Final Report

Evaluation of the Effects of Biodiesel and Biodiesel Blends on Exhaust Emission Rates and Reactivity - 2

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Executive Summary

Alternative diesel fuels continue to be of interest as important measures in controlling diesel emissions. The present program was designed to further investigate the effects of alternative diesel fuels on exhaust emission rates and reactivity in comparison with California specification reformulated diesel (CARB). In this project, an in-use CARB fuel was compared with ARCO's Emission Control-diesel (EC-D) and three 20% biodiesel blends (2 soy-based and 1 yellow grease-based). Chassis dynamometer tests were performed on 7 vehicles using each of the 5 fuels. For these tests, emissions measurements were collected for regulated gaseous emissions and particulate matter (PM). Additional measurements were performed to provide chemical characterization of the exhaust PM including elemental and organic carbon, ions and trace elements and metals, identification of semi-volatile and particulate phase PAHs, and speciation of gas phase C_1-C_{12} hydrocarbons and carbonyls.

Table ES-1 summarizes the results of this study. The EC-D and the OXy-G B-60 yellow grease biodiesel blend both showed significant reductions in THC and CO emissions over the test vehicle fleet. THC emission reductions for EC-D compared with CARB fuel were found for 6 of the 7 test vehicles with reductions ranging from 32 to 56%. Five of the seven test vehicles showed THC emission reductions for the OXy-G B-60 biodiesel blend ranged from 21 to 66% compared with the CARB fuel. CO emissions reductions ranged from 12 to 41% for the EC-D and from 0 to 46% for the OXy-G B-60 relative to the CARB fuel. The THC and CO emissions for the soy-base biodiesel blends were comparable over the test fleet to those of the CARB fuel. NO_x emissions were comparable for the different fuel types over the range of vehicles tested.

EC-D showed the most significant reductions in PM emission rates, with reductions ranging from 5 to 43%. The OXy-G B-60 showed some promise in reducing PM emissions for the highest emitting vehicle, but had PM emissions rates comparable with those of the in-use fuel for the remaining vehicles. The soy-based biodiesel blends had higher PM emissions rates than the in-use fuel for 4 of the 7 vehicles, with comparable PM emission rates for the remaining three vehicles.

Table ES-1. FTP Weighted Emissions Results for Diesel Vehicles on Different Fuel Blends

	1993 Ford F350 pick-up				1990 Ford E350 Van				1990 Chevy 2500 pick-up				1989 Chevy 2500 pick-up			
	THC g/mi	CO g/mi	NO_x g/mi	PM mg/mi	THC g/mi	CO g/mi	NO_x g/mi	PM mg/mi	THC g/mi	CO g/mi	NO_x g/mi	PM mg/mi	THC g/mi	CO g/mi	NO_x g/mi	PM mg/mi
CARB	6.430	7.708	2.019	2282	0.090	0.815	9.210	126.6	0.437	1.883	2.852	164.4	0.425	1.679	2.275	221.1
EC-D	2.800	5.601	2.099	1292	0.111	0.720	8.380	118.8	0.240	1.110	2.690	149.3	0.287	1.375	2.327	182.1
20% SoyGold Biodiesel	4.909	7.262	2.002	2578	0.146	0.818	9.469	116.7	0.331	1.705	2.982	159.7	0.602	1.913	2.302	271.8
20% World Energy Biodiesel	5.214	7.207	2.064	2773	0.105	0.805	9.469	116.1	0.255	1.662	2.908	160.9	0.596	1.848	2.393	268.1
20% OXyG B-60 Biodiesel	3.381	5.579	2.196	1830	0.106	0.728	8.752	127.8	0.147	1.016	2.991	158.5	0.481	1.673	2.380	256.3

	1987 Chevy C-30 pick-up				1985 Chevy C-30 pick-up				1983 Ford F350 pick-up			
	THC g/mi	CO g/mi	NO_x g/mi	PM mg/mi	THC g/mi	CO g/mi	NO_x g/mi	PM mg/mi	THC g/mi	CO g/mi	NO_x g/mi	PM mg/mi
CARB	0.696	2.592	2.087	314.6	0.253	1.360	3.845	220.6	1.278	3.506	3.687	616.5
EC-D	0.464	1.731	1.986	221.1	0.169	0.972	3.818	188.9	0.763	2.326	3.804	526.7
20% SoyGold Biodiesel	0.853	2.590	2.119	359.2	0.224	1.339	4.185	193.9	1.248	3.403	3.909	808.1
20% World Energy Biodiesel	0.758	2.529	2.124	364.9	0.233	1.332	4.172	197.5	1.289	3.245	3.725	915.4
20% OXyG B-60 Biodiesel	0.457	1.820	2.099	291.2	0.201	1.189	3.975	206.4	0.919	2.491	3.865	575.3

Detailed C_1-C_{12} NMOG speciation showed alkenes and carbonyls were the most prominent compound classes in this range. The species distribution as a function of carbon number showed a peak at the C_2 species, which included ethane, ethyne, and acetaldehyde. The four primary toxic air contaminants (formaldehyde, acetaldehyde, benzene, and 1,3-butadiene) composed approximately 15 to 20% of the total organic gases.

Total carbon accounted for more than 70% of the PM mass for 4 of the 5 sampled vehicles. The elemental and organic fractions varied significantly from vehicle to vehicle but showed very little fuel dependence. Inorganic species including ions and elements represented a smaller portion of the composite total, ranging from 0.2 to 3.3% of the total particulate. For each test vehicle, the EC-D had the lowest emission rates for S and SO_4^{2-} consistent with the lower sulfur levels found in this fuel. The soy-based World Energy biodiesel blend also had a tendency for higher emissions rates of elements and ions relative to the other fuels.

Total PAH emissions ranged from approximately 1.8 mg/mi to 67.8 mg/mi over the different vehicle/fuel combinations representing between 1.6 and 3.8% of the total PM mass. For 3 of the 5 vehicles, the EC-D had the lowest PAH emissions. The biodiesel blends generally had emissions comparable to or lower than the RFD fuel.

1.0 Introduction

As the impetus to reduce diesel emissions continues, the need to develop more advanced or alternative diesel fuels becomes more important. Two fuels that are being examined to meet these needs include biodiesel and ARCO Emission Control Diesel (EC-D). Biodiesel is renewable and can be produced domestically from sources such as vegetable oils, animal fats, restaurant grease, or other feedstocks. Several legislative measures have been passed promoting the increased use of biodiesel fuels, including a measure to allow fleets to meet alternative fuel vehicle acquisition requirements by using biodiesel added to conventional diesel at blends of 20% and higher. A number of studies of larger heavy-duty engines and heavy-duty vehicles have shown that biodiesel can provide emissions reductions in hydrocarbons (HC), carbon monoxide (CO) and particulate matter (PM), with some increases observed for nitrogen oxides (NO_x) (Clark et al., 1999; Graboski et al., 1996; McDonald et al., 1995; Smith et al., 1998; Starr, 1997; Sharp, 1998, Wang et al., 2000). Much of this work has focused on comparisons with Federal diesel, however, with limited studies providing comparisons with California reformulated diesel (CARB)(Clark et al., 1999; Starr, 1997).

The College of Engineering-Center for Environmental Research and Technology (CE-CERT) at the University of California, Riverside, has conducted some limited studies to evaluate biodiesel fuels in comparison with CARB diesel for light heavy-duty diesel vehicles. For this work, a comparison was made between a CARB diesel, a 100% biodiesel, an 80/20 (CARB/biodiesel) blend and a synthetic diesel for emissions performance (Durbin et al., 2000a). Chassis dynamometer tests were performed on four light heavy-duty diesel vehicles using each of the four fuels. The results of this study indicated that biodiesel and biodiesel blends generally lowered THC and CO emissions in comparison with the CARB diesel, while NO_x emissions were either not significantly different or slightly higher. PM emissions, on the other hand, were generally higher for the biodiesel fuels, in contrast to previous results.

More recently, ARCO has developed a new diesel fuel called Emission Control Diesel (EC-D). EC-D is produced from typical crude oil using conventional refining processes but is designed to have a sulfur content below 15 ppmw and lower aromatics and a higher cetane number in comparison with typical in-use fuels. The ultra-low sulfur content of the fuel provides a significant added benefit in that the fuel can be used in conjunction with sulfur-sensitive emission control devices. A more commercial version of this fuel, called EC-D1, is also available with a sulfur content below 15 ppmw, but with an aromatics content and cetane number more similar to in-use fuels.

EC-D is currently being used in an extensive demonstration program in the Southern California area with an emphasis on using the fuel in conjunction with diesel particulate filters (DPFs) (LeTavec et al., 2000). The DPFs include Johnson-Matthey's continuously regenerating technology filter (CRT^{TM}) and Engelhard's catalytic soot filter (DPX^{TM}). Tests of class 8 Ralphs grocery trucks with DPFs showed PM reductions between 91 and 97% and also significant reductions in THC and CO (Clark et al., 2000; Vertin et al., 2000). Similar results were also found in tests conducted on tanker trucks, school buses, and refuse trucks (LeTavec et al., 2000; Chatterjee et al., 2001). Emission reductions were also found for the EC-D fuel in comparison with CARB fuel. Ralphs grocery trucks operated on EC-D had average NOx emissions 15% lower than those operated on CARB fuel. These reductions could not be considered statistically significant, however, due to high vehicle-to-vehicle variability (Clark et al., 2000). For tanker trucks tested on both CARB fuel and EC-D, emissions were found to be 11% lower for NO_x and 3% lower for PM for the EC-D compared with the CARB fuel (LeTavec et al., 2000). Similarly, school buses were found to have reductions in NO_x and PM emissions of 10 and 15%, respectively, for the EC-D compared with CARB fuel (LeTavec et al., 2000). Emission reductions for EC-D in comparison with CARB fuel were also found for refuse trucks (Chatterjee et al., 2001).

The present program was designed to expand the scope of CE-CERT's previous biodiesel work and provide comparisons with EC-D for light heavy-duty diesel vehicles. This work is a follow-up of CE-CERT's previous biodiesel project (Durbin et al., 2000a) and also provides ties to CE-CERT's on-going work in testing Hertz equipment rental trucks as part of the ARCO EC-D demonstration program (LeTavec et al., 2000). For this study, the test matrix included 7 light heavy-duty diesel vehicles tested on a series of 5 fuels. The five fuels included an in-use CARB fuel, EC-D, and three 20% biodiesel blends (1 yellow grease and 2 soy-based). In addition to the regulated emissions, PM samples were collected on a 5-vehicle subset for analysis of chemical composition and PAHs. Non-methane organic gas (NMOG) speciation was also conducted for two vehicles to assess the profile of the gas-phase C_1-C_{12} hydrocarbons and carbonyls. The results and conclusions of this study are presented in the following report.

2.0 Experimental Procedures

2.1 Vehicle Recruitment

A total of 7 light heavy-duty diesel vehicles were recruited for vehicle testing. Six of these vehicles were obtained from the City of San Bernardino, CA municipal fleet. The 1983 Ford F250 is an in-house CE-CERT test vehicle. Each vehicle was inspected to establish its general condition and ensure it was safe to test before acceptance into the program. The test vehicles and their characteristics are listed in Table 1.

Table 1. Vehicle Descriptions for Test Fleet

Model Year	Make	Model	Odometer (miles)	Engine	Fuel, Air System
1993	Ford	F-350 PU	26784	7.3 liter Navistar V8	IDI, no-turbo
1990	Ford	E-350 Van	88534	7.3 liter Navistar V8	IDI, no-turbo
1990	Chevy	2500 PU	90448*	6.2 liter GM V8	IDI, no-turbo
1989	Chevy	2500 PU	140752	6.2 liter GM V8	IDI, no-turbo
1987	Chevy	C-30 PU	88170	6.2 liter GM V8	IDI, no-turbo
1985	Chevy	C-20 PU	67796	6.2 liter GM V8	IDI, no-turbo
1983	Ford	F-250 PU	74235	6.9 liter Navistar V8	IDI, no-turbo

IDI = Indirect Fuel injection, PU=pickup, * odometer non operational when tested

2.2 Test Fuels

Each vehicle was tested on a series of 5 test fuels. The test fuels were:

- An in-use California diesel fuel (CARB).
- ARCO EC-D fuel. A diesel fuel produced from conventional crude oil refining process targeted to have less than 15 ppm sulfur, less than 10% aromatics by volume, and a nominal cetane number of 60.

- A blend of 80% CARB fuel and 20% SoyGold biodiesel. The CARB fuel was the in-use fuel listed above. The SoyGold biodiesel was a soy-based biodiesel produced by Ag Processing, Inc. and distributed by Radtke & Tomberlin Distribution, Inc., Leawood, KS.
- A blend of 80% CARB fuel and 20% World Energy biodiesel. The CARB fuel was the in-use fuel listed above. The World Energy biodiesel was a soy-based biodiesel produced by Procter & Gamble and distributed by World Energy Alternatives, Cambridge, MA.
- A blend of 80% CARB fuel and 20% OXyG-B60 biodiesel. The CARB fuel was the in-use fuel listed above. The OXyG B60 was a yellow grease biodiesel produced and distributed by Southern States Power Company, Ontario, CA.

A summary of the specifications for each of the neat test fuels is provided in Table 2 with more complete fuel specifications provided in Appendix A. In this listing, several properties in particular are notable. The ARCO EC-diesel fuel has an aromatic content considerably lower than that of the in-use CARB fuel and a very low sulfur content. The biodiesel fuels have negligible aromatic and sulfur contents as neat fuels (Howell, 1999). The biodiesel blends with the CARB fuel have aromatic and sulfur contents closer to those of the CARB fuel, however. The cetane numbers are also considerably different for the fuels tested. In particular, the cetane numbers for the EC-diesel and OXyG B-60 were both greater than 60 while those of the CARB fuel and the other two biodiesel fuels were in the low 50s.

Table 2. Selected Fuel Properties

	CARB	EC-D	SoyGold	World Energy	OXyG B-60
API gravity	37.8	42.6	NA	NA	NA
Aromatics, vol. %	22.9	10.86	NA	NA	NA
PNAs, wt. %	3.7	0.9	NA	NA	NA
Cetane index	51.3				
Cetane number		63.4	52.3	52.9	61.9
Distillation, T50, ºF	508	530	NA	NA	NA
T90, ºF	620	618			
Free glycerin, mass %	NA	NA	0.002	0.001	0.002
Total glycerin, mass %	NA	NA	0.228	0.122	0.156
Sulfur, ppm	72	3	0.000%	0.000%	0.000%

Notes: NA = not available. The glycerin test is applicable to only the biodiesel fuels. Biodiesel is approximately a single boiling point compound, and thus distillation tests are not applicable. Biodiesel also includes non-aromatic compounds that interfere with the standard method for measuring aromatics. Biodiesel is expected to have negligible levels of aromatics, however.

2.3 Protocol for Vehicle Testing

All vehicles were tested over the FTP to obtain mass emission rates for total PM, THC, CO, and NO_x. THC measurements were collected using a heated sample line as specified in the Code of Federal Regulations (CFR) for diesel vehicles (§86.110-94). Vehicles were preconditioned prior to the first test on any new fuel by driving on the dynamometer over two back-to-back iterations of the LA4 driving schedule followed by an overnight soak at a temperature of approximately 72ºF. Each vehicle was tested at least twice on each of the 5 test fuels. In a few cases additional tests were conducted to verify the observed emissions trends. An opacity test was also conducted for each vehicle/fuel combination. All tests were conducted in CE-CERT's Vehicle Emission Research Laboratory (VERL) equipped with a Burke E. Porter 48-inch single-roll electric dynamometer and a 12-inch diameter tunnel for diesel vehicles.

To meet the program objectives regarding fuel effects on exhaust and PM composition, additional sampling was conducted for a subset of the FTP tests. PM samples were collected for analysis of elemental and organic carbon, trace elements and metals, and ions for 5 of the 7 test vehicles. Polyaromatic hydrocarbon (PAH) samples were also collected on these same vehicles. PM size distributions were collected for some vehicle/fuel combinations, as discussed below. On two vehicles, gas-phase samples were collected for analysis of C_1-C_4, C_4-C_{12}, and C_1-C_8 carbonyls. Analyses of C_1-C_4 hydrocarbons, C_4-C_{12} hydrocarbons, and C_1-C_8 carbonyls, and particle size distributions were done by CE-CERT. Analyses of the PAHs and PM composition were done by the Desert Research Institute (DRI), Reno, NV. Table 3 shows analyses conducted for each vehicle. The additional analyses just discussed were all performed for at least one test per fuel type.

Table 3. Sample Collection and Analysis Matrix

	FTP 3 phase			Cumulative over 3 phases	
Vehicle	**PM, gases**	**C_1-C_4, C_4-C_{12}**	**Carbonyls**	**Ions, XRF EC, OC**	**PAH**
93 Ford F-350	✓			✓	✓
90 Ford E-350	✓			✓	✓
90 Chevy 2500	✓				
89 Chevy 2500	✓	✓	✓	✓	✓
87 Chevy C-30	✓				
85 Chevy C-20	✓			✓	✓
83 Ford F-250	✓	✓	✓	✓	✓

2.4 Particulate Sample Collection

The sampling protocol for this project was designed to provide mass emissions rates, size distributions, and samples for analysis of PM composition. The dilution tunnel used for sampling was fitted with three sampling probes located approximately 130 inches downstream of the exhaust mixing flange. The sampling configuration, filter media, and analyses to be performed are summarized below:

- Probe 1 was fitted with 47 mm, 2.0 µm Gelman Teflon membrane filters using a Pierburg particle sampling system to obtain total PM mass emission rates for each phase of the FTP. Each filter assembly was fitted with a primary and a backup filter.

- Probe 2 was fitted with a two-way flow splitter that was used to collect samples for PM composition analyses for 5 of the test vehicles. For these tests, one filter holder was fitted with 47 mm, 2.0 µm Gelman Teflon membrane filters for analysis of trace elements and ions. A second filter holder was fitted with prefired Pallflex 2500 QAT-UP quartz fiber filters for organic and elemental carbon analyses, and detailed speciation of the PM PAHs. Thin stainless steel rings were placed in front of the quartz fiber filters to provide a more uniform and well defined deposit for carbon analysis. The quartz filters were backed up using a vapor-phase trap for collection of semi-volatile PAHs consisting of XAD-4 resin (polystyrene, divinylbenzene polymer) sandwiched between two polyurethane foam plugs (PUF).

- Probe 3 was fitted with a Microorifice Uniform Deposit Impactor (MOUDI) for collection of size segregated samples. For this project, MOUDI samples were collected for only a subset of the vehicle/fuel combinations due to problems with the MOUDI sampling system. A partial MOUDI was used for all sample collection runs employing the inlet for particles greater than 18.0 µm, the 10 µm, 3.2 µm, 1.8 µm, and 1.0 µm impaction stages, and the after-filter to provide size distributions for PM_{10}, $PM_{2.5}$, and $PM_{1.0}$. Although there is no specific impaction substrate for the collection of 2.5 µm PM, the mass of PM below 2.5 µm can be obtained by assuming that half of the mass collected on the 1.8 µm impaction substrate is from sub-2.5 µm PM. Uncoated aluminum foils were used for impaction substrates together with 47 µm, 2.0 µm pore size Gelman Teflon membrane after-filters.

For each test, mass emission rates were determined for each phase of the FTP. Samples for chemical analysis on quartz-fiber filters, PUF/XAD substrate, and Teflon membrane filters were collected cumulatively over the entire FTP. Chemical analyses were performed on samples from one test for each vehicle/fuel combination for the 5 test vehicles specified in Table 3. MOUDI samples were collected over only phase 2 of the FTP to prevent the MOUDI from getting overloaded with PM. All samples were collected at 20 liters per minute (lpm) with the exception of the MOUDI, which was operated at 30 lpm. All flows were measured and controlled using mass flow controllers, and all sampling is performed under isokinetic conditions using removable probe tips.

2.5 Particulate Sample Analysis

Teflon membrane filters and aluminum MOUDI substrates were weighted before and after sampling to determine the collected mass using an ATI Orion ultra-microbalance. The microbalance is located in an environmental weighing chamber maintained at a temperature of 25.3±0.6°C and a relative humidity of 44±6%. Before and at the completion of sample collection, substrates were preconditioned for at least 24 hours in the environmental chamber before weighing. Tunnel blanks were collected weekly throughout testing and used to correct the PM mass emission rates. Tunnel blanks were converted to mass emission rates based on sample flows and the length of the testing period.

The Teflon membrane filters collected from probe 2 were utilized for chemical analysis of metals and other trace elements, and sulfate, nitrate, and ammonium ions. All analyses were conducted by DRI. After sampling, filters were stored in petri dishes in a refrigerator prior to shipment to

DRI. Shipment to DRI was in a cooler with blue ice packs. Metals and other trace elements were analyzed using x-ray fluorescence (XRF). Teflon filters were extracted in a 60:40 mixture of isopropyl alcohol and distilled, deionized water for nitrate and sulfate analyses using ion chromatography. A separate extraction with distilled, deionized water was used for analysis of ammonium ions, since the isopropyl alcohol causes interference in the measurement of this ion. Ammonium ions were measured using automated colorimetry.

The quartz fiber filters collected at probe 2 were used for elemental and organic carbon analyses. Quartz fiber filters were obtained from DRI after prefiring at 900°C for three hours to reduce background carbon levels. The filters were shipped in blue ice to CE-CERT and stored in a refrigerator until used. Following sample collection, filters were stored in a freezer in petri dishes lined with aluminum foil prior to return shipment to DRI in a cooler with blue ice packs. Elemental and organic carbon analyses were performed by DRI using the Thermal Optical Reflectance (TOR) method (Chow et al., 1993). Analyses were performed on an approximately 0.516 cm^2 punch from the filter.

