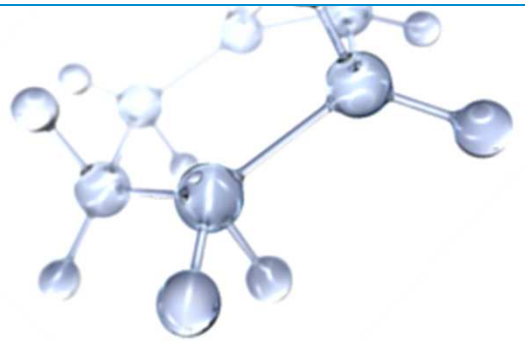
ExxonMobil Chemical

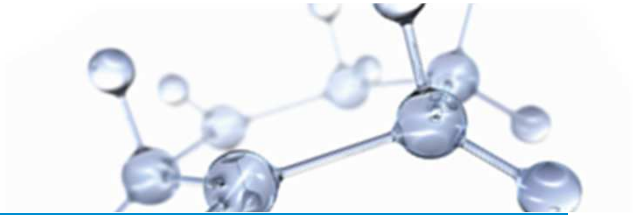


Alkylated Naphthalenes

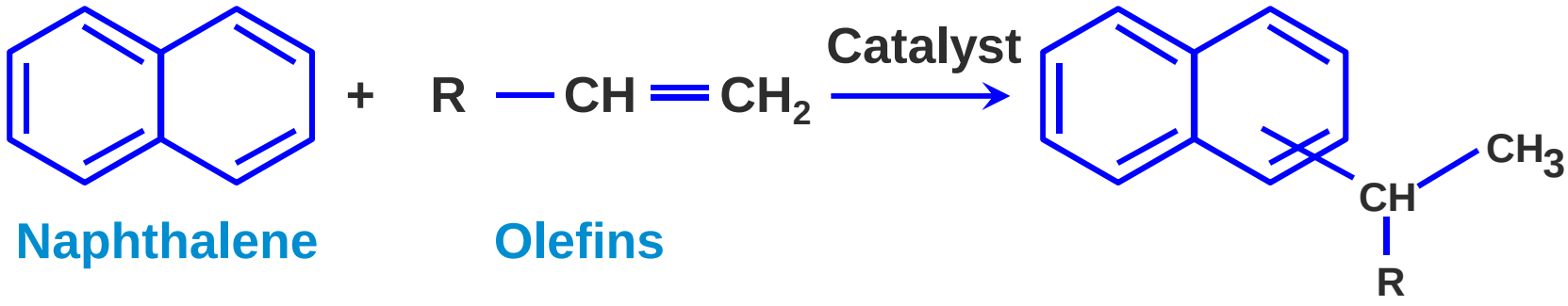
UTS Seminar
St Petersburg Sept 13-15, 2011
Sandy Reid-Peters

ADVANCED SYNTHETIC BASE STOCKS | *Innovative lubricants start here*

What are Alkylated Naphthalenes (AN)?



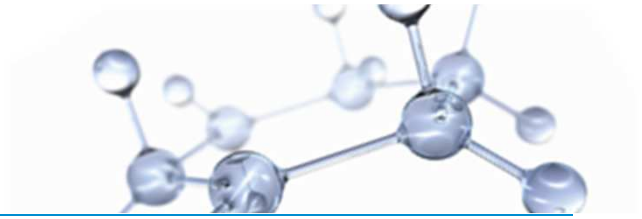
- **Alkylated aromatic fluids**
- **Reaction products of olefins and naphthalene**
- **American Petroleum Institute (API) Group V fluids**
- **Synthetic blendstocks for automotive and industrial lubricants**
- **NSF registration for Incidental Food Contact (H1 & H1-X) -** All EMC Synesstic™ grades

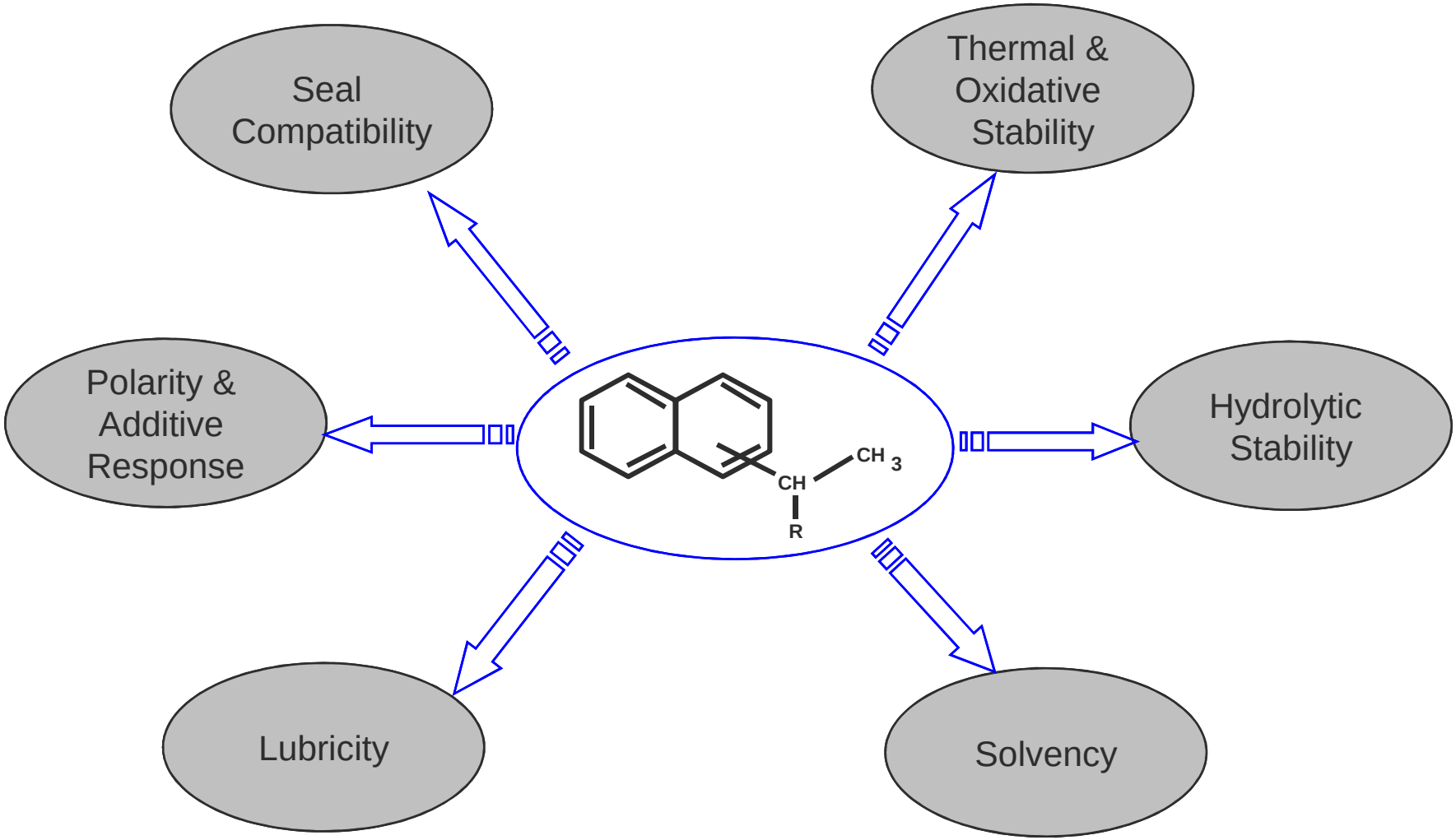


Naphthalene **Olefins**

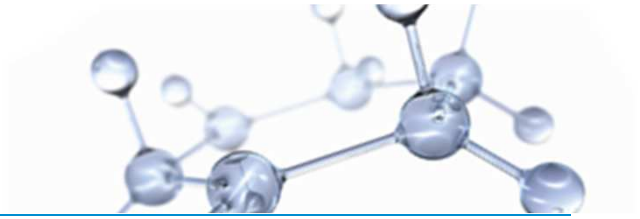
Alkylated Naphthalene (AN)

