ZSCHIMMER & SCHWARZ

ESTERTEC® VSP – NEXT GENERATION ESTERS FOR VALUE, SUSTAINABILITY AND PERFORMANCE

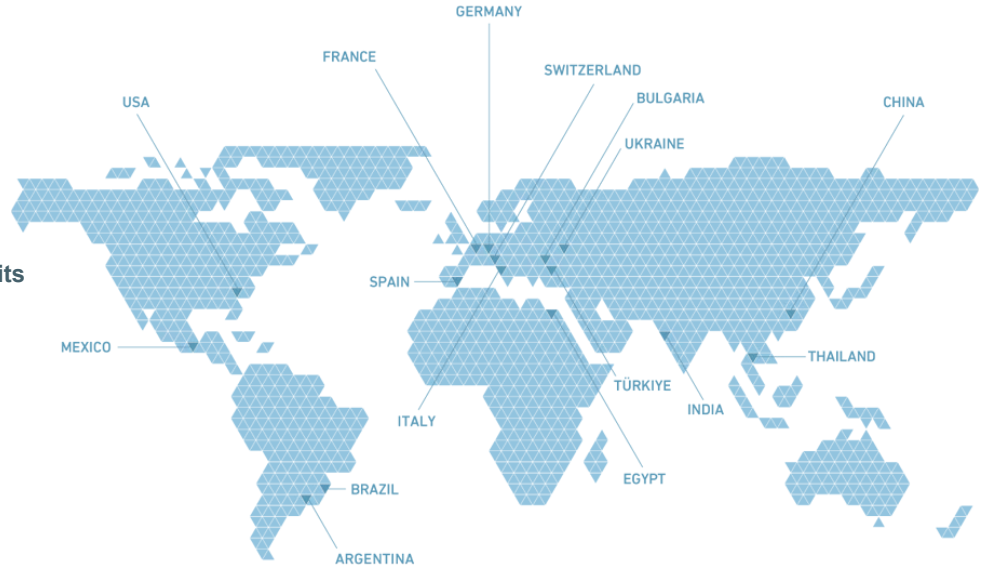
Doug Placek

Global Business Division Director

STLE Annual Meeting – New Orleans, LA, USA
Commercial Marketing Forum
May 18, 2026

Zschimmer & Schwarz Group – Company Profile

28 subsidiaries
in 17 countries
on 5 continents
with 21 production units



- Lubricant Components
- Industrial Specialties
- Fibre/Textile Auxiliaries
- Personal Care
- Ceramic Auxiliaries
- Cleaning Specialties
- Leather Auxiliaries

1894

Foundation of the company in Chemnitz, Germany

1909

First in-house production

1959 - 2019

Rapid globalisation. New company headquarters in Oberlahnstein.

ISO 9001 ISO 14001 ISO 50001

2021

Joining the United Nations Global Compact

UN GLOBAL COMPACT

2020-26

Z&S Commitment to Sustainability

ecovadis GOLD | Top 5% Sustainability Rating JAN 2026

ecovadis SILVER | Top 15% Sustainability Rating JAN 2026

ecovadis BRONZE | Top 35% Sustainability Rating JAN 2026

Market Trends Favor Synthetic Ester Lubricant Components

HIGHER PERFORMANCE AND LONGER LIFE FOR OVERALL LOWER COST

- Wider temperature range performance
- Improved control of friction and wear
- Energy efficiency advantages
- Environmentally friendly with ESG and carbon footprint advantages whenever possible
- Availability of Group III base oil

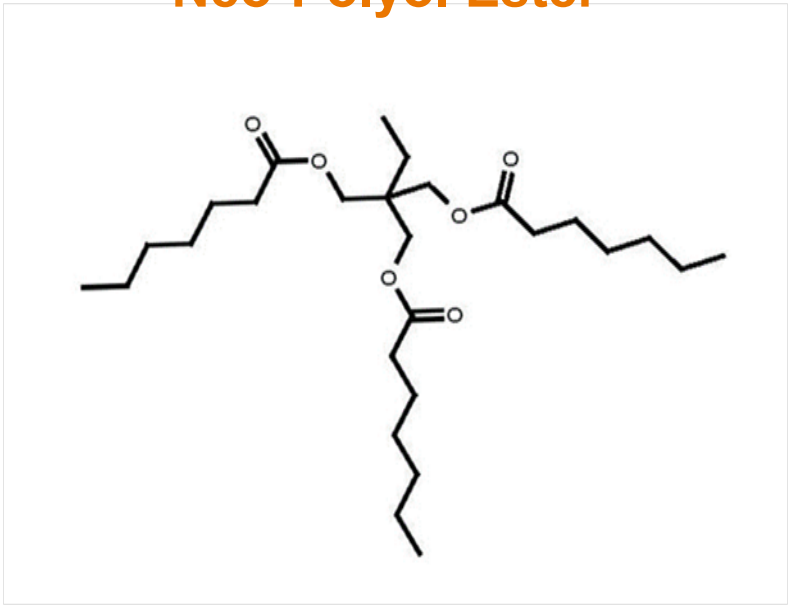
Agenda

1. Introduction to VSP synthetic esters
2. Performance advantages
   - 2025 STLE CMF
     - ✓ Lower friction and wear
     - ✓ Hydrolytic stability
     - ✓ Low Volatility
   - **Today! 2026 STLE CMF:**
     - ✓ Oxidative stability, Reduced deposit tendency
     - ✓ AW additive synergy
     - ✓ Dielectric properties
3. Value proposition – Cost Savings

Introduction to VSP synthetic ester technology

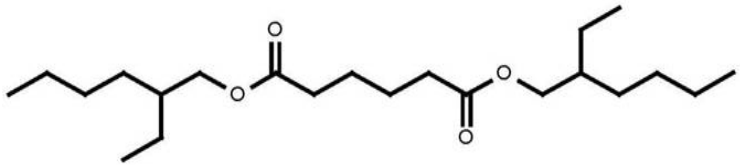
Standard Synthetic Ester Molecular Structures

Neo-Polyol Ester



TMP Ester

Dibasic Acid Ester

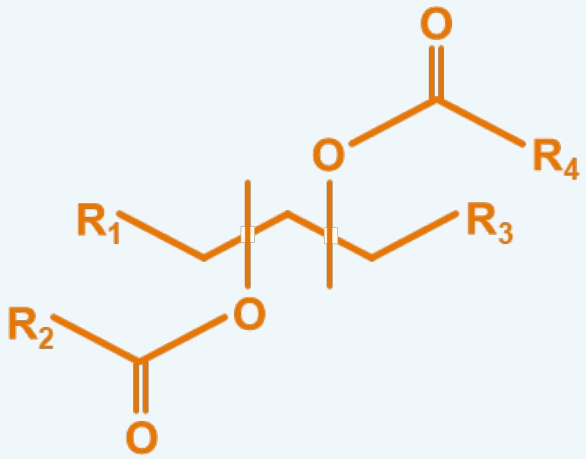


Adipate Ester

A New Ester Technology Is Now Available

- Novel structure, unique production process
- Based on standard raw materials that are globally and readily available commodities
- High stability vicinal ester molecular positioning
- Steric hindrance that improves oxidative stability
- Secondary alcohols on adjacent carbons improve hydrolytic stability

"VSP" Synthetic Esters with Improved Performance



VSP Molecular Structure

EsterTec
synthetic esters

EsterTec
synthetic esters

The VSP Molecular Technology Platform. Exceptional Performance in a Wide Viscosity Range.

