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Peak performance, more fuel economy savings through SpectraSyn™ PAO basestock technology

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Automotive trends

ICE market trends dominated by fuel economy

Global regulations continue to be aggressive;
EU imposed emission penalties on OEMs in 2021

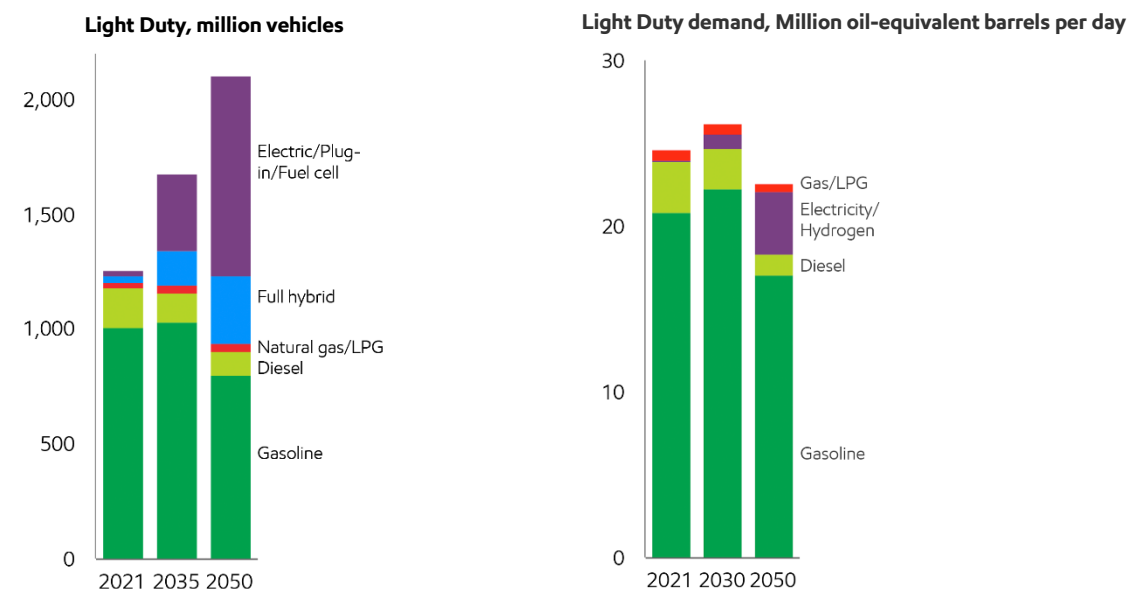


Figure 1. Historical average NEDC and WLTP CO₂ emission values and targets of new passenger cars.

Source – ICCT: <https://theicct.org/wp-content/uploads/2022/08/co2-new-passenger-cars-europe-aug22.pdf>

