Influence of Lubricant Ash Content on DPF-Performance in Medium-Speed Diesel Engines

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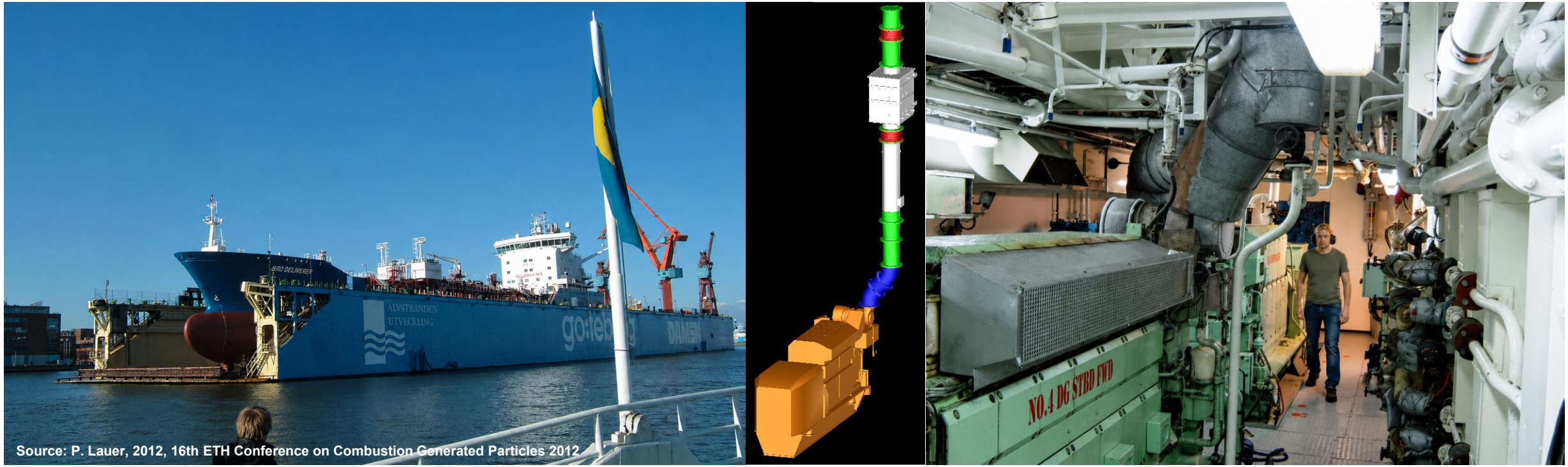
Chevron

29th ETH Nanoparticles Conference, ETH Zurich, Switzerland

Stefanos Melekidis, Dr. Daniel Peitz, Andreas Neidel, | Hug Engineering
Luc Verbeeke, Marc De Weerdt, Robert Mills | Chevron Lubricants

First Diesel Particulate Filter for a Medium-Speed Marine Engine

… 15 years ago



Source: P. Lauer, 2012, 16th ETH Conference on Combustion Generated Particles 2012

Results reported by Peter Lauer (*MAN* [today: *Everllence*]) at 16th ETH Conference on Combustion Generated Particles 2012:

On the experience of: "*First DPF at a Medium Speed 4-Stroke Diesel Engine on Board of an Ocean Going Vessel*"

⇨ **Filtration of elemental carbon soot worked well, but overall, still unsatisfactory solution!**

