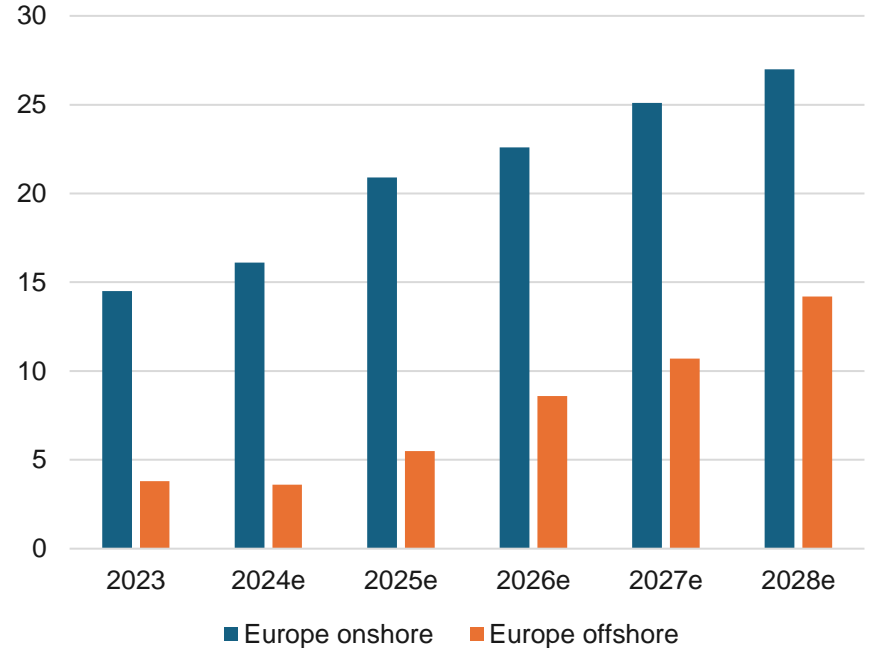


Global High Viscosity PAO demand trend



Source: ExxonMobil assessment of publicly available information and customer feedback

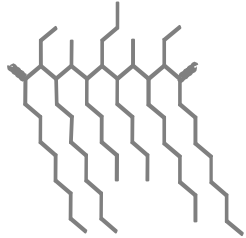
Wind market outlook 2024-2028 European onshore and offshore wind outlook for new installations (GW)



Source: GWEC | GLOBAL WIND REPORT 2024, gwec.net

Metallocene PAO molecular structure

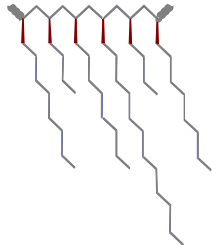
Conventional PAO



Conventional PAO

- Prominent “backbone”
- Isomerization prevalent, Random side-chain orientation, more carbons in the main chain
- More extended with more chain interactions. greater sweep volume

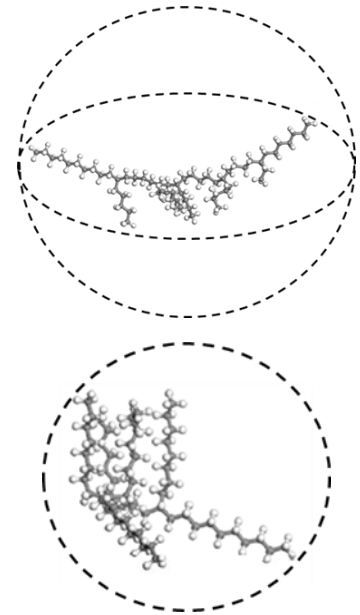
Metallocene PAO



Metallocene PAO (mPAO)

- Uniform, comb-like structure with absence of short side chains
- No isomerization, more carbons in the branches
- High viscosity with narrow molecular weight distribution, smaller molecular volume
- More compact with few chain interactions

Software modeling of C₆₀ hydrocarbons



Key performance advantages of Metallocene PAO in comparison with conventional PAO are: high VI, enhanced oxidation stability, superior low-temperature properties

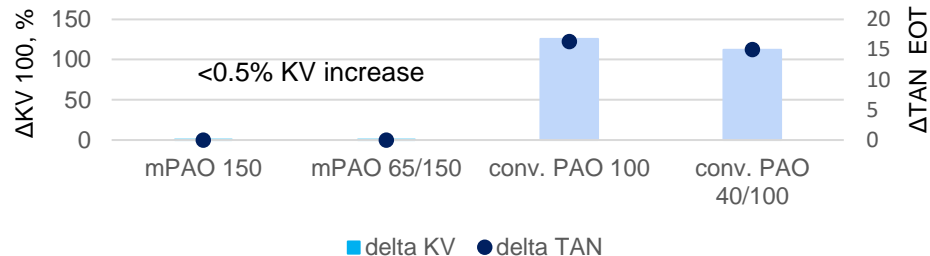
Blend Study: Oxidation Stability & Foaming