EV market trend focused on extending range

New energy efficient fluids required for e-mobility



Source: ExxonMobil Energy Outlook 2022

Low viscosity fluids enable improved energy efficiency

LVLV platform pushing PAOs to new limits

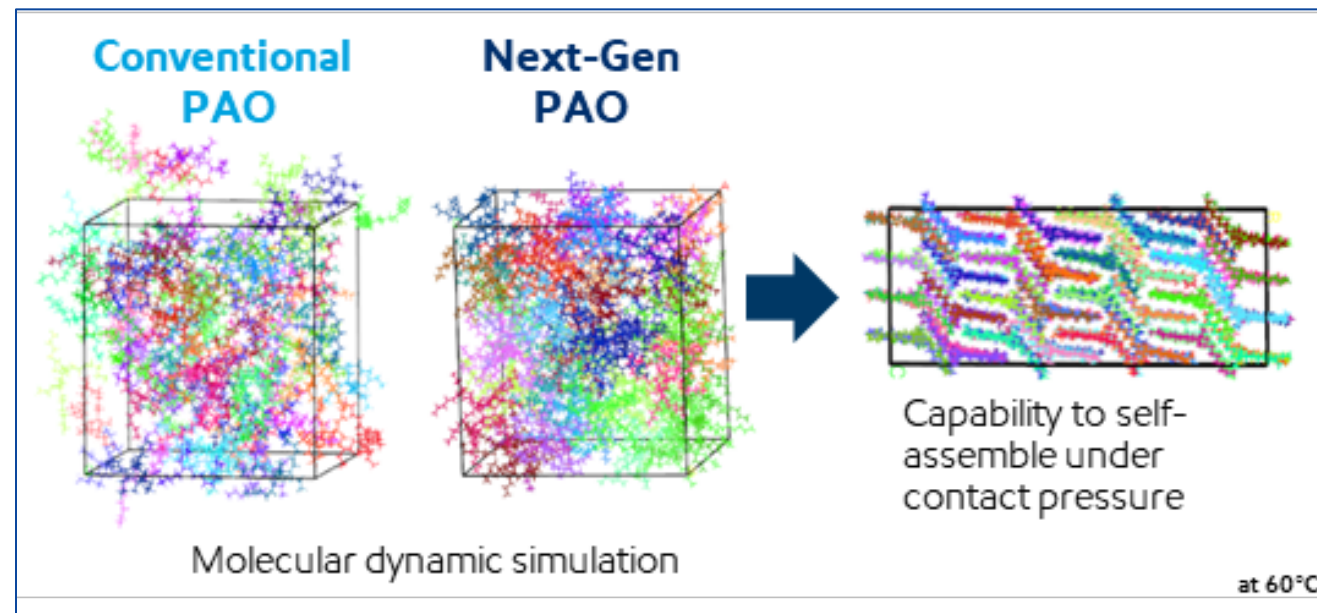
Introducing SpectraSyn™ MaX 3.5:

Leverages unique PAO structure

- Exceptional low viscosity, low volatility balance
- Excellent low-temperature properties
- Improved oxidative stability
- Enhanced lubricity and traction
- Improved flashpoint versus conventional PAO

Delivers step-out performance:

- Fuel economy improvements for PCMO and driveline
- Energy efficiency for EV driveline
- Enhanced durability for extended oil drain intervals



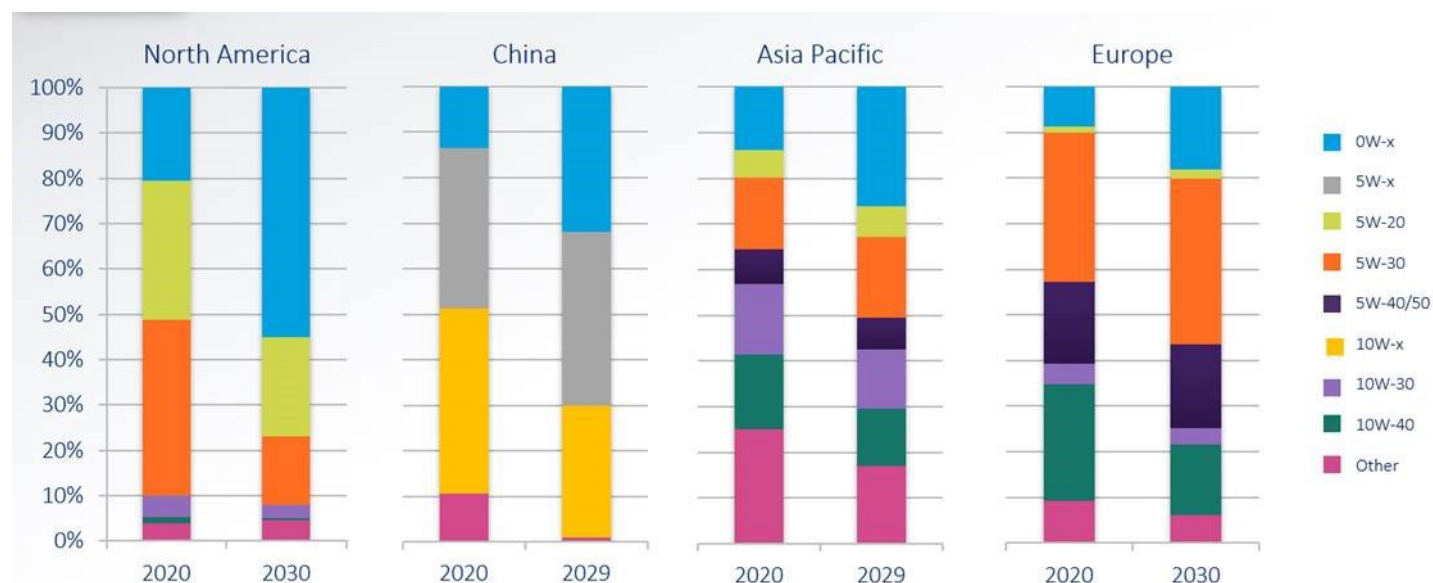
LVLV products outperform existing molecules, enabling next-gen performance

