Measurements of engine exhaust particle physical and chemical characteristics at transient driving conditions

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CLEEN MMEA WP4.5.2

Background. Particle emission standards are based typically on transient cycles and integrated measures of particle mass or particle number emissions. The studies at different steady state modes has shown that the exhaust particle emissions and particle characteristics depends on driving conditions. Also the transient itself can affect the emissions. Thus, the development of engines, fuels, and exhaust after-treatment need the methods and instruments to measure particle emissions and characteristics on-line and with high time resolution.

Objectives for the first field campaign.

- To construct large and versatile exhaust measurement setup to understand the details of the emissions at transient driving conditions
- To study the exhaust particle sampling and dilution at transient driving conditions
- To construct the measurement setup for on-line measurements of particle chemical characteristics
- To test new particle instruments at transient driving conditions (link to WP 4.5.1)

a) b)

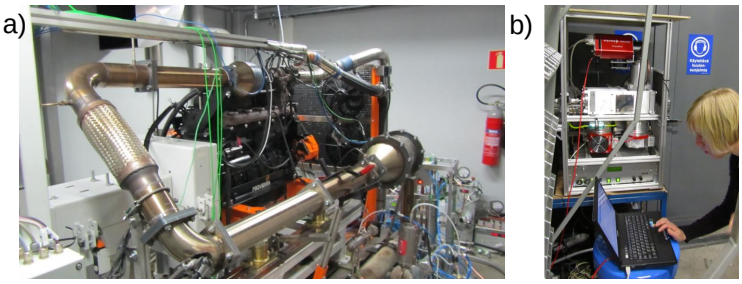

Figure 1. Engine test cell (a) and ACSM measurement (b).

The first field campaign

- Heavy duty diesel engine at the engine dynamometer
  - Without exhaust aftertreatment, with a DOC and with a DOC + SCR
- Transient and steady state driving cycles
  - NRTC (Fig.2a), NRSC and modified NRTC
- Two exhaust sampling and dilution setups
  - Porous tube diluter and ageing chamber (PTD)
  - Dilution with heated air (HECE)
- Particle instruments:
  - ELPI and ELPI+: particle number and size distribution real-time with high time resolution
  - CPC:s with different cut-off sizes
  - PPS: soot measurement from undiluted exhaust
  - SMPS and NanoSMPS: size distributions (only NRSC)
  - MAAP: on-line measurement of soot
  - ACSM: on-line measurement of organic material and inorganic ions
  - Thermodenuder (+ particle instruments): volatile particle fraction and its chemistry
  - Gaseous compounds

a) b)

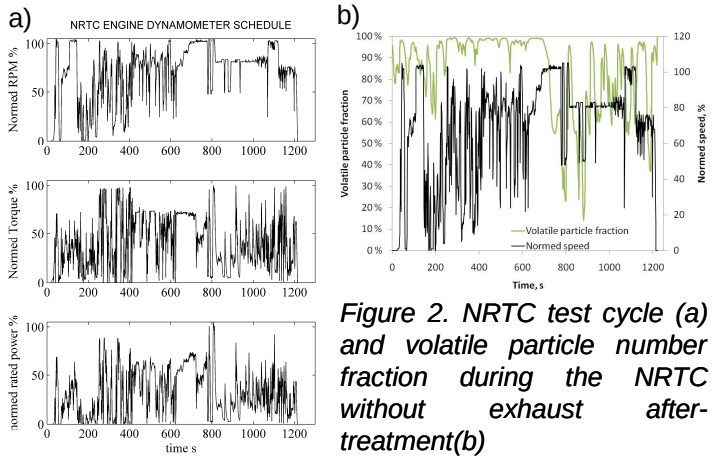

Figure 2. NRTC test cycle (a) and volatile particle number fraction during the NRTC without exhaust after-treatment(b)

Preliminary results.

- Especially the semivolatile particle fraction was affected by transient driving (Fig.2) and exhaust after-treatment (Fig. 4)
- Particle size distribution consisted the nucleation and soot mode, both affected by driving mode
- Only small changes are required to the dilution setup
  - More constant dilution ratio in transient cycles
  - Better insulation/heating of transfer lines
  - Comparison with standardized methods
- ACSM measurement was successful (Fig.4). Next campaigns: metals, better time resolution.
- The field campaign provided an excellent test environment for new particle instruments (WP 4.5.1)

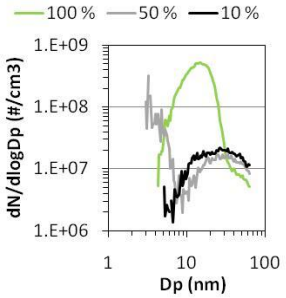

Figure 3. Effect of engine torque % on particle size distribution (NRSC)

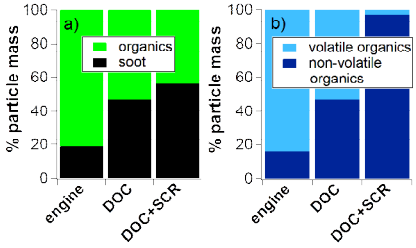

Figure 4. Effect of exhaust after-treatment on chemical composition of particles (modified NRTC)

Field campaigns during the second funding period

- At Metropolia: GDI passenger car with different fuels
- At Wärtsilä: Heavy duty diesel, particle chemistry at steady state conditions
- At Proventia: Heavy duty diesel engine, improvements on time resolution of particle chemical compound measurements

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