Properties of AN





Thermal Stability



Thermal Stability Test: 72 hours @ 288° C under Nitrogen

	Adipate Ester	Polyol Ester	Branched Alkyl Benzene	6 cSt PAO	5 cSt AN	12 cSt AN
Viscosity Change, %	-9.2	-0.1	-0.9	-9.1	0.4	1.1
TAN Change, mg KOH/g	53.9	8.1	0.55	0.22	0.32	0.24
Weight Loss, %	23.1	1.09	1.23	1.15	0.51	0.33

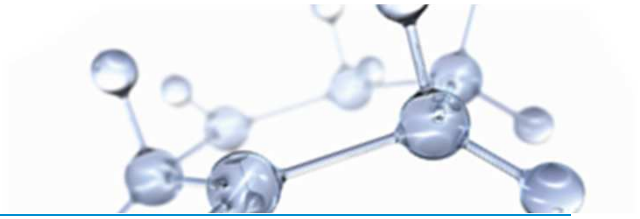
Increased acidity

Reduced viscosity due to thermal cracking

higher evaporative loss

AN exhibits improved thermal stability compared to alkyl benzene, PAO and ester base fluids

Oxidative Stability

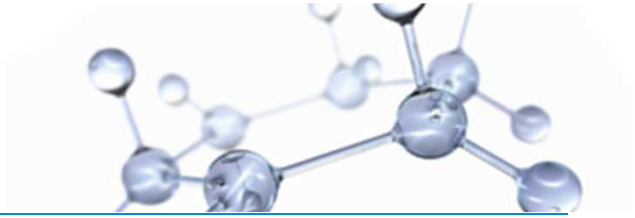


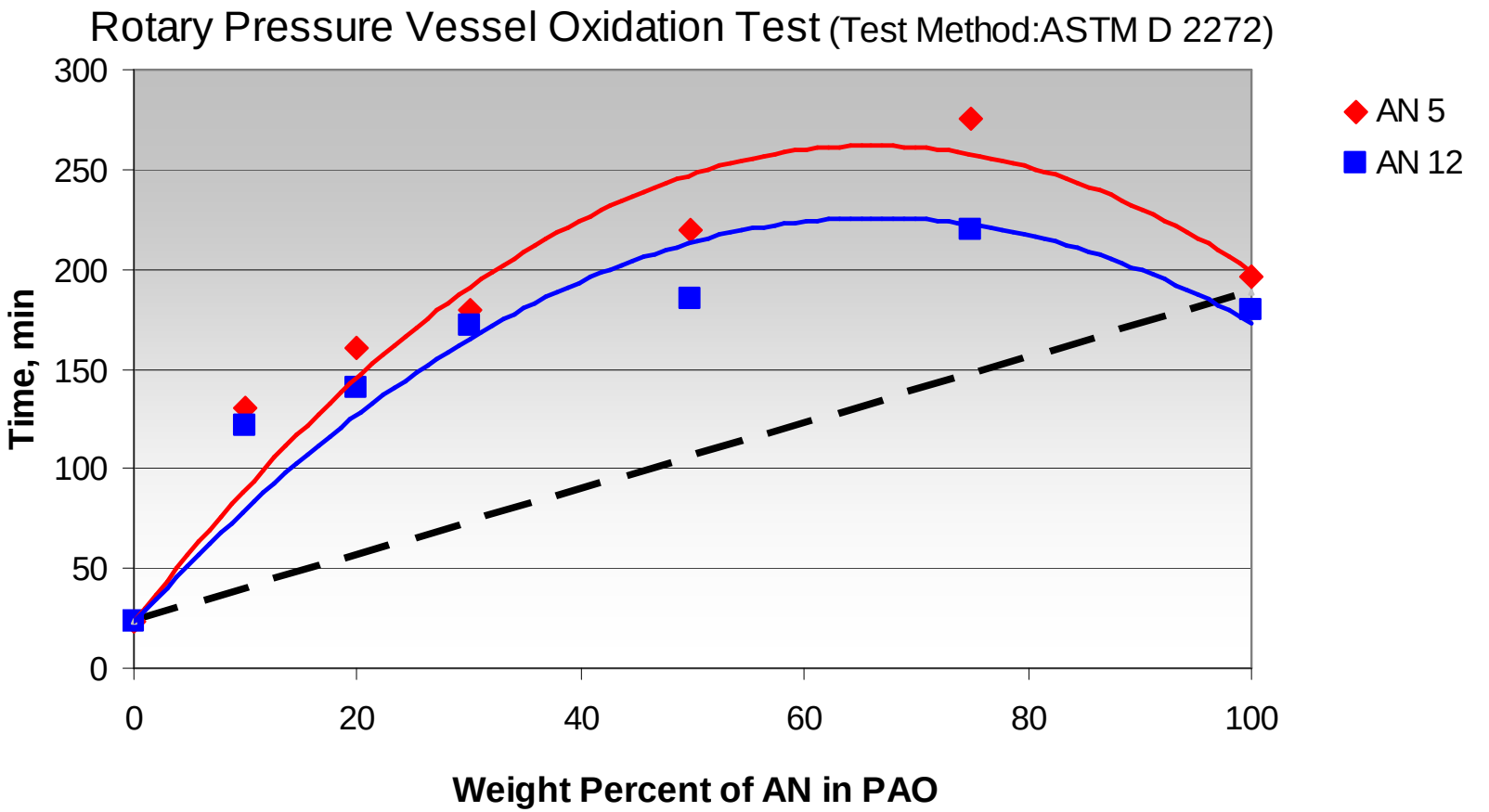
(Test Method: modified in house Oxidation-Corrosion Test in the presence of air and metal coupons)

ISO VG 32	Ester Blend	AN Blend
6 cSt PAO	73 %	73 %
Adipate Ester	25 %	---
5 cSt AN	---	25 %
Additives	2 %	2 %
Viscosity Change, %		
120 hours @ 163 ℃	71	5
48 hours @ 177 ℃	103	5
24 hours @ 191 ℃	76	3

AN improves the oxidative performance of PAO-based formulations compared to ester

Synergy with PAO





Blending Alkylated Naphthalene with PAO yields more oxidative resistant fluids.

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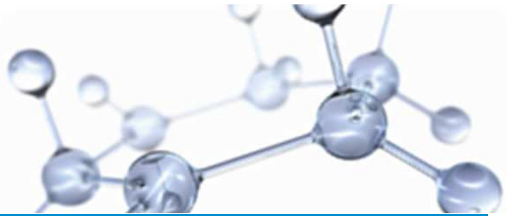
Source: Exxon Mobil data

