LUBRIZOL

11th Diesel Engine Emissions Reduction Conference

Future Engine Fluids Technologies: Durable, Fuel-Efficient, and Emissions-Friendly

Dr. Ewa A. Bardasz
August 21-25th, 2005
Chicago, Ill

The Drivers


Advanced Additive Technology
Base Oil
New lubricant technology
Defined by new lubricant specifications
Demand for higher quality lubricants
New engine designs and exhaust aftertreatment
The Environment

Future Lubricant Technology Drivers

Reduced friction

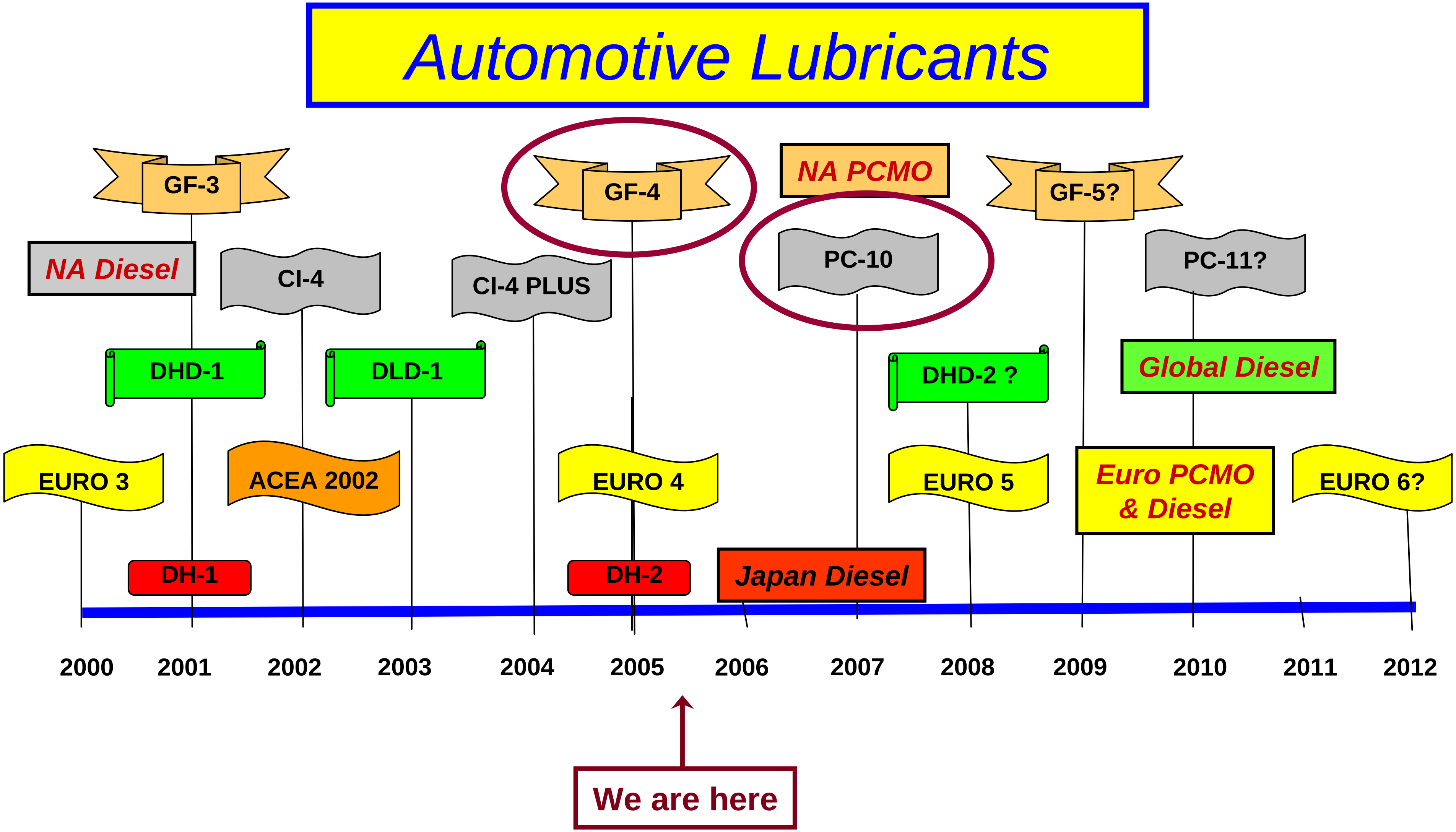
Enhanced oil and additive durability

Compatible with emission systems

Reduced emissions

Diesel Oils Specifications

Timing of Lubricant Specifications



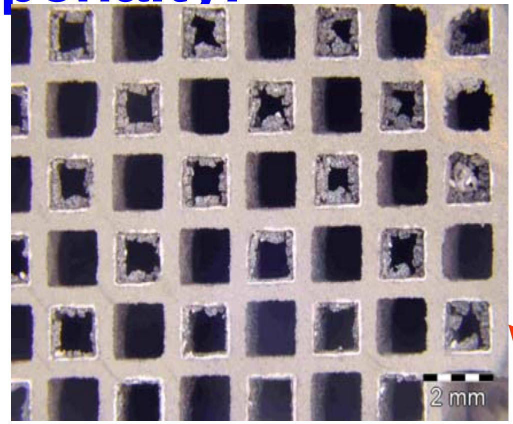
What is PC-10 Lubricant?