PAH analyses were performed on the PUF/XAD vapor-phase trap and quartz fiber filters. PUF/XAD backup cartridges were utilized to collect semi-volatile PAHs. XAD resin and PUF cartridges were obtained precleaned from DRI. The XAD resin was cleaned by washing with distilled water and methanol, followed by Soxhlet extraction for 48 hours with methanol. The XAD was then drained and Soxhlet extracted for an additional 48 hours with dichloromethane (CH_2Cl_2). The resin was dried in a vacuum oven at 50°C. A second Soxhlet extraction was then performed with dichloromethane for 48 hours. PUF cartridges were cleaned by first washing with distilled water, followed by Soxhlet extraction in acetone for 48 hours, followed by Soxhlet extraction for 48 hours in 10% diethyl ether in hexane. The extracted PUFs were then dried in a vacuum oven at 50°C for approximately 3 days. XAD resin and PUF cartridges were stored in a freezer before sampling and after sampling prior to return to DRI. XAD and PUF filters were shipped to CE-CERT from DRI, and from CE-CERT back to DRI in a cooler with blue ice.

For the sample analysis, the PUF plugs were Soxhlet extracted with 10% diethyl ether in hexane, while the filters and XAD resin were microwave extracted with dichloromethane. The combined extract was then reduced to a volume of ~1 ml by rotary evaporation and analyzed by gas chromatograph/mass spectrometer (GC/MS) in selected ion monitoring mode.

2.6 Detailed NMOG Speciation Sampling and Analysis

Detailed NMOG speciation measurements were made for the 1989 Chevrolet 2500 pickup and the 1983 Ford F-250 pickup for each fuel type. These measurements included bag hydrocarbon speciation measurements for C_1-C_{12} and carbonyl measurements. Samples for the C_1-C_{12} HC speciation were collected in 8 liter black Tedlar GC bags. Hydrocarbon speciation analyses for C_1-C_{12} were conducted utilizing the protocols developing during Auto/Oil Phase 2 (Siegl et al., 1993). Light hydrocarbons (C_1 through C_4) were measured using a Hewlett-Packard (HP) 5890 Series II GC with a flame ionization detector (FID) maintained at 250°C. A 15 m x 0.53 mm polyethylene glycol pre-column and a 50 m x 0.53 mm aluminum oxide “S” deactivation porous layer open tubular (PLOT) column were used. A 5-ml stainless steel sample loop was conditioned with the sample prior to analysis. A second HP 5890 Series II GC with a FID maintained at 300°C was used to measure the C_4 to C_{12} hydrocarbons. A 2 m x 0.32 mm deactivated fused silica pre-column and a 60 m x 0.32 mm HP-1 column was used. A 5-ml stainless steel sample loop was conditioned with the sample from the GC bag prior to analysis. Analyses were completed within four hours of sample collection.

Dilute exhaust gas aldehydes and ketones were collected through a heated line (190°C) onto dinitrophenyl-hydrazine (DNPH)-coated silica gel cartridges. The DNPH cartridges were analyzed by high performance liquid chromatography (HPLC).

2.7 Opacity Testing

Opacity tests were conducted on each vehicle for each of the test fuels and with the fuel in the tank at the time the vehicle was received. Opacity tests were performed with a Wager (MDL 6500) smoke meter using the Snap and Idle procedure. This smoke meter is compliant with the SAE J1667 standard for Snap and Idle testing in California. Testing was conducted with the vehicles warmed up to their operational temperature. In accordance with the SAE J1667 protocol, each vehicle was given three “clean out” engine accelerations to the maximum governed engine revolutions per minute (RPM) for approximately 3 seconds followed by a return to idle. Tests were then conducted by placing the sensor head across the exhaust stream, accelerating the engine to the maximum governed RPM for approximately 3 seconds and returning it to idle. This procedure was repeated for two additional Snap and Idle sequences. Criteria for test acceptance was a span deviation of less than 5%.

3.0 Emissions Test Results

3.1 Mass Emission Results

The FTP weighted gaseous and PM mass emission rates for each vehicle/fuel combination are presented in Figures 1-4. These data represent the average of all tests conducted for each vehicle/fuel combination. The error bars in Figures 1-4 were calculated from the replicate tests for each vehicle/fuel combination as 2 times the standard deviation of the mean. It should be noted that the THC and PM emissions for the 1993 Ford F350 are divided by a factor of five in Figures 1 and 3, respectively, to allow the details in the emissions changes for the lower emitting vehicles to be more clearly presented. Complete FTP data for each vehicle and fuel are presented in Appendix B.

The strongest fuel effect was observed for THC and CO emissions, as shown in Figures 1 and 2. Specifically, the EC-D and OXyG B-60 biodiesel blend both showed significant reductions in these emissions for most of the test vehicles. THC emission reductions for EC-D compared with CARB fuel were found for 6 of the 7 test vehicles with reductions ranging from 32 to 56%. THC emissions for EC-D and CARB fuel comparable for the 1990 Ford E350. Five of the 7 vehicles showed THC emission reductions for the OXyG B-60 biodiesel blend ranging from 21 to 66% compared with the CARB fuel. In most of these cases, the magnitude of these changes were greater than the experimental error. Significant reductions in THC emissions were found for the soy-based biodiesel fuels compared with the CARB fuel for the 1993 Ford F350 (the vehicle with the highest THC emissions) and the 1990 Chevrolet 2500. On the other hand, THC emissions were slightly higher for the soy-based biodiesel blend for the 1987 Chevrolet C-30 and the 1989 Chevrolet 2500. THC emissions for the soy-based biodiesel blends for the other test vehicles were comparable with those of the baseline CARB fuel.

CO emissions reductions were also relatively dramatic for the EC-D and OXyG B-60 fuel with reductions relative to the CARB fuel ranging from 12 to 41% for the EC-D and from 0 to 46% for the OXyG B-60. Again, these reductions were greater than the experimental error in most cases. CO emissions for the soy-based biodiesel fuels were lower compared with the CARB fuel for the 1993 Ford F350 and 1990 Chevy 2500. For the other test vehicles, however, CO emissions were comparable with those of the CARB fuel.

Regarding THC and CO emissions, several other points are worth mentioning. The fuels with the best emissions for THC and CO (EC-D and OXy-G B-60) both had cetane numbers greater than 60 while the other fuels had cetane numbers in the low 50s. It should also be noted that the OXyG B-60 fuel is present in only a 20% blend, as opposed to EC-D, which is a neat fuel. Thus, if higher blend ratios of OXyG B-60 were used, it is possible that even greater reductions in these emissions might also be achieved.

Some fuel effects were also observed for PM emission rates. The EC-D fuel showed the most significant reductions in PM emission rates. The largest and most significant PM reductions for EC-D were observed for the 1987 Chevy C-30 and the 1993 Ford F350, which were 30% and 43% compared with the CARB fuel, respectively. The remaining vehicles showed reductions in the 5 to 20% range for EC-D with some of the differences within the experimental error. The OXyG B-60 showed some promise in reducing PM emissions for the highest emitting vehicle, the 1993 Ford F350, and the 1983 Ford F250, although the latter results were not statistically significant. PM emissions over the remaining vehicles were overall comparable with those of the CARB fuel. The soy-based biodiesel blends had higher PM emissions rates than the CARB fuel for 4 of the 7 vehicles, with roughly comparable PM emission rates for the remaining three vehicles. This is consistent with the results of our previous study on light heavy-duty diesel vehicles that showed a tendency for higher PM emissions with the soy-based biodiesel blends (Durbin et al., 2000a). It is worth noting that studies of heavier duty diesel engines in different testing configurations, i.e., engine dynamometer and opacity testing, have indicated opposite trends with PM emissions being reduced with biodiesel fuels (Clark et al., 1999; Durbin et al., 2000b; Graboski et al., 1996; McDonald et al., 1995; Smith et al., 1998; Starr, 1997; Sharp, 1998, Wang et al., 2000). Additional testing is probably needed to determine the nature of these discrepancies, which could include differences in the duty cycle for the light heavy-duty diesel vehicles.

NO_x emissions were comparable for the different fuel types over the range of vehicles tested. The 1990 Ford E350 showed the most significant differences between different fuel types, with EC-D and OXy-G B-60 NO_x emissions being lower than those for the other fuels. For this vehicle, the CARB fuel was tested over two testing periods, leading to the relatively large error bars. For some vehicles, the biodiesel fuels also showed some slight increases in NO_x although these increases were generally within the experimental error. It should be noted that other studies have shown that biodiesel blends can increase NO_x (Clark et al., 1999; Durbin et al., 2000a; Graboski et al., 1996; McDonald et al., 1995; Smith et al., 1998; Starr, 1997; Sharp, 1998, Wang et al., 2000). Although some increases were observed for 100% biodiesel in our previous work, no differences were observed for the B20 blends (Durbin et al., 2000a).

Figure 1. FTP THC Emissions

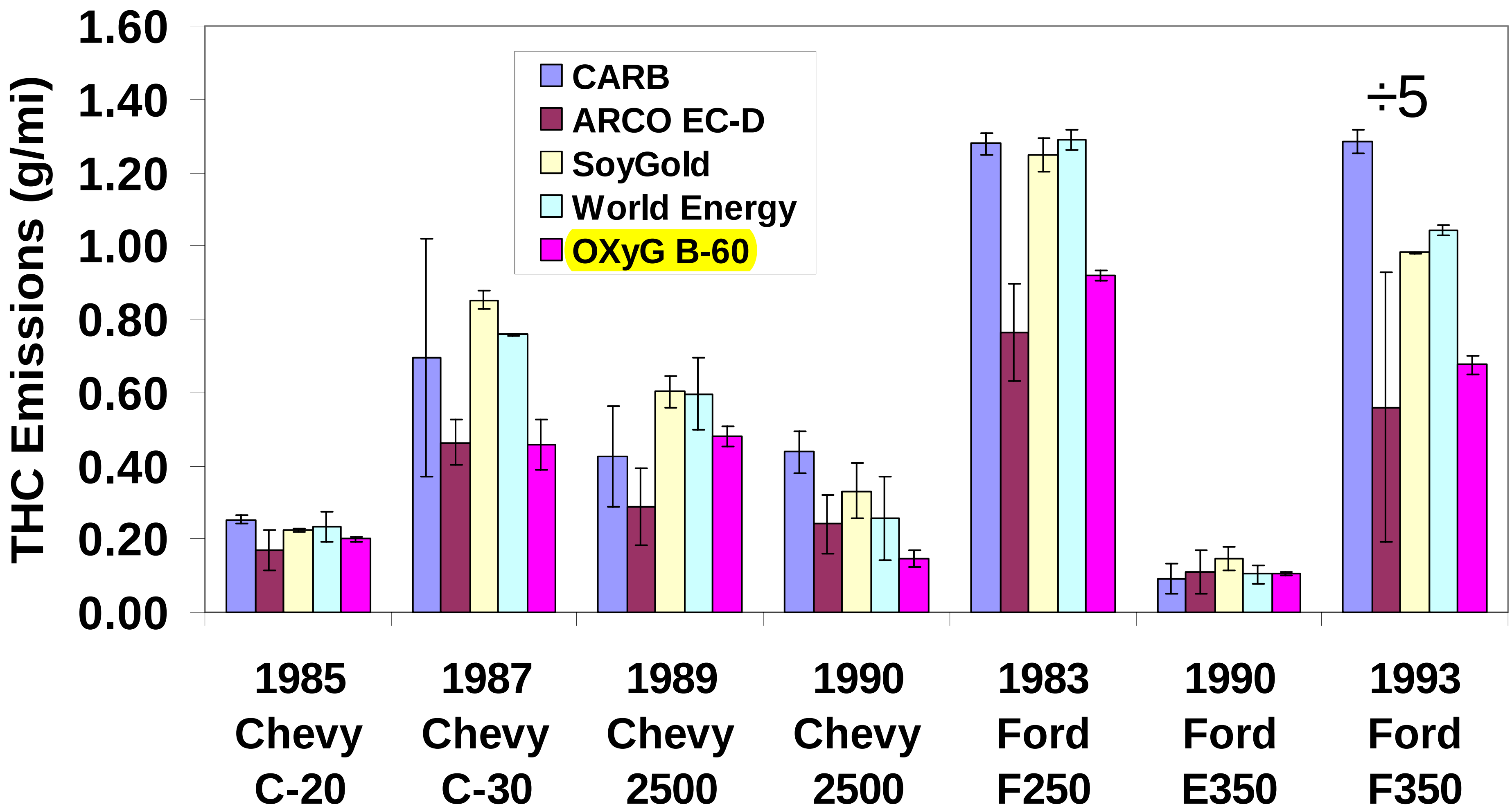


Figure 2. FTP CO Emissions

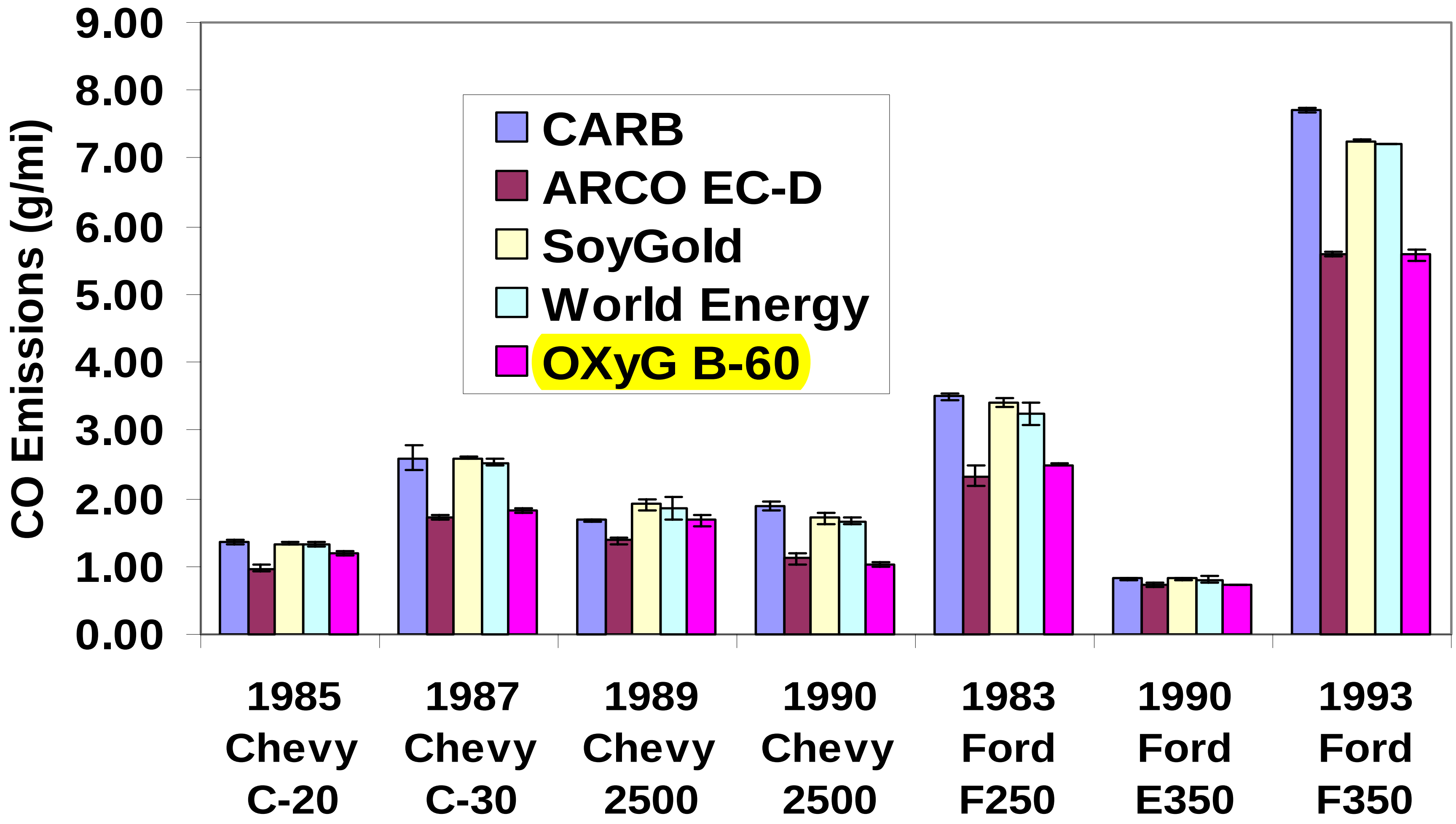


Figure 3. FTP PM Emissions

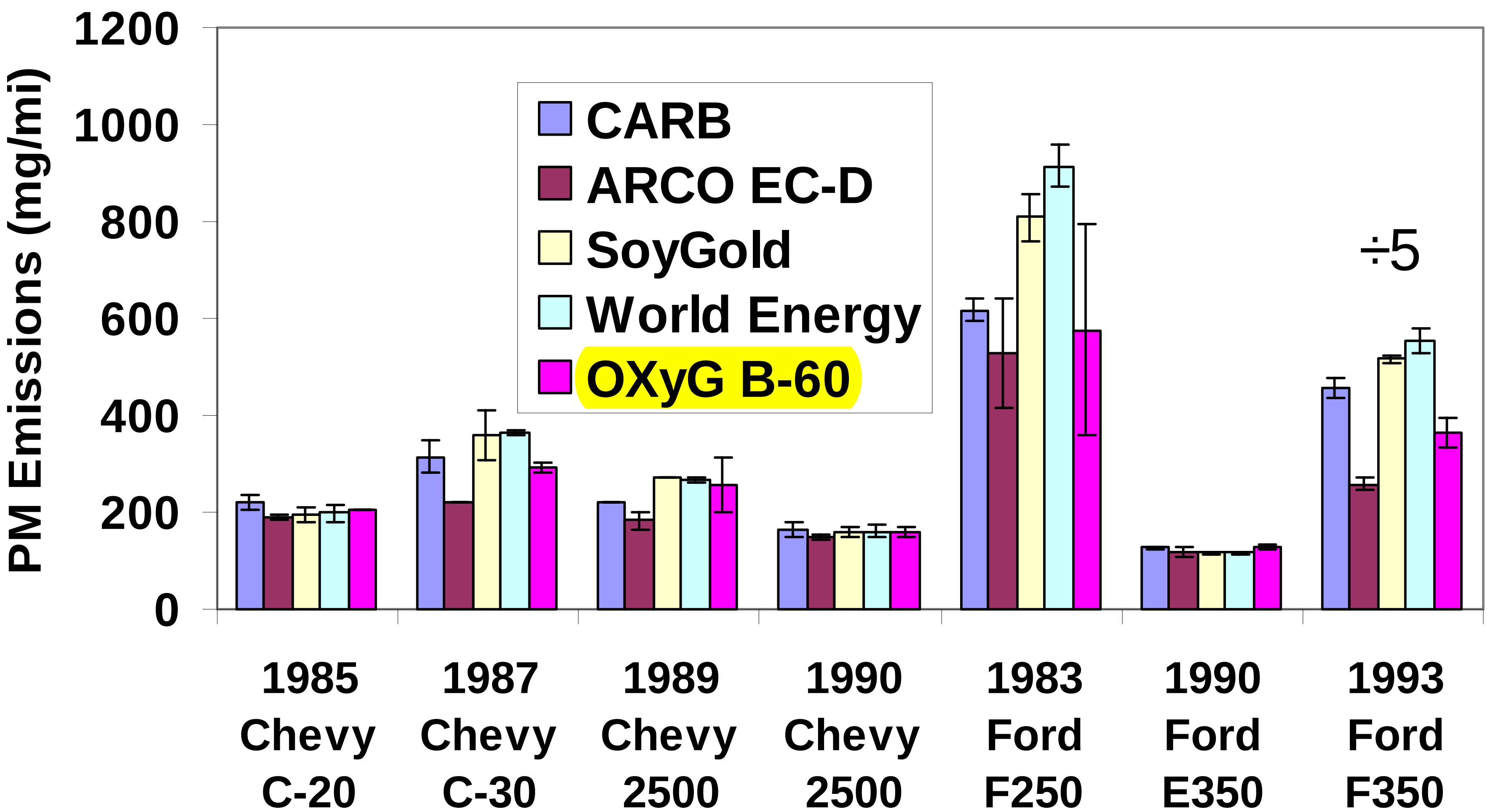
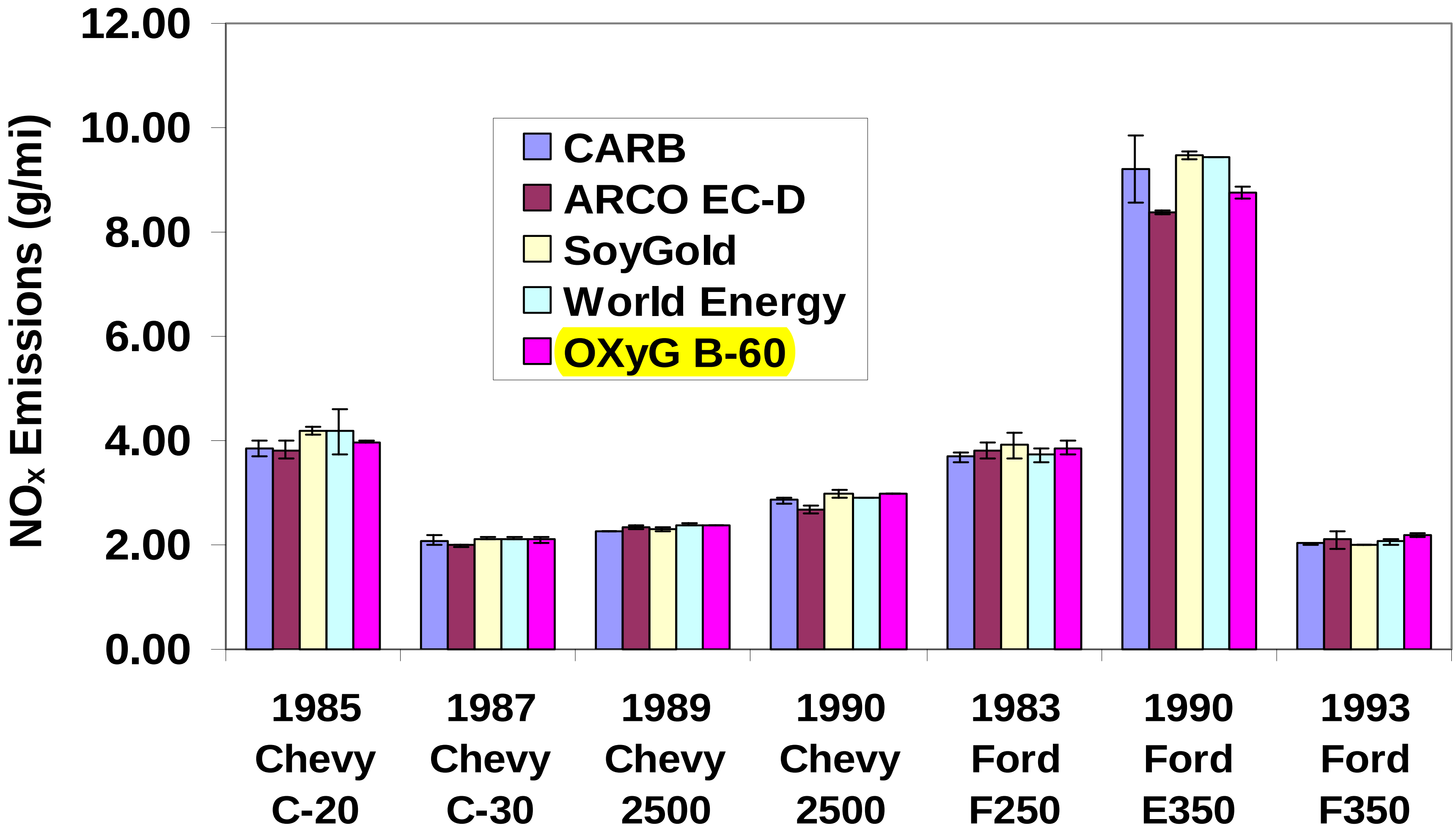


Figure 4. FTP NO_x Emissions



3.2 Hydrocarbon Speciation Results

Figures 5 and 6, respectively, summarize the detailed non-methane organic gas (NMOG) speciation results by compound class for the 1989 Chevy 2500 and the 1983 Ford F250. Note that data for the World Energy Blend was not available for the 1989 Chevy 2500. These results are presented in terms of percent of NMOG found for the quantified C_1 to C_{12} species. It should be noted that previous studies have shown that hydrocarbon species profiles for diesel vehicles extend considerably beyond the C_1 to C_{12} species typically measured for gasoline vehicles (Hammerle et al., 1995; Sagebiel et al., 1996; Schauer et al., 1999). This is primarily due to the fact that diesel fuel contains a wider range of hydrocarbon species than gasoline extending well beyond C_{12} hydrocarbons. As such, it is important to point out the C_1-C_{12} NMOG results presented here represent only a portion of the total NMOG. Overall, the C_1-C_{12} NMOG represented about 40 to 60% of the total NMOG.