ExxonMobil Chemical

Hydrolytic stability

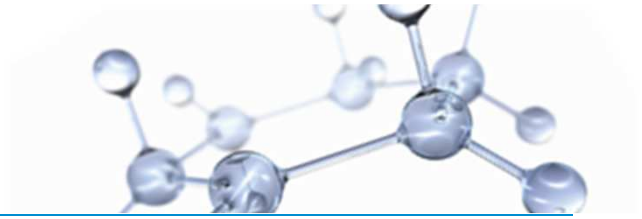


Test Method: ASTM D 2619

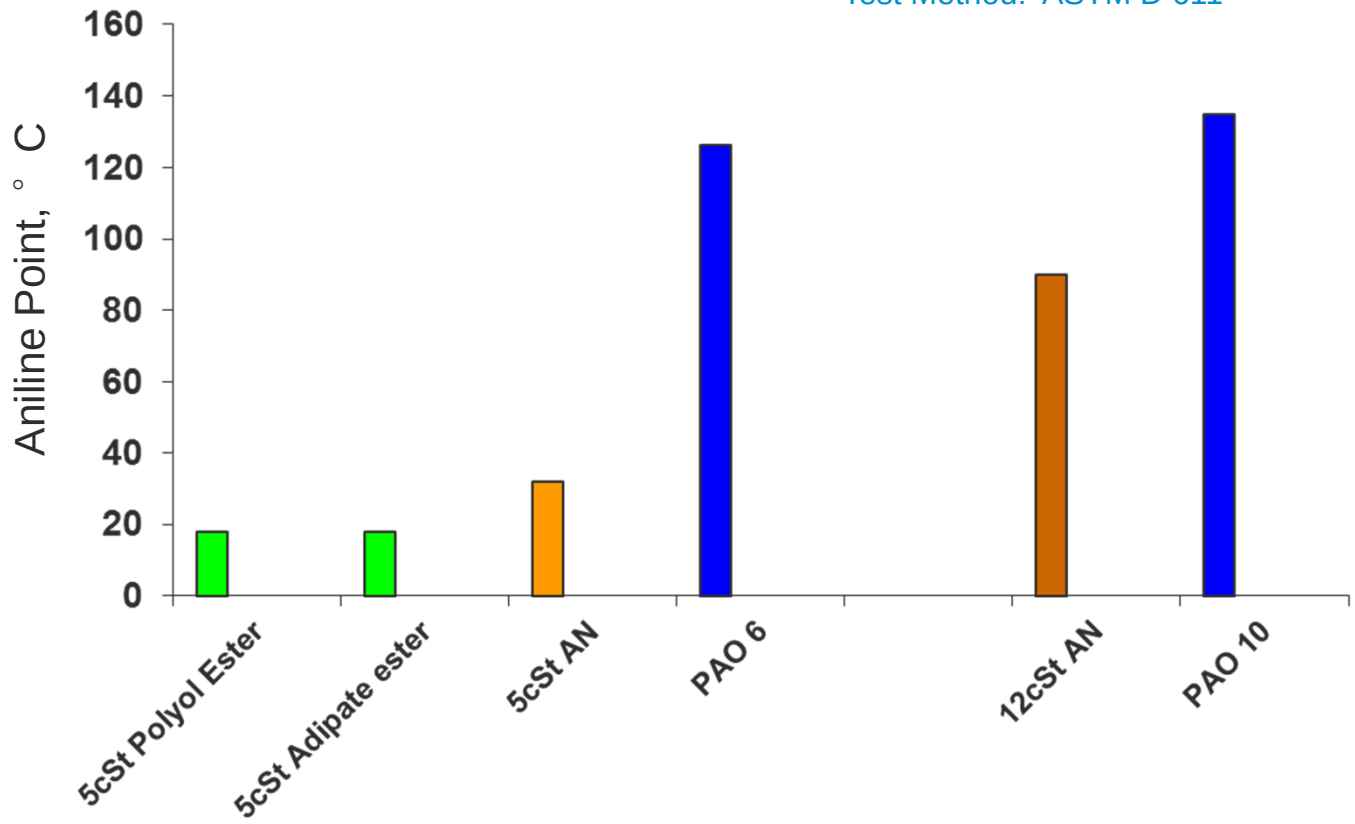
ISO VG 32	Ester Blend	AN Blend
6 cSt PAO	73 %	73 %
Adipate Ester	25 %	---
5 cSt AN	---	25 %
Additives	2 %	2 %
ASTM D 2619		
Copper Corrosion, mg/cm²	0.15	0.00
TAN Change, mg KOH/g	0.22	0.03
Total Acidity of Water, mg KOH	19.9	4.9

Replacing adipate ester with AN improves hydrolytic stability in a formulated oil.

Solvency



Test Method: ASTM D 611



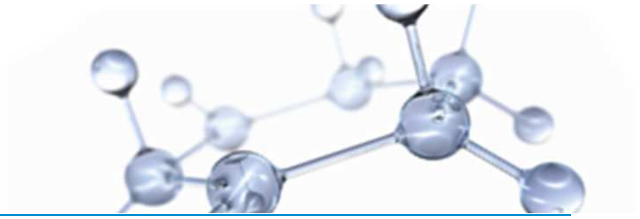
AN have good additive solvency for polar compounds due to their aromatic structures.

ADVANCED SYNTHETIC BASE STOCKS | *Innovative lubricants start here*

Source: Exxon Mobil data

ExxonMobil Chemical

Lubricity

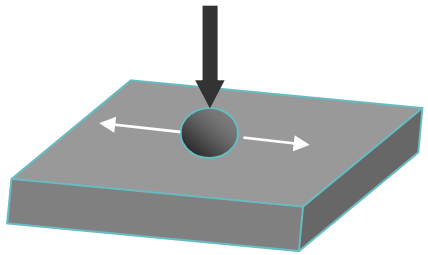


Test Method: ASTM D 6079

HFRR ASTM D 6079	PAO	5cSt AN	Polyol Ester
Kinematic Viscosity @ 100 C, cSt	3.87	4.83	4.39
Wear Scar Diameter, micron	368	242	246
Average Coefficient of Friction	0.157	0.110	0.098
Average Film %	20	75	83

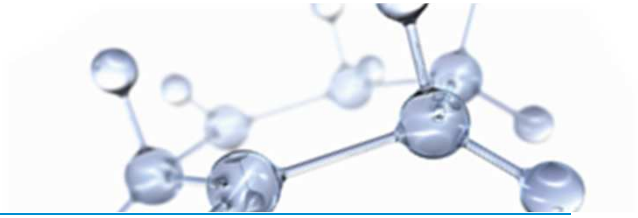
AN offers similar wear protection to ester and can help reduce friction

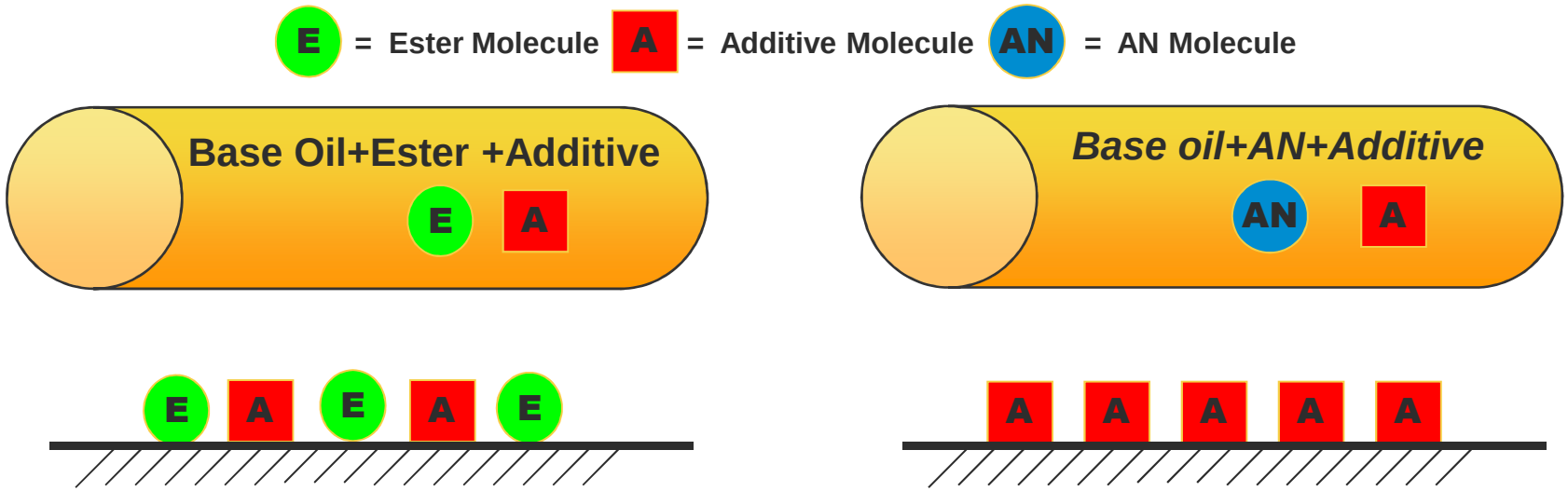
Test conditions:
Stroke Length 1 + 0.02mm
Frequency 50 + - 1 Hz
Applied load 500g
Test Duration 75 mins
Fluid Temperature 60C
24-30% Relative Humidity



