HEAVY DUTY DIESEL LUBRICANT TRENDS

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Performance you can rely on.

Infineum

Contents

Aim of Talk:

Point out the HDD vehicle environment differences in South America

Outline the diesel engine oil trends in South America

Show the opportunities for oil marketers to differentiate

INFINEUM OVERVIEW

Introduction to Infineum

Infineum additives are inside **1 in 3** vehicles

Infineum additives are in over **200 million** motorcycles worldwide

Our fuel additives treat more than **150 million** tons of diesel fuel/year

We operate in **every continent**

Technology Leadership: Global Footprint

EMISSIONS & DIESEL FUEL LEGISLATION

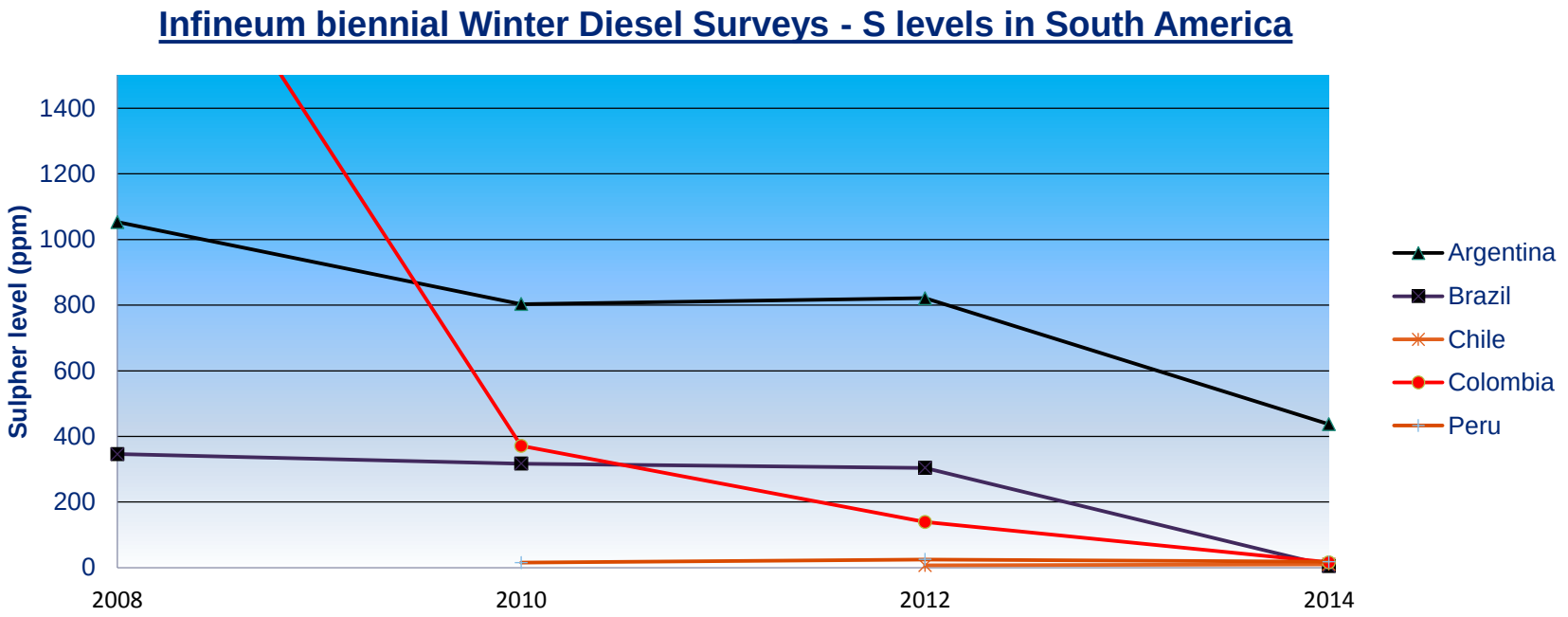
Diesel Engines – Emission Legislation

Buses and Trucks		2011	2012	2013	2014	2015	2016	2017	2018
Mexico	Trucks	Euro IV / EPA 2004							Euro VI / EPA 2010
	Buses								
Brazil	All regions	Euro III	Euro V						
Argentina	New models	Euro IV		Euro IV			Euro V		
	All models	Euro III							
Chile	Metrop. Regions	Euro III	Euro IV			Euro V	Euro V		
	All other regions	Euro III		Euro IV					
Colombia	Buses metropolitan regions	Euro II		Euro IV		Euro IV			
	Buses & Trucks all regions			Euro II					
Peru	Trucks	Euro II	Euro III						
	Buses								

Source: Infineum

- Fuel Economy/ CO_2 emissions is still not legislated for commercial vehicles in South America, albeit it is already becoming a differentiating factor
- Lack of wide availability of low S diesel has slowed down the introduction of more stringent emission legislation in some countries