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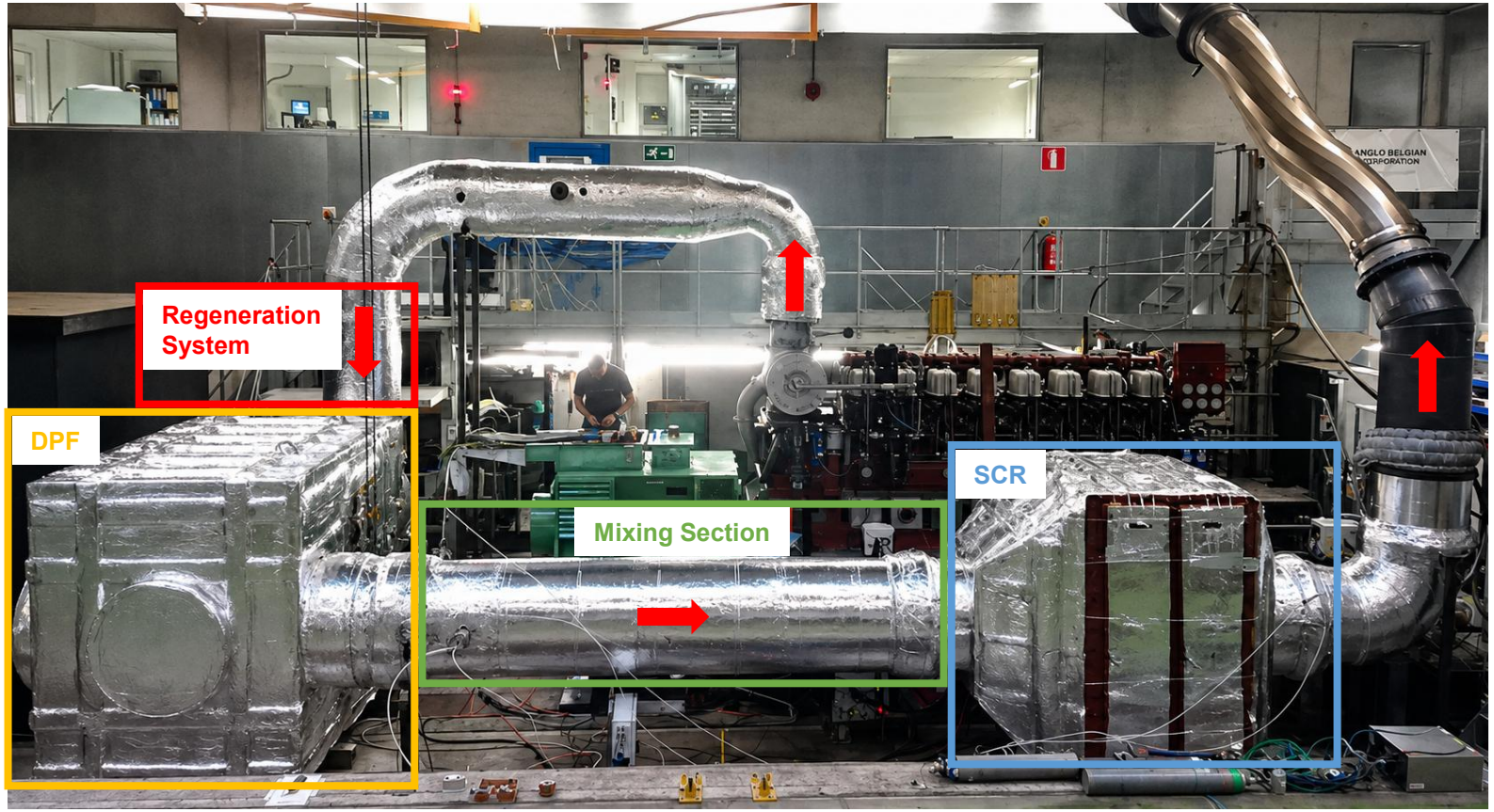
Today: Ultra-Low Emission Vessels With DPF + SCR in Service



- Medium-speed engines*
- Typ. operation $6000\ h/a$
  → ash as a key DPF constraint
- For distillate fuels, lubricant ash dominates DPF loading
- Ash determines service interval and downtime
- Maintenance predictability is crucial

DPF available for medium-speed marine engines – ash management is key.