Source: Exxon Mobil data

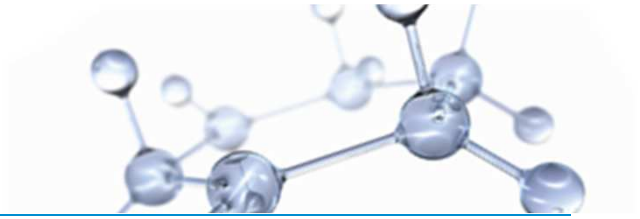
Competition for the surface





AN may improve additive effectiveness through less competition for the surface

Elastomer effects



Test Method: ASTM D 471

	Polyol Ester	Adipate Ester	6 cSt PAO	5 cSt AN	12 cSt AN
Fluoroelastomer*					
volume change, %	4.7	3.4	0.4	0.8	0.4
Polyacrylate*					
volume change, %	27.4	19.8	-2.2	17.9	1.2
Nitrile**					
volume change, %	16.9	12.0	-3.3	14.1	0.1

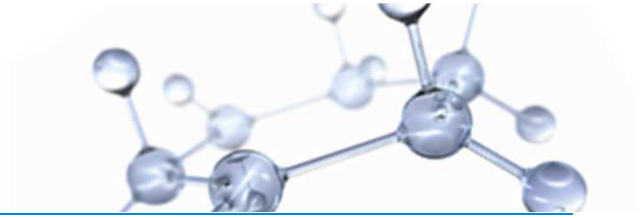
* 240 hrs, 150 ℃

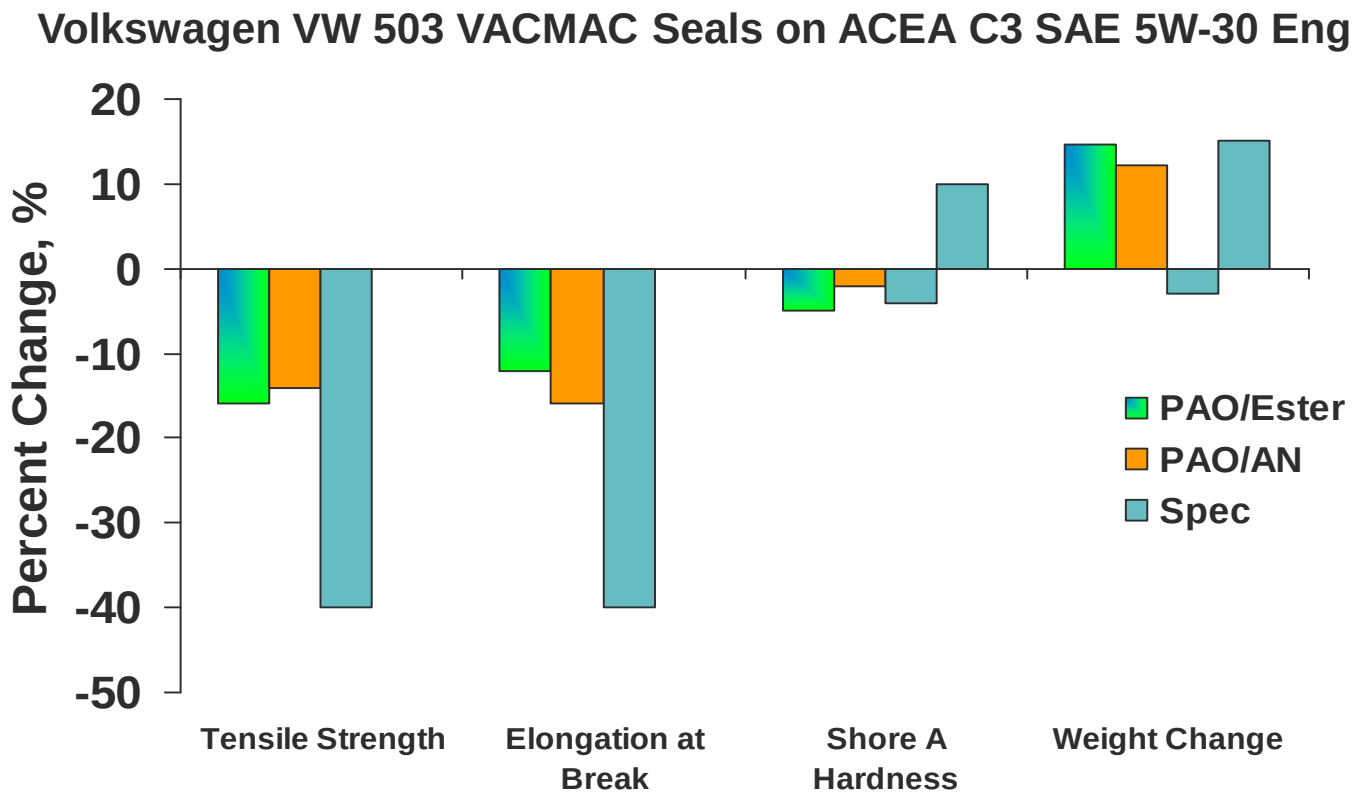
** 240 hrs, 100 ℃

AN demonstrate seal swell performance and none of the seal shrinkage associated with PAO

Source: Exxon Mobil data

Elastomer performance





AN shows similar performance to esters when used as a blend stock in PAO-based engine oils.

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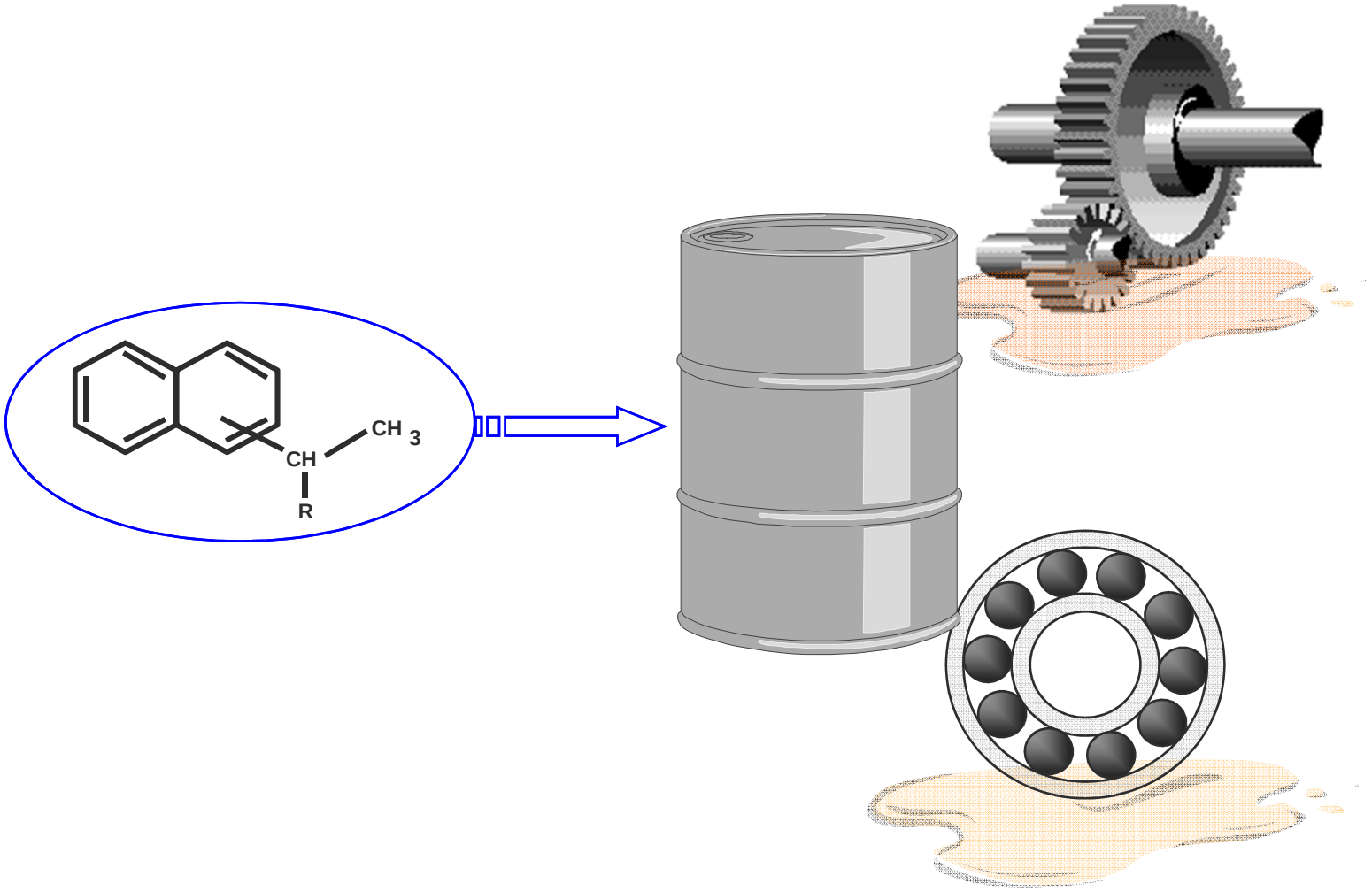
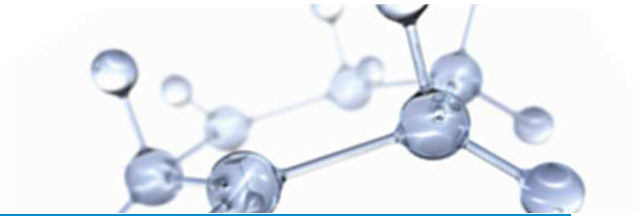
Source: Exxon Mobil data

