Particulate emissions of heavy duty engines on different test cycles

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Goal

How are different transient test-cycles reflected by the particulate emissions of heavy duty engines.
(regarding particle number – mass correlation)

What is the influence on number size distribution of emitted particles.
(measured by ELPI)

Euro 2 - HD-Engines / Cycle / Diesel Fuel

Brand	Engine 1	Engine 2	Engine 3	Engine 4
No of cylinders	V 6	V 8	In-line 6	In-line 6
Displacement [ccm]	11'000	14'618	11'705	12'124
Rated power	248 kW @ 1900 rpm	280 kW @ 1600 rpm	280 kW @ 1500 – 1900 rpm	275 kW @ 1800 rpm
Max. torque	1612 Nm @ 1200 rpm	1848 Nm @ 1000 – 1400 rpm	1765 Nm @ 1100 – 1550 rpm	1720 Nm @ 1200 rpm

Transient Cycles	
• ETC	• TUG (TU Graz)
• FTP hot	• TNO 7 kW/t
• FTP cold	• TNO 12,5 kW/t

Fuel	Market Fuel
Density (at 15°C) [kg/m^3]	831.4 to 832.1
Sulphur content [mg/kg]	330 to 339
Cetane number [--]	49.1

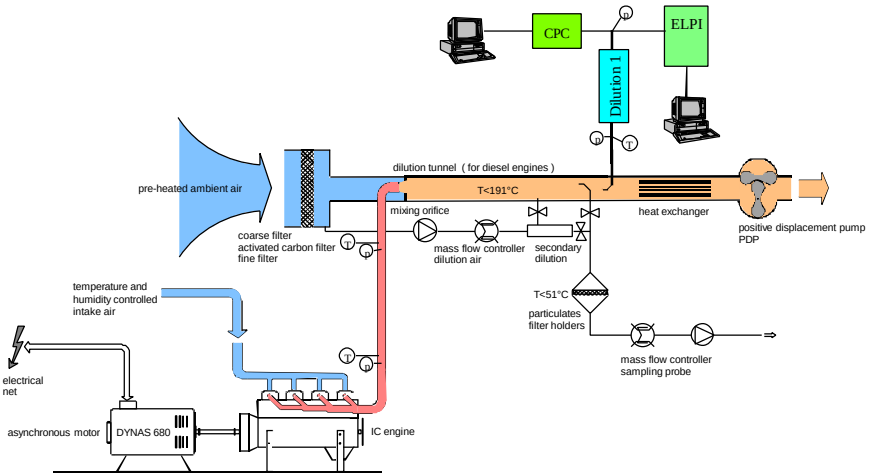
standard business fuel (CEC RF-03-A-84)

6 different transient cycles:

ETC	European transient cycle
FTP cold	US federal test procedure, US transient cycle (started at cold condition)
FTP hot	US federal test procedure, US transient cycle (started at warm condition)
TUG	TU Graz Real-world test cycle according to the D/A/CH handbook data
TNO 7 kW/t	Real-world test cycle [cycle-length: 3809 s] related to a power-mass ratio
TNO 12.5 kW/t	Real-world test cycle [cycle-length: 3837 s] related to a power-mass ratio

(TNO: Road-Vehicles Research Institute in the Netherlands)

Experiment Set-Up



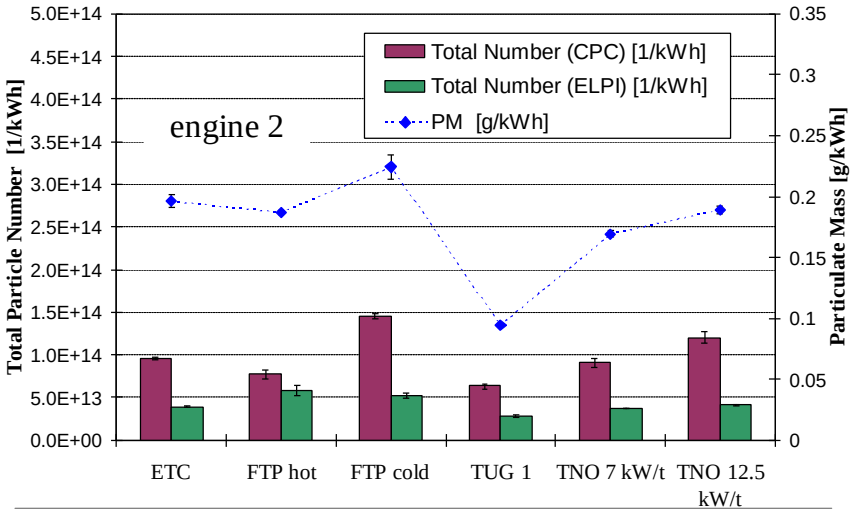
The particulate mass was determed using a state-of-the-art gravimetric filter measurement systems.

