FINAL REPORT

STUDY TO DETERMINE THE FATE OF BENZENE PRECURSORS IN GASOLINE

by

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ABSTRACT

Exhaust emissions from five late model vehicles were measured to determine the effect of aromatic fuel components on benzene emissions. The purpose of the work was to determine if there are any fuel components that are major sources of benzene emissions. Reducing the content of such components in gasoline could then be a means of reducing benzene emissions. Analyses of engine-out (before catalyst) and tailpipe-out (after catalyst) exhaust emissions were made to determine catalyst efficiency for reducing benzene emissions.

Benzene (in fuel) effect on benzene exhaust emissions was much greater than that of the other aromatic species. On an equal volume basis, the non-benzene aromatics--toluene, ethylbenzene, xylenes, and C_9^+ aromatics--had an average effect on benzene emissions about 1/12 that of fuel benzene. All of the non-benzene aromatic components tend to increase exhaust benzene levels. However, the ethlybenzene effect was not statistically significantly different from zero.

The benzene reduction efficiency of the exhaust emissions control systems was about the same as total hydrocarbon reduction efficiency. Benzene emissions were reduced by 70 to 95% by the exhaust emission control systems.

Predictive equations were developed using the results of this study. These equations enable estimation of the changes in the benzene emissions as a function of changes in gasoline composition.

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DISCLAIMER

The statements and conclusions in this report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source or their use in connection with material reported herein, is not to be construed as either an actual or implied endorsement of such products.

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SUMMARY AND CONCLUSIONS

Exhaust emission rates of benzene were measured for five current production vehicles. Fuel composition was varied in order to determine the effect of selected aromatic components on benzene emissions.

Analyses of exhaust sampled before and after the exhaust catalyst showed that the source of benzene in the exhaust is from the engine and it is not formed in the exhaust catalyst. Benzene content of the exhaust after the catalyst was invariably less than that before the catalyst. The reduction in benzene emissions across the catalyst ranged from about 70 to 90%.

The work was conducted in three phases. The tests in Phase I were done to determine if the aromatic species of interest did indeed act as sources of benzene emissions. The results of these tests showed that all of the species (benzene, toluene, ethylbenzene, o-xylene) did cause benzene emissions. Another blend component, a mixture of aromatics containing nine or more carbon atoms, also acted as a benzene precursor. On the basis of equal content in the fuel, benzene itself was by far the most significant precursor of benzene in the exhaust. Benzene emission per volume percent component in fuel was about 16 times greater for benzene than for the other aromatic species.

The tests in Phase II utilized fuels containing all of the aromatic components examined in Phase I. For the matrix of 9 fuels, the levels of the individual components were varied in a manner designed to enable determination of linear and quadratic effects of each precursor on benzene emissions. Predictive equations were developed using the results of Phase II.

Phase III consisted of emissions tests with three full-boiling-range commercial fuels and one special blended fuel. The purpose of these tests was to verify the predictive equations developed in Phase II. A comparison of the predicted levels with actual benzene emissions is given in table 1.

TABLE 1. - Benzene emissions with commercial and blended fuels, predicted versus actual

	Benzene Emissions, wt % of Total HC			
	Engine-out		Tailpipe-out	
Fuel	Actual	Fitted	Actual	Fitted
NIPER Blend	3.8	3.8	4.4	3.6
Indolene	2.4	1.9	1.8	0.9
Commercial #1	3.6	3.1	2.6	2.5
Commercial #2	3.6	3.1	2.9	2.4

The actual benzene emissions were consistently higher than the fitted (or predicted) emissions. This could be due to benzene being formed from naphthenes and olefins in Indolene and the commercial fuels. There were no naphthenes or olefins in the fuels that were used to develop the predictive equations.

Although the equations did not accurately predict the absolute level of benzene emissions, they did reasonably well predict changes in emissions for the different composition fuels. For the type of vehicles used in this program, the predictive equations can be used to estimate changes in benzene emissions as a function of changes in gasoline composition.

RECOMMENDATIONS

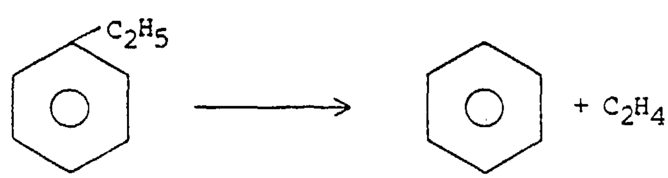
Determine the effects of other potential benzene precursors on benzene emissions. Specifically, measure the effects of naphthenes and olefins in gasoline on benzene emissions.

INTRODUCTION

Background

Benzene is a toxic air contaminant identified by the Air Resources Board (ARB) which will be regulated in accordance with the Health and Safety Code section 39650 et seq. Evaporative and exhaust emissions from gasoline-fueled vehicles are the largest known source of benzene to the air pollution inventory. The ARB has projected that the annual vehicular benzene emissions in California are 13,363 tons or 83% of the total state-wide benzene emissions (1)*. Appropriate means of control can best be addressed with an understanding of the interactive effects of fuel composition, engine combustion, and catalytic conversion on exhaust emissions.

As early as 1970, research (2) showed that benzene was formed during the combustion event using benzene-free fuels consisting of mixtures of isooctane, isooctene, and meta-xylene. Analysis of the results of three more recent experimental studies (3,4,5) indicates that the benzene weight fraction of total exhaust hydrocarbon correlates rather well with certain fuel compositional variables--specifically, benzene content and total aromatic content. Thus, it is highly likely that some (or all) aromatic species are precursors of benzene that is formed in the combustion process and emitted to the atmosphere. Benzene can be formed from other aromatic compounds by removal of alkyl groups from the benzene ring, perhaps by thermal cracking. An example of this is shown for ethylbenzene:



Ethylbenzene   Benzene + ethylene

Benzene in fuel can be a source of benzene exhaust emissions as a consequence of incomplete combustion.

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*Underlined numbers in parentheses refer to items in the list of references at the end of the report.

By identifying the most significant benzene precursors and limiting their level in gasoline, benzene emissions can be reduced. However, the significance of the individual species as benzene precursors (other than benzene itself) cannot be discerned from the previous studies. Because this information was lacking, NIPER was contracted by the ARB to investigate the relative contribution of several probable benzene precursors to exhaust emissions of benzene from current production vehicles.

Objectives

The objectives of this research project were to identify the specific aromatic compounds (e.g., toluene, isomers of xylene, ethylbenzene, etc.) that are converted in the engine or on the catalyst to benzene and to quantify the effects of the concentrations of these compounds in gasoline upon the benzene concentration in the exhaust emissions.

EXPERIMENTAL METHODOLOGY

Experimental Design

Exhaust emissions from a fleet of current production vehicles were measured following the protocol specified in the Federal Test Procedure (FTP). Emission rates of benzene, toluene, ethylbenzene, and xylenes as well as regulated pollutants were determined for both engine-out (pre-catalyst) and tailpipe-out (post-catalyst) exhaust. Fuel composition was varied systematically within three different matrices corresponding to the three experimental phases of the project.