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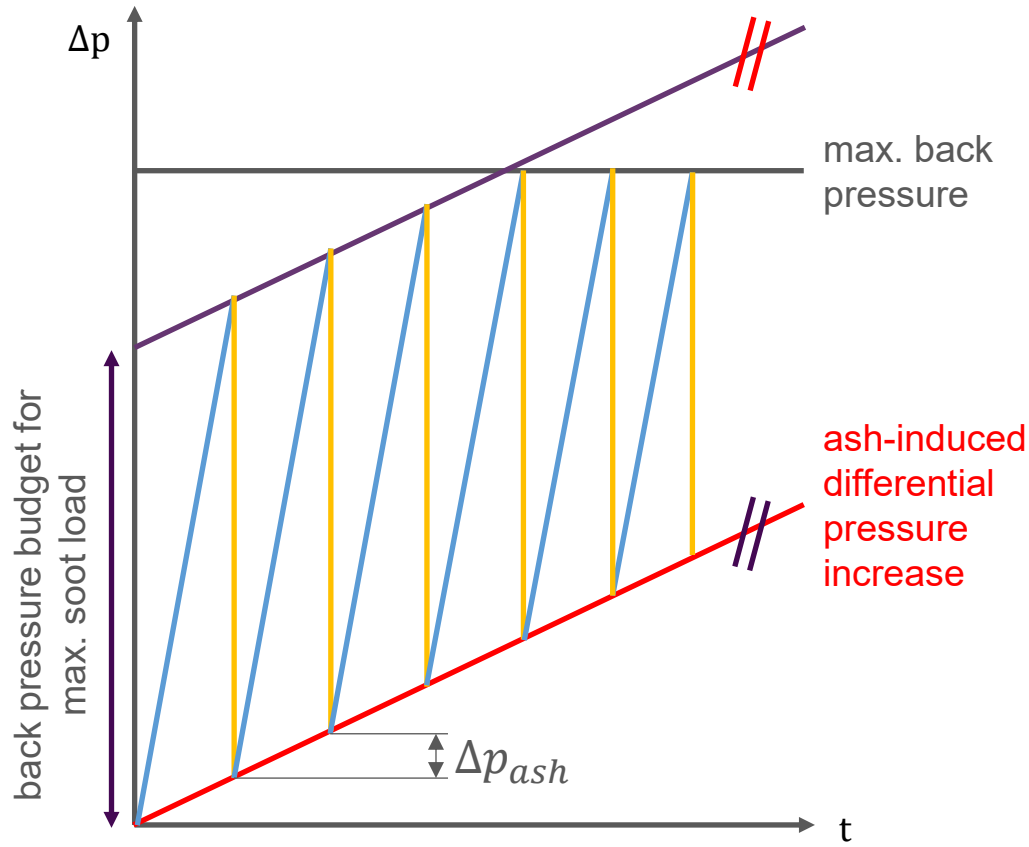
Service Interval is Driven by Ash (Not Soot!)

- **Soot** is transient → continuously removed via **regeneration**
- Ash is permanent → accumulates over **lifetime** of the filter
- Progressive ash loading reduces effective filtration volume
- Continuous **increase in backpressure** over operating hours
- Determining service interval and maintenance predictability



Ash accumulation defines maintenance – not soot regeneration.

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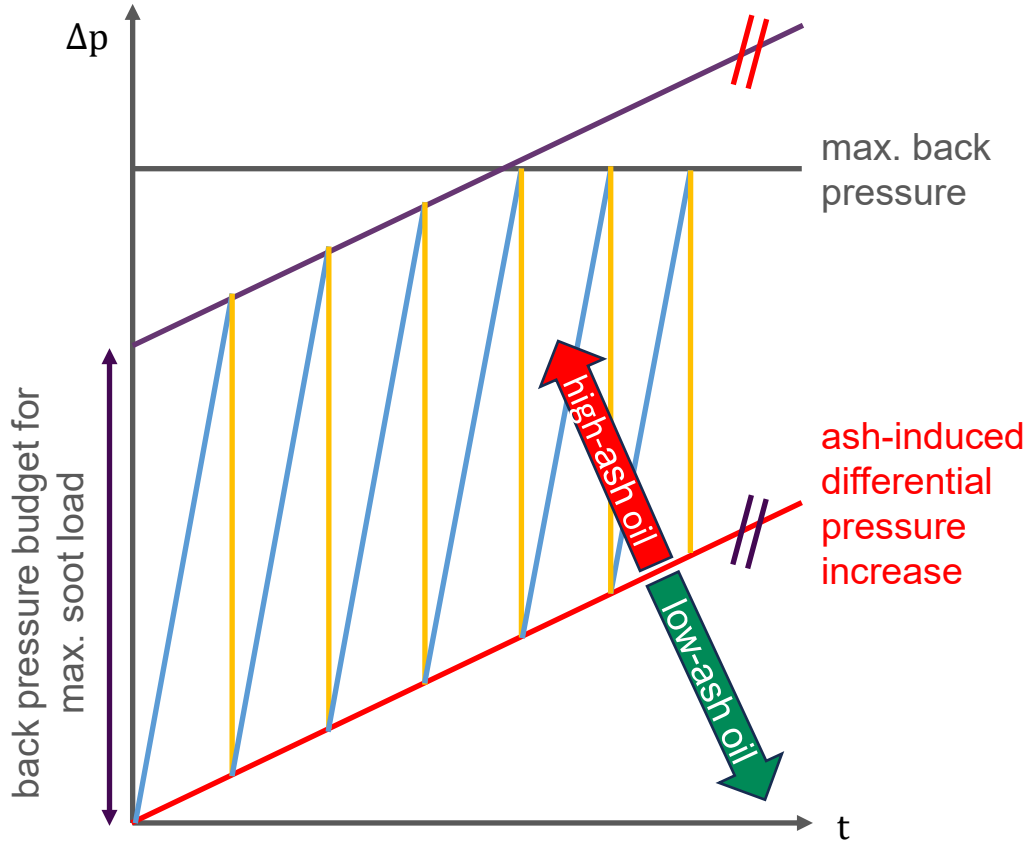
Marine Engine Lubricants and DPF Requirements

