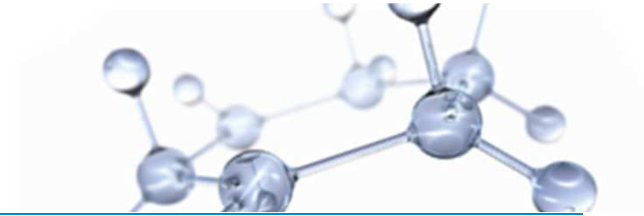

Alkylated Naphthalenes

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

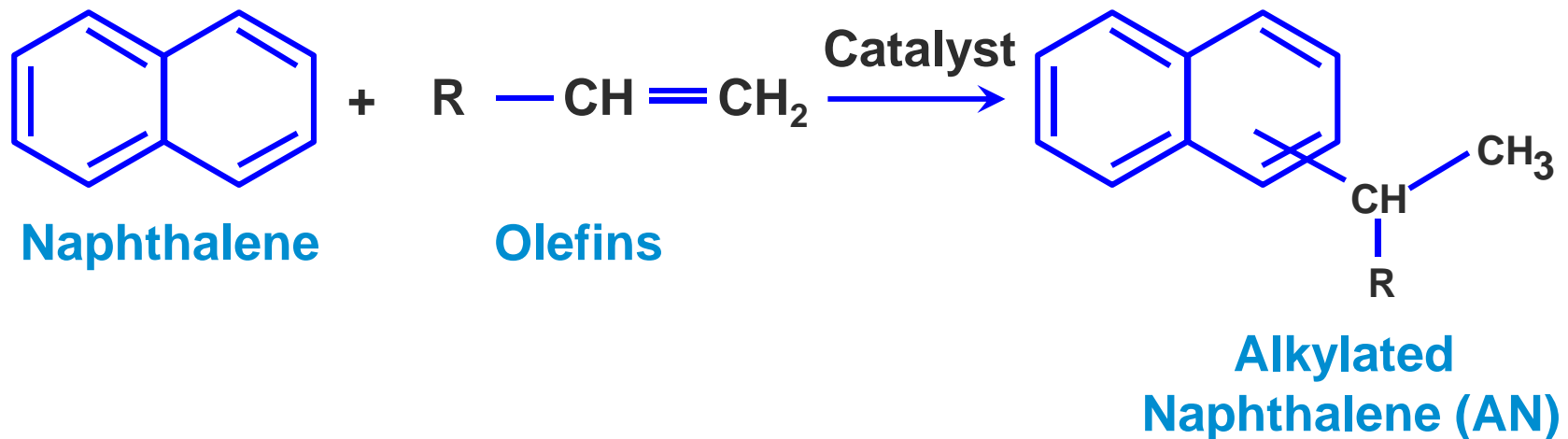


ADVANCED | *Innovative*
SYNTHETIC | *lubricants*
BASE STOCKS | *start here*

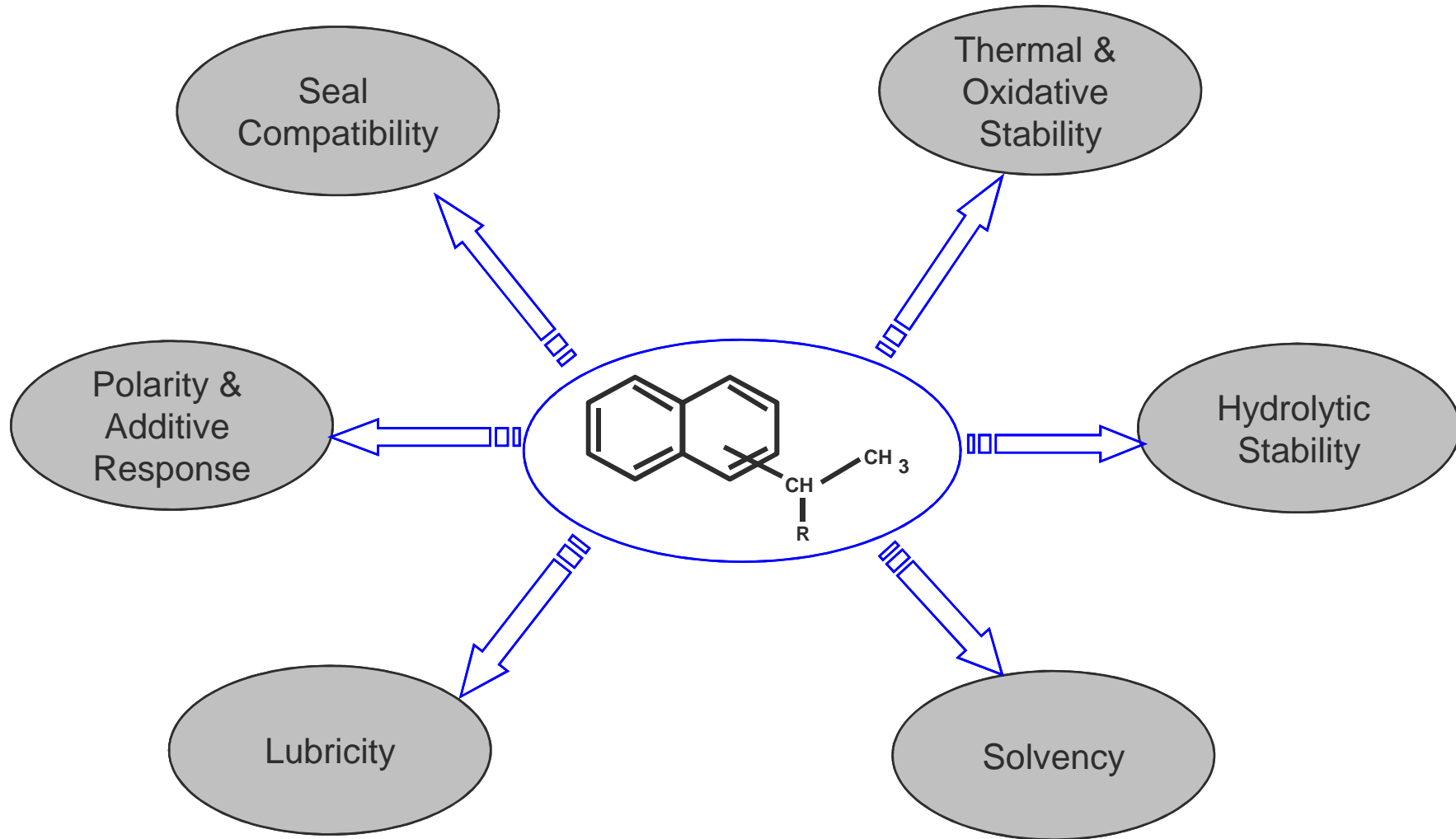
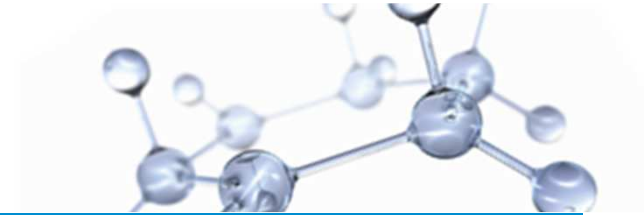
What are Alkylated Naphthalenes (AN)?



