

Effects of severe congestion on PAH emissions from a heavy vehicle diesel engine



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Background

- Internal combustion engines - dominant source of fine particles in urban air.
- PM emissions depend heavily on engine technology, maintenance and operating conditions.
- Extended low-load operation, characteristic for severe congestion, is characterized by poor combustion and decreased catalytic converter efficiency due to low exhaust gas temperatures.

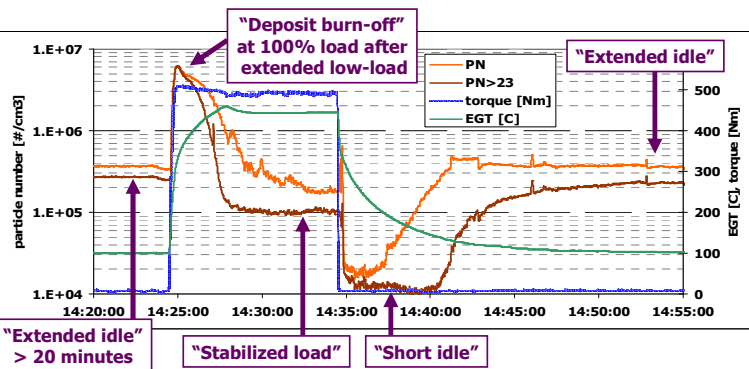
Goal

Characterization of diesel engine particulate matter emissions during and after extended low-load operation.

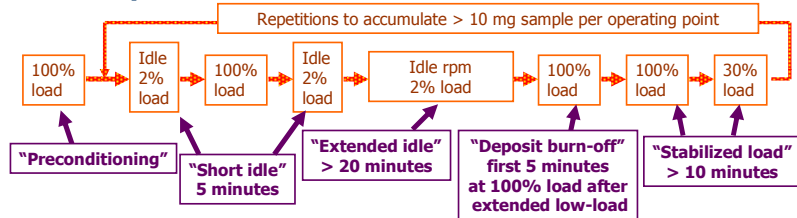
Experimental

- Traditional diesel engine (Zetor 1505, inline mechanical injection pump)
- Steady-state operating points:
 - 30% load, 1500 rpm – corresponds to "highway cruise" (EGT 265°C)
 - 100% load, 1500 rpm – corresponds to hill / acceleration (EGT 460°C)
 - 2% load at elevated idle – corresponds to "creep" (EGT 100°C)
- Sampling with tandem high-volume samplers (EcoTech 3000) on 8"x10" filters
 - Teflon (Pall TX40HI20WW) – gravimetric, PAH, toxicology
 - Quartz (Whatman QMA) – gravimetric, PAH, EC/OC (not shown here)
- US EPA 16 priority and 7 carcinogenic PAH (organic extract) by HPLC, UV detection
- Online measurement of PM size distributions (Engine Exhaust Particle Sizer), sampling from full-flow dilution tunnel, no removal of volatile particles

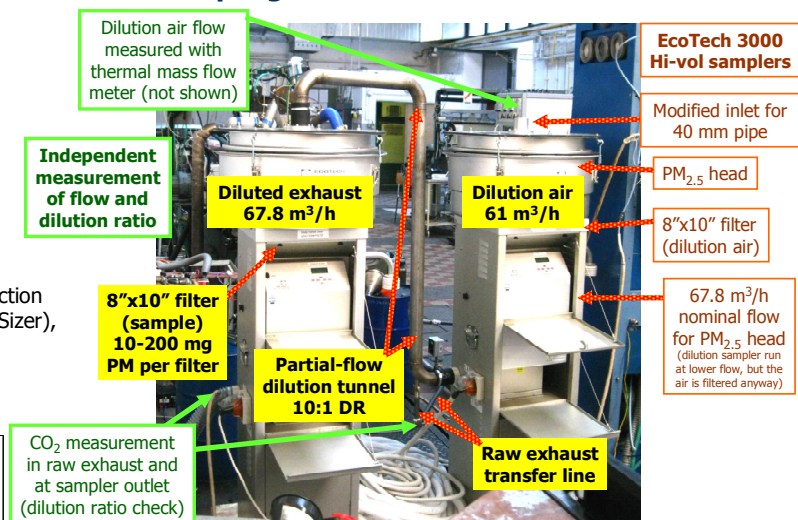
Results – online measurements



Test sequence

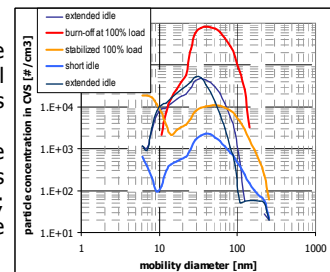


Dilution & Sampling



Results – online measurements

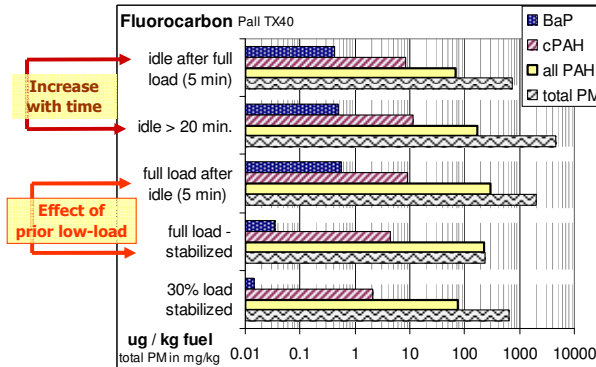
- Idle after a higher load: exhaust temperature drops, particle concentrations increase until they reach a stabilized value; nanoparticles increase first; particle size increases
- High load after idle: exhaust temperature increases and stabilizes, particle emissions initially higher and decreasing to stable values; peak = 1-2 orders of magnitude above stabilized value



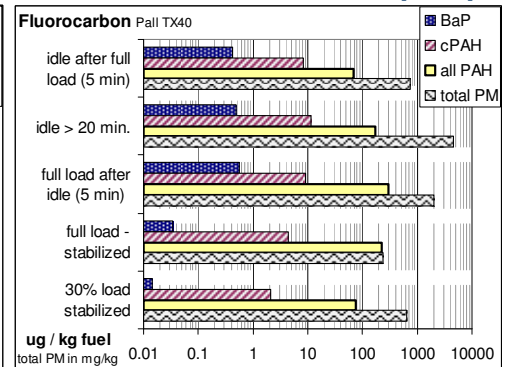
Results – PM mass and PAH

- The emissions of PM mass, US EPA 16 priority PAH, 7 carcinogenic PAH and benzo(a)pyrene were, for both diesel and biodiesel, an order of magnitude higher
 - a) during extended operation at 2% load, as compared to operation at 2% load immediately after higher load
 - b) at 100% load immediately after extended low-load operation, as compared to stabilized operation at 100% load
- These effects for biodiesel, relative to diesel fuel, were higher for PM mass, but lower for cPAH. Biodiesel had lower cPAH except for stabilized full load.

PM mass and PAH – diesel fuel



PM mass and PAH – biodiesel (B100)



Conclusions

Total particle number, particulate matter mass, US EPA 16 priority PAH, carcinogenic PAH (cPAH), and benzo(a)pyrene were an order of magnitude higher

a) during extended operation at 2% load, as compared to operation at 2% load immediately after higher load

b) during operation at 100% load immediately after extended low-load operation, as compared to stabilized operation at 100% load.

Extended operation at low-load, common in urban areas, can result in excess emissions not foreseen by currently used emission models.

Results of toxicological assays on collected samples: See poster B242 – Pavlíková et al. Late breaking poster - presented within this session

Acknowledgments:

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