Product Name	ESTERTEC 2N-1416	ESTERTEC 2LN-1418	ESTERTEC 2L-1425	ESTERTEC 2G-1432	ESTERTEC 7GX-1446	ESTERTEC 7GX-1468	ESTERTEC 8LX-14100	ESTERTEC 8LX-14150
KV100, cSt	3.6	4.1	5	7	9	11	14	18
KV40, cSt	16	18	25	32	46	68	100	150
Viscosity Index	115	125	140	180	165	155	140	130
Pour Point, °C	-60	-40	-25	-42	-40	-40	-35	-30
Density	0.895	0.893	0.890	0.890	0. 900	0.915	0.925	0.935
NOACK volatility, %	9	7	3	1	1	1	1	1
Biogenic Content, %	64	65	70	74	60	50	40	30
Oxidative Stability	☑	☑	☑	☑	☑	☑	☑	☑
Hydrolytic Stability	☑	☑	☑	☑	☑	☑	☑	☑
Friction/Wear Reduction	☑	☑	☑	☑	☑	☑	☑	☑
Energy Efficiency Advantage	☑	☑	☑	☑	☑	☑	☑	☑
Cost/Performance Advantage	☑	☑	☑	☑	☑	☑	☑	☑

☑ = Equal or Better than standard synthetic esters

EsterTec
synthetic esters

A Novel and Cost-Effective Molecular Technology Platform

VSP Product Viscosity Grade	ESTERTEC 2N-1416	ESTERTEC 2LN-1418	ESTERTEC 2L-1425	ESTERTEC 2G-1432	ESTERTEC 7GX-1446	ESTERTEC 7GX-1468	ESTERTEC 8LX-14150
KV100, cSt	3.6	4.1	5	7	9	11	18
KV40, cSt	16	18	25	32	46	68	150
Viscosity Index	110	125	140	180	165	155	130
Pour Point, °C	-60	-40	-25	-42	-40	-40	-35
Density	0.895	0.893	0.890	0.890	0. 900	0.915	0.935
Noack volatility, %	9	7	3	1	1	1	1
Biogenic Content, %	60	65	70	74	60	50	30

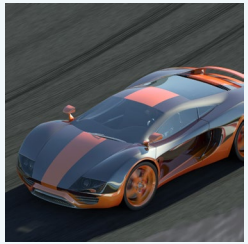
ISO 15-32 Transport / MW / EV Fluids

ISO 68+ OCL / Gear / MW

ISO 32-100 Industrial Lubricants

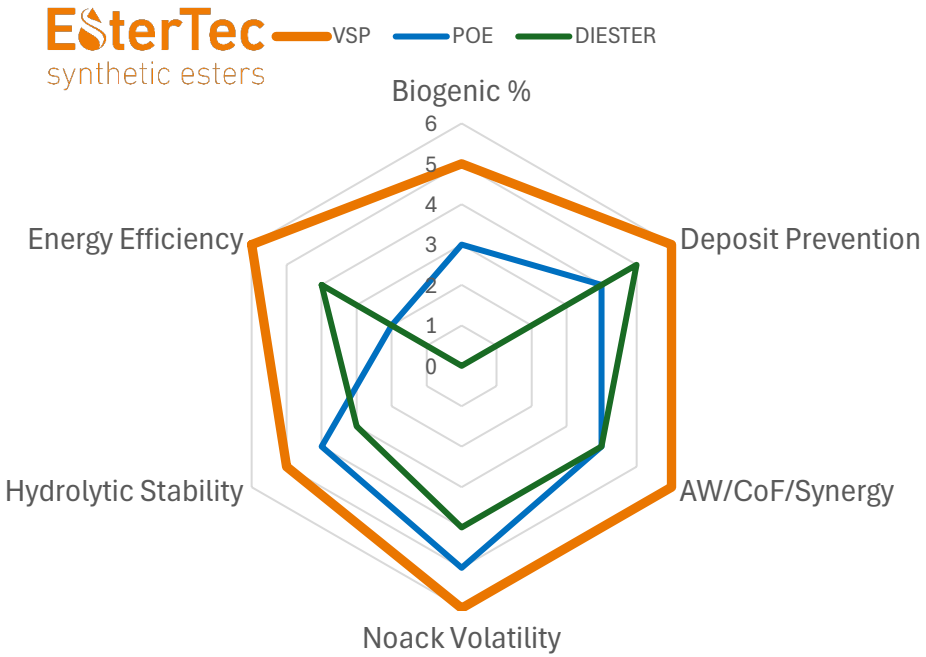
Applications for VSP Synthetic Esters

- Metalworking fluids
- Hydraulic fluids
- Grease
- Compressor fluids
- Transformer oils
- Bearing lubricants
- EALs for environmentally sensitive applications
- Engine oils
- Transmission fluids
- Gear oils
- Drilling muds
- H1 lubricants for food processing
- Multifunctional dielectric/coolant/ lubricants



All the Performance Advantages Expected from a Standard Diester or Polyol Ester, Plus…

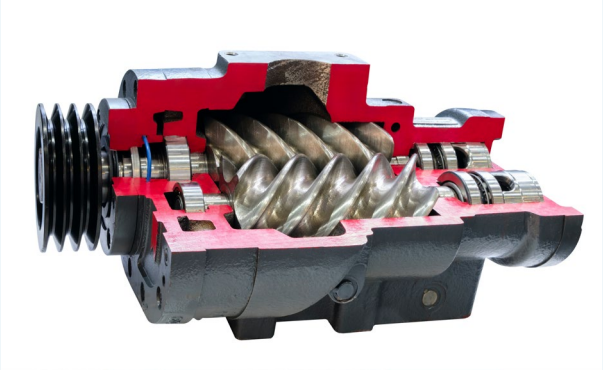


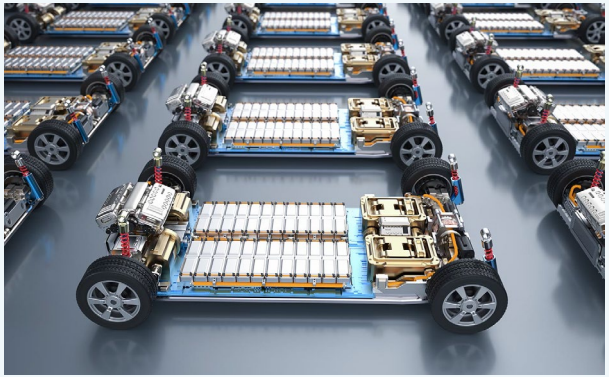
Standard POE Features

- Low Pour Point
- High Flash Point
- Low Foam Tendency
- Good Demulsibility
- Not Corrosive to Copper
- Good Oxidative Stability
- Strong Dielectric Properties
- Good Thermal Conductivity
- Clear with Low Odor & Color

Target Applications for ESTERTEC VSP Synthetic Esters

- **Reduced Friction and Wear**
  - Reduce formulation additive content (e.g., metalworking, automotive, industrial)
  - EV lubricant/coolants need better EP/AW
- **Low Volatility**
  - Improved low viscosity lubricant performance (0W EO, high speed EV motors)
  - Extended fluid life in high temp. applications (bearing grease, mist lubes, engine oil)
- **Excellent Hydrolytic Stability**
  - Metalworking emulsions
  - ICE engine oils, H_2ICE engine oils
  - HFO refrigeration compressor oils
  - Paper machine oils
- **Dielectric Fluids**
  - EV multifunctional coolant/lubricant, data center immersion coolants
  - Excellent heat transfer, high flash/fire point, high dielectric strength





Performance Advantages of VSP Next Generation Synthetic Esters

Comparison of VSP to Standard Synthetic Esters Friction and Wear – Without Additives

