Idle Emissions from Heavy-Duty Diesel Vehicles

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Idle Emissions from Heavy-Duty Diesel Vehicles have Environmental, Economic, and Health Effects

- Idling periods may be necessary for driver comfort
- Idling produces particulate matter, regulated gaseous emissions, and carbon dioxide
- Fuel consumption and maintenance cost increases due to idling
- Health risks are posed for drivers and transportation workers

Economic Impact of Idling

- A typical truck consumes 1800 gallons diesel fuel per year in idling
- At today's market price idle fuel consumption costs $4300 per year
- American Trucking Association (ATA) estimated a $2000 annual increase in maintenance cost per truck due to idling

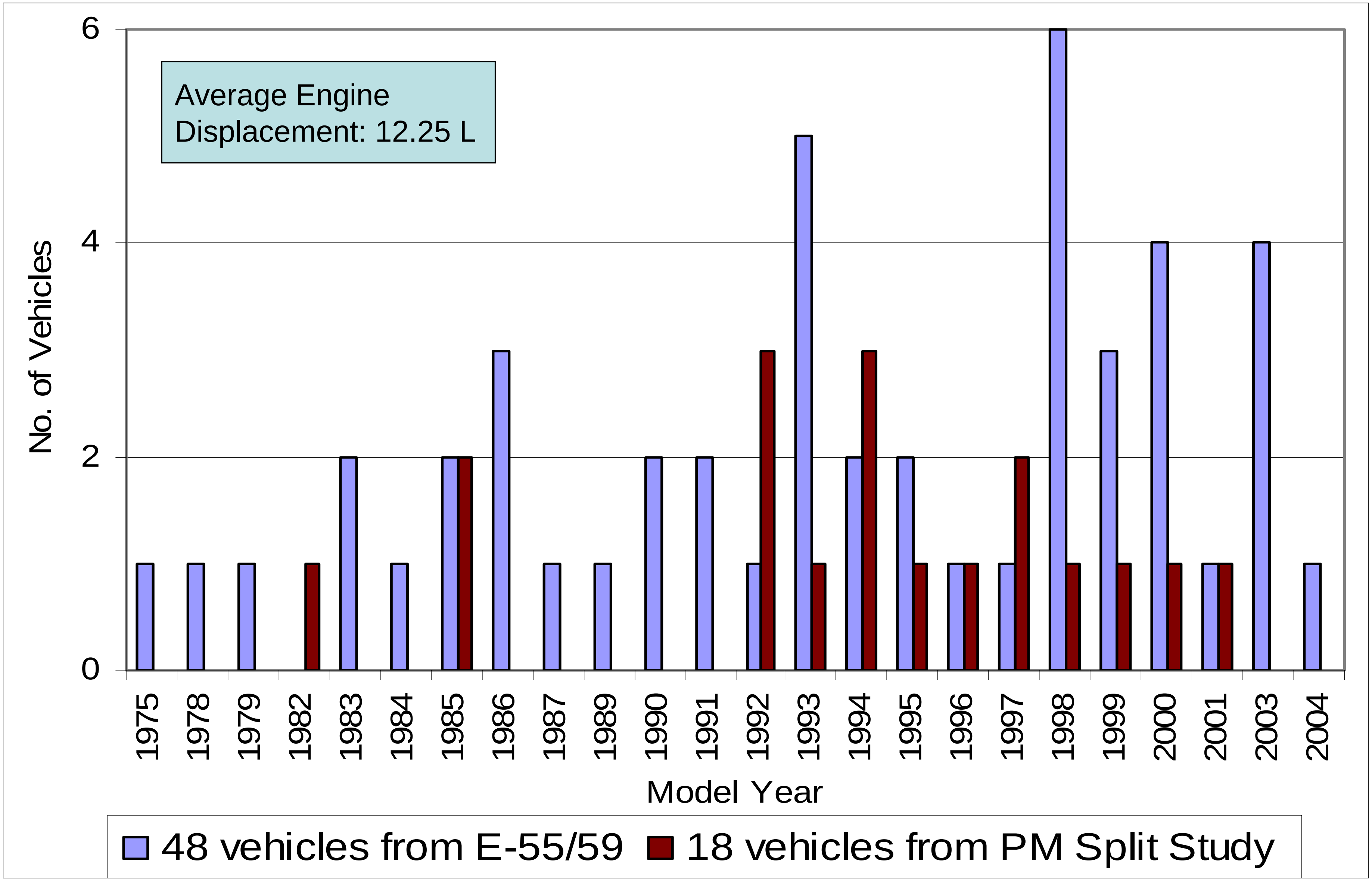
(Reference: www.epa.gov/ne/eco/diesel/)

Objectives of this Research

- Study idle emissions from sixty four Heavy-Duty Diesel Trucks (HDDT), and two transit buses*
- Compare idle emissions rates from heavy-duty trucks of Model Year (MY) 1975 to 2004
- Quantify idle fuel consumption
- Compare WVU idle emissions and fuel consumption data with data from other research projects
- Help the market to avoid ambiguity in quantifying idle emissions and fuel consumption

(* Data from the E-55/59 Study and the DOE's Gasoline-Diesel PM Split Study)

Vehicle Statistics



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Vehicle Data Collection with WVU Transportable Laboratory

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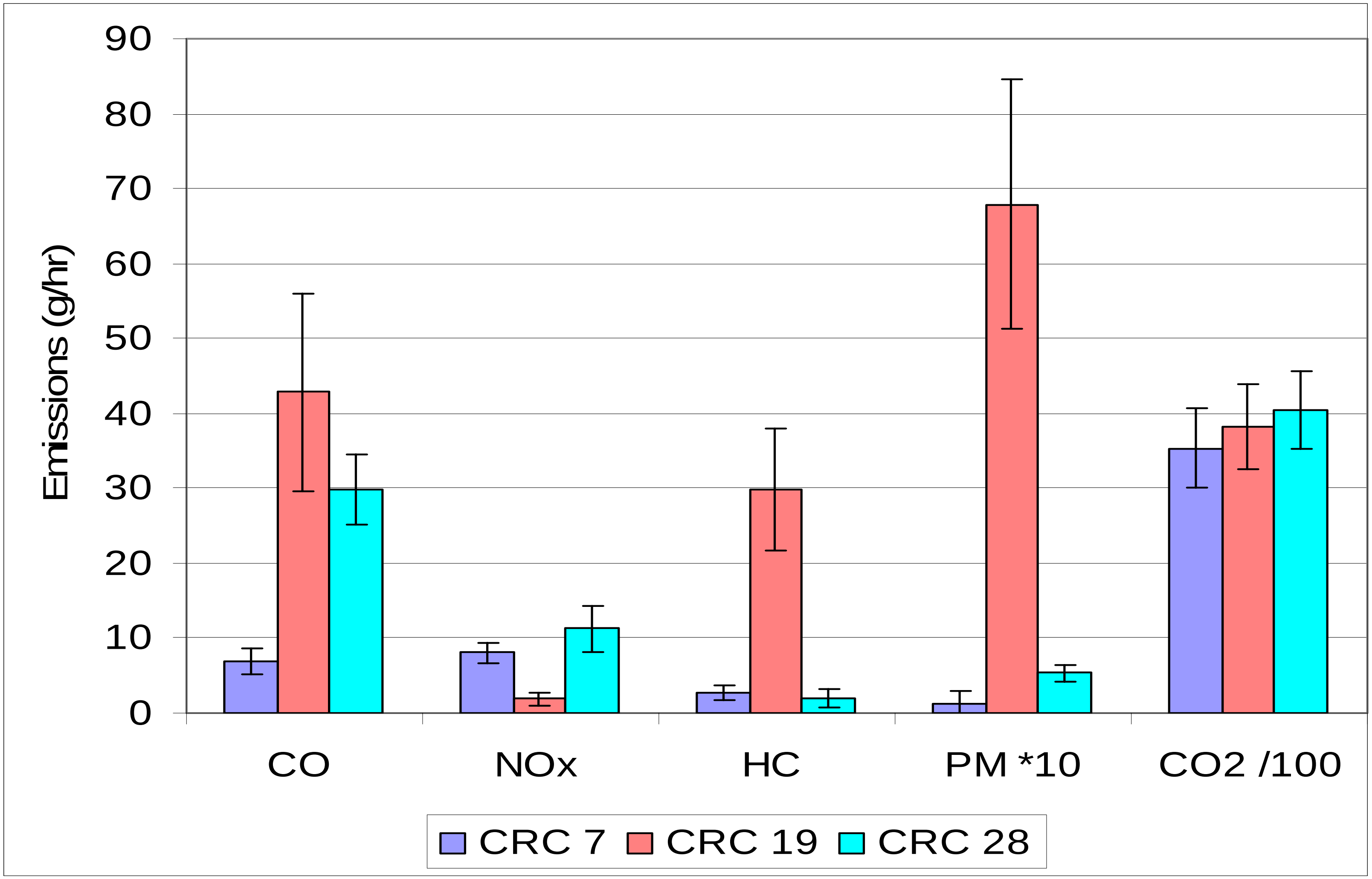
Data Collection: Regulated Emissions Bench