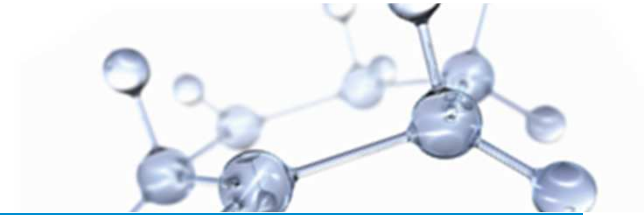
- Alkylated aromatic fluids
- Reaction products of olefins and naphthalene
- American Petroleum Institute (API) Group V fluids
- Synthetic blendstocks for automotive and industrial lubricants
- NSF registration for Incidental Food Contact (H1 & H1-X) - All EMC Synesstic™ grades



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

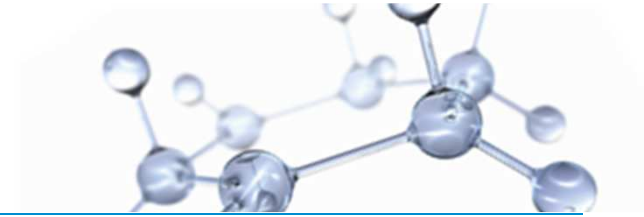
Increased acidity

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

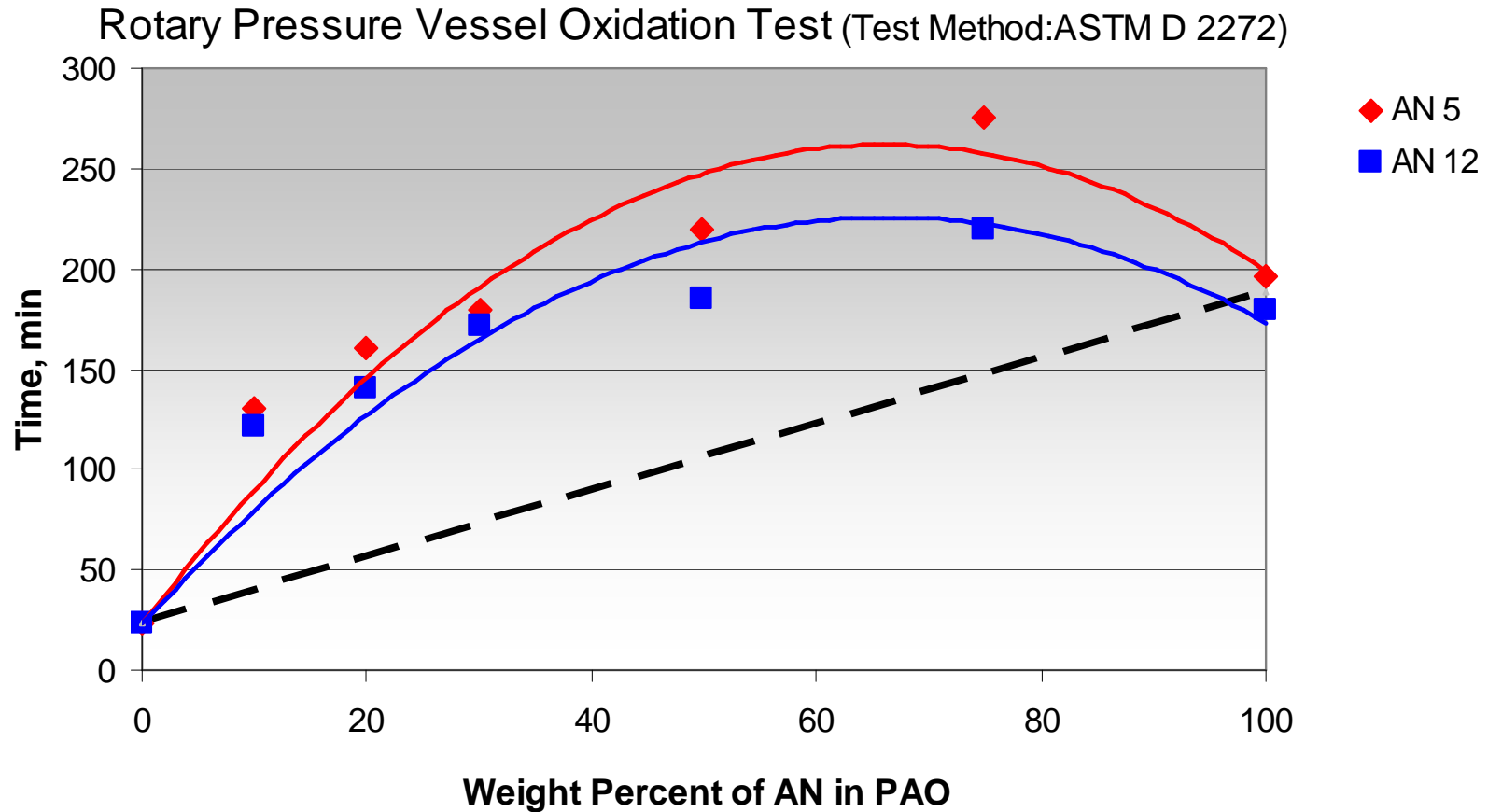
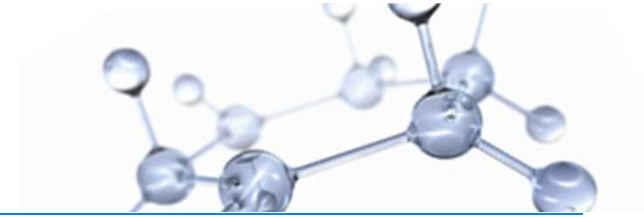


(Test Method: modified in house Oxidation-Corrosion Test in the presence of air and metal coupons)

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 °C	71	5
48 hours @ 177 °C	103	5
24 hours @ 191 °C	76	3

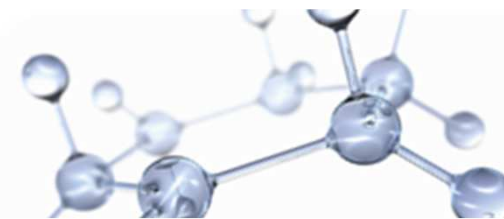
AN improves the oxidative performance of PAO-based formulations compared to ester