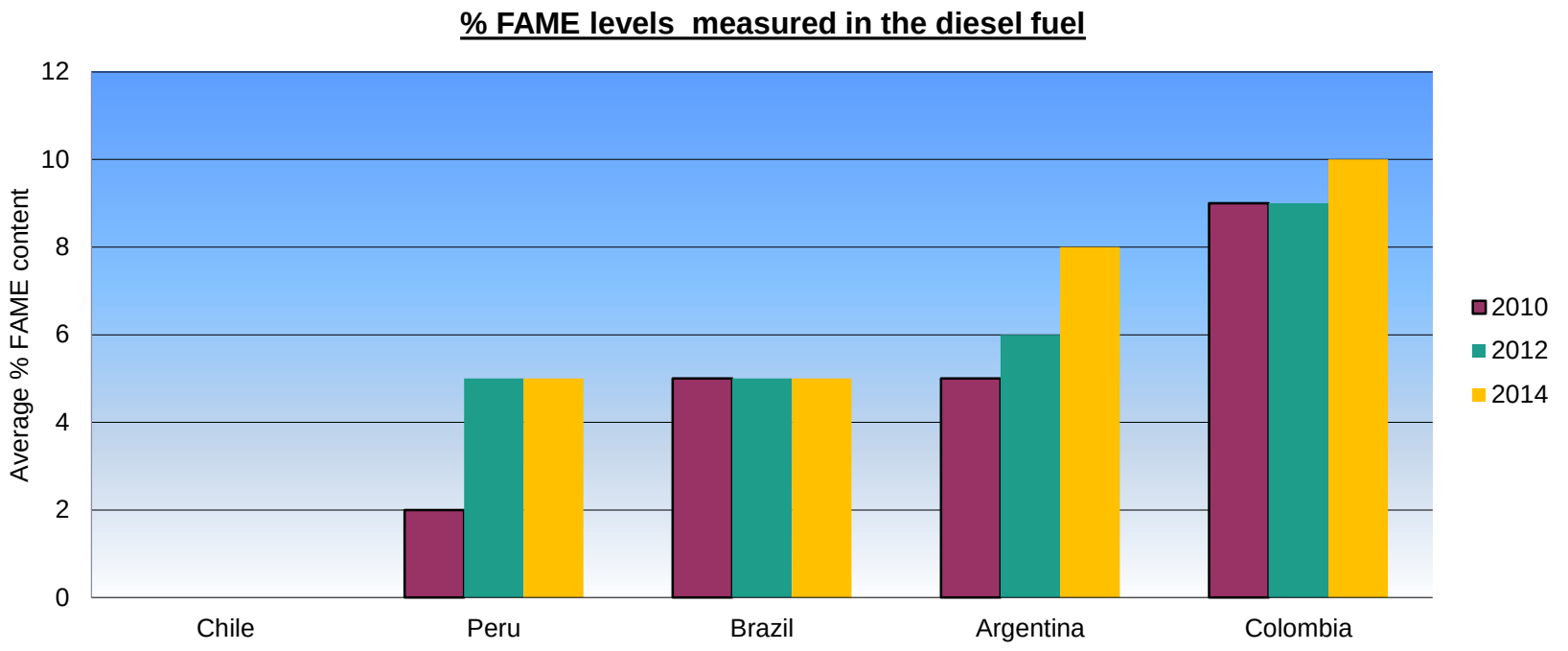
Diesel Fuel – S levels



Source: Infineum Winter Diesel Survey

- Diesel S levels have been falling steady in South America, albeit at different paces and with regional differences within each country
- Low S diesel (50 ppm or lower) has become increasingly available as a higher quality diesel in most countries

Diesel Fuel – Biodiesel content

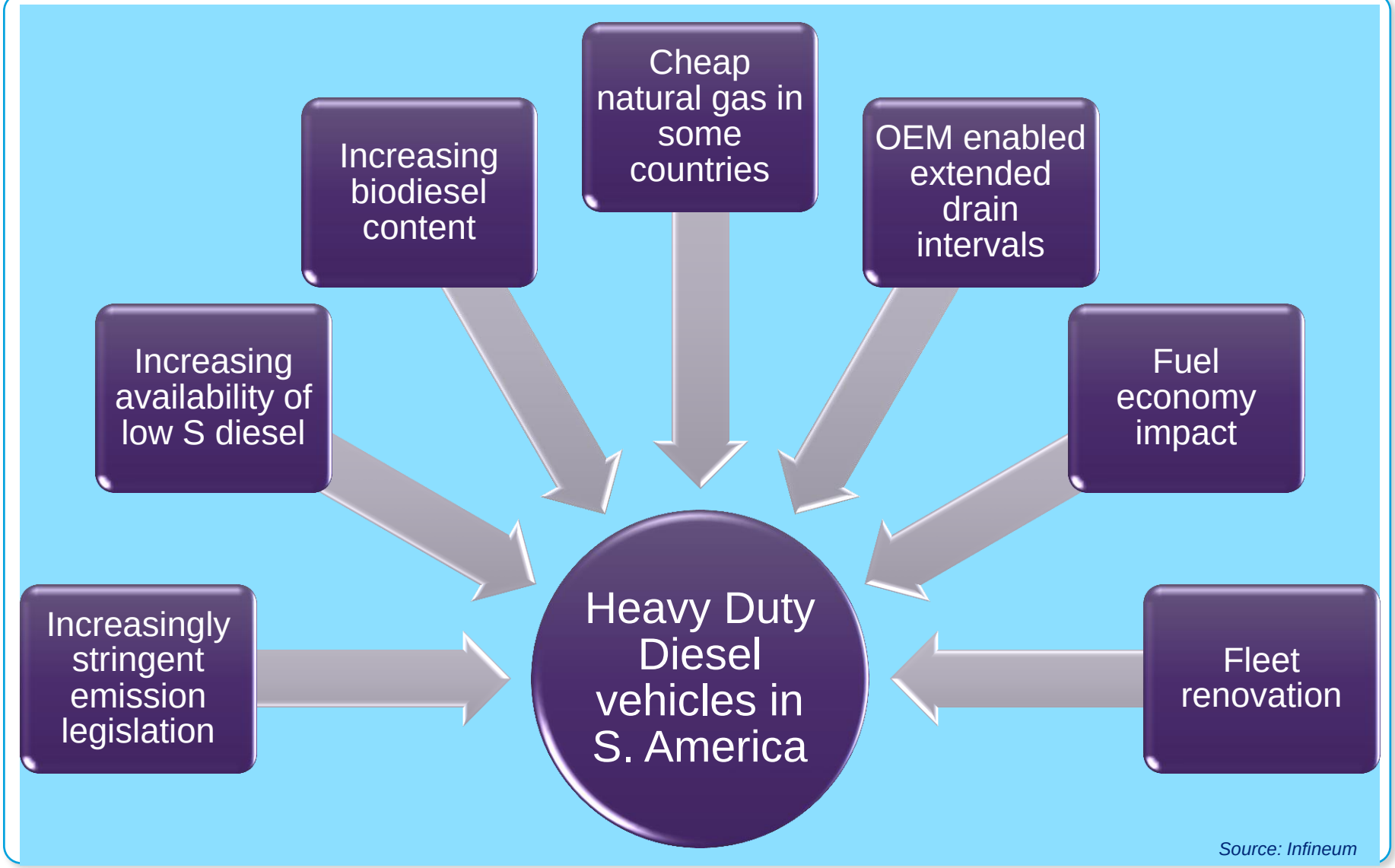


Source: Infineum Winter Diesel Survey

- Different biodiesel sources are used in the different countries (soy, palm, animal fat)
- Gradually increasing towards B10 (e.g. Colombia, Argentina, Brazil)