ExxonMobil Chemical

An in service



Improved additive response

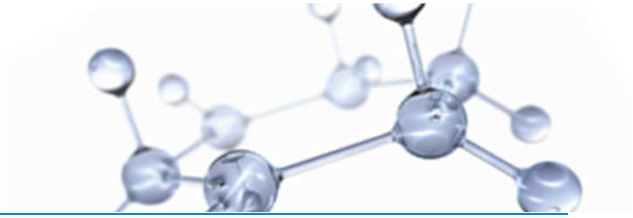


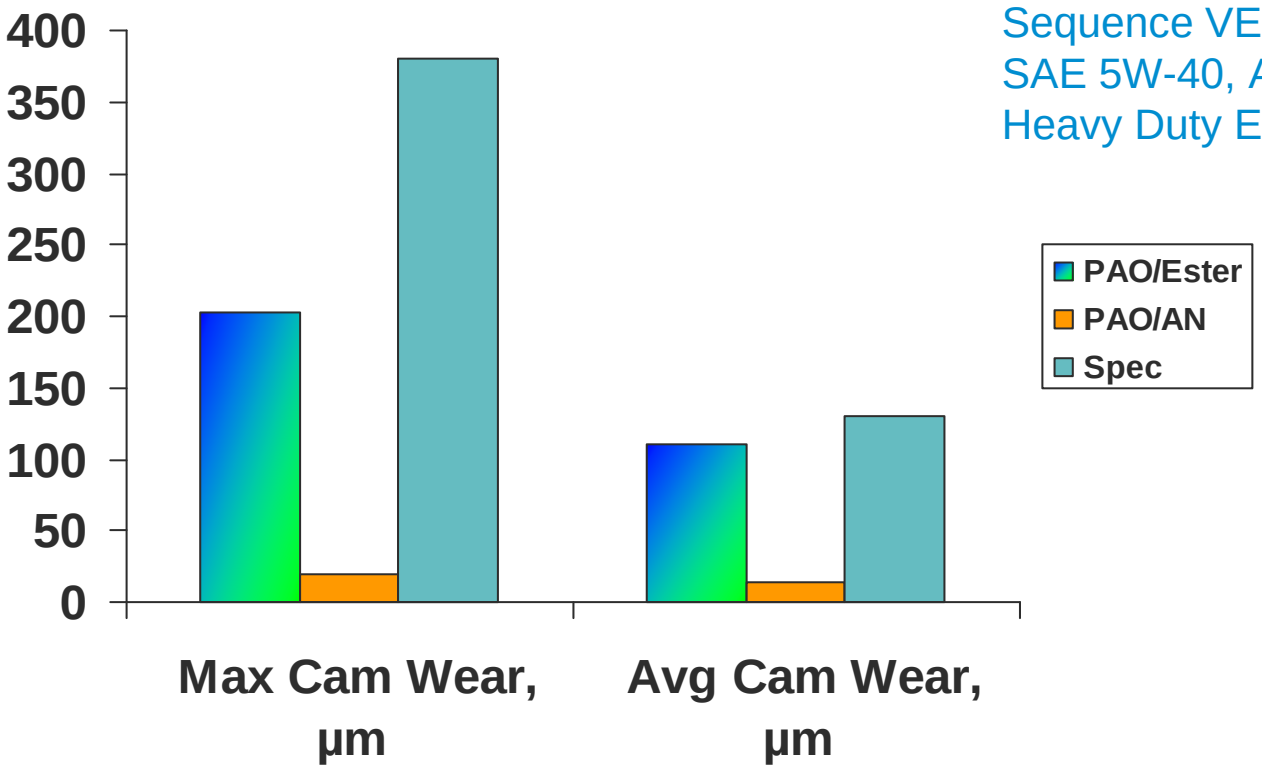
Test Method: ASTM D 4472

ISO VG 220	Ester Blend	AN Blend
40 cSt PAO	78 %	78 %
Adipate Ester	20 %	---
5 cSt AN	---	20 %
Additives	2 %	2 %
4-Ball Wear Test (D 4472)	Wear Scar, mm	
1800 rpm, 93 ℃ for 30 minutes		
60 kg load	0.822	0.739
80 kg load	2.094	0.822

AN demonstrates improved wear protection in an ISO VG 220 gear oil formulation.

Improved additive response



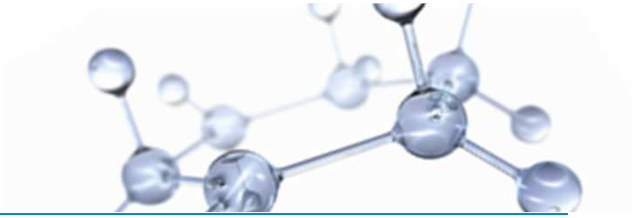


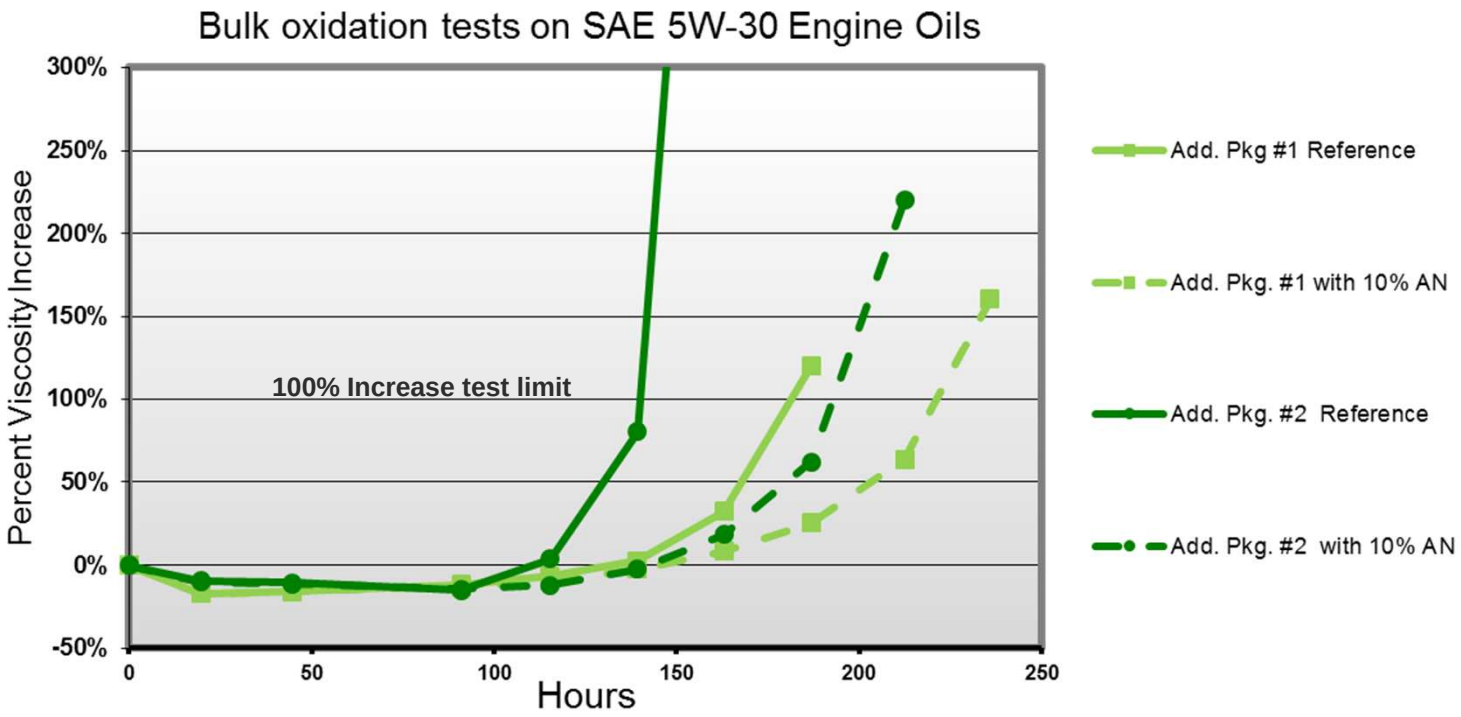
Sequence VE Engine Test
SAE 5W-40, API CG-4
Heavy Duty Engine Oils

Synthetic heavy duty engine oils blended with PAO and AN demonstrate improved wear performance to PAO/ester formulations.