SpectraSyn™ MaX 3.5 – key properties

| | Test | Unit | Test method | SpectraSyn™ MaX 3.5 | PAO 3.6 | PAO 4 | Gr III+ 4 (A) | Gr III+ 4 (B) | Gr II |
|---|-----------------------------|------|-------------|---------------------|---------|-------|---------------|---------------|-------|
| 1 | Kinematic Viscosity @ 100°C | cSt | D445 | 3.51 | 3.60 | 4.10 | 4.16* | 4.11 | 2.74 |
| | Kinematic Viscosity @ 40°C | cSt | D445 | 14.26 | 15.40 | 18.40 | 17.90* | 18.30 | 10.10 |
| | Viscosity Index | none | D2270 | 128 | 120 | 126 | 134* | 129 | 114 |
| 2 | Noack Volatility | wt % | D5800 | 11.6 | 17.0 | 12.4 | 13.0* | 11.9 | 40.6 |
| | Pour Point | °C | D5950** | -78 | -65 | -66 | -18* | -33 | -36 |
| 3 | CCS @ -35°C | cP | D5293 | 790 | 1050 | 1430 | 2045 | 1780 | 513 |
| 4 | RPVOT (oxidation test) | min | D2272B | 102 | 47 | 41 | 40 | 35 | 28 |
| 5 | Flash Point COC | °C | D92 | 234 | 224 | 220 | 224 | 232 | 201 |

SpectraSyn™ MaX 3.5 achieves low viscosity, while improving or maintaining other key properties

Engine oils are trending to low / ultra-low viscosities



Source
Graphs Design: Third Party Supplied Estimations
Raw Data Source: Kline Supplied Data - LubesNet Database, Feb 2021

Global PVL engine oil trends

5W-30 Decreasing or flattening growth

0W-20 To grow significantly

Focus

0W-16 Japan / GF6B intro (2020)

0W-12 Niche Application

0W-8 JASO GLV-1 spec (2019)