	Test Method	VSP 3.6 EsterTec 2N-1416	DIDA	TMP-C7		VSP 7 EsterTec 2G-1432	NPG-DO		VSP 9 EsterTec 7GX-1446	TMP-TO
KV100, cSt	ASTM D7042	3.6	3.6	3.4		7	5.8		9	9
KV40, cSt	ASTM D7042	16	14	14		32	24		46	46
Pour Point, °C	ASTM D5950	-60	-60	-65		-42	-30		-40	-40
4-Ball Wear, mm*	ASTM D4172	0.52	0.84	0.65		0.63	0.72		0.61	0.77
Wear Protection Improvement**	Δ	---	78%	59%		---	31%		---	47%
Coefficient of Friction*	ASTM D4172	0.167	0.208	0.217		0.182	0.201		0.178	0.246
CoF Decrease, %	Δ	---	25%	30%		---	10%		---	38%

*40kg load, 1200 rpm, 75C, 52100 steel, 1 hour

**Considering the Hertzian contact diameter of 0.43mm

ISO 15-32 Transport / MW / EV Fluids

ISO 32-68 Industrial Lubes

ISO 68+ OCL / Gear / MW

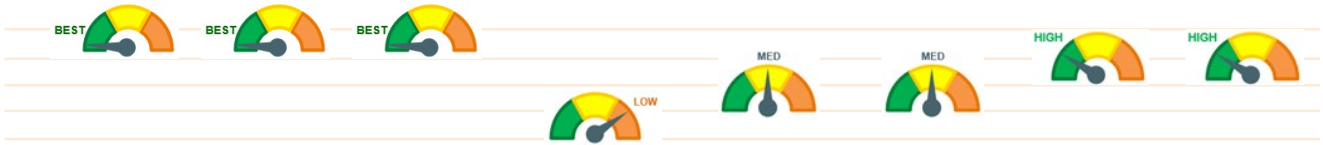
Hydrolytic Stability, ISO 15 – 150 Viscosity Grades

ESTERTEC DEMONSTRATES EXCELLENT HYDROLYTIC STABILITY.

- All esters compared with no inhibitor or passivation additives

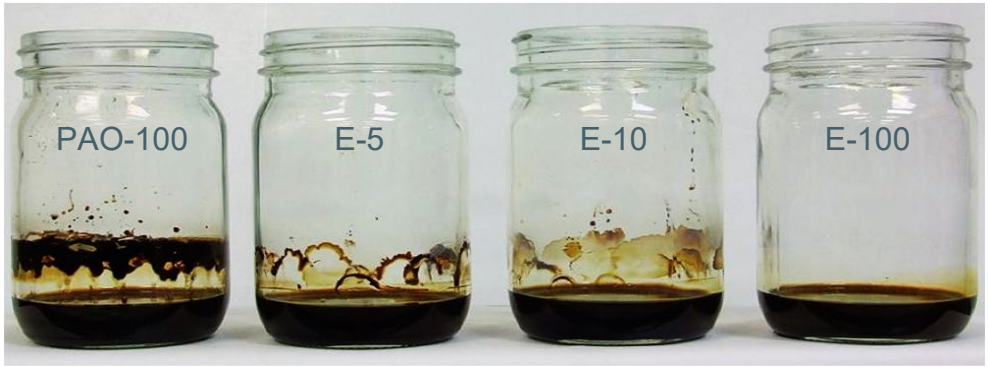
ASTM D2619	EsterTec 2N-1416	EsterTec 2G-1432	EsterTec 8LX-14150	NGDO	DIOA	DTDA/1	PE C7/9	TMP C8/10	Pass/ Fail*
Oil Tan Δ, mg KOH/g	0.03	0.01	0.12	2.90	0.16	0.05	0.10	0.05	<0.2
Water Layer Acidity, mg KOH	1.00	0.80	0.30	18.0	3.47	3.75	1.65	1.26	<5.0
Copper Corrosion Rating, ASTM D130	1b	1b	1b	2	1b	1b	1b	1b	<2

Rating Scale:
0-2 = HIGH
2-5 = MED
>5 = LOW



*Typical limits for a formulated lubricant

Ester base oils are used as blend components to reduce deposits and sludge



BLENDS OF PAO AND POE

- All fluids were ISO 68
- Tested 20 hours at 260ºC
- All levels of POE will significantly reduce deposits and improve low temperature viscometrics

Measuring Deposit Formation Tendency in the Laboratory

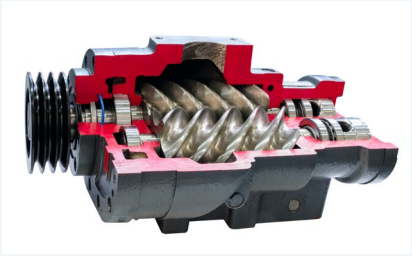
Oxidation:

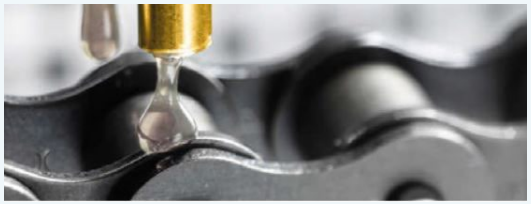
- OOT - Oxidation Onset Temperature by DSC
- RPVOT – Rotary Pressurized Vessel Oxidation Time

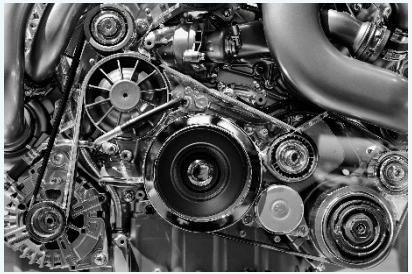
Deposits:

- Panel Coker – High Temperature Varnish/Deposit Test
- 3PP – Three Phase Pan Test
- RCR – Ramsbottom Carbon Residue Test

NOTE: The performance of all base stocks were measured without standard antioxidants and metal passivators







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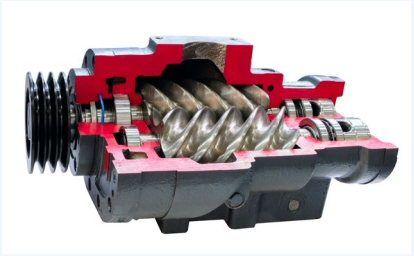
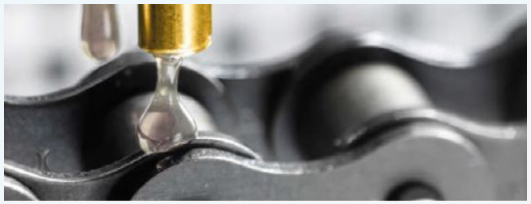
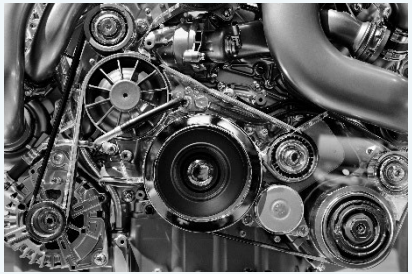