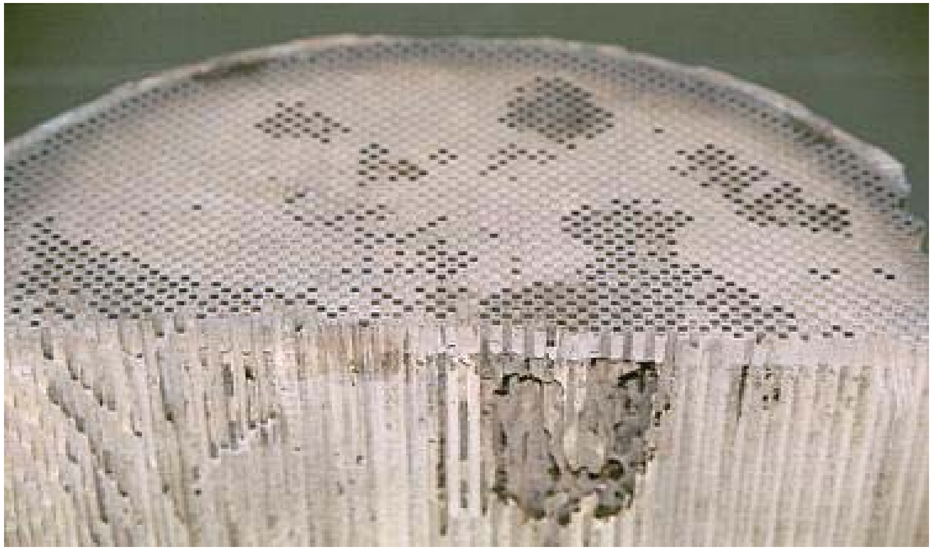
- An exhaust aftertreatment friendly engine oil used with ultra-low sulphur (<15 ppm) diesel fuels
- A more robust and lower volatility fluid
- To be in commercial service from 4th quarter 2006
- Also likely to be used in older engines (backward compatibility)

The Lube Impact on Exhaust Aftertreatment Systems

Sulphated Ash

Sulphated ash from the engine oil can contribute to ash blockage in DPFs and CRTs. This results in raised back pressure on the engine and a fuel economy penalty.





As
h

Lubricant Impact on Exhaust Aftertreatment Systems

Phosphorus

Phosphorus from the engine oil can contribute to the irreversible deactivation of catalysts. This results in increased emissions.