Synergy with PAO



**Blending Alkylated Naphthalene with PAO
yields more oxidative resistant fluids.**

Hydrolytic stability

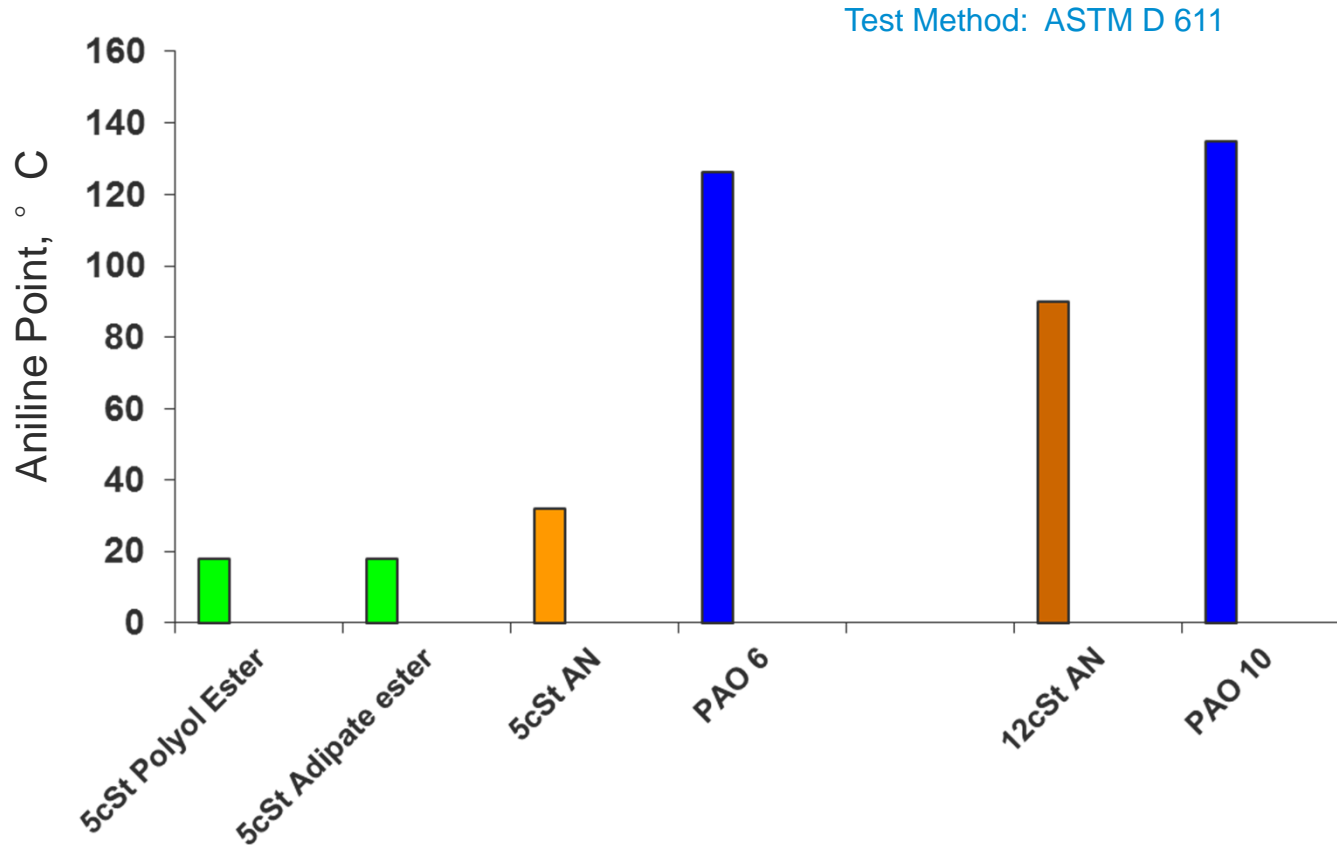
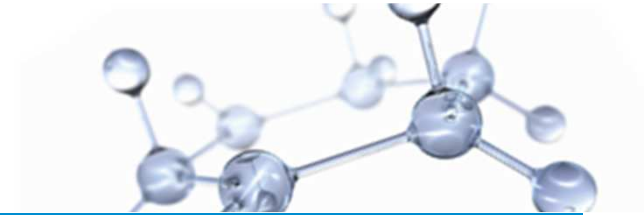


Test Method: ASTM D 2619

ISO VG 32	Ester Blend	AN Blend
6 cSt PAO	73 %	73 %
Adipate Ester	25 %	---
5 cSt AN	---	25 %
Additives	2 %	2 %
<u>ASTM D 2619</u>		
Copper Corrosion, mg/cm ²	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



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

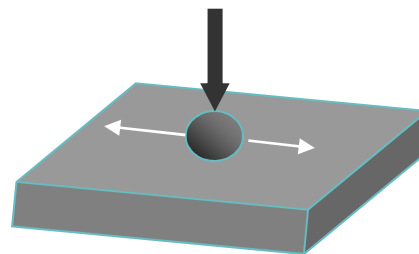
Lubricity



Test Method: ASTM D 6079

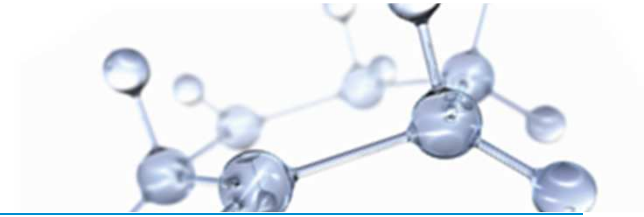
HFRR ASTM D 6079	PAO	5cSt AN	Polyol Ester
Kinematic Viscosity @ 100 C, cSt	3.87	4.83	4.39
Wear Scar Diameter, micron	368	242	246
Average Coefficient of Friction	0.157	0.110	0.098
Average Film %	20	75	83

