

Results from DOE's Gasoline/Diesel PM Split Study – Overview and LD Vehicle Emissions Data

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Gasoline/Diesel PM Split Study

Objective: To characterize uncertainties in quantifying the contributions of PM emissions from SI and CI engines in the South Coast Air Basin

Participants: BAR and SCAQMD (LD vehicle recruitment); Ralphs Grocery Distribution Center; EPA and CAVTC (LD vehicle dynamometer measurements); WVU (HD vehicle dynamometer measurements); DRI and U WI-Madison (source & ambient measurements, source apportionment)

Gasoline/Diesel PM Split Study

Approach:

- Perform source testing of large set of gasoline- and diesel-powered motor vehicles using EPA's and WVU's transportable dynamometers (May-September 2001)
- Collect **concurrent** ambient samples at a variety of locations (source areas and regionally representative sites – June 20-July 27, 2001). Ambient sampling conducted at two SCAQMD monitoring sites plus several source sites, along with mobile sampling on freeways
- Analyze all collected data from source and ambient samples [PM and semi-volatile organic compounds (SVOCs)] chemically – completed March 2003 (analyses by DRI and UWM)
- Construct source profiles and perform Chemical Mass Balance Receptor modeling (independent and blind analyses by DRI and UWM)
- Submit papers for peer-reviewed publication

Features of Study and Caveats

- Study performed in Los Angeles during summertime
 - No cold, cold-start emissions measured (especially important for SI vehicles)
 - Maximum amount of secondary carbonaceous PM formed (greatest challenge for CMB modeling because of large amount of unresolved “organic” carbon)
- Vehicles sampled “as is” with California fuels
- Results represent on-road fleet characteristics and ambient data during the summer of 2001; future on-road HD regulations (2007 and 2010) will reduce fleet emissions.
- Mobile emissions profiles from this study should not be used in other parts of California, under cool or cold ambient temperature conditions, or the rest of the country until it can be demonstrated that source profiles under those conditions are chemically similar to those obtained in this program

LD Vehicle Recruitment Sample

Vehicles tested in June 2001

Category	Model Year	Odometer (miles)	Number of Vehicles	Number of Composites
1	1996 and newer	low mileage (< 50,000)	4	1
2	1993-95	low mileage (< 75,000)	4	1
3	1996 and newer	high mileage (> 100,000)	4	1
4	1990-92	lower mileage (< 100,000)	4	1
5	1993-95	higher mileage (> 125,000)	8	2
6	1990-92	> 125,000	9	3
7	1986-89	> 125,000	6	3
8	1981-85	> 125,000	6	3
9	1980 and earlier	> 125,000	6	3
10	Smoker	no model year or odometer criteria	6	6
11	LD Diesel	no model year or odometer criteria	2	2
		Total	59	26

Gasoline/Diesel PM Split Study – Light-Duty Vehicles Conditioned Using BAR Smog Check ASM Tests



Gasoline/Diesel PM Split Study – Light-Duty Vehicles Tested Over Unified Driving Cycle



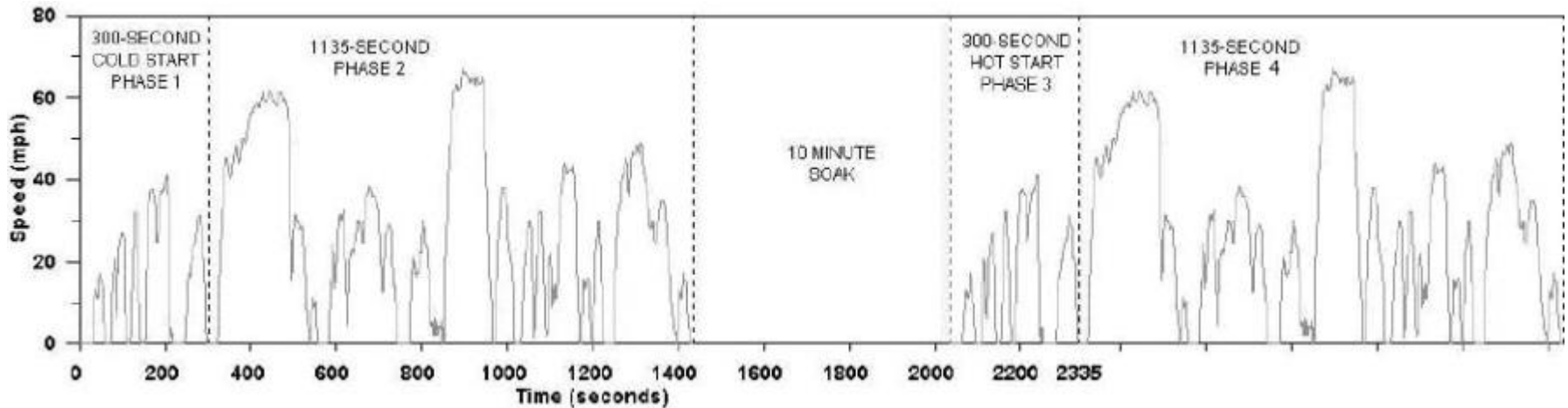
Gasoline/Diesel PM Split Study – LDV and HDV Exhaust Sampling Systems



Gasoline/Diesel PM Split Study – Light-Duty Vehicle Driving Cycle: Modified Unified Driving Cycle (LA-92)

Cold Phase

Warm Phase



- Modified Unified Cycle – Phases 3 and 4 are a warm repeat of phases 1 and 2
- 2 sampling phases: “Cold” phase and “Warm” phase, each lasting 1435 seconds; 24.6 mph ave. speed; 67 mph max. speed; 6.9 mph/sec max acceleration
- PM Summary Statistics: Min=0 mg/mi; Max=185 mg/mi; Mean=19 mg/mi; Median=5 mg/mi; Mode=0 mg/mi (skewed distribution)

Gasoline/Diesel PM Split Study – LD Vehicle Recruitment

Recruitment:

- BAR recruited first 9 LD vehicle categories; BKI recruited “smokers” and diesels
- Incentives: \$200 and free rental car; \$50 if vehicle was rejected; free repairs up to \$500 if vehicle failed California Smog Check inspection

Rejects and Why:

- 74 vehicles recruited; 15 rejected
 - 6 rejected because category was over-recruited
 - 4 due to engine/exhaust problems; 3 were too large/incompatible with EPA's transportable dynamometer
 - 2 for other reasons: engine rebuilt at 230,000 miles; owner brought in vehicle wrong day

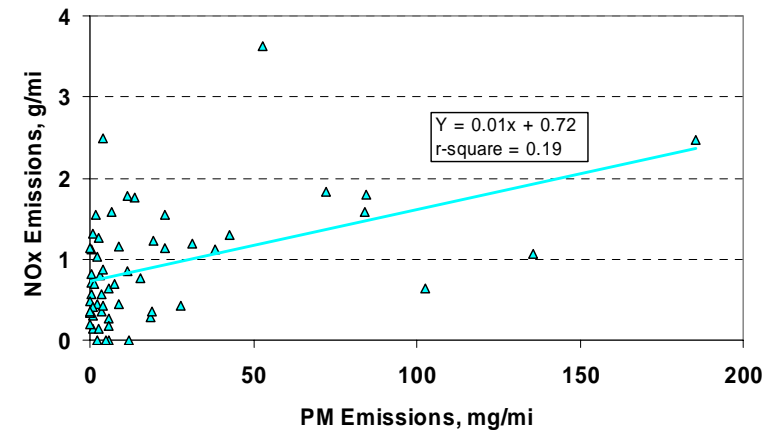
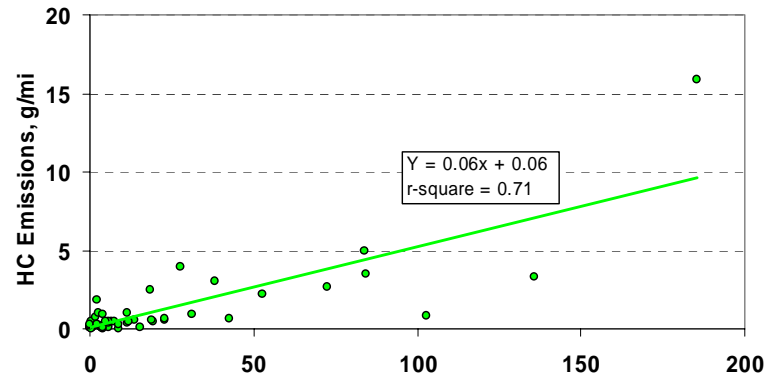
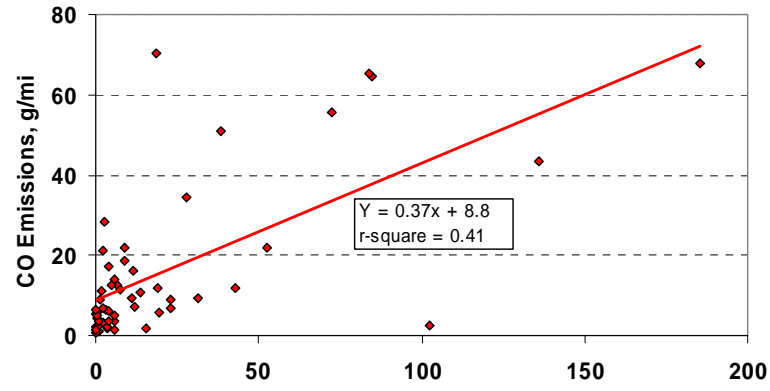
Other Vehicle Problems:

- 1 overheated on cold phase of Unified Cycle
- 1 had brakes catch fire during cold phase of Unified Cycle

Smog Check Results:

- 33 vehicles passed Smog Check (I/M) inspection; 24 vehicles failed
 - 7 “gross polluters” according to Smog Check criteria; 5 were tampered with
 - the only 1996+ vehicle that failed Smog Check did not have its MIL illuminated (OBD “false pass”)
 - 2 aborted Smog Check inspections; 2 vehicles were diesels

Gasoline/Diesel PM Split Study



Gasoline/Diesel PM Split Study

HD Vehicle Recruitment & Test Matrix

GVW (lbs.)	Pre 90	90-93	94-97	98-current	Total
	BOX 1	BOX 2	BOX 3	BOX 4	
8501> 14000	Total 1	Total 1	Total 2	Total 4	8
	(C) [1]	(C) [2]	(B) [3]	(D) [5]	
			(C) [4]	(C) [6]	
				(C) [7]	
				(C) [34]	
14001> 33000	BOX 5	BOX 6	BOX 7	BOX 8	
	Total 2	Total 0	Total 3	Total 3	8
	(C) [8]		(B) [10]	(D) [13]	
	(C) [9]		(C) [11]	(B) [14]	
			(C) [12]	(C) [15]	
33001> 80000	BOX 9	BOX 10	BOX 11	BOX 12	
	Total 2	Total 3	Total 6	Total 5	16
	(B) [16]	(B) [18]	(C) [21]	(E) [26]	
	(E) [17]	(C) [19]	(C) [22]	(B) [27]	
		(C) [20]	(C) [23]	(C) [28]	
			(C) [24]	(C) [29]	
			(C) [25]	(C) [30]	
			(C) [33]		
	Total	5	4	11	12

Transit Buses			
One Powered By Electronic Controlled Diesel - (A)	[32]		
One Powered By Manual Controlled Diesel - (A)	[31]		

Letters in () are Set ID

Numbers in [] are Vehicle Number

Cycle Set:

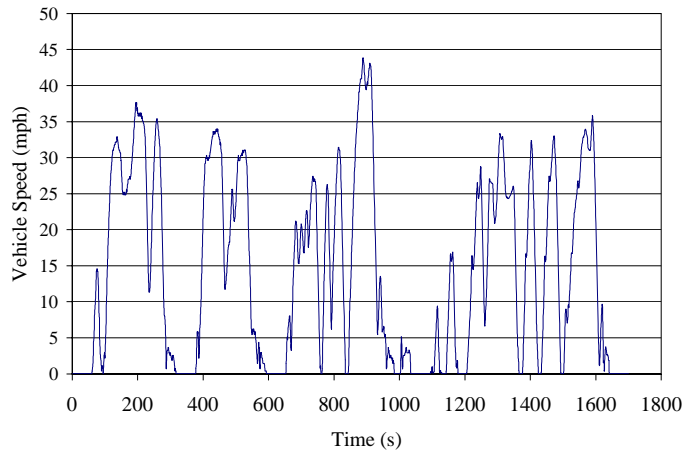
- (A) CSHVR + Manhattan + Idle
- (B) Cold CSHVR + CSHVR + Highway +Idle
- (C) CSHVR + Highway +Idle
- (D) Cold CSHVR + Highway + Idle + Repeat CSHVRs
- (E) Cold CSHVR w/engine brake + CSHVR + Highway + Idle + Cold Idle + UDDS + CSHVR w/engine brake

All vehicles tested with CA diesel fuel; 5 tested with federal diesel fuel

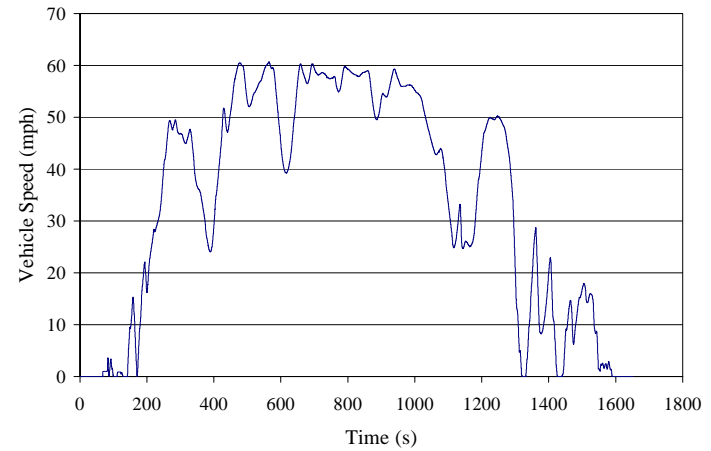
Gasoline/Diesel PM Split Study – Heavy-Duty Vehicles Tested Over Several Driving Cycles



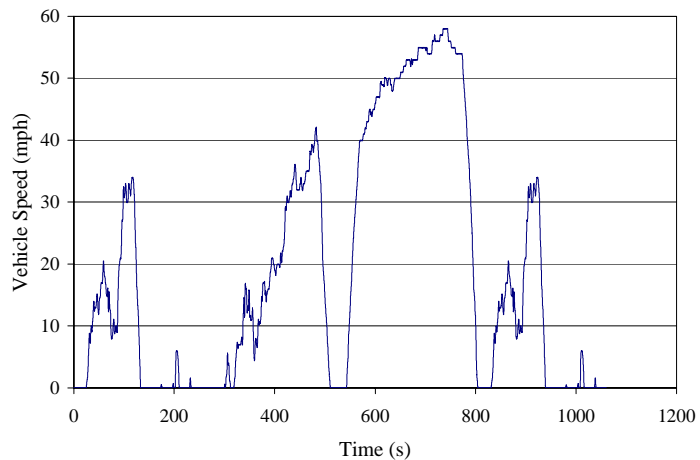
Gasoline/Diesel PM Split Study – Heavy-Duty Vehicle Test Cycles



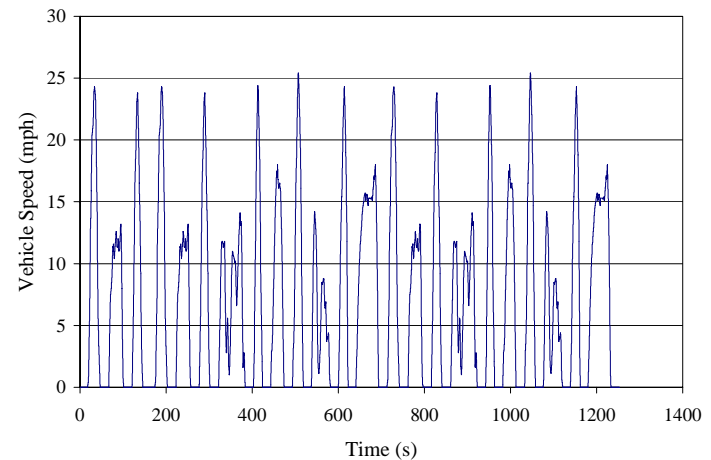
City/Suburban Heavy Vehicle Route (CSHVR)



Highway



HD Urban Dynamometer Driving Schedule (UDDS)