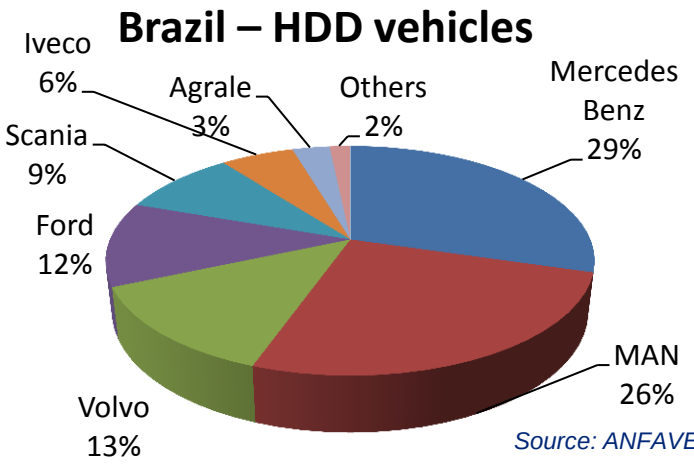
DIESEL ENGINE OIL TRENDS

Main drivers of change in HDD vehicles

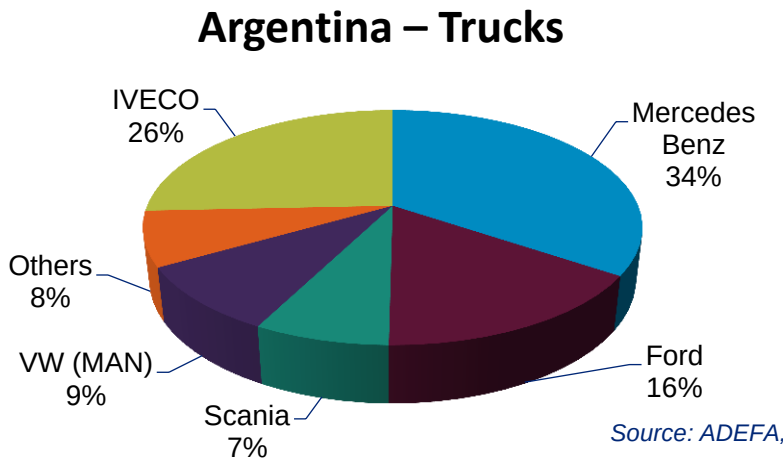


Source: Infineum

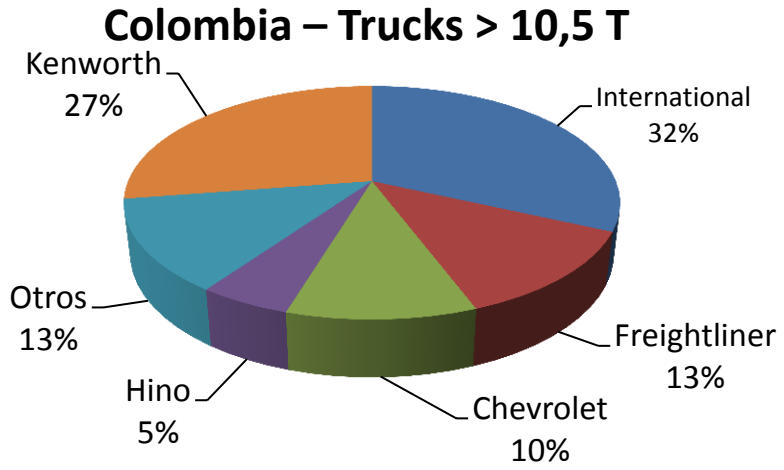
OEMs presence in South America



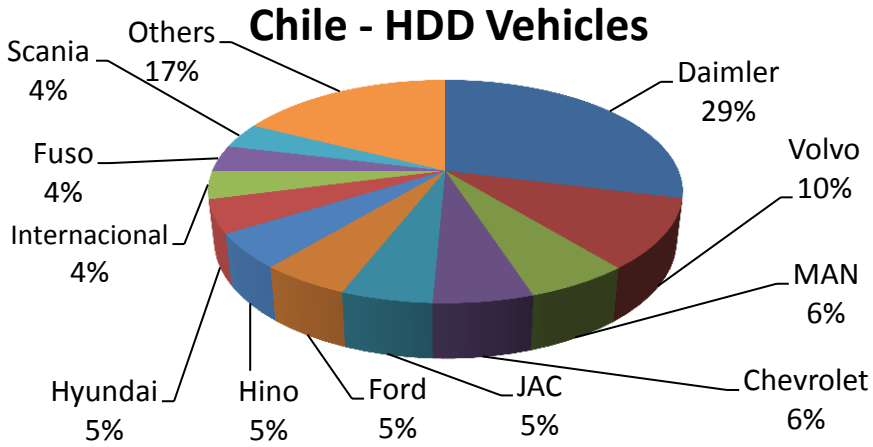
Source: ANFAVEA, 2014



Source: ADEFA, 2014



Source: ANDEMOS, 2014



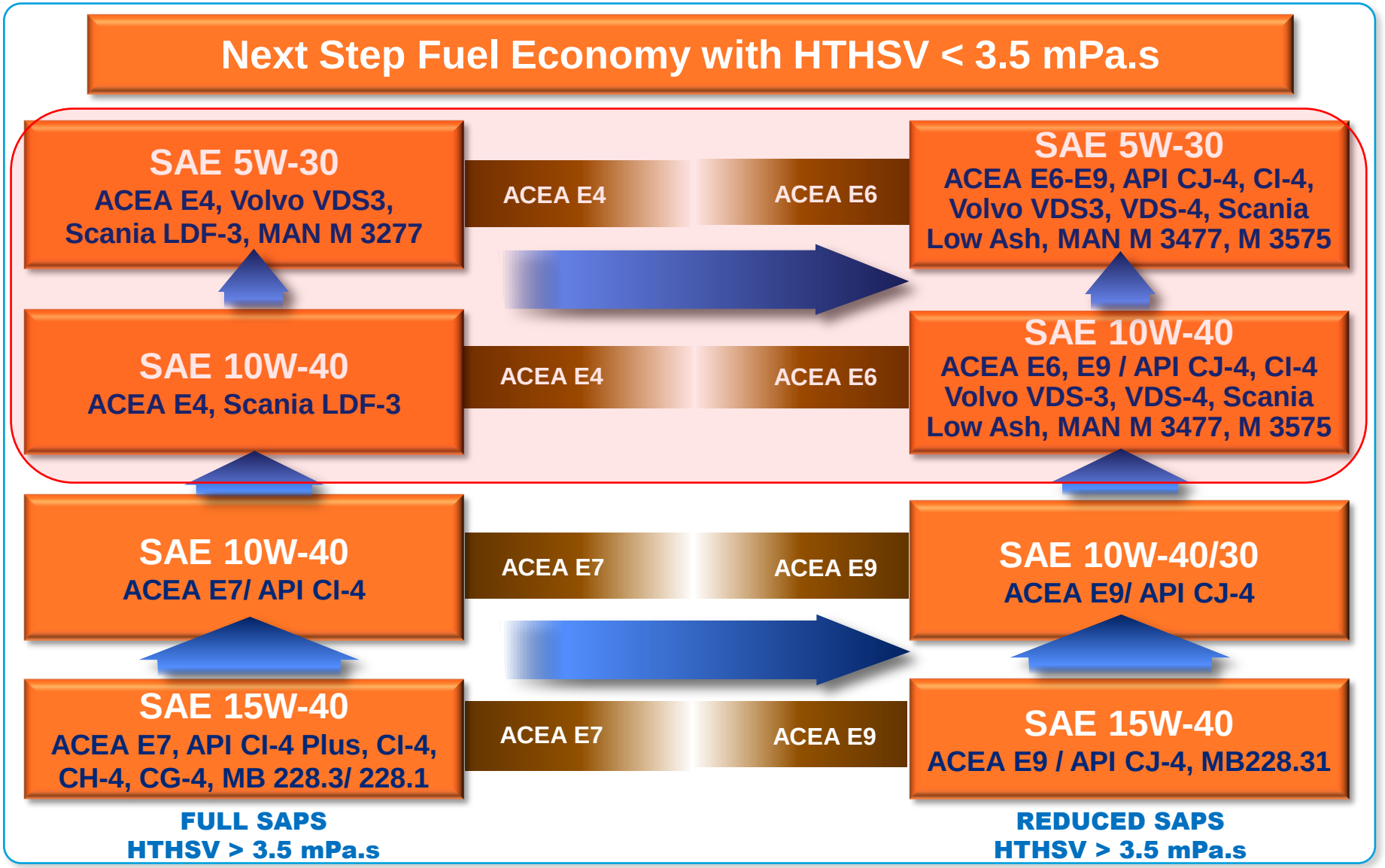
Source: ANAC, 2014

- European OEMs in the LA Eastern countries, more North American and Asiatic OEM presence in the LA Western countries

ACEA 2012 HDDO “consumer language”

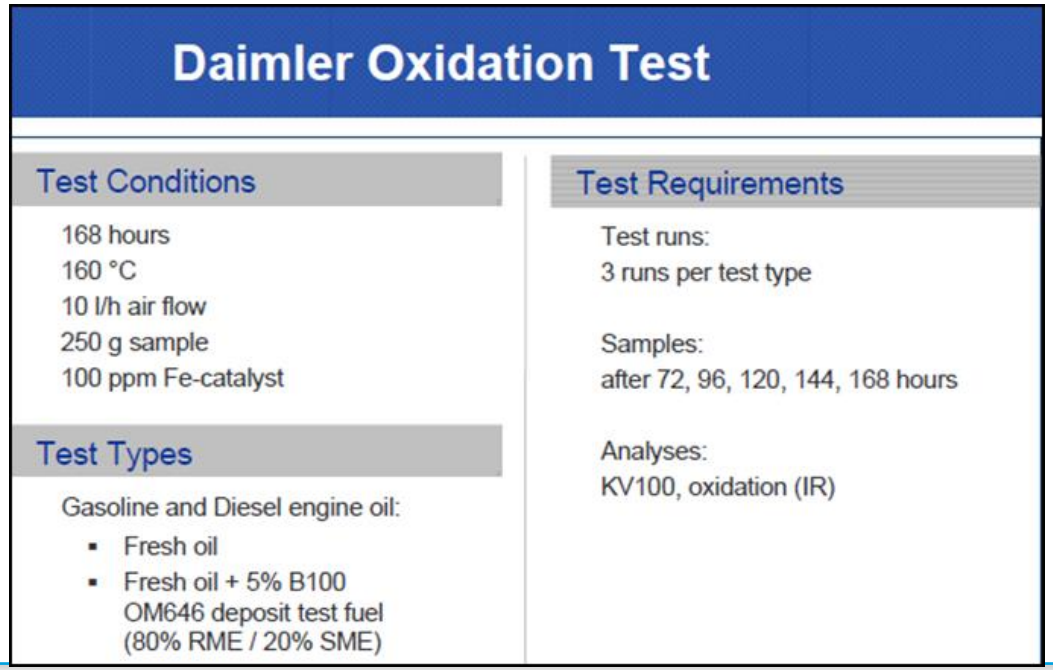
	Unrestricted SAPS	Restricted SAPS
Premium	**E4** “… ***excellent*** control of piston cleanliness, … running under ***very*** severe conditions, e.g. ***significantly*** extended drains …”	**E6** “… ***excellent*** control of piston cleanliness, … running under ***very*** severe conditions, e.g. ***significantly*** extended drains …”
Mainline	**E7** “… ***effective*** control of piston cleanliness, … running under severe conditions, e.g. extended drains …”	**E9** “… ***effective*** control of piston cleanliness, … running under severe conditions, e.g. extended drains …”

HDD Engines Oils vis grades are getting thinner



Daimler Biodiesel Compatibility requirements

- Daimler reviewed its lubricant specs in 2012, to prevent against the impact of biodiesel accumulation in the sump
  - More stringent pass/ fail requirements for the extended drain (ED) specs
  - Some parameters have been set as Rate and Report