The species profiles show that alkenes and carbonyls were the most significant compound classes for the C_1-C_{12} NMOG. The alkenes represented about 35-45% of the C_1-C_{12} NMOG for 1989 Chevy 2500 and about 30% of the NMOG for the 1983 Ford F250. The carbonyls represented about 20-30% of the C_1-C_{12} NMOG for the 1989 Chevy 2500 and about 35-40% of the C_1-C_{12} NMOG for the 1983 Ford F250. Alkanes represented about 5% of the C_1-C_{12} mass for both vehicles while the alkynes and aromatics represented 5-10% of the C_1-C_{12} NMOG between the 2 vehicles. Overall, there were no trends in the distribution of compound classes that were consistent over both sampled vehicles.

Breakdowns of the NMOG emissions by carbon number for the 1989 Chevy 2500 and the 1983 Ford F250 are presented in Figures 7 and 8, respectively. The distributions show that C_2 NMOG species represented the most significant portion of the mass for both vehicles. C_1, C_3, C_4 and C_6 species also make an important contribution to the total NMOG distribution. As discussed above, it is anticipated that NMOG species above C_{12} would also make an important contribution to the total NMOG although these species are not included here.

The emissions of some of the more prominent species are presented in Figure 9 for both vehicles. These breakdowns show that C_2 compounds are among the most significant and include ethane, ethyne, and acetaldehyde. Formaldehyde was another one of the more significant compounds. The four primary motor vehicle toxic air contaminants (formaldehyde, acetaldehyde, benzene, and 1,3-butadiene) represented approximately 15 to 20% of the total NMOG.

Figure 5. Organic Gas Emissions by Compound Class for the 1989 Chevy 2500

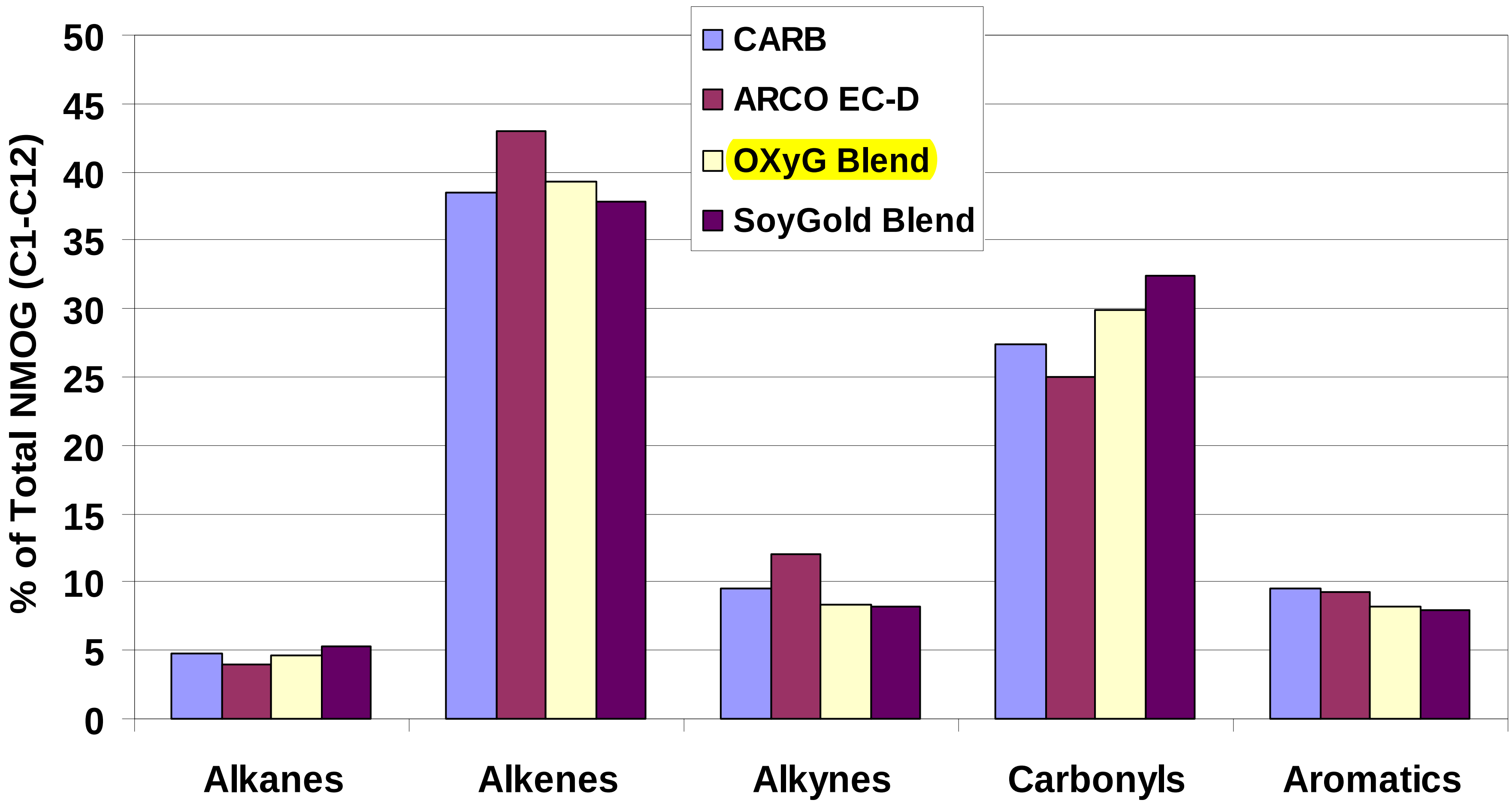
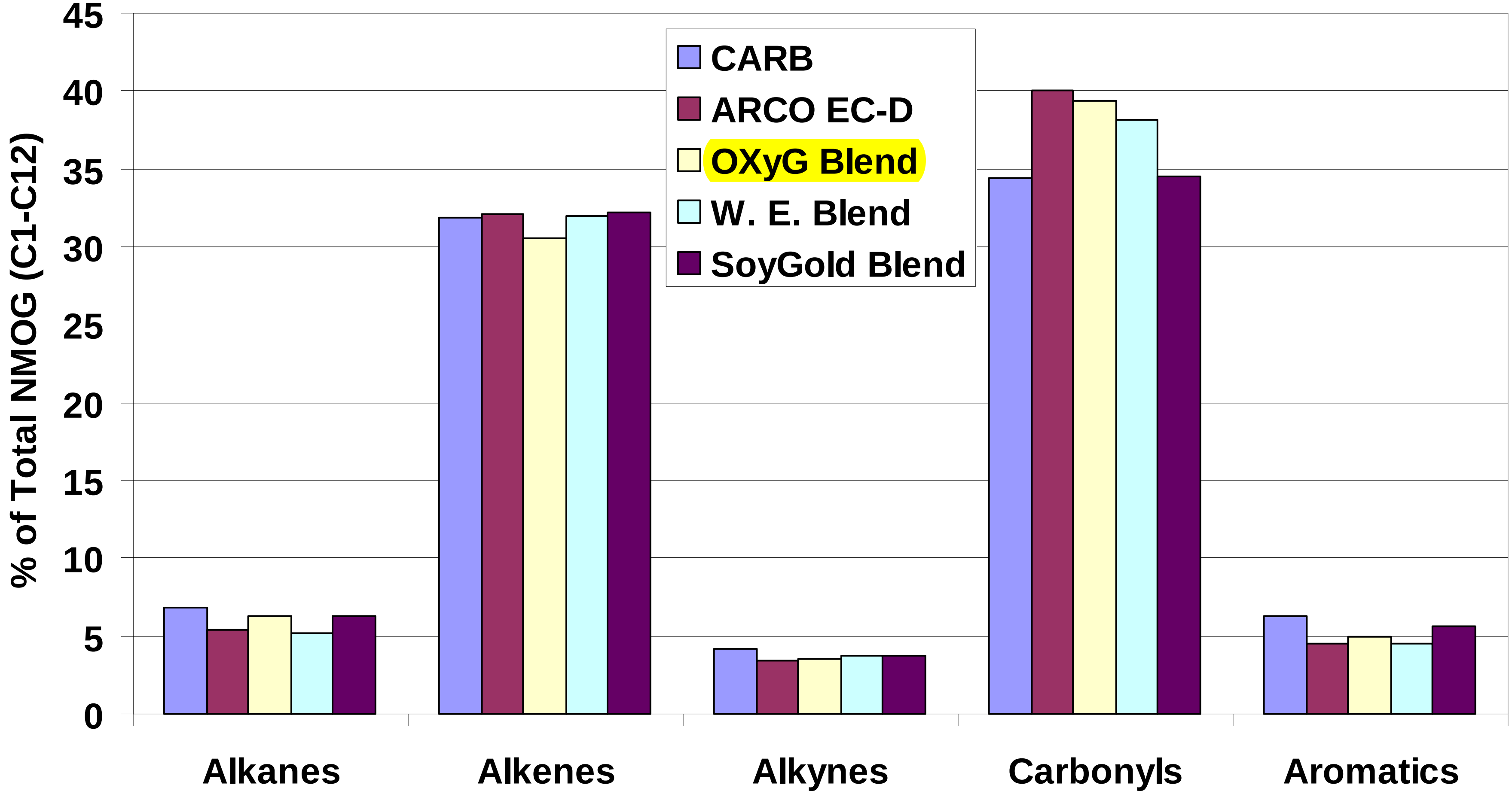


Figure 6. Organic Gas Emissions by Compound Class for the 1983 Ford F250



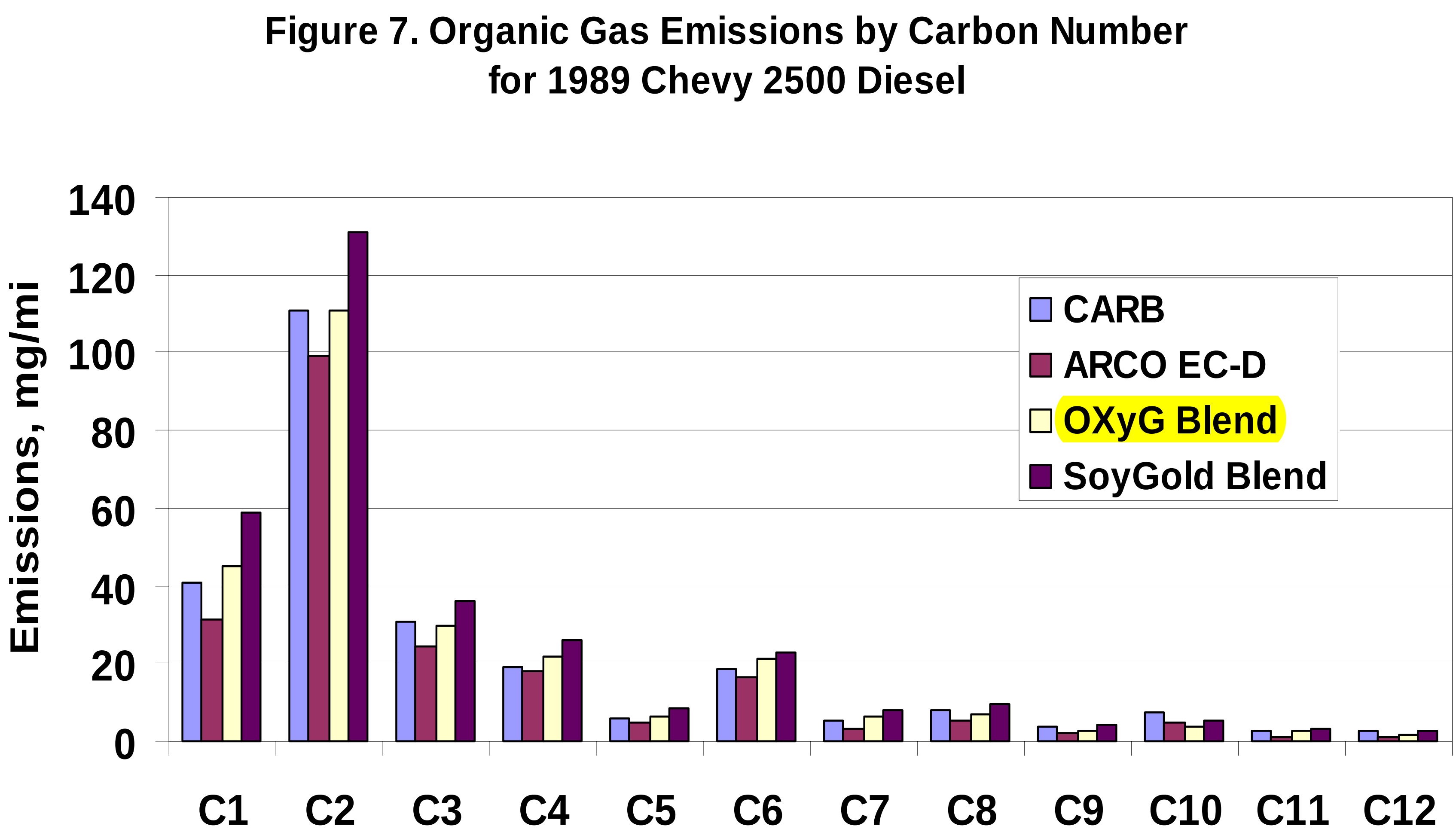


Figure 7. Organic Gas Emissions by Carbon Number
for 1989 Chevy 2500 Diesel
Emissions, mg/mi
140
120
100
80
60
40
20
0
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
CARB
ARCO EC-D
OXyG Blend
SoyGold Blend

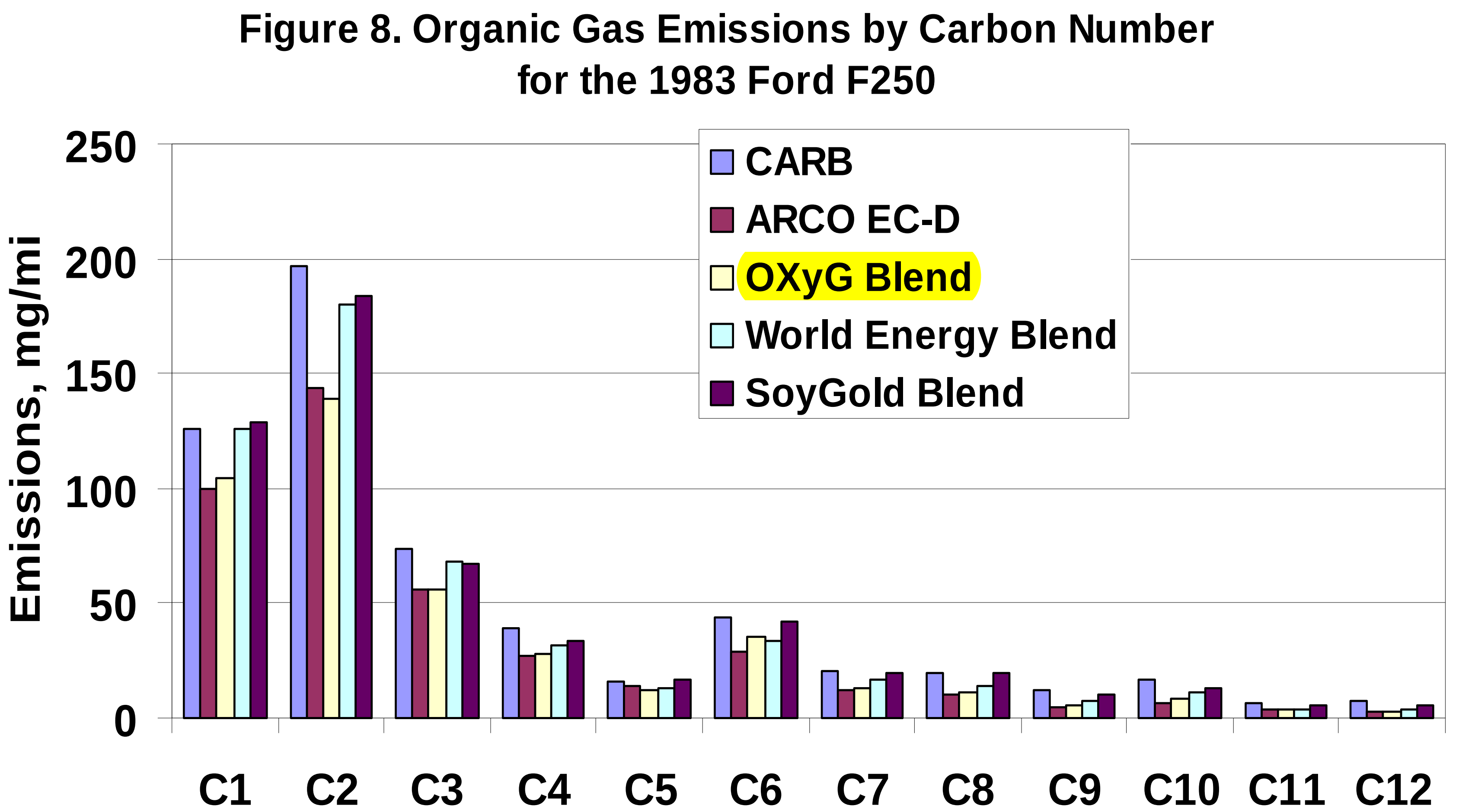
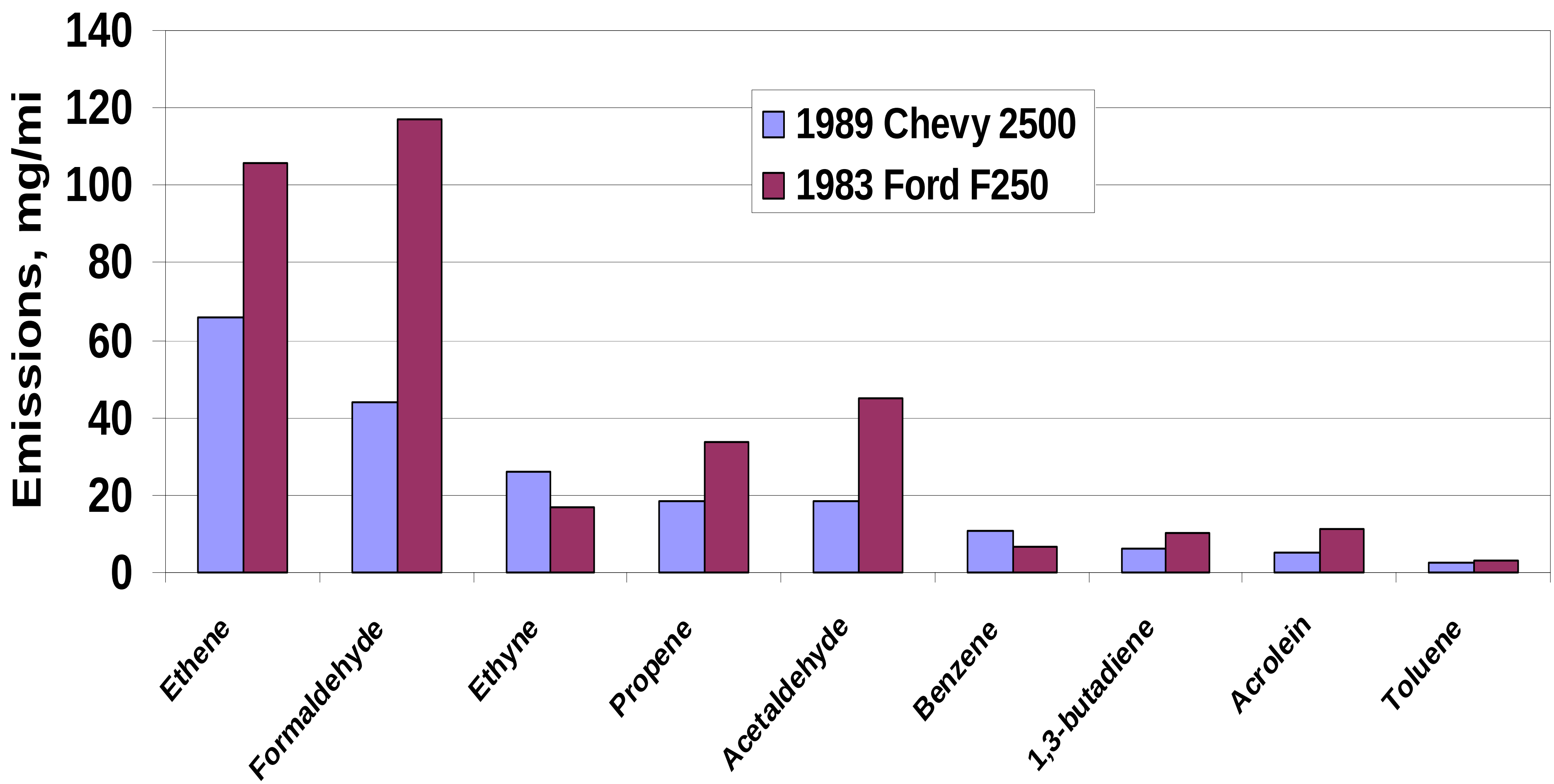


Figure 8. Organic Gas Emissions by Carbon Number
for the 1983 Ford F250
Emissions, mg/mi
0
50
100
150
200
250
CARB
ARCO EC-D
OXyG Blend
World Energy Blend
SoyGold Blend
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12

Figure 9. Important Species of Organic Gas Emissions



3.3 PM Size Distributions

The percentage of PM mass <10 µm, <2.5 µm, and <1.0 µm is presented in Table 4 for each vehicle/fuel combination for which a sample was collected. As discussed above, MOUDI samples were collected for only a subset of the vehicle/fuel combinations due to problems with the sampling system. The results show that the size distributions in these categories are similar for different vehicle/fuel combinations. In particular, over 95% of the mass is below 1 µm in diameter for all vehicle/fuel combinations. These results are consistent with previous MOUDI results for the diesel vehicles and alternative diesel fuels (Durbin, et al. 2000a).