Test-to-Test Variation



- Each truck above has been tested for six different idle tests
- Error bars show ±1 standard deviations
- Variations between test runs could be due to changes in injection timing, accessory loading, and measurement errors

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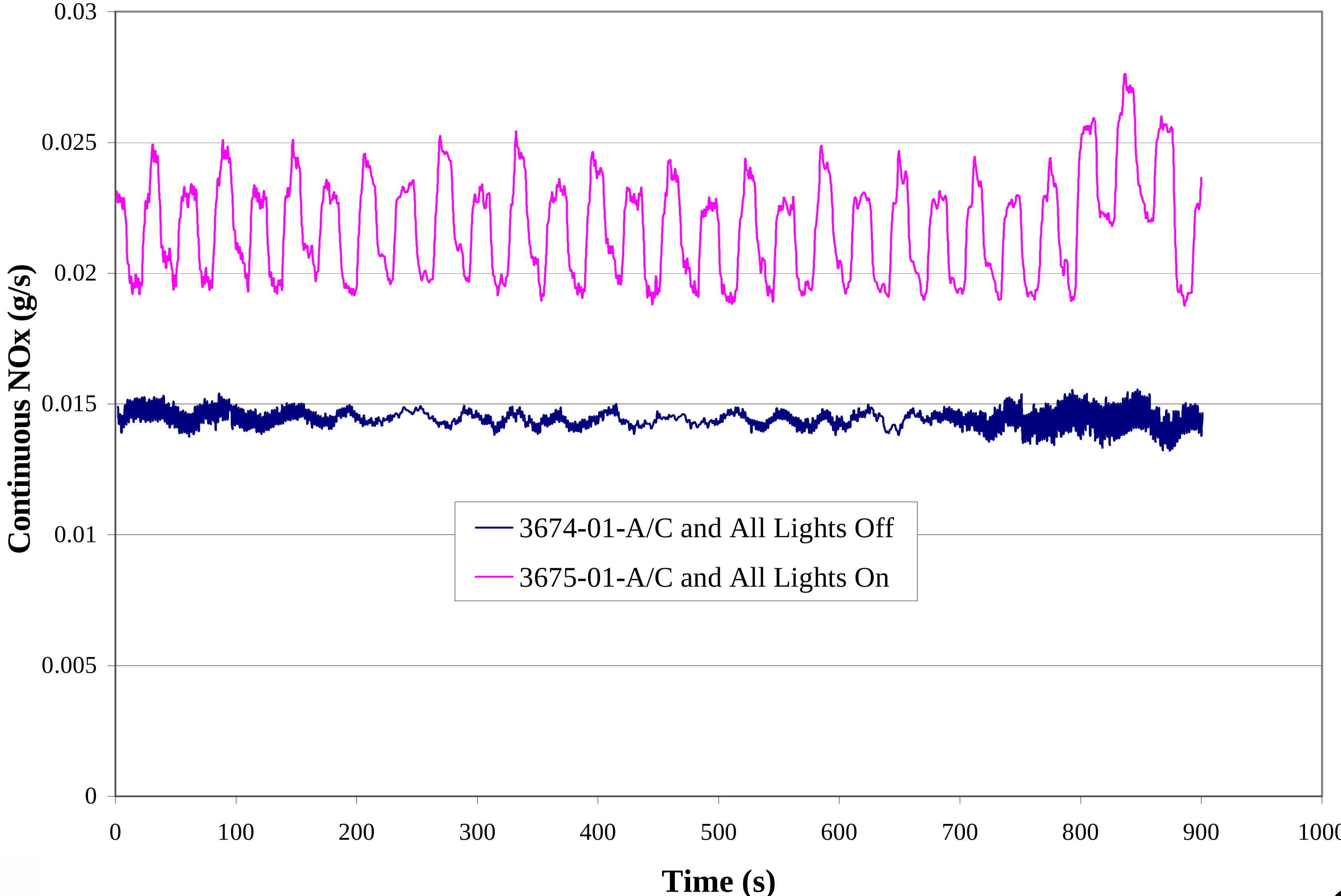
Variation in Idle NOx Concentration with Different Engine Accessories Operating

(Source: SAE Paper 2004-01-2904)



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Model Year Split

All trucks are broadly divided into two groups –

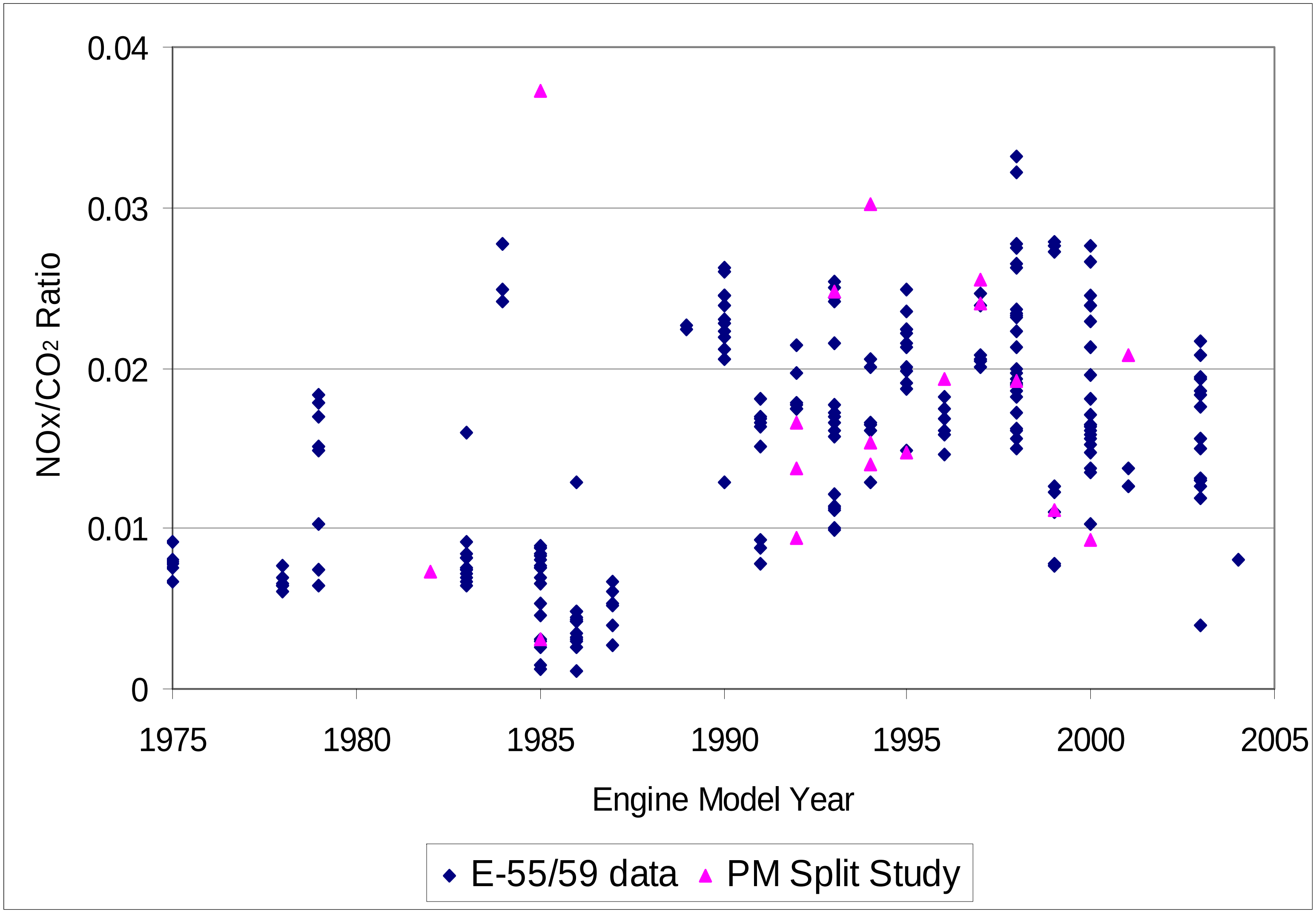
MY 1975 to 1990 and MY 1991 to 2004 as a surrogate for engine technology:

- **The majority of the MY 1975-1990 heavy-duty trucks had mechanically managed engines**
- **A high proportion of heavy-duty trucks after 1990 had electronically managed engines**
- **Electronically managed engines may have advanced timing at low loads or low temperature to avoid 'white smoking'**
- **Advanced timing increases NOx**
- **Superior fuel atomization, air management, and charge motion decreases PM for later MY vehicles**
- **The data will be reprocessed in the future for an exact mechanical vs. electronic control split**

Available Data

- Regulated gases, CO_2, fuel consumption, and PM emissions from idle tests
- NOx/CO_2 ratio from the idle mode and the transient mode of the ‘HHDDT Schedule’ for comparative purposes
- Accessory (Fan) loading may differ between idle tests and transient mode
- Engine speed at idle was not elevated, except for two runs on truck CRC-38 (MY 2003)
- Air conditioning was not used except for two idle runs on truck CRC-38 (MY 2003)
- CRC-16 and CRC-45 had high PM and HC levels and were excluded as malfunctioning vehicles

Idle NOx/CO_2 Ratio



NOx/CO_2 Ratio	MY 1975-1990	MY 1991-2004
E-55/59	0.0104	0.0182
PM Split Study	0.015	0.018

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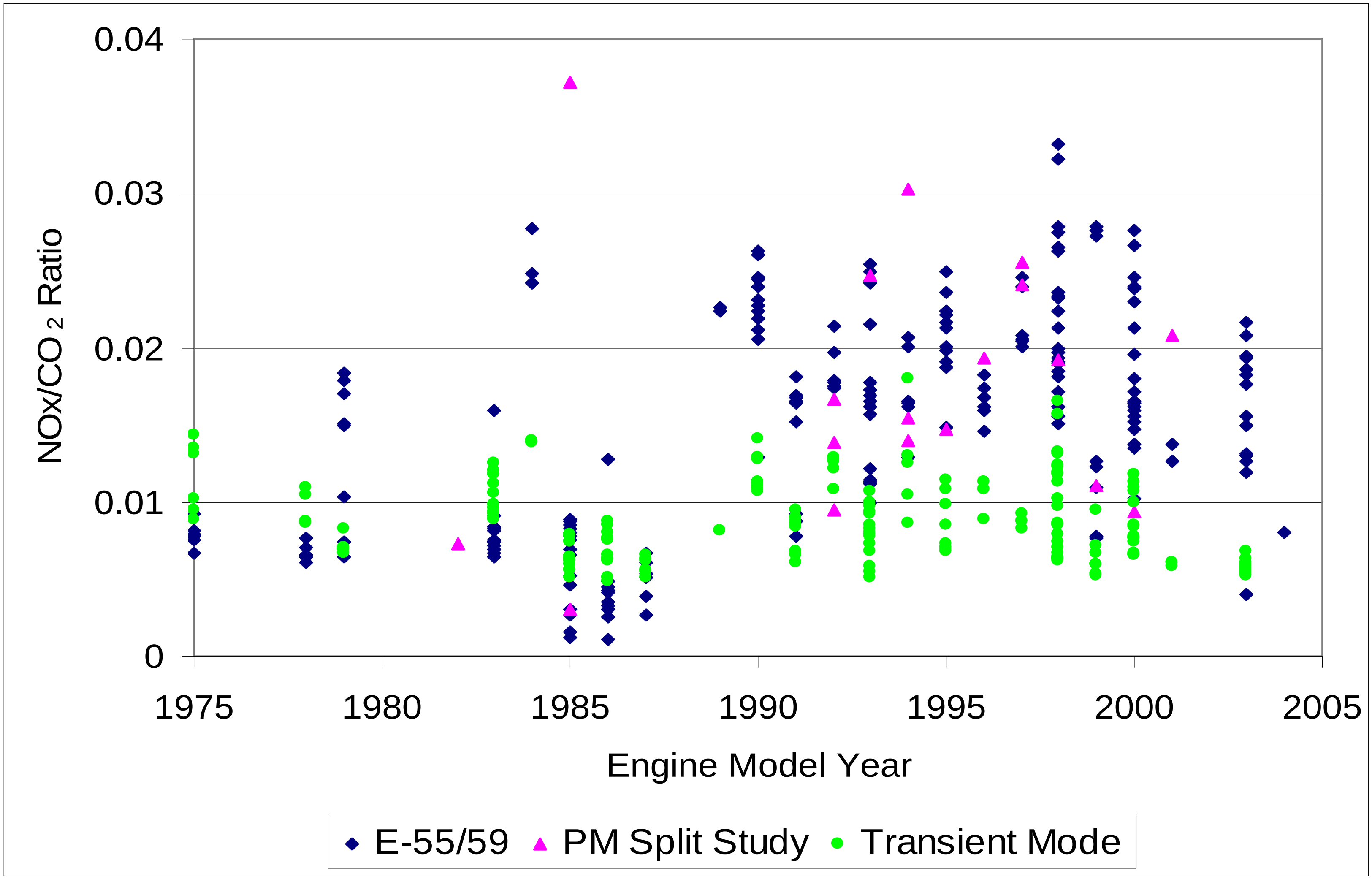
NOx/CO_2 Ratio from Idle and Transient Mode



NOx/CO_2 Ratio	1975-1990	1991-2004
Idle (E-55/59)	0.0104	0.0182
Transient (E-55/59)	0.0087	0.0089
Idle/Transient Ratio	1.2	2.0

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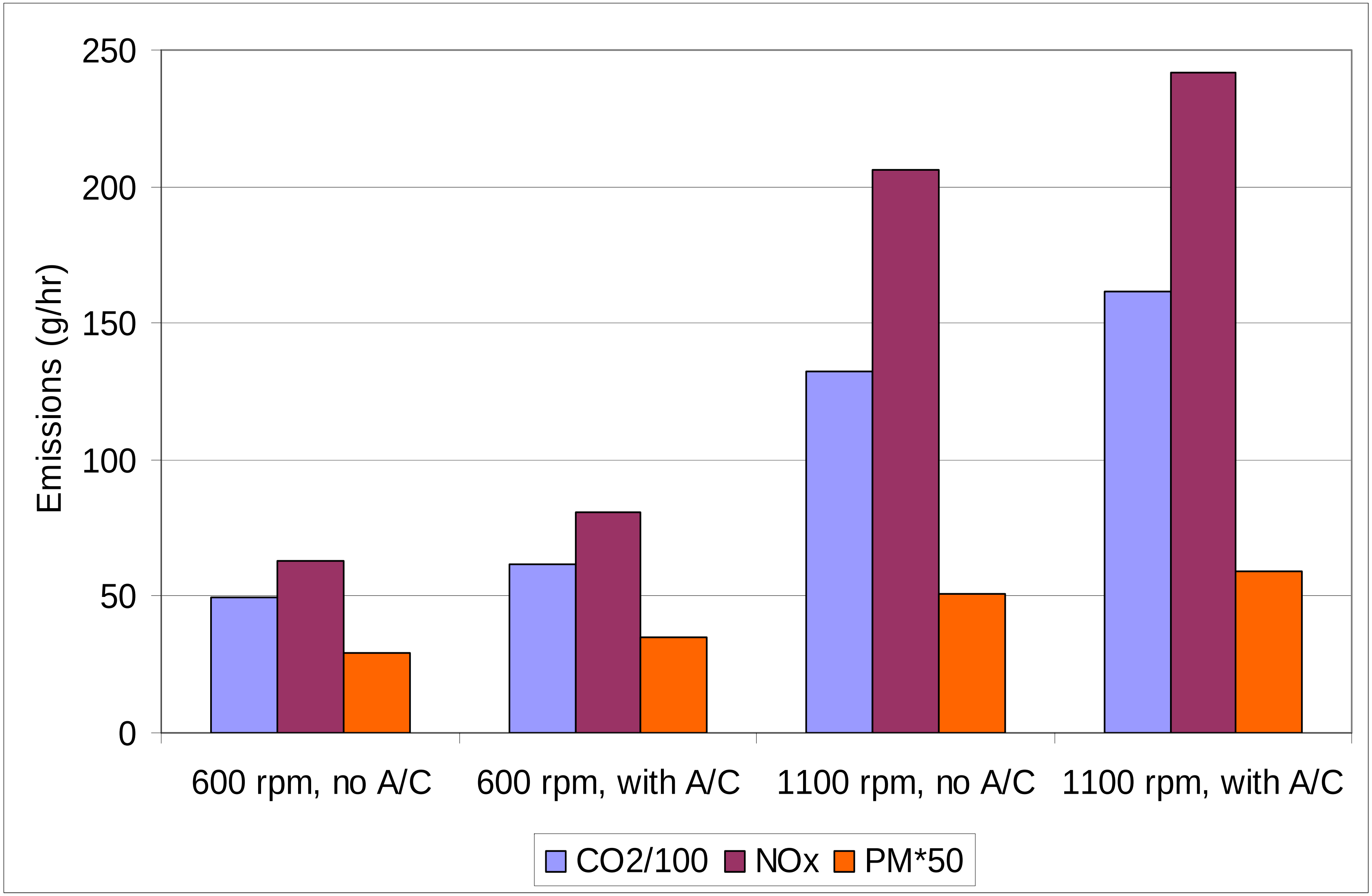
Idle Speed and Air Conditioning Effects

(Tests were performed on CRC-38 truck (MY 2003) on 1/7/2004)



Note: Air conditioning load depends on temperature, humidity, and heat load, and may not be repeatable.