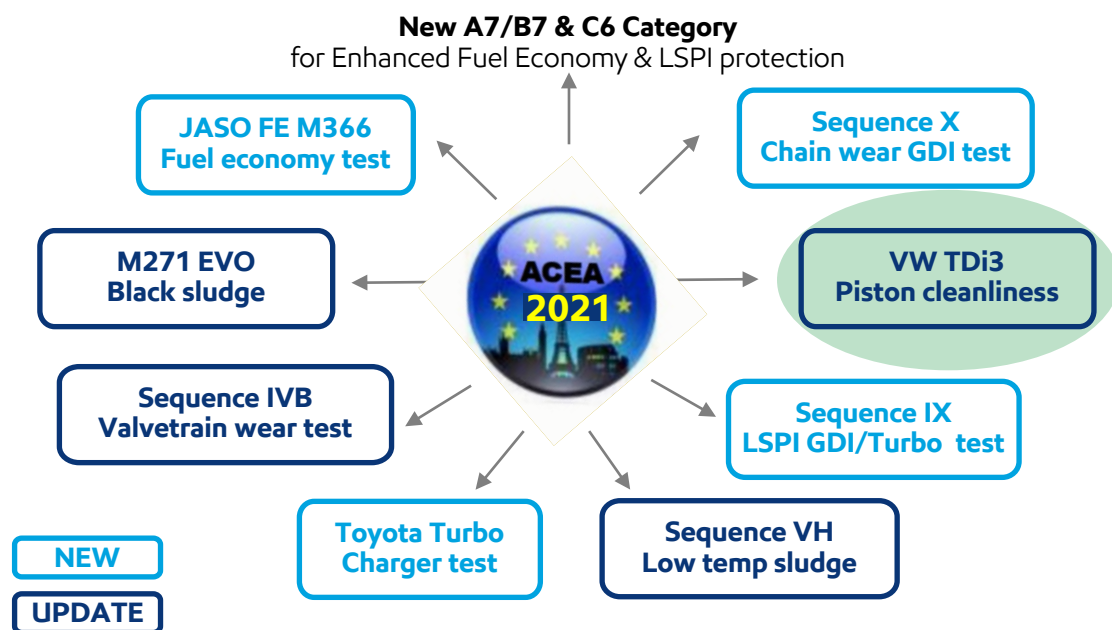
0W-20 grades projected to grow significantly across all regions by 2030

Formulation benefits for passenger vehicle engines

ACEA light duty category / specification evolution

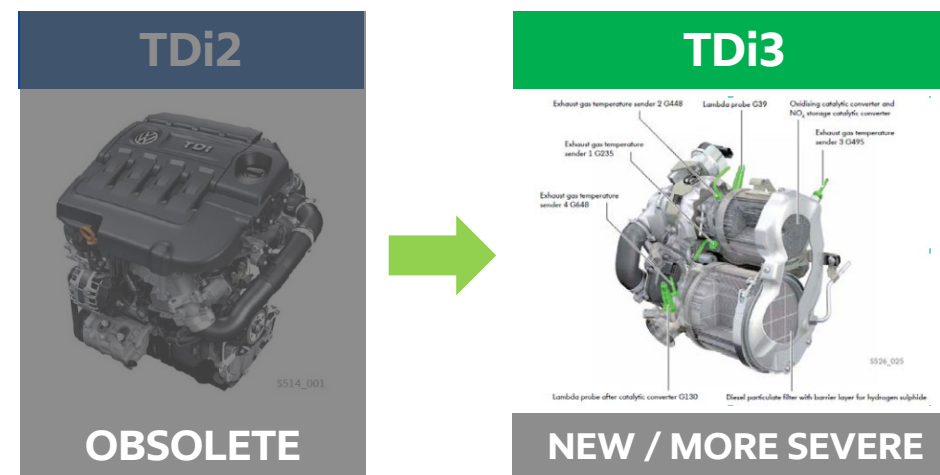
ACEA 2021

- Mandatory for new claims by 2Q2022
- Generous grandfathering of legacy tests;
No new testing required to upgrade legacy categories



TDi3 test – Driving up performance requirement

- VW TDi3 replaced legacy VW TDi2 test



VW 508/509 claim considerations

- VW claims pre-requisite is to meet ACEA Specifications
- VW TDi3 passing limits higher compared to ACEA-2021 (59 vs. 52)
- Tests results accepted within a 5 years window

New TDi3 more severe than TDi2 by ~10 merit points, selected to represent modern turbo engine