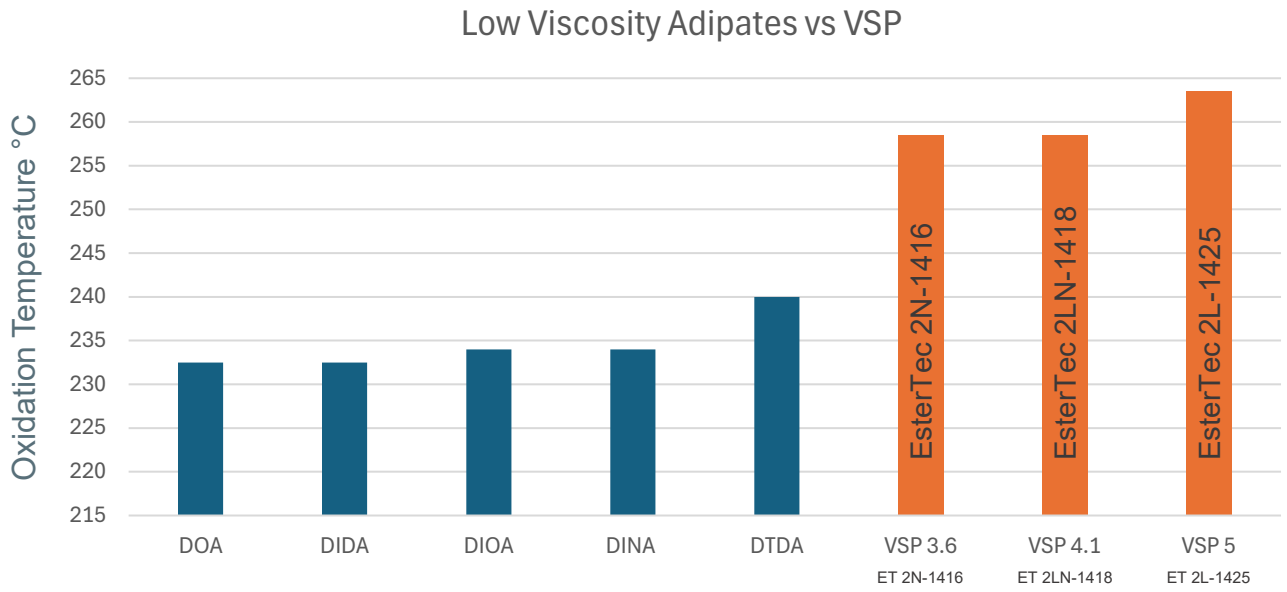




Laboratory Simulations of Lubricant Deposit Formation Tendency

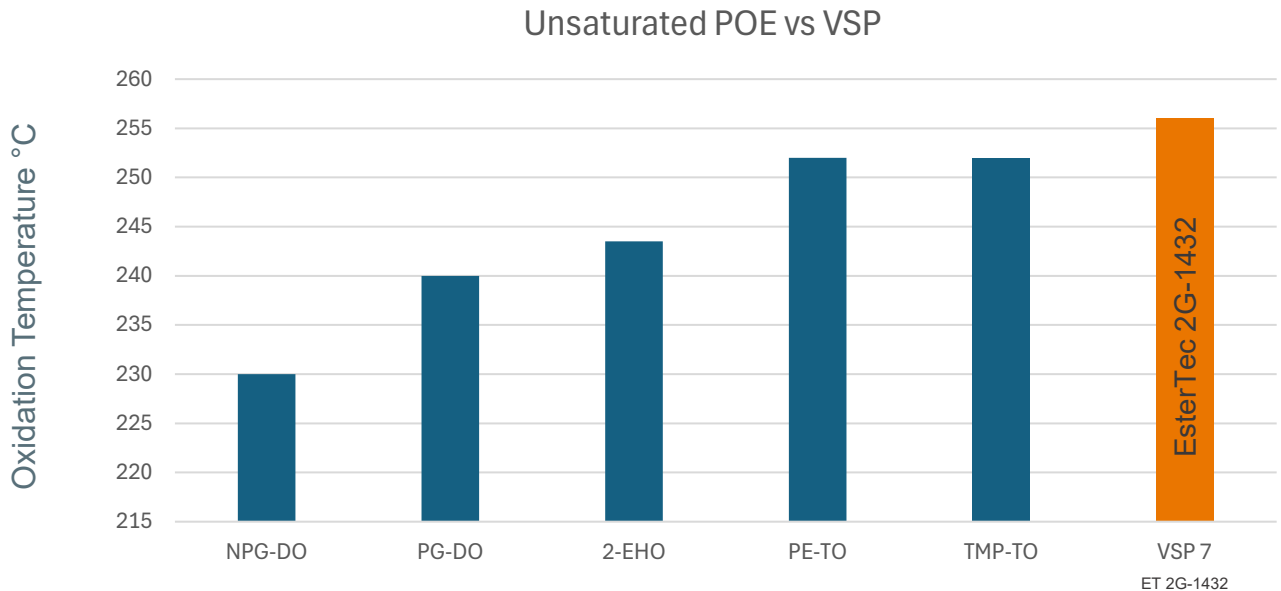
Test	Method	Temperature	Environment	Water?	Catalyst	Screening Purpose
OOT **Oxidation Onset Temperature**	ASTM E2009	Ramp	Air	No	None (aluminum pan)	All
RPVOT **Rotating Pressurized Vessel Oxidation Test**	ASTM D2272	150 °C	Oxygen	YES	Copper coil	Industrial
Panel Coker	FTM 791a	315 °C	Air	No	Steel panel (or other metal choice)	Engine Oils
3PP **Three Phase Pan Test**	Z&S	200 °C	Air	No	None (aluminum pan)	Industrial Gear/Chain
RCR **Ramsbottom Carbon Residue**	ASTM D524	550 °C	Air	No	None (glass)	All

ESTERTEC VSP compared to Adipate Diesters



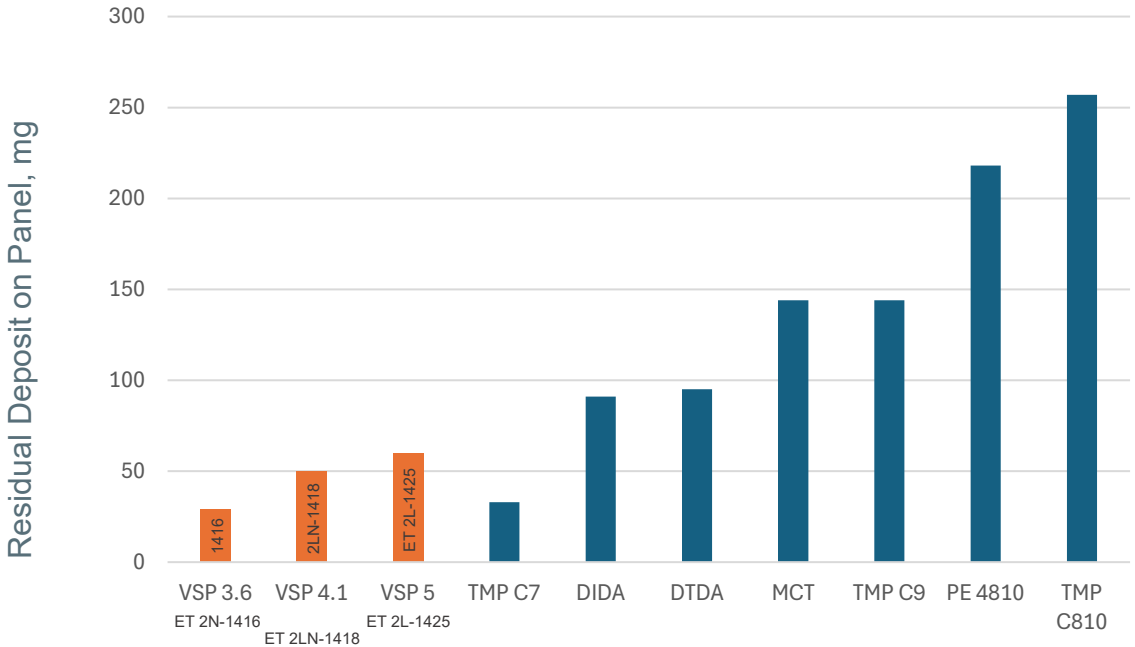
Saturated Adipate Diesters with KV100: 2.3 – 5.3 cSt
Relevant for Engine and Driveline oils