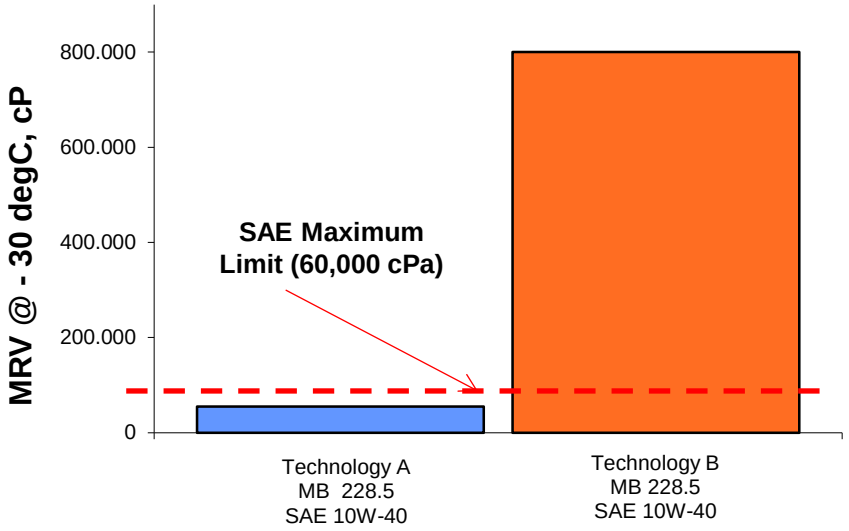


DIFFERENTIATION APPROACH

Biodiesel Compatibility: Additional performance

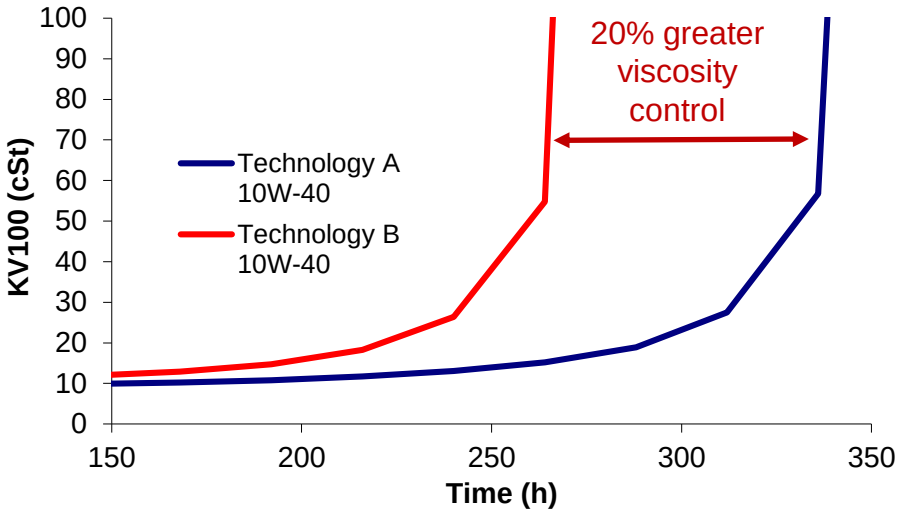
Different **extended drain** lubricants show different protection levels against the impact of **biodiesel**

Aged oil MRV data through the Daimler Oxidation test



Source: Infineum

Extended Daimler oxidation test (10% B7)



Source: Infineum

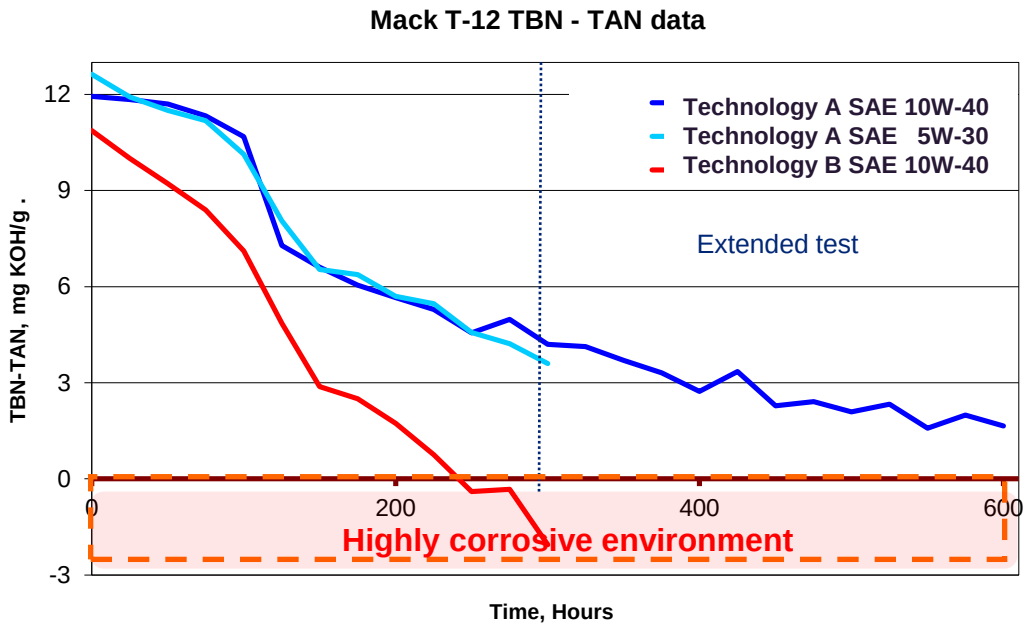
Pumpability differences of as much as 30 times between different MB-Approval 228.5 technologies

Different technologies offer **different Viscosity control** in the presence of biofuel

Extended drain:
TBN Retention and TAN Control

Some MB-Approval 228.5 formulations provides **extra protection** against acid build up and corrosive wear

- One key aspect is the additive technology's **TBN retention**
- TBN – TAN curve in red below shows early TBN depletion, potentially resulting in acid build up



Source: Infineum

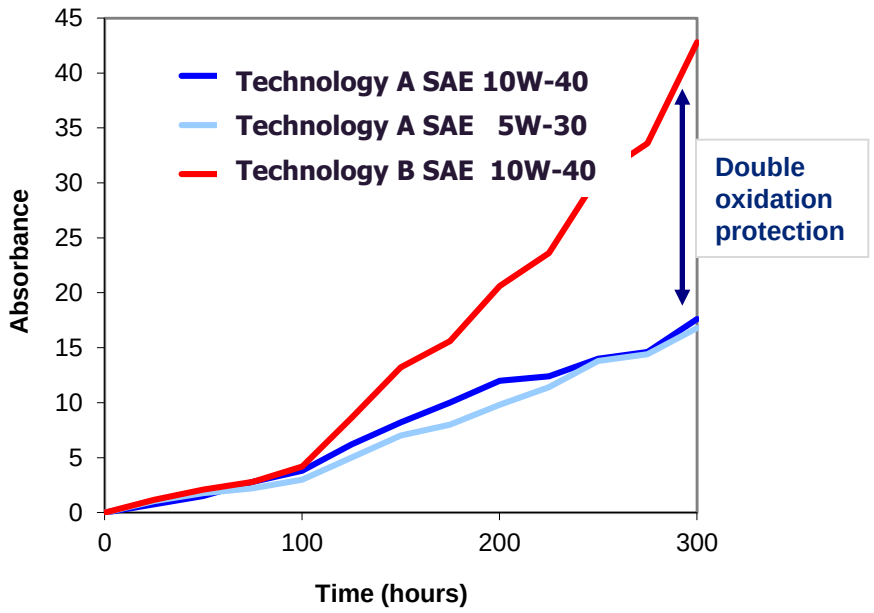
Extended Drain:
Anti-oxidancy & Anti-corrosion

Some MB-Approval 228.5 formulations shows
superb resistance to oxidation and corrosion

