9th Diesel Engine Emissions Reduction Conference

August 24 - 28, 2003, Newport, Rhode Island

Session 5: Diesel and CNG Bus Emissions

CNG and Diesel Transit Bus Emissions in Review

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Acknowledgements

- Funding by CARB and SCAQMD
- BP donated ECD-1 fuel
- LACMTA facilitated this research
- So.Cal. Gas Co. for CNG fuel analyses
- Technical Collaborators:

CARB: Leo Zafonte, Chri Maddox, Julia Sandoval, Shiou-mei Huang, Richard Ling, Lyman Dinkins, Norma Castillo, Jack Horrocks, Keshav Sahay, George Gatt, John Karim, Jim Shears, Namita Verma, Mark Fuentes, Bart Croes, and Hector Maldonado.

UCONN: Professor Britt Holmén

CAVTC: Harvey Porter, Keith Stiglitz, Fred Gonzalez

SCAQMD: Mike Bogdanoff, Steve Barbosa

UCD: Geraldine Navarro

Project Objectives

Compare heavy-duty engine technology options for transit buses:

- ❑ Evaluate fuel/after-treatment options
- ❑ Assess driving cycle effects
- ❑ Characterize emission rates of several exhaust components of toxic risk significance
- ❑ Investigate PM and ultrafine particle emissions

Test Buses*

	Model Year	Engine Make	After-treatment	Fuel
Diesel	1998	DDC-S50	DOC CB-DPF	ULSD
CNG-1	2000	DDC-S50G	none OC	CNG
CNG-2	2001	Cummins-Westport C-Gas Plus	OC	CNG

*All 40 passenger, New Flyer chassis from Los Angeles and San Bernardino public fleets

Experimental Methods

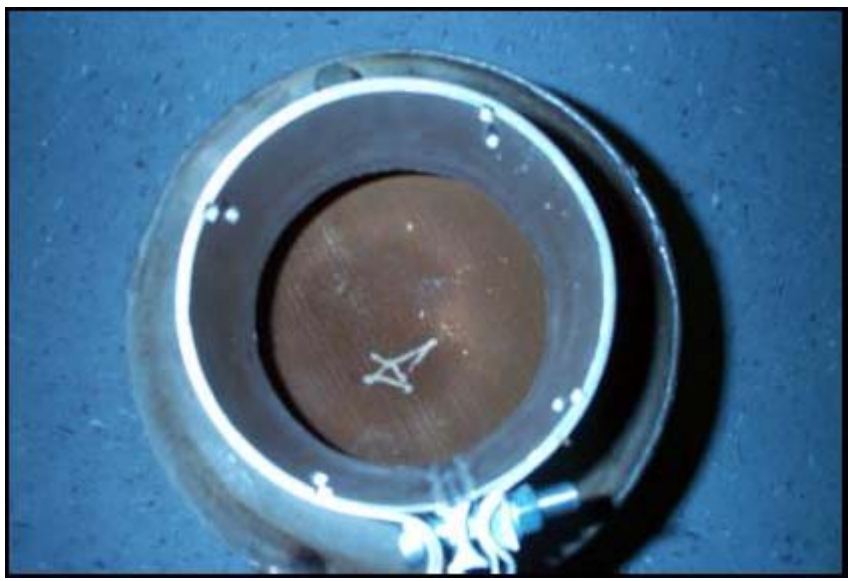
- Testing at CARB's Emissions Laboratory in Los Angeles
- Cycles: Idle, SS, **CBD**, NYBC, UDDS
- After-treatment was degreened for testing
- Lubricating oil and fuel samples (diesel and CNG) analyzed for composition
- All testing at ambient temperature

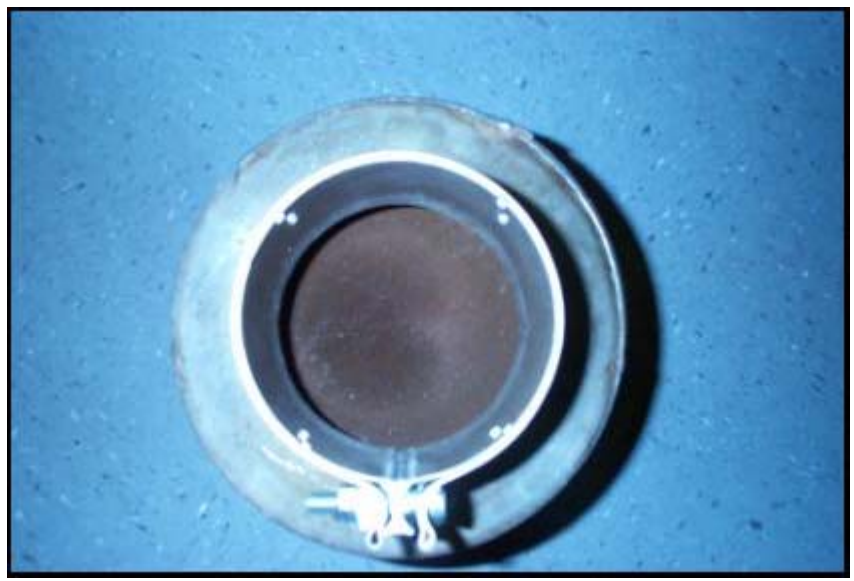
	Test Bus Configuration	Test Date
Phase 1.A	**CNG-1**	March 2001
	Diesel (DOC)	April 2001
	Diesel (DPF)	May 2001
	CNG-1	June 2001
Phase 1.B	**CNG-2 (OC)**	May 2002
	CNG-1 (OC)	May 2002
	CNG-1	May 2002

