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CNG AND DIESEL TRANSIT BUS EMISSIONS IN REVIEW

California Environmental Protection Agency, Air Resources Board; University of California, Davis; and University of Connecticut

Cal/EPA, ARB-Alberto Ayala, Robert Okamoto, Norman Kado, Michael Gebel, and Paul Rieger **UCONN-** Britt Holmén **UCD-** Paul Kuzmicky and Reiko Kobayashi

http://www.arb.ca.gov/research/cng-diesel/cng-diesel.htm

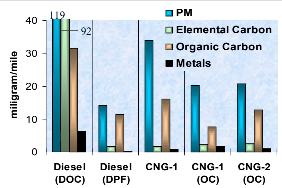
Abstract

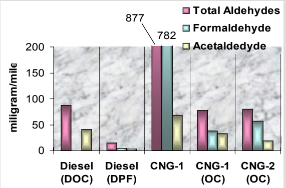
Over the past three years, the California Air Resources Board (CARB), in collaboration with the Universities of California, Connecticut, and other entities, has investigated the tailpipe emissions from three different late-model, in-use heavy-duty transit buses in five different configurations. The study has focused on the measurement of regulated emissions (NOx, HC, CO, total PM), other gaseous emissions (CO2, NO2, CH4, NMHC), a number of pollutants of toxic risk significance (aromatics, carbonyls, PAHs, elements), composition (elemental and organic carbon), and the physical characterization (size-segregated number count and mass) of the particles in the exhaust aerosol. The impact of oxidation catalyst control for both diesel and compressed natural gas (CNG) buses and a passive diesel particulate filter (DPF) were evaluated over multiple driving cycles (idle, 55 mph cruise, CBD, UDDS, NYBC) using a chassis dynamometer. The database of results is large and some findings have been reported already at various forums including previous ETH conferences. The goal of this poster is to offer an overview of the findings and attempt to draw overall conclusions and interpretations based on key results to date.

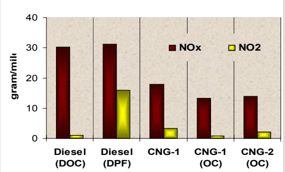
Experimental Methods

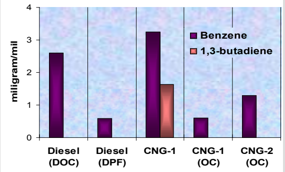
1. Testing was conducted at CARB's Heavy-duty Emissions Testing Laboratory.
2. Test cycles: idle, SS cruise, CBD, NYBC, and UDDS.
3. Regulated emissions were determined following CFR methods.
4. PM: filters and MOUDI
5. Carbonyls: DNPH cartridges/HPLC
6. Metals: Teflon filter/XRF
7. Mutagenicity: filter/PUF/XAD, tested in modified salmonella microsuspension assay.
8. PAHs: filter/PUF/XAD, GC-MSD.
9. EC/OC: Quartz filter/TOR.
10. VOCs and NMHC: Tedlar bag/GC with flame ionization detection following cryogenic pre-concentration.
11. PM number/size: SMPS and ELPI at micro-diluter and SMPS at CVS.
12. Fuel and lubricating oil samples were collected and analyzed by commercial laboratories.
13. CNG fuel was obtained from refueling station for the Los Angeles County Metropolitan Transit Authority (LACMTA).
14. ECD-1 diesel fuel was provided in-kind by BP.

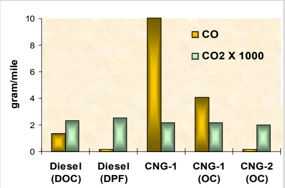
Average Test Results - CBD Cycle

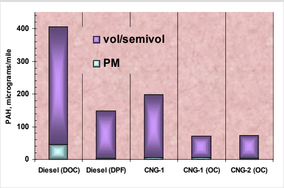


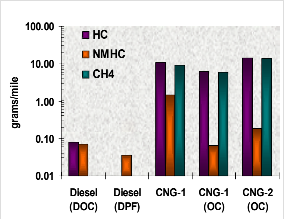


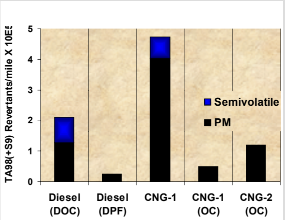




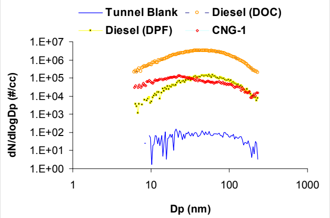


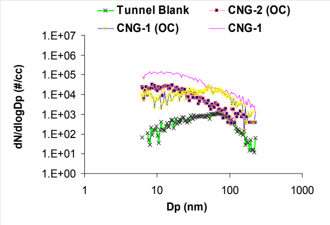






Average Particle Size Distribution - SS (55mph)





Description of Bus Test Configuration

	AFTER-TREATMENT	ENGINE MAKE	FUEL TYPE
DIESEL	DOC DPF	DDC-S50	ULSD
CNG	Ø	DDC-S50G	CNG
	OC	DDC-S50G/ Cummins-Wesport C-Gas	

Discussion and Conclusions

Although not shown, results show duty cycle dependence. References for this project may be found at the project website. Findings support dual-fuel path regulations for California. Results are a snap-shot of three buses only. While it is believed emissions from buses typify the differences between the tested technologies, results cannot be used to infer differences for the fleet as a whole. After-treatment durability, deterioration, and vehicle maintenance are not investigated. Testing of "clean" technologies challenges the analytical methodologies to the limit of detection. Dilution tunnel background is important. Tunnel blanks are not constant or negligible. Final interpretations from study results include:

1. After-treatment shows potential for significant emission reductions for both CNG and diesel heavy-duty engines.
2. Catalyzed DPF yields reductions of PM, EC, OC, metals, CO, HC, NMHC, carbonlys, VOCs, PM-bound and semivolatile PAHs, PM-bound and semivolatile mutagen emissions, and ultrafine particle number concentrations.
3. Catalyst for CNG applications yields reductions of PM, OC, CO, HC, NMHC, CH4, carbonyls, VOCs, semivolatile PAHs, PM-bound mutagen emissions, and ultrafine particle number concentrations.
4. NOx emissions from CNG engines are approximately 50% lower than NOx from diesel engine. DPF-equipped bus has NOx emissions that are approximately 50% NO2.
5. DPF yields lower emissions of all pollutants measured in this study relative to CNG without catalyst with the exception of EC, NOx, NO2, and CO2.

Disclaimer

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