Manhattan

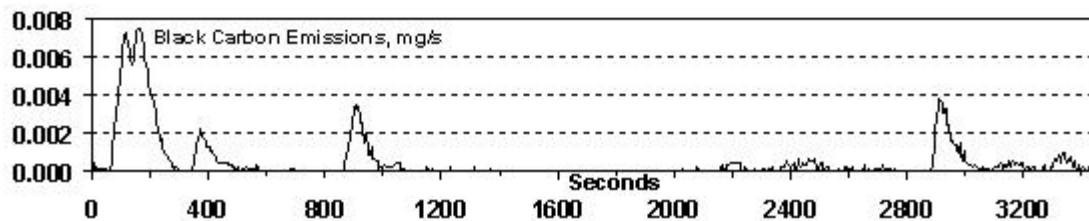
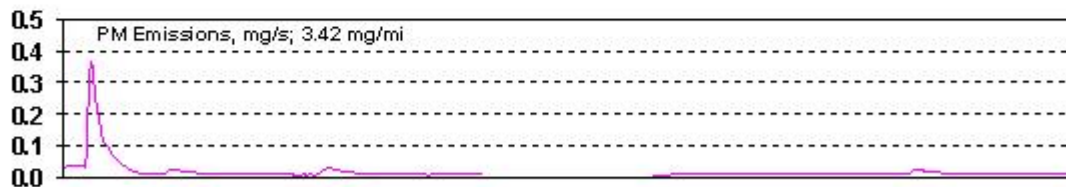
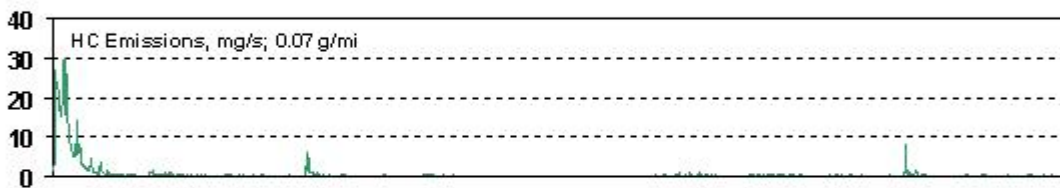
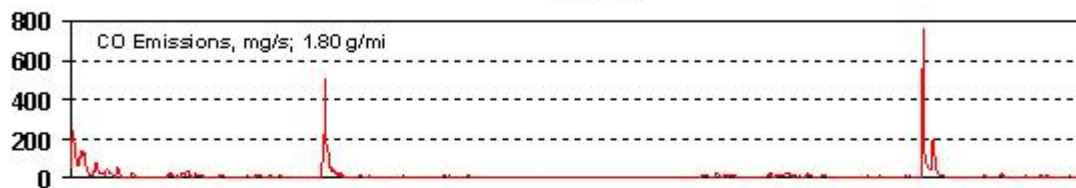
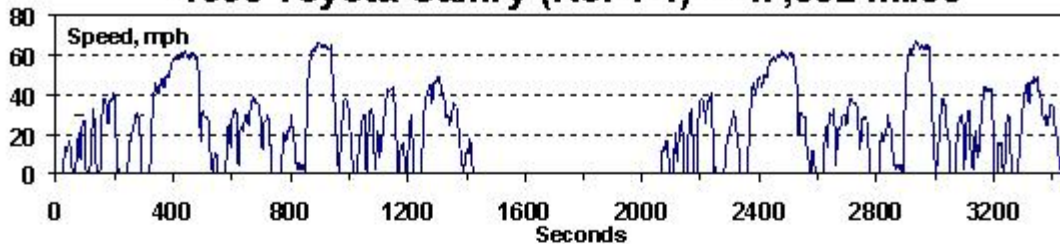
Fixed Site and Mobile Ambient Sampling



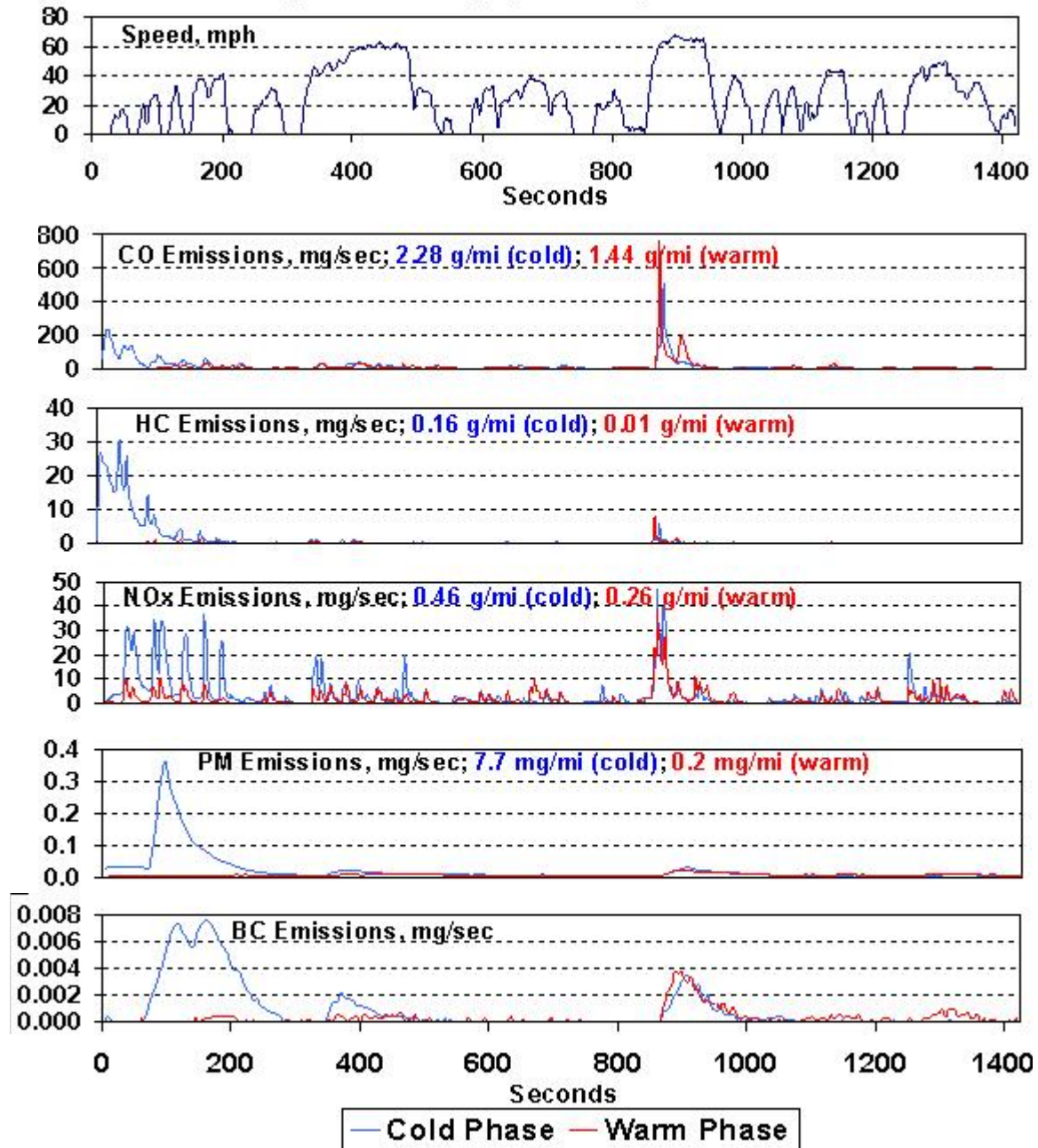
- Downtown Los Angeles and Azusa - daily 24-hour samples for four consecutive weeks, composited by day of week
- Variety of locations with variable amount of gasoline and diesel traffic