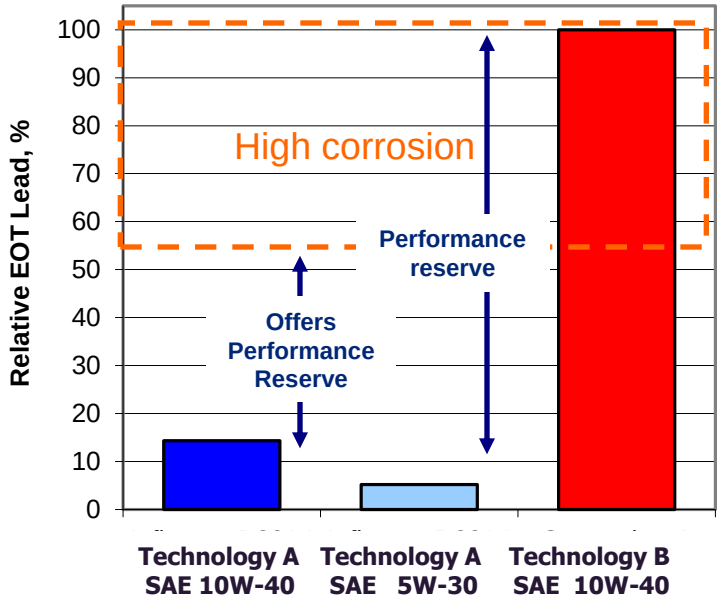
Test shows different extended drain technologies offer up to double of the oxidation protection

Through superior acid control, the resistance to corrosion is greatly improved

Mack T-12 Oxidation Data



Mack T-12 Lead Results



Source: Infineum

Extended drain: Cleanliness

Some MB-Approval 228.5 formulations have **proven cleanliness** benefits, protecting all critical engine components

OM441LA Turbocharger
MB-Approval 228.5
Technology A
SAE 10W-40
0.7 g deposits

OM441LA Turbocharger
MB-Approval 228.5
Technology B
10W-40
28.3 g deposits

Source: Infineum

Extended Drain: Wear Protection

Some MB-Approval 228.5 formulations show **excellent wear control** in both SAE 10W-40 & 5W-30 vis. grades at **low P levels**

- ≥ 100% extra wear protection at low levels of phosphorus
  - Lower phosphorus levels improve compatibility with after treatment devices
- SAE 5W-30 showing no compromise on wear vs. traditional 10W-40 grades

OM646LA	Technology A SAE 10W-40	Technology A SAE 5W-30	Technology B SAE 10W-40	MB-approval 228.5 Limit
Average Inlet cam wear (µm)	**24.6**	**26.8**	63.5	≤ 100 µm
Average Outlet cam wear (µm)	**27.6**	**19.5**	65.1	≤ 120 µm

Phosphorus level as low as 0.12% mass

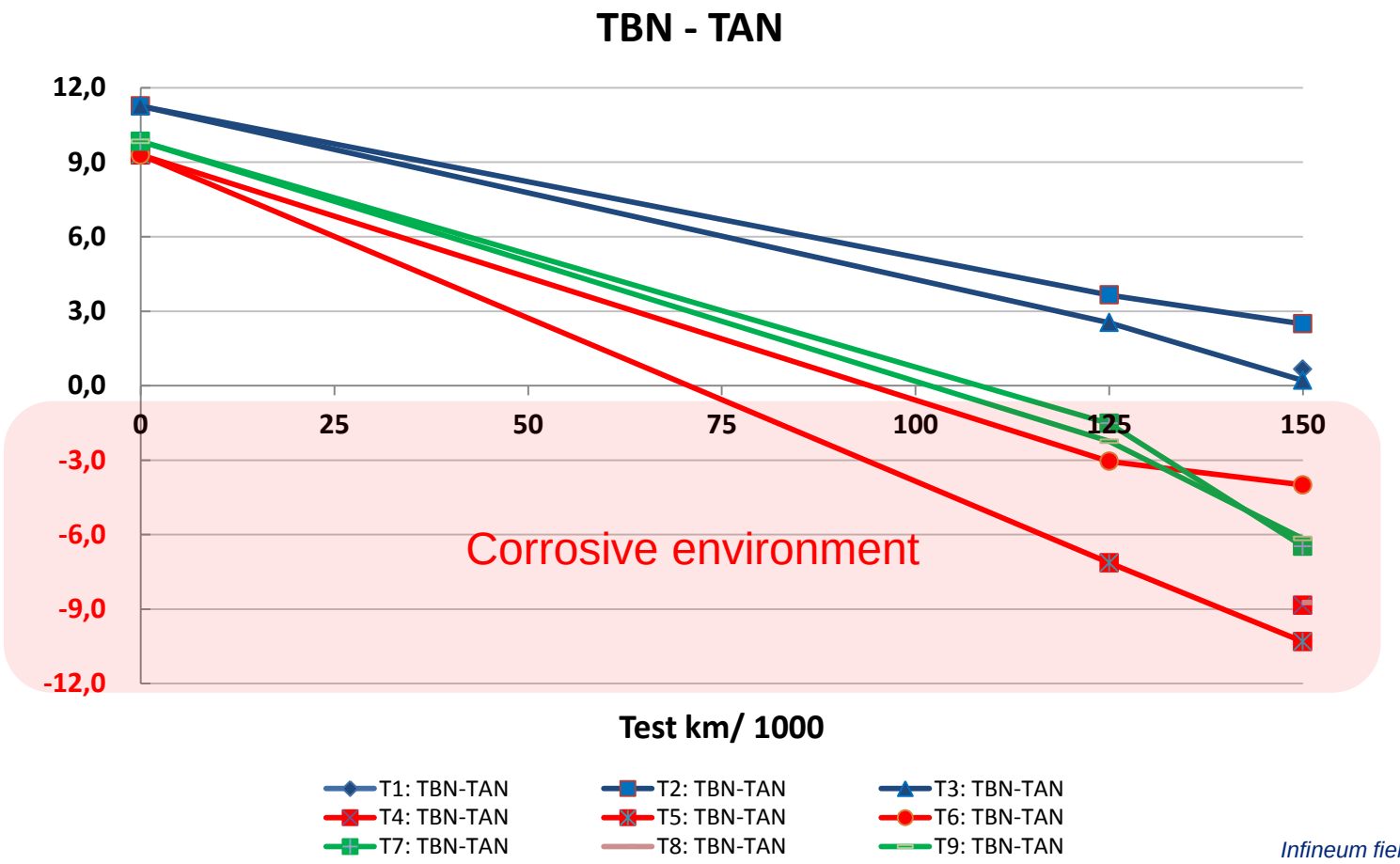
Source: Infineum

MB-Approval 228.5 SAE 10W-40 field test

- Field test with nine (9) Actros 1845LS trucks (OM471, Euro V)
  - Started late 2012, will be completed by 2Hf'15
- Normal long distance general haulage in Germany, using B7 diesel
- Running with 3 different ACEA E4/ MB-Approval 228.5 SAE 10W-40 engine oil with various OEM approvals:
  - Two full synthetic formulations
  - One part-synthetic formulation
- Field test will run to encompass 2 x 150 k km oil changes

