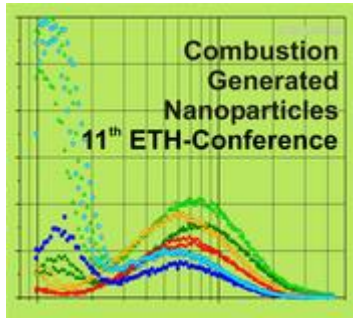
Reducing diesel particle emissions by particle oxidation catalyst

Lehtoranta Kati, Matilainen Pekka, Åsenbrygg Juha-Matti, Lievonen Ari & Kinnunen Toni

Ecocat Oy, Vihtavuori, Finland



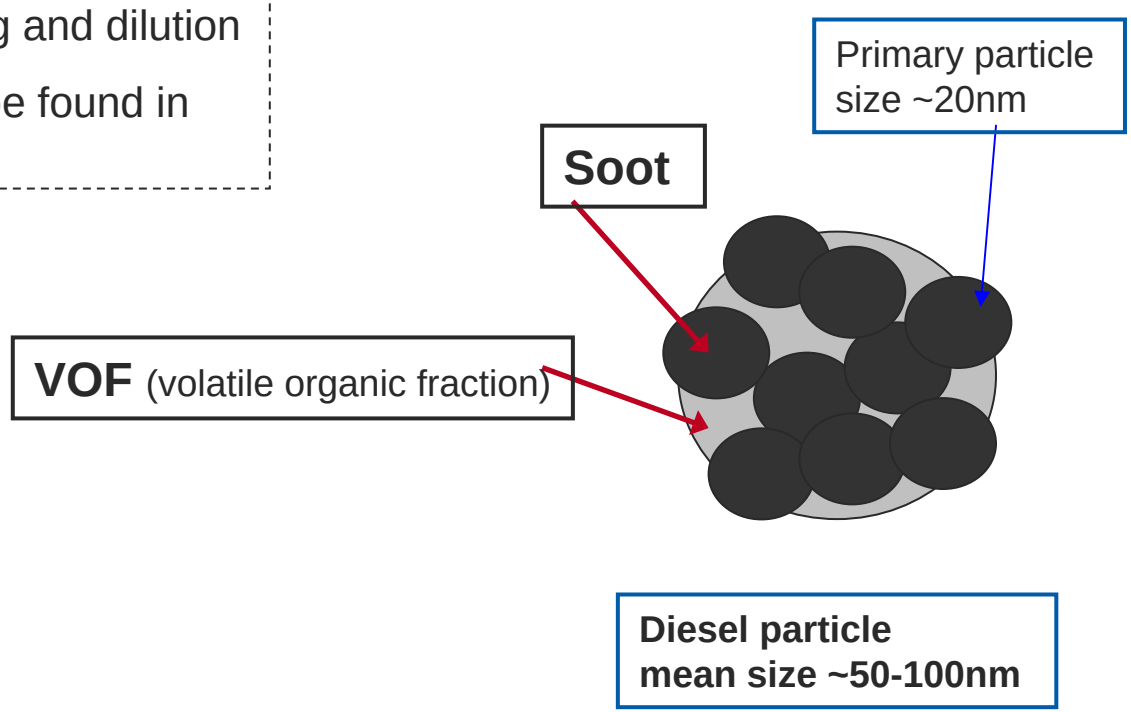
Contents

Introduction - What are diesel particulates

- Soot is formed in the engine through the incomplete combustion process

- VOF condensates on soot particles during exhaust gas cooling and dilution

- In addition sulfates can be found in diesel particulate matter

