MEASURING SELF-POLLUTION IN SCHOOL BUSES USING A TRACER GAS TECHNIQUE

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BACKGROUND

• The ARB has declared diesel exhaust particulate to be a toxic air contaminant

• Some children spend 3 hours a day on school buses

• Children may be exposed to high concentrations of diesel particles and gases during bus commutes

• Inadequate data concerning children’s in-vehicle exposure on diesel school buses in CA
OBJECTIVES

• Quantify the introduction of a bus's own exhaust into the passenger compartment

• Determine the percentage of diesel exhaust-related pollutant concentrations inside the cabin originating from a bus’s own exhaust

• Study the correlation between self-pollution and diesel-related pollutants and “background” pollutants


**APPROACH**

- Results are part of a project to characterize the range of children’s pollutant exposure during school bus commutes (Fitz et al., 2003)

- Measurements using several school buses under realistic operating conditions (routes, time)

- Tracer gas ($\text{SF}_6$) was metered, using a mass flow controller, into the bus’s exhaust system

- On-board measurements with 10-second time resolution
MEASUREMENTS

• Real-time measurements:
  – $\text{SF}_6$ (AeroVironment Model CTA 1000 analyzer).
  – Black Carbon (Magee Scientific Aethalometers).
  – PM$_{2.5}$ (8520 DustTrak Aerosol Monitors).

• Six school buses:
  – Four conventional diesel buses (1975 to 1998)
  – One 1998 particulate trap outfitted diesel bus
  – One 2002 CNG bus

• Measurements during ten morning and ten afternoon bus commutes from South Central Los Angeles (LA) to the west side of LA
Mechanisms of self-pollution were not part of this study.
RESULTS
Percentage of Bus’s Own Exhaust Entering the Cabin

- HE3 (1975)
- HE2 (1985)
- RE2 (1993)
- RE1 (1998)
- TO1 (1998)
- CNG (2002)

Graph showing the percentage of exhaust entering the cabin with different types of buses and window conditions.
Means and 95% C.I. - Windows Closed

SF6 Means and 95% Confidence Intervals

LOCATION
- Front
- Rear
- Outside

Run
- HE2: Run 5; HE3: Run 8; RE2: Runs 17, 19, 23, and 25; TO1: Run 28; CNG: Run 35
Means and 95% C.I. - Windows Open

HE2: Run 6; HE3: Run 10; RE1: Run 15; RE2: Runs 18, 20, and 24; TO1: Runs 30 and 33; CNG: Run 36
SUMMARY

• Several routes are responsible for self-pollution (SP)

• Windows closed lead to higher self-pollution

• Older buses showed a larger percentage of their own exhaust entering into the cabin (up to ten times higher than newer buses)

• Exposure to pollutants from the bus’s own emissions are higher at the rear of the cabin (windows closed)

• Higher correlations between SP and BC ($r = 0.5$) than between SP and PM$_{2.5}$ ($r = 0.3$)
CONCLUSIONS

• Self-pollution varies significantly between buses and also depends on window position

• Up to 0.3% of a bus’s own exhaust can be found inside its cabin

• Buses that exhibit high emissions and high self-pollution also exhibit the highest average within-cabin concentrations of black carbon (25% variance explained by self-pollution)

• Vehicle-related pollutant exposure inside buses is a function of the amount of exhaust entering the cabin from a bus itself. This effect may be the dominant factor for within cabin exposure with windows closed
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