Emission Measurements

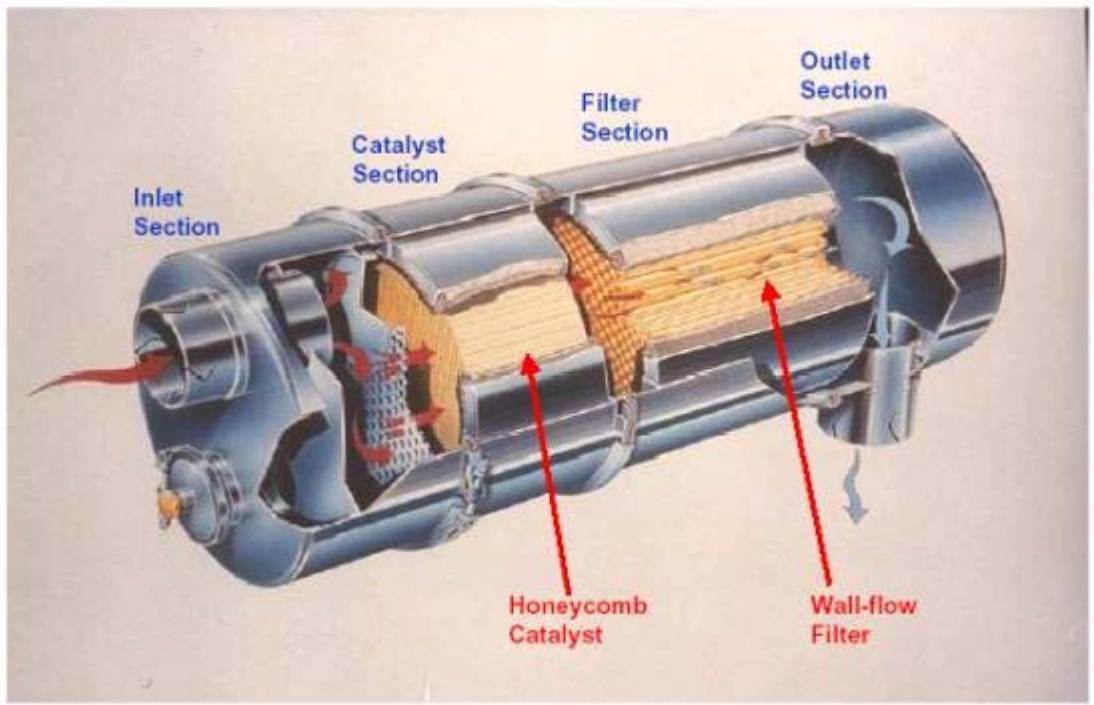
- **Gases:**
  - Total HC's: heated FID
  - NO_X, NO_2: chemiluminescence
  - CO, CO_2: NDIR
  - CH_4, VOC's and NMHC: Tedlar bag/GC-FID
  - Carbonyls: DNPH cartridges/HPLC
- **Volatile/semivolatile phase:**
  - Mutagenicity: filter/PUF/XAD, modified Ames assay
  - PAHs: filter/PUF/XAD, GC-MS
- **PM:**
  - Total PM: filters and MOUDI
  - Elements: Teflon filter/XRF
  - Mutagenicity: filter/PUF/XAD, modified Ames assay
  - PAHs: filter/PUF/XAD, GC-MS
  - EC/OC: Quartz filter/TOR
  - PM number/size: SMPS & ELPI@micro-diluter and SMPS@CVS