Different MB-Approval 228.5 SAE 10W-40 technologies: Alkaline reserve comparison

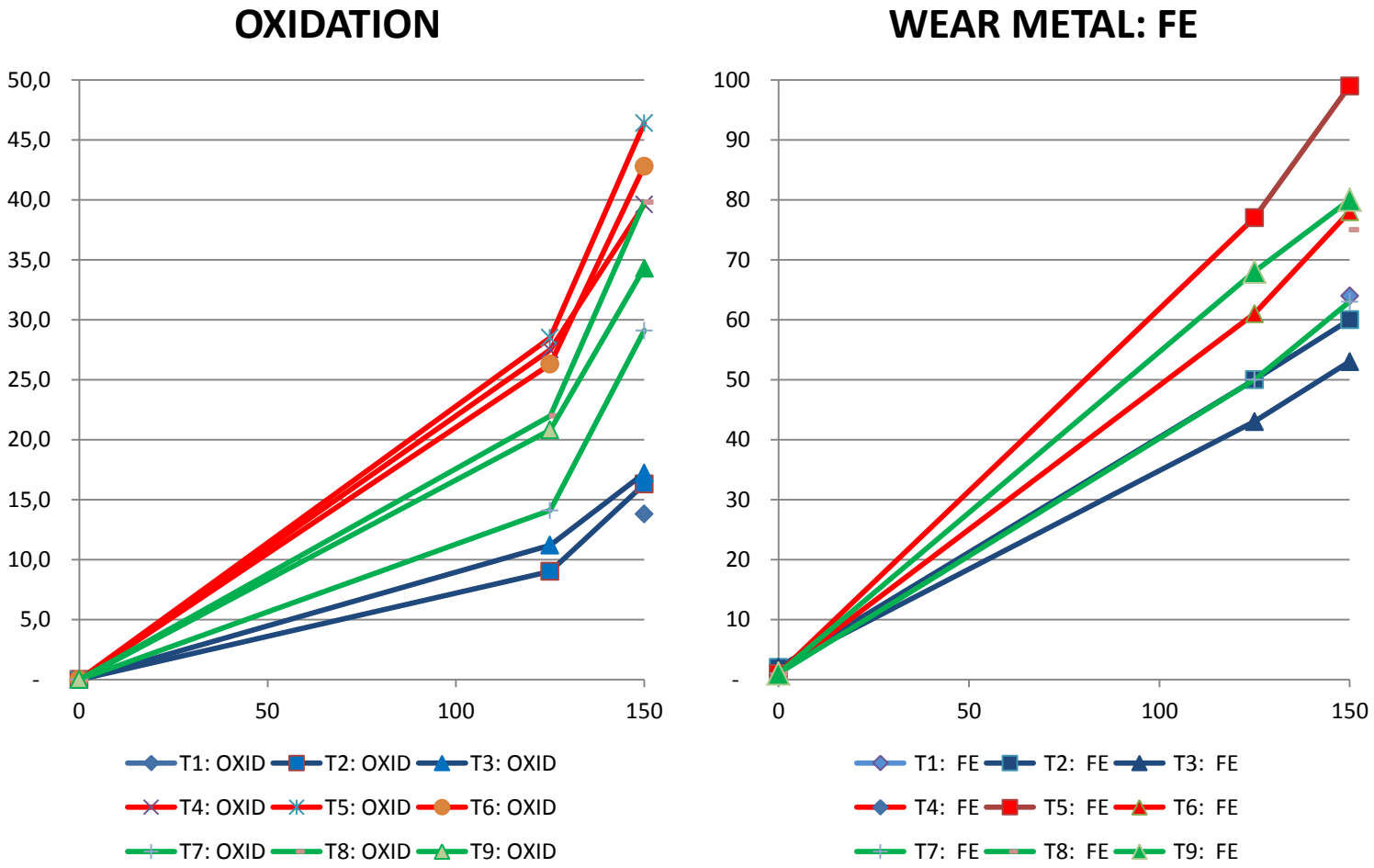
- Different technologies have different alkaline reserve
- Results shown are based on the analysis of used oil samples collected



Source: Infineum field test data

Different MB-Approval 228.5 SAE 10W-40 technologies: Oxidation and Wear metals

- Based on the used oil analysis collected:



Source: Infineum field test data

ACEA E4 SAE 5W-30 field test

- Field test with three (3), Euro V 12.7L 440 HP Euro trucks equipped with VG turbocharging and EGR system
  - Started 2Q'11, completed by 1Q'13
- Long distance haulage (60 Tons) along north of Europe
- Used an ACEA E4 SAE 5W-30 Gp III+ IV based engine oil
  - MB-Approval 228.5 capable
  - Vis. Grade to capture fuel economy
- Field test will run to encompass 2 x 120 k km oil changes
  - Actual duty severity would have required 3 x 90k km OD periods

ACEA E4 SAE 5W-30 field test: Cleanliness

Oil Pans

Side Covers

Rocker Covers

VG Turbo

Source: Infineum field test data

Meeting the needs of the future Euro VI engines

It is possible to combine the global requirements of European ACEA and US API claims in a single high performance lubricant