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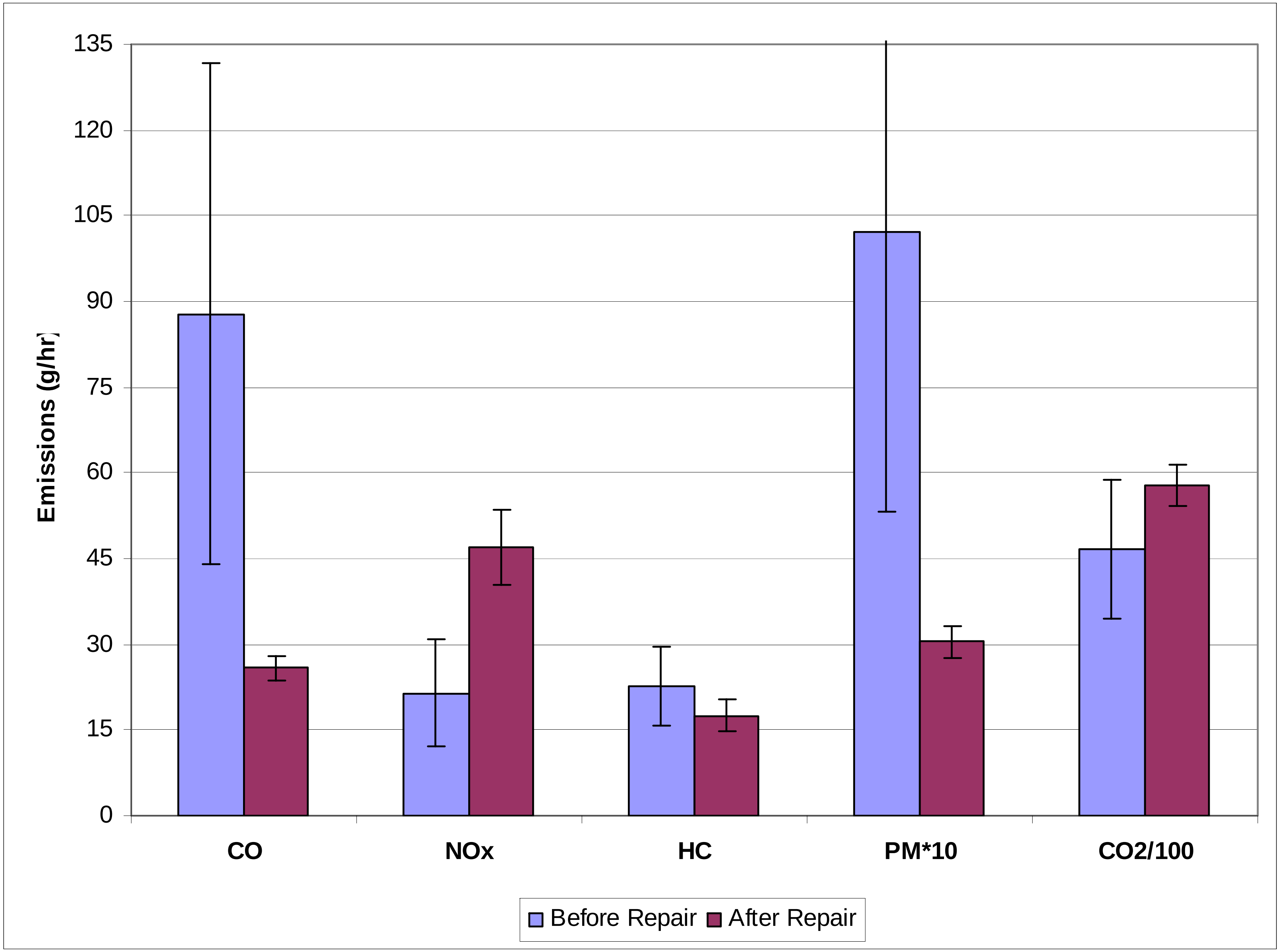
Effect of Injection Timing Repair: CRC-3 Truck



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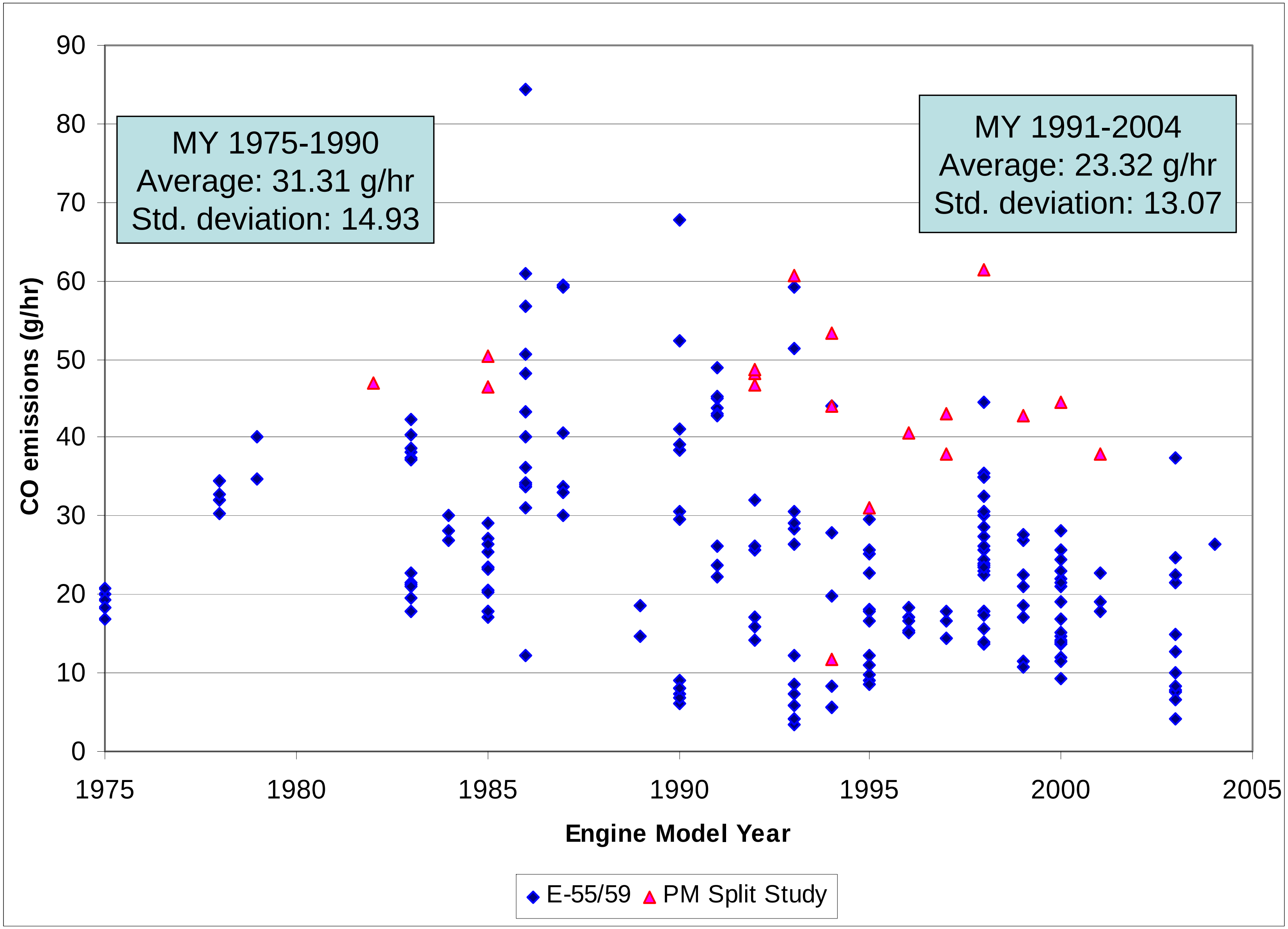
Idle CO Emissions



