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)
  - 100% 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 Size), sampling from full-flow dilution tunnel, no removal of volatile particles

Test sequence
- Repetitions to accumulate > 10 mg sample per operating point
- 100% load
- Idle 2% load
- 100% load
- Idle 2% load
- 100% load
- Idle rpm 2% load
- 100% load
- Idle rpm 2% load
- 100% load
- 30% load

Dilution & Sampling
- Dilution air flow measured with thermal mass flow meter (not shown)
- Dilated exhaust
- Dilution air
- Partial-flow dilution tunnel 10:1 DR
- 8”x10” filter (dilution air)
- Modified inlet for measurement
- Raw exhaust transfer line

Results – online measurements
- 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.

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.

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Results of toxicological assays on collected samples:
See poster B242 – Pavliková et al.

Late breaking poster - presented within this session