Catalyst for 2000 DDC Series 50G Transit Bus



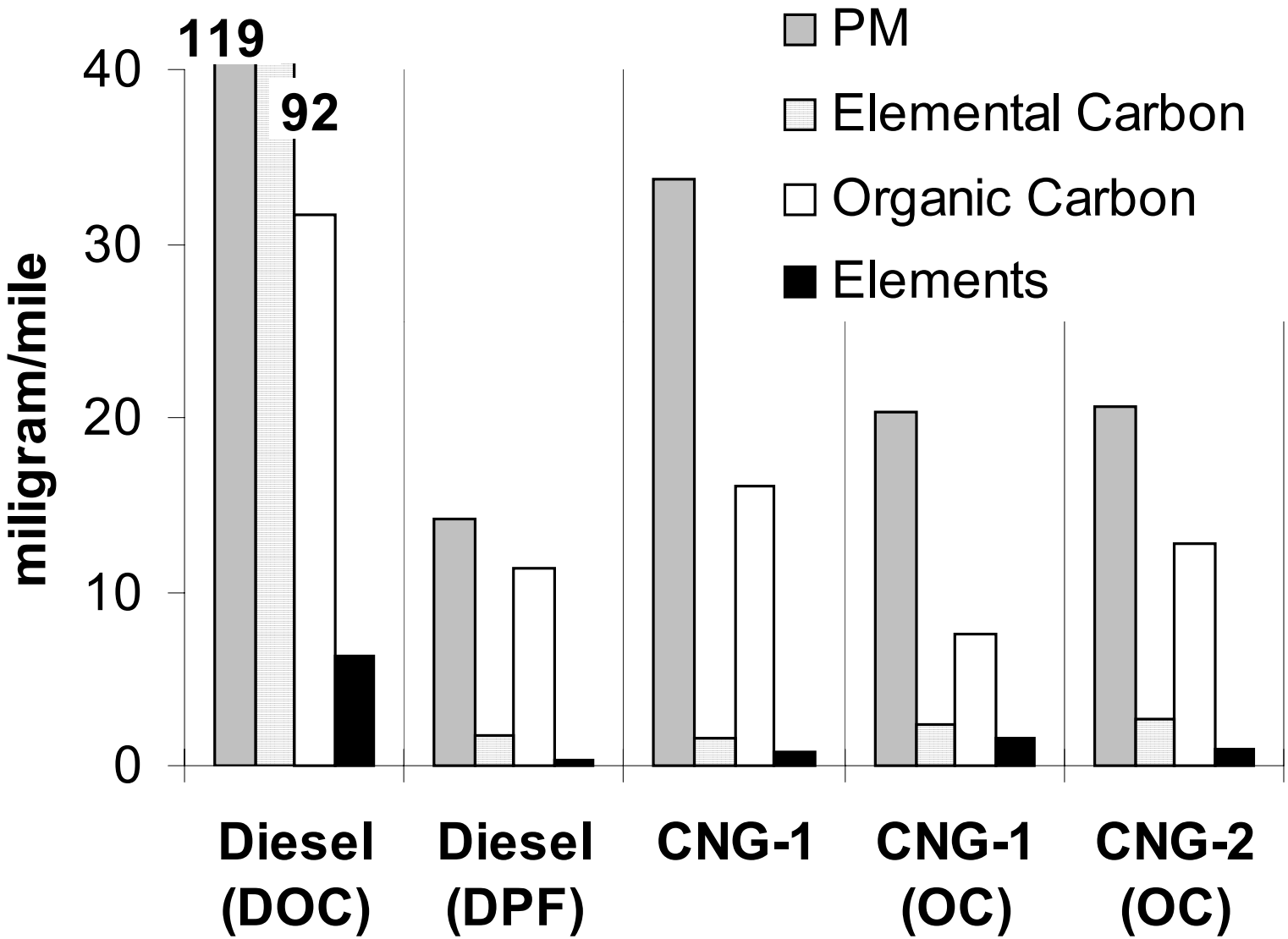


CB-DPF for 1998 DDC Series 50G Transit Bus

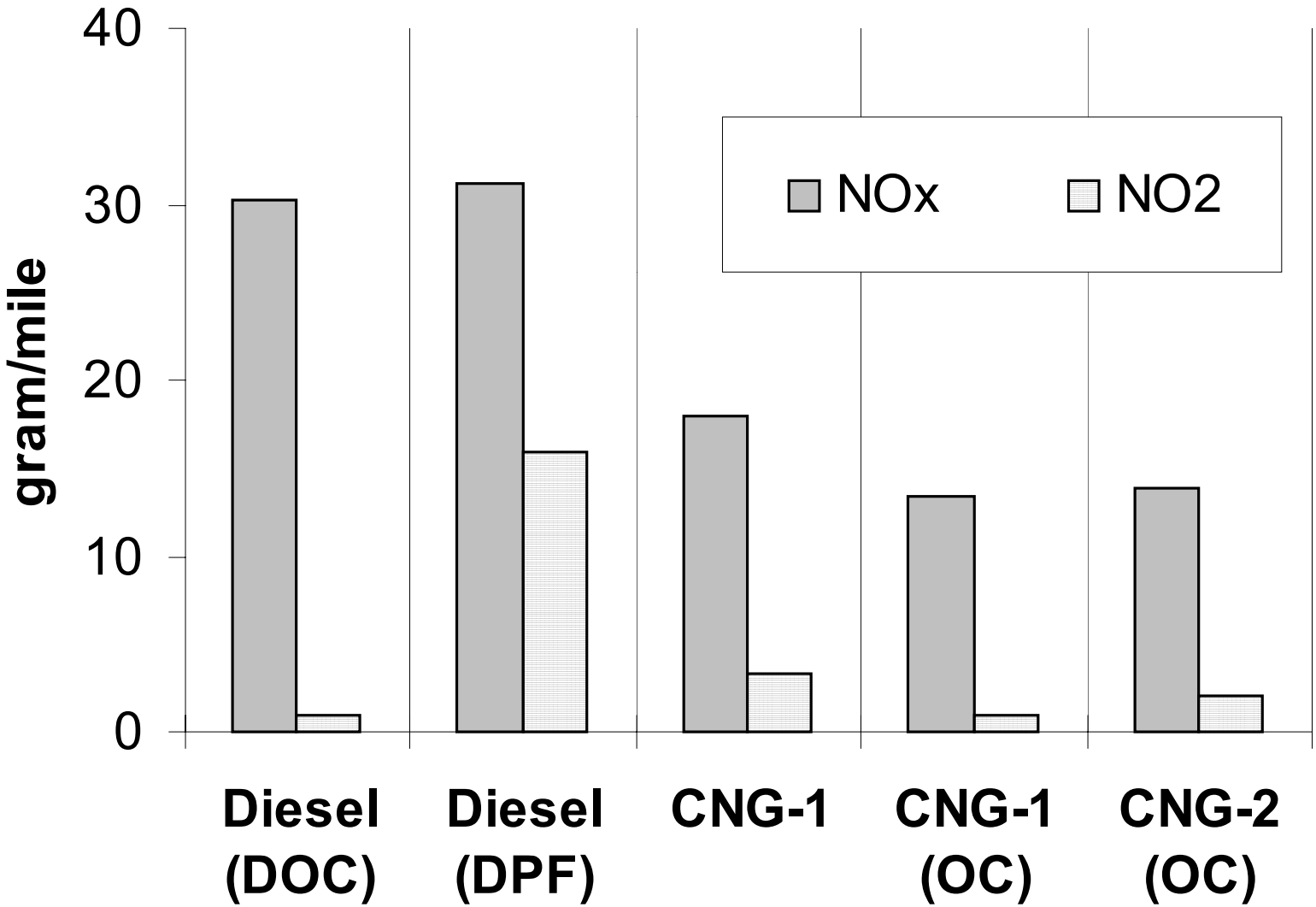


http://www.jmcsd.com/html/crt.html

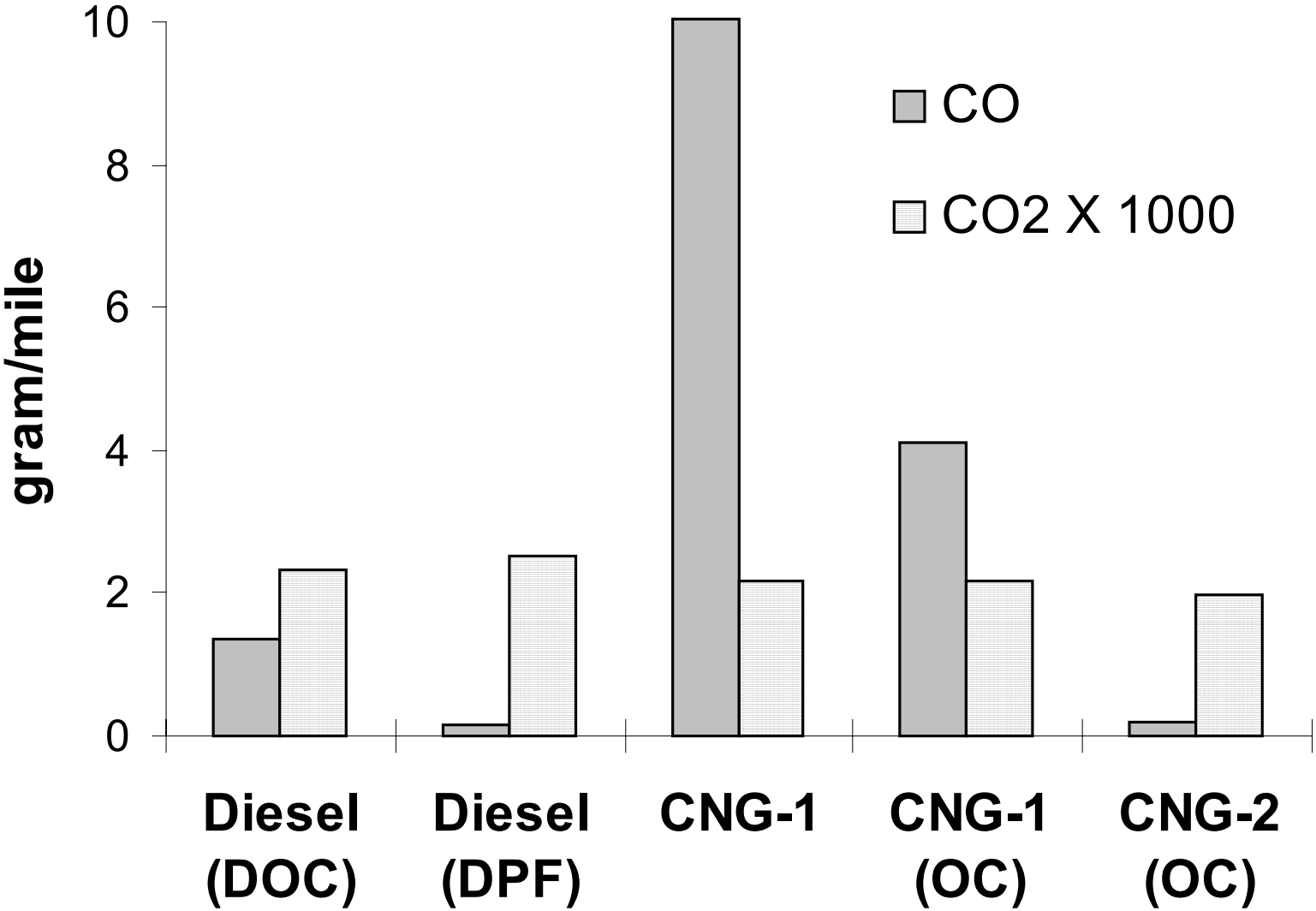
Average Emissions - CBD Cycle



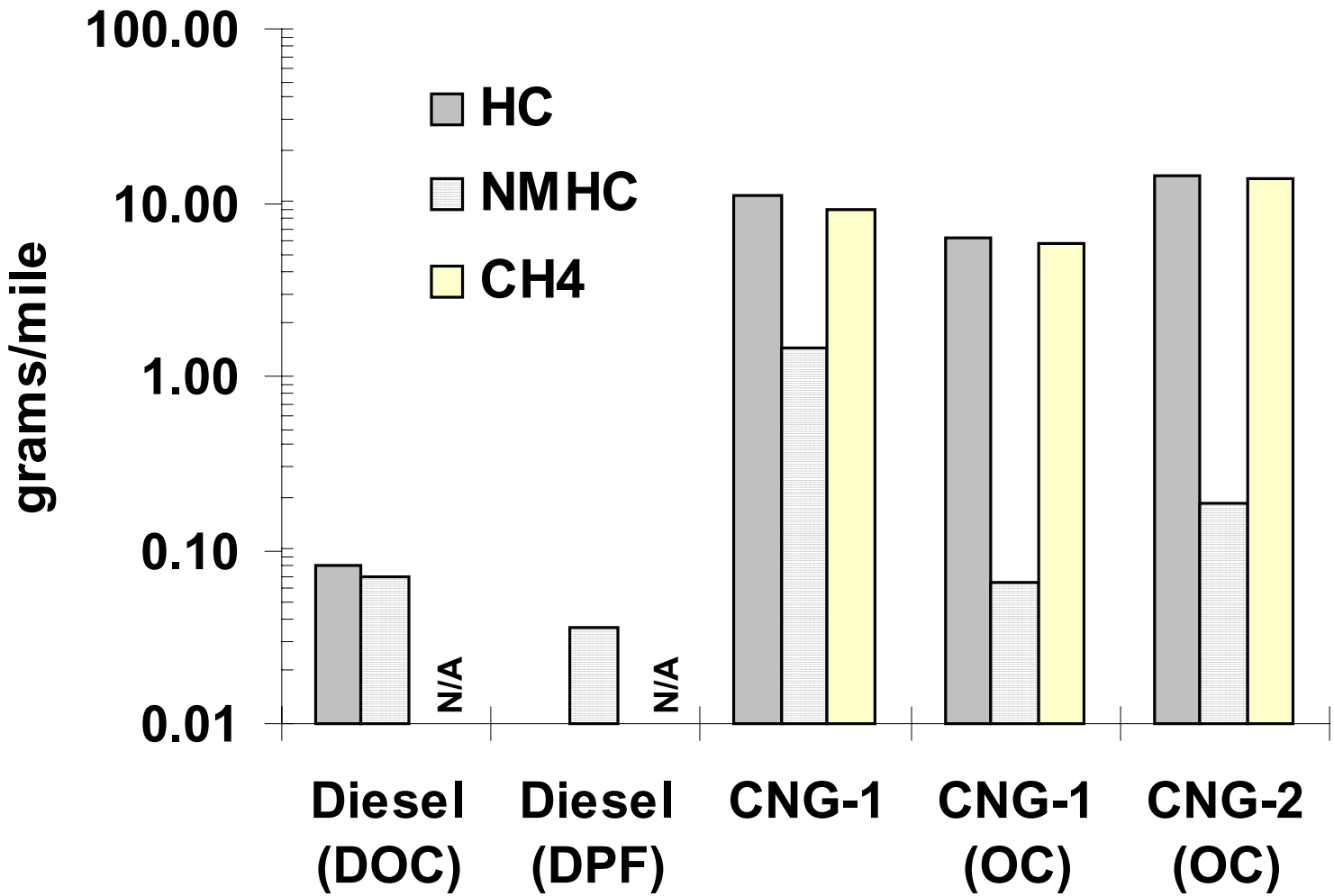
Average Emissions – CBD Cycle