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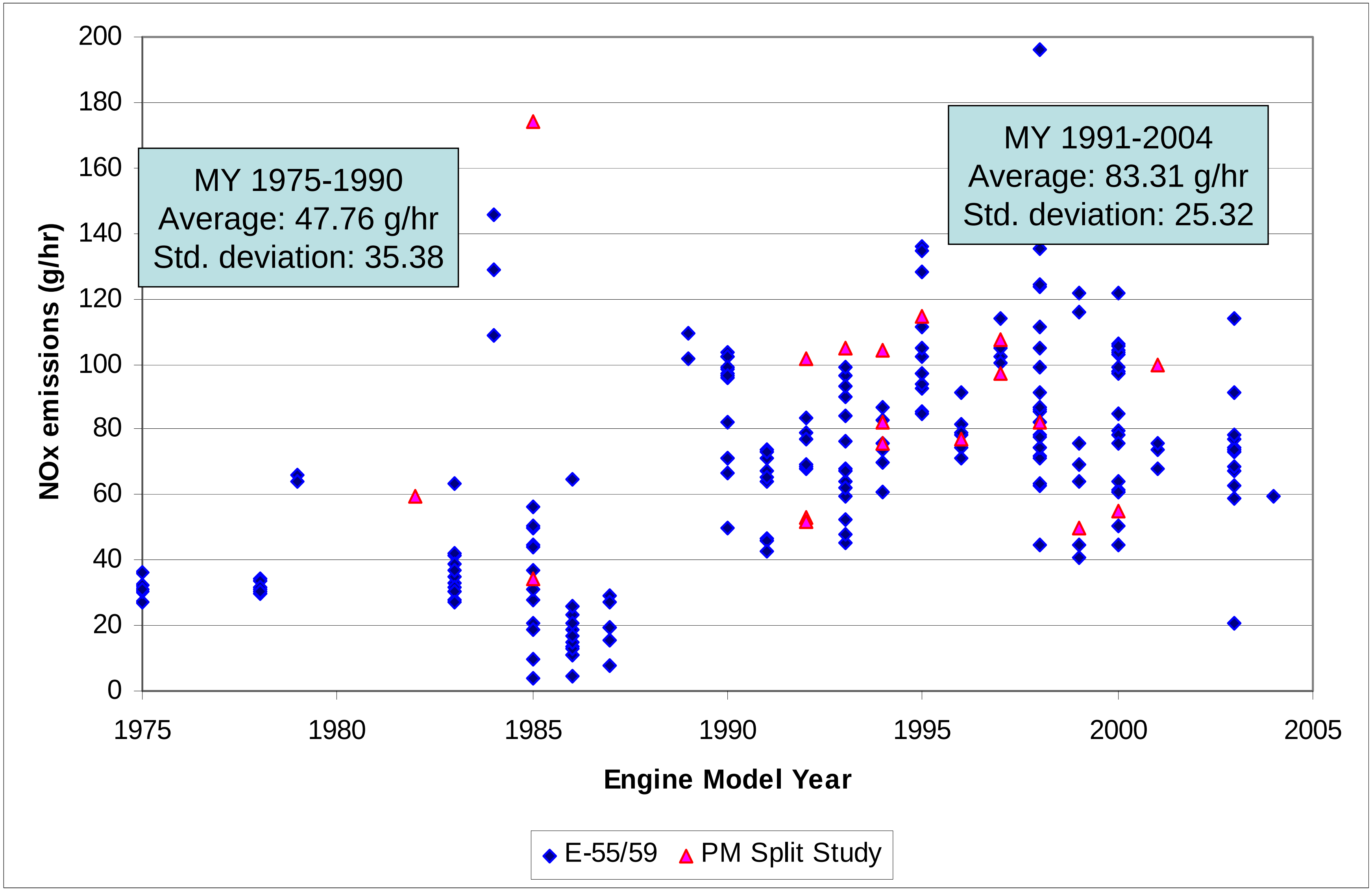
Idle NOx Emissions



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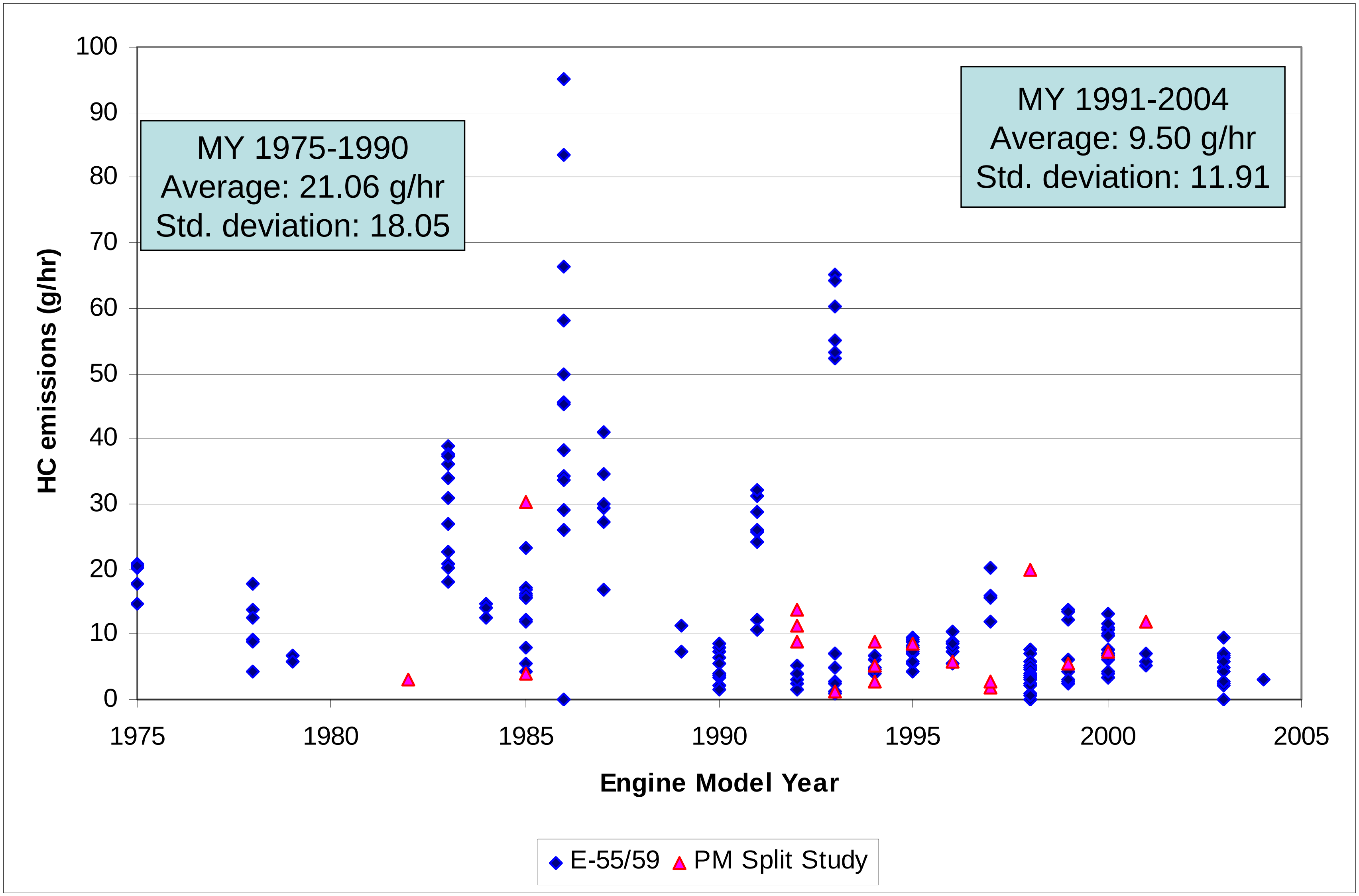
Idle HC Emissions



