Lubricants for Heavy Duty Vehicles
-Challenges and opportunities

Dr. Anders Pettersson
Global Lubricant Coordinator
Agenda

- Volvo Group and Volvo CE
- PC-11 and the new API categories
- T13 test
- VDS-4-5
- Saving fuel with lubricants?
- Lubricant development at Volvo CE
The Volvo Group’s vision is to become the world leader in sustainable transport solutions by

- creating value for customers in selected segments
- pioneering products and services for the transport and infra-structure industries
- driving quality, safety and environmental care
- working with energy, passion and respect for the individual
PC-11 New API specifications

(PC, proposed change)

- API categories are developed by North American “Auto/Oil” industry (Volvo is a member)

- Major driver for new categories
  - Green House Gas (GHG) step 2 regulation 2017

- Additional benefits
  - Improved oxidation and thermal stability: Longer drains possible
  - Improved shear stability: Oil keep viscosity during full drain interval
  - Better Aeration properties: Keeps the engine oil under control in the lubrication system
PC-11 New API specifications

Before

API CJ-4

Dec 1, 2016

Substantial increase in thermal and oxidadative stability
Conventional viscosity
VDS-4.5

API CK-4 (PC-11A)

As above + Fuel Economy
Low viscosity

API FA-4 (PC-11B)
PC-11 New API specifications
- Low viscosity?

We define low viscosity oils as
- XW-30 or lower (e.g. 5W-30, 10W-30, 5W-20, 0W-20)
- And with High Temperature/High Shear (HTHS) viscosity of max 3.2 mPas
- Conventional oils (e.g., CJ-4, CK-4) have min HTHS viscosity of 3.5 mPas

Identified risks
- Lower oil film thickness → durability issues
- Lower oil pressure → functionality issues, e.g. engine brake
New Engine test: T13
- Background

- Intention to replace T12 Lubricant test
- Problem to get Ring and Liner wear in T13
  - Even with increased Peak Cylinder pressure
    and heavily soot-loaded oils
- Engine failure before Wear
  - Failed Bearing and fatal rod breakage
- Cylinder liner wear and top ring weight loss parameters in T12 will remain
New Engine test: T13

- Volvo D13 US10 500hp engine
  - 210 bar PCP
  - 1500 rpm
  - Oil gallery temp 130°C
    (~135-140°C sump temperature)
  - 360 hours
  - Rated oil parameters
    • Oxidation (FTIR Peak, at end of test)
    • Viscosity increase @40°C (increase between 300-360h)
New Engine test: T13

• Will substantially increase the oxidative and thermal stability of the oils
  - May allow longer oil drain intervals
  - Will better protect against carbon build-up on hot surfaces (pistons, turbo chargers etc.)

• Most Current CJ-4/VDS-4 oils will not pass T13 test

• Volvo has stricter limits than API CK-4 for VDS-4.5 on
  - IR Oxidation 80 vs. 125 in peak height
  - Viscosity increase kv@40°C 40% vs. 75%
New Engine test: T13
"High End" CJ-4 Round Robin

<table>
<thead>
<tr>
<th></th>
<th>&quot;high end&quot; ref</th>
<th>CK-4/FA-4 limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity increase</td>
<td>&gt;&gt; 100%</td>
<td>75%</td>
</tr>
<tr>
<td>(300-360 h)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxidation</td>
<td>&gt; 200</td>
<td>125</td>
</tr>
</tbody>
</table>

Most current oils will not pass
New Engine test: T13
- How will current and coming oils perform?
New Engine test: T13
- How will VDS-4.5 perform?

Dr. Anders Pettersson, UNITI Stuttgart 2017
The Strubeck curve
What “knobs” can be manipulated?

Friction Coefficient

Dry, solid contact

Boundary Lubrication

Mixed Lubrication

(EHD)

Hydrodynamic Lubrication

Oil Viscosity x Contact Velocity / Load
The Stribeck curve
What “knobs” can be manipulated?

- Base fluid
- Additives
- Viscosity
- Surfaces structure
- Coatings
The Striebeck curve
What “knobs” can be manipulated?

Additive Performance

Base fluid, (viscosity and type)

Dry, solid contact

Boundary Lubrication

Mixed Lubrication

(EHD)

Hydrodynamic Lubrication

Friction Coefficient

Oil Viscosity x Contact Velocity / Load
Fuel efficiency; HD engine and engine oils

What can be done with engine oils, short and long term?

• Energy can be saved by reduce friction
  - Reduced boundary friction by friction modifiers
  - Reduced hydrodynamic losses by lower viscosity

• Potential savings is in 0.5-1.5% range
  - 15W-40, API CJ-4 => 5W-30, API FA-4 ~1% improvement
  - 0W-XX oils to become more common in future, give even higher savings.

• Most Friction modifiers are not effective over full drain interval in HD applications. More R&D necessary

• Low HTHS and low volatility demand good base fluid, Might be tricky to met with a reasonable cost increase?
Fuel efficiency; HD engine and engine oils

Reduce hydrodynamic losses by lowering oil viscosity

OFT $\sim \eta \nu / L$
Fuel efficiency; HD engine and engine oils

Friction coefficient vs. Viscosity × Speed/Load

- Baseline
- Low viscosity oil
- Low viscosity oil + FM

Dr. Anders Pettersson, UNITI Stuttgart 2017
Lubricants at Volvo CE
lubricant development at VCE

R&D pre-study

Idea, needs, legislations

Additive, Lubricant Company University

Concept
To be used Direct or put on shelf for later use

Dr. Anders Pettersson, UNITI Stuttgart 2017
Lubricants at Volvo CE
lubricant development at VCE

Lubricant product development projects

Additive company

Oil company

Technology

AM

H&S

IPS

New lubricant!
Standard
Legal documents
Training material
Labels
Supply agreements

Dr. Anders Pettersson, UNITI Stuttgart 2017
Lubricants at Volvo CE
lubricant development at VCE

- Lubricant = Machine element!
  Should have part number, BOM, etc, just as gears, bearings and other components

  - Always select the optimal lubricant
  - lubricant consideration first, not last in projects

- Lubricant is used to build quality and add features
  - Reduce fuel consumption
  - Increase uptime
  - Reduce scheduled maintenance by longer service life
  - Make profit from the Volvo genuine oil program
Drive train comparison
-On and Off Road
Drive train comparison
-On and Off Road

A40G Hauler

- Engine: 55 l
- Hydraulic system: 262 l
- Wet Brake fluid: 241 l
- Transmission: 40 l
- Axles x3: 90 l
- Transfer case: 9 l

Sum: 697 liters!

(Typical 18m, 46 ton on-road truck ~75L)
Energy efficient oils?
Product strategy

• Shear stable oils, “tailored” viscosity profile
  - High natural VI of base fluid (no Grp I)
  - Minimal use of (advanced) polymers

• Low losses
  - Base fluids with low EHD friction
  - State of the art AW/EP additives

• Long drain capable
  - High quality base fluids
  - Efficient additive systems to prevent oxidation
  - Durable Friction modifiers

Result: Optimized oil, fit for purpose!
Energy efficient lubricants, with long drain capability

-Shear stability: Don’t use diesel to make your fluid thinner!

1000h transmission dyno test
Dexron IIIG VS.
State of the art technology

20h KRL @100C data corresponds well to 1000h transmission dyno

Dr. Anders Pettersson, UNITI Stuttgart 2017
Thank you!

Questions?