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

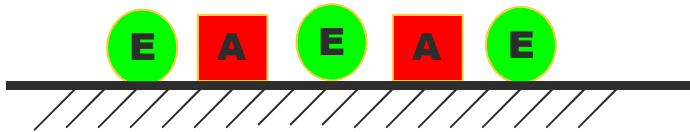


AN offers similar wear protection to ester and can help reduce friction

Competition for the surface

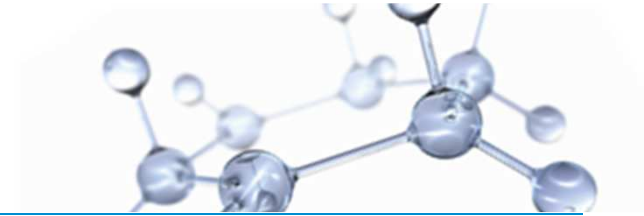


E = Ester Molecule **A** = Additive Molecule **AN** = AN Molecule



AN may improve additive effectiveness through less competition for the surface

Elastomer effects

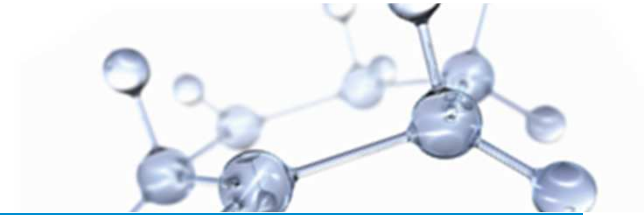


Test Method: ASTM D 471

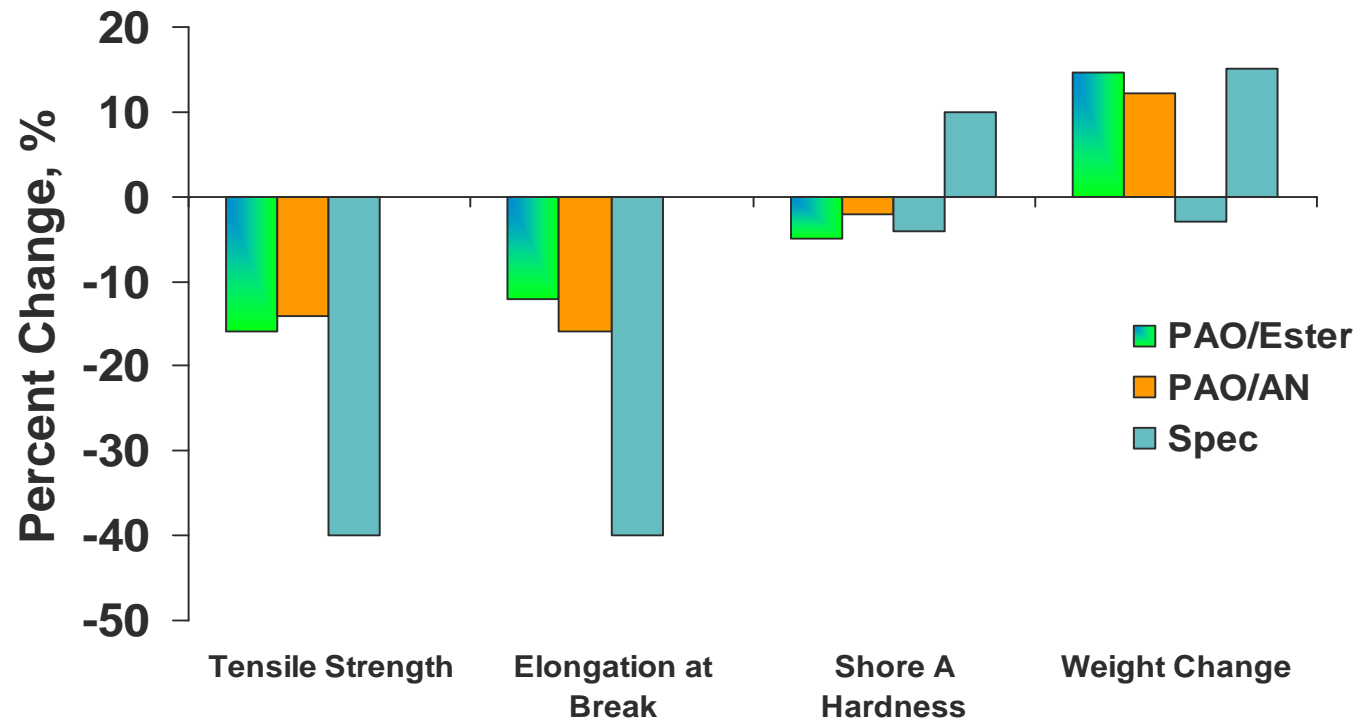
	Polyol Ester	Adipate Ester	6 cSt PAO	5 cSt AN	12 cSt AN
Fluoroelastomer*					
volume change, %	4.7	3.4	0.4	0.8	0.4
Polyacrylate*					
volume change, %	27.4	19.8	-2.2	17.9	1.2
Nitrile**					
volume change, %	16.9	12.0	-3.3	14.1	0.1
* 240 hrs, 150 °C					
** 240 hrs, 100 °C					

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

Elastomer performance

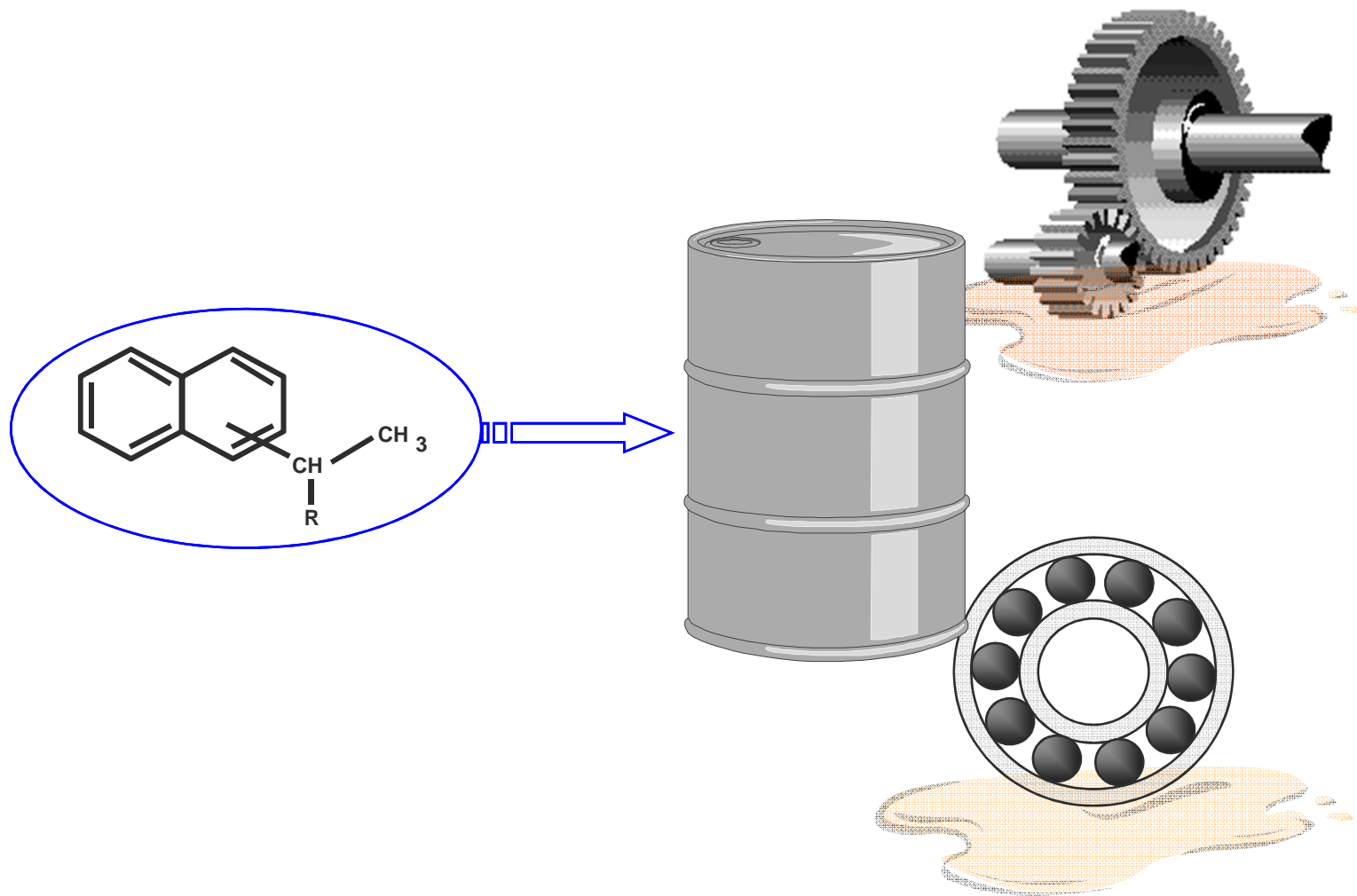
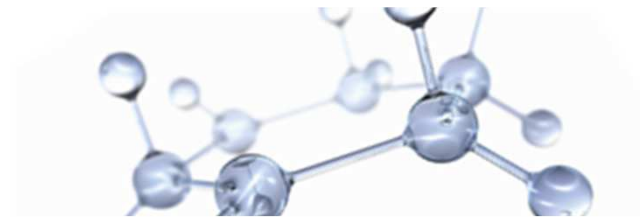