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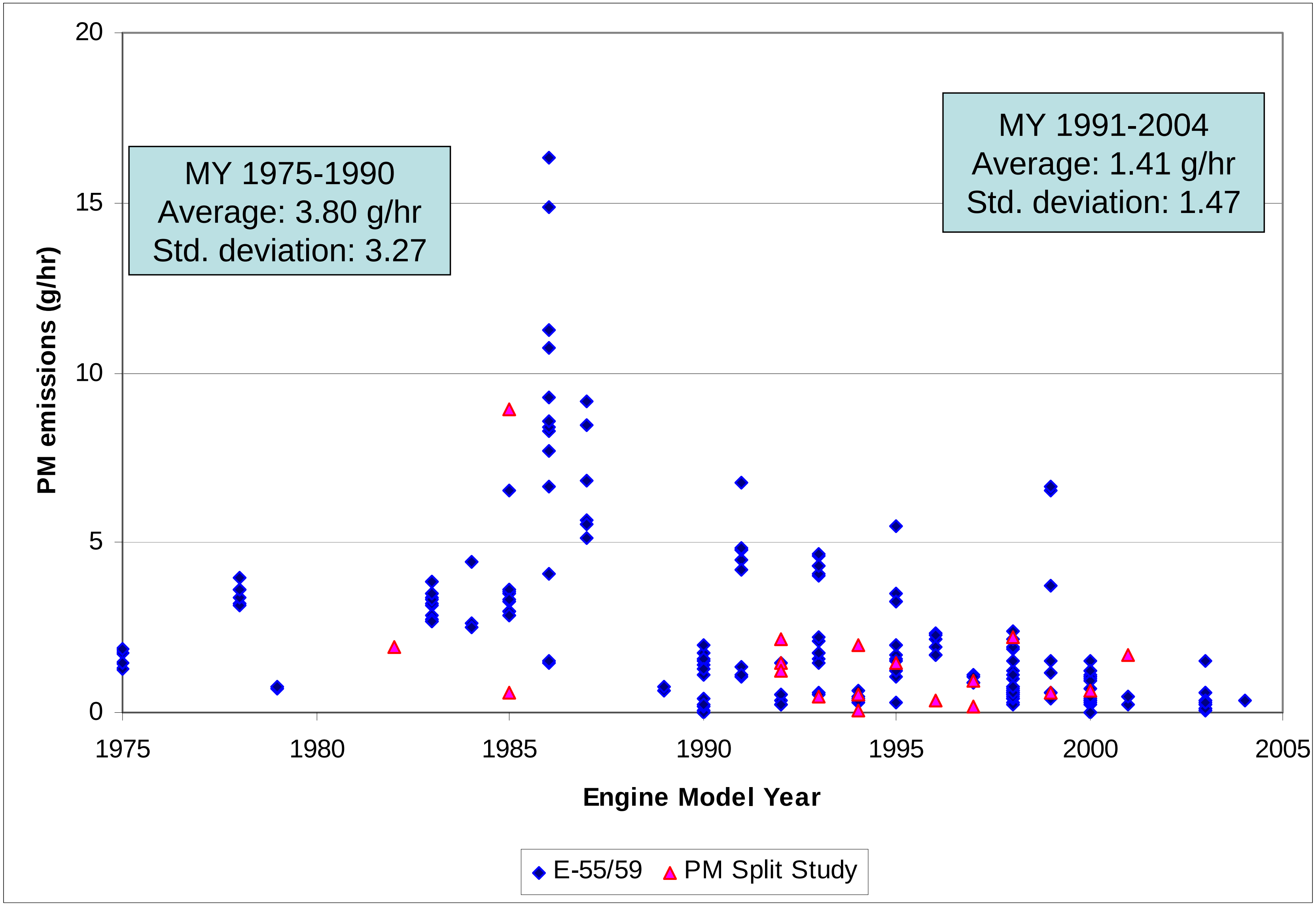
Idle PM Emissions



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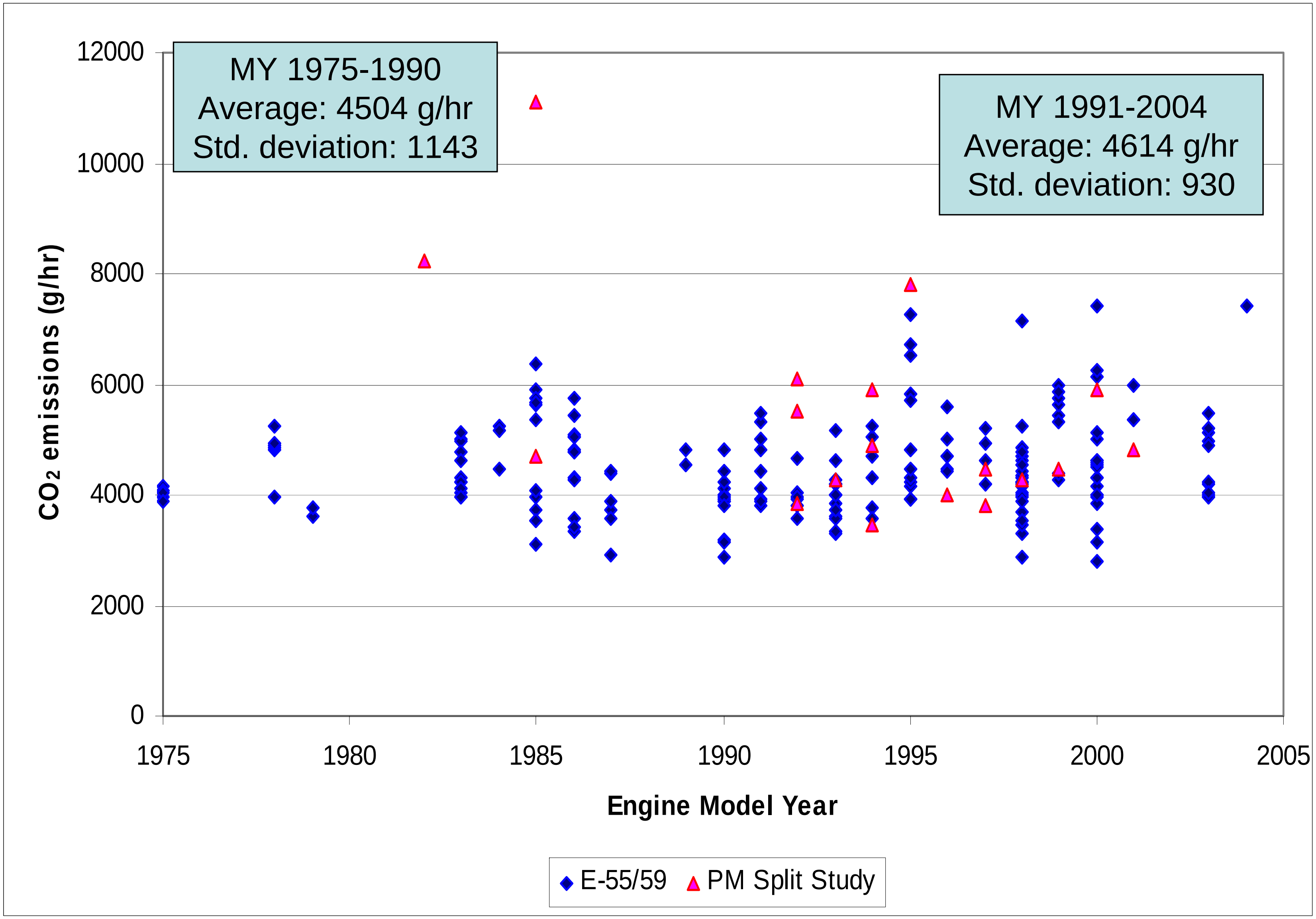
Idle CO_2 Emissions