Lubricant Impact on Exhaust Aftertreatment Systems

Sulphur

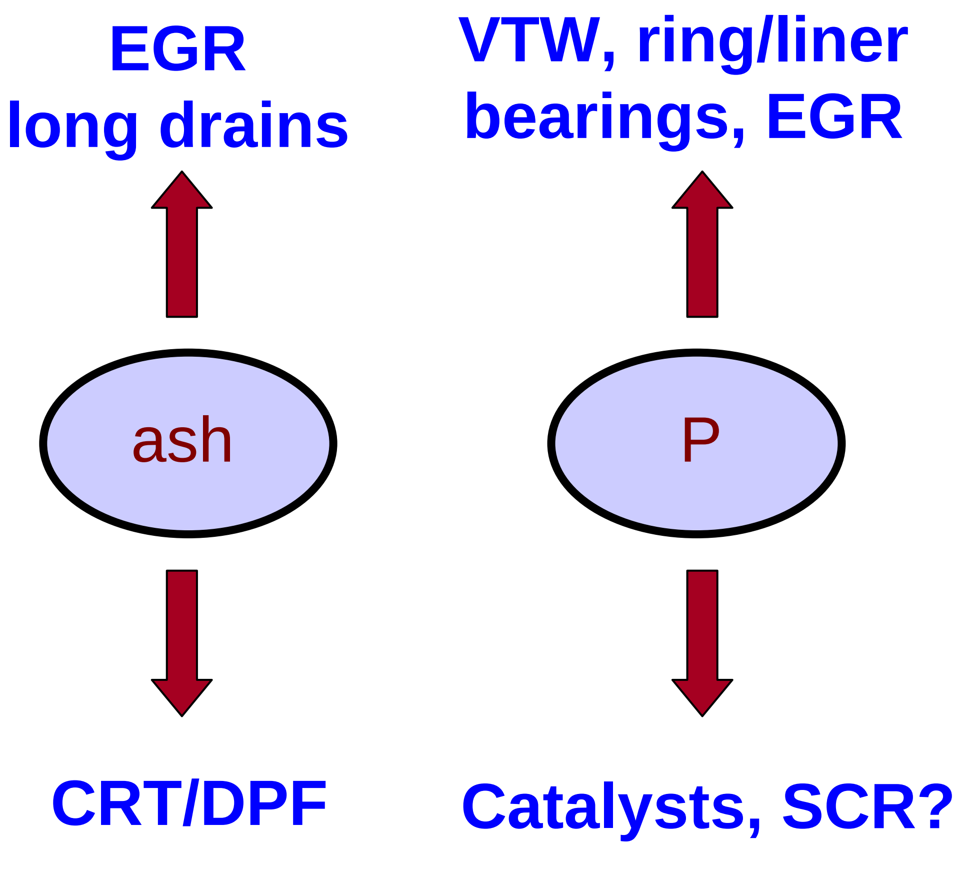
Sulphur from the engine oil contributes to blockage of NOx storage sites (NOx traps), increases in sulphate particles (DOC, CRT, SCR, cDPF) and the desensitisation decreases catalytic conversion (deNox traps).

Origin of Sulphated Ash, Phosphorous and Sulphur (SAPS) in Lubricants

Component	SAPS contribution
Dispersant	-
Detergents*	**Ash + Sulphur**
Antioxidants*	Sulphur
Friction Modifiers*	Sulphur
Corrosion Inhibitors*	Sulphur
Antiwear	**Phosphorous + Sulphur**
diluent oil*	Sulphur
Viscosity Modifier	-