Second-by-Second Data
from
Light-Duty SI Vehicles

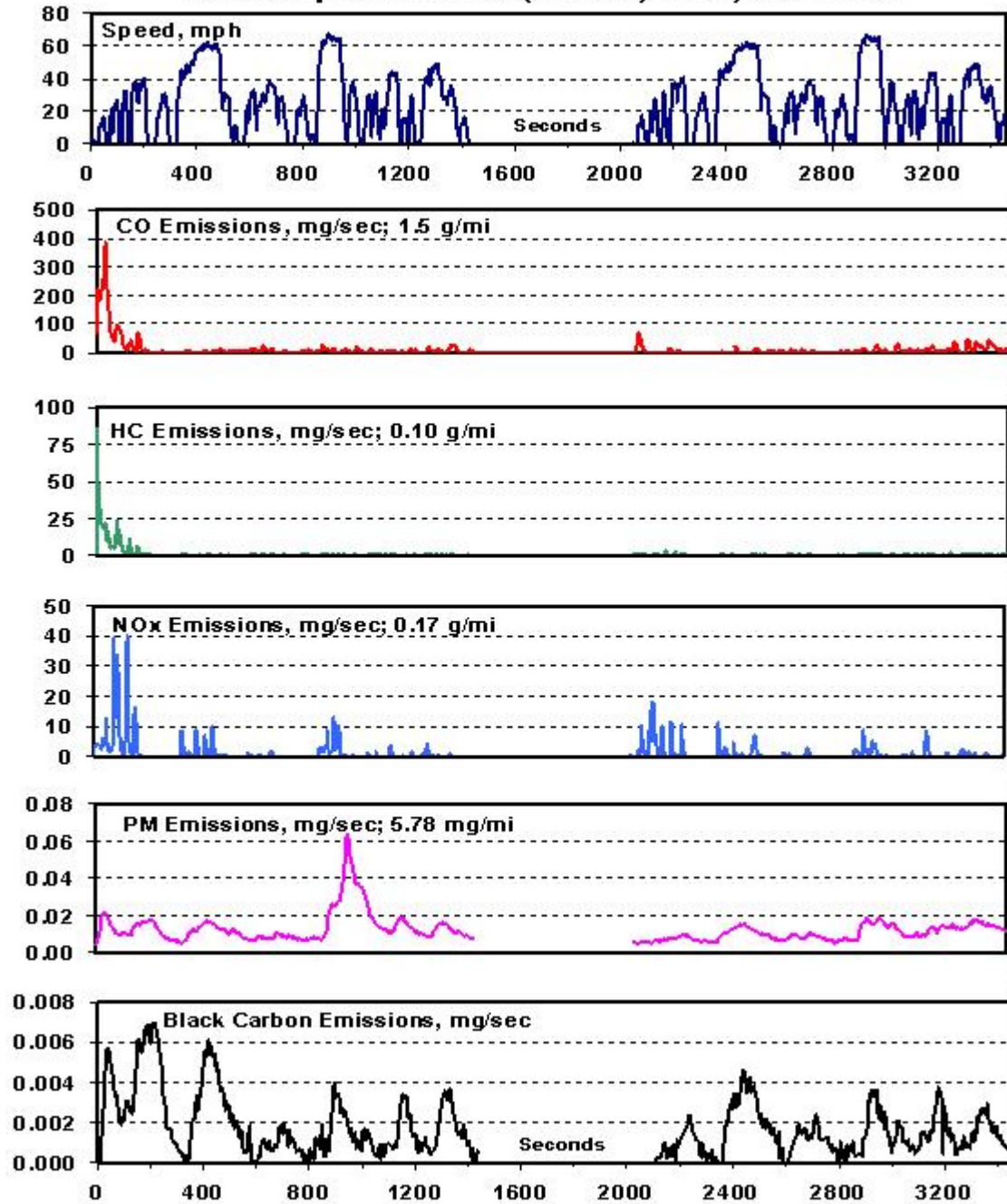
1995 Toyota Camry (No. 1-1) -- 47,502 miles