Volkswagen VW 503 VACMAC Seals on ACEA C3 SAE 5W-30 Engine Oils



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

An in service



Improved additive response

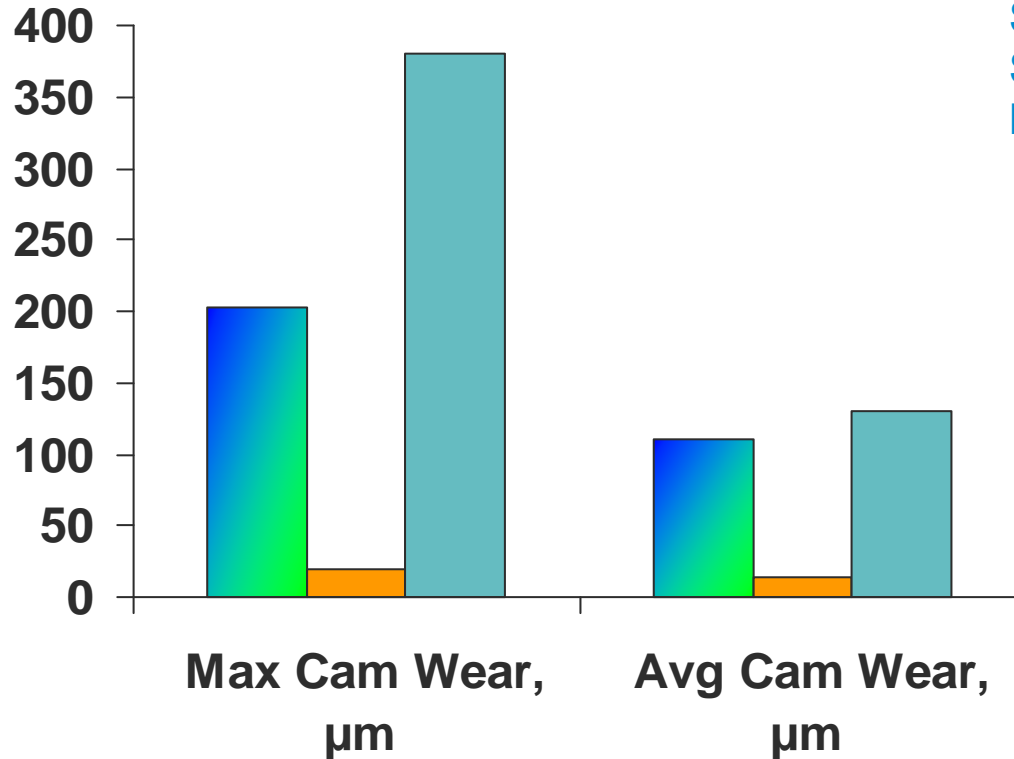
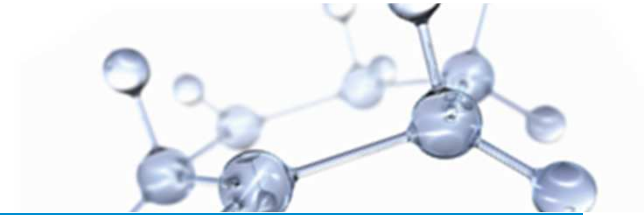


Test Method: ASTM D 4472

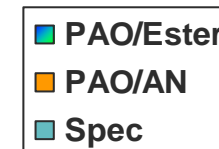
ISO VG 220	Ester Blend	AN Blend
40 cSt PAO	78 %	78 %
Adipate Ester	20 %	---
5 cSt AN	---	20 %
Additives	2 %	2 %
4-Ball Wear Test (D 4472)	Wear Scar, mm	
1800 rpm, 93 °C for 30 minutes		
60 kg load	0.822	0.739
80 kg load	2.094	0.822

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

Improved additive response

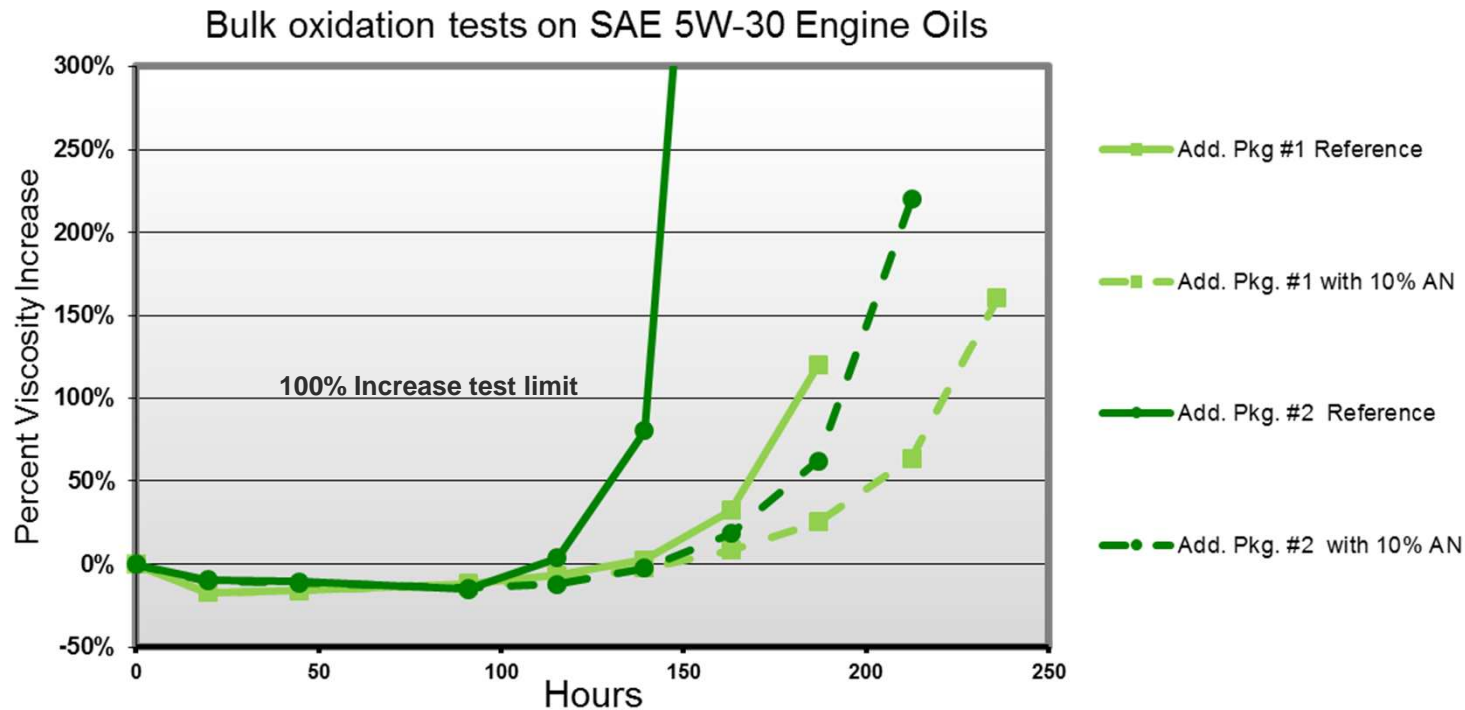
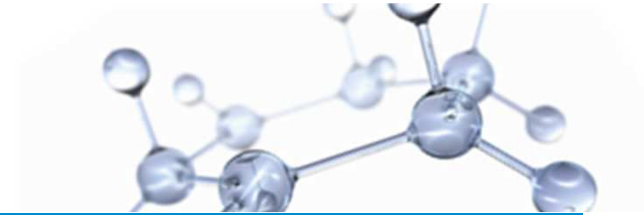