Source: Exxon Mobil data

Boosted oxidation stability

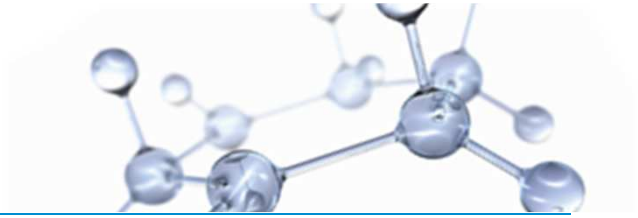




Alkylated Naphthalene improves oxidation stability of 5W-30 engine oils based on group II base stocks with market general GF4 additive packages

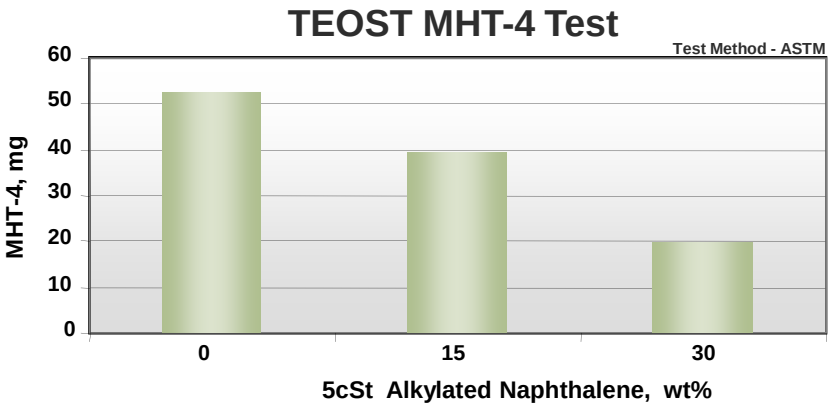
Source: Exxon Mobil data

Improved engine deposits



Caterpillar 1-K Diesel Test*

Wt.% AN	0	20
WDK (Weighted deposit demerits)	500	385
TGF (Top groove fill)	19	12



Alkylated Naphthalene helps provide improved deposit protection in engine oil formulations

*** CI-4 quality oil in Gp II base stocks**

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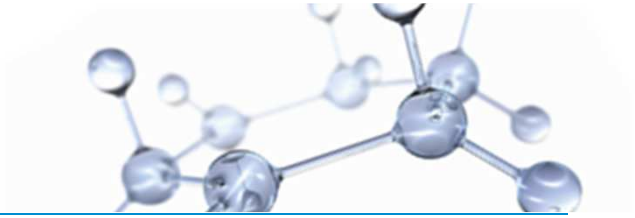
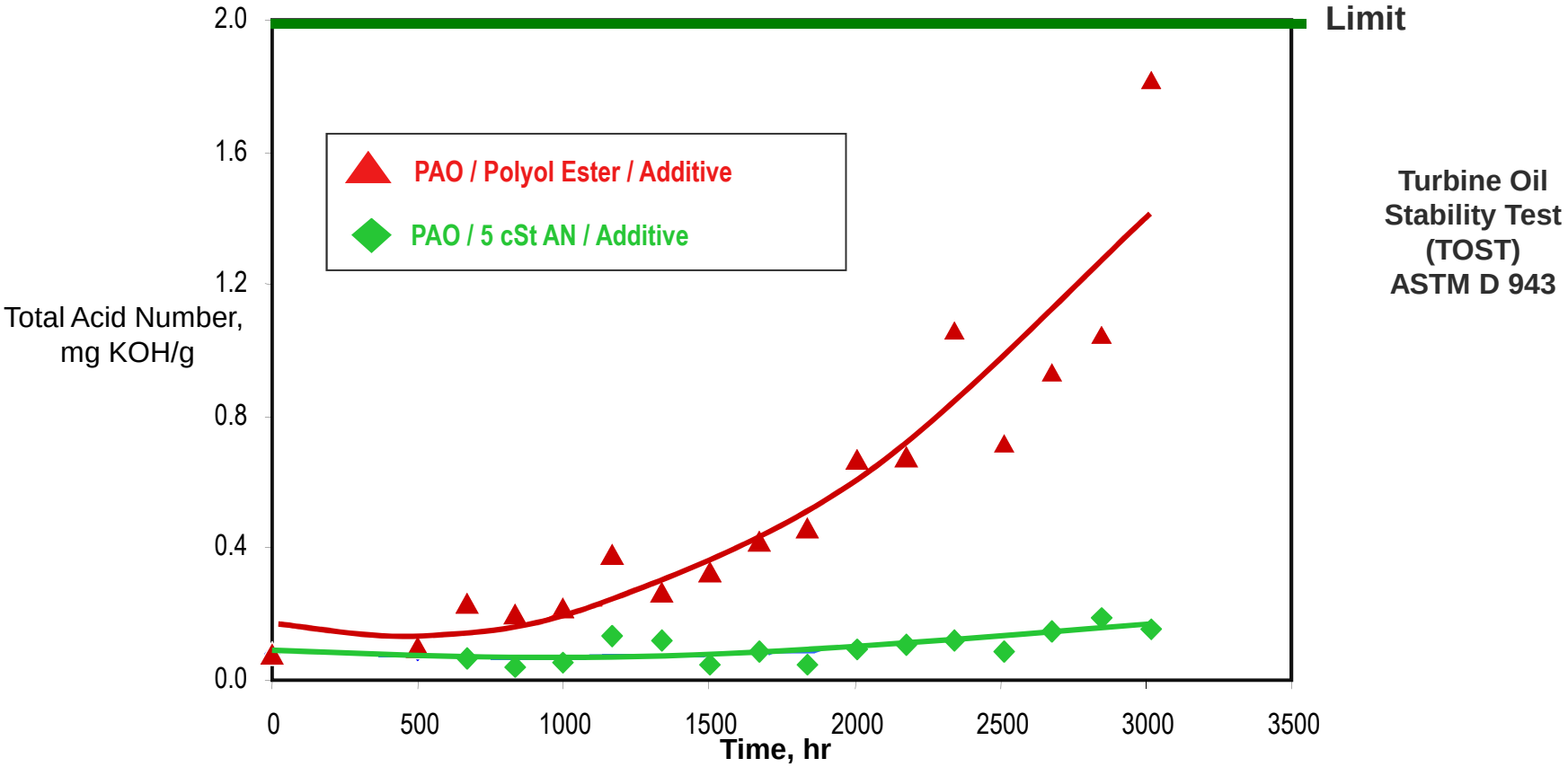
Source: Exxon Mobil data

ExxonMobil Chemical

ISO VG 46 compressor oil





Turbine Oil Stability Test (TOST) ASTM D 943

AN improves oxidative and hydrolytic stability with the potential to extend compressor oil lifetime

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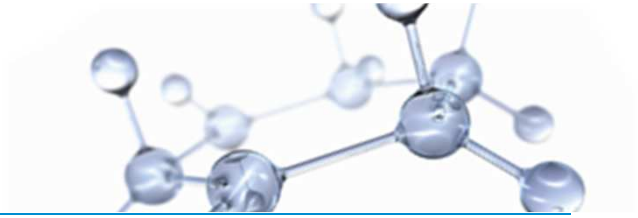
Source: Exxon Mobil data