The purpose of the Phase I experiments was to determine which of the test compounds have any effect on benzene emissions. Each test fuel for this phase consisted of a single aromatic compound blended into a light alkylate stock. Each aromatic test compound (benzene, toluene, ethylbenzene, o-xylene) was added at a level of either 5 or 10 volume percent, whichever was closer to the level of the specific component in commercial gasolines. A fifth fuel was formulated with a heavy reformate (primarily C_9^+ aromatics) at a level of 10 volume percent in the alkylate.

A measure of the significance of each test compound as a benzene precursor was then obtained by comparing the emissions for each test fuel with the emissions for the neat alkylate fuel. The test components that appeared to influence benzene emissions were then included in subsequent experiments. All of the test components did cause increased benzene emissions.

The purpose of the Phase II experiments was to quantify the influence of the precursors at various levels in fuel. The four components (benzene, toluene, ethylbenzene, and mixed xylenes) were each blended at equally-spaced low, medium, and high levels into an alkylate + reformate base to formulate nine fuels. The medium level of each aromatic component was approximately equal to the average level of the component in commercial gasolines.

Including three levels of each aromatic in the design made it possible to determine whether benzene concentrations are adequately fitted by a linear function of the aromatic levels or whether including second-order terms would significantly improve the fit. The nine sets of levels of four aromatics constitute a fractional factorial design (one-ninth of a complete factorial design with four factors, each at three levels, to be precise.) Advantages of the fractional factorial design include the statistical independence of all of the linear and quadratic effects of the aromatic concentrations, which greatly simplifies evaluation of properties of the relationships and their subsequent use for prediction.

The purpose of the Phase III experiments was to verify the predictive equations developed from Phase II test results. This was done by comparing the results of the exhaust emissions tests with predictions using analyses of the Phase III fuels and equations developed in Phase II.

Equipment and Materials

Vehicles - Five vehicles were used in this program. Their descriptions are given in table 2. All vehicles were 50-state certified and were selected from a California vehicle certification list supplied by the ARB. The vehicle selection was limited to electronic fuel injection systems--central and port. All five vehicles were equipped with three-way catalyst systems with closed loop control. Three of the vehicles utilized air injection, and one of these also used an oxidation catalyst. The vehicle selection required specific vehicle identification based on individual engine family numbers which are included in table 2, test vehicle specification. The fleet consisted of three domestic and two foreign manufactured vehicles. One of the imported vehicles carried the Dodge nameplate but was built in Japan by Mitsubishi and was identified as an imported vehicle. All vehicles had a minimum of 4,000 miles at the start of the test program.

TABLE 2. - Vehicle descriptions

Vehicle No.	Model Year	Manufacturer	Model	Engine Family No.	Current[1] Mileage	Fuel System[2]	Emission Control System[3]
505	1985	GM[4]	Regal	F4G3.8V8XEB3	20,131	PFI	EGR, 3CL
606	1986	Ford[4]	Thunderbird	GFM2.3V5FGK3	4,222	PFI, TC	EGR, 3CL
603	1986	Mazda[5]	626	GTK2.0V5FFJ0	\8,092	PFI	EGR, 3CL, AIR
605	1986	Dodge[5]	Colt (Mitsubishi)	GMT1.6V5FFD6	4,097	CFI, TC	EGR, 3CL, AIR
604	1986	Ford[4]	Escort	GFM1.9V5HMK9	4,045	PFI	EGR, 3CL, OX, AIR

[1]Vehicle mileage at start of the test program.
[2]Fuel system: CFI - central fuel injection; PFI - port fuel injection; and TC - turbocharged.
[3]Emission control system: EGR - exhaust gas recirculation; 3CL - three-way catalyst and closed loop; AIR - air injection; OX - oxidation catalyst.
[4]Domestic manufacturer.
[5]Foreign manufacturer.

To enable collection of engine-out exhaust samples, a sampling port was installed in the exhaust system after the exhaust manifold or turbocharger (if equipped) and in front of the exhaust catalyst. The engine-out sampling port was installed in all five test vehicles.

Fuels - A different fuel matrix was used in each of the three phases of the experimental program. The test fuels for Phases I and II were blended at NIPER. One of the fuels for Phase III was blended at NIPER and the others were purchased from commercial suppliers.

There were six test fuels in Phase I. These included an aromatic-free alkylate stock and five blends of the alkylate stock with each of the individual aromatic species: benzene, toluene, ethylbenzene, ortho-xylene, and reformate (C_9^+ aromatic blending stock). The target compositions and analyzed compositions are given in table 3. Specific gravity, hydrogen-to-carbon ratio, and Reid vapor pressure were also measured for each fuel and are included in table 3.

There were nine test fuels used in Phase II. Nine of the fuels were formulated with four aromatic components (benzene, toluene, ethylbenzene, and xylenes) blended at low, medium, and high levels in the alkylate base stock. The target level of reformate in all nine fuels was 10 volume percent.

TABLE 3. - Composition of Phase I test fuels

Fuel No.	8603	8635	8636	8637	8638	8639
	Volume Percent					
	Target Fuel Composition					
	Alkylate 100	Benzene 5	Toluene 10	Ethyl-benzene 5	o-Xylene 10	Reformate 10
Fuel Component	Analyzed Fuel Composition					
Benzene	0.0	5.10	0.01	0.01	0.01	0.01
Toluene	0.11	0.17	11.23	0.11	0.10	0.10
Ethylbenzene	0.01	0.00	0.02	5.36	0.02	0.02
m- and p-Xylene	0.05	0.05	0.06	0.00	0.15	0.01
o-Xylene	0.02	0.02	0.02	0.02	10.53	0.96
C_9 and higher	0	0	0	0	0	10.09
Alkylate	99.8	94.7	88.7	94.5	89.2	88.8
H/C Ratio	2.29	2.20	2.13	2.22	2.14	2.16
Specific Gravity	0.688	0.698	0.707	0.698	0.708	0.698
RVP, psi	10.4	9.8	9.3	9.6	9.1	9.4

The individual blending components used in the Phase II fuels were the same as those used in Phase I, except that a mixture of xylene isomers was used in place of the ortho-xylene used in Phase I. The xylene mixture was approximately 50% ortho-xylene and 50% meta- plus para-xylenes. The target compositions and analyzed values are given in table 4. Analyses of the Phase II fuels were also performed by Chevron Research Company. The results of these analyses are in reasonably good agreement with NIPER's. Comparisons are given in appendix A. Specific gravity, hydrogen-to-carbon ratio, and Reid vapor pressure were also measured for each fuel and are included in table 4.

The four fuels used in Phase III include a vehicle emissions certification fuel (Indolene), two commercial gasolines, and a fuel blended at NIPER. The commercial gasolines were procured from California fuel distributors marketing ARCO and Chevron fuels in the Los Angeles Basin. The analyses of the Phase III fuels are given in table 5.

All test fuels were stored in closed containers in a facility that was maintained at 60° F.