For the particlulate measurements (CPC and ELPI), the sample was taken out of the CVS tunnel close to the gravimetric sampling system.

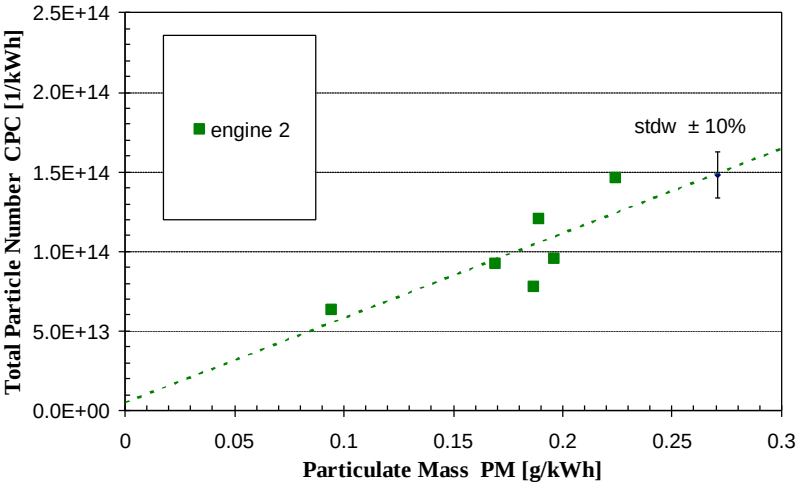
These 4 engines were measured on 6 cycles with at least 3 repetitions.
$\rightarrow$ the duration of the whole programm was quite long

Therefore it was very important to use always the same intruments and set-up. Also the conditioning of the instruments before a measurement-period was according a fixed protcol.