Table 4. PM Mass Size Distribution

		Size Cut		
Vehicle	**Fuel**	**<10.0 µm**	**<2.5 µm**	**<1.0 µm**
1987 Chevy C-30	CARB	100.0%	99.2%	97.5%
	EC-D	100.0%	99.7%	98.1%
	SoyGold	100.0%	99.7%	98.0%
	World Energy	100.0%	99.6%	97.5%
	OXyG B-60	99.5%	99.2%	97.7%
Average		99.9%	99.5%	97.8%
1990 Chevy 2500	CARB	99.3%	99.3%	98.1%
	EC-D	99.6%	99.6%	99.4%
	SoyGold	99.6%	99.4%	97.7%
	World Energy	99.5%	98.1%	94.9%
	OXyG B-60	99.8%	99.0%	95.8%
Average		99.6%	99.1%	97.2%
1985 Chevy C-20	CARB	98.8%	98.7%	96.0%
	EC-D	98.9%	98.9%	97.5%
	World Energy	99.4%	99.2%	97.4%
	OXyG B-60	100.0%	99.7%	98.5%
Average		99.3%	99.1%	97.3%
1989 Chevy 2500	CARB	100.0%	99.7%	98.8%
	EC-D	100.0%	100.0%	99.8%
	World Energy	99.4%	99.0%	97.9%
Average		99.8%	99.6%	98.8%

3.4 Opacity Test Results

Opacity test results for each of the vehicles are presented in Table 5. Results are presented for each of the test fuels and for most vehicles for the fuel that was in the fuel tank when it arrived. The opacity measurements for each of the vehicles were relatively low. Given the relatively low opacity readings and the variability of the measurements, it is difficult to identify any consistent fuel trends in opacity. In particular, it should noted that the opacity readings for each vehicle/fuel combination were only collected for a single day. Hence, differences in opacity readings reflect day-to-day as well as fuel differences. The differences between the in-tank fuel and the CARB test fuel (supposedly equivalent fuels) indicate that the day to day variability could be relatively large compared to the fuel differences observed here. Three vehicles showed reductions with each of the alternative diesel fuels, the 1990 Chevrolet 2500, the 1990 Ford E350, and the 1993 Ford F350. Two of these vehicles, however, showed little to no change in FTP PM emissions. PM composition for specific test vehicles was also relatively unchanged between different test fuels (see section 4.1). The EC-D opacity values are lower than those for the CARB fuel for 4 test vehicles, but again two of these vehicles showed little change in FTP PM emission rates with different fuels. Overall, the opacity results did not show significant trends with regard to fuel differences. It is suggested that additional data on vehicles with higher opacity emissions are needed to evaluate the impact of these fuels on opacity. In this regard, previous studies have shown that consistent reductions in opacity for higher emitters on B20 and B30 blends for RFD and SoyGold (Durbin et al., 2000b).

Table 5. Opacity Test Results

	In-Tank	CARB	EC-D	B20 SoyGold	B20 World En.	B20 OXyG
1985 Chevy C-20	6.1 (0.7)	6.5 (1.0)	7.0 (0.7)	6.0 (2.4)	7.2 (3.8)	8.8 (0.4)
1987 Chevy C-30	NA	4.1 (0.9)	2.2 (1.2)	5.1 (0.9)	7.9 (1.8)	7.3 (0.9)
1989 Chevy 2500	14.8 (6.6)	8.2 (0.9)	8.6 (2.6)	8.2 (2.8)	9.4 (2.3)	9.2 (2.5)
1990 Chevy 2500	NA	4.0 (1.2)	1.8 (0.5)	1.2 (0.7)	2.2 (1.4)	2.7 (0.7)
1983 Ford F250	12.1 (0.6)	6.3 (0.2)	6.3 (0.3)	5.7 (0.5)	6.4 (0.3)	6.6 (1.0)
1990 Ford E350	10.2 (2.4)	5.7 (0.9)	3.7 (1.0)	3.8 (0.4)	3.2 (0.6)	3.6 (0.2)
1993 Ford F350	5.4 (2.5)	8.6 (3.7)	1.8 (0.1)	4.1 (0.1)	2.9 (1.4)	2.0 (0.2)

Note: Standard deviation is presented in ()

4.0 Particulate Chemical Analysis Results

4.1 Particulate Chemical Species

For the 5 vehicles specified in Table 3, chemical analyses of the PM were performed on one test for each vehicle/fuel combination to determine emissions for elemental and organic carbon, ions, and trace elements. The mass emissions results for each of the tests are presented in Table 6. The mass emission rates for individual chemical species are corrected for the contribution of trace components found in tunnel blanks. The full results including measurement uncertainties are presented in Appendix C. The measurement errors are calculated by propagating the uncertainty for the chemical analysis and sampling volumes. Chemical components whose concentrations are at least twice the analytical uncertainty are shown in bold.

Table 7 gives the fractions of total carbon, inorganic compounds, and PAHs as percentage of total PM, and gives elemental carbon and organic carbon as a percentage of total carbon. Note since the chemical analysis samples were collected cumulatively over the FTP, these percentages are based on cumulative PM mass over the entire FTP rather than FTP weighted values. The results show that elemental and organic carbon are the primary constituents for diesel PM, consistent with the observations of other researchers (Hildemann et al., 1991; Watson et al., 1994; Durbin et al, 1999; Cadle et al., 1998; Whitney, 1998). Total carbon accounted for more than 70% of the PM mass for 4 of the 5 test vehicles. The elemental and organic fractions varied significantly from vehicle to vehicle but showed very little fuel dependence. The vehicles with the highest PM mass emission rates also showed the largest percentage of organic carbon relative to elemental carbon. The EC-D fuel had the highest percentage of elemental carbon for 4 of the 5 vehicles, but these differences were very small for all but one vehicle. The other fuels showed no significant trends over the 5 vehicles.

Inorganic species including ions and elements represented a smaller portion of the composite total, ranging from 0.2 to 3.3% of the total particulate. All inorganic species had emission rates of less than 1 mg/mi for each test vehicle, with the only species with average emission rates of

Table 6. PM Emission Rates for Chemical Species (mg/mi)

vehicle	1989 Chevy 2500					1993 Ford F350					1990 Ford E350				
fuel	CARB	EC-D	OXy-G	SoyGold	World Energy	CARB	EC-D	OXy-G	SoyGold	World Energy	CARB	EC-D	OXy-G	SoyGold	World Energy
Organic C	176.0	110.9	153.9	201.0	192.6	1167.1	627.8	961.4	1211.2	1513.9	96.4	74.3	89.8	77.1	70.8
Elemental C	29.4	70.5	43.7	31.5	40.3	71.5	40.4	58.1	63.5	54.2	25.5	41.9	33.2	35.0	36.5
Total C	205.4	181.4	197.6	232.5	232.9	1238.6	668.2	1019.5	1274.7	1568.1	121.9	116.1	123.0	112.2	107.3
Cl^-	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.2
NO_3-	0.2	0.3	0.2	0.2	0.8	0.4	0.4	0.3	0.4	0.6	0.3	0.4	0.3	0.3	1.2
SO_4^{2-}	0.4	0.3	0.4	0.5	1.0	0.5	0.5	0.5	0.6	1.1	0.7	0.4	0.8	0.9	1.5
NH_{4+}	0.3	0.2	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3
Mg	0.0	0.0	0.1	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3
Si	0.5	0.6	0.5	0.4	0.5	0.2	0.3	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2
P	0.1	0.1	0.1	0.1	0.6	0.1	0.1	0.1	0.1	0.4	0.2	0.3	0.2	0.2	0.7
S	0.4	0.3	0.4	0.4	0.6	0.6	0.4	0.6	0.5	0.6	0.4	0.3	0.4	0.4	0.5
Cl	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.2
Ca	0.1	0.2	0.2	0.2	1.5	0.3	0.2	0.3	0.3	1.2	0.4	0.5	0.4	0.5	1.9
Fe	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.0	0.1	0.0	0.0	0.1	0.0	0.1
Zn	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.3	0.2	0.4	0.5	0.4	0.4	0.4
Pb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0

vehicle	1985 Chevy C-20					1983 Ford F250				
fuel	CARB	EC-D	OXy-G	SoyGold	World Energy	CARB	EC-D	OXy-G	SoyGold	World Energy
Organic C	91.5	75.6	80.0	76.9	88.1	505.3	379.1	466.4	584.7	634.2
Elemental C	105.3	86.3	116.9	88.0	84.0	41.7	36.3	40.3	33.3	32.2
Total C	196.8	161.9	196.9	164.9	172.1	547.0	415.4	506.6	618.1	666.4
Cl^-	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1
NO_3-	0.2	0.1	0.3	0.2	0.8	0.5	0.7	0.7	0.8	1.4
SO_4^{2-}	0.4	0.1	0.4	0.4	0.8	1.4	0.9	1.2	1.3	2.0
NH_{4+}	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3
Mg	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.1	0.0	0.1
Si	0.5	0.4	0.5	0.4	0.4	0.2	0.1	0.1	0.1	0.2
P	0.1	0.1	0.1	0.1	0.6	0.5	0.6	0.5	0.6	0.8
S	0.3	0.2	0.4	0.4	0.5	1.0	0.8	0.9	1.1	1.1
Cl	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
Ca	0.1	0.1	0.1	0.2	1.4	1.6	1.6	1.7	1.8	2.8
Fe	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2
Zn	0.2	0.2	0.2	0.2	0.2	1.1	1.1	1.1	1.3	1.4

Table 7. Particle Mass Fractions

Vehicle	Fuel	FTP PM mg/mi	OC % of TC	EC % of TC	TC % of PM	Elements +Ions % of PM	Total PAH % of PM
1993 Ford F350	CARB	2281.7	94.2	5.8	55.2	0.1	3.0%
1993 Ford F350	EC-D	1291.9	94.0	6.0	55.6	0.2	1.3%
1993 Ford F350	OXy-G blend	1830.2	94.3	5.7	61.4	0.2	1.7%
1993 Ford F350	SoyGold blend	2578.1	95.0	5.0	51.0	0.1	1.9%
1993 Ford F350	W.E.blend	2773.4	96.5	3.5	56.9	0.2	0.8%
	Average	**2151.1**	**94.8%**	**5.2%**	**56.0%**	**0.2%**	**1.8%**
1990 Ford E350	CARB	126.6	79.0	21.0	92.0	2.4	3.7%
1990 Ford E350	EC-D	118.8	64.0	36.0	91.2	2.4	2.3%
1990 Ford E350	OXy-G blend	127.8	73.0	27.0	93.0	2.5	1.4%
1990 Ford E350	SoyGold blend	116.7	68.8	31.2	91.7	2.8	2.7%
1990 Ford E350	W.E.blend	116.1	66.0	34.0	91.8	6.3	3.6%
	Average	**121.2**	**70.2%**	**29.8%**	**91.9%**	**3.3%**	**2.7%**
1989 Chevy 2500	CARB	221.1	85.7	14.3	78.9	0.9	4.8%
1989 Chevy 2500	EC-D	182.1	61.1	38.9	82.3	1.1	4.9%
1989 Chevy 2500	OXy-G blend	256.3	77.9	22.1	74.5	0.9	4.5%
1989 Chevy 2500	SoyGold blend	271.8	86.4	13.6	73.0	0.9	4.0%
1989 Chevy 2500	W.E.blend	268.1	82.7	17.3	74.0	1.9	0.9%
	Average	**239.9**	**78.8%**	**21.2%**	**76.5%**	**1.1%**	**3.8%**
1985 Chevy C-20	CARB	220.6	46.5	53.5	91.8	1.0	2.9%
1985 Chevy C-20	EC-D	188.9	46.7	53.3	84.4	0.7	1.5%
1985 Chevy C-20	OXy-G blend	206.4	40.6	59.4	93.2	1.2	3.9%
1985 Chevy C-20	SoyGold blend	193.9	46.6	53.4	84.2	1.1	2.2%
1985 Chevy C-20	W.E.blend	197.5	51.2	48.8	87.7	2.7	2.5%
	Average	**201.5**	**46.3%**	**53.7%**	**88.3%**	**1.3%**	**2.6%**
1983 Ford F250	CARB	616.5	92.4	7.6	72.6	0.9	2.1%
1983 Ford F250	EC-D	526.7	91.3	8.7	76.7	1.2	0.9%
1983 Ford F250	OXy-G blend	575.3	92.1	7.9	92.1	1.2	
1983 Ford F250	SoyGold blend	808.1	94.6	5.4	61.8	0.7	2.0%
1983 Ford F250	W.E.blend	915.4	95.2	4.8	62.0	1.0	1.5%
	Average	**688.4**	**93.1%**	**6.9%**	**73.0%**	**1.0%**	**1.6%**

greater than 0.1 mg/mi for each of the test vehicles being SO_4^{2-}, NH_4^+, Mg, Si, P, S, Cl, Ca, and Zn. The 1990 Ford E350 had the highest emission rate for elements and ions on a percentage basis while the 1983 Ford F250 had the highest emission rates for elements and ions on a mg/mi basis. Interestingly, the 1993 Ford F350 with the highest emission rate for total PM had relatively low emissions of PM elements and ions. For each test vehicle, EC-D had the lowest emission rates for S and SO_4^{2-}, consistent with the lower sulfur levels found in this fuel. The World Energy biodiesel blend also had a tendency for higher emissions rates of elements and ions relative to the other fuels, with element and ion emission rates more than twice those of the other fuels for 3 of the 5 vehicles sampled.

4.2 PAH Emission Results

PAH emissions are presented in Table 8 for each of the 5 test vehicles. This table includes nearly 40 of the PAHs with the highest emission rates averaged over the 5 vehicles. A more complete listing of the PAH species is provided in Appendix D.

Total PAH emissions ranged from approximately 1.8 mg/mi to 67.8 mg/mi over the different vehicle/fuel combinations. PAHs represented between 1.6 and 3.8% of the total PM mass over the 5 vehicles. For 3 of the 5 vehicles, EC-D had the lowest PAH emissions. This is consistent with the lower PAH content of EC-D relative to the RFD. For the other two vehicles, the World Energy biodiesel blend and OXy-G B-60 biodiesel blend had the lowest emissions, although EC-D had the second-lowest emissions. The biodiesel blends generally had emissions comparable to or lower than the CARB fuel, although for two vehicle/fuel combinations a biodiesel blend had higher PAH emissions than the CARB fuel.

Naphthalene, 1-methylnaphthalene, 2-methylnaphthalene were the three most significant PAH species averaged over all five vehicles. Other PAHs present at levels greater than twice the standard deviations included biphenyl, methylbiphenyls, dimethylnaphthalenes, and trimethylnaphthalenes.

Table 8. PAH Emission Rates (mg/mi)

vehicle	1989 Chevy 2500					1993 Ford F350					1990 Ford E350				
fuel	CARB	EC-D	OXy-G	SoyGold	World Energy	CARB	EC-D	OXy-G	SoyGold	World Energy	CARB	EC-D	OXy-G	SoyGold	World Energy
Total PAHs	**12.43**	**10.89**	**11.92**	**12.64**	**2.72**	**67.77**	**15.76**	**28.69**	**46.72**	**23.31**	**4.95**	**2.97**	**1.82**	**3.34**	**4.17**
Naphthalene	3.85	4.91	4.03	4.09	1.42	6.82	3.16	3.37	4.55	2.28	2.32	1.97	0.74	2.08	2.39
1-methylnaphthalene	1.32	1.07	1.29	1.13	0.12	9.59	1.51	3.41	6.04	1.65	0.29	0.17	0.20	0.30	0.12
2-methylnaphthalene	0.92	0.80	0.84	0.74	-0.15	7.80	1.31	2.90	5.23	1.35	0.15	0.04	0.01	0.12	-0.03
1,3+1,6+1,7-dimethylnaphthalene	0.57	0.27	0.56	0.71	-0.08	7.59	1.24	2.51	4.91	0.37	0.13	0.04	-0.06	-0.06	0.08
3-methylbiphenyl	0.59	0.37	0.48	0.50	0.20	3.16	1.20	1.36	2.20	1.01	0.28	0.14	0.07	0.16	0.23
2,6+2,7-dimethylnaphthalene	0.25	0.11	0.23	0.33	-0.04	4.58	0.68	1.33	2.71	0.14	0.05	0.02	-0.03	-0.03	0.06
Biphenyl	0.35	0.22	0.28	0.34	0.02	2.15	0.56	0.81	1.44	0.31	0.06	0.03	0.03	0.04	0.05
4-methylbiphenyl	0.25	0.19	0.20	0.22	0.12	1.46	0.51	0.54	0.96	0.46	0.14	0.08	0.03	0.09	0.09
A-trimethylnaphthalene	0.20	0.08	0.20	0.27	0.00	1.80	0.41	1.02	1.50	0.40	0.06	0.02	0.01	0.01	0.04
1,4+1,5+2,3-dimethylnaphthalene	0.20	0.09	0.18	0.22	-0.02	2.34	0.38	0.80	1.47	0.13	0.04	0.01	-0.01	-0.01	0.02
B-trimethylnaphthalene	0.20	0.07	0.19	0.24	0.01	1.46	0.32	0.94	1.32	0.48	0.07	0.02	0.02	0.02	0.05
bibenz	0.12	0.03	0.11	0.11	0.05	1.04	0.21	0.57	0.87	1.53	0.10	0.07	0.21	0.20	0.13
2-methylbiphenyl	0.22	0.15	0.15	0.16	0.06	0.58	0.52	0.31	0.49	0.37	0.34	0.11	0.03	0.07	0.40
1+2-ethylnaphthalene	0.13	0.13	0.19	0.25	-0.01	2.04	0.37	0.62	1.28	0.10	0.04	0.02	-0.01	-0.01	0.02
C-trimethylnaphthalene	0.18	0.05	0.16	0.21	-0.01	1.34	0.27	0.79	1.14	0.43	0.06	0.01	0.01	0.01	0.04
Phenanthrene	0.39	0.34	0.39	0.42	0.05	0.93	0.19	0.47	0.61	0.56	0.09	0.03	0.03	0.03	0.04
2,3,5-trimethylnaphtha	0.14	0.02	0.11	0.15	-0.02	1.12	0.18	0.69	0.96	0.59	0.04	-0.01	0.01	0.01	0.02
Acenaphthylene	0.42	0.93	0.68	0.60	0.03	0.22	0.10	0.13	0.14	0.12	0.04	0.03	0.04	0.07	0.05
E-trimethylnaphthalene	0.13	0.03	0.11	0.14	0.00	0.85	0.19	0.59	0.83	0.35	0.04	0.01	0.01	0.01	0.02
Fluorene	0.17	0.15	0.18	0.17	0.06	0.45	0.12	0.28	0.34	1.14	0.03	0.01	0.08	0.08	0.03
F-trimethylnaphthalene	0.11	0.03	0.09	0.11	0.00	0.75	0.16	0.45	0.63	0.48	0.03	0.00	0.02	0.02	0.02
C-dimethylphenanthrene	0.06	0.02	0.05	0.07	0.05	0.73	0.09	0.32	0.45	0.70	0.03	0.01	0.03	0.02	0.02
1,2-dimethylnaphthalene	0.08	0.06	0.08	0.09	0.00	0.80	0.15	0.28	0.51	0.08	0.03	0.01	0.00	0.00	0.01
2-methylphenanthrene	0.08	0.03	0.06	0.07	0.02	0.52	0.10	0.24	0.34	0.48	0.04	0.02	0.03	0.02	0.02
A-methylphenanthrene	0.07	0.03	0.05	0.07	0.02	0.49	0.09	0.24	0.32	0.59	0.04	0.02	0.03	0.02	0.02
Pyrene	0.20	0.21	0.20	0.20	0.14	0.29	0.14	0.18	0.22	0.20	0.02	0.01	0.01	0.01	0.02
1-Methylfluorene	0.04	0.02	0.05	0.06	0.00	0.50	0.07	0.25	0.37	0.53	0.04	0.01	0.01	0.01	0.01
C-methylphenanthrene	0.06	0.03	0.05	0.07	0.02	0.52	0.09	0.24	0.34	0.44	0.03	0.02	0.02	0.02	0.02
J-trimethylnaphthalene	0.03	0.02	0.06	0.08	0.03	0.59	0.10	0.30	0.48	0.18	0.05	0.01	0.00	0.02	0.01
4-methylpyrene	0.04	0.03	0.03	0.04	0.04	0.34	0.18	0.19	0.26	0.63	0.01	0.00	0.01	0.00	0.00
A-methylfluorene	0.04	0.02	0.04	0.04	0.00	0.42	0.08	0.24	0.37	0.35	0.03	0.01	0.01	0.01	0.01
D-MePy/MeFl	0.04	0.02	0.03	0.04	0.04	0.34	0.17	0.18	0.24	0.58	0.01	0.00	0.01	0.01	0.01
1-methylphenanthrene	0.04	0.02	0.04	0.05	0.02	0.41	0.07	0.20	0.26	0.42	0.02	0.01	0.02	0.01	0.00
2,4,5-trimethylnaphtha	0.05	0.01	0.04	0.06	0.01	0.38	0.06	0.23	0.32	0.24	0.03	0.00	0.01	0.01	0.01
1,7-dimethylphenanthre	0.03	0.01	0.03	0.03	0.03	0.38	0.05	0.17	0.21	0.38	0.02	0.01	0.02	0.01	0.01
9-anthraldehyde	0.04	0.01	0.02	0.03	0.04	0.25	0.04	0.12	0.18	0.48	0.01	0.01	0.02	0.01	0.02
1-methylpyrene	0.02	0.02	0.02	0.03	0.03	0.24	0.12	0.13	0.18	0.47	0.01	0.00	0.00	0.00	0.00
Acenaphthene	0.05	0.00	0.00	0.03	0.02	0.18	0.13	0.11	0.15	0.11	0.09	0.07	-0.01	0.01	-0.01