ESTERTEC VSP compared to Unsaturated Esters



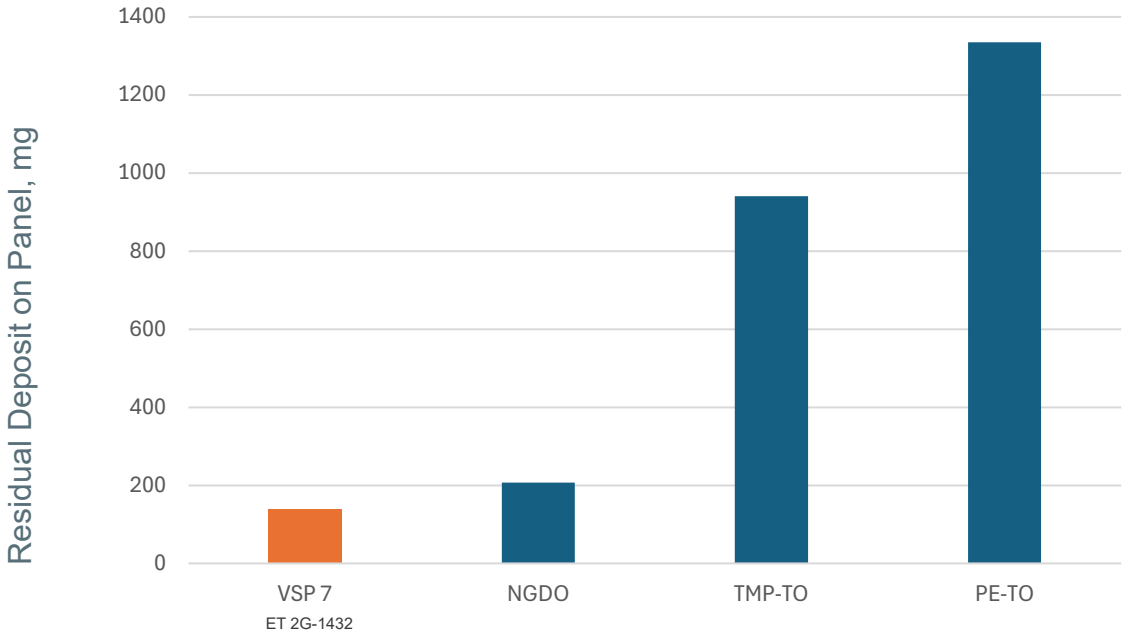
Unsaturated polyol esters with KV100: 5 – 12 cSt
Relevant for standard MW and Industrial Oils

ESTERTEC VSP compared to Saturated Esters



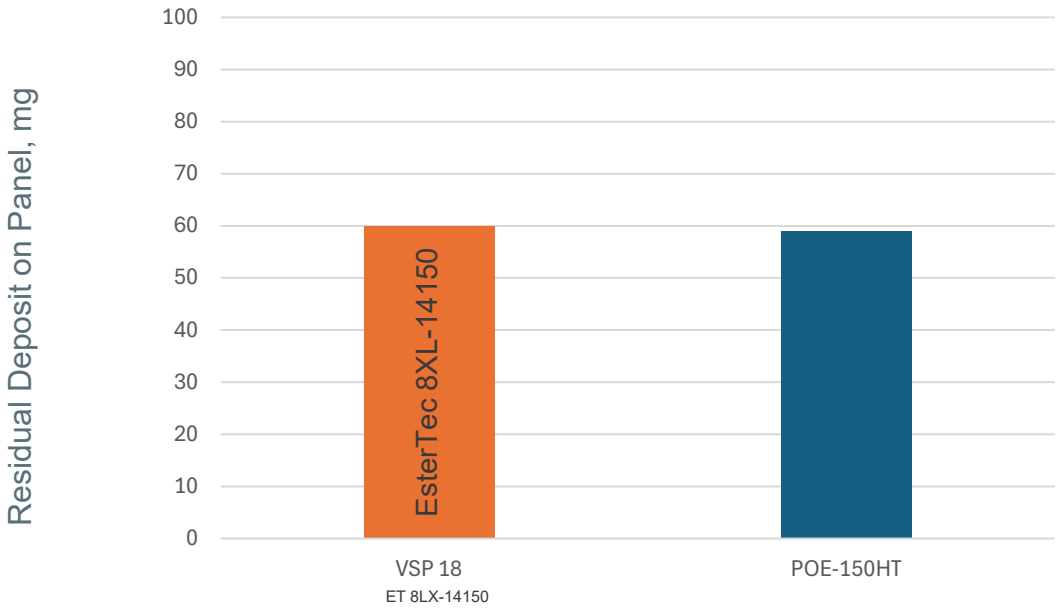
Saturated Polyol Esters with KV100: 3.5 – 6.5 cSt

ESTERTEC VSP compared to Unsaturated Esters



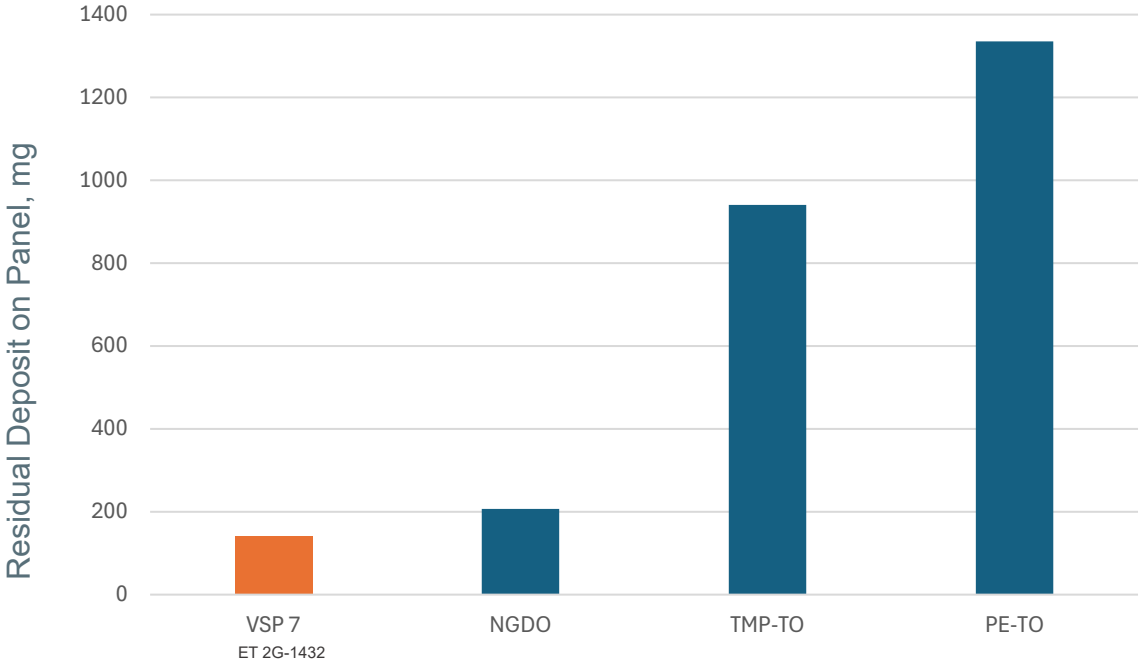
Unsaturated polyol esters with KV100: 5 – 12 cSt