TABLE 4. - Composition of Phase II fuels analyses

Fuel No.	8715	8716	8717	8718	8719	8720	8721	8722	8723
Fuel Components	Fuel Composition, volume percent								
	Target Values								
Benzene	1	1	1	2	2	2	3	3	3
Toluene	10	5	15	5	10	15	5	10	15
Ethylbenzene	3	1	5	3	5	1	5	1	3
Xylenes	10	5	15	15	5	10	10	15	5
C_9^+	10	10	10	10	10	10	10	10	10
Total aromatics	34	22	46	35	32	38	33	39	36
	Analyzed Values								
Benzene	1.2	1.1	1.0	2.1	2.1	2.2	3.4	3.4	3.2
Toluene	10.1	5.1	15.9	5.2	10.2	16.1	5.2	10.4	15.5
Ethylbenzene	2.8	0.9	5.1	2.9	5.1	0.9	5.0	0.9	2.7
m- and p-Xylene	5.2	2.6	8.2	8.4	2.6	5.5	5.3	7.9	2.4
o-Xylene	5.6	3.1	8.5	8.6	3.3	6.5	5.9	8.7	3.2
Total xylenes	10.8	5.7	16.7	17.0	5.9	12.0	11.2	16.6	5.6
C_9^+ Aromatics	10.4	10.1	10.5	10.7	10.8	12.3	10.5	10.7	10.8
Total aromatics	35.3	22.9	49.2	37.9	34.1	43.5	35.3	42.0	37.8
H/C Ratio	1.85	1.99	1.70	1.83	1.85	1.75	1.85	1.77	1.80
Specific gravity	0.749	0.731	0.772	0.754	0.749	0.768	0.754	0.765	0.762
RVP, psi	9.2	9.1	9.6	9.5	9.2	9.5	9.5	9.2	9.5

TABLE 5. - Composition of Phase III fuels

Fuel No. Description	8724 Blend	8594 Indolene	8725 Commercial	8726 Commercial
Components	Fuel Composition, volume percent			
Benzene	1.1	0.4	1.5	1.5
Toluene	11.6	7.3	6.0	6.0
Ethylbenzene	3.4	1.7	1.2	1.3
m- and p-Xylene	5.3	2.6	6.0	5.7
o-Xylene	7.9	0.9	2.0	1.8
C_9^+ Aromatics	18.5	10.7	13.8	13.3
H/C Ratio	1.74	1.97	1.85	1.86
Specific Gravity	0.768	0.726	0.754	0.751
RVP, psi	9.8	8.7	8.4	8.6

Test Facility - The vehicle test facility schematic is shown in figure 1. Temperature-controlled air (75° F) was supplied to the front of the test vehicle during emission testing. The air speed over the vehicle was modulated to follow the dynamometer roll speed. The vehicle's tailpipe-out exhaust sample was collected using a constant volume sampling (CVS) system. A small portion of the engine-out exhaust was collected using a mini CVS system. The samples collected from both systems were analyzed for regulated emissions (CO, HC, and NO_x) using instrumentation that meets the requirements specified by the EPA for light-duty vehicle emissions determination.

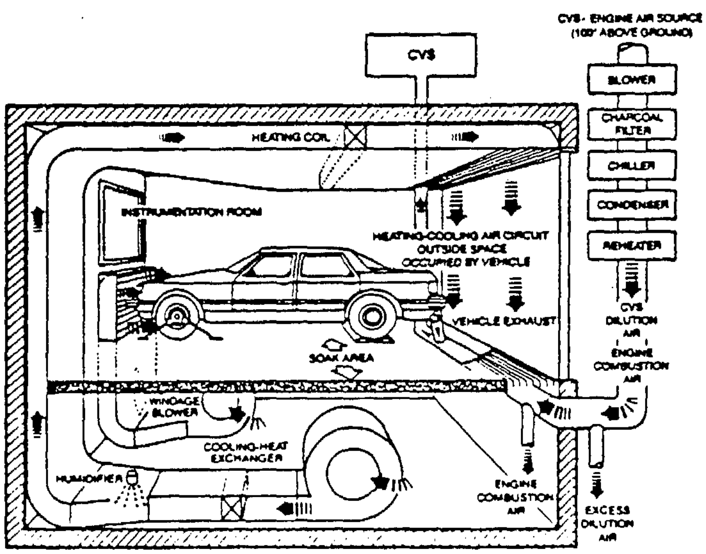


FIGURE 1 - Vehicle test facility schematic.

Mini CVS System - The mini CVS system was developed for use in a research project sponsored by Coordinating Research Council (5). Benzene, hydrocarbon, and other engine-out (before catalyst) and tailpipe-out (after catalyst) emissions were measured to determine the catalyst efficiency for reduction of benzene and hydrocarbons across the catalyst. The before-catalyst samples were collected simultaneously with after-catalyst samples using the mini CVS system. A schematic of the exhaust sampling system is shown in figure 2. The operation of the mini CVS included a control logic circuit which monitored the diluted exhaust CO_2 analyzer signal (main CVS) and varied the amount of the air dilution into a constant flow of engine-out exhaust such that the dilution of the mini CVS was dynamically adjusted to equal that of the main CVS. The diluted engine-out mixture was sampled at a constant rate and ducted into a Tedlar bag. Analysis of the composition of this batch sample enabled the determination of mass emission rates in the same manner as that done for the tailpipe-out emissions.