- Marine engine lubricants designed for high-sulfur fuel operation → requiring **high BN** for acid neutralization and corrosion control
- Traditional marine engine design without required oil exchange → maintaining relatively **high oil consumption** levels
- For distillates, biofuels and synthetic fuels: **oil type and consumption are key drivers** for **DPF service interval** → compare different ash-content oils regarding DPF performance



Lubrication not only an engine protection system – direct parameter in DPF operation.

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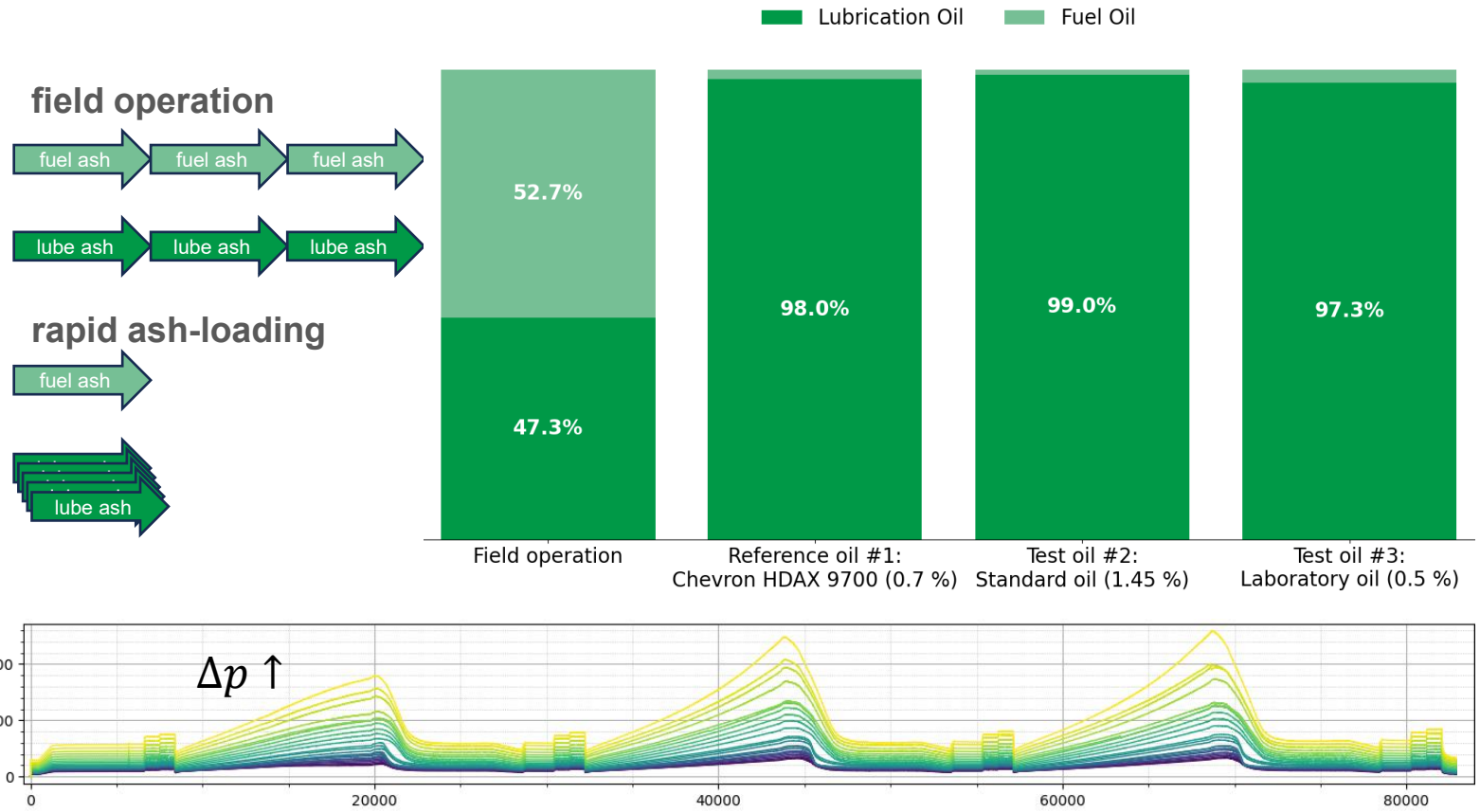
Accelerated Testing of Marine Engine Oils With Different Ash Content