ESTERTEC VSP compared to High Viscosity Saturated Esters



Saturated polyol esters with KV100: 15-20 cSt

Panel Coker Data – Unsaturated Esters



Unsaturated polyol esters with KV100: 5 – 12 cSt
315°C for 8 hours - Steel Panel

3PP Images

Pictures 24 hours after oven tests

Example: Good

Residual “solids” after tilting

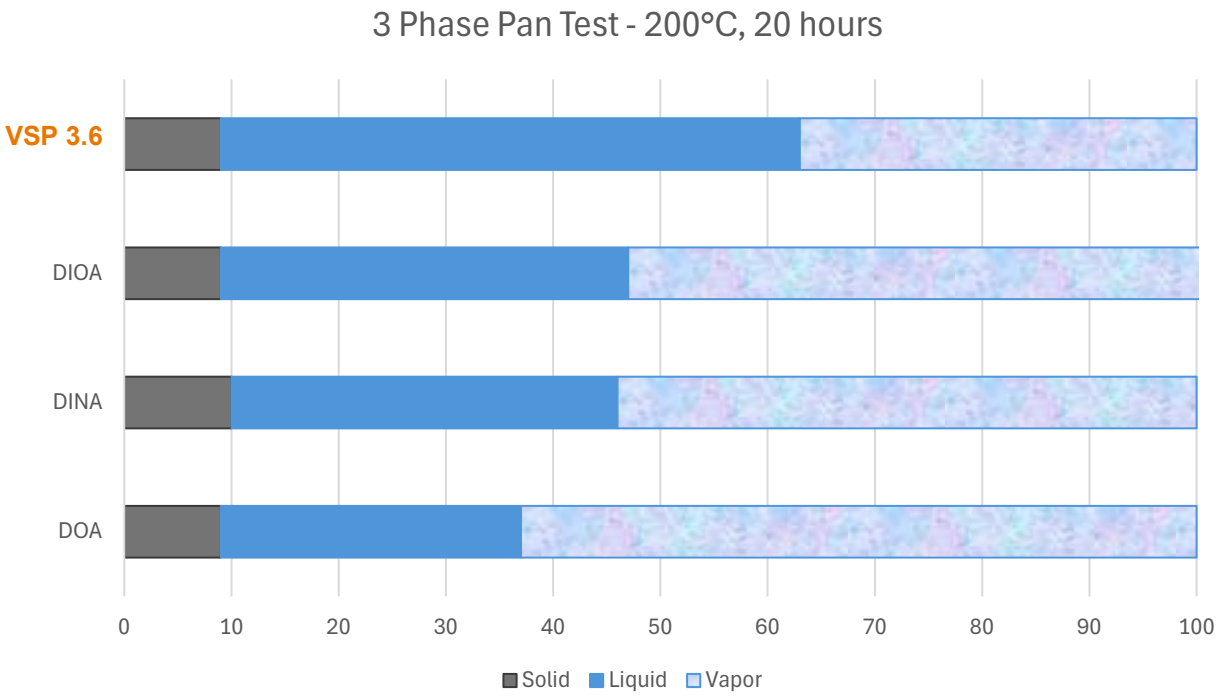
Example: OK

Solid / Liquid / Vapor

<25 / >50 / <40

Example: Poor

3 Phase Pan Test – VSP Compared to Adipate Esters



3PP Images – 24 hours after oven test

Low Viscosity Diesters

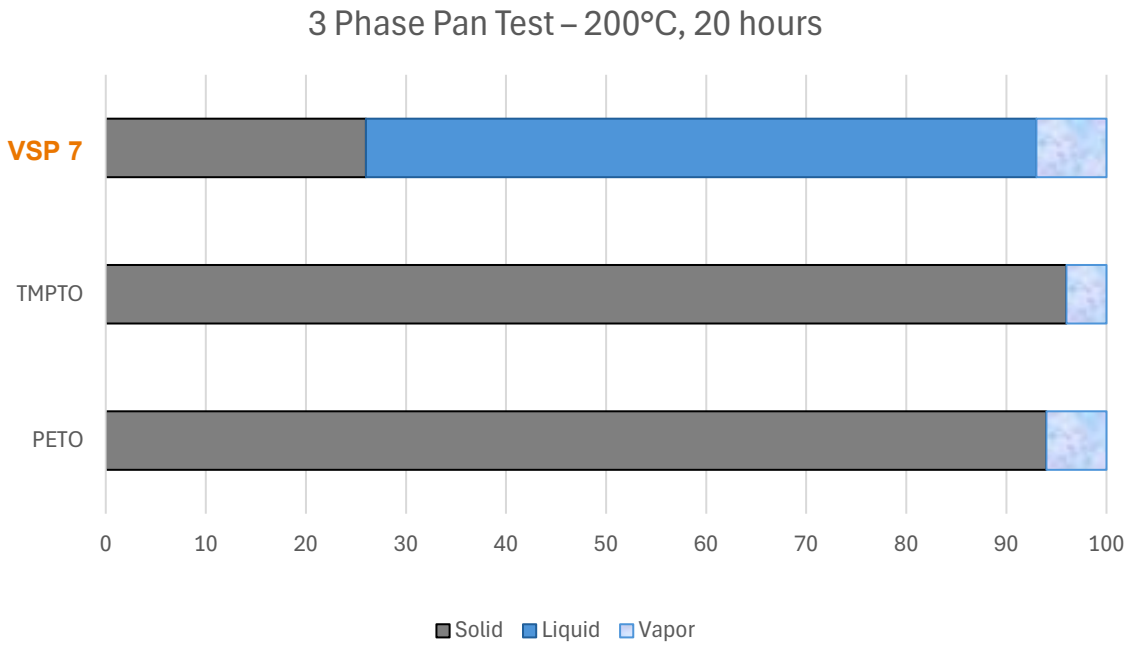
Solid / Liquid / Vapor

9 / 54 / 37

Solid / Liquid / Vapor

10 / 36 / 54

3PP – VSP Compared to Unsaturated Polyol Esters



3PP Images – 24 hours after oven test
Unsaturated polyol esters