Sequence VE Engine Test
SAE 5W-40, API CG-4
Heavy Duty Engine Oils



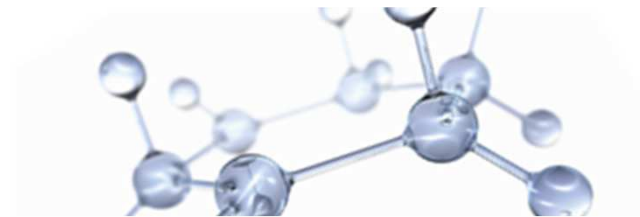
Synthetic heavy duty engine oils blended with PAO and AN demonstrate improved wear performance to PAO/ester formulations.

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

Improved engine deposits

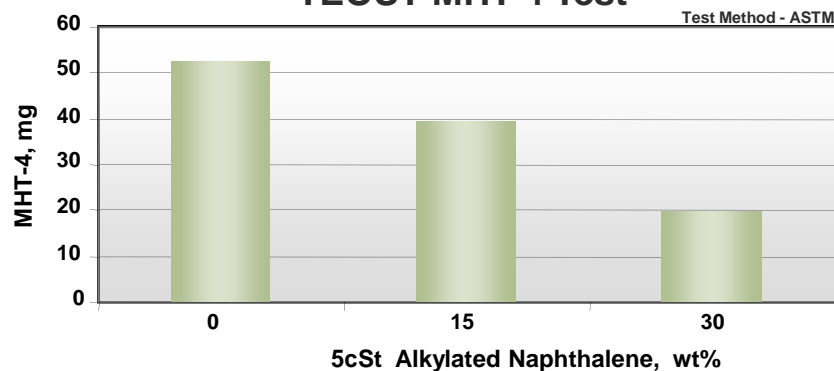


Caterpillar 1-K Diesel Test*

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



TEOST MHT-4 Test



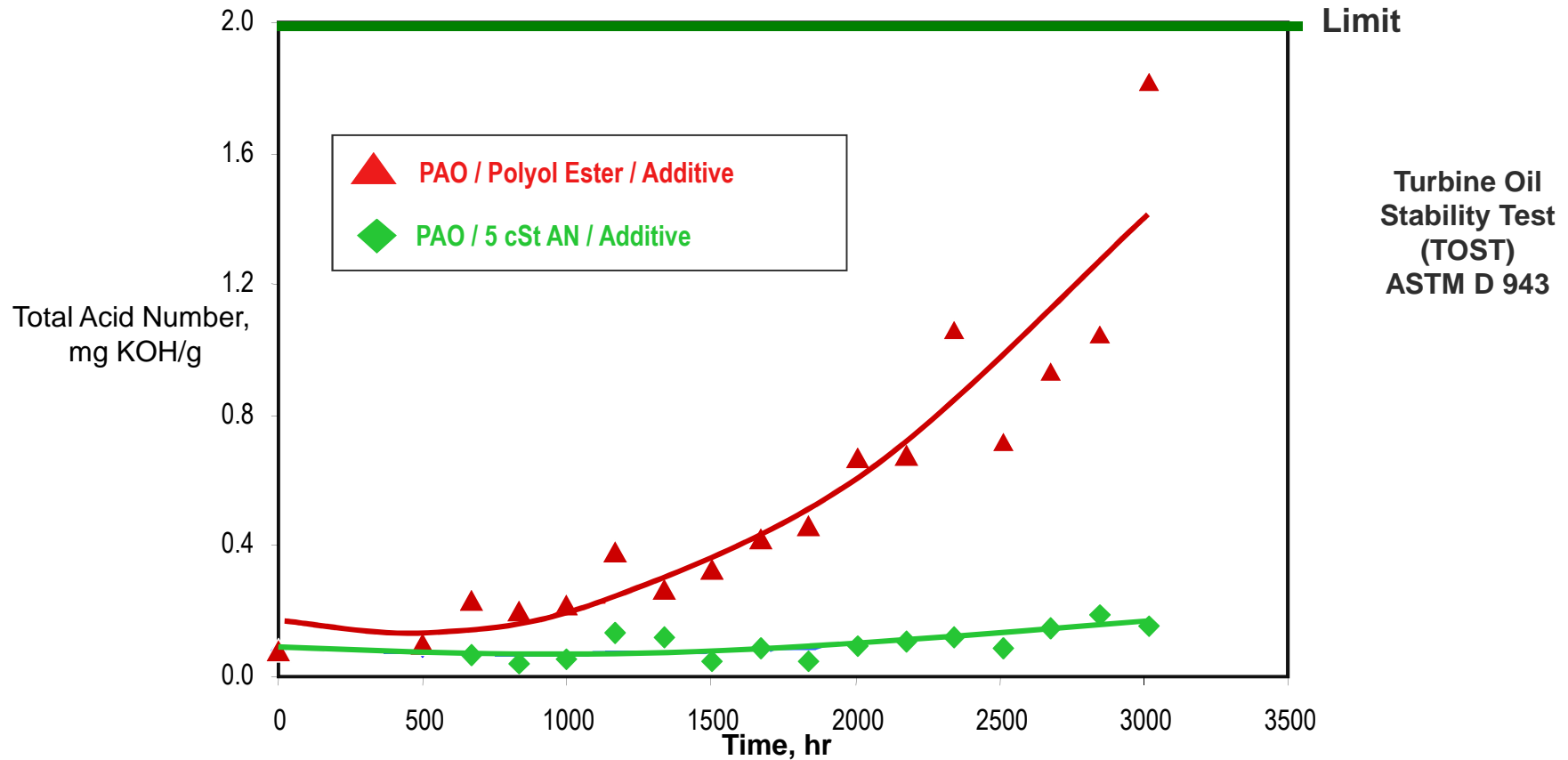
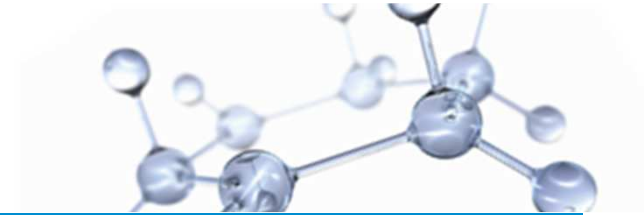
Alkylated Naphthalene helps provide improved deposit protection in engine oil formulations