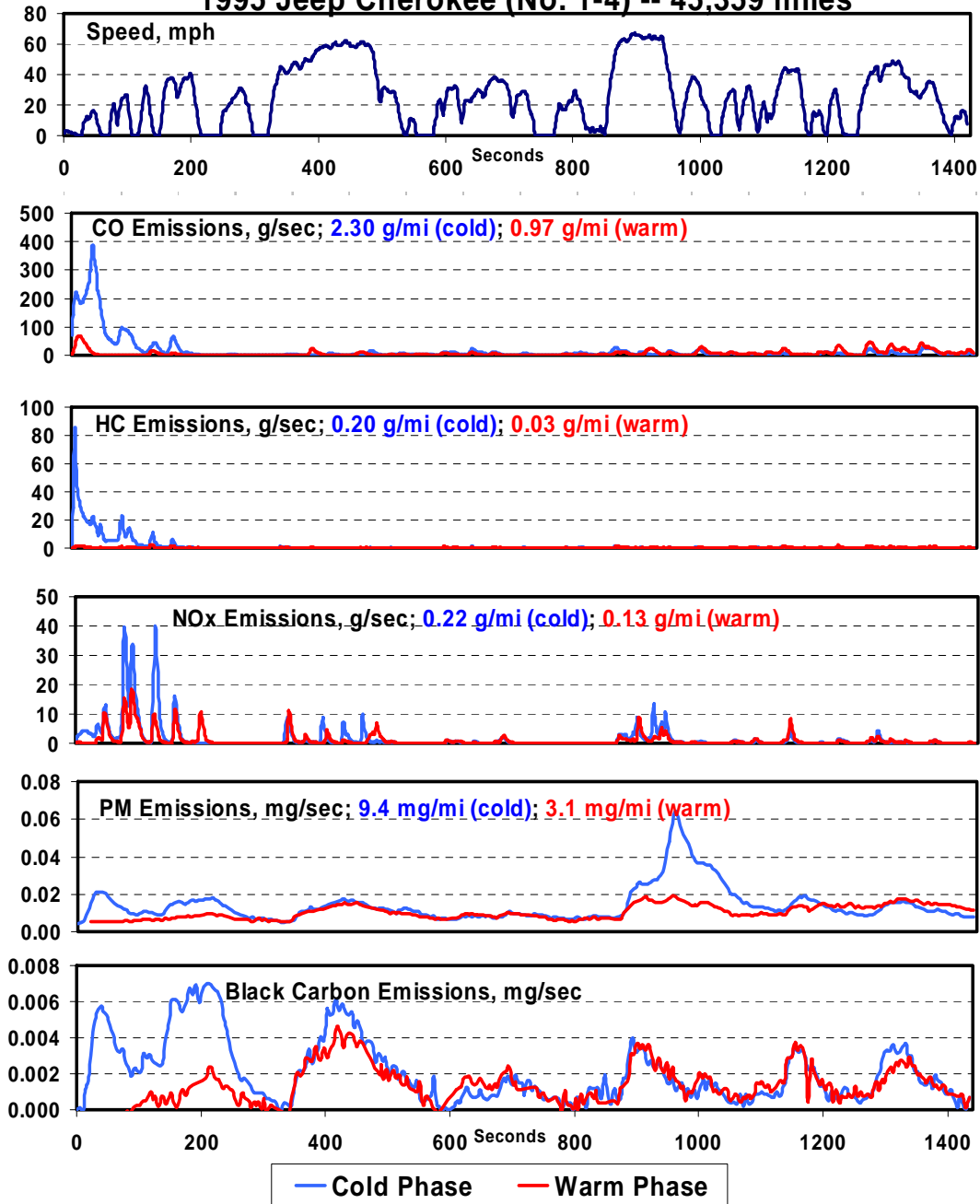
1995 Toyota Camry (No. 1-1) -- 47,502 miles



1995 Jeep Cherokee (No.1-4) -- 45,359 miles



1995 Jeep Cherokee (No. 1-4) -- 45,359 miles



Mobile Source Air Toxics Data

(Light-duty SI Vehicles)

EPA's List of Mobile Source Air Toxics (MSATs)

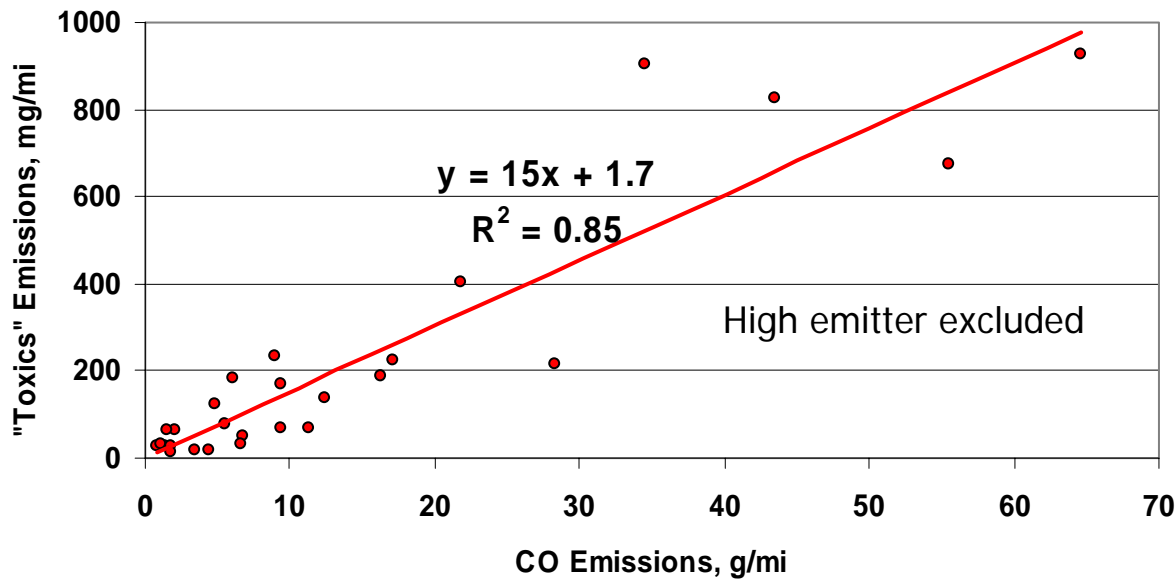
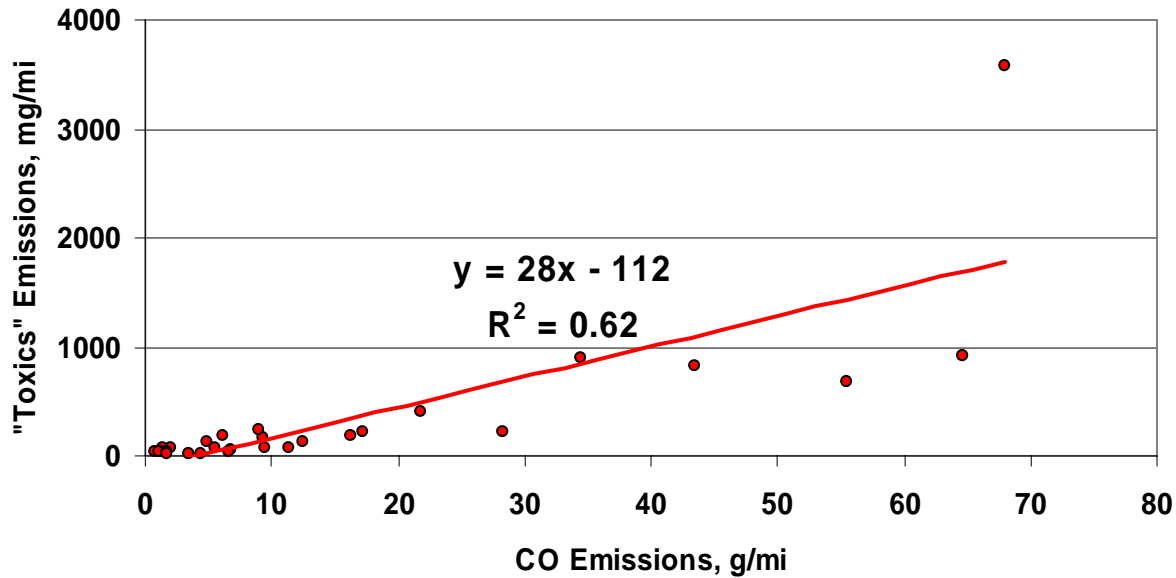
Acetaldehyde	Diesel exhaust	MTBE
Acrolein	Ethylbenzene	Naphthalene
Arsenic compounds	Formaldehyde	Nickel compounds
Benzene	n-Hexane	POM (Sum of 7 PAHs)
1,3-Butadiene	Lead compounds	Styrene
Chromium compounds	Manganese compounds	Toluene
Dioxins/furans	Mercury compounds	Xylenes