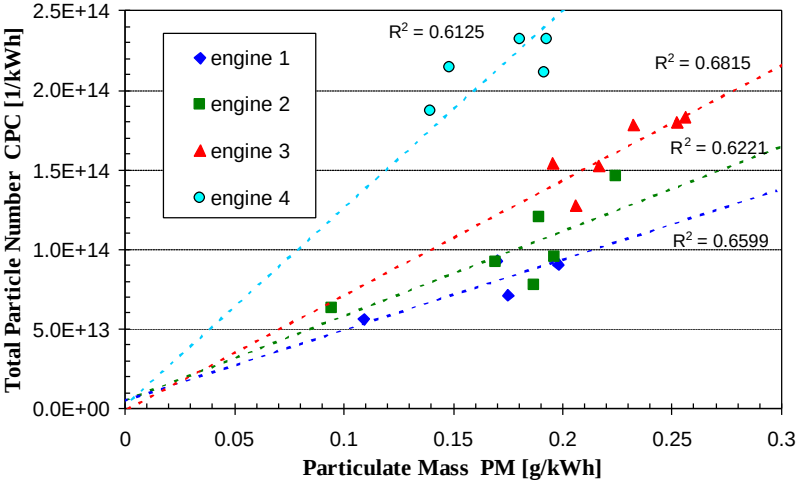
Comparison Total Number – PM



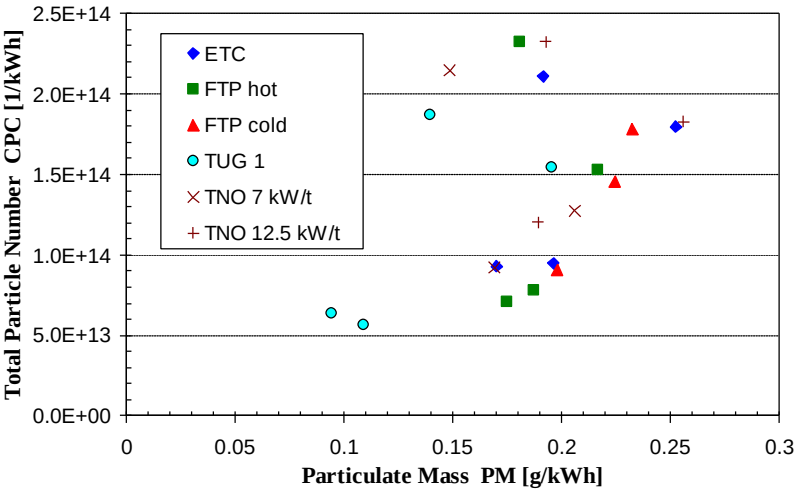
Correlation PM - Particle Number (CPC)



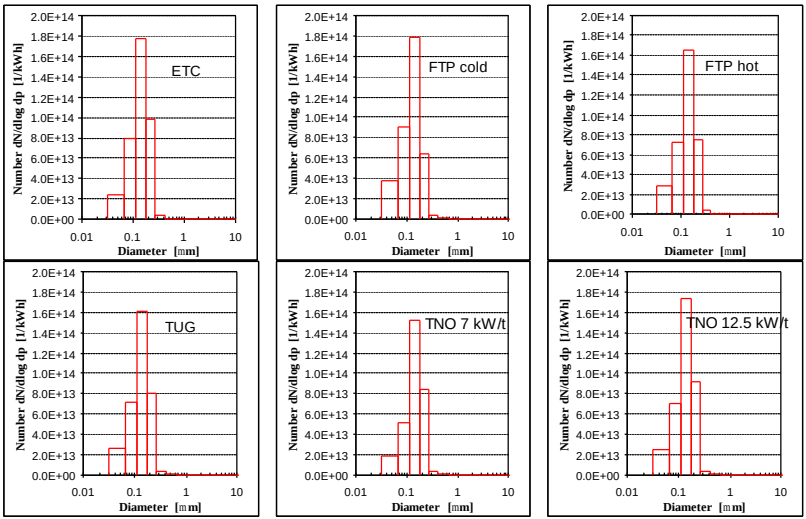
Correlation PM - Particle Number (CPC)



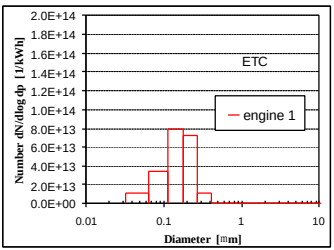
Correlation PM - Particle Number (CPC)

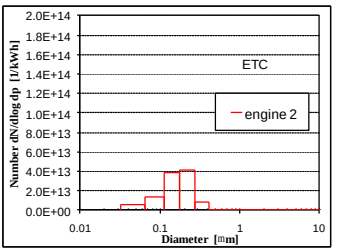


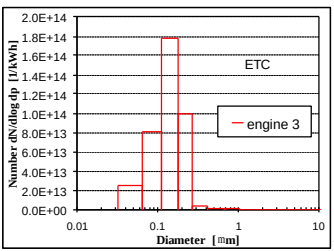
NSD / all transient cycles / engine 3

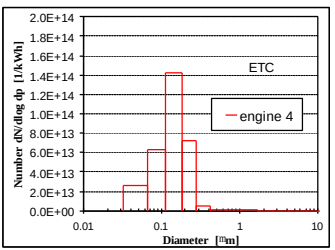


NSD / all engines / ETC / ELPI









Conclusion

- Generally, a reduction of particulate mass is correlated with a reduction of particulate number.
- The test cycle has almost no influence on the correlation between particulate mass and number.
- The correlation between particulate mass and number is more influenced by the measured engine.
- The Number Size Distribution is almost not influenced by different transient cycles.