ExxonMobil Chemical

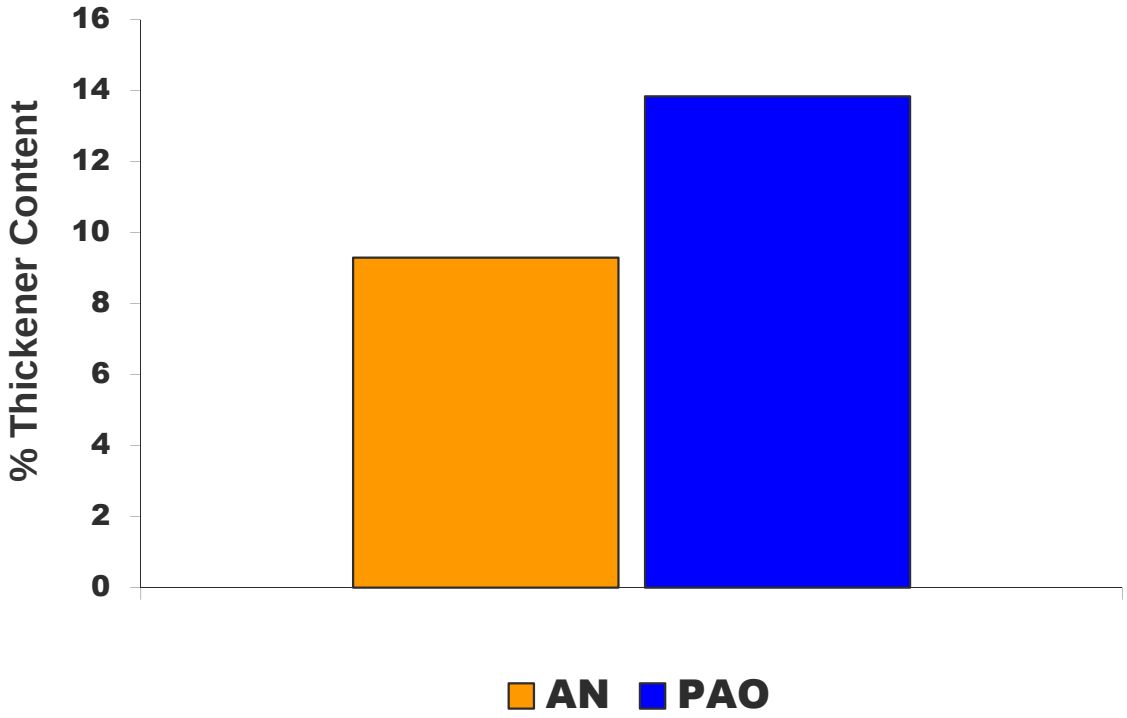
Greases



Two Greases Manufactured:

1. **100% AN**
2. **100 % PAO**

- **NLGI #2 Grease**
- **Lithium Complex Thickener**
- **Base oil viscosity - 110 cSt**
- **Commercial Additive package**



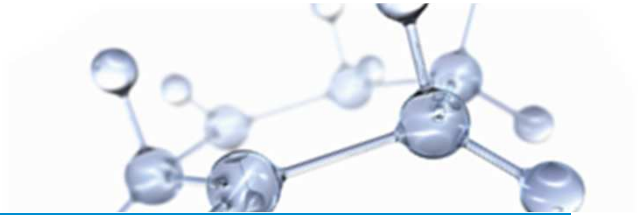
The solvency of AN allows improved thickener efficiency with good mechanical stability in synthetic grease manufacture.