Red = Measured in this study

Orange = not reported due to stability problems in canisters

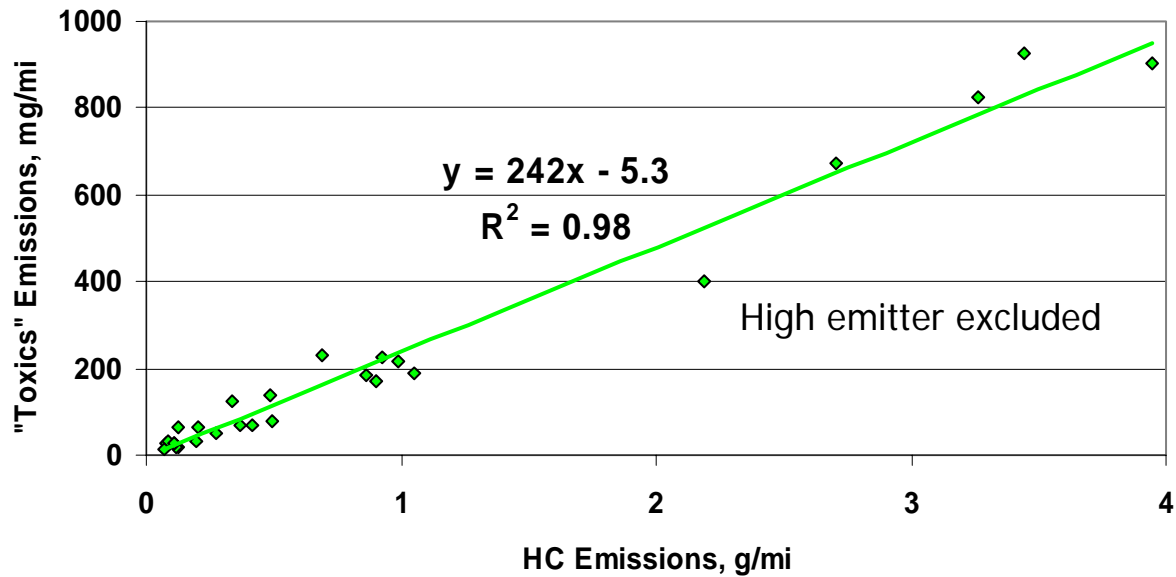
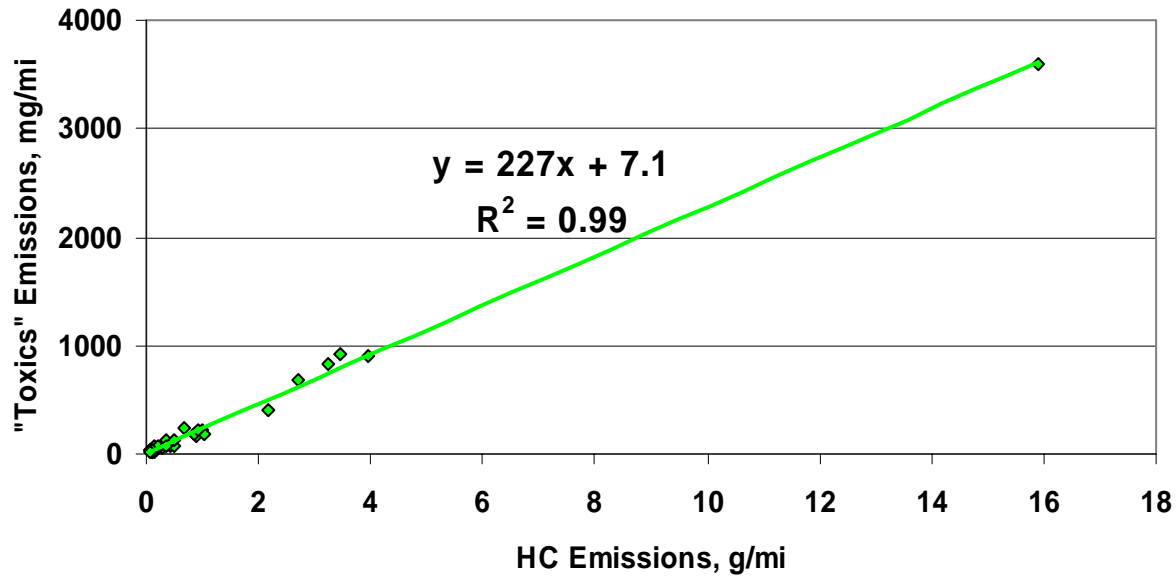
Gasoline/Diesel PM Split Study

(Sum of 12 species, less 1,3-butadiene)