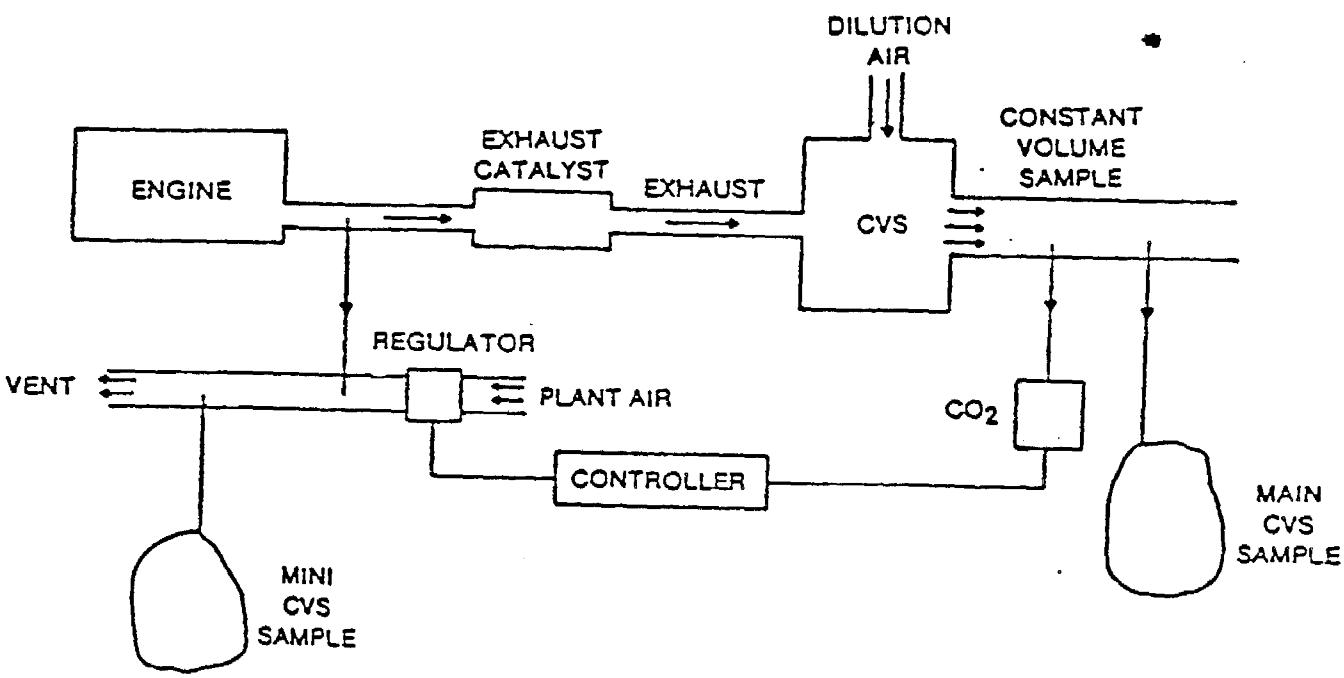


FIGURE 2. - Schematic of mini and main CVS systems.

The mini CVS system capability was compared directly with the main CVS system using two vehicles with the catalysts removed. The vehicles were fueled with Indolene. Both sampling systems were used to collect engine-out emission samples. The vehicles were preconditioned and operated through three-bag FTP cyclic vehicle tests.

The mini and main engine-out HC, CO, and NO_x emission levels measured in each bag are given in table 6. This table includes the percent difference of the main versus mini CVS samples. The results in table 6 show only minor differences between mini and main CVS HC and CO levels in each bag sample. The NO_x results show more differences between the mini and main CVS sampling systems. This is presumably due to errors in the dynamic dilution control during extreme transients of the engine system.

TABLE 6. - Evaluation of the mini CVS system, vehicle 501

Vehicle 501
2.5L TBI Chevrolet without catalyst

Exhaust Sample System	Exhaust Emissions: HC grams/mile Cold	HC Stab	HC Hot	HC Cycle	CO grams/mile Cold	CO Stab	CO Hot	CO Cycle	NO_x grams/mile Cold	NO_x Stab	NO_x Hot	NO_x Cycle	MPG Cycle
Main CVS	1.78	1.84	1.48	1.72	8.69	8.38	7.10	8.09	3.02	3.52	3.18	3.32	26.3
Mini CVS	1.72	1.85	1.46	1.72	8.72	8.02	7.08	7.91	2.95	3.10	2.97	3.03	
Main CVS	1.86	1.90	1.50	1.79	10.97	8.54	7.31	8.70	2.83	3.19	2.76	3.00	26.1
Mini CVS	1.83	1.93	1.53	1.80	10.49	8.51	7.35	8.60	2.75	2.76	2.58	2.70	

Differences in Emission Rates Between Mini and Main, Percent

HC Cold	HC Stab	HC Hot	HC Cyc	CO Cold	CO Stab	CO Hot	CO Cyc	NO_x Cold	NO_x Stab	NO_x Hot	NO_x Cyc
-3	1	-1	0	0	-4	0	-2	-2	-12	-7	-9
-2	2	2	1	-4	0	1	-1	-3	-13	-7	-10

The above emissions data were collected from vehicle 501 which was equipped with a catalyst without air injection and not used in this test program, whereas vehicle 603 which was used in this program was equipped with a catalyst plus air injection. In order to test the effect of the vehicular air injection system on the mini CVS sampling system, the catalyst on vehicle 603 was removed and the air injection system left intact. The mini and main CVS test results of a single FTP test for vehicle 603 fueled with Indolene are given in table 7. For other than total hydrocarbon emissions, there was good agreement between the two sampling systems. Oxidation of hydrocarbons in the exhaust system could be, at least in part, the cause of the differences in hydrocarbon emissions measured by the two sampling systems.

TABLE 7. - Evaluation of the mini CVS system, vehicle 603

Vehicle 603
2.0 L PFI Mazda without catalyst, with air

Regulated Emissions

Exhaust Sample	HC grams/mile				CO grams/mile				NO_x grams/mile			
	COLD	STAB	HOT	FTP	COLD	STAB	HOT	FTP	COLD	STAB	HOT	FTP
Main CVS	1.65	1.65	1.34	1.57	17.54	19.25	14.12	17.48	2.16	1.46	1.94	1.74
Mini CVS	1.79	1.98	1.46	1.80	17.63	20.40	14.26	18.13	2.22	1.37	1.90	1.69

Aromatic Emissions

Exhaust Sample	BENZENE mg/mile				TOLUENE mg/mile				ETHYL BZ mg/mile				TOTAL XYLENES mg/mile			
	COLD	STAB	HOT	FTP	COLD	STAB	HOT	FTP	COLD	STAB	HOT	FTP	COLD	STAB	HOT	FTP
Main CVS	48	48	39	46	163	147	112	140	46	38	28	37	92	82	64	79
Mini CVS	45	51	40	47	152	149	115	140	43	42	31	39	84	92	65	83

Differences in Emission Rates Between Mini and Main, Percent

Emissions	COLD	STAB	HOT	FTP
HC	8	20	9	15
CO	1	6	1	4
NO_x	3	-6	-2	-3
Benzene	-6	6	3	2
Toluene	-7	1	3	0
Ethylbenzene	-7	11	11	5
Xylenes	-9	12	2	5