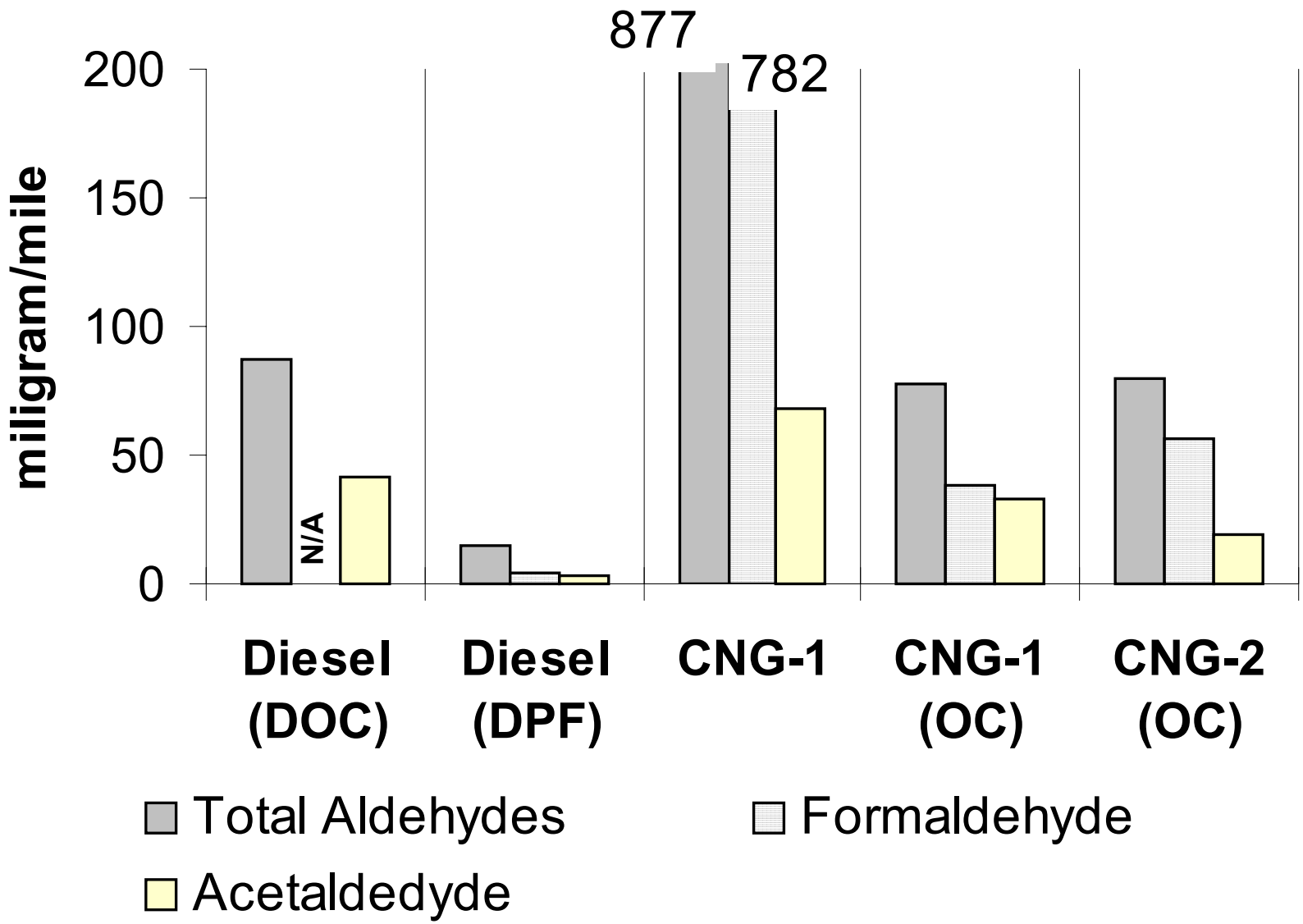
Average Emissions - CBD Cycle



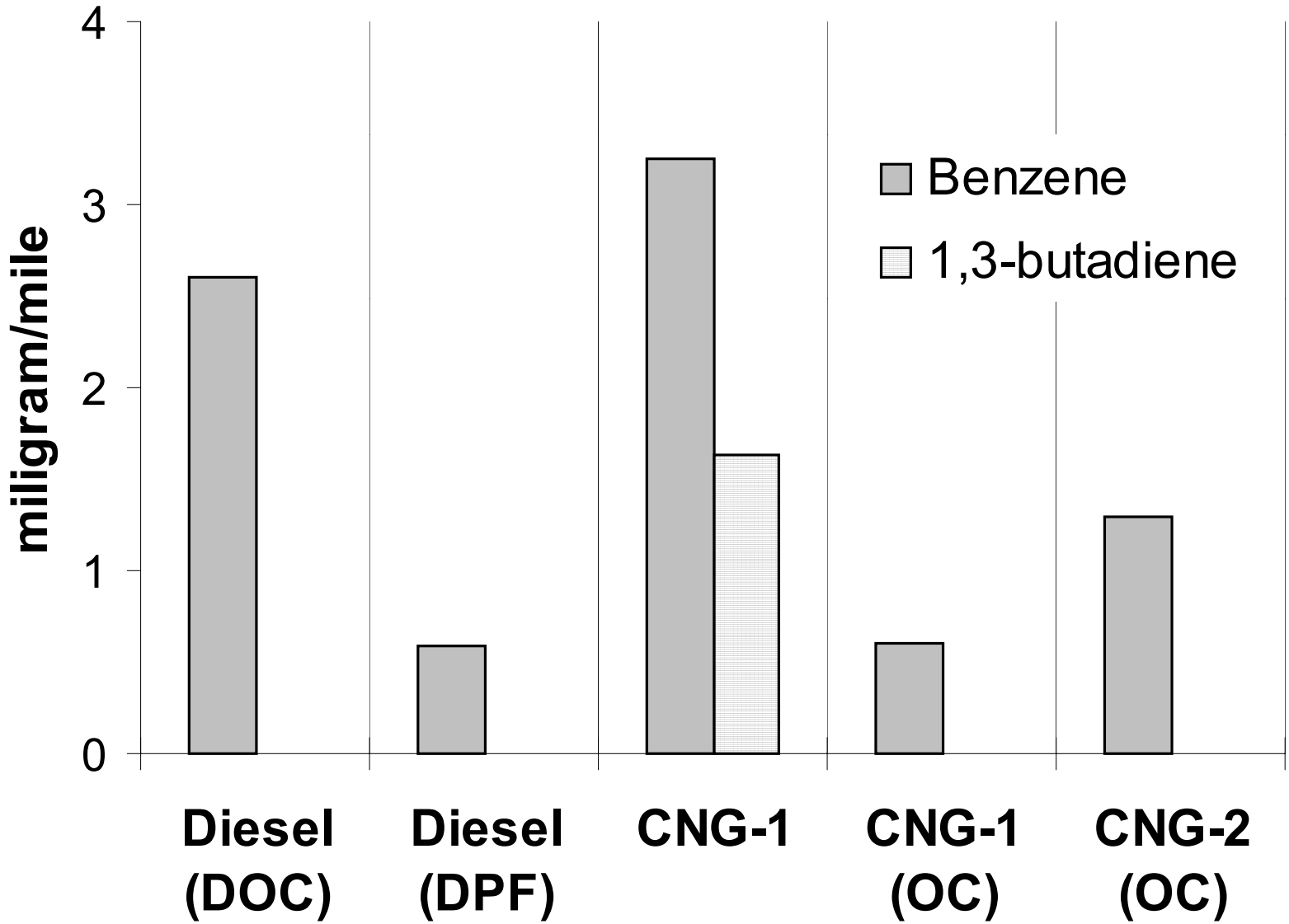
Average Emissions over CBD Cycle



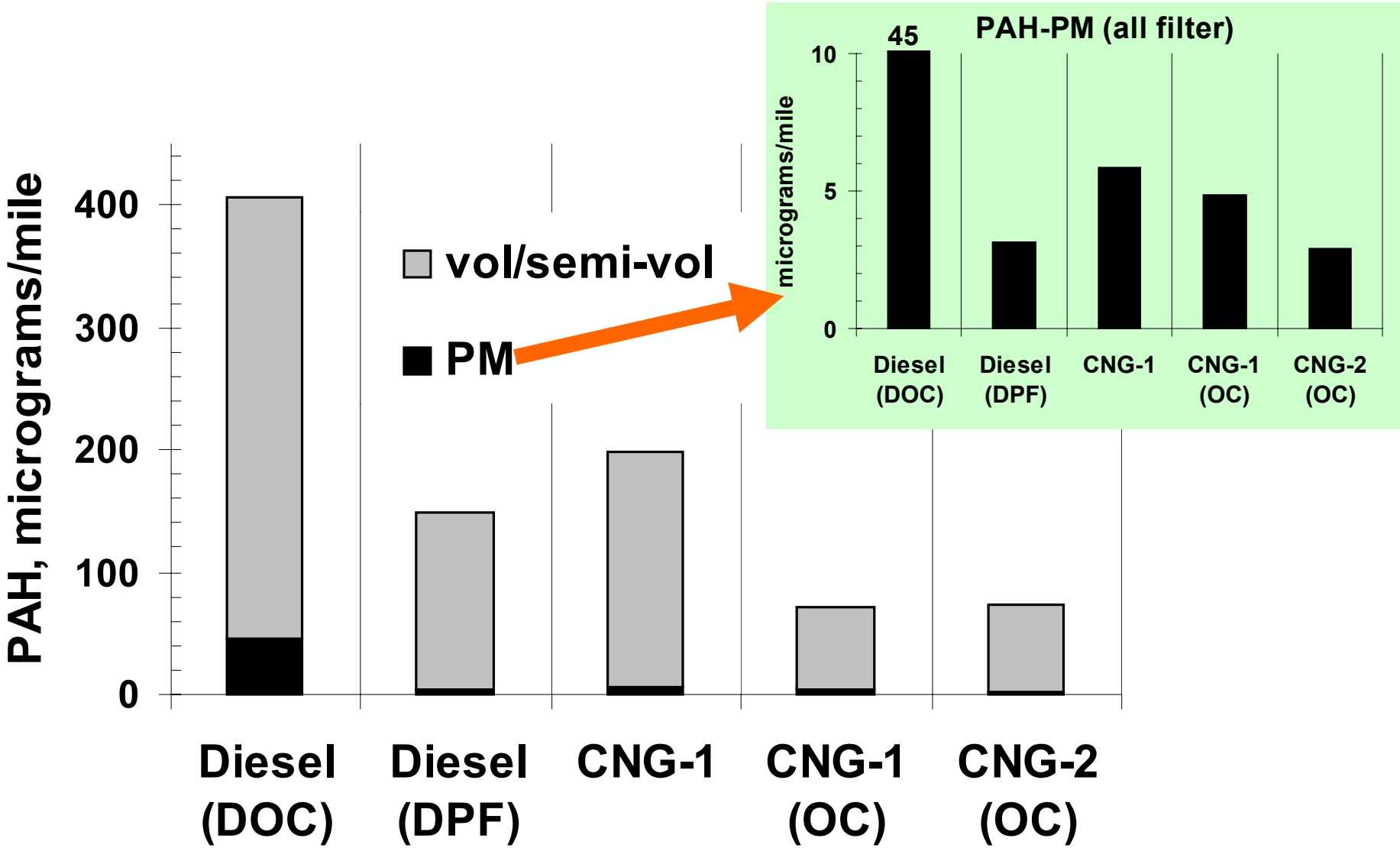
Average Carbonyl Emissions - CBD Cycle



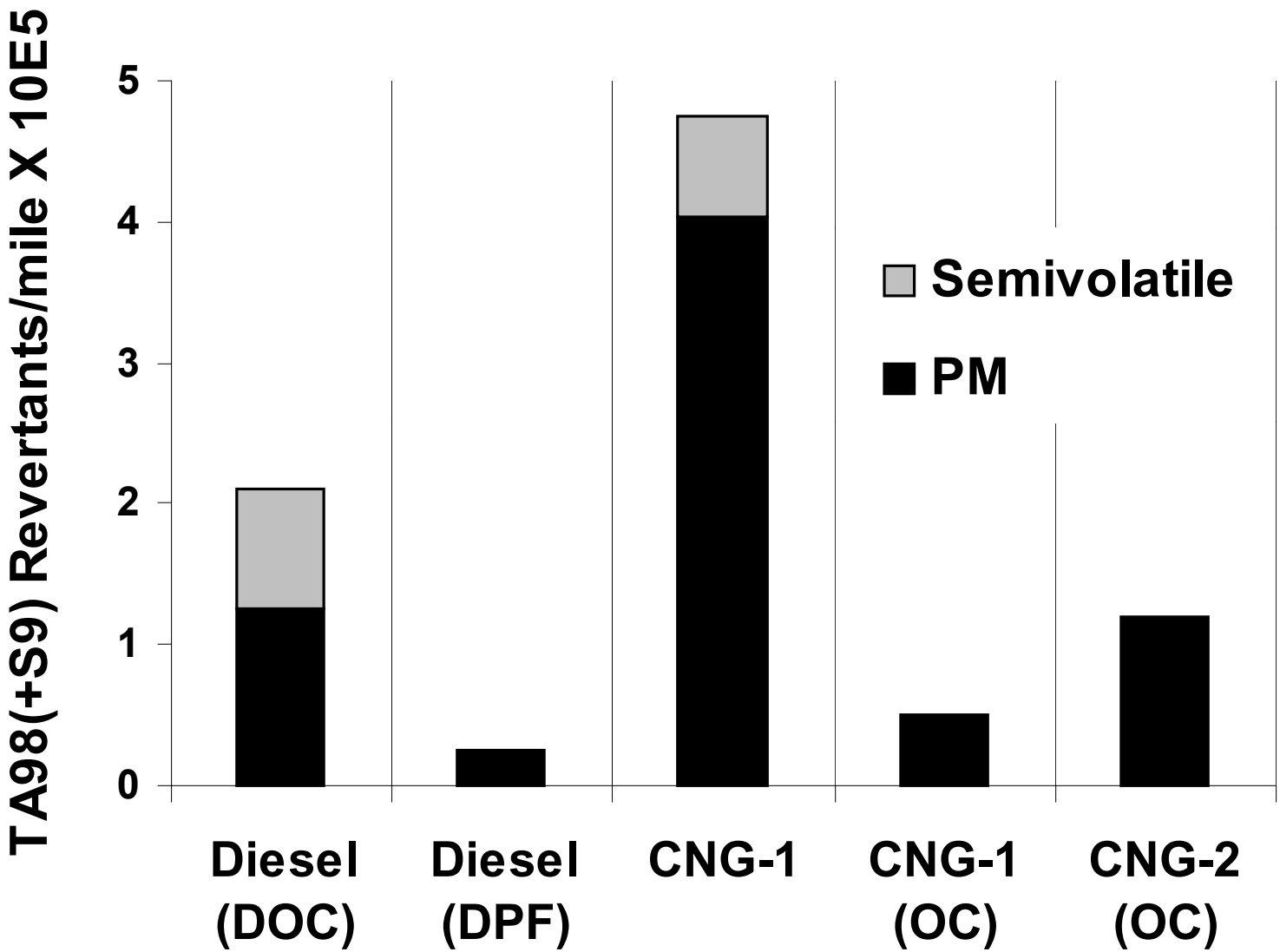
Average Emissions over CBD Cycle



Average PAH Emissions - CBD Cycle