Table 8. PAH Emission Rates (mg/mi) - continued

vehicle	1985 Chevy C-20					1983 Ford F250				
fuel	CARB	EC-D	OXy-G	SoyGold	World Energy	CARB	EC-D	OXy-G	SoyGold	World Energy
Total PAHs	**6.22**	**2.79**	**8.33**	**4.39**	**4.85**	**16.02**	**4.81**	NA	**20.02**	**15.59**
Naphthalene	3.16	1.86	5.81	2.52	2.94	2.67	1.77	NA	3.83	3.34
1-methylnaphthalene	0.32	0.07	0.19	0.20	0.19	2.00	0.53	NA	2.12	1.33
2-methylnaphthalene	0.00	-0.19	-0.11	-0.09	-0.07	1.58	0.33	NA	1.93	1.14
1,3+1,6+1,7-dimethylnaphthalene	0.17	-0.08	0.09	0.11	0.10	0.57	0.21	NA	1.48	1.22
3-methylbiphenyl	0.50	0.26	0.60	0.28	0.27	1.20	0.42	NA	1.00	0.78
2,6+2,7-dimethylnaphthalene	0.06	-0.04	0.03	0.04	0.03	0.25	0.10	NA	0.73	0.58
Biphenyl	0.14	0.04	0.11	0.12	0.12	0.54	0.13	NA	0.48	0.39
4-methylbiphenyl	0.21	0.16	0.32	0.13	0.13	0.50	0.18	NA	0.42	0.33
A-trimethylnaphthalene	0.06	0.00	0.04	0.05	0.05	0.29	0.08	NA	0.59	0.49
1,4+1,5+2,3-dimethylnaphthalene	0.06	-0.02	0.03	0.04	0.04	0.21	0.07	NA	0.47	0.38
B-trimethylnaphthalene	0.06	0.00	0.04	0.05	0.05	0.36	0.07	NA	0.59	0.46
Bibenz	0.03	0.03	0.05	0.01	0.01	0.52	0.03	NA	0.36	0.33
2-methylbiphenyl	0.47	0.09	0.32	0.13	0.13	0.30	0.19	NA	0.62	0.28
1+2-ethylnaphthalene	0.08	0.00	0.04	0.05	0.04	0.10	0.08	NA	0.36	0.31
C-trimethylnaphthalene	0.05	0.00	0.03	0.04	0.03	0.36	0.05	NA	0.53	0.40
Phenanthrene	0.13	0.07	0.12	0.12	0.13	0.31	0.04	NA	0.36	0.21
2,3,5-trimethylnaphtha	0.02	-0.02	0.01	0.01	0.00	0.46	0.02	NA	0.47	0.33
Acenaphthylene	0.17	0.20	0.13	0.19	0.19	0.15	0.03	NA	0.08	0.08
E-trimethylnaphthalene	0.03	0.00	0.02	0.02	0.02	0.28	0.03	NA	0.37	0.28
Fluorene	0.04	0.13	0.04	0.04	0.04	0.40	0.02	NA	0.21	0.13
F-trimethylnaphthalene	0.02	0.01	0.01	0.02	0.01	0.32	0.03	NA	0.32	0.22
C-dimethylphenanthrene	0.03	0.02	0.03	0.02	0.03	0.21	0.02	NA	0.16	0.16
1,2-dimethylnaphthalene	0.03	0.00	0.02	0.02	0.02	0.09	0.03	NA	0.19	0.15
2-methylphenanthrene	0.04	0.03	0.04	0.03	0.04	0.16	0.02	NA	0.16	0.13
A-methylphenanthrene	0.04	0.03	0.04	0.03	0.04	0.14	0.02	NA	0.14	0.12
Pyrene	0.05	0.03	0.04	0.05	0.05	0.13	0.04	NA	0.08	0.08
1-Methylfluorene	0.02	0.01	0.02	0.01	0.01	0.15	0.01	NA	0.21	0.14
C-methylphenanthrene	0.03	0.01	0.02	0.02	0.02	0.15	0.02	NA	0.14	0.12
J-trimethylnaphthalene	0.02	0.01	0.01	0.01	0.01	0.06	0.02	NA	0.21	0.18
4-methylpyrene	0.01	0.01	0.01	0.01	0.01	0.12	0.03	NA	0.08	0.08
A-methylfluorene	0.01	0.00	0.02	0.02	0.01	0.11	0.01	NA	0.19	0.12
D-MePy/MeFl	0.02	0.01	0.01	0.01	0.01	0.11	0.03	NA	0.08	0.08
1-methylphenanthrene	0.02	0.01	0.02	0.01	0.02	0.12	0.01	NA	0.12	0.10
2,4,5-trimethylnaphtha	0.02	0.01	0.01	0.01	0.01	0.14	0.01	NA	0.17	0.12
1,7-dimethylphenanthre	0.02	0.01	0.02	0.01	0.01	0.11	0.02	NA	0.08	0.08
9-anthraldehyde	0.02	0.01	0.01	0.01	0.01	0.09	0.01	NA	0.06	0.08
1-methylpyrene	0.01	0.00	0.01	0.01	0.01	0.07	0.02	NA	0.05	0.06
Acenaphthene	0.00	0.01	0.01	0.01	0.02	0.13	0.09	NA	0.07	0.17

5.0 Summary and Conclusions

The present program was designed to further investigate the effects of alternative diesel fuels on exhaust emission rates and composition in comparison with CARB fuel. In this project, CARB fuel was compared with EC-D, and three 20% biodiesel blends including two soy-based biodiesels and one yellow grease-based biodiesel (OXyG B-60). Chassis dynamometer tests were performed on 7 vehicles using each of the 5 fuels. The major results of this study are:

- EC-D and the OXyG B-60 biodiesel blend both showed significant reductions in THC emissions for nearly all of the test vehicles. THC emission reductions for EC-D compared with CARB fuel were found for 6 of the 7 test vehicles with reductions ranging from 32 to 56%. Five vehicles of the seven test vehicles showed THC emission reductions for the OXyG B-60 biodiesel blend ranging from 21 to 66% compared with the CARB fuel. The soy-based biodiesel blends did not show consistent reductions or increases in THC relative to the CARB fuel over the test vehicle fleet.

- CO emissions reductions were also relatively dramatic for EC-D and OXyG B-60 fuel with reductions relative to the baseline in-use fuel ranging from 12 to 41% for EC-D and from 0 to 46% for the OXyG B-60. CO emissions for the soy-based biodiesel blends were comparable with those of the CARB fuel over the test fleet.

- EC-D showed the greatest reductions in PM emission rates with reductions ranging from 5 to 43%. The OXyG B-60 showed some promise in reducing PM emissions for the highest emitting vehicle, but had PM emissions rates comparable to those of the in-use fuel for the remaining vehicles. The soy-based biodiesel blends had slightly higher PM emissions rates than the CARB fuel for 4 of the 7 vehicles, with comparable PM emission rates for the remaining three vehicles.

- NO_x emissions were comparable for the different fuel types over the range of vehicles tested.

- Detailed C_1-C_{12} NMOG speciation showed alkenes and carbonyls were the most prominent compound classes in this range.

- The species distribution as a function of carbon number showed a peak at the C_2 species, which included ethane, ethyne, and acetaldehyde. The four primary toxic air contaminants (formaldehyde, acetaldehyde, benzene, and 1,3-butadiene) composed approximately 15 to 20% of the total organic gases.

- Total carbon accounted for more than 70% of the PM mass for 4 of the 5 sampled test vehicles. The elemental and organic fractions varied significantly from vehicle to vehicle but showed very little fuel dependence.

- Inorganic species including ions and elements represented a smaller portion of the composite total, ranging from 0.2 to 3.3% of the total particulate. The only species with average emission rates of greater than 0.1 mg/mi for each of the test vehicles being SO_4^{2-}, NH_4^+, Mg, Si, P, S, Cl, Ca, and Zn.

- For each test vehicle, the ARCO EC-diesel fuel had the lowest emission rates for S and SO_4^{2-} consistent with the lower sulfur levels found in this fuel. The World Energy biodiesel blend also had a tendency for higher emissions rates of elements and ions relative to the other fuels.

- Total PAH emissions ranged from approximately 1.8 mg/mi to 67.8 mg/mi over the different vehicle/fuel combinations representing between 1.6 and 3.8% of the total PM mass. For 3 of the 5 vehicles, the ARCO EC-diesel fuel had the lowest PAH emissions. The biodiesel blends generally had PAH emissions comparable to or lower than the RFD fuel.

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Appendix A. Fuel Analysis

	CARB	EC-D
SFC-Saturates (wt%)	76.4	89.6
SFC-Aromatics (wt%)	23.6	10.4
PNA (wt%)	3.69	0.89
SFC-Saturates (vol%)	77.07	89.14
SFC-Aromatics (vol%)	22.93	10.86
Sulfur (ppm)	72.5	3
API Gravity	37.8	42.6
Calc. Cetane Index	51.3	67
D86 IBP Rec. (°F)	352	418
10% Rec. (°F)	412	450
50% Rec. (°F)	508	530
90% Rec. (°F)	620	618
EP Rec. (°F)	671	659

Appendix A - continued - Biodiesel Fuel Analyses

	Method	**SoyGold**	**World Energy**	**OXyG B60**
Flash Point	D93	149°C	180°C	122°C
Water/Sediment	D2709	0.01 vol %	0.0 vol %	0.0 vol %
Carbon Residue	D524	0.01%	0.01%	0.03%
Sulfated Ash	D874	0.003 mass %	0.020 mass %	0.003 mass %
Kinematic Viscosity	D445	4.11 cst @ 40°C	4.064 cst @ 40°C	4.588 cst @ 40°C
Sulfur	D2622	0.000 mass %	0.000 mass %	0.000 mass %
Cetane Number	D613	52.3	52.9	61.9
Cloud Point	D5773	0°C	0°C	4°C
Copper Corrosion	D130	1A	1B	1B
Acid Number	D664	0.12 mg KOH/gm	0.39 mg KOH/gm	0.18 mg KOH/gm
Free Glycerin	C. Plank	0.002 mass %	0.001 mass %	0.002 mass %
Monoglyceride	C. Plank	0.739 mass %	0.418 mass %	0.498 mass %
Diglyceride	C. Plank	0.199 mass %	0.086 mass %	0.123 mass %
Triglyceride	C. Plank	0.044 mass %	0.000 mass %	0.062 mass %
Glycerin	C. Plank	0.228 mass %	0.122 mass %	0.156 mass %

Appendix B. FTP Emissions Results

1993 Ford F-350 PU		Bag 1				Bag 2				Bag 3				Weighted			
		THC	CO	NOx	PM	THC	CO	NOx	PM	THC	CO	NOx	PM	THC	CO	NOx	PM
Test #	Fuel	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi
I0003028	CARB	5.728	6.828	1.901	2082.1	7.410	8.997	2.102	2531.0	4.817	5.901	1.885	1795.1	6.349	7.697	2.001	2235.9
I0003030	CARB	5.889	6.893	1.924	2234.7	7.566	8.949	2.142	2623.8	4.994	6.030	1.926	1840.4	6.511	7.719	2.037	2327.6
	CARB Ave.	5.809	6.861	1.913	2158.4	7.488	8.973	2.122	2577.4	4.906	5.966	1.906	1817.8	6.430	7.708	2.019	2281.7
I0003032	EC-D	3.099	4.883	2.059	1083.9	4.372	6.568	2.315	1421.1	2.957	4.370	2.044	1080.3	3.719	5.615	2.188	1257.5
I0003034	EC-D	1.089	4.915	1.914	1185.7	1.751	6.528	2.126	1494.8	2.723	4.324	1.861	1115.9	1.881	5.586	2.009	1326.3
	EC-D Ave	2.094	4.899	1.987	1134.8	3.062	6.548	2.221	1458.0	2.840	4.347	1.953	1098.1	2.800	5.601	2.099	1291.9
I0003043	SoyGold blend	4.110	6.189	1.892	2342.9	5.731	8.482	2.124	2916.4	3.939	5.742	1.877	2198.9	4.902	7.252	2.008	2600.0
I0003045	SoyGold blend	4.390	6.379	1.880	2229.6	5.660	8.424	2.114	2878.9	3.913	5.779	1.859	2195.5	4.916	7.272	1.995	2556.1
	20% Soygold blend Ave.	4.250	6.284	1.886	2286.2	5.696	8.453	2.119	2897.7	3.926	5.761	1.868	2197.2	4.909	7.262	2.002	2578.1
I0003055	W.E. Bio blend	4.645	6.194	1.963	2724.4	6.033	8.378	2.216	3127.6	4.223	5.773	1.938	2379.1	5.248	7.209	2.087	2838.2
I0003057	W.E. Bio blend	4.539	6.258	1.942	2451.6	5.935	8.343	2.156	2981.1	4.242	5.777	1.897	2390.3	5.180	7.204	2.041	2708.6
	20% World E. Blend Ave	4.592	6.226	1.953	2588.0	5.984	8.361	2.186	3054.4	4.233	5.775	1.918	2384.7	5.214	7.207	2.064	2773.4
I0003040	OXy-G blend	2.791	4.766	2.101	1483.2	3.929	6.487	2.305	2039.2	2.570	4.357	2.005	1424.4	3.319	5.544	2.180	1754.7
I0003042	OXy-G blend	2.896	4.835	2.131	1669.9	4.039	6.498	2.343	2177.9	2.737	4.542	2.023	1571.5	3.443	5.614	2.211	1905.6
	20% OxyG blend Ave	2.844	4.801	2.116	1576.5	3.984	6.493	2.324	2108.6	2.654	4.450	2.014	1498.0	3.381	5.579	2.196	1830.2

Appendix B. FTP Emissions Results

1990 Ford E-350 Van	Bag 1				Bag 2				Bag 3				Weighted			
	THC	CO	NOx	PM	THC	CO	NOx	PM	THC	CO	NOx	PM	THC	CO	NOx	PM
Test # Fuel	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi
I0004022 CARB	0.081	0.774	7.797	151.1	0.122	0.863	9.797	112.0	0.067	0.649	6.667	136.0	0.098	0.786	8.522	126.7
I0004023 CARB	0.037	0.759	7.923	128.1	0.016	0.925	10.245	112.9	0.056	0.698	6.770	139.0	0.031	0.828	8.808	123.2
I0005013 CARB	0.127	0.832	8.591	NA	0.126	0.809	11.536	NA	0.108	0.716	7.708	NA	0.122	0.809	9.870	NA
I0005021 CARB	0.117	0.819	8.554	149.8	0.117	0.911	11.191	116.2	0.085	0.707	7.539	140.7	0.109	0.836	9.638	129.9
CARB Ave.	0.091	0.796	8.216	143.0	0.095	0.877	10.692	113.7	0.079	0.693	7.171	138.6	0.090	0.815	9.210	126.6
I0004028 EC-D	0.079	0.642	7.661	130.8	0.087	0.783	9.688	100.3	0.071	0.602	6.553	123.9	0.081	0.704	8.406	113.1
I0004034 EC-D	0.087	0.631	7.558	136.1	0.175	0.846	9.672	116.6	0.113	0.604	6.472	130.4	0.140	0.735	8.353	124.4
EC-D Ave	0.083	0.637	7.610	133.4	0.131	0.815	9.680	108.5	0.092	0.603	6.513	127.1	0.111	0.720	8.380	118.8
I0004047 SoyGold blend	0.127	0.775	8.350	135.6	0.197	0.912	11.048	109.0	0.125	0.686	7.447	123.7	0.163	0.821	9.499	118.6
I0004051 SoyGold blend	0.115	0.779	8.191	120.6	0.165	0.907	10.867	107.5	0.073	0.665	7.697	124.0	0.129	0.814	9.438	114.8
20% Soygold blend Ave.	0.121	0.777	8.271	128.1	0.181	0.910	10.958	108.3	0.099	0.676	7.572	123.8	0.146	0.818	9.469	116.7
I0004052 W.E. Bio blend	0.097	0.730	7.878	116.1	0.090	0.847	11.038	109.9	0.093	0.692	7.573	125.3	0.092	0.780	9.429	115.4
I0004055 W.E. Bio blend	0.111	0.797	8.496	120.7	0.126	0.916	10.962	110.4	0.105	0.694	7.225	126.2	0.117	0.830	9.421	116.9
20% World E. blend Ave	0.104	0.764	8.187	118.4	0.108	0.882	11.000	110.1	0.099	0.693	7.399	125.7	0.105	0.805	9.425	116.1
I0004035 OXy-G blend	0.074	0.678	7.812	129.9	0.127	0.799	10.077	116.3	0.083	0.606	6.766	136.0	0.104	0.721	8.696	124.5
I0004038 OXy-G blend	0.087	0.688	8.035	134.3	0.126	0.817	10.190	128.3	0.089	0.613	6.791	134.3	0.108	0.734	8.807	131.2
20% OXyG blend Ave	0.081	0.683	7.924	132.1	0.127	0.808	10.134	122.3	0.086	0.610	6.779	135.2	0.106	0.728	8.752	127.8

Appendix B. FTP Emissions Results

1990 Chevy 2500 PU		Bag 1				Bag 2				Bag 3				Weighted			
		THC	CO	NOx	PM	THC	CO	NOx	PM	THC	CO	NOx	PM	THC	CO	NOx	PM
Test #	Fuel	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi
H9911024	CARB	0.408	2.326	2.516	172.9	0.398	1.797	3.389	164.0	0.429	1.831	2.181	188.6	0.409	1.916	2.877	172.6
H9911028	CARB	0.471	2.213	2.506	146.2	0.429	1.691	3.354	148.3	0.526	1.874	2.072	178.5	0.465	1.849	2.827	156.2
	CARB Ave.	0.440	2.270	2.511	159.6	0.414	1.744	3.372	156.2	0.478	1.853	2.127	183.5	0.437	1.883	2.852	164.4
H9911029	EC-D	0.309	1.330	2.260	143.9	0.264	1.108	3.144	155.5	0.293	1.092	2.019	154.1	0.281	1.150	2.652	152.7
H9911032	EC-D	0.215	1.234	2.415	184.9	0.188	1.015	3.213	133.0	0.209	1.049	2.044	140.6	0.199	1.069	2.727	145.8
	EC-D Ave	0.262	1.282	2.338	164.4	0.226	1.062	3.179	144.3	0.251	1.071	2.032	147.3	0.240	1.110	2.690	149.3
H9911041	SoyGold blend	0.377	2.093	2.582	160.8	0.335	1.627	3.595	159.1	0.424	1.734	2.253	177.3	0.368	1.753	3.017	164.5
H9911048	SoyGold blend	0.340	2.067	2.568	153.0	0.242	1.498	3.495	150.0	0.357	1.646	2.195	165.7	0.294	1.657	2.946	154.9
	20% Soygold Blend Ave.	0.359	2.080	2.575	156.9	0.289	1.563	3.545	154.5	0.391	1.690	2.224	171.5	0.331	1.705	2.982	159.7
H9911049	World Energy blend	0.356	2.102	2.456	171.0	0.277	1.538	3.412	163.1	0.346	1.656	2.290	175.6	0.312	1.687	2.906	168.2
H9911054	World Energy blend	0.177	1.987	2.590	146.1	0.140	1.558	3.518	155.2	0.314	1.518	2.059	156.5	0.197	1.636	2.910	153.7
	20% World E. Blend Ave	0.267	2.045	2.523	158.5	0.209	1.548	3.465	159.2	0.330	1.587	2.175	166.0	0.255	1.662	2.908	160.9
H9911065	OXy-G blend	0.152	1.201	2.752	152.6	0.151	0.986	3.482	167.8	0.176	0.996	2.233	163.9	0.158	1.033	2.989	163.6
H9911069	OXy-G blend	0.118	1.180	2.758	133.8	0.129	0.949	3.475	154.6	0.162	0.957	2.993	165.9	0.136	0.999	2.993	153.4
	20% OXy-G Blend Ave	0.135	1.191	2.755	143.2	0.140	0.968	3.479	161.2	0.169	0.977	2.613	164.9	0.147	1.016	2.991	158.5