Meet the needs of engines for lower SAPS ACEA E6, E9 & API CJ-4 based products

Fully compatible with Euro VI after-treatment equipment devices

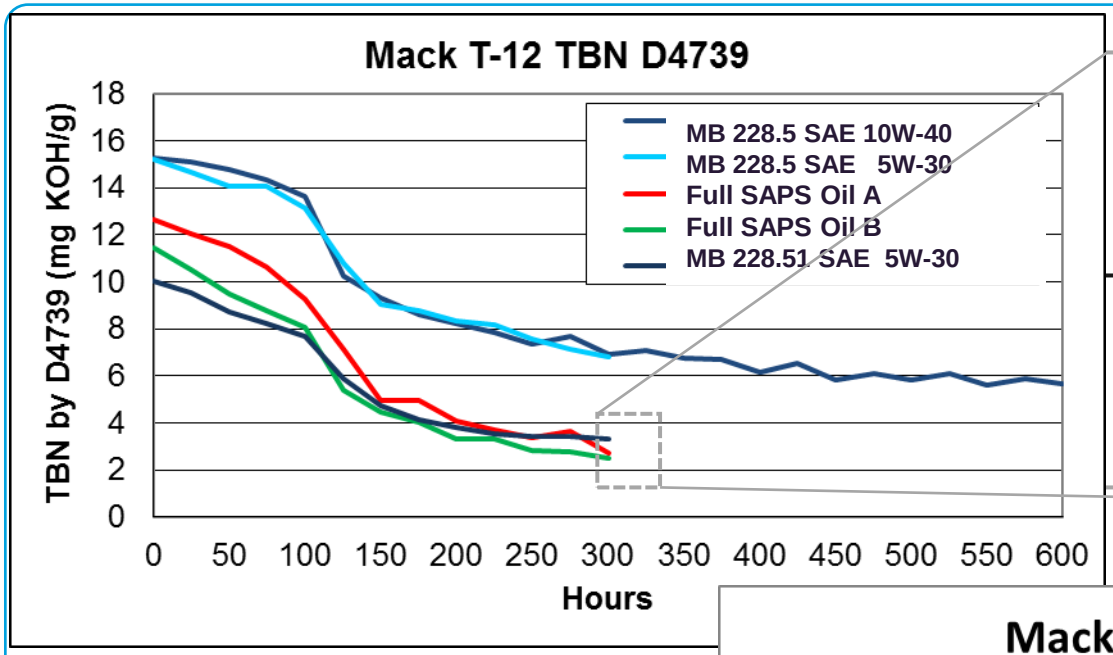
Global Top Tier Engine Oil
SAE 10W-40 & 5W-30 Technologies

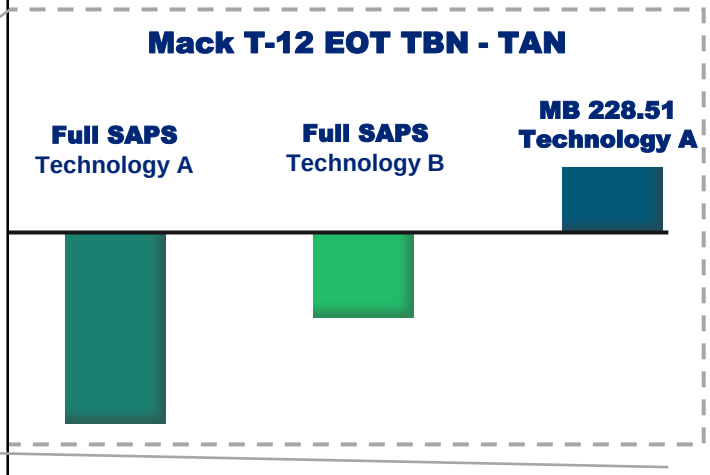
- Newer technologies meets the requirements of modern global HD engine platforms for a mid SAPS oil compatible with exhaust after treatment systems
- They are also an excellent replacement for full SAPS products in older engine technologies
- Different viscosity grades:
  - SAE10W-40 using Gp III b/s
  - SAE 5W-30 using Gp III b/s part. subst. w/Gp IV, delivers 1% fuel economy in the OM501FE test whilst no compromise on wear

Typical Inspections		
TBN (D2896)	mg KOH/g	12.7
Sulphated Ash	% Mass	0.95
Phosphorus	% Mass	0.08
Sulphur	% Mass	0.02

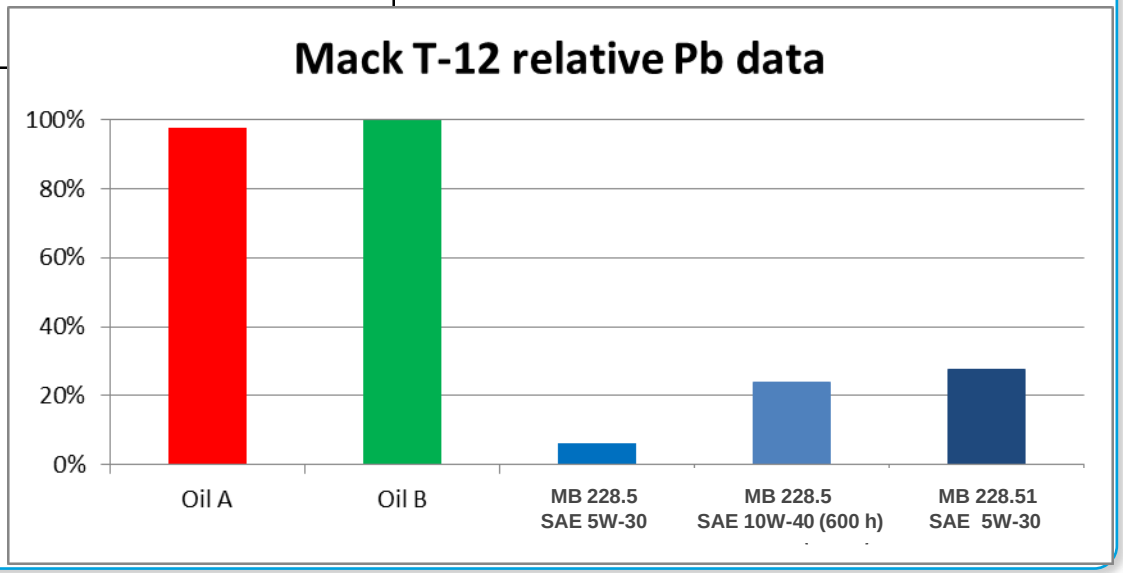
Technology designed to provide outstanding FE performance while maintaining superb wear protection

Global Top Tier Engine Oil Technologies
SAE 10W-40 & 5W-30: TBN comparison





- Latest E6/ API CJ-4 oil technologies show comparable TBN performance to ACEA E4 oils …
- … whilst protecting the engine against lead corrosion to a superior level



CONCLUSIONS

Conclusions

- Various OEMs in South America have pioneered the introduction of extended drain lubricant technologies through their specific OEM specs
- The choice between a full SAPS or a restricted SAPS lubricant technology depends on the compatibility needed with the after-treatment systems
- A second wave of lubricants combining extended drain and fuel economy are making their way in the South American market, through lower viscosity grades and adequate additive technologies

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