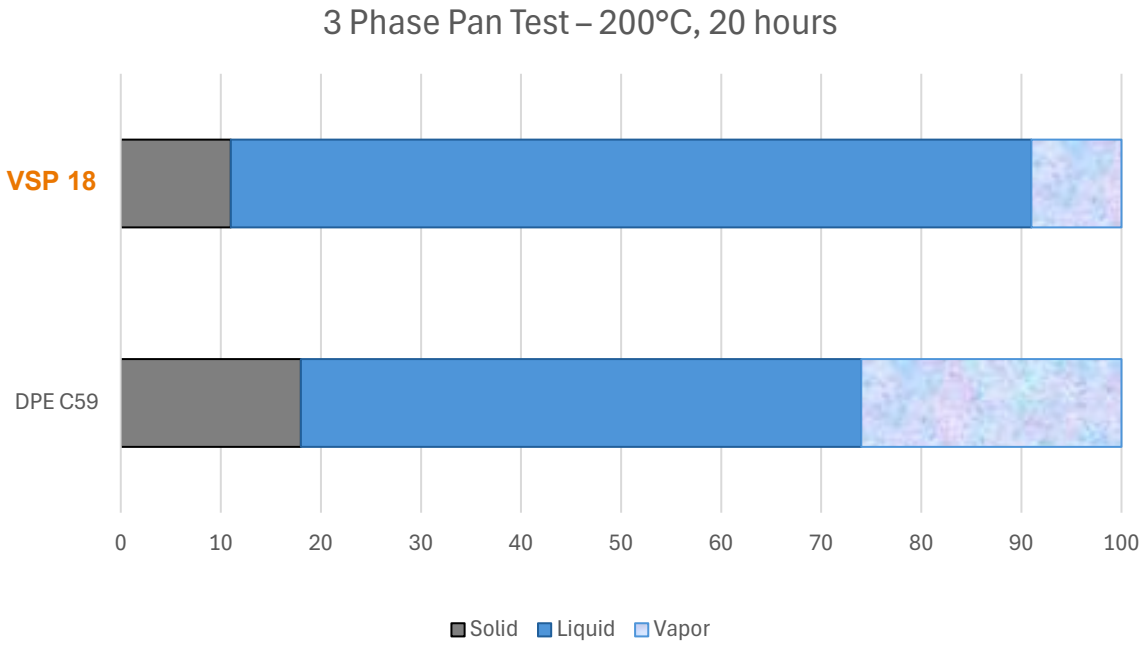
Solid / Liquid / Vapor

29 / 64 / 7

Solid / Liquid / Vapor

96 / 0 / 4

3PP – VSP Compared to DPE Polyol Esters



3PP Images – 24 hours after oven test

High Viscosity DPE esters

Solid / Liquid / Vapor

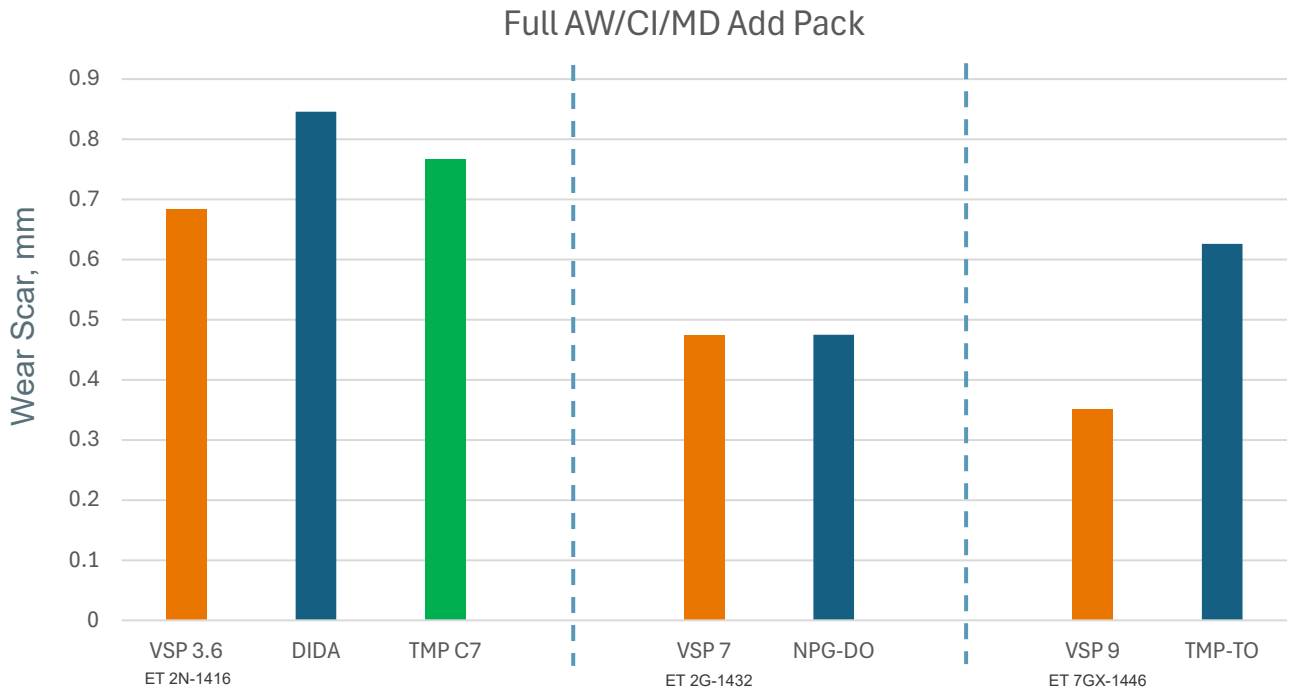
11 / 80 / 9

Solid / Liquid / Vapor

18 / 56 / 26

What Happens When We Include Standard Inhibitor Additives?

ESTERTEC VSP Compared to Standard Esters
Full Industrial Additive Package: AW + CI + MD



Standard Industrial Additive Combination:

1.0% Triaryl Phosphate (AW)
0.5% Oleyl Sarcosine (CI)
0.1% Benzotriazole (MD)

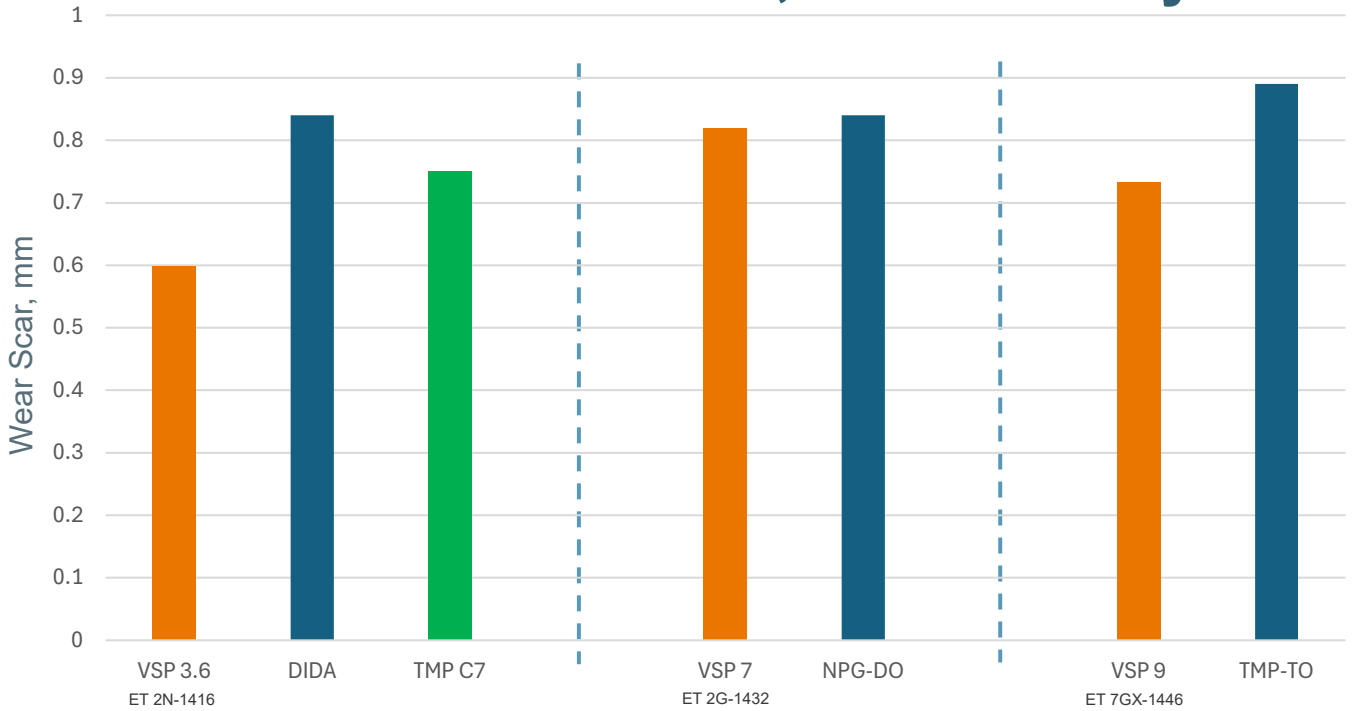
All CoF are low (0.12-0.20)

The VSP base stocks respond with an equal or better AW result, compared to standard synthetic esters.