Average Mutagen Emissions - CBD Cycle



Summary of Results

- CB-DPF reduces PM, EC, OC, elements, CO, HC, NMHC, carbonyls, VOCs, PM-bound and semivolatile PAHs, and PM-bound and semivolatile mutagen emissions
- CNG catalyst reduces PM, OC, CO, HC, NMHC, CH_4, carbonyls, VOCs, semivolatile PAHs, and PM-bound and semivolatile mutagen emissions
- NO_X emissions from CNG engines are approximately 50% lower than NO_X from diesel engine
- DPF-equipped bus has NO_X emissions that are approximately 50% NO_2
- DPF yields lower emissions of all pollutants measured relative to CNG without catalyst with the exception of EC, NO_X, NO_2, and CO_2
- Although not shown, results show duty cycle dependence
- After-treatment durability and deterioration and vehicle maintenance were not evaluated

Final Interpretations

- After-treatment shows potential for significant emission reductions for both CNG and diesel heavy-duty engine applications
- Magnitude of reductions differs by pollutant and duty cycle
- Speciation of emission profiles suggest that, at least, CNG with catalyst and Diesel with CB-DPF are equivalent
- Aside from NO_X, based on average gram per average gram, diesel trap still appears to have a slight advantage over CNG catalyst
- Difficulty arises because diesel PM is considered a toxic by the State of California whereas CNG PM has no such designation at present