- Low-ash com. oil – *Chevron HDAX 9700*: $0.7\ wt\%$ sulfated ash
- Conventional com. oil: $1.45\ wt\%$ sulfated ash
- Ultra-low-ash laboratory formulated oil: $0.5\ wt\%$ sulfated ash
- Repeated ash loading using oil-enriched fuel to simulate $6000\ h$ in reasonable time scale ($< 600\ h$) in the lab



Controlled sulfated ash gradient in accelerated cycling to reproduce DPF aging effects.

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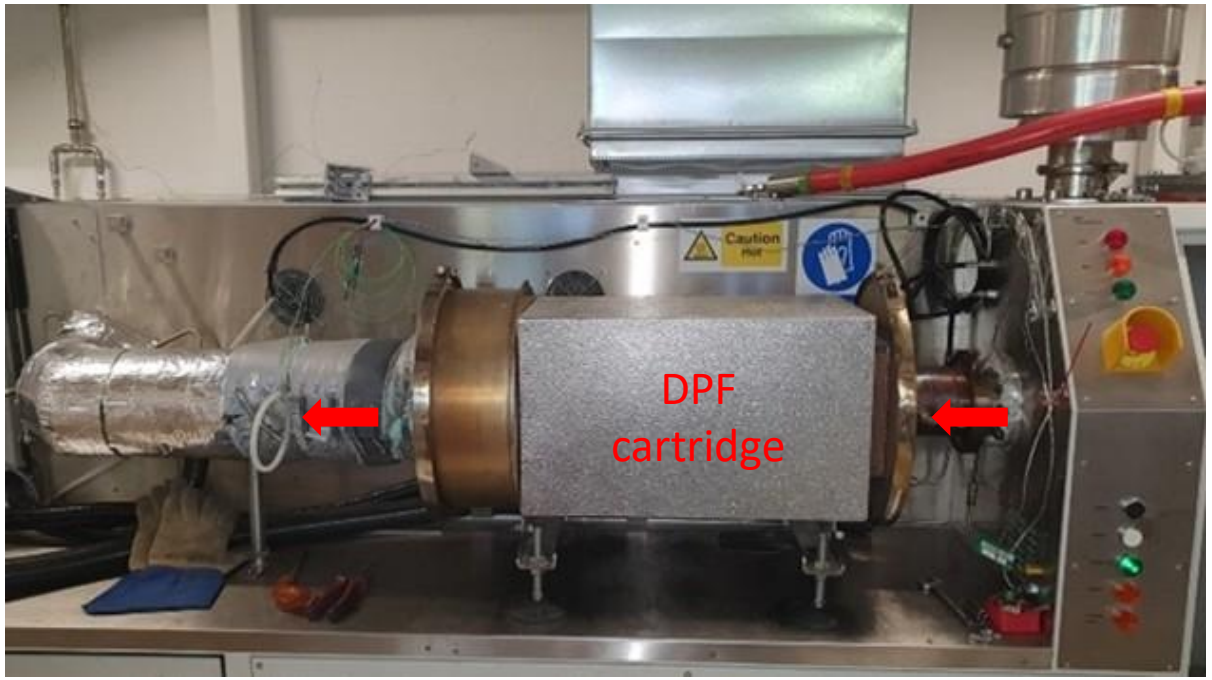
Experimental Setup for Accelerated Ash Loading Test

Lab procedure representing $\approx 6{,}000\ h$ ash maintenance interval

- Representative marine operating conditions
- Repeated cycle: performance check, soot + ash loading, regeneration
- Lab: Cambustion DPG + single Hug DPF cartridge
- Field: MW-scale multi-cartridge Hug DPF-SCR system
- Same cartridge geometry enables direct comparability



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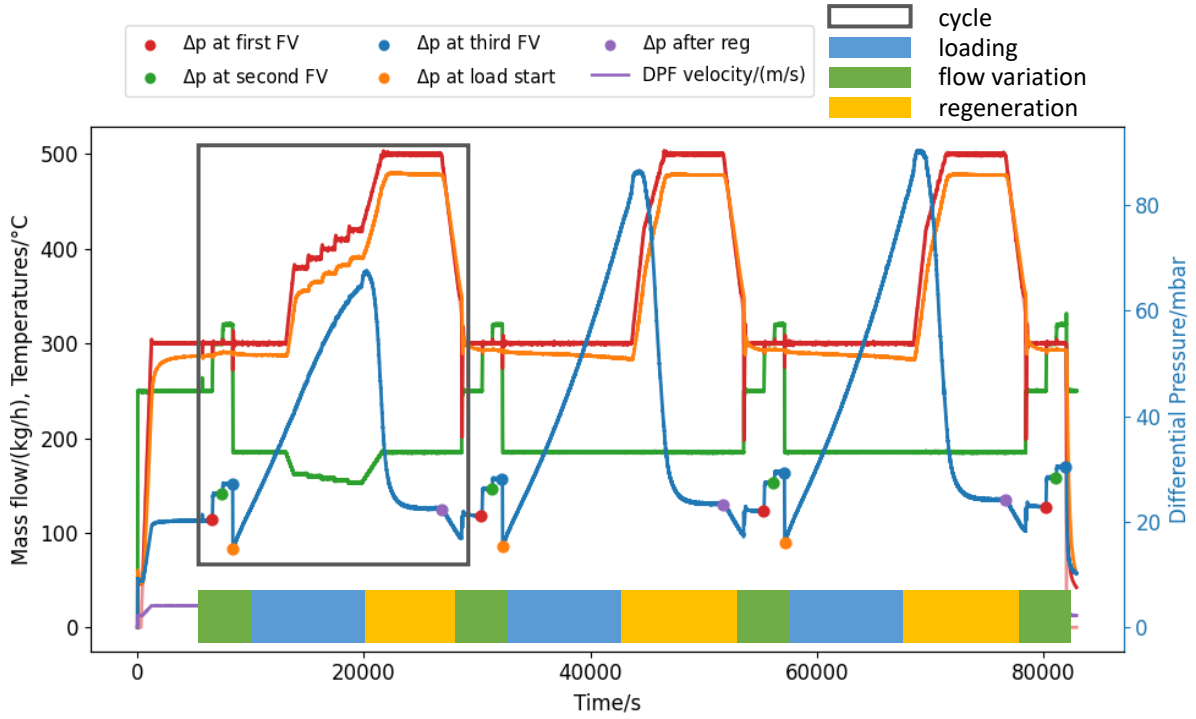

Accelerated cycling reproduces field DPF ash aging under controlled conditions.

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Result: Higher Ash Oil Accelerates Backpressure Increase

Key mechanism – ash → Δp trajectory shift:

- 0.7 wt% oil: linear → acc. Δp increase at higher ash loading
- 1.45 wt% oil: early onset of steep, non-linear Δp increase
- 0.5 wt% oil: near-linear Δp increase

Mechanistic interpretation: higher ash input

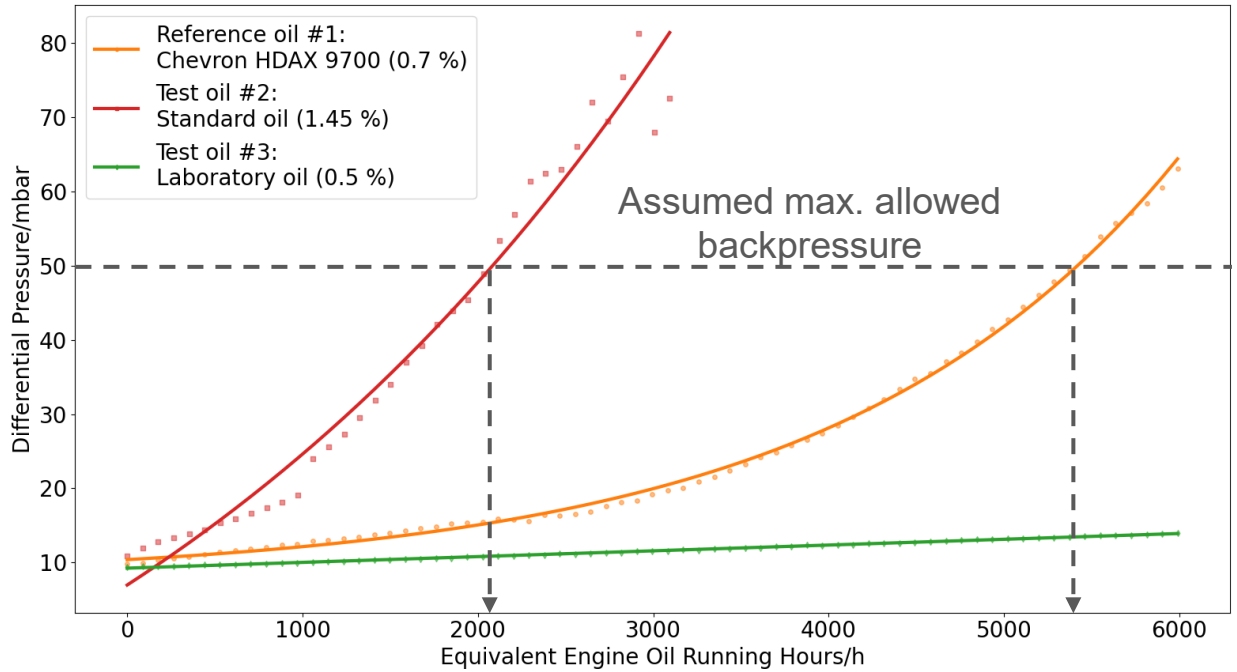
→ faster channel ash accumulation

→ regeneration-induced ash rearrangement

→ downstream movement and channel-end plugging

→ effective channel shortening

→ accelerated Δp rise and earlier Δp limit



$\approx 2000\ h$ $\approx 5500\ h$

With identical hardware and testing, lube ash cont. and formulation determine Δp trend.

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Field Evidence: $> 6,000\ h$ and $> 98\ \%$ Particle Reduction

- MW-scale medium-speed engines with DPF-SCR
- Vessel: *Jan De Nul 'Voltaire'*
- Low-ash lubricant for elevated Sulphur marine fuel: *Chevron HDAX 9700*

Field validation and key results:

- $\gg 6{,}000\ h$ without DPF ash cleaning demonstrated
- $> 98\ \%$ particle reduction efficiency (PM/PN)
- Stable filtration performance over extended intervals
- HC-NPET enables direct lab/field PN comparability

Low-ash lubrication enables long service intervals at high particle filtration efficiency.

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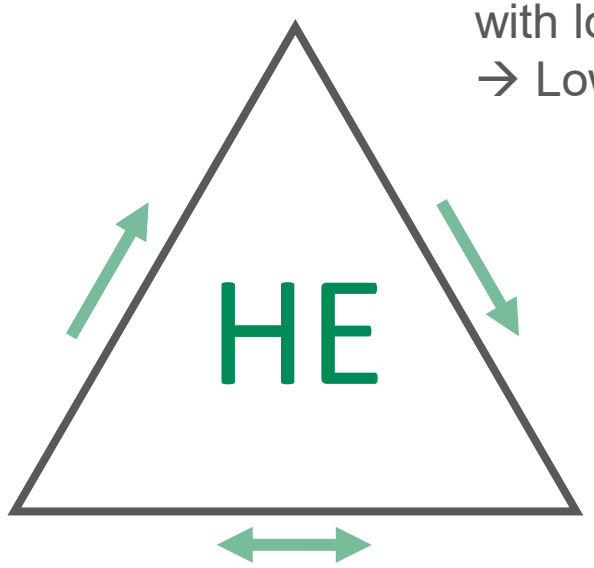
Takeaway: Lubricant Choice Is a DPF Lifetime Lever

DPF system trade-off triangle

Emissions Reduced oil consumption with low-ash content
→ Lower particulate emissions



Maintenance Interval
Slower ash build-up
→ Delayed Δp limit
→ Longer service interval

Operating Costs
Fewer DPF services
→ Less downtime
→ Lower total cost of ownership

→ **Oil formulation shifts the balance point of this triangle**
Right lubricant choice improves all three outcomes simultaneously!

Lubricant as lever for DPF lifetime, backpressure evolution, and service interval.

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