Appendix B. FTP Emissions Results

1989 Chevy 2500 PU	Bag 1				Bag 2				Bag 3				Weighted			
	THC	CO	NOx	PM	THC	CO	NOx	PM	THC	CO	NOx	PM	THC	CO	NOx	PM
Test # Fuel	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi
I0002005 CARB	1.008	2.483	2.081	377.0	0.296	1.283	2.442	119.8	0.474	1.776	2.099	295.6	0.493	1.668	2.272	221.6
I0002007 CARB	0.540	2.489	2.086	366.8	0.217	1.309	2.444	119.0	0.482	1.799	2.111	301.3	0.357	1.689	2.278	220.6
CARB Ave.	0.774	2.486	2.084	371.9	0.257	1.296	2.443	119.4	0.478	1.788	2.105	298.5	0.425	1.679	2.275	221.1
I0002014 EC-D	0.389	2.155	2.073	308.6	0.127	1.008	2.501	109.0	0.318	1.567	2.125	252.8	0.234	1.399	2.309	189.9
I0002016 EC-D	0.603	2.016	2.076	253.9	0.218	1.008	2.535	105.5	0.369	1.495	2.188	243.7	0.340	1.351	2.344	174.3
EC-D Ave	0.496	2.086	2.075	281.2	0.173	1.008	2.518	107.2	0.344	1.531	2.157	248.3	0.287	1.375	2.327	182.1
I0002034 Soygold blend	1.173	2.835	2.089	487.8	0.441	1.623	2.427	160.0	0.551	1.902	2.142	319.0	0.623	1.951	2.279	271.8
I0002036 Soygold blend	1.115	2.735	2.116	NA	0.384	1.515	2.496	NA	0.548	1.901	2.159	NA	0.581	1.874	2.324	NA
20% Soygold Blend Ave.	1.144	2.785	2.103	487.8	0.413	1.569	2.462	160.0	0.550	1.902	2.151	319.0	0.602	1.913	2.302	271.8
I0002020 W.E. Bio blend	1.020	2.689	2.165	496.9	0.377	1.364	2.576	155.7	0.507	1.817	2.206	317.1	0.546	1.764	2.389	271.0
I0002032 W.E. Bio blend	1.210	2.913	2.136	504.0	0.453	1.532	2.578	146.9	0.578	1.945	2.25	307.9	0.645	1.932	2.396	265.3
20% World E. Blend Ave	1.115	2.801	2.151	500.4	0.415	1.448	2.577	151.3	0.543	1.881	2.228	312.5	0.596	1.848	2.393	268.1
I0002043 OXy-G blend	0.833	2.386	2.166	566.8	0.369	1.389	2.534	145.9	0.476	1.795	2.242	333.5	0.495	1.708	2.378	284.8
I0002048 OXy-G blend	0.853	2.487	2.132	381.3	0.331	1.29	2.571	129.1	0.429	1.648	2.217	296.7	0.466	1.638	2.382	227.7
20% OXy-G Blend Ave	0.843	2.437	2.149	474.0	0.350	1.340	2.553	137.5	0.453	1.722	2.230	315.1	0.481	1.673	2.380	256.3

Appendix B. FTP Emissions Results

987 Chevy 30 PU		Bag 1				Bag 2				Bag 3				Weighted			
		THC	CO	NOx	PM	THC	CO	NOx	PM	THC	CO	NOx	PM	THC	CO	NOx	PM
est #	Fuel	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi
9911025	CARB	1.203	3.852	1.960	504.7	0.623	1.995	2.391	210.1	1.039	3.122	1.779	430.2	0.857	2.687	2.134	331.3
9911027	CARB	1.277	3.695	1.833	481.9	0.226	1.866	2.277	191.9	0.559	2.791	1.743	360.5	0.534	2.497	2.039	297.9
	CARB Ave.	1.240	3.774	1.897	493.3	0.425	1.931	2.334	201.0	0.799	2.957	1.761	395.3	0.696	2.592	2.087	314.6
9911030	EC-D	0.725	2.397	1.779	304.8	0.381	1.328	2.222	152.6	0.534	2.062	1.684	286.9	0.494	1.750	1.983	220.8
9911033	EC-D	0.620	2.351	1.796	297.4	0.320	1.286	2.240	155.9	0.512	2.037	1.654	288.3	0.434	1.711	1.988	221.3
	EC-D Ave	0.673	2.374	1.788	301.1	0.351	1.307	2.231	154.3	0.523	2.050	1.669	287.6	0.464	1.731	1.986	221.1
9911042	SoyGold blend	1.363	3.770	1.917	355.1	0.558	1.920	2.387	242.1	0.977	2.946	1.790	492.2	0.839	2.584	2.126	334.0
9911047	SoyGold blend	1.491	3.920	1.859	668.2	0.593	1.921	2.388	237.8	0.912	2.871	1.778	447.1	0.866	2.595	2.111	384.1
	20% Soygold Blend Ave.	1.427	3.845	1.888	511.7	0.576	1.921	2.388	240.0	0.945	2.909	1.784	469.7	0.853	2.590	2.119	359.1
9911050	World Energy blend	1.155	3.726	1.908	578.6	0.541	1.928	2.367	224.2	0.872	2.835	1.778	458.1	0.759	2.549	2.110	361.7
9911053	World Energy blend	1.201	3.769	1.920	627.0	0.546	1.891	2.398	231.3	0.820	2.728	1.812	432.1	0.757	2.509	2.138	368.2
	20% World E. Blend Ave	1.178	3.748	1.914	602.8	0.544	1.910	2.383	227.8	0.846	2.782	1.795	445.1	0.758	2.529	2.124	364.9
9911064	OXy-G blend	0.654	2.485	1.918	410.4	0.401	1.446	2.314	193.4	0.536	2.085	1.728	368.7	0.490	1.836	2.072	286.4
9911070	OXy-G blend	0.638	2.547	1.983	454.6	0.307	1.388	2.372	196.7	0.480	2.026	1.768	363.9	0.423	1.803	2.126	295.9
	20% OXy-G blend Ave	0.646	2.516	1.951	432.5	0.354	1.417	2.343	195.0	0.508	2.056	1.748	366.3	0.457	1.820	2.099	291.2

Appendix B. FTP Emissions Results

1985 Chevy C-20 PU	Bag 1				Bag 2				Bag 3				Weighted			
	THC	CO	NOx	Parts.	THC	CO	NOx	Parts.	THC	CO	NOx	Parts.	THC	CO	NOx	Parts.
Test # Fuel	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi
I0001020 RFD	0.234	1.460	3.664	233.8	0.258	1.427	4.053	208.5	0.273	1.273	3.227	228.9	0.257	1.391	3.745	219.4
I0001022 RFD	0.261	1.414	3.719	276.7	0.254	1.417	4.141	214.1	0.269	1.256	3.249	237.8	0.260	1.372	3.808	233.6
I0002001 RFD	0.254	1.376	3.768	231.3	0.232	1.358	4.338	195.1	0.248	1.199	3.476	218.2	0.241	1.318	3.983	209.0
RFD Ave.	0.250	1.417	3.717	247.3	0.248	1.401	4.177	205.9	0.263	1.243	3.317	228.3	0.253	1.360	3.845	220.6
I0001023 EC-D	0.152	1.002	3.844	208.4	0.193	1.000	4.273	175.5	0.219	0.964	3.330	200.0	0.192	0.991	3.924	189.1
I0001024 EC-D	0.173	0.996	3.576	211.2	0.207	1.020	3.959	176.8	0.214	0.932	3.145	206.3	0.202	0.991	3.656	192.1
I0002003 EC-D	0.093	0.966	3.793	213.4	0.077	0.940	4.198	169.9	0.194	0.899	3.322	193.9	0.113	0.934	3.873	185.5
EC-diesel Ave	0.139	0.988	3.738	211.0	0.159	0.987	4.143	174.1	0.209	0.932	3.266	200.1	0.169	0.972	3.818	188.9
I0001048 Soygold	0.239	1.410	4.227	228.2	0.219	1.375	4.575	161.9	0.232	1.230	3.568	200.1	0.227	1.342	4.226	186.2
I0001049 Soygold	0.242	1.419	4.068	240.1	0.212	1.374	4.483	178.3	0.223	1.202	3.565	216.6	0.221	1.336	4.144	201.7
20% Soygold Blend Ave.	0.241	1.415	4.148	234.2	0.216	1.375	4.529	170.1	0.228	1.216	3.567	208.4	0.224	1.339	4.185	193.9
I0001038 W.E. Bio	0.209	1.388	3.769	212.6	0.209	1.358	4.277	171.4	0.220	1.192	3.482	206.7	0.212	1.318	3.953	189.6
I0001046 W.E. Bio	0.240	1.461	4.155	245.8	0.267	1.375	4.826	182.8	0.237	1.199	3.754	217.0	0.253	1.345	4.391	205.3
20% World E. Blend Ave	0.225	1.425	3.962	229.2	0.238	1.367	4.552	177.1	0.229	1.196	3.618	211.9	0.233	1.332	4.172	197.5
I0001032 OXy-G	0.179	1.229	3.851	224.7	0.195	1.181	4.296	192.1	0.216	1.101	3.514	218.4	0.197	1.169	3.989	206.1
I0001035 OXy-G	0.186	1.269	3.832	232.5	0.195	1.231	4.316	190.4	0.232	1.118	3.385	217.9	0.204	1.208	3.960	206.7
20% OXy-G Blend Ave	0.183	1.249	3.842	228.6	0.195	1.206	4.306	191.2	0.224	1.110	3.450	218.1	0.201	1.189	3.975	206.4

Appendix B. FTP Emissions Results

1983 Ford F-250 PU	Bag 1				Bag 2				Bag 3				Weighted			
	THC	CO	NOx	PM	THC	CO	NOx	PM	THC	CO	NOx	PM	THC	CO	NOx	PM
Test # Fuel	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi
I0003020 CARB	2.369	4.989	3.163	1064.4	0.422	2.462	4.521	275.3	2.01	4.257	2.698	960.1	1.264	3.481	3.737	627.8
I0003021 CARB	2.456	5.002	3.167	929.7	0.461	2.556	4.361	290.1	1.976	4.250	2.627	953.1	1.292	3.530	3.636	605.2
CARB Ave.	2.413	4.996	3.165	997.0	0.442	2.509	4.441	282.7	1.993	4.254	2.663	956.6	1.278	3.506	3.687	616.5
I0003022 EC-D	1.125	3.049	3.248	683.2	0.323	1.692	4.492	261.3	1.071	2.715	2.675	704.0	0.696	2.255	3.734	470.8
I0003027 EC-D	1.295	3.270	3.250	859.3	0.434	1.808	4.673	314.6	1.224	2.847	2.839	878.6	0.830	2.397	3.874	582.6
EC-D Ave	1.210	3.160	3.249	771.2	0.379	1.750	4.583	288.0	1.148	2.781	2.757	791.3	0.763	2.326	3.804	526.7
I0003029 SoyGold blend	2.061	4.777	3.234	1353.1	0.644	2.492	4.578	352.8	1.851	4.197	2.728	1346.0	1.270	3.435	3.791	833.5
I0003031 SoyGold blend	2.027	4.882	3.366	1359.8	0.590	2.386	4.920	306.1	1.813	4.080	2.850	1242.1	1.225	3.371	4.027	782.7
20% Soygold Blend Ave.	2.044	4.830	3.300	1356.5	0.617	2.439	4.749	329.5	1.832	4.139	2.789	1294.0	1.248	3.403	3.909	808.1
I0003033 W.E. Bio blend	2.045	4.861	3.208	1426.9	0.638	2.445	4.596	412.4	2.011	4.100	2.634	1438.7	1.308	3.402	3.768	920.1
I0003039 W.E. Bio blend	2.097	4.657	3.107	1435.9	0.636	2.259	4.345	378.9	1.811	3.848	2.566	1409.7	1.262	3.193	3.599	881.5
I0003054 W.E. Bio blend	2.041	4.473	3.305	1505.5	0.642	2.223	4.590	429.0	1.966	3.859	2.717	1490.9	1.297	3.140	3.808	944.5
20% World E. Blend Ave	2.061	4.664	3.207	1456.1	0.639	2.309	4.510	406.8	1.929	3.936	2.639	1446.4	1.289	3.245	3.725	915.4
I0003041 OXy-G blend	1.415	3.398	3.322	1043.6	0.506	1.891	4.541	339.2	1.348	2.917	2.778	1063.5	0.926	2.486	3.803	684.5
I0003044 OXy-G blend	1.401	3.427	3.530	886.1	0.467	1.853	4.670	271.3	1.378	3.001	2.824	516.0	0.911	2.495	3.926	466.1
20% OXy-G Blend Ave	1.408	3.413	3.426	964.9	0.487	1.872	4.606	305.3	1.363	2.959	2.801	789.7	0.919	2.491	3.865	575.3

Appendix C. FTP PM Composition for 1993 Ford F350 PU (mg/mi)

Fuel	CARB			EC-D			OXy-G blend			SoyGold blend			World Energy		
Organic C	1167.1	+/-	115.5	627.8	+/-	62.3	961.4	+/-	95.2	1211.2	+/-	119.8	1513.9	+/-	149.7
Elemental C	71.5	+/-	9.0	40.4	+/-	5.1	58.1	+/-	7.3	63.5	+/-	8.0	54.2	+/-	6.8
Total C	1238.6	+/-	115.8	668.2	+/-	62.7	1019.5	+/-	95.4	1274.7	+/-	119.1	1568.1	+/-	146.5
Cl^-	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0	0.0	+/-	0.0
NO_3^-	0.4	+/-	0.1	0.4	+/-	0.1	0.3	+/-	0.1	0.4	+/-	0.1	0.6	+/-	0.1
SO_4^{2-}	0.5	+/-	0.1	0.5	+/-	0.1	0.5	+/-	0.1	0.6	+/-	0.1	1.1	+/-	0.1
NH_4^+	0.1	+/-	0.0	0.2	+/-	0.0	0.1	+/-	0.1	0.1	+/-	0.0	0.1	+/-	0.0
Na	0.0	+/-	0.1	0.0	+/-	0.1	-0.1	+/-	0.1	-0.1	+/-	0.1	0.0	+/-	0.1
Mg	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0
Al	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Si	0.2	+/-	0.0	0.3	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0
P	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.4	+/-	0.0
S	0.6	+/-	0.1	0.4	+/-	0.0	0.6	+/-	0.1	0.5	+/-	0.0	0.6	+/-	0.1
Cl	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0
K	0.0	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ca	0.3	+/-	0.0	0.2	+/-	0.0	0.3	+/-	0.0	0.3	+/-	0.0	1.2	+/-	0.1
Ti	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1
V	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Mg	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Fe	0.1	+/-	0.0	0.1	+/-	0.0	0.2	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0
Co	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ni	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cu	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Zn	0.3	+/-	0.0	0.2	+/-	0.0	0.3	+/-	0.0	0.3	+/-	0.0	0.2	+/-	0.0
Ga	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
As	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Se	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Br	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Rb	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Y	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Zr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Mo	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Pd	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ag	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cd	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
In	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sn	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sb	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1
Ba	0.0	+/-	0.2	0.0	+/-	0.2	-0.1	+/-	0.2	-0.1	+/-	0.2	0.0	+/-	0.2
La	0.0	+/-	0.2	0.0	+/-	0.1	0.1	+/-	0.2	0.0	+/-	0.2	0.0	+/-	0.2
Au	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Hg	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Tl	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Pb	0.0	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0
U	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0

Appendix C. FTP PM Composition for 1990 Ford F350 Van (mg/mi)

Fuel	CARB			EC-D			OXy-G blend			SoyGold blend			World Energy		
Organic C	96.4	+/-	9.9	74.3	+/-	7.8	89.8	+/-	9.3	77.1	+/-	8.0	70.8	+/-	7.4
Elemental C	25.5	+/-	3.2	41.9	+/-	5.3	33.2	+/-	4.2	35.0	+/-	4.4	36.5	+/-	4.6
Total C	121.9	+/-	11.8	116.1	+/-	11.2	123.0	+/-	11.9	112.2	+/-	10.9	107.3	+/-	10.4
Cl^-	0.0	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.2	+/-	0.0
NO_3^-	0.3	+/-	0.1	0.4	+/-	0.1	0.3	+/-	0.1	0.3	+/-	0.1	1.2	+/-	0.1
SO_4^{2-}	0.7	+/-	0.1	0.4	+/-	0.1	0.8	+/-	0.1	0.9	+/-	0.1	1.5	+/-	0.1
NH_4^+	0.2	+/-	0.1	0.2	+/-	0.0	0.2	+/-	0.1	0.3	+/-	0.1	0.3	+/-	0.1
Na	-0.1	+/-	0.1	0.0	+/-	0.1	0.1	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1
Mg	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.3	+/-	0.0
Al	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Si	0.3	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0
P	0.2	+/-	0.0	0.3	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0	0.7	+/-	0.1
S	0.4	+/-	0.0	0.3	+/-	0.0	0.4	+/-	0.0	0.4	+/-	0.0	0.5	+/-	0.0
Cl	0.0	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.2	+/-	0.0
K	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ca	0.4	+/-	0.0	0.5	+/-	0.0	0.4	+/-	0.0	0.5	+/-	0.0	1.9	+/-	0.2
Ti	0.0	+/-	0.0	0.0	+/-	0.1	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
V	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Mg	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Fe	0.0	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0
Co	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ni	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cu	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Zn	0.4	+/-	0.0	0.5	+/-	0.0	0.4	+/-	0.0	0.4	+/-	0.0	0.4	+/-	0.0
Ga	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
As	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Se	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Br	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Rb	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Y	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Zr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Mo	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Pd	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ag	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cd	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
In	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sn	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sb	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1
Ba	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	-0.1	+/-	0.1	-0.1	+/-	0.1
La	0.0	+/-	0.1	0.1	+/-	0.1	0.0	+/-	0.1	-0.1	+/-	0.1	0.0	+/-	0.1
Au	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Hg	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Tl	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Pb	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
U	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0

Appendix C. FTP PM Composition for 1989 Chevy 2500 (mg/mi)

Fuel	CARB			EC-D			OXy-G blend			SoyGold blend			World Energy		
Organic C	176.0	+/-	17.8	110.9	+/-	11.4	153.9	+/-	15.6	201.0	+/-	20.2	192.6	+/-	19.4
Elemental C	29.4	+/-	3.7	70.5	+/-	8.9	43.7	+/-	5.5	31.5	+/-	4.0	40.3	+/-	5.1
Total C	205.4	+/-	19.6	181.4	+/-	17.3	197.6	+/-	18.8	232.5	+/-	22.1	232.9	+/-	22.1
Cl^-	0.0	+/-	0.0	0.1	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0
NO_3^-	0.2	+/-	0.0	0.3	+/-	0.1	0.2	+/-	0.0	0.2	+/-	0.1	0.8	+/-	0.1
SO_4^{2-}	0.4	+/-	0.1	0.3	+/-	0.1	0.4	+/-	0.1	0.5	+/-	0.1	1.0	+/-	0.1
NH_4^+	0.3	+/-	0.1	0.2	+/-	0.1	0.2	+/-	0.0	0.1	+/-	0.0	0.2	+/-	0.1
Na	0.0	+/-	0.1	0.0	+/-	0.1	0.1	+/-	0.0	0.0	+/-	0.1	0.0	+/-	0.1
Mg	0.0	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0	0.0	+/-	0.0	0.2	+/-	0.0
Al	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Si	0.5	+/-	0.1	0.6	+/-	0.1	0.5	+/-	0.0	0.4	+/-	0.0	0.5	+/-	0.0
P	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.6	+/-	0.1
S	0.4	+/-	0.0	0.3	+/-	0.0	0.4	+/-	0.0	0.4	+/-	0.0	0.6	+/-	0.1
Cl	0.1	+/-	0.0	0.1	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0
K	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ca	0.1	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0	1.5	+/-	0.1
Ti	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1
V	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Mg	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Fe	0.0	+/-	0.0	0.1	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0
Co	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ni	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cu	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Zn	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0
Ga	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
As	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Se	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Br	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Rb	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Y	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Zr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Mo	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Pd	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ag	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cd	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
In	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sn	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sb	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1
Ba	0.0	+/-	0.1	0.0	+/-	0.1	-0.1	+/-	0.1	-0.1	+/-	0.2	-0.1	+/-	0.2
La	0.1	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1
Au	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Hg	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Tl	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Pb	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
U	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0

Appendix C. FTP PM Composition for 1985 Chevy C20 PU (mg/mi)

Fuel	CARB			EC-D			OXy-G blend			SoyGold blend			World Energy		
Organic C	91.5	+/-	9.4	75.6	+/-	7.9	80.0	+/-	8.3	76.9	+/-	8.0	88.1	+/-	9.1
Elemental C	105.3	+/-	13.3	86.3	+/-	10.9	116.9	+/-	14.7	88.0	+/-	11.1	84.0	+/-	10.6
Total C	196.8	+/-	18.8	161.9	+/-	15.5	196.9	+/-	18.8	164.9	+/-	15.8	172.1	+/-	16.4
Cl^-	0.1	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
NO_3^-	0.2	+/-	0.0	0.1	+/-	0.0	0.3	+/-	0.1	0.2	+/-	0.1	0.8	+/-	0.1
SO_4^{2-}	0.4	+/-	0.1	0.1	+/-	0.0	0.4	+/-	0.1	0.4	+/-	0.1	0.8	+/-	0.1
NH_4^+	0.2	+/-	0.1	0.1	+/-	0.0	0.2	+/-	0.1	0.2	+/-	0.1	0.2	+/-	0.1
Na	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1
Mg	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.2	+/-	0.0
Al	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Si	0.5	+/-	0.0	0.4	+/-	0.0	0.5	+/-	0.0	0.4	+/-	0.0	0.4	+/-	0.0
P	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.6	+/-	0.1
S	0.3	+/-	0.0	0.2	+/-	0.0	0.4	+/-	0.0	0.4	+/-	0.0	0.5	+/-	0.0
Cl	0.0	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0
K	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ca	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.2	+/-	0.0	1.4	+/-	0.1
Ti	0.0	+/-	0.1	0.0	+/-	0.0	0.0	+/-	0.1	0.0	+/-	0.0	0.0	+/-	0.1
V	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Mg	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Fe	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Co	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ni	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cu	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Zn	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0
Ga	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
As	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Se	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Br	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Rb	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Y	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Zr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Mo	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Pd	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ag	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cd	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
In	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sn	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sb	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1
Ba	-0.1	+/-	0.1	-0.1	+/-	0.1	0.0	+/-	0.1	-0.1	+/-	0.1	0.0	+/-	0.2
La	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1
Au	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Hg	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Tl	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Pb	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
U	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0

Appendix C. FTP PM Composition for 1983 F-250 PU (mg/mi)