SpectraSyn™ MaX 3.5 – Expanding formulation window

| Components | 20% cPAO | 80% cPAO |
|----------------------------|-------------|-------------|
| Group III+ | 60 | - |
| Group III | - | - |
| AdPack/VM | ~20 | ~20 |
| cPAO | 20 | 80 |
| SpectraSyn™ MaX 3.5 | - | - |
| ExxonMobil EHC™ 50 | - | - |
| P&C properties | | |
| KV100 (6.9-9.3 cSt) | 8.1 | 8.4 |
| HTHS (≥ 2.6 cP) | 2.6 | 2.7 |
| CCS -35 °C (<6200 cP) | 5290 | 5014 |

- Benchmark

Note - AdPack not optimized to meet ACEA 2021 – VW 508/509 requirements

SpectraSyn™ MaX 3.5 Data Source: ExxonMobil Testing Data

cPAO Data Source: Third Party Supplied Data

SpectraSyn™ MaX 3.5 – Expanding formulation window

| Components | 20% cPAO | 80% cPAO | 10% MaX 3.5 | 16% MaX 3.5 | 20% MaX 3.5 |
|----------------------------|-------------|-------------|----------------|----------------|----------------|
| Group III+ | 60 | - | 48 | 42 | 34 |
| Group III | - | - | 22 | 20 | 26 |
| AdPack/VM | ~20 | ~20 | ~20 | ~20 | ~20 |
| cPAO | 20 | 80 | - | - | - |
| SpectraSyn™ MaX 3.5 | - | - | 10 | 16 | 20 |
| ExxonMobil EHC™ 50 | - | - | - | - | - |
| P&C properties | | | | | |
| KV100 (6.9-9.3 cSt) | 8.1 | 8.4 | 8.0 | 7.8 | 8.1 |
| HTHS (≥ 2.6 cP) | 2.6 | 2.7 | 2.7 | 2.7 | 2.6 |
| CCS -35 °C (<6200 cP) | 5290 | 5014 | 6038 | 5242 | 5500 |

- **Benchmark**
- **Reduce PAO treat with SpectraSyn™ MaX 3.5 and/or use Grp III**

Note - AdPack not optimized to meet ACEA 2021 – VW 508/509 requirements

SpectraSyn™ MaX 3.5 Data Source: ExxonMobil Testing Data

cPAO Data Source: Third Party Supplied Data

SpectraSyn™ MaX 3.5 – Expanding formulation window

| Components | 20% cPAO | 80% cPAO | 10% MaX 3.5 | 16% MaX 3.5 | 20% MaX 3.5 | 38% MaX 3.5 |
|----------------------------|-------------|-------------|----------------|----------------|----------------|----------------|
| Group III+ | 60 | - | 48 | 42 | 34 | - |
| Group III | - | - | 22 | 20 | 26 | - |
| AdPack/VM | ~20 | ~20 | ~20 | ~20 | ~20 | ~22 |
| cPAO | 20 | 80 | - | - | - | - |
| SpectraSyn™ MaX 3.5 | - | - | 10 | 16 | 20 | 38 |
| ExxonMobil EHC™ 50 | - | - | - | - | - | 40 |
| P&C properties | | | | | | |
| KV100 (6.9-9.3 cSt) | 8.1 | 8.4 | 8.0 | 7.8 | 8.1 | 7.9 |
| HTHS (≥ 2.6 cP) | 2.6 | 2.7 | 2.7 | 2.7 | 2.6 | 2.6 |
| CCS -35 °C (<6200 cP) | 5290 | 5014 | 6038 | 5242 | 5500 | 5439 |

- **Benchmark**
- Reduce PAO treat with SpectraSyn™ MaX 3.5 and/or use Grp III
- Unlock max EHC™ 50 with SpectraSyn™ MaX 3.5