* Alternatives not containing Sulphur are commercially available

But there are Lubricant Conflicts



Source: Bengt Otterholm - Volvo

PC-10 solution

- **Phosphorus, sulphur and sulphated ash will be limited:**

  0.12% (wt) phosphorus

  0.4% (wt) sulphur

  1.0% (wt) ash

- **Volatility for 15W-40 will be reduced from 15% to 13% NOACK**

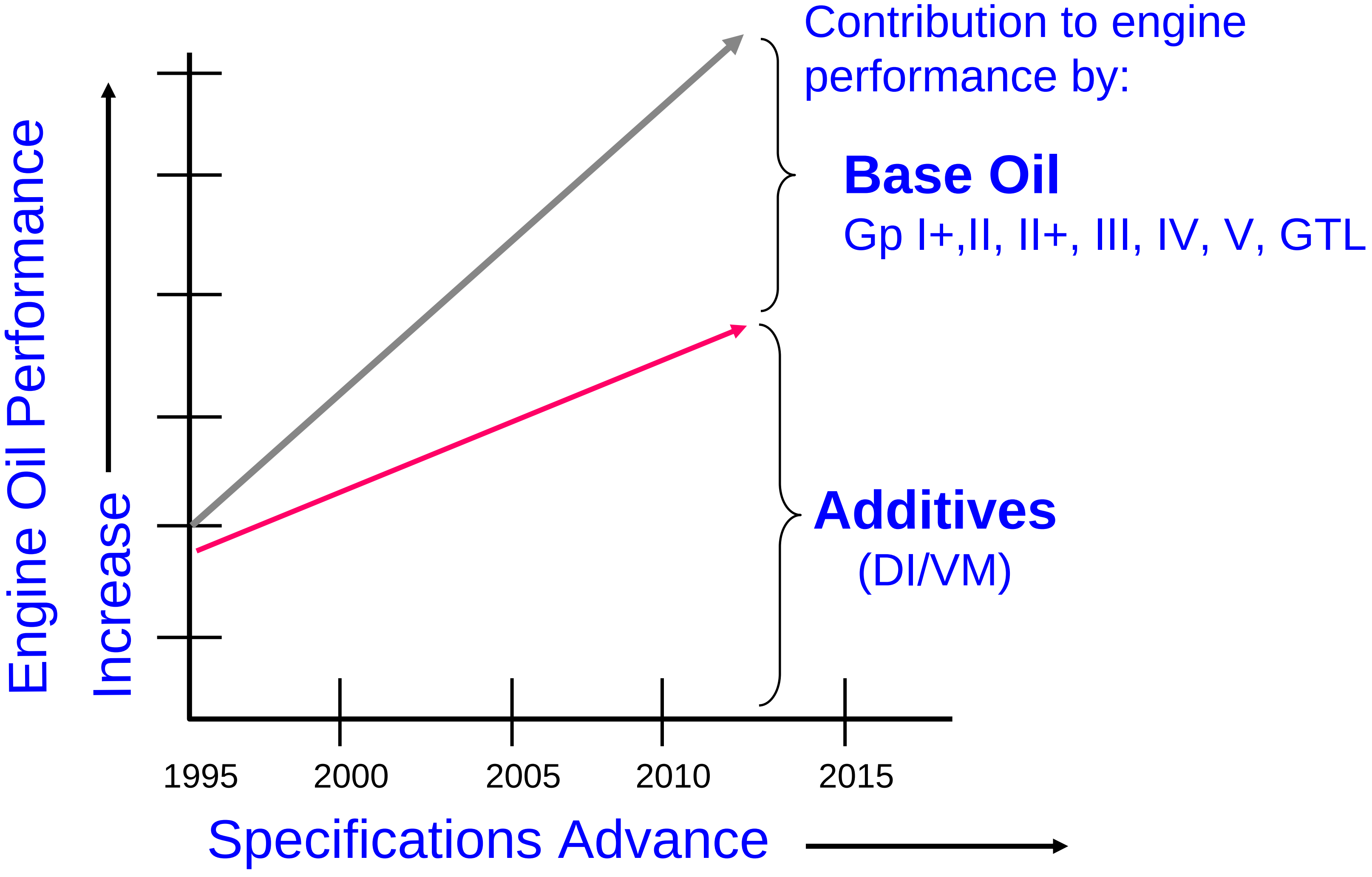
Global Chemical Limits for HD Lubricants

These restrictions will have a major impact on lubricant formulation strategies.