Base stock blends – ISO VG 320 treat rates

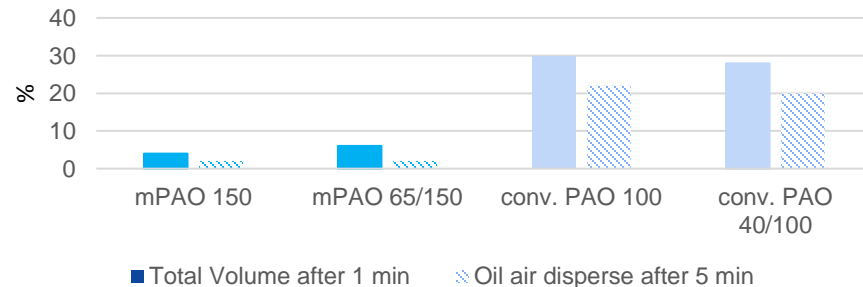
Basestock	mPAO 150	mPAO 65/150	PAO 100	PAO 40/100
PAO 6	22%		22%	4%
mPAO 65		88%		
mPAO 150	78%	12%		
PAO 40				55%
PAO 100			78%	41%

Blends of high-/low-viscosity base stocks only were tested to remove any additive and co-base stock impact

Oxidation stability - ASTM D2893, 312 hours, 121°C & ASTM D664



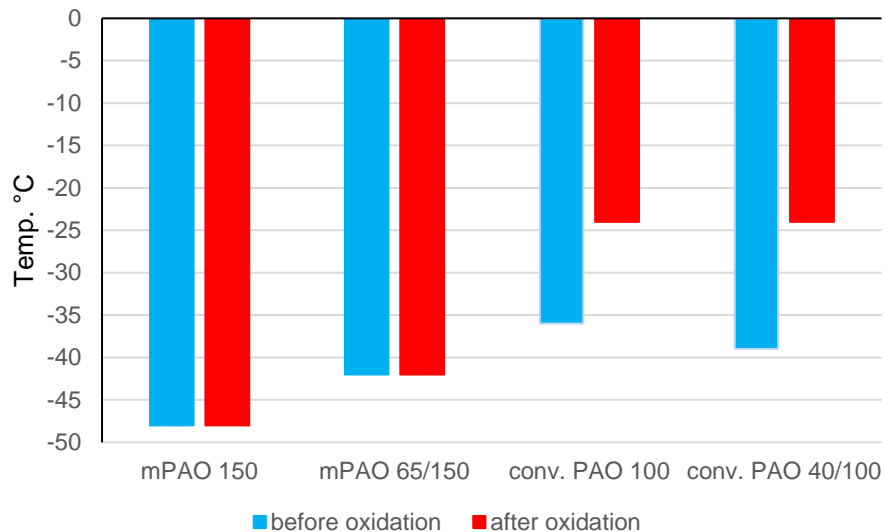
Flender Foam Test - ISO 12152



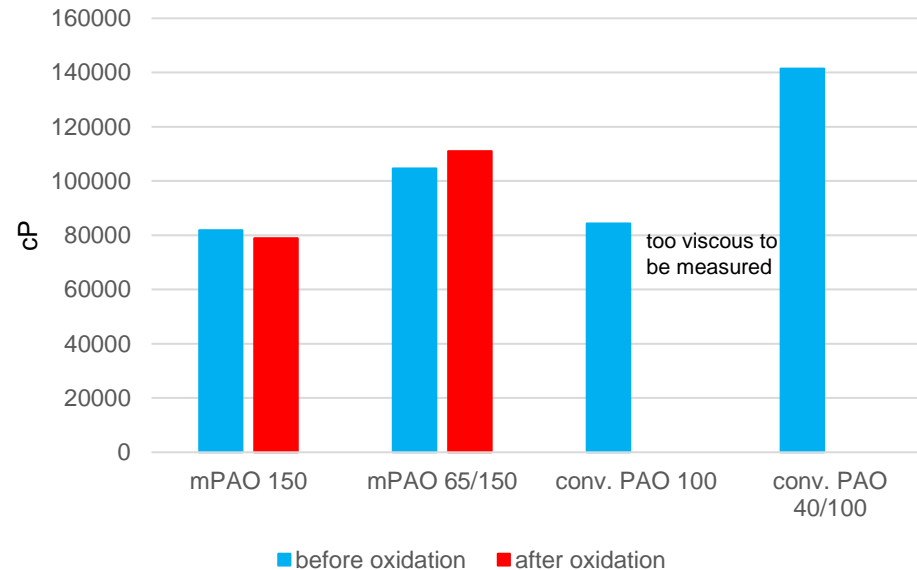
The mPAO blends have excellent oxidation stability in the ASTM D 2893 test and have a significantly lower foaming tendency demonstrated in the Flender foam test

Blend Study: Low-Temperature Properties

Low Temperature Properties - Pour Point before/after Oxidation – ASTM D5950



Brookfield Viscosity at -26°C before/after Oxidation ASTM D2893



The mPAO blends have enhanced low-temperature properties before oxidation compared to conv. PAO. Due to the excellent oxidative stability the mPAO blends have constant low-temperature fluidity after oxidation, which can contribute to longer oil drain intervals

- Wind industry growth is increasing - the global wind industry broke a new annual record in 2023 with a 117 GW of new wind power was installed worldwide.*
- Wind turbines are often subject to extreme conditions such as high load, high shear, low temperature
- Extension of oil drain intervals are anticipated to reduce maintenance complexity and costs
- Metallocene PAO can provide step-out performance (versus conventional PAO) with regards to:
 - Oxidation stability
 - Low-temperature fluidity
 - Foaming resistance
- Metallocene PAO can enhance the performance and durability of wind-turbine gear oils



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