* CI-4 quality oil in Gp II base stocks

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BASE STOCKS | Innovative
lubricants
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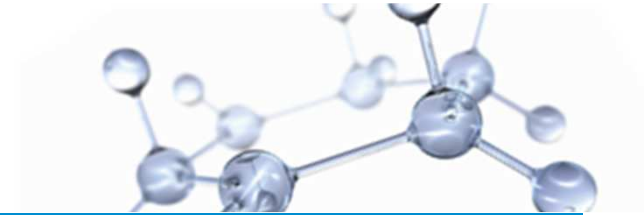
Source: Exxon Mobil data

ISO VG 46 compressor oil



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

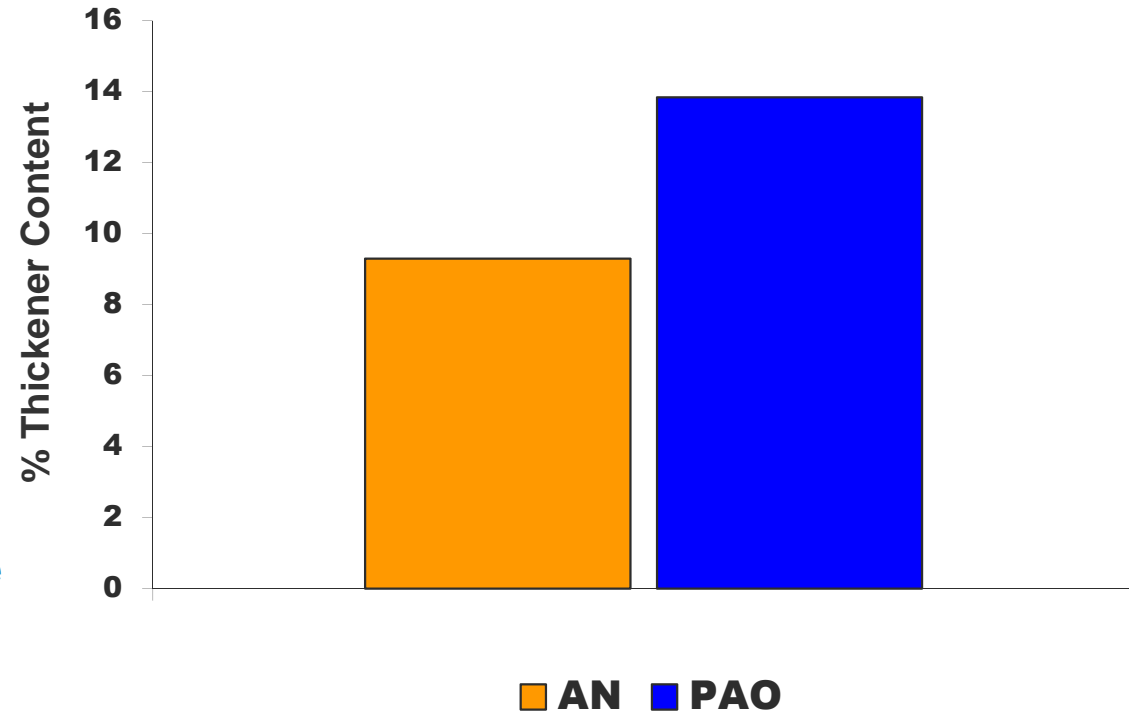
Greases



Two Greases Manufactured:

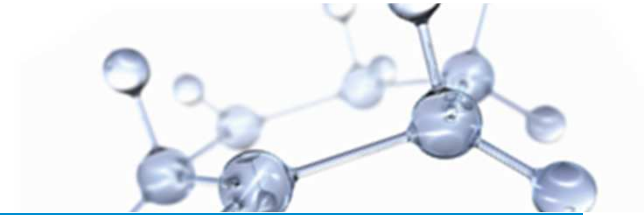
1. 100% AN
2. 100 % PAO

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



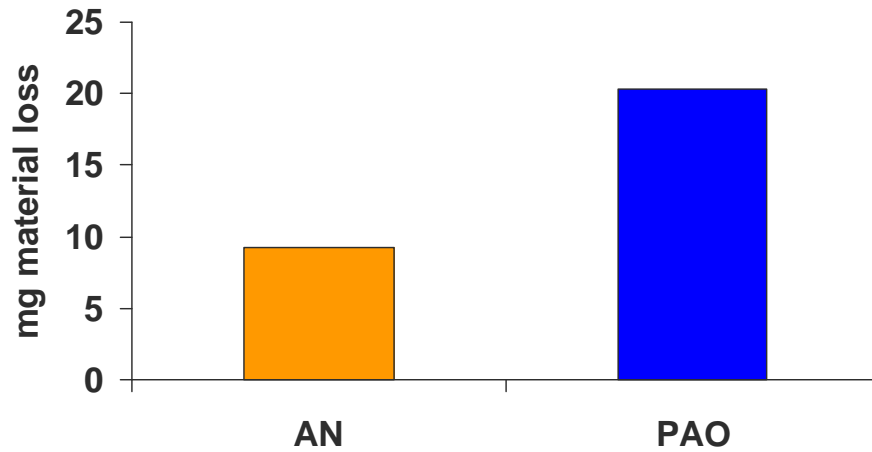
The solvency of AN allows improved thickener efficiency with good mechanical stability in synthetic grease manufacture.

Greases

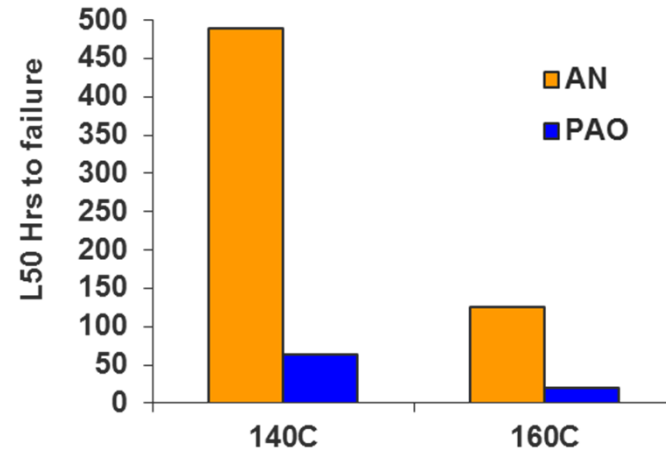


NLGI #2 Li Complex grease
110cSt base oil viscosity
Same additive package

Fretting wear (Test Method: D 4170)

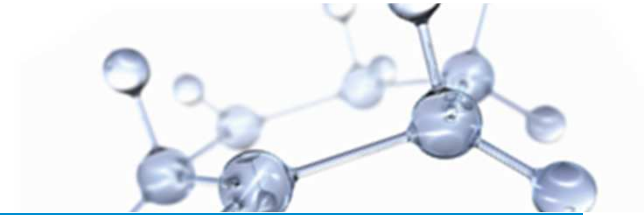


FE9 Bearing test (Test method: DIN 51821)