Note - AdPack not optimized to meet ACEA 2021 – VW 508/509 requirements

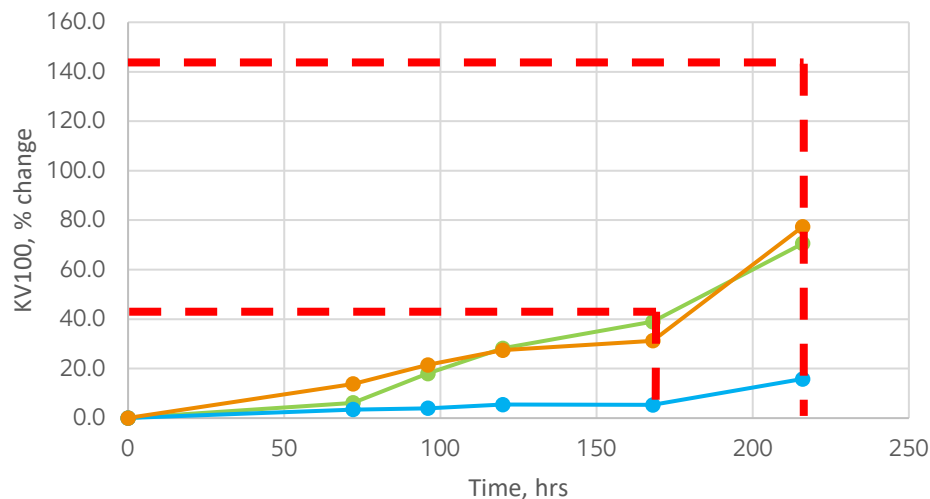
SpectraSyn™ MaX 3.5 Data Source: ExxonMobil Testing Data; cPAO Data Source: Third Party Supplied Data

SpectraSyn™ MaX 3.5 containing formulations could provide visible cost improvement compared to benchmark product

SpectraSyn™ MaX 3.5 PAO – Oxidative stability benefits

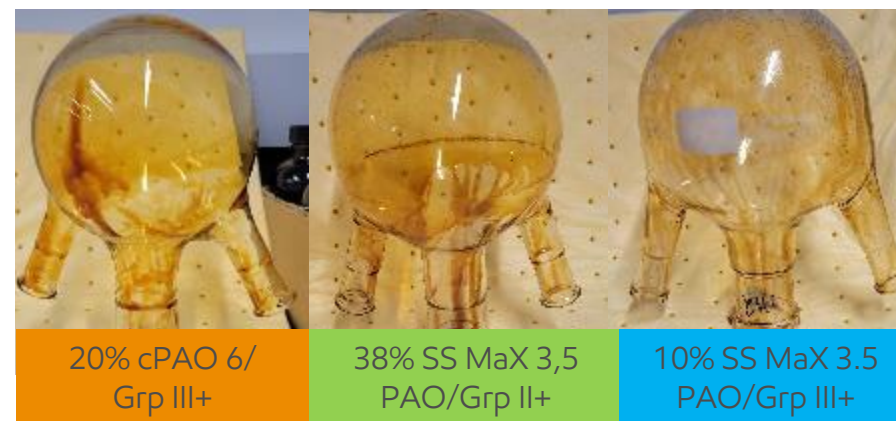
- Assessed oxidative stability of finished lubricants in presence of Biodiesel (CEC L-109)
- Standard test run for 168 and 216 hours, with oxidation change $\leq 60\%$ change $\leq 150\%$ respectively
- Pictures were taken at the end of test after 216 hours