EXPERIMENTAL WORK

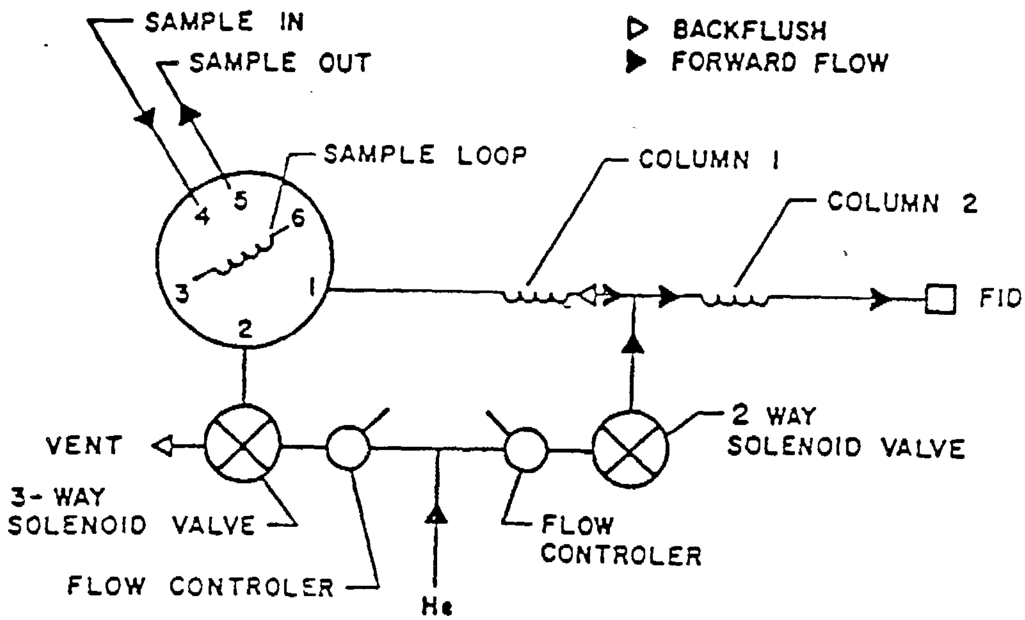
Analytical Instrumentation

The levels of aromatics in test fuels and exhaust samples were measured using two different gas chromatographic (GC) systems. One GC system was used to measure benzene, and the other GC system was used to measure C_7 and C_8 aromatics including toluene, ethylbenzene and individual xylene isomers (meta-, para-, and ortho-xylenes). Both systems use a nonpolar column connected in series with a polar column patterned after the ASTM Standard Method 3606-82 entitled "Benzene and Toluene in Finished Motor and Aviation Gasoline by Gas Chromatography" (6).

Separation of aromatic compounds from paraffins and olefins was accomplished by suitable control of temperature and carrier gas flow. Complete separation of the compounds of interest enabled their measurement without interferences from the other compounds.

A flow schematic, column description, and operating parameters of both chromatographic systems are shown in figure 3. The sample was injected onto column 1, the nonpolar column, which separates the components by boiling point. Following elution of the aromatic compound of interest from column 1 onto column 2, column 1 is backflushed (flow direction reversed) to prevent higher boiling materials from entering column 2. (Note that the flow of the carrier gas is maintained in the same direction through column 2 throughout the analysis.) The hydrocarbons that pass onto column 2 range in boiling point from subambient (methane) up to slightly greater than that of the aromatic compounds of interest.

Subsequent separation of the aromatic species from the other hydrocarbons in column 2 is a consequence of the polar characteristics of aromatic components. Because column 2 is highly polar, aromatics are retained for a longer time than nonpolar hydrocarbons (paraffins). High-boiling nonpolar compounds that would have eluted at the same time as the aromatic compound of interest were segregated from the material on column 2 by virtue of the backflush operation. Thus, the measurement of the aromatic compound is interference-free.



BENZENE ANALYSIS

COLUMN 1: Non-polar-1/8 in. x 3 ft., 5% Siponate DS-10 on Chromosorb WHP (80/100 mesh)

COLUMN 2: Polar-1/8 in. x 10 ft., 10% TCEP on Chromosorb PAW (80/100 mesh)

TEMP. PROGRAM: 20 to 105° C at 16° C/min.

HELIUM CARRIER: Forward flow 69 psig
Backflush flow 49 psig

TOLUENE and C_8 AROMATIC ANALYSIS

COLUMN 1: Non-polar-1/8 in. x 6 ft. 3% SP2100 on Chromosorb WHP (80/100 mesh)

COLUMN 2: Polar-1/8 in. x 10 ft. 15% TCEB on Neutraport S (80/100 mesh)

TEMP. PROGRAM: 40 to 125° C at 8° C/min.

HELIUM CARRIER: Forward flow 96 psig
Backflush flow 60 psig

FIGURE 3. - Flow schematic of chromatograph system.

The ability of the two GC systems to provide accurate measurement of the aromatic compounds of interest has been verified. For the benzene GC, the backflush phase occurs at the point where normal octane begins to elute from column 1. Normal octane, therefore, is the highest boiling compound that is eluted onto column 2. The retention time of this compound on the polar column is significantly less than that of benzene as shown in figure 4. Because n-octane is the highest boiling nonpolar compound present and it elutes well ahead of benzene, there can be no nonpolar compounds eluting at the same time as benzene. Therefore, the benzene determinations are free from interfering compounds. An example exhaust chromatogram of benzene including a calibration chromatogram of benzene is shown in figure 5.

This same verification approach was applied to the GC system for analysis of C_7 and C_8 aromatics using n-nonane as a backflush "marker." Example chromatograms of C_8 aromatics in synthetic blends and exhaust are shown in figure 6.

The interference problem with benzene on the C_8 aromatic GC system was anticipated and was the basis for using two different GC systems to analyze the C_6 through C_8 aromatic species without interferences.