%wt	ACEA E6 MB 228.51 MAN 3477	Euro III Typical oil	CH-4 Typical oil	PC-10 (Draft)
Sulfur	0.3 max	0.4 – 1.5	0.4 – 0.8	0.4 max
Phosphorus	0.08 max	0.10 – 0.15	0.12 – 0.15	0.12 max
Sulfated Ash	1.0 max	1.2 – 1.9	1.2 – 1.6	1.00 max

Impact on Future Additive Demand

Increasing Demand on Additive and Base Oil



Drivers of Component Chemistry

- Emission trends are driving down the levels of
  - sulphated ash
  - phosphorus
  - sulphur

  for aftertreatment system compatibility
- Shift toward sulphur-free detergents
- ZDDP replacement chemistry
  - More antioxidant chemistry
  - Reduced or zero P/S antiwear components

Drivers of Component Chemistry

- Fuel economy trends normally increase the levels of phosphorus and sulphur-containing compounds to help reduce friction and prevent wear
  - Conflict with emissions requirements!
- Shift to ZDDP replacement chemistry
  - More antioxidant chemistry
  - Reduced or zero P/S antiwear components
  - Increased use of zero P/S friction modifiers
- Lower viscosity grades and increase dependence on base stock quality…

Fuel Economy Challenge

Fuel Economy

Effect on Viscosity Grade/Base Stocks

Lower Viscosity ↑

- 0W-20
- 5W-20
- 5W-30
- 10W-30
- 15W-40
- 20W-50
- mono

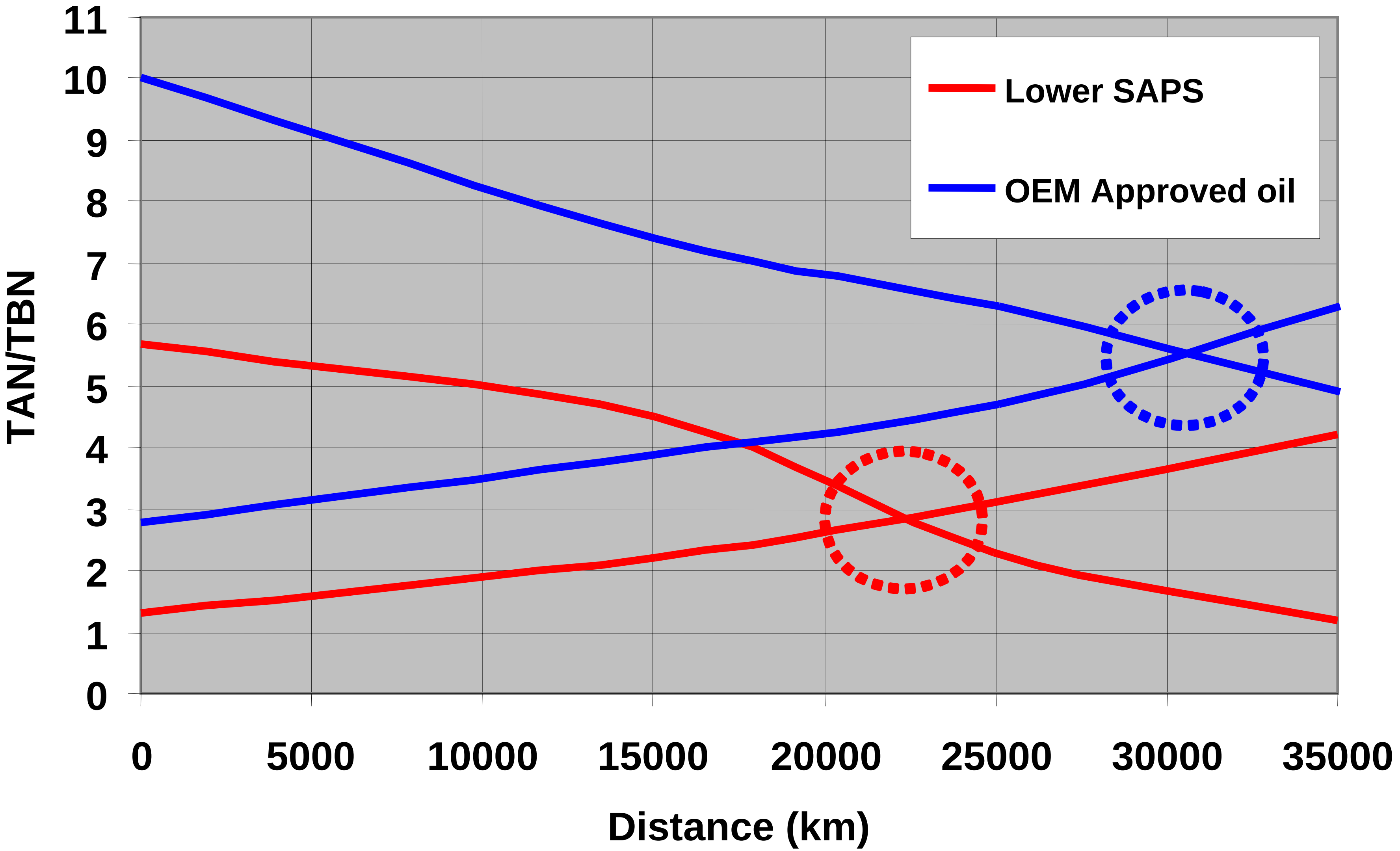
- Group III
- Group II+
- Group II
- Mixed Base stock
- Group I+
- Group I