ASTM D4172: 40kg load, 1200 rpm, 75C, 52100 steel, 1 hour

ESTERTEC VSP Compared to Standard Esters

Partial Add Pack: No AW, CI + MD only



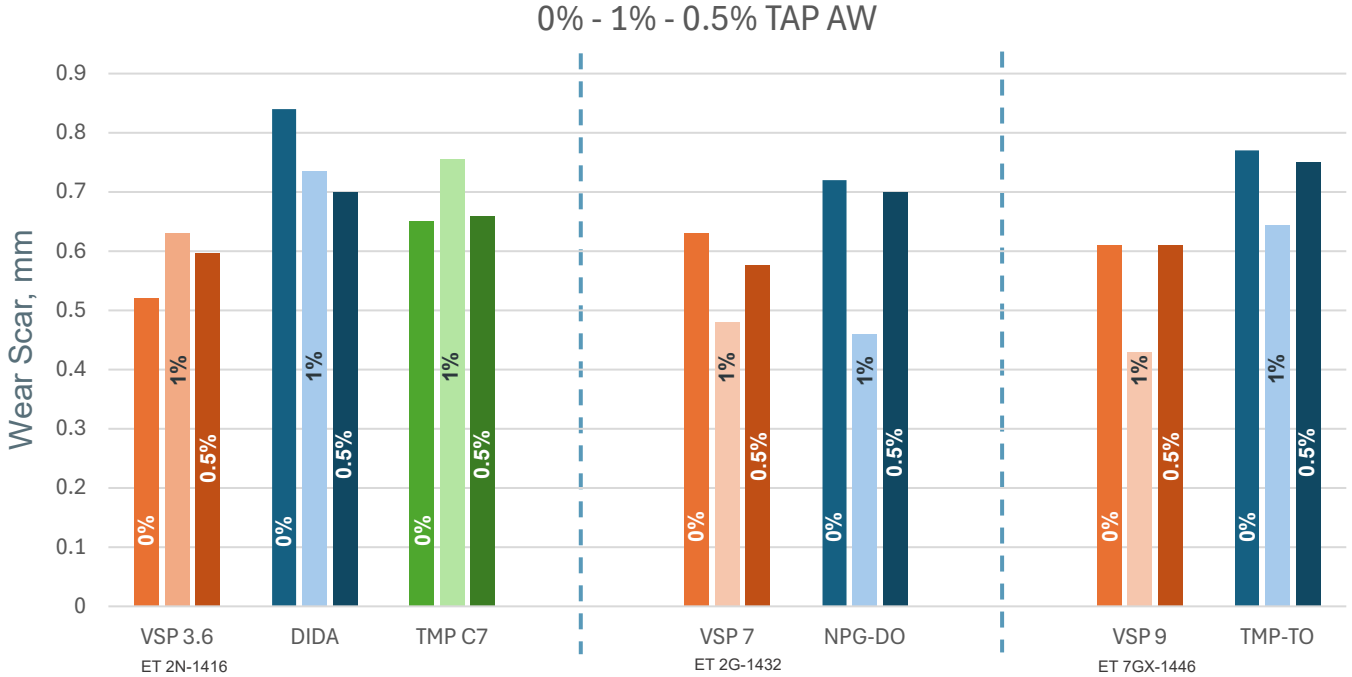
Additive Combination:

0% Triaryl Phosphate (AW)
0.5% Oleyl Sarcosine (CI)
0.1% Benzotriazole (MD)

ASTM D4172: 40kg load, 1200 rpm, 75C, 52100 steel, 1 hour

ESTERTEC VSP Compared to Standard Esters

Various AW levels



ASTM D4172: 40kg load, 1200 rpm, 75C, 52100 steel, 1 hour

EsterTec VSP Dielectric Fluid Properties

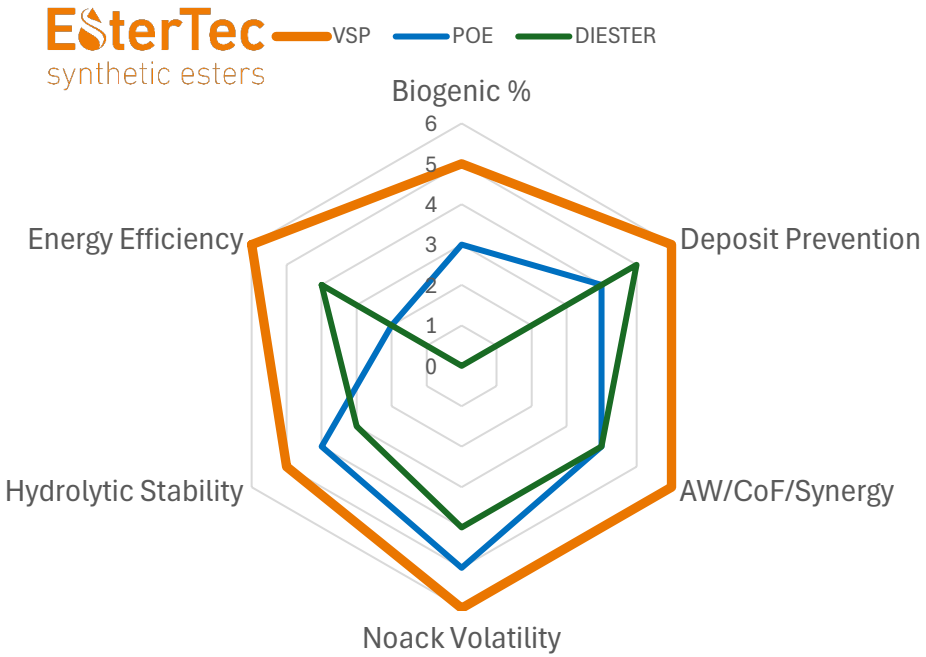
EsterTec
synthetic esters

A Novel Molecular Technology Platform. Exceptional Dielectric Fluid Potential.

Product Property	ESTERTEC 2N-1416	ESTERTEC 2LN-1418	ESTERTEC 2L-1425	ESTERTEC 2G-1432	Standard PE Ester
KV100, cSt	3.6	4.1	5	7	5
KV40, cSt	16	18	25	32	30
Viscosity Index	115	125	140	180	120
Pour Point, °C	-60	-40	-25	-42	-50
Density	0.895	0.893	0.890	0.890	0.970
Flash/Fire Point, °C	230 / 255	240 / 265	250 / 275	295 / 315	270 / 310
Biogenic Content, %	64	65	70	74	0
Specific Heat Capacity, J/g·°K	2.17	2.11	2.16	2.19	1.928
Thermal Conductivity, W/m·K	0.135	0.137	0.142	0.145	0.142
Dielectric Breakdown Voltage, 2mm, kV	> 50	> 50	> 50	> 50	> 50
Hydrolytic Stability	☑	☑	☑	☑	☑
Oxidative Stability	☑	☑	☑	☑	☑
Cost/Performance Advantage	☑	☑	☑	☑	

☑ = Equal or Better than standard synthetic esters

All the Performance Advantages Expected from a Standard Diester or Polyol Ester, Plus…



Standard POE Features

- Low Pour Point
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- Strong Dielectric Properties
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- Clear with Low Odor & Color

Special Thanks to the Z&S Global Technical Team for Data Development and Review!

- Andy Johnson
  - Applications Technology Manager
- Michael Creamer
  - Technical Specialist

EsterTec
synthetic esters

CONCLUSIONS

- EsterTec® VSP synthetic esters are a new class of base oils and additives demonstrating enhanced performance at lower cost:
  - Lower friction and wear – *with and without standard inhibitor additives*
  - Better hydrolytic stability
  - Lower volatility
  - Lower deposit/sludge forming tendency

- Expand your formulation toolbox with cost effective EsterTec VSP to deliver:
  - Longer fluid life
  - Sustainability based on Energy Efficiency and Biogenic Content

- **EsterTec® VSP for Value – Sustainability - Performance**

ZSCHIMMER & SCHWARZ

QUESTIONS?

VISIT Z&S AT EXHIBIT BOOTH #501

FOR MORE INFORMATION

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