Fuel	CARB			EC-D			OXy-G blend			SoyGold blend			World Energy		
Organic C	505.3	+/-	50.2	379.1	+/-	37.8	466.4	+/-	46.4	584.7	+/-	58.1	634.2	+/-	62.9
Elemental C	41.7	+/-	5.3	36.3	+/-	4.6	40.3	+/-	5.1	33.3	+/-	4.2	32.2	+/-	4.1
Total C	547.0	+/-	51.4	415.4	+/-	39.1	506.6	+/-	47.6	618.1	+/-	58.0	666.4	+/-	62.5
Cl^-	0.1	+/-	0.0	0.1	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0
NO_3^-	0.5	+/-	0.1	0.7	+/-	0.1	0.7	+/-	0.1	0.8	+/-	0.1	1.4	+/-	0.1
SO_4^{2-}	1.4	+/-	0.1	0.9	+/-	0.1	1.2	+/-	0.1	1.3	+/-	0.1	2.0	+/-	0.2
NH_4^+	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.1	0.3	+/-	0.1
Na	-0.1	+/-	0.2	-0.2	+/-	0.2	-0.2	+/-	0.2	-0.3	+/-	0.2	-0.2	+/-	0.2
Mg	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.0	+/-	0.0	0.1	+/-	0.0
Al	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Si	0.2	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.2	+/-	0.0
P	0.5	+/-	0.0	0.6	+/-	0.1	0.5	+/-	0.0	0.6	+/-	0.1	0.8	+/-	0.1
S	1.0	+/-	0.1	0.8	+/-	0.1	0.9	+/-	0.1	1.1	+/-	0.1	1.1	+/-	0.1
Cl	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0	0.2	+/-	0.0
K	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ca	1.6	+/-	0.1	1.6	+/-	0.1	1.7	+/-	0.2	1.8	+/-	0.2	2.8	+/-	0.3
Ti	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1
V	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Mg	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Fe	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.1	+/-	0.0	0.2	+/-	0.0
Co	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ni	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cu	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Zn	1.1	+/-	0.1	1.1	+/-	0.1	1.1	+/-	0.1	1.3	+/-	0.1	1.4	+/-	0.1
Ga	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
As	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Se	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Br	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Rb	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Y	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Zr	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Mo	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Pd	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Ag	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Cd	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
In	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sn	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Sb	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1	0.0	+/-	0.1
Ba	-0.1	+/-	0.2	0.0	+/-	0.2	0.0	+/-	0.2	0.0	+/-	0.2	0.0	+/-	0.2
La	0.0	+/-	0.2	0.0	+/-	0.2	0.0	+/-	0.2	0.1	+/-	0.2	0.1	+/-	0.2
Au	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Hg	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Tl	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
Pb	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0
U	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0	0.0	+/-	0.0

Appendix D. FTP PAH Emissions for the 1993 Ford F350 PU (mg/mi)

	CARB			EC-D			OXy-G blend			SoyGold blend			World Energy blend		
Naphthalene	6.82	+/-	0.62	3.16	+/-	0.29	3.37	+/-	0.31	4.55	+/-	0.42	2.28	+/-	0.22
2-methylnaphthalene	7.80	+/-	0.96	1.31	+/-	0.19	2.90	+/-	0.38	5.23	+/-	0.65	1.35	+/-	0.19
1-methylnaphthalene	9.59	+/-	1.13	1.51	+/-	0.19	3.41	+/-	0.41	6.04	+/-	0.72	1.65	+/-	0.20
Biphenyl	2.15	+/-	0.23	0.56	+/-	0.06	0.81	+/-	0.09	1.44	+/-	0.15	0.31	+/-	0.03
1+2-ethylnaphthalene	2.04	+/-	0.19	0.37	+/-	0.03	0.62	+/-	0.06	1.28	+/-	0.12	0.10	+/-	0.01
2,6+2,7-dimethylnaphthalene	4.58	+/-	0.51	0.68	+/-	0.08	1.33	+/-	0.15	2.71	+/-	0.31	0.14	+/-	0.04
1,3+1,6+1,7-dimethylnaphthalene	7.59	+/-	0.71	1.24	+/-	0.12	2.51	+/-	0.23	4.91	+/-	0.46	0.37	+/-	0.04
1,4+1,5+2,3-dimethylnaphthalene	2.34	+/-	0.21	0.38	+/-	0.04	0.80	+/-	0.07	1.47	+/-	0.13	0.13	+/-	0.02
1,2-dimethylnaphthalene	0.80	+/-	0.07	0.15	+/-	0.02	0.28	+/-	0.03	0.51	+/-	0.05	0.08	+/-	0.01
2-methylbiphenyl	0.58	+/-	0.06	0.52	+/-	0.06	0.31	+/-	0.03	0.49	+/-	0.05	0.37	+/-	0.04
3-methylbiphenyl	3.16	+/-	0.29	1.20	+/-	0.11	1.36	+/-	0.13	2.20	+/-	0.20	1.01	+/-	0.09
4-methylbiphenyl	1.46	+/-	0.14	0.51	+/-	0.05	0.54	+/-	0.05	0.96	+/-	0.09	0.46	+/-	0.05
bibenz	1.04	+/-	0.09	0.21	+/-	0.02	0.57	+/-	0.05	0.87	+/-	0.08	1.53	+/-	0.14
A-trimethylnaphthalene	1.80	+/-	0.16	0.41	+/-	0.04	1.02	+/-	0.09	1.50	+/-	0.14	0.40	+/-	0.04
1-ethyl-2-methylnaphth	0.13	+/-	0.01	0.03	+/-	0.00	0.07	+/-	0.01	0.10	+/-	0.01	0.07	+/-	0.01
B-trimethylnaphthalene	1.46	+/-	0.17	0.32	+/-	0.04	0.94	+/-	0.11	1.32	+/-	0.16	0.48	+/-	0.06
C-trimethylnaphthalene	1.34	+/-	0.18	0.27	+/-	0.04	0.79	+/-	0.11	1.14	+/-	0.15	0.43	+/-	0.06
2-ethyl-1-methylnaphth	0.04	+/-	0.00	0.01	+/-	0.00	0.03	+/-	0.00	0.04	+/-	0.00	0.01	+/-	0.00
E-trimethylnaphthalene	0.85	+/-	0.11	0.19	+/-	0.03	0.59	+/-	0.08	0.83	+/-	0.11	0.35	+/-	0.05
F-trimethylnaphthalene	0.75	+/-	0.11	0.16	+/-	0.02	0.45	+/-	0.07	0.63	+/-	0.09	0.48	+/-	0.07
2,3,5-trimethylnaphtha	1.12	+/-	0.13	0.18	+/-	0.02	0.69	+/-	0.08	0.96	+/-	0.11	0.59	+/-	0.07
2,4,5-trimethylnaphtha	0.38	+/-	0.04	0.06	+/-	0.01	0.23	+/-	0.03	0.32	+/-	0.04	0.24	+/-	0.03
J-trimethylnaphthalene	0.59	+/-	0.07	0.10	+/-	0.01	0.30	+/-	0.04	0.48	+/-	0.06	0.18	+/-	0.02
1,4,5-trimethylnaphtha	0.13	+/-	0.01	0.01	+/-	0.00	0.08	+/-	0.01	0.12	+/-	0.01	0.11	+/-	0.01
1,2,8-trimethylnaphtha	0.22	+/-	0.03	0.03	+/-	0.00	0.13	+/-	0.02	0.21	+/-	0.03	0.12	+/-	0.02
Acenaphthylene	0.22	+/-	0.02	0.10	+/-	0.01	0.13	+/-	0.01	0.14	+/-	0.01	0.12	+/-	0.01
Acenaphthene	0.18	+/-	0.07	0.13	+/-	0.05	0.11	+/-	0.05	0.15	+/-	0.06	0.11	+/-	0.05
Fluorene	0.45	+/-	0.05	0.12	+/-	0.02	0.28	+/-	0.03	0.34	+/-	0.04	1.14	+/-	0.14
Phenanthrene	0.93	+/-	0.08	0.19	+/-	0.02	0.47	+/-	0.04	0.61	+/-	0.06	0.56	+/-	0.05
A-methylfluorene	0.42	+/-	0.05	0.08	+/-	0.01	0.24	+/-	0.03	0.37	+/-	0.04	0.35	+/-	0.04
1-Methylfluorene	0.50	+/-	0.04	0.07	+/-	0.01	0.25	+/-	0.02	0.37	+/-	0.03	0.53	+/-	0.05
B-methylfluorene	0.14	+/-	0.02	0.03	+/-	0.00	0.07	+/-	0.01	0.09	+/-	0.01	0.10	+/-	0.01
fl9one	0.03	+/-	0.01	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
Xanthone	0.00	+/-	0.00	0.10	+/-	0.01	0.19	+/-	0.02	0.36	+/-	0.03	0.16	+/-	0.01
acquone	0.24	+/-	0.02	0.03	+/-	0.00	0.08	+/-	0.01	0.12	+/-	0.01	0.07	+/-	0.01
Perinaphthenone	0.10	+/-	0.01	0.03	+/-	0.00	0.03	+/-	0.00	0.08	+/-	0.01	0.07	+/-	0.01
A-methylphenanthrene	0.49	+/-	0.05	0.09	+/-	0.01	0.24	+/-	0.02	0.32	+/-	0.03	0.59	+/-	0.05
2-methylphenanthrene	0.52	+/-	0.05	0.10	+/-	0.01	0.24	+/-	0.02	0.34	+/-	0.03	0.48	+/-	0.04
B-methylphenanthrene	0.02	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
C-methylphenanthrene	0.52	+/-	0.06	0.09	+/-	0.01	0.24	+/-	0.03	0.34	+/-	0.04	0.44	+/-	0.05
1-methylphenanthrene	0.41	+/-	0.04	0.07	+/-	0.01	0.20	+/-	0.02	0.26	+/-	0.03	0.42	+/-	0.04
Anthraquinone	0.03	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.00	+/-	0.00
3,6-dimethylphenanthre	0.19	+/-	0.02	0.03	+/-	0.00	0.08	+/-	0.01	0.12	+/-	0.01	0.19	+/-	0.02
A-dimethylphenanthrene	0.24	+/-	0.02	0.04	+/-	0.00	0.10	+/-	0.01	0.15	+/-	0.01	0.25	+/-	0.02
B-dimethylphenanthrene	0.12	+/-	0.01	0.02	+/-	0.00	0.05	+/-	0.01	0.07	+/-	0.01	0.13	+/-	0.01
C-dimethylphenanthrene	0.73	+/-	0.07	0.09	+/-	0.01	0.32	+/-	0.03	0.45	+/-	0.04	0.70	+/-	0.06
1,7-dimethylphenanthre	0.38	+/-	0.05	0.05	+/-	0.01	0.17	+/-	0.02	0.21	+/-	0.03	0.38	+/-	0.06
D-dimethylphenanthrene	0.24	+/-	0.02	0.03	+/-	0.00	0.10	+/-	0.01	0.17	+/-	0.02	0.20	+/-	0.02
E-dimethylphenanthrene	0.22	+/-	0.03	0.03	+/-	0.00	0.09	+/-	0.01	0.13	+/-	0.02	0.12	+/-	0.02
Anthracene	0.10	+/-	0.01	0.02	+/-	0.00	0.05	+/-	0.00	0.07	+/-	0.01	0.05	+/-	0.00
9-methylanthracene	-0.11	+/-	0.12	-0.11	+/-	0.12	-0.12	+/-	0.12	-0.11	+/-	0.12	0.03	+/-	0.17
Fluoranthene	0.04	+/-	0.00	0.03	+/-	0.00	0.03	+/-	0.00	0.04	+/-	0.00	0.09	+/-	0.01

Pyrene	0.29	+/-	0.03	0.14	+/-	0.01	0.18	+/-	0.02	0.22	+/-	0.02	0.20	+/-	0.02
9-anthraldehyde	0.25	+/-	0.02	0.04	+/-	0.00	0.12	+/-	0.01	0.18	+/-	0.02	0.48	+/-	0.05
Retene	0.04	+/-	0.01	0.01	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.01	0.06	+/-	0.01
Benzonaphthothiophene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00
1-MeFl+C-MePy/Fl	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.08	+/-	0.02
4H-cyclopenta(def)phenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
1-phenylnaphthalene	0.05	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.03	+/-	0.00	0.12	+/-	0.01
2-phenylnaphthalene	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.03	+/-	0.00
D-MePy/MeFl	0.34	+/-	0.03	0.17	+/-	0.02	0.18	+/-	0.02	0.24	+/-	0.02	0.58	+/-	0.05
4-methylpyrene	0.34	+/-	0.03	0.18	+/-	0.02	0.19	+/-	0.02	0.26	+/-	0.02	0.63	+/-	0.06
1-methylpyrene	0.24	+/-	0.02	0.12	+/-	0.01	0.13	+/-	0.01	0.18	+/-	0.02	0.47	+/-	0.04
benzo(c)phenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.02	+/-	0.00
Benz(a)anthracene	0.01	+/-	0.01	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
7-methylbenz(a)anthracene	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Chrysene	0.04	+/-	0.01	0.01	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.03	+/-	0.00
Benz(a)anthracene-7,12-dione	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
5+6-methylchrysene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benzo(b+j+k)fluoranthe	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
7-methylbenzo(a)pyrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
BeP	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Perylene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
BaP	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Indeno[123-cd]pyrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benzo(ghi)perylene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Dibenz(ah+ac)anthracene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Coronene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Total PAHs	67.77			15.76			28.69			46.72			23.31		

Appendix D. FTP PAH Emissions for the 1990 Ford F350 Van (mg/mi)

	RFD			ARCO			OXy-G Blend			SoyGold Blend			World Energy Blend		
Naphthalene	2.32	+/-	0.22	1.97	+/-	0.19	0.74	+/-	0.10	2.08	+/-	0.20	2.39	+/-	0.23
2-methylnaphthalene	0.15	+/-	0.07	0.04	+/-	0.06	0.01	+/-	0.06	0.12	+/-	0.07	-0.03	+/-	0.06
1-methylnaphthalene	0.29	+/-	0.05	0.17	+/-	0.04	0.20	+/-	0.04	0.30	+/-	0.05	0.12	+/-	0.03
Biphenyl	0.06	+/-	0.01	0.03	+/-	0.00	0.03	+/-	0.00	0.04	+/-	0.00	0.05	+/-	0.01
1+2-ethylnaphthalene	0.04	+/-	0.00	0.02	+/-	0.00	-0.01	+/-	0.00	-0.01	+/-	0.00	0.02	+/-	0.00
2,6+2,7-dimethylnaphthalene	0.05	+/-	0.03	0.02	+/-	0.03	-0.03	+/-	0.03	-0.03	+/-	0.03	0.06	+/-	0.03
1,3+1,6+1,7-dimethylnaphthalene	0.13	+/-	0.02	0.04	+/-	0.01	-0.06	+/-	0.01	-0.06	+/-	0.01	0.08	+/-	0.01
1,4+1,5+2,3-dimethylnaphthalene	0.04	+/-	0.01	0.01	+/-	0.01	-0.01	+/-	0.01	-0.01	+/-	0.01	0.02	+/-	0.01
1,2-dimethylnaphthalene	0.03	+/-	0.01	0.01	+/-	0.01	0.00	+/-	0.01	0.00	+/-	0.01	0.01	+/-	0.01
2-methylbiphenyl	0.34	+/-	0.04	0.11	+/-	0.01	0.03	+/-	0.01	0.07	+/-	0.01	0.40	+/-	0.04
3-methylbiphenyl	0.28	+/-	0.03	0.14	+/-	0.02	0.07	+/-	0.01	0.16	+/-	0.02	0.23	+/-	0.02
4-methylbiphenyl	0.14	+/-	0.01	0.08	+/-	0.01	0.03	+/-	0.00	0.09	+/-	0.01	0.09	+/-	0.01
bibenz	0.10	+/-	0.01	0.07	+/-	0.01	0.21	+/-	0.02	0.20	+/-	0.02	0.13	+/-	0.01
A-trimethylnaphthalene	0.06	+/-	0.01	0.02	+/-	0.01	0.01	+/-	0.01	0.01	+/-	0.01	0.04	+/-	0.01
1-ethyl-2-methylnaphth	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
B-trimethylnaphthalene	0.07	+/-	0.01	0.02	+/-	0.01	0.02	+/-	0.01	0.02	+/-	0.01	0.05	+/-	0.01
C-trimethylnaphthalene	0.06	+/-	0.01	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.04	+/-	0.01
2-ethyl-1-methylnaphth	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
E-trimethylnaphthalene	0.04	+/-	0.01	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.01
F-trimethylnaphthalene	0.03	+/-	0.01	0.00	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.01
2,3,5-trimethylnaphtha	0.04	+/-	0.01	-0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00
2,4,5-trimethylnaphtha	0.03	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
J-trimethylnaphthalene	0.05	+/-	0.01	0.01	+/-	0.00	0.00	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00
1,4,5-trimethylnaphtha	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
1,2,8-trimethylnaphtha	0.02	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Acenaphthylene	0.04	+/-	0.01	0.03	+/-	0.01	0.04	+/-	0.01	0.07	+/-	0.01	0.05	+/-	0.01
Acenaphthene	0.09	+/-	0.04	0.07	+/-	0.03	-0.01	+/-	0.01	0.01	+/-	0.01	-0.01	+/-	0.01
Fluorene	0.03	+/-	0.01	0.01	+/-	0.00	0.08	+/-	0.01	0.08	+/-	0.01	0.03	+/-	0.00
Phenanthrene	0.09	+/-	0.01	0.03	+/-	0.00	0.03	+/-	0.00	0.03	+/-	0.00	0.04	+/-	0.00
A-methylfluorene	0.03	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
1-Methylfluorene	0.04	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
B-methylfluorene	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
fl9one	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.02	+/-	0.00
Xanthone	0.03	+/-	0.00	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00
acquone	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Perinaphthenone	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.04	+/-	0.01
A-methylphenanthrene	0.04	+/-	0.00	0.02	+/-	0.00	0.03	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00
2-methylphenanthrene	0.04	+/-	0.00	0.02	+/-	0.00	0.03	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00
B-methylphenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
C-methylphenanthrene	0.03	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00
1-methylphenanthrene	0.02	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00	0.00	+/-	0.00
Anthraquinone	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
3,6-dimethylphenanthre	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
A-dimethylphenanthrene	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
B-dimethylphenanthrene	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
C-dimethylphenanthrene	0.03	+/-	0.00	0.01	+/-	0.00	0.03	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00
1,7-dimethylphenanthre	0.02	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
D-dimethylphenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
E-dimethylphenanthrene	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
Anthracene	0.01	+/-	0.00	0.00	+/-	0.00	0.04	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00
9-methylanthracene	-0.11	+/-	0.12	-0.12	+/-	0.12	0.03	+/-	0.17	-0.12	+/-	0.12	-0.12	+/-	0.12
Fluoranthene	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00

Pyrene	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00
9-anthraldehyde	0.01	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00
Retene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benzonaphthothiophene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
1-MeFl+C-MePy/Fl	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
4H-cyclopenta(def)phenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
1-phenylnaphthalene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
2-phenylnaphthalene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
D-MePy/MeFl	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
4-methylpyrene	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
1-methylpyrene	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
benzo(c)phenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benz(a)anthracene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
7-methylbenz(a)anthracene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Chrysene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.02	+/-	0.00
Benz(a)anthracene-7,12-dione	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
5+6-methylchrysene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benzo(b+j+k)fluoranthe	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
7-methylbenzo(a)pyrene	0.00	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
BeP	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Perylene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
BaP	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Indeno[123-cd]pyrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benzo(ghi)perylene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Dibenz(ah+ac)anthracene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Coronene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00
Total PAHs	4.95			2.97			1.82			3.34			4.17		

Appendix D. FTP PAH Emissions for the 1989 Chevy 2500 PU (mg/mi)