↑ Higher Base Oil Quality

Drivers of Component Chemistry

- Extended drain intervals are requiring the additive system to function for **increasingly longer durations** - traditionally achieved through increasing the levels of many of the formulation components
    - Higher levels of sulphated ash, phosphorus and sulphur
  - **Conflict with emissions requirements!**
- Increasing dependence on base stock quality
- Higher use of antioxidants

Low/High Ash Fluids: Basicity Reserve



Perspective on Ash: Fuel Derived (mild case)

Vehicle and engine dynamometer programs suggest:

>20-30% of DPF ash is **<u>not</u>** engine oil related

– Diesel fuel, fuel/exhaust system corrosion are likely sources

Estimate of ash accumulation in DPF from fuel consumption:

120,000 miles x 15mpg fuel consumption => 25,284 kg diesel fuel

If ash is 0.01 wt %	= 2500 g ~ max. from bulk refinery fuel
If ash is 0.001 wt %	= 250 g ~ max. based on detection limit
If ash is < 0.00001 wt %	= 2.5 g

Current ASTM fuel spec is 0.01 % max ash; most US fuels have <0.001%

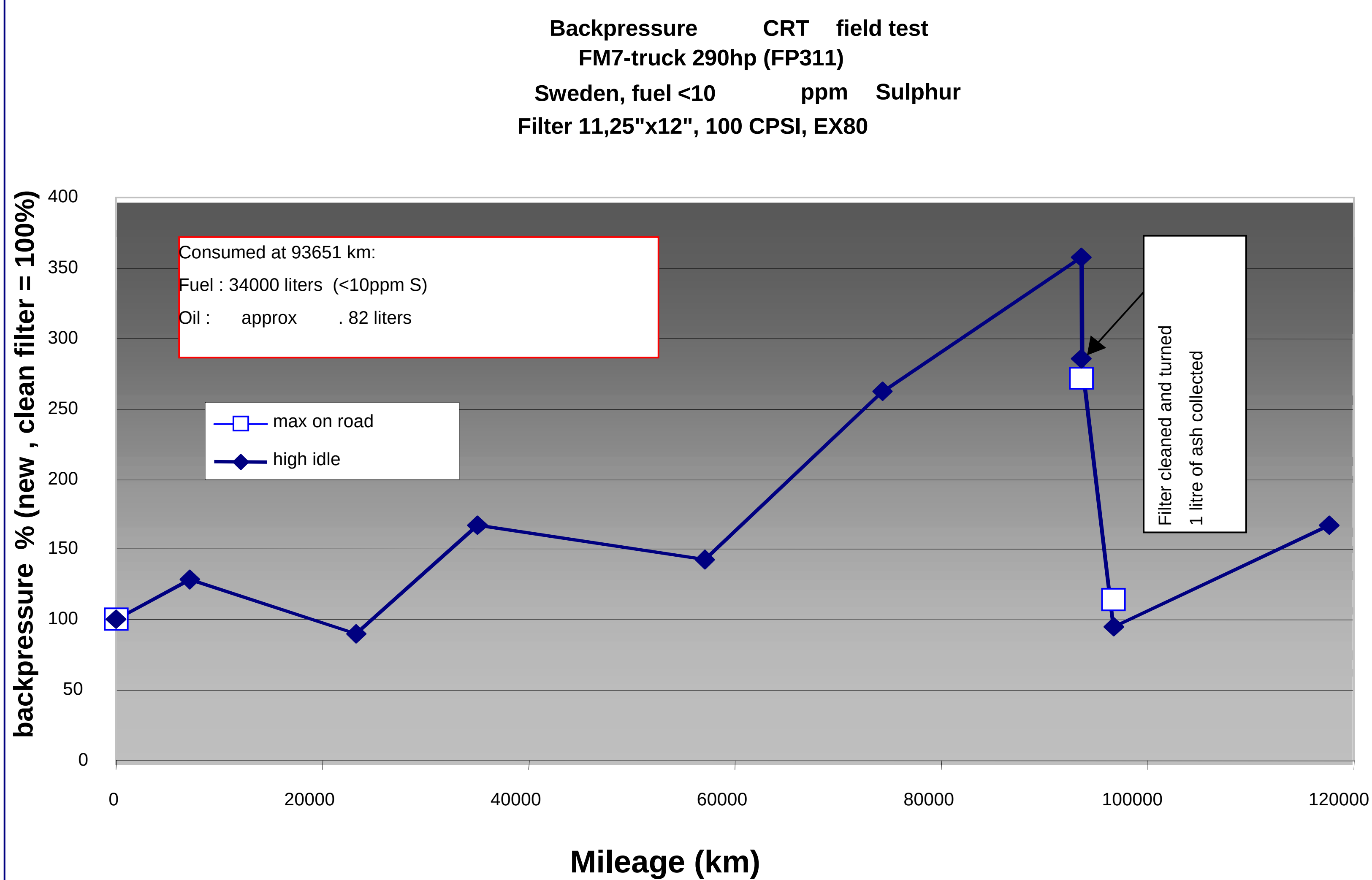
Perspective on Ash: Engine Oil Derived (severe case)

Estimate of ash accumulation in DPF from oil consumption:

120,000 miles x 3000 mpg consumption =>34 kg oil burned

If engine oil is 1.5 wt % = 510 g ~ max. from current HD oils
If engine oil is 1.0 wt % = 340 g ~ max. from API “PC-10” oils