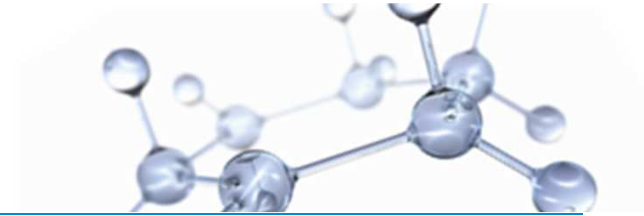
AN offers good protection in greases

Challenges for formulators of food grade fluids

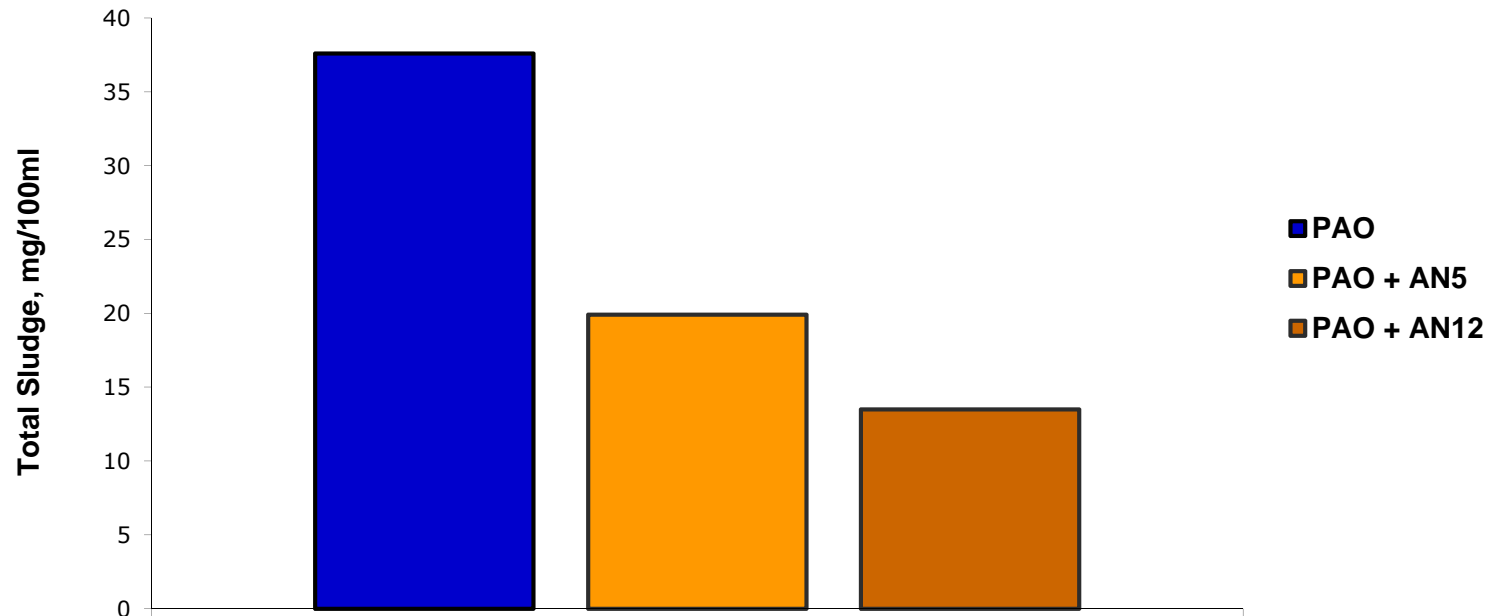


- New laws on food health and safety are being developed world-wide
- Limited selection of H1/HX-1 base stocks which can provide improved oxidation, solvency and seal performance
- Limited selection of additives approved for food grade applications
- Treat rates of additives approved for food grade applications 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)



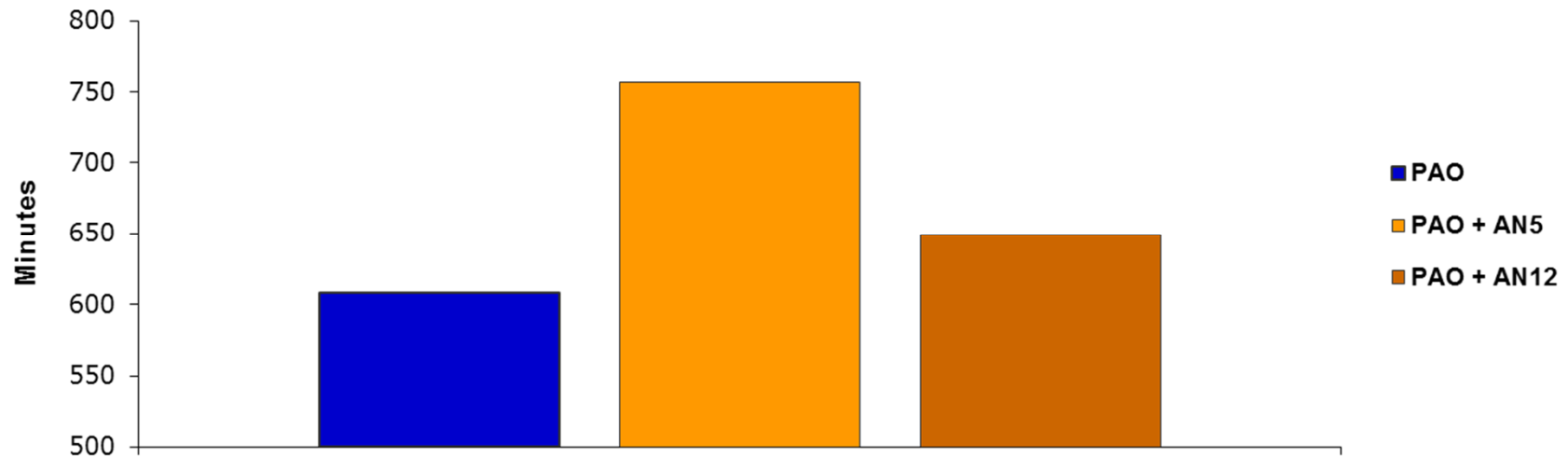
Addition of Synesstic™ AN base stocks to PAO increases overall blend solubility and cleanliness in formulated industrial oils.

Synesstic™ AN base stocks

Oxidation stability

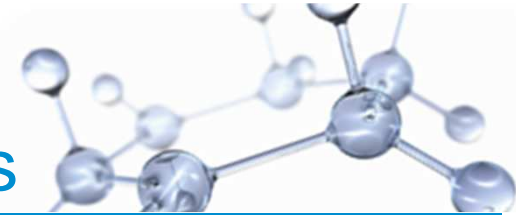


ISO VG 46 - Rotary Pressure Vessel Oxidation Test (RPVOT) (ASTM D2272)



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

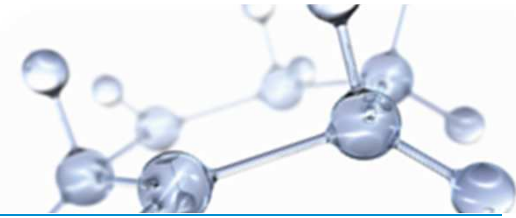
Synesstic™ AN base stocks benefits



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



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