ADVANCED SYNTHETIC BASE STOCKS | *Innovative lubricants start here*

Source: Exxon Mobil data

ExxonMobil Chemical

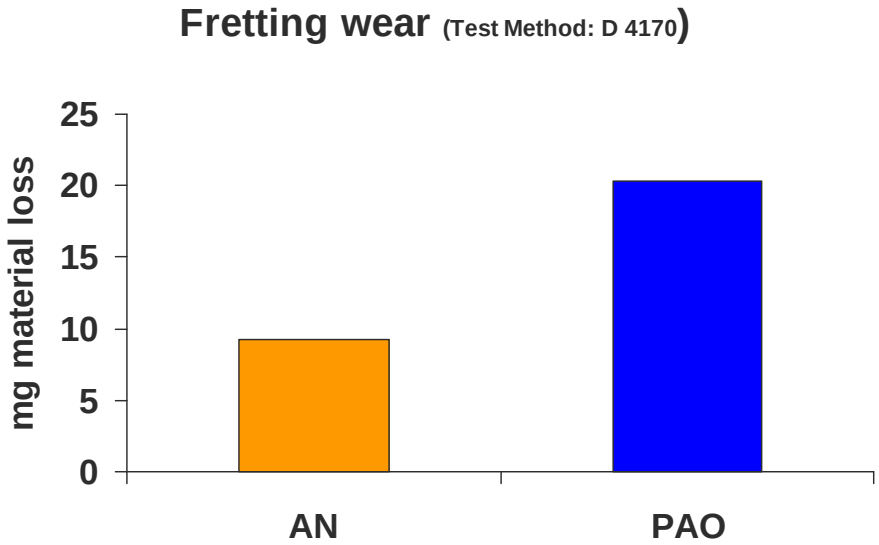
Greases

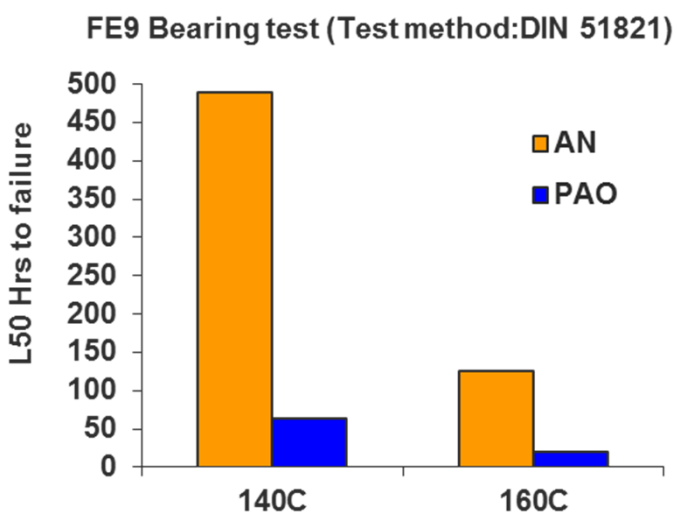


NLGI #2 Li Complex grease

110cSt base oil viscosity

Same additive package





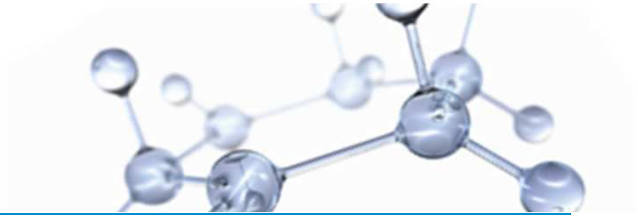
AN offers good protection in greases

ADVANCED SYNTHETIC BASE STOCKS | *Innovative lubricants start here*

Source: Exxon Mobil data

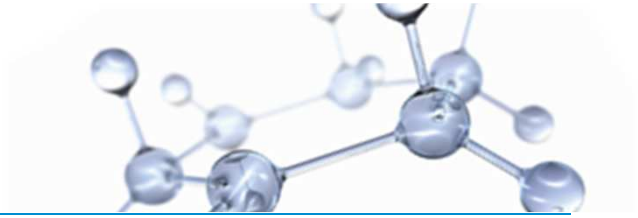
ExxonMobil Chemical

Challenges for formulators of food grade fluids

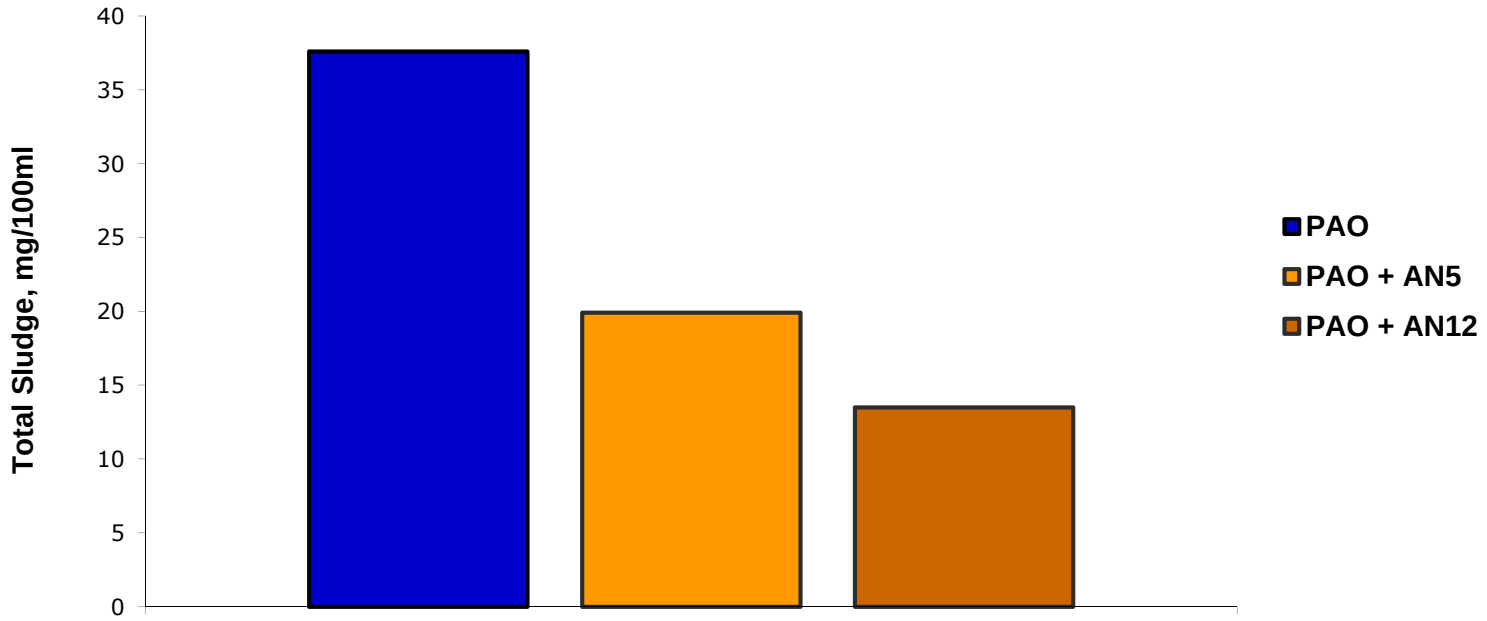


- New laws on food health and safety are being developed world-wide
- Limited selection of H1/HX-1 base stocks which can provide improved oxidation, solvency and seal performance
- Limited selection of additives approved for food grade applications
- Treat rates of additives approved for food grade applications may be limited
- Food-related applications are often in high-temperature, and moist environments, making oxidative, thermal and hydrolytic stability key performance challenges
- The FDA has approved Synesstic™ AN base stock fluids for use as a component of lubricants with incidental food contact
- H1, HX-1 registration with NSF

Synesstic™ AN base stocks
Sludge performance



ISO VG 46 - Cincinnati Milacron Test (ASTM D 2070)



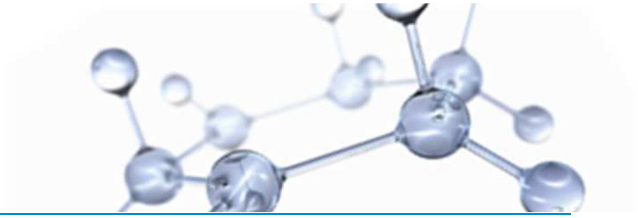
Addition of Synesstic™ AN base stocks to PAO increases overall blend solubility and cleanliness in formulated industrial oils.

Source: Exxon Mobil data

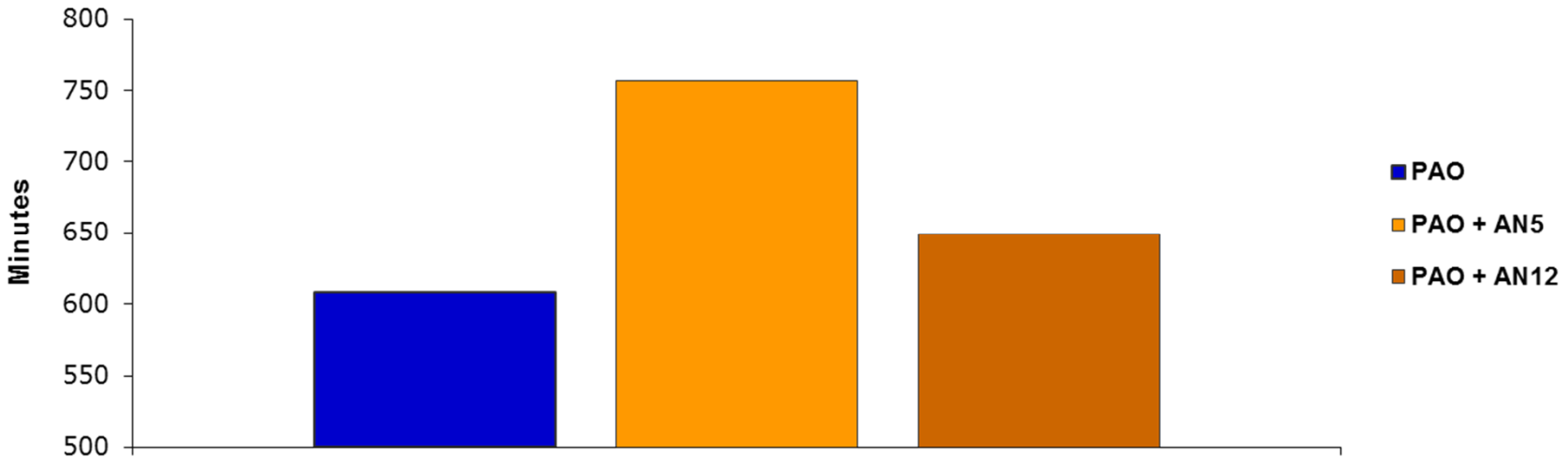
ADVANCED SYNTHETIC BASE STOCKS | *Innovative lubricants start here*

ExxonMobil Chemical

Synesstic™ AN base stocks
Oxidation stability



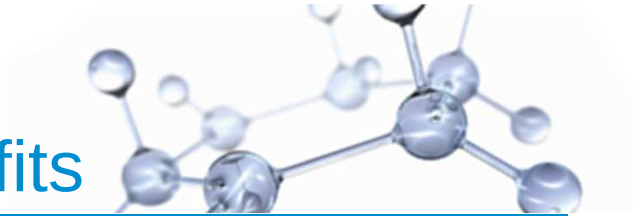
ISO VG 46 - Rotary Pressure Vessel Oxidation Test (RPVOT) (ASTM D2272)



Addition of Synesstic™ AN base stocks to PAO improves the oxidation performance of formulated industrial oils.

Source: Exxon Mobil data

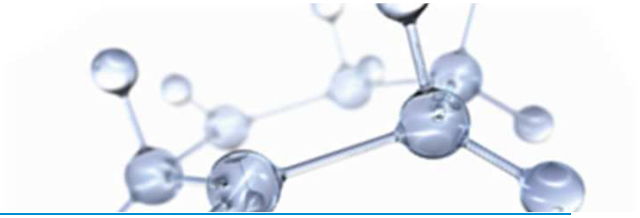
Synesstic ™ AN base stocks benefits



Synesstic ™ AN base stocks provide:

- Thermal and oxidative stability for improved oil life and deposit control
- Good hydrolytic stability for use in high moisture environments
- Solvency for additives and oxidation products
- Seal compatibility enhancement
- Improved additive effectiveness (when replacing esters)

For more information visit: www.synesstic.com



"Except as otherwise specified, all charts included in the presentation are based on ExxonMobil data".