CEC L-109 - Viscosity Control



Source: ExxonMobil testing data

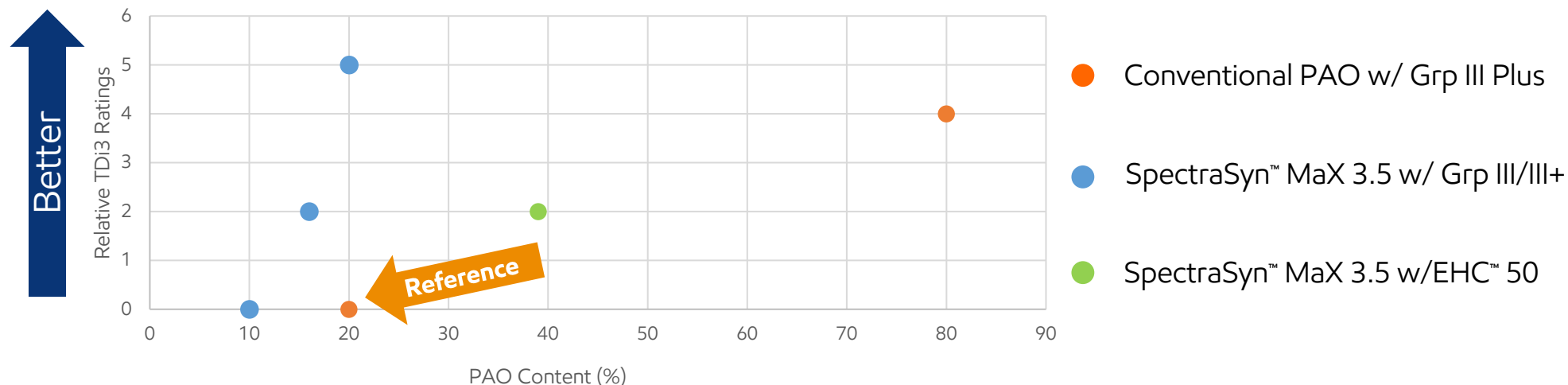
Pictures taken at the end of test – 216 hours



All formulations meet ACEA requirements, but platforms with SS MaX 3.5 PAO outperforms benchmark
SS MaX 3.5 PAO enables formulation flexibility use of Grp II+ in place of Grp III+

VW TDi3 Proof of Concept: Doing MORE with less

PAO impact & relative TDi3 rating in 0W-20 candidates

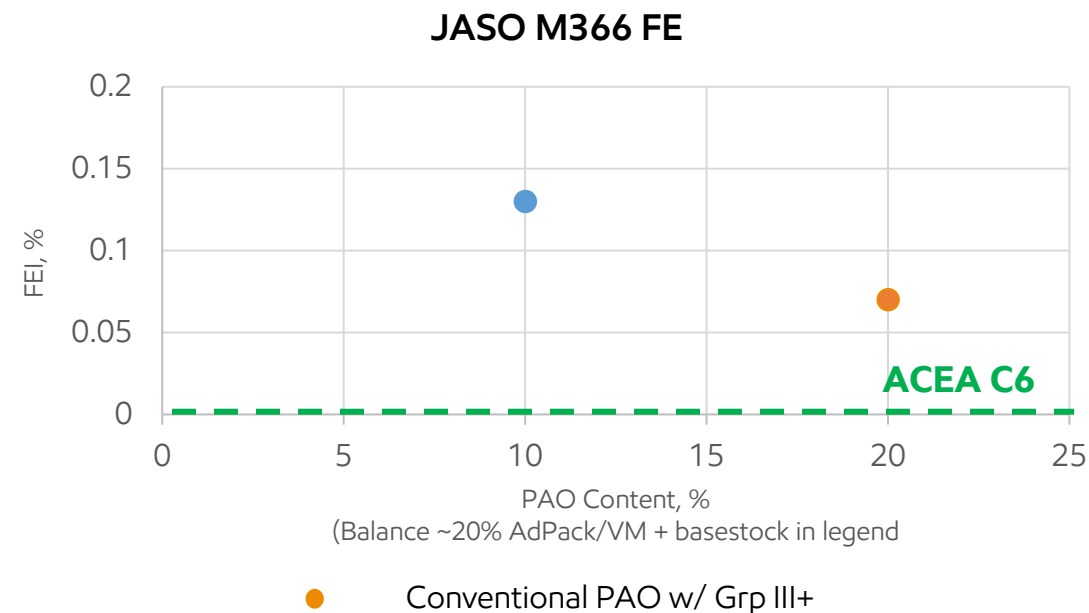
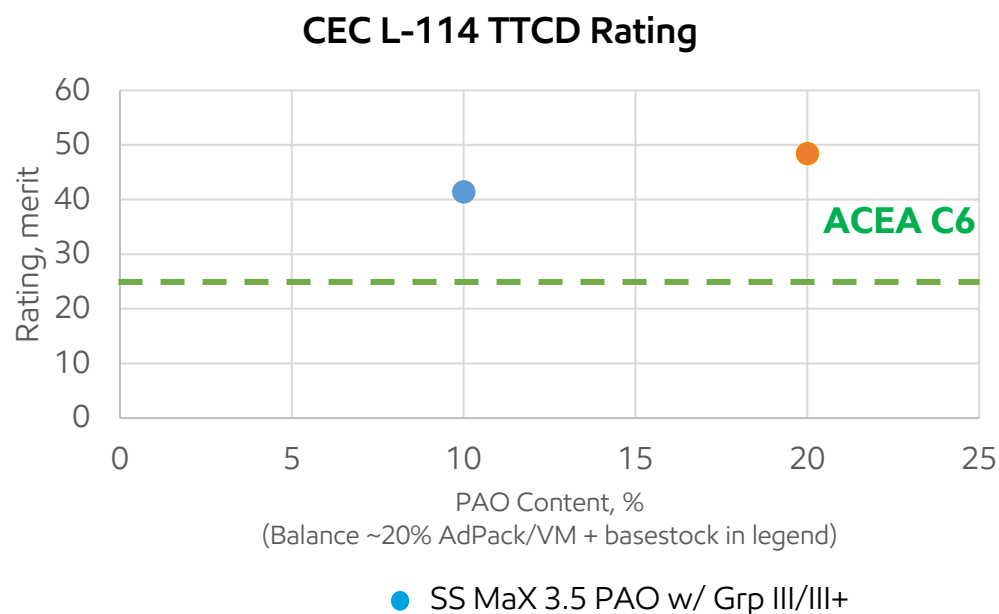