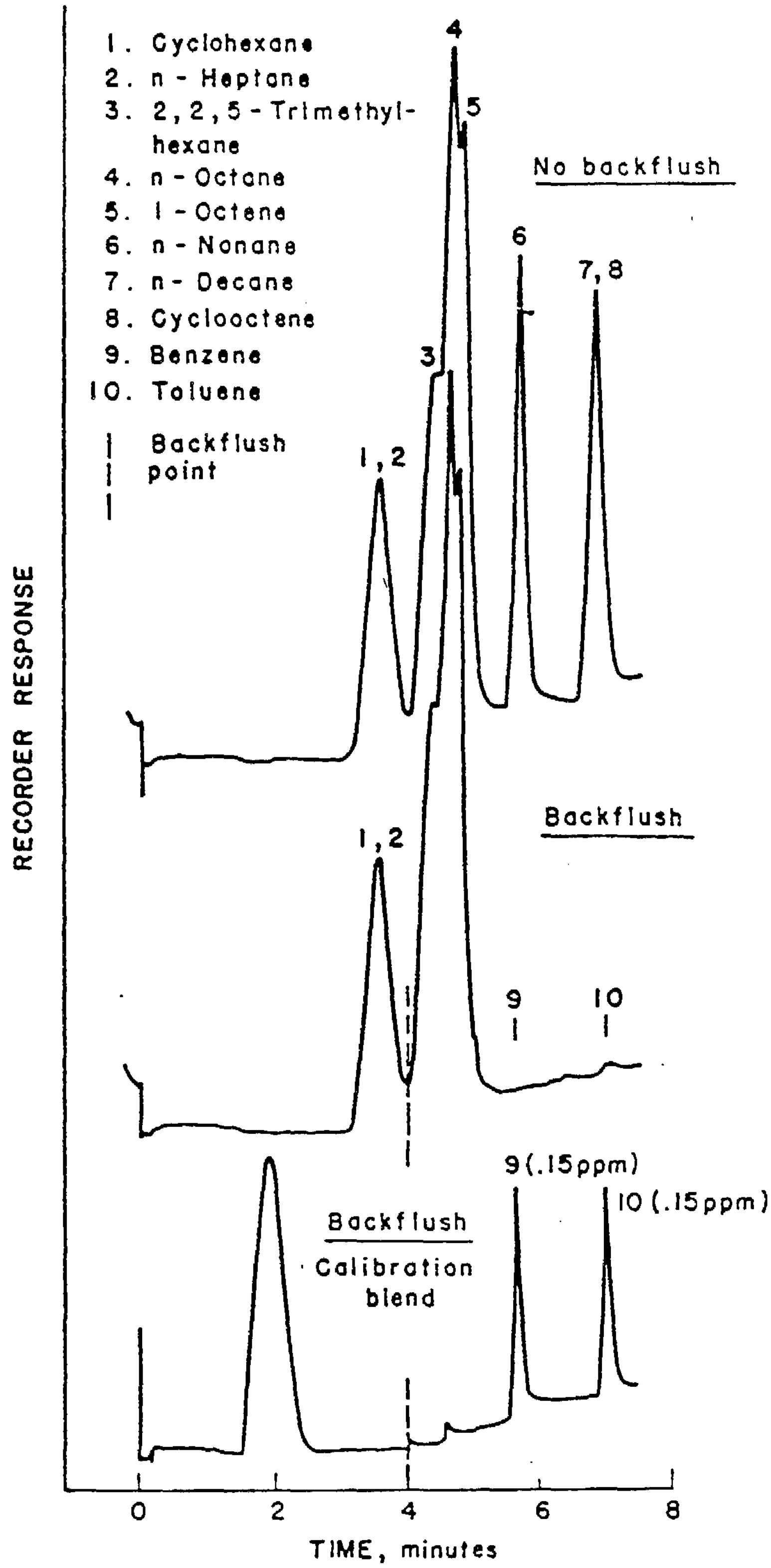


FIGURE 4. - Retention times of benzene and normal octane in a chromatographic column.

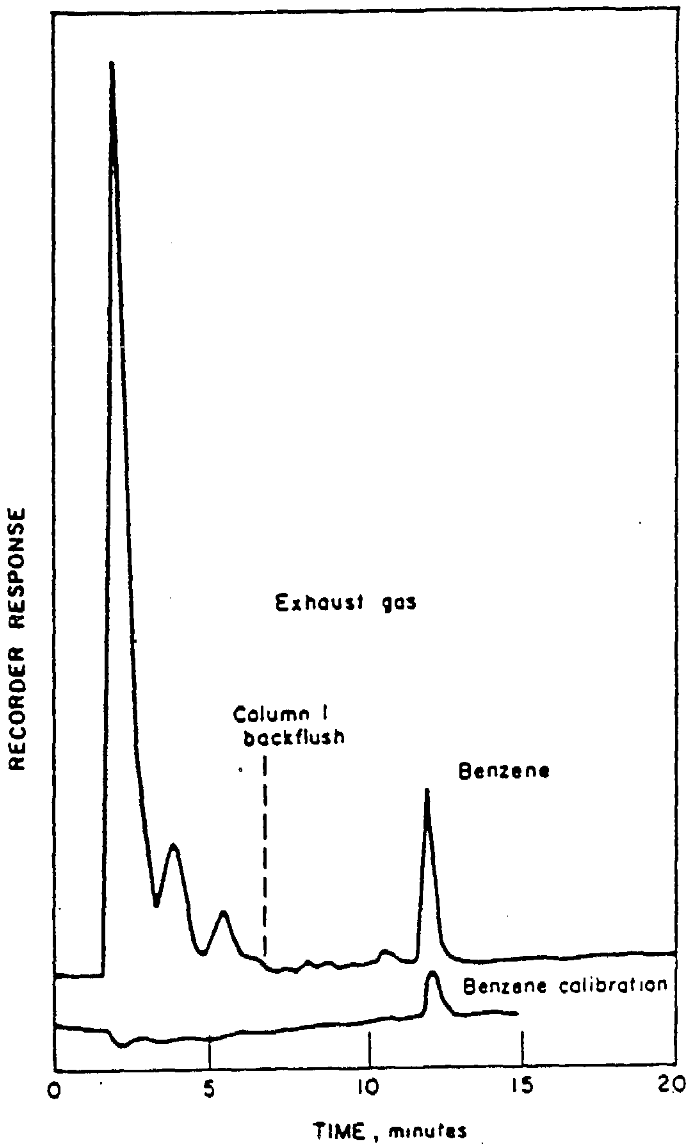


FIGURE 5. - Chromatogram of benzene in exhaust sample.

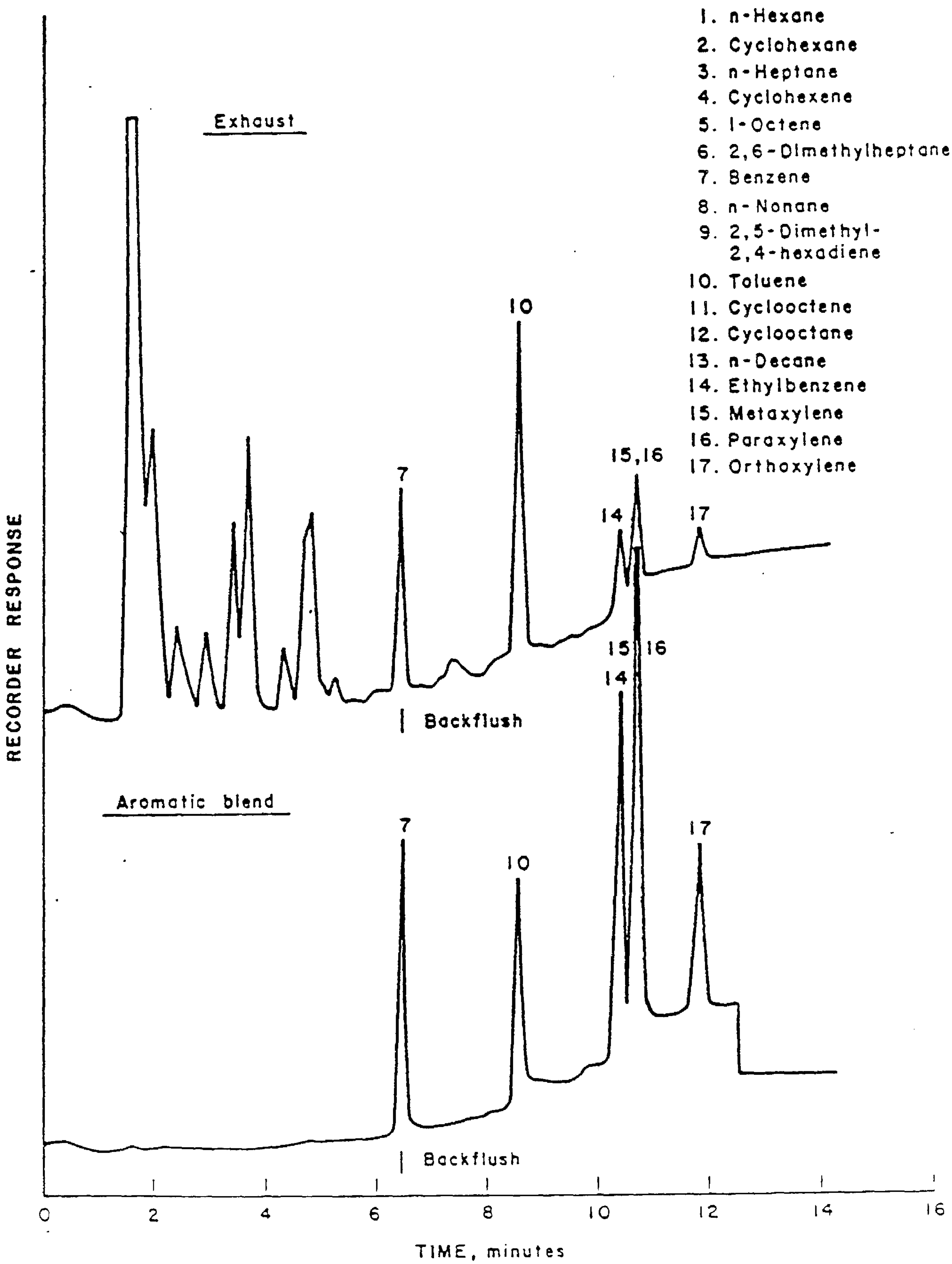


FIGURE 6. - Chromatograms of C_8 aromatics in synthetic blends and exhaust.