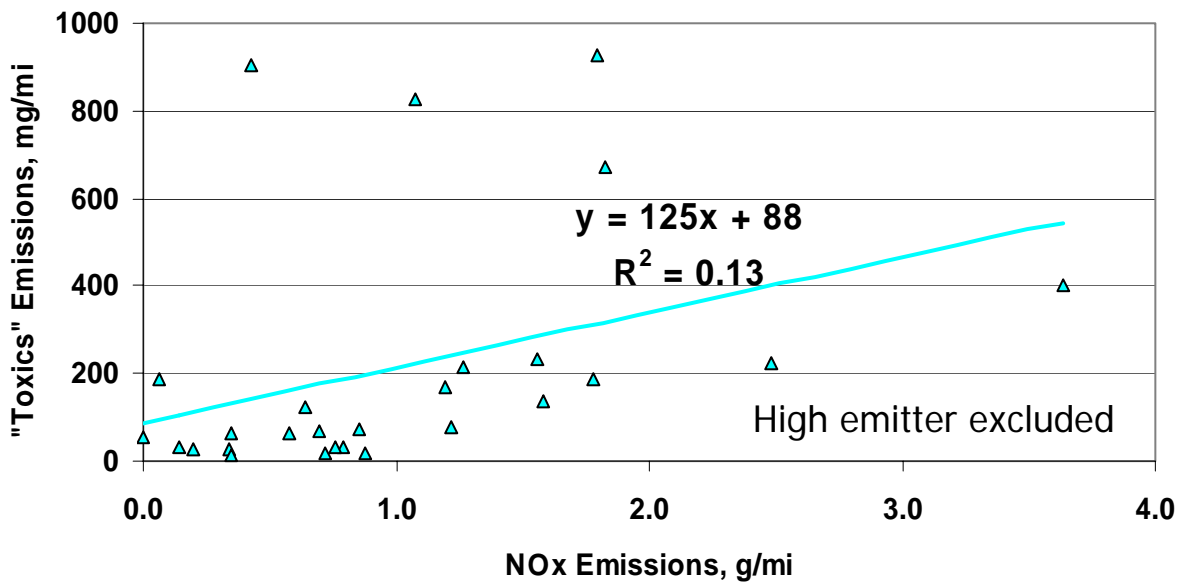
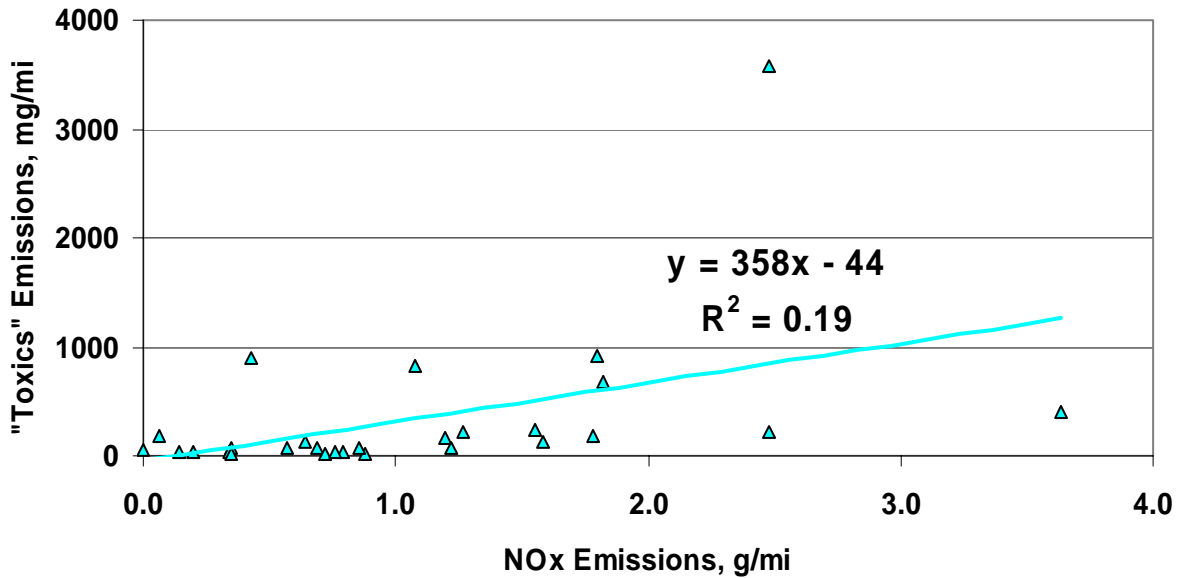
Gasoline/Diesel PM Split Study

(Sum of 12 species, less 1,3-butadiene)



Gasoline/Diesel PM Split Study

(Sum of 12 species, less 1,3-butadiene)



Observations/Implications

- The sampled spark-ignition fleet weighted toward older, high mileage vehicles, where the ten highest PM, HC, CO, and NO_x emitters contributed 66, 66, 58, and 39%, respectively, of the total PM, HC, CO, and NO_x emissions from the 57 SI vehicles tested. A VMT-weighted fleet will have even more emissions skewness.
- The ten highest PM emitters were also the seven, eight, and five highest HC, CO, and NO_x emitters, respectively.
- For “normal” emitter SI vehicles, nearly all of the PM is from cold start and hard acceleration conditions. The number of high emitters and the amount and composition of emissions they produce is critical.
- “Normal” emitter SI vehicles produce “elemental” carbon emissions.
- Excellent correlation between total hydrocarbons as measured by heated FID and sum of mobile source air toxics HC species collected in canisters and analyzed by GC/MS.
- Cold phase PM emissions significantly higher than warm phase PM emissions for SI vehicles; only slightly higher for the 2 LD diesel vehicles. This has important implications for ambient cold start conditions cooler than room temperature for SI vehicles.
- Source profiles developed during this study should not be used for other seasons/locations until mobile emissions profiles from those seasons/areas can be shown to be similar to those from this program.

Data and reports from
the DOE's Gasoline/Diesel PM Split Study
will be available at
<http://www.nrel.gov/vehiclesandfuels/nfti>

Gasoline/Diesel PM Split Study

Mobile Source Air Toxics -- 28 vehicles

Species (MIR)