SpectraSyn™ MaX 3.5 Data Source: ExxonMobil Testing Data
cPAO Data Source: Third Party Supplied Data

- SpectraSyn™ MaX 3.5 seems to provide directional cleanliness benefits compared to conventional PAO at lower treat rates
- SpectraSyn™ MaX 3.5 with EHC™ 50 can perform comparably to PAOs and Group III/III+
- Candidate SpectraSyn™ MaX 3.5 with EHC™ 50 passed VW T4 test considered to be challenging with high amount of EHC™ 50

SpectraSyn™ MaX 3.5 enables formulation flexibility / performance balance

Additional validations against new ACEA 2021 tests

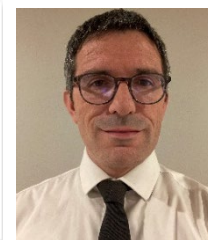


- SpectraSyn MaX 3.5 PAO and cPAO offer excellent/comparable performance in Toyota Turbo Charger Deposit Test (TTCD)
- Formulations containing SpectraSyn MaX 3.5 PAO and cPAO are close in FE performance

SpectraSyn™ MaX 3.5 provides excellent performance in newly introduced engine tests

Summary

- Described ideal automotive applications that could leverage SpectraSyn™ MaX 3.5 well-balanced Low Viscosity, Low Volatility properties with high oxidation stability and improved lubricity
- Identified key industry requirements where SpectraSyn MaX 3.5 **can provide a performance benefit**
- Demonstrated SpectraSyn MaX 3.5 **positive impact** in TDi3 test
- Expanded formulation window for high performance 0W-20 engine oils
- Demonstrated the possibility to utilize Grp II+ basestocks and SpectraSyn MaX 3.5 PAO (**removed PAO**) to **target** VW 508/509 requirements



Connect with us if you have any specific requests or if you are interested in SpectraSyn™ MaX 3.5 PAO



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