Test Procedures

The exhaust emissions tests followed the protocol specified in the Federal Test Procedure (FTP), with some exceptions that are noted below. There are seven events in the FTP. These are, in order of execution:

1. Fuel drain and fill.
2. Vehicle preconditioning on the dynamometer.
3. Cold-soak parking.
4. Fuel drain and fill.
5. Diurnal heat build, in which the fuel in the vehicle in the vehicle tank is heated from 60° to 84° F in 1 hour.
6. Cold-start exhaust test, which includes the cold-transient and stabilized portions of the driving cycle.
7. Hot-start exhaust test, which consists of the hot-transient portion of the driving cycle.

In the current work, steps 4 and 5 were omitted. These steps, fuel drain and refill and diurnal heat build, have considerable influence on evaporative losses but only minor effects on exhaust emissions. When tests were replicated, the first step was omitted as there was sufficient fuel in the vehicle tank to conduct the second test.

RESULTS

The results of all three phases of the project are given in appendices B and C for tailpipe-out and engine-out emissions, respectively. Mass emission rates over each segment of the driving cycle as well as for the composite are included. The individual aromatic species are also reported as weight percent of total hydrocarbon emissions and, for benzene only, as mass emitted per gallon of fuel consumed. The percent reduction of regulated emissions and individual aromatics across the catalyst is given in appendix B.

Phase I Test Results

All of the aromatic species appeared to act as benzene precursors. Benzene emission rates were greater with fuels containing the various aromatic components than with the non-aromatic alkylate alone. This was the case for all five vehicles for both tailpipe-out and engine-out emissions.

Engine-out emissions of benzene were very consistent across the entire five-car fleet for each of the six fuels. Benzene, as weight percent of engine-out hydrocarbon, ranged from about 0.3% for the alkylate fuel to greater than 5% for the fuel containing benzene. The benzene weight percent of total hydrocarbon emissions ranged from about 0.6 to 1.2% for the four fuels containing the other aromatic components. The higher level occurred in the tests with the toluene-alkylate blend. These results are summarized in table 8.

TABLE 8. - Engine-out benzene emissions, weight percent of total HC, Phase I

Fuel	Vehicle					5-Car Average
	505	603	604	605	606	
Alkylate	0.25	0.36	0.30	0.28	0.24	0.29
5% Benzene	5.56	5.25	5.15	5.36	5.20	5.30
11% Toluene	1.05	1.18	1.18	0.91	0.98	1.06
5% Ethylbenzene	0.64	0.89	0.81	0.63	0.55	0.70
11% o-Xylene	0.79	0.97	0.88	0.71	0.64	0.80
10% C_9^+ Aromatics	0.71	0.89	1.03	0.72	0.63	0.80

An indication of the relative response of each aromatic component as a benzene precursor can be obtained by comparing the results of each blended fuel with that of the non-aromatic alkylate. For example, the average increase in weight percent benzene for the toluene-alkylate blend was 0.77% or 0.07% benzene per 1 volume percent toluene in the fuel. This computation was performed for all of the tests in Phase I, and the results are given in table 9.

On the basis of equal content in the fuel, benzene itself has by far the greatest effect on benzene in the exhaust. The other species were roughly comparable to each other, with toluene and ethylbenzene having slightly greater effect than o-xylene and heavy reformate on benzene emissions.

TABLE 9. - Engine-out benzene emissions, incremental weight percent of total HC per volume percent of aromatic component

Aromatic Compound	Vehicle 505	603	604	605	606	5-Car Average	Effect Relative To benzene
Benzene	1.04	0.96	0.95	1.00	0.97	0.98	1.00
Toluene	0.071	0.073	0.079	0.056	0.066	0.069	0.07
Ethylbenzene	0.072	0.098	0.094	0.065	0.057	0.077	0.08
o-Xylene	0.050	0.057	0.054	0.040	0.037	0.048	0.05
C_9^+ Aromatics	0.041	0.047	0.067	0.040	0.035	0.046	0.05

Tailpipe-out emissions of benzene were less consistent across the five-car fleet than were the engine-out emissions. This indicates that there was a vehicle emission control system effect on benzene emissions. For most of the fuel-vehicle test combinations, the benzene weight fraction of tailpipe-out hydrocarbon was slightly lower than the corresponding engine-out weight fraction. This indicates that there might be preferential oxidation of benzene in the emission control system. A summary of the tailpipe-out results is given in table 10.

TABLE 10. - Tailpipe-out benzene emissions, weight percent of total HC, Phase I

Fuel	Vehicle 505	603	604	605	606	5-Car Average
Alkylate	0.38	0.17	0.27	0.28	0.17	0.25
Benzene	5.46	5.29	3.46	4.03	3.56	4.36
Toluene	1.01	0.53	0.69	0.61	0.96	0.76
Ethylbenzene	0.85	0.29	0.66	0.73	0.42	0.59
o-Xylene	0.82	0.38	0.56	0.36	0.60	0.54
C_9^+ Aromatics	0.77	0.38	0.48	0.69	0.63	0.59

The tailpipe-out mass emission rate of benzene was always lower than the corresponding engine-out mass rate. Tailpipe-out rates were roughly 5 to 20% of engine-out rates. This indicates that benzene is not synthesized in the catalyst system or, if it is synthesized, it is oxidized at a fast rate and the net effect is a reduction in the mass of benzene emitted.