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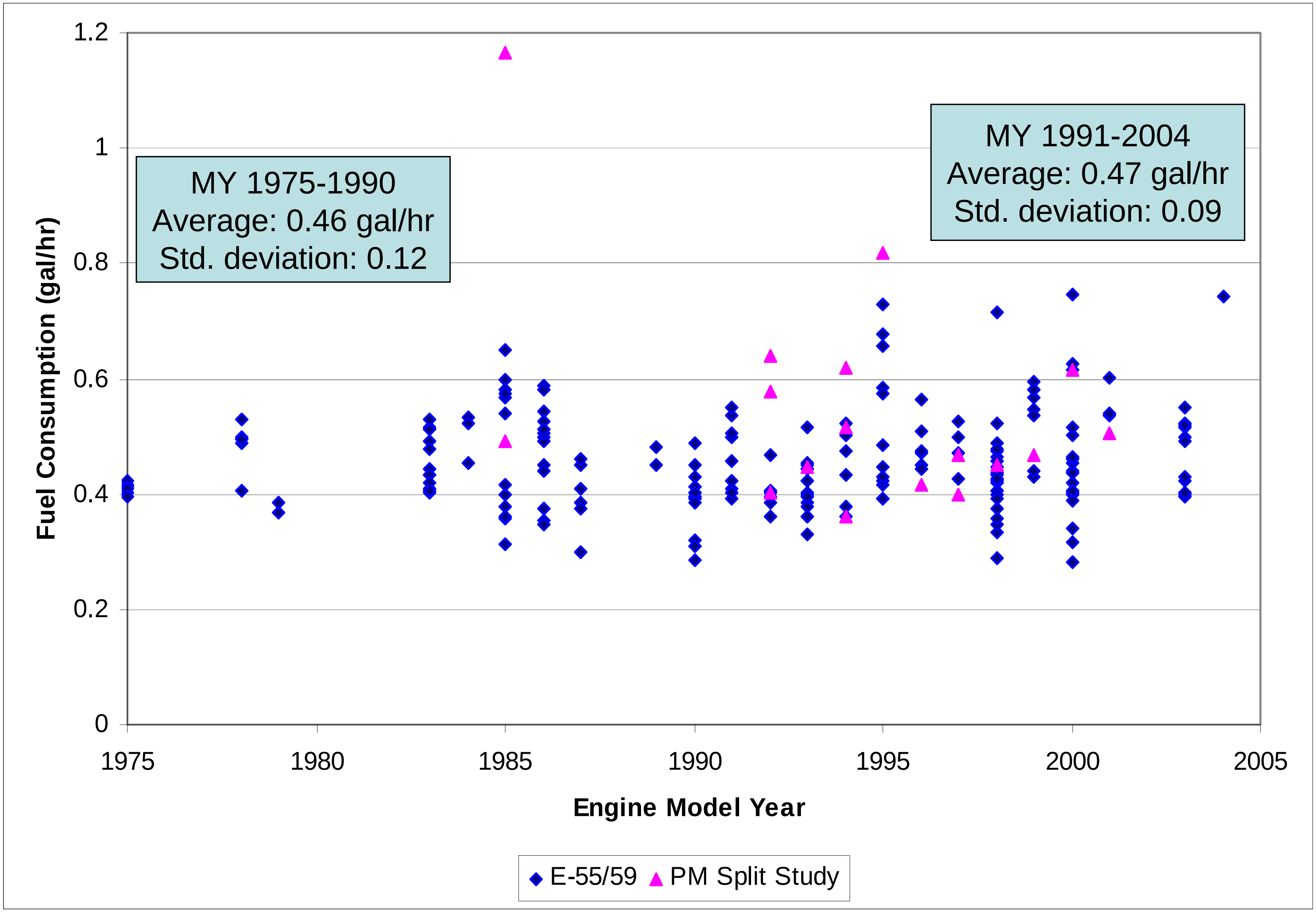
Idle Fuel Consumption



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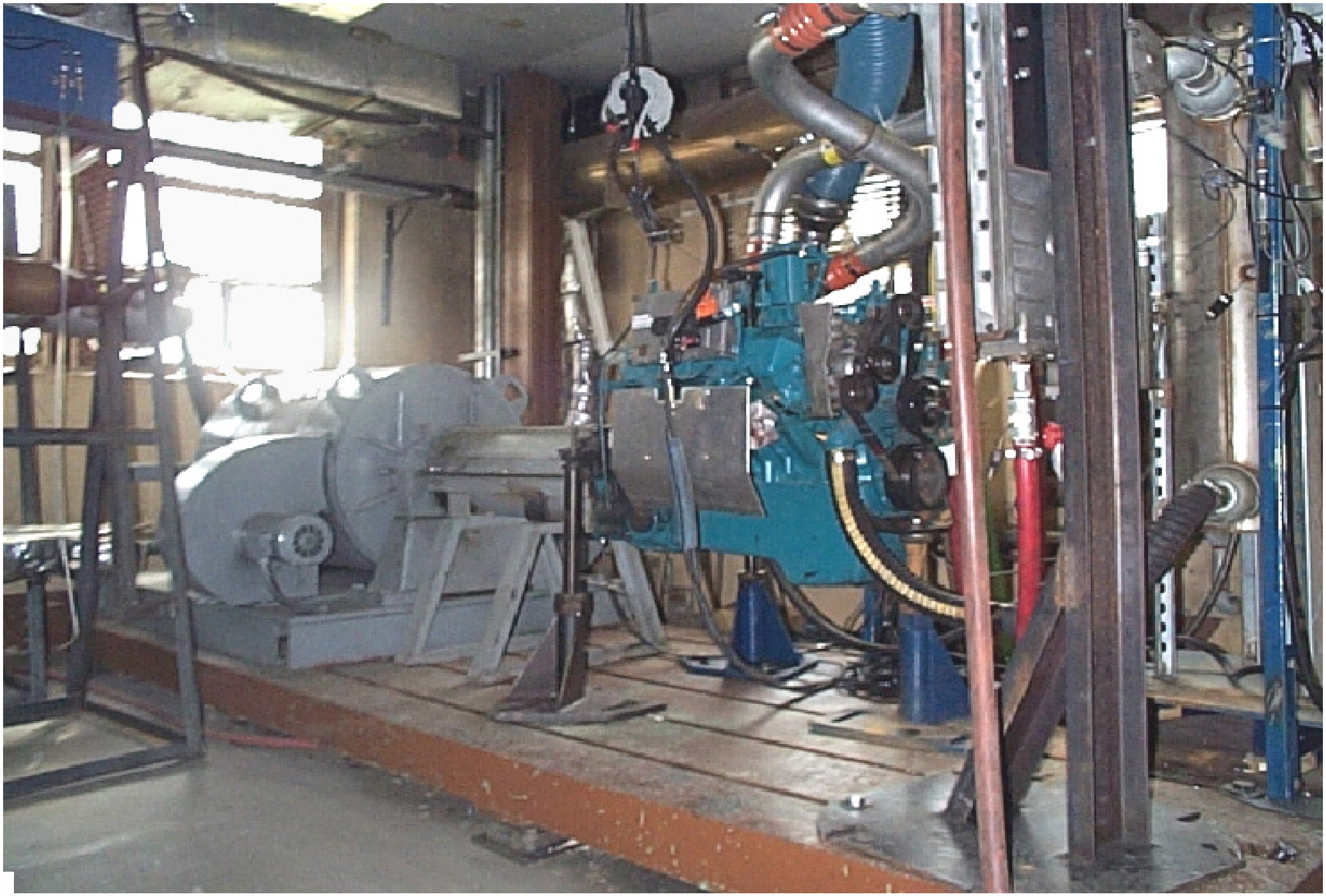
Engine Data Collection with WVU Engine Dynamometer



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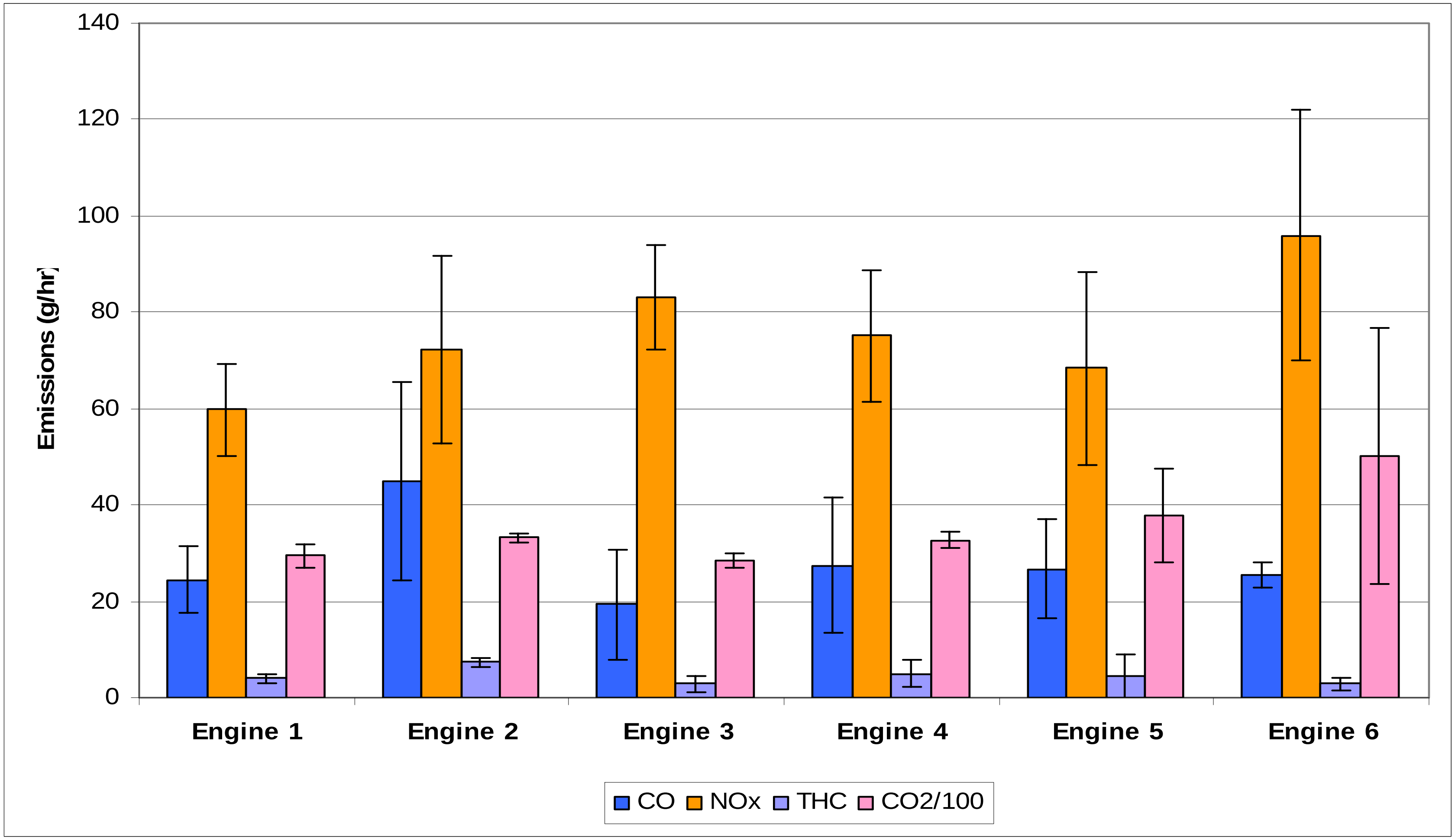
Engine Idle Emissions (Set 1)