	CARB			EC-D			OXy-G blend			SoyGold blend			World Energy blend		
Naphthalene	3.85	+/-	0.35	4.91	+/-	0.45	4.03	+/-	0.37	4.09	+/-	0.38	1.42	+/-	0.15
2-methylnaphthalene	0.92	+/-	0.14	0.80	+/-	0.13	0.84	+/-	0.14	0.74	+/-	0.12	-0.15	+/-	0.05
1-methylnaphthalene	1.32	+/-	0.16	1.07	+/-	0.14	1.29	+/-	0.16	1.13	+/-	0.14	0.12	+/-	0.03
Biphenyl	0.35	+/-	0.04	0.22	+/-	0.02	0.28	+/-	0.03	0.34	+/-	0.04	0.02	+/-	0.00
1+2-ethylnaphthalene	0.13	+/-	0.01	0.13	+/-	0.01	0.19	+/-	0.02	0.25	+/-	0.02	-0.01	+/-	0.00
2,6+2,7-dimethylnaphthalene	0.25	+/-	0.04	0.11	+/-	0.04	0.23	+/-	0.04	0.33	+/-	0.05	-0.04	+/-	0.03
1,3+1,6+1,7-dimethylnaphthalene	0.57	+/-	0.05	0.27	+/-	0.03	0.56	+/-	0.05	0.71	+/-	0.07	-0.08	+/-	0.01
1,4+1,5+2,3-dimethylnaphthalene	0.20	+/-	0.02	0.09	+/-	0.01	0.18	+/-	0.02	0.22	+/-	0.02	-0.02	+/-	0.01
1,2-dimethylnaphthalene	0.08	+/-	0.01	0.06	+/-	0.01	0.08	+/-	0.01	0.09	+/-	0.01	0.00	+/-	0.01
2-methylbiphenyl	0.22	+/-	0.02	0.15	+/-	0.02	0.15	+/-	0.02	0.16	+/-	0.02	0.06	+/-	0.01
3-methylbiphenyl	0.59	+/-	0.06	0.37	+/-	0.04	0.48	+/-	0.05	0.50	+/-	0.05	0.20	+/-	0.02
4-methylbiphenyl	0.25	+/-	0.02	0.19	+/-	0.02	0.20	+/-	0.02	0.22	+/-	0.02	0.12	+/-	0.01
bibenz	0.12	+/-	0.01	0.03	+/-	0.01	0.11	+/-	0.01	0.11	+/-	0.01	0.05	+/-	0.01
A-trimethylnaphthalene	0.20	+/-	0.02	0.08	+/-	0.01	0.20	+/-	0.02	0.27	+/-	0.03	0.00	+/-	0.01
1-ethyl-2-methylnaphth	0.02	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00
B-trimethylnaphthalene	0.20	+/-	0.03	0.07	+/-	0.01	0.19	+/-	0.02	0.24	+/-	0.03	0.01	+/-	0.01
C-trimethylnaphthalene	0.18	+/-	0.03	0.05	+/-	0.01	0.16	+/-	0.02	0.21	+/-	0.03	-0.01	+/-	0.00
2-ethyl-1-methylnaphth	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.00	+/-	0.00
E-trimethylnaphthalene	0.13	+/-	0.02	0.03	+/-	0.01	0.11	+/-	0.01	0.14	+/-	0.02	0.00	+/-	0.00
F-trimethylnaphthalene	0.11	+/-	0.02	0.03	+/-	0.01	0.09	+/-	0.01	0.11	+/-	0.02	0.00	+/-	0.00
2,3,5-trimethylnaphtha	0.14	+/-	0.02	0.02	+/-	0.00	0.11	+/-	0.01	0.15	+/-	0.02	-0.02	+/-	0.00
2,4,5-trimethylnaphtha	0.05	+/-	0.01	0.01	+/-	0.00	0.04	+/-	0.01	0.06	+/-	0.01	0.01	+/-	0.00
J-trimethylnaphthalene	0.03	+/-	0.00	0.02	+/-	0.00	0.06	+/-	0.01	0.08	+/-	0.01	0.03	+/-	0.00
1,4,5-trimethylnaphtha	0.02	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.03	+/-	0.00	0.00	+/-	0.00
1,2,8-trimethylnaphtha	0.02	+/-	0.00	0.01	+/-	0.00	0.03	+/-	0.00	0.04	+/-	0.01	0.00	+/-	0.00
Acenaphthylene	0.42	+/-	0.04	0.93	+/-	0.08	0.68	+/-	0.06	0.60	+/-	0.05	0.03	+/-	0.01
Acenaphthene	0.05	+/-	0.02	0.00	+/-	0.01	0.00	+/-	0.01	0.03	+/-	0.02	0.02	+/-	0.01
Fluorene	0.17	+/-	0.02	0.15	+/-	0.02	0.18	+/-	0.02	0.17	+/-	0.02	0.06	+/-	0.01
Phenanthrene	0.39	+/-	0.04	0.34	+/-	0.03	0.39	+/-	0.04	0.42	+/-	0.04	0.05	+/-	0.00
A-methylfluorene	0.04	+/-	0.01	0.02	+/-	0.00	0.04	+/-	0.01	0.04	+/-	0.01	0.00	+/-	0.00
1-Methylfluorene	0.04	+/-	0.00	0.02	+/-	0.00	0.05	+/-	0.00	0.06	+/-	0.01	0.00	+/-	0.00
B-methylfluorene	0.01	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.00	+/-	0.00
fl9one	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Xanthone	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
acquone	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.00	+/-	0.00
Perinaphthenone	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
A-methylphenanthrene	0.07	+/-	0.01	0.03	+/-	0.00	0.05	+/-	0.01	0.07	+/-	0.01	0.02	+/-	0.00
2-methylphenanthrene	0.08	+/-	0.01	0.03	+/-	0.00	0.06	+/-	0.01	0.07	+/-	0.01	0.02	+/-	0.00
B-methylphenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
C-methylphenanthrene	0.06	+/-	0.01	0.03	+/-	0.00	0.05	+/-	0.01	0.07	+/-	0.01	0.02	+/-	0.00
1-methylphenanthrene	0.04	+/-	0.00	0.02	+/-	0.00	0.04	+/-	0.00	0.05	+/-	0.01	0.02	+/-	0.00
Anthraquinone	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
3,6-dimethylphenanthre	0.03	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00
A-dimethylphenanthrene	0.03	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00
B-dimethylphenanthrene	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
C-dimethylphenanthrene	0.06	+/-	0.01	0.02	+/-	0.00	0.05	+/-	0.00	0.07	+/-	0.01	0.05	+/-	0.01
1,7-dimethylphenanthre	0.03	+/-	0.00	0.01	+/-	0.00	0.03	+/-	0.00	0.03	+/-	0.00	0.03	+/-	0.00
D-dimethylphenanthrene	0.02	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00
E-dimethylphenanthrene	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00
Anthracene	0.25	+/-	0.02	0.04	+/-	0.00	0.05	+/-	0.00	0.05	+/-	0.00	0.00	+/-	0.00
9-methylanthracene	-0.03	+/-	0.14	-0.12	+/-	0.12	-0.11	+/-	0.12	-0.12	+/-	0.12	-0.11	+/-	0.12
Fluoranthene	0.15	+/-	0.01	0.14	+/-	0.01	0.14	+/-	0.01	0.13	+/-	0.01	0.19	+/-	0.02

Pyrene	0.20	+/-	0.02	0.21	+/-	0.02	0.20	+/-	0.02	0.20	+/-	0.02	0.14	+/-	0.01
9-anthraldehyde	0.04	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.03	+/-	0.00	0.04	+/-	0.00
Retene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benzonaphthothiophene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
1-MeFl+C-MePy/Fl	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
4H-cyclopenta(def)phenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
1-phenylnaphthalene	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.03	+/-	0.00
2-phenylnaphthalene	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
D-MePy/MeFl	0.04	+/-	0.00	0.02	+/-	0.00	0.03	+/-	0.00	0.04	+/-	0.00	0.04	+/-	0.00
4-methylpyrene	0.04	+/-	0.00	0.03	+/-	0.00	0.03	+/-	0.00	0.04	+/-	0.00	0.04	+/-	0.00
1-methylpyrene	0.02	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.03	+/-	0.00	0.03	+/-	0.00
benzo(c)phenanthrene	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
Benz(a)anthracene	0.02	+/-	0.01	0.01	+/-	0.01	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.01
7-methylbenz(a)anthracene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Chrysene	0.02	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.03	+/-	0.00
Benz(a)anthracene-7,12-dione	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
5+6-methylchrysene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benzo(b+j+k)fluoranthe	0.04	+/-	0.01	0.04	+/-	0.01	0.04	+/-	0.01	0.04	+/-	0.01	0.04	+/-	0.01
7-methylbenzo(a)pyrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
BeP	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Perylene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
BaP	0.00	+/-	0.00	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Indeno[123-cd]pyrene	0.02	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00
Benzo(ghi)perylene	0.03	+/-	0.00	0.04	+/-	0.01	0.03	+/-	0.00	0.03	+/-	0.00	0.03	+/-	0.00
Dibenz(ah+ac)anthracene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Coronene	0.01	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
Total PAHs	12.43			10.89			11.92			12.64			2.72		

Appendix D. FTP PAH Emissions for the 1985 Chevy C-20 PU (mg/mi)

	CARB			EC-D			OXy-G blend			SoyGold blend			World Energy blend		
Naphthalene	3.16	+/-	0.29	1.86	+/-	0.18	5.81	+/-	0.53	2.52	+/-	0.24	2.94	+/-	0.28
2-methylnaphthalene	0.00	+/-	0.06	-0.19	+/-	0.05	-0.11	+/-	0.06	-0.09	+/-	0.06	-0.07	+/-	0.06
1-methylnaphthalene	0.32	+/-	0.05	0.07	+/-	0.03	0.19	+/-	0.04	0.20	+/-	0.04	0.19	+/-	0.04
Biphenyl	0.14	+/-	0.02	0.04	+/-	0.01	0.11	+/-	0.01	0.12	+/-	0.01	0.12	+/-	0.01
1+2-ethylnaphthalene	0.08	+/-	0.01	0.00	+/-	0.00	0.04	+/-	0.01	0.05	+/-	0.00	0.04	+/-	0.00
2,6+2,7-dimethylnaphthalene	0.06	+/-	0.03	-0.04	+/-	0.03	0.03	+/-	0.04	0.04	+/-	0.03	0.03	+/-	0.03
1,3+1,6+1,7-dimethylnaphthalene	0.17	+/-	0.02	-0.08	+/-	0.01	0.09	+/-	0.02	0.11	+/-	0.01	0.10	+/-	0.01
1,4+1,5+2,3-dimethylnaphthalene	0.06	+/-	0.01	-0.02	+/-	0.01	0.03	+/-	0.03	0.04	+/-	0.01	0.04	+/-	0.01
1,2-dimethylnaphthalene	0.03	+/-	0.01	0.00	+/-	0.01	0.02	+/-	0.02	0.02	+/-	0.01	0.02	+/-	0.01
2-methylbiphenyl	0.47	+/-	0.05	0.09	+/-	0.01	0.32	+/-	0.04	0.13	+/-	0.02	0.13	+/-	0.01
3-methylbiphenyl	0.50	+/-	0.05	0.26	+/-	0.03	0.60	+/-	0.06	0.28	+/-	0.03	0.27	+/-	0.03
4-methylbiphenyl	0.21	+/-	0.02	0.16	+/-	0.02	0.32	+/-	0.03	0.13	+/-	0.01	0.13	+/-	0.01
bibenz	0.03	+/-	0.01	0.03	+/-	0.01	0.05	+/-	0.01	0.01	+/-	0.01	0.01	+/-	0.01
A-trimethylnaphthalene	0.06	+/-	0.01	0.00	+/-	0.01	0.04	+/-	0.01	0.05	+/-	0.01	0.05	+/-	0.01
1-ethyl-2-methylnaphth	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
B-trimethylnaphthalene	0.06	+/-	0.01	0.00	+/-	0.01	0.04	+/-	0.01	0.05	+/-	0.01	0.05	+/-	0.01
C-trimethylnaphthalene	0.05	+/-	0.01	0.00	+/-	0.00	0.03	+/-	0.01	0.04	+/-	0.01	0.03	+/-	0.01
2-ethyl-1-methylnaphth	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
E-trimethylnaphthalene	0.03	+/-	0.01	0.00	+/-	0.00	0.02	+/-	0.01	0.02	+/-	0.01	0.02	+/-	0.01
F-trimethylnaphthalene	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00
2,3,5-trimethylnaphtha	0.02	+/-	0.00	-0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.00	+/-	0.00
2,4,5-trimethylnaphtha	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
J-trimethylnaphthalene	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
1,4,5-trimethylnaphtha	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.00	+/-	0.00
1,2,8-trimethylnaphtha	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
Acenaphthylene	0.17	+/-	0.02	0.20	+/-	0.02	0.13	+/-	0.02	0.19	+/-	0.02	0.19	+/-	0.02
Acenaphthene	0.00	+/-	0.01	0.01	+/-	0.01	0.01	+/-	0.01	0.01	+/-	0.01	0.02	+/-	0.01
Fluorene	0.04	+/-	0.01	0.13	+/-	0.02	0.04	+/-	0.01	0.04	+/-	0.01	0.04	+/-	0.01
Phenanthrene	0.13	+/-	0.01	0.07	+/-	0.01	0.12	+/-	0.01	0.12	+/-	0.01	0.13	+/-	0.01
A-methylfluorene	0.01	+/-	0.00	0.00	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00
1-Methylfluorene	0.02	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
B-methylfluorene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
fl9one	0.00	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Xanthone	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
acquone	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Perinaphthenone	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
A-methylphenanthrene	0.04	+/-	0.00	0.03	+/-	0.00	0.04	+/-	0.00	0.03	+/-	0.00	0.04	+/-	0.00
2-methylphenanthrene	0.04	+/-	0.00	0.03	+/-	0.00	0.04	+/-	0.00	0.03	+/-	0.00	0.04	+/-	0.00
B-methylphenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
C-methylphenanthrene	0.03	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00
1-methylphenanthrene	0.02	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00
Anthraquinone	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
3,6-dimethylphenanthre	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
A-dimethylphenanthrene	0.02	+/-	0.00	0.02	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00
B-dimethylphenanthrene	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
C-dimethylphenanthrene	0.03	+/-	0.00	0.02	+/-	0.00	0.03	+/-	0.00	0.02	+/-	0.00	0.03	+/-	0.00
1,7-dimethylphenanthre	0.02	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
D-dimethylphenanthrene	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
E-dimethylphenanthrene	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
Anthracene	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
9-methylanthracene	-0.12	+/-	0.12	-0.12	+/-	0.12	-0.12	+/-	0.12	-0.12	+/-	0.12	-0.12	+/-	0.12
Fluoranthene	0.03	+/-	0.00	0.02	+/-	0.00	0.03	+/-	0.01	0.03	+/-	0.00	0.03	+/-	0.00

Pyrene	0.05	+/-	0.01	0.03	+/-	0.00	0.04	+/-	0.01	0.05	+/-	0.00	0.05	+/-	0.01
9-anthraldehyde	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
Retene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benzonaphthothiophene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.01	0.00	+/-	0.00	0.00	+/-	0.00
1-MeFl+C-MePy/Fl	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
4H-cyclopenta(def)phenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
1-phenylnaphthalene	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
2-phenylnaphthalene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
D-MePy/MeFl	0.02	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
4-methylpyrene	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
1-methylpyrene	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
benzo(c)phenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benz(a)anthracene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.01	0.00	+/-	0.00	0.00	+/-	0.00
7-methylbenz(a)anthracene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Chrysene	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benz(a)anthracene-7,12-dione	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
5+6-methylchrysene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benzo(b+j+k)fluoranthe	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
7-methylbenzo(a)pyrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
BeP	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Perylene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
BaP	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.01	0.00	+/-	0.00	0.00	+/-	0.00
Indeno[123-cd]pyrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.01	0.00	+/-	0.00	0.00	+/-	0.00
Benzo(ghi)perylene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.01	0.00	+/-	0.00	0.00	+/-	0.00
Dibenz(ah+ac)anthracene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.01	0.00	+/-	0.00	0.00	+/-	0.00
Coronene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Total PAHs	6.22			2.79			8.33			4.39			4.85		

Appendix D. FTP PAH Emissions for the 1983 Ford F250 PU (mg/mi)

	CARB			EC-D			SoyGold Blend			World Energy Blend		
Naphthalene	2.67	+/-	0.25	1.77	+/-	0.18	3.83	+/-	0.35	3.34	+/-	0.31
2-methylnaphthalene	1.58	+/-	0.22	0.33	+/-	0.08	1.93	+/-	0.26	1.14	+/-	0.17
1-methylnaphthalene	2.00	+/-	0.24	0.53	+/-	0.07	2.12	+/-	0.26	1.33	+/-	0.17
Biphenyl	0.54	+/-	0.06	0.13	+/-	0.01	0.48	+/-	0.05	0.39	+/-	0.04
1+2-ethylnaphthalene	0.10	+/-	0.01	0.08	+/-	0.01	0.36	+/-	0.03	0.31	+/-	0.03
2,6+2,7-dimethylnaphthalene	0.25	+/-	0.04	0.10	+/-	0.04	0.73	+/-	0.09	0.58	+/-	0.07
1,3+1,6+1,7-dimethylnaphthalene	0.57	+/-	0.05	0.21	+/-	0.02	1.48	+/-	0.14	1.22	+/-	0.11
1,4+1,5+2,3-dimethylnaphthalene	0.21	+/-	0.02	0.07	+/-	0.01	0.47	+/-	0.04	0.38	+/-	0.04
1,2-dimethylnaphthalene	0.09	+/-	0.01	0.03	+/-	0.01	0.19	+/-	0.02	0.15	+/-	0.02
2-methylbiphenyl	0.30	+/-	0.03	0.19	+/-	0.02	0.62	+/-	0.07	0.28	+/-	0.03
3-methylbiphenyl	1.20	+/-	0.11	0.42	+/-	0.04	1.00	+/-	0.09	0.78	+/-	0.07
4-methylbiphenyl	0.50	+/-	0.05	0.18	+/-	0.02	0.42	+/-	0.04	0.33	+/-	0.03
bibenz	0.52	+/-	0.05	0.03	+/-	0.01	0.36	+/-	0.03	0.33	+/-	0.03
A-trimethylnaphthalene	0.29	+/-	0.03	0.08	+/-	0.01	0.59	+/-	0.05	0.49	+/-	0.04
1-ethyl-2-methylnaphth	0.02	+/-	0.00	0.01	+/-	0.00	0.05	+/-	0.01	0.03	+/-	0.00
B-trimethylnaphthalene	0.36	+/-	0.04	0.07	+/-	0.01	0.59	+/-	0.07	0.46	+/-	0.06
C-trimethylnaphthalene	0.36	+/-	0.05	0.05	+/-	0.01	0.53	+/-	0.07	0.40	+/-	0.05
2-ethyl-1-methylnaphth	0.01	+/-	0.00	0.00	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00
E-trimethylnaphthalene	0.28	+/-	0.04	0.03	+/-	0.01	0.37	+/-	0.05	0.28	+/-	0.04
F-trimethylnaphthalene	0.32	+/-	0.05	0.03	+/-	0.01	0.32	+/-	0.05	0.22	+/-	0.03
2,3,5-trimethylnaphtha	0.46	+/-	0.05	0.02	+/-	0.00	0.47	+/-	0.05	0.33	+/-	0.04
2,4,5-trimethylnaphtha	0.14	+/-	0.02	0.01	+/-	0.00	0.17	+/-	0.02	0.12	+/-	0.01
J-trimethylnaphthalene	0.06	+/-	0.01	0.02	+/-	0.00	0.21	+/-	0.03	0.18	+/-	0.02
1,4,5-trimethylnaphtha	0.06	+/-	0.01	0.01	+/-	0.00	0.06	+/-	0.01	0.03	+/-	0.00
1,2,8-trimethylnaphtha	0.03	+/-	0.00	0.01	+/-	0.00	0.09	+/-	0.01	0.07	+/-	0.01
Acenaphthylene	0.15	+/-	0.01	0.03	+/-	0.01	0.08	+/-	0.01	0.08	+/-	0.01
Acenaphthene	0.13	+/-	0.05	0.09	+/-	0.04	0.07	+/-	0.03	0.17	+/-	0.07
Fluorene	0.40	+/-	0.05	0.02	+/-	0.00	0.21	+/-	0.03	0.13	+/-	0.02
Phenanthrene	0.31	+/-	0.03	0.04	+/-	0.00	0.36	+/-	0.03	0.21	+/-	0.02
A-methylfluorene	0.11	+/-	0.01	0.01	+/-	0.00	0.19	+/-	0.02	0.12	+/-	0.01
1-Methylfluorene	0.15	+/-	0.01	0.01	+/-	0.00	0.21	+/-	0.02	0.14	+/-	0.01
B-methylfluorene	0.04	+/-	0.00	0.01	+/-	0.00	0.05	+/-	0.01	0.04	+/-	0.00
fl9one	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00
Xanthone	0.00	+/-	0.00	0.01	+/-	0.00	0.00	+/-	0.00	0.13	+/-	0.01
acquone	0.02	+/-	0.00	0.00	+/-	0.00	0.02	+/-	0.00	0.05	+/-	0.00
Perinaphthenone	0.03	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00	0.03	+/-	0.00
A-methylphenanthrene	0.14	+/-	0.01	0.02	+/-	0.00	0.14	+/-	0.01	0.12	+/-	0.01
2-methylphenanthrene	0.16	+/-	0.01	0.02	+/-	0.00	0.16	+/-	0.01	0.13	+/-	0.01
B-methylphenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
C-methylphenanthrene	0.15	+/-	0.02	0.02	+/-	0.00	0.14	+/-	0.02	0.12	+/-	0.02
1-methylphenanthrene	0.12	+/-	0.01	0.01	+/-	0.00	0.12	+/-	0.01	0.10	+/-	0.01
Anthraquinone	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00
3,6-dimethylphenanthre	0.06	+/-	0.01	0.01	+/-	0.00	0.05	+/-	0.00	0.05	+/-	0.00
A-dimethylphenanthrene	0.07	+/-	0.01	0.01	+/-	0.00	0.05	+/-	0.00	0.06	+/-	0.01
B-dimethylphenanthrene	0.04	+/-	0.00	0.01	+/-	0.00	0.03	+/-	0.00	0.03	+/-	0.00
C-dimethylphenanthrene	0.21	+/-	0.02	0.02	+/-	0.00	0.16	+/-	0.01	0.16	+/-	0.01
1,7-dimethylphenanthre	0.11	+/-	0.02	0.02	+/-	0.00	0.08	+/-	0.01	0.08	+/-	0.01
D-dimethylphenanthrene	0.07	+/-	0.01	0.00	+/-	0.00	0.05	+/-	0.01	0.05	+/-	0.01
E-dimethylphenanthrene	0.06	+/-	0.01	0.01	+/-	0.00	0.04	+/-	0.01	0.05	+/-	0.01
Anthracene	0.04	+/-	0.00	0.00	+/-	0.00	0.04	+/-	0.00	0.03	+/-	0.00
9-methylanthracene	-0.10	+/-	0.12	-0.12	+/-	0.12	-0.11	+/-	0.12	-0.11	+/-	0.12
Fluoranthene	0.04	+/-	0.00	0.01	+/-	0.00	0.02	+/-	0.00	0.01	+/-	0.00

Pyrene	0.13	+/-	0.01	0.04	+/-	0.00	0.08	+/-	0.01	0.08	+/-	0.01
9-anthraldehyde	0.09	+/-	0.01	0.01	+/-	0.00	0.06	+/-	0.01	0.08	+/-	0.01
Retene	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
Benzonaphthothiophene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
1-MeFl+C-MePy/Fl	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
4H-cyclopenta(def)phenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
1-phenylnaphthalene	0.02	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
2-phenylnaphthalene	0.01	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
D-MePy/MeFl	0.11	+/-	0.01	0.03	+/-	0.00	0.08	+/-	0.01	0.08	+/-	0.01
4-methylpyrene	0.12	+/-	0.01	0.03	+/-	0.00	0.08	+/-	0.01	0.08	+/-	0.01
1-methylpyrene	0.07	+/-	0.01	0.02	+/-	0.00	0.05	+/-	0.00	0.06	+/-	0.01
benzo(c)phenanthrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benz(a)anthracene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
7-methylbenz(a)anthracene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Chrysene	0.01	+/-	0.00	0.00	+/-	0.00	0.01	+/-	0.00	0.01	+/-	0.00
Benz(a)anthracene-7,12-dione	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
5+6-methylchrysene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benzo(b+j+k)fluoranthe	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
7-methylbenzo(a)pyrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
BeP	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Perylene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
BaP	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Indeno[123-cd]pyrene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Benzo(ghi)perylene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Dibenz(ah+ac)anthracene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Coronene	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00	0.00	+/-	0.00
Total PAHs	16.02			4.81			20.02			15.59		