Ash Challenge: DPF Deposits Removal



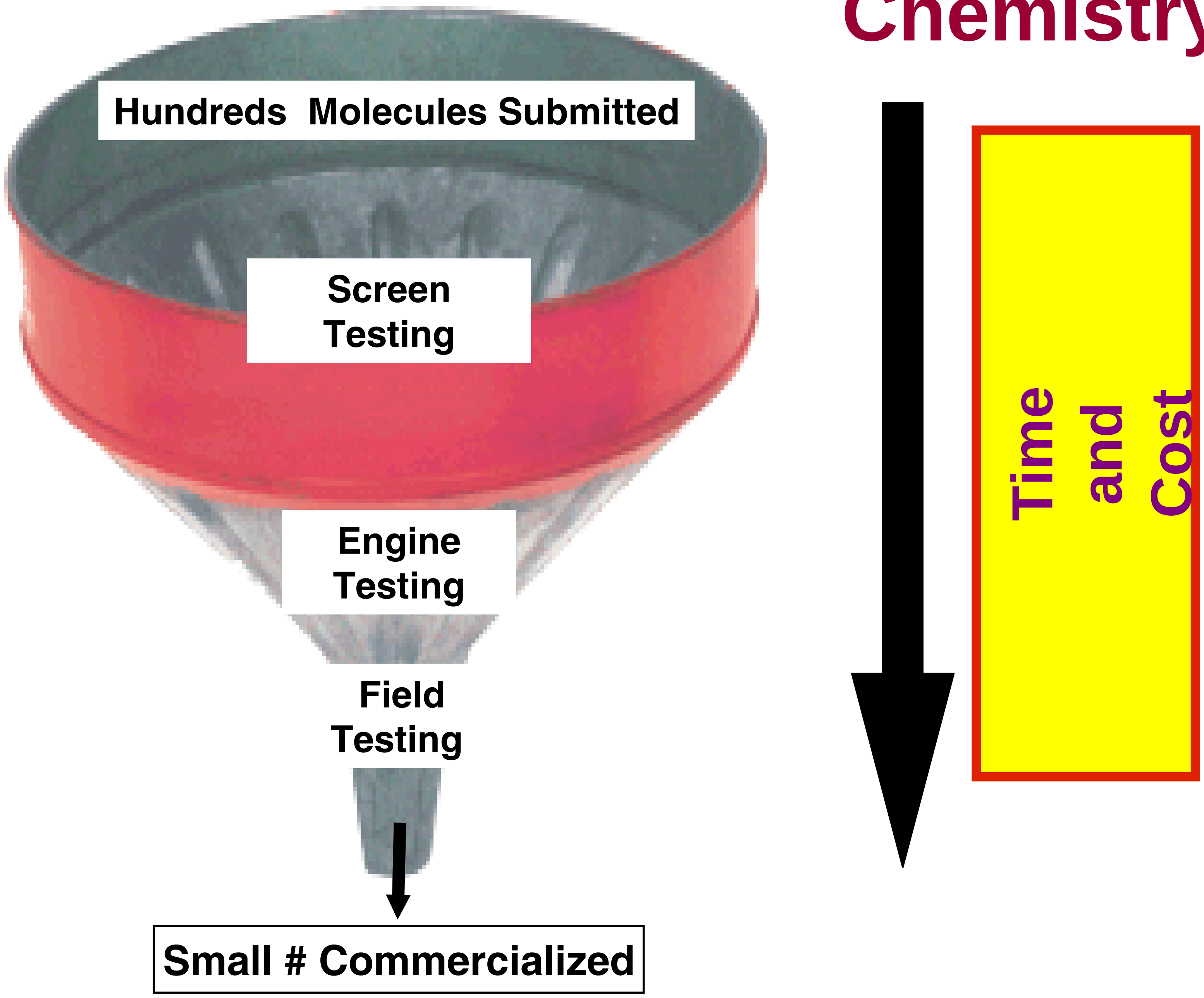
Courtesy of Volvo Trucks

Source: Dept. 24484, VTC

Challenges to Formulate Future Engine Fluids

- Chemical restrictions: limiting Sulphated Ash, S, P levels
- High massive cooled EGR: wear, corrosion, viscosity increase, sludge, deposits,
- Increased thermal demands in combustion systems
- Fuel dilution – early/post injection schemes

Challenge – Development of New Chemistry



A Way Foreword

To continue to create *excellent durable, fuel efficient, emissions-friendly engine oils*, industry needs to be prepared to:

- Invest in new technology / componentry
- Use a total formulation approach
- *Consider lubricant as an integrated component (similar to combustion systems, exhaust controls, fuels, etc.) in order to achieve <u>optimal</u> system performance*.

Goal: Creating Clean Environment

Goal: Creating Clean Environment

Thank you.