Engine 1: 12.7 L DDC Series 60, MY 1992 (Hot Start)

Engine 2: Engine 1 with rebuilt head and new Injectors (Hot Start)

Engine 3: 11.1 L DDC Series 60, MY 1991 (Hot Start)

Engine 4: 12.7 L DDC Series 60, MY 1991 (Hot Start)

Engine 5: 12.7 L DDC Series 60, MY 2000 (Warm Start)

Engine 6: 12.7 L DDC Series 60, MY 1995 (Warm Start)

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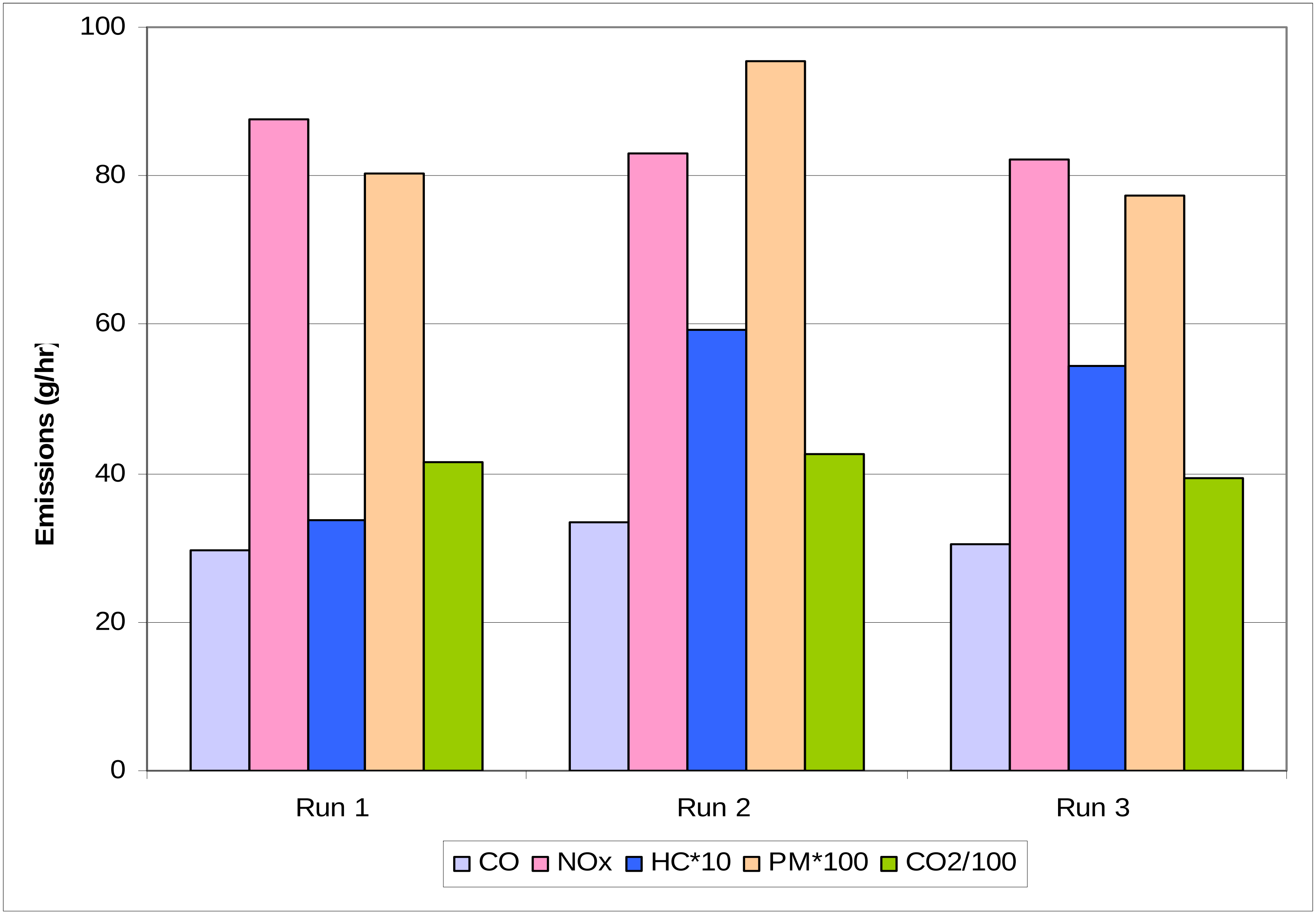
Engine Idle Emissions

(Engine 2 with PM Data included)



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Comparison of Idle Emissions (Class 8 Vehicles)

Source	CO (g/hr)	HC (g/hr)	NOx (g/hr)	PM (g/hr)	CO_2 (g/hr)	Fuel (gal/hr)	Comments
EMFAC 2000 Model	94	12.5	55	2.57			Summer (75ºF)
EMFAC 2000 Model	94.6	12.6	56.7	2.57			Winter (30ºF)
WVU Vehicle Idle data	23.32	9.50	83.31	1.41	4614	0.47	MY 1991-2004
WVU Vehicle Idle data	31.31	21.06	47.76	3.80	4504	0.46	MY 1975-1990
WVU Engine Idle data	29.46	4.84	74.88	0.84	3300	0.36	MY 1991,92, 95, and 2000 MY DDC
Stodolsky et al. @	94.6	12.6	56.7	2.57	10397	1.0*	* With heating/ air-conditioning,1000 rpm
Brodrick et al.@	14.6	1.8	103	n/a	4034	0.36	Idling after cruise
Brodrick et al.@	15.9	2.9	105	n/a	4472	0.39	Idling after transient
Han Lim, EPA@	n/a	n/a	84.54	n/a	4256	0.42	1995 International
Pekula et al.@	n/a	n/a	97		5170	0.46	600 RPM, 65ºF
Storey et al.@	29.8	25.2	78.6	0.85	4720	0.4	600 RPM, 65ºF, MY 2001 Freightliner
McCormick et al.@	79.56	8.22	120.9	2.8			Diesel bus average
McCormick et al.	67.14	86.1	16.02	0.18			CNG bus average
EMFAC 2002 (version 2.2)	26.3	3.48	80.7	1.004*	4098		* MY1994+

@ See Reference

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Total Daily Idle Emissions in California

[Based on WVU data and EMFAC 2000 and EMFAC 2002 Model]

	EMFAC 2000 Model (Summer Condition)	EMFAC 2002 Model	WVU Vehicle Idle Data (Post 1990 MY)
CO (tpd*)	846	237	210
NOx (tpd)	500	726	750
HC (tpd)	112	31	86
PM (tpd)	23	9	13

* tpd: tons per day

Note: Data considered 1,500,000 class 8 trucks, each truck idling for 6 hours per day

Conclusions

- Idle emissions in the literature may include cooling fan, air compressor, air conditioner, and alternator loads, which can cause substantial variability in data collection
- Average idle NOx/CO_2 for post 1990 MY was found to be higher (approximately 67%) than NOx/CO_2 during transient mode indicating that many of these vehicles had advanced timing at low load to avoid 'white smoking'
- Average idle NOx from post 1990 MY was 83.31 g/hr while from 1975-1990 MY it was 47.76 g/hr
- Average idle PM from post 1990 MY was 1.41 g/hr while from 1975-1990 it was 3.80 g/hr
- Data in the literature are highly variable for all species
- Variability in CO_2/fuel ratios in studies may be partly due to correction for engine intake CO_2 mass.
- Data in this study showed that idle fuel consumption did not change with MY

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