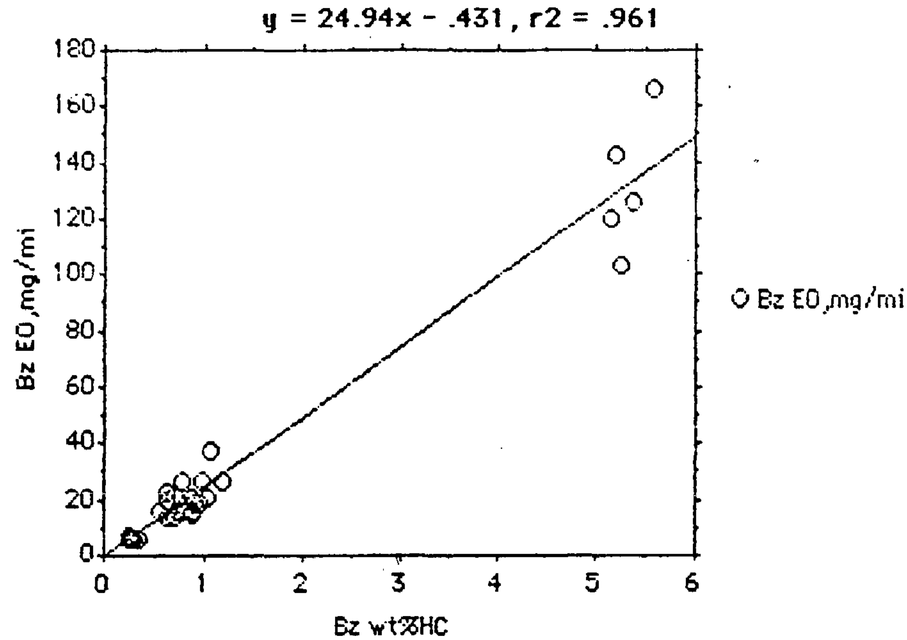
The tailpipe-out benzene emissions per volume percent of aromatic species is given in table 11. For the five-car average, the weight percent benzene tailpipe-out per volume percent aromatic is less than the engine-out weight percent for all of the aromatic species. The effect of the aromatics relative to that of benzene is about the same for engine-out and tailpipe-out benzene emissions, however.

TABLE 11. - Tailpipe-out benzene emissions, incremental weight percent of total HC per volume percent of aromatic component

Aromatic Compound	Vehicle 505	603	604	605	606	5-Car Average	Effect relative to benzene
Benzene	1.00	1.00	0.63	0.74	0.66	0.81	1
Toluene	0.056	0.032	0.037	0.029	0.070	0.045	0.06
Ethylbenzene	0.088	0.022	0.073	0.084	0.047	0.063	0.07
o-Xylene	0.042	0.020	0.028	0.008	0.041	0.028	0.05
C_9^+ Aromatics	0.036	0.018	0.018	0.038	0.043	0.031	0.04

The results of other work (3,4,5) were analyzed for comparison with the Phase I results. The effect of total non-benzene aromatics relative to that of benzene was about 0.07 for the Concawe results (3) and 0.08 for the EPA results (4). The CRC results (5) are 0.05 for engine-out weight percent benzene and 0.12 for tailpipe-out. These results are consistent with those determined in Phase I where the average effect of the aromatic components relative to that of benzene was about 0.06.

Benzene mass emission rates are plotted against benzene weight percent of total hydrocarbon emissions in figure 7. These plots show that benzene mass emission rate is highly correlated with benzene weight percent of total HC. This simply reflects the fact that total hydrocarbon emissions were not significantly affected by fuel composition for the Phase I fuels. Note that the slopes of the lines in figure 7 are the total hydrocarbon emission rates (engine-out and tailpipe-out). In subsequent analyses of the data only the weight percent terms were used.



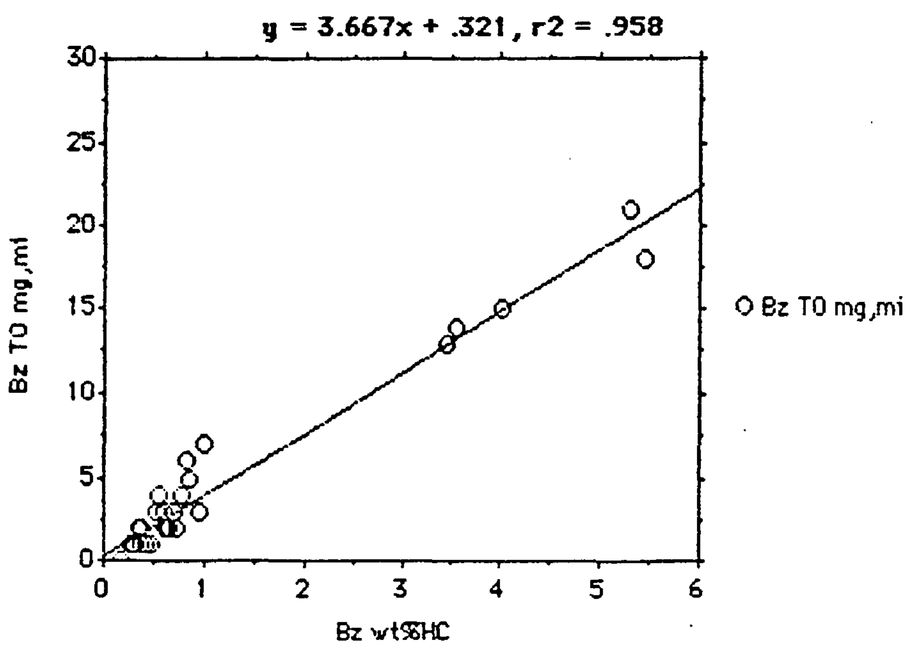


FIGURE 7. Benzene, weight percent of total HC vs. mass rate, mg/mile--Phase 1

For the fuel containing 5 volume percent benzene, the amount of benzene consumed by the engine averaged about 7900 mg/mi. The engine-out emission rate was about 130 mg/mile, which accounts for about 2% of the input. Nearly 90% of the engine-out benzene was oxidized in the catalyst resulting in an average tailpipe-out emission rate of 16 mg/mi. This corresponds to about 0.2% of the benzene in the fuel.

For the fuel containing 11% toluene, the amount of benzene formed in the engine corresponds to about 0.2% of the toluene in the fuel. The net effect across the catalyst is a reduction in benzene emissions of nearly 90%. The tailpipe-out benzene emission rate corresponds to about 0.02% of the toluene in the fuel.

In summary, the results of the Phase I tests show that:

1. All of the aromatic species studied appear to be benzene precursors,
2. Benzene itself has the greatest effect on benzene exhaust emissions on the basis of equal volume percent in fuel,
3. The non-benzene aromatics were all roughly equal in their effect on benzene emissions on the basis of equal volume percent in fuel, and
4. The production of benzene in exhaust emission occurred in the engine; 80 to 95% of the benzene in the engine's exhaust was subsequently oxidized in the exhaust emission control system.

Because all of the aromatic species acted as benzene precursors, all of them were included in the Phase II test fuels.

Phase II Test Results

The experimental design for Phase II was an orthogonal matrix of fuels with each component (benzene, toluene, ethylbenzene, and xylenes) at three different levels with the midpoint level at approximately the average for commercial fuels. The specific selection of the level of each component in each fuel was made to facilitate analysis of the effect of each component on the resulting exhaust emissions.

Replicate tests were conducted with three of the fuels for all five vehicles. These fuels (8716, 8717, 8721) were selected because their compositions cover the entire range from low to high content of each aromatic component. The purpose of the replicate tests was to determine the repeatability of the emissions results. The pooled standard deviations for benzene emissions for the 15 pairs of tests are given in table 12. These indicate that the variability of the tests is roughly the same for engine-out and tailpipe-out benzene emissions.

TABLE 12. - Results of replicate tests, pooled standard deviations

Benzene, Weight percent of