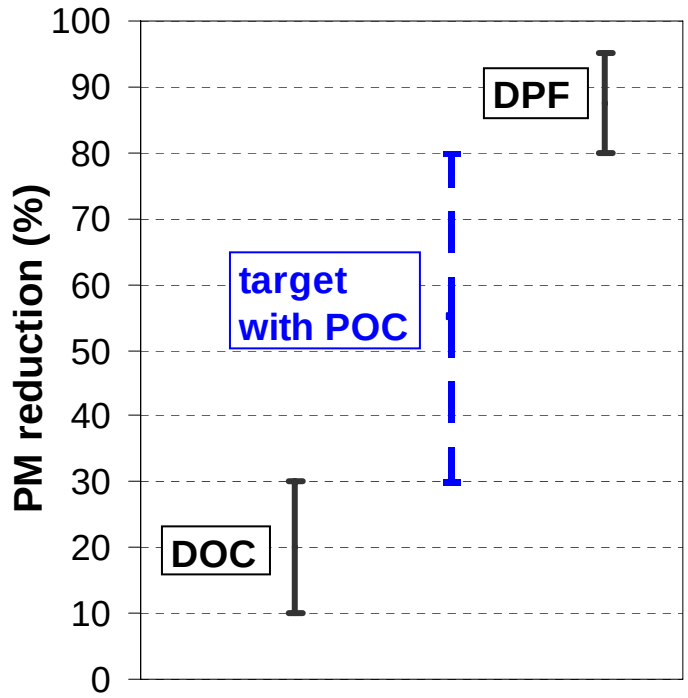


Introduction – diesel PM reduction with after-treatment

- **Diesel oxidation catalyst (DOC)**
  - effective reduction of HC and CO
  - some reduction of PM (reduction of VOF)
  - typical PM reduction 10-30%

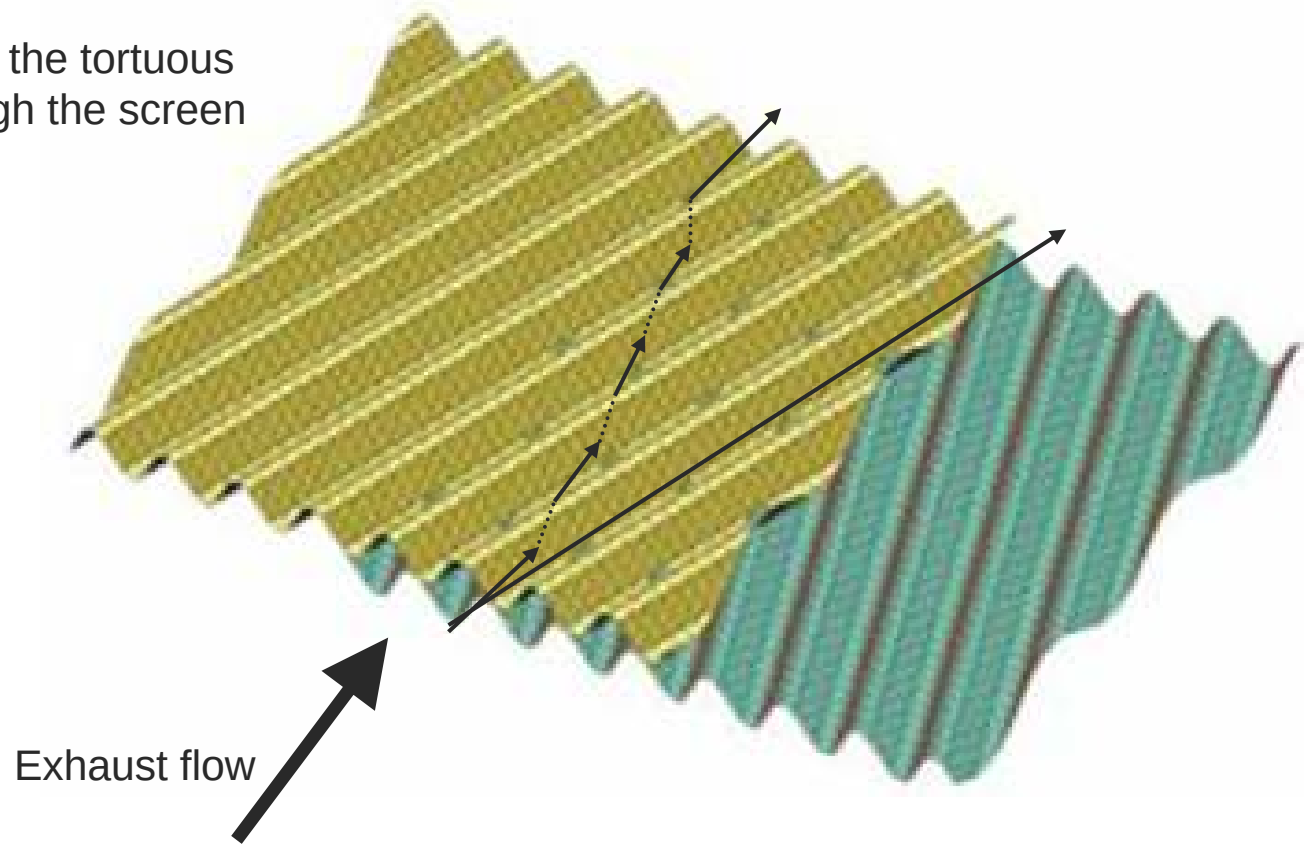
- **Diesel particulate filter (DPF)**
  - effective reduction of PM (soot)
  - typical PM reduction 80-95%
  - regeneration of filter needed (to avoid back pressure increase, blocking risk)

- **Particle oxidation catalyst (POC)**
  - first target: to increase particle deposition in catalyst without significant back pressure increase and to avoid blocking risk



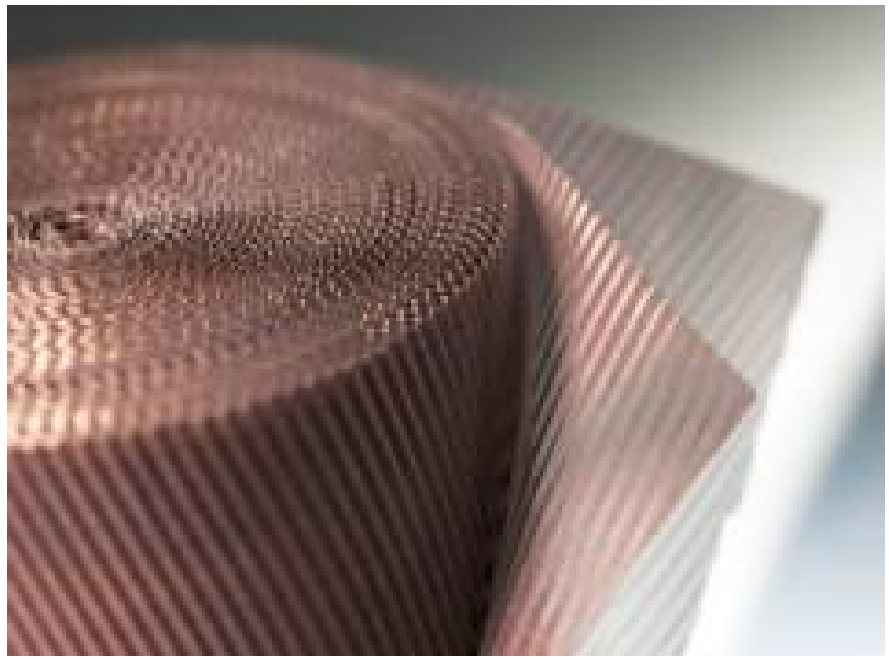
Structure of POC® *(EP 1230978, 2002)*

- Substrate channels are produced with several corrugated screen layers subsequently welded together
- Exhaust gas follows the tortuous paths or goes through the screen



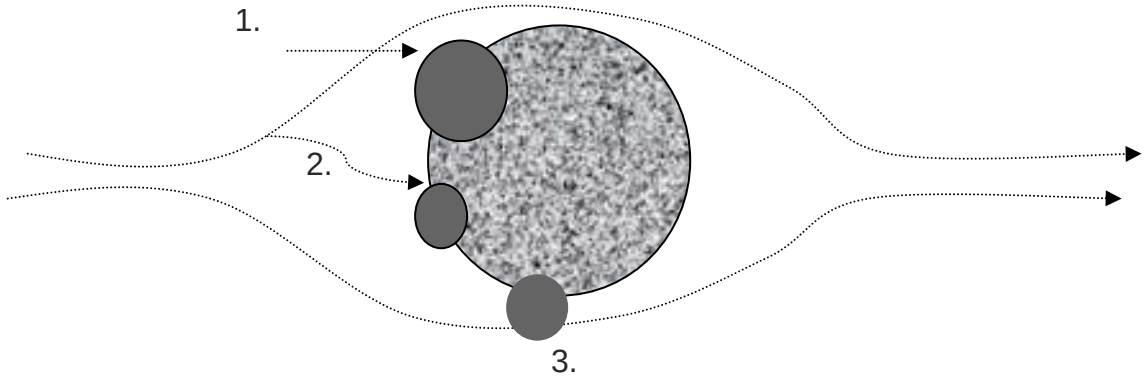
Structure of POC®

- Selection of cell densities and corrugation angles.



- Novel POC coating on fine screen
- Screen holes are open or partly closed.
- Soot is collected on the surface of the wire or on the edges.

Trapping Principles



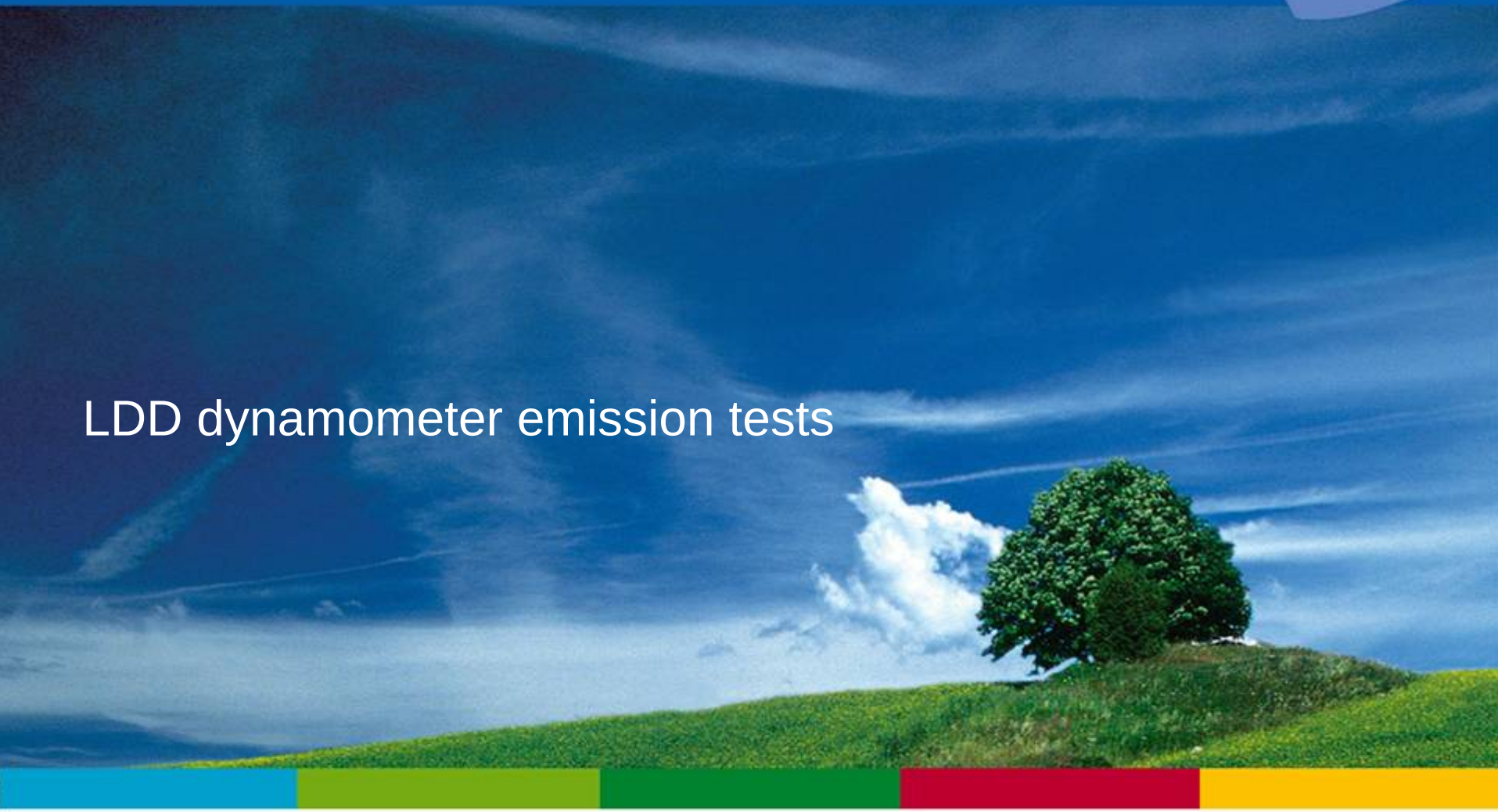
1. **Impaction:** coarse particles don't follow the flow curves

2. **Diffusion and thermophoresis**: in a temperature gradient small particles move from a hotter to a colder region

3. **Particle Capture:** small particles close to surface can be captured

-> Trapping methods of POC are studied in co-operation with Aerosol Physics Laboratory, Tampere University of Technology

LDD dynamometer emission tests



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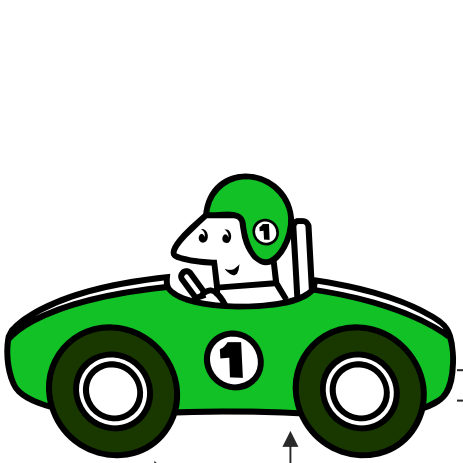
Emission test set-up



DOC (cc) + POC (uf)

DMM → Mass concentration

FPS

CVS

Gas analyzers, PM filter

Regulated emissions
- PM → VOF

Test vehicle: VW Touran (1.9 dm³, Euro 4)
Test fuel: Futura Diesel (EN590) (S < 10ppm)

Test-cycles:
- NEDC
- Steady modes: 60 km/h – 80 km/h – 120 km/h

Always minimum 3 test repetitions

Measurement equipments

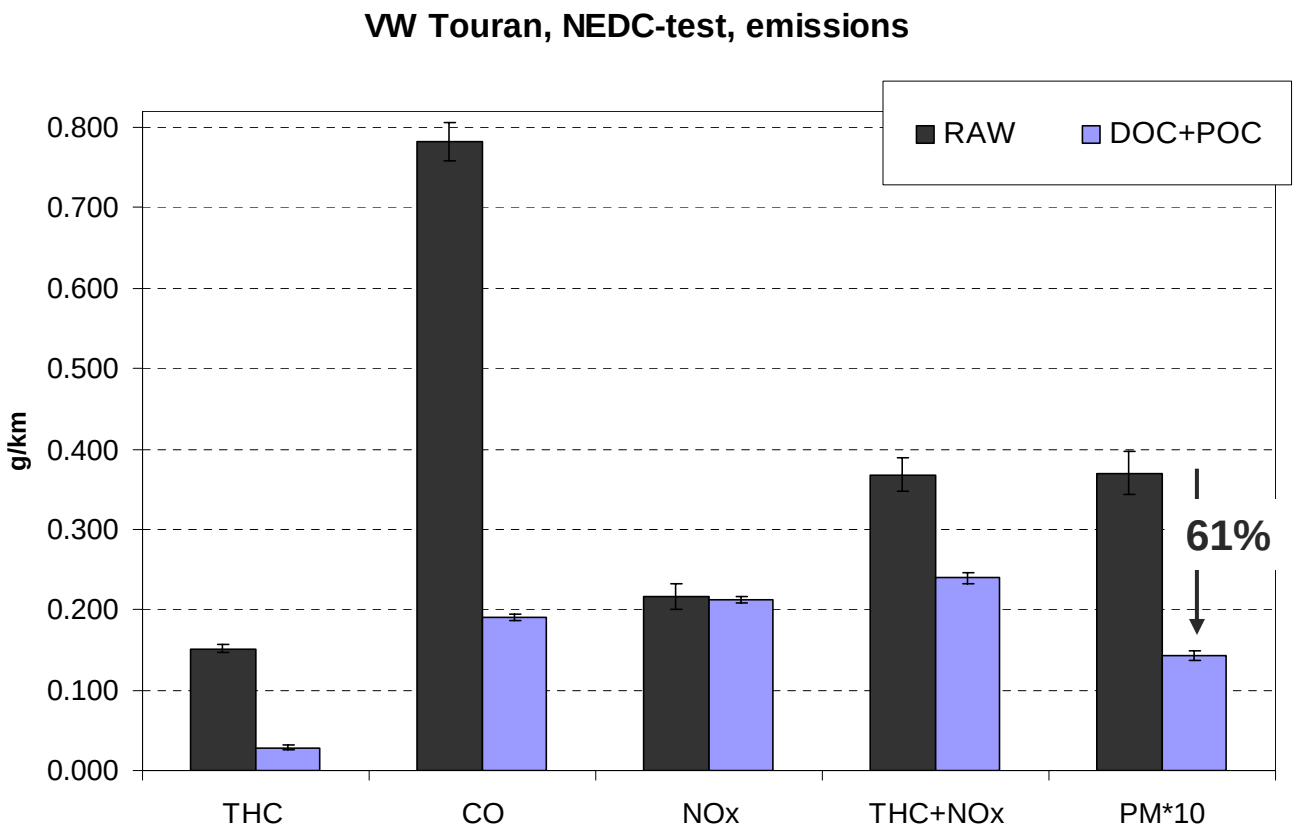
- **Gaseous and particulate matter (PM) emissions are measured according to the European regulations (Directive 1999/96/EC), CVS tunnel is used to dilute the exhaust gas.**

- **Volatile organic fraction (VOF) is analyzed from PM filters by weighing the PM samples before and after vacuum evaporation.**

- **Dekati Mass Monitor (DMM) is used to measure mass concentration in real time.** (In DMM this is done by compining aerodynamic and mobility size particle classification). **Fine Particle Sampler (FPS) is used for sampling and diluting the sample for DMM.** (Two stage dilution, primary with porous probe, secondary with ejector diluter).

- **In addition to emission tests e.g. exhaust temperatures and back pressures are measured.**

Example of POC efficiency

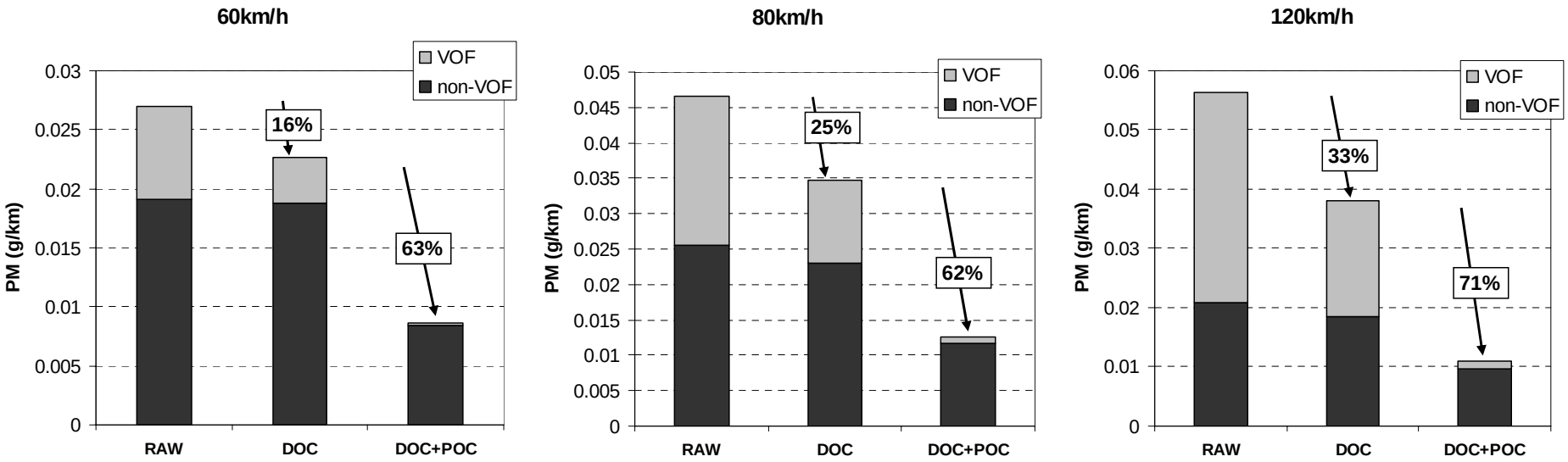


DOC = 120 cpsi,
d 90, L90, coated

POC = 400 cpsi,
d 118, L225, coated

DOC+POC clearly reduces particle mass, in this case ~60%

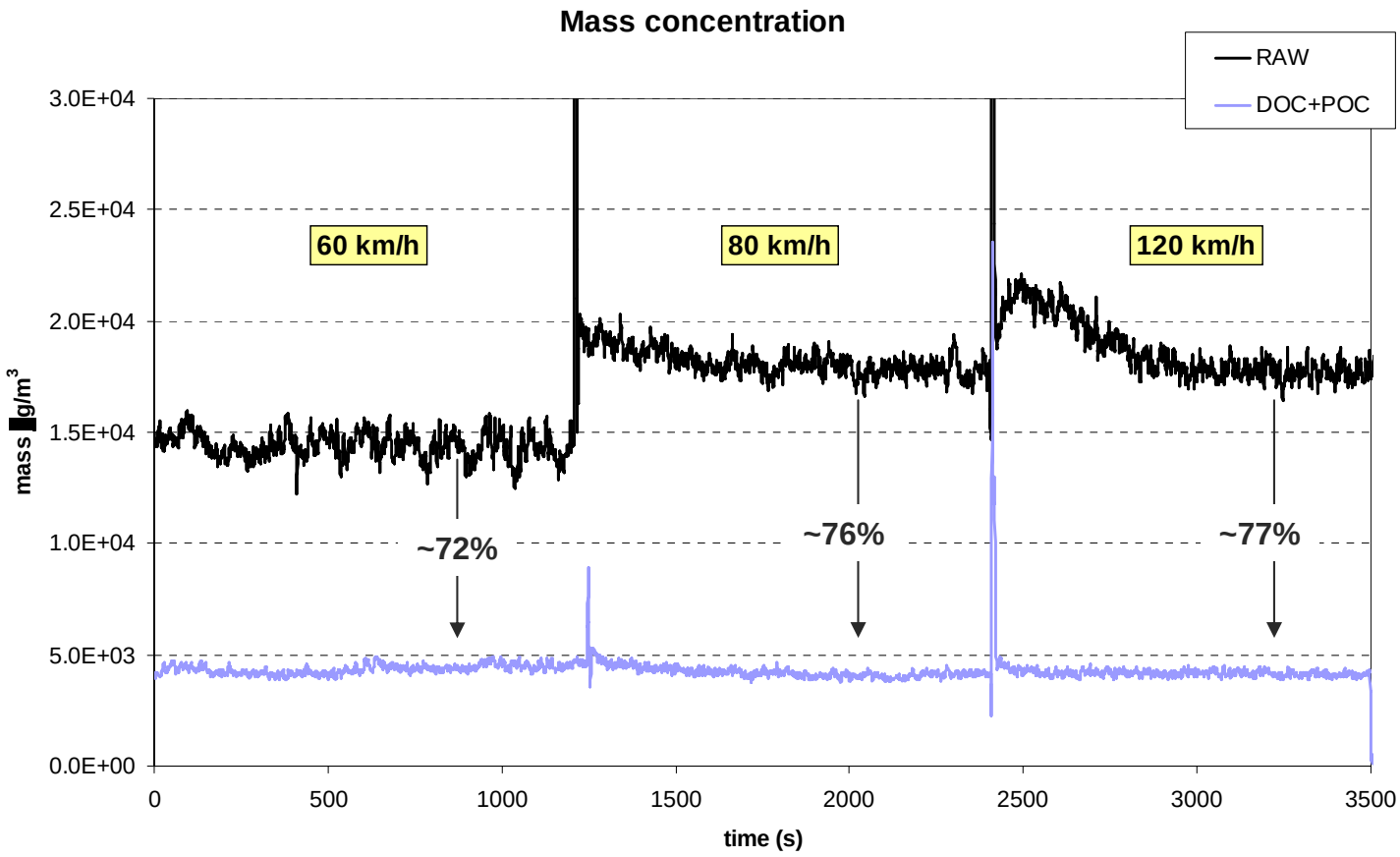
Example of POC PM efficiency – steady state driving



DOC can reduce the volatile fraction (VOF) of PM

POC reduces both VOF and non-VOF emissions

Example of POC PM efficiency – measured with DMM



Example of POC PM efficiency – 4000 km endurance test

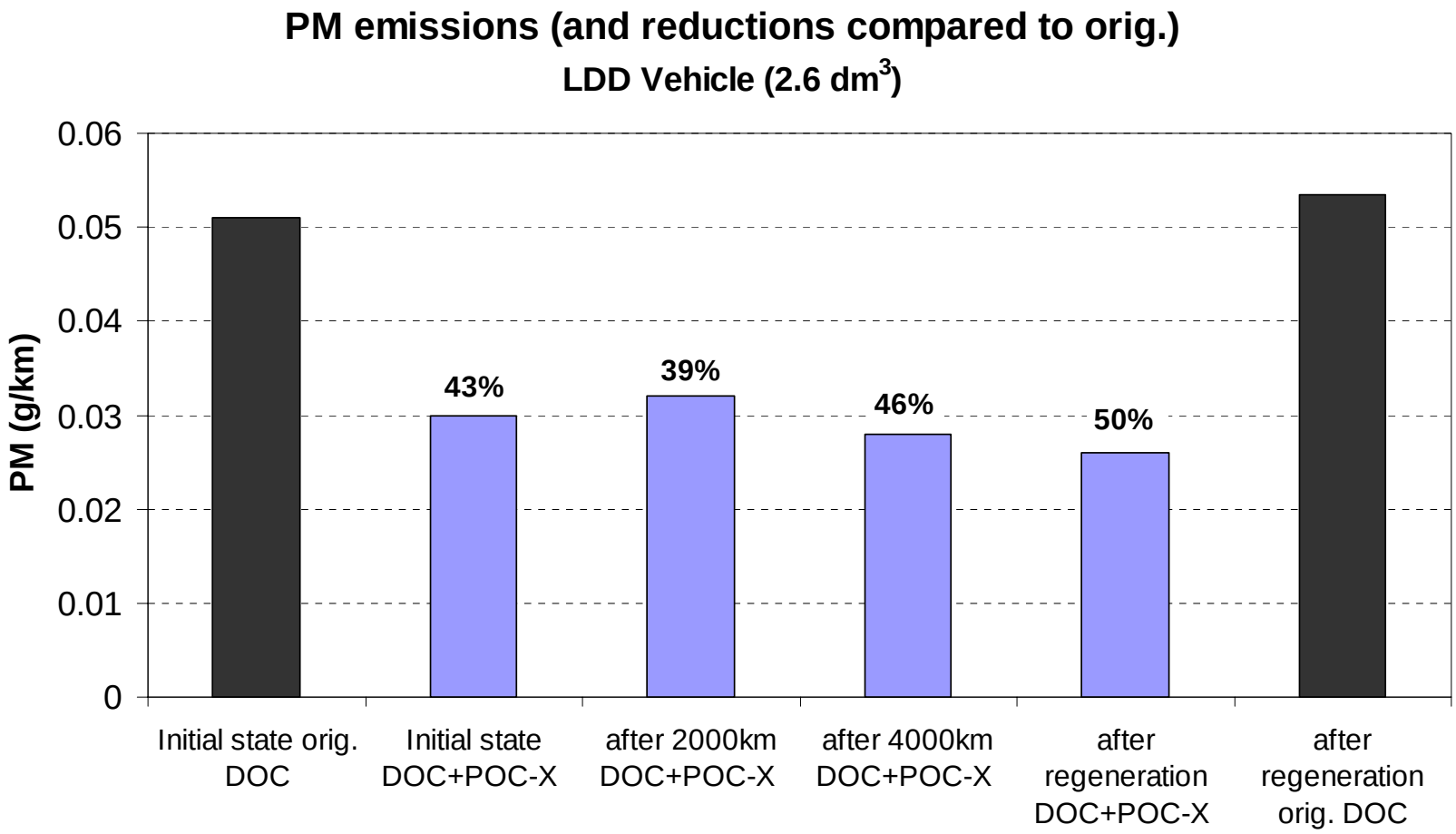
Target: average PM efficiency at least 30%

Description of the 4000km Endurance Test

- Average speed between 25 and 35 km/h
- Maximum speed 70 km/h
- Speed between 50 and 70 km/h for maximum 10% of test time
- Minimum 7% of test time is idling
- Average temperature before and after particle reduction system always below 300°C
- Maximum engine speed < 60% of rated speed

- **Initial state emission tests**
- **Emissions after 2000 km**
- **Emissions after 4000 km**
- **Worst case regeneration measurement**
- **Emissions after worst case regeneration**

4000 km endurance test results



Summary

- Comparative test results of the POC and DOC catalysts have proven that the POC has 30-60% PM conversion in addition to DOC (Note: Efficiency depends on application)
- Coating with precious metals is utilized in POC for regeneration purposes and to get the highest PM reduction possible (both VOF and non-VOF reduction)
- 4000km 'worst case' endurance test passed with POC → further on road tests needed and are running at the moment, e.g. HDD truck over 100 000km

- More information e.g. heavy duty test results, see *SAE 2007-24-0093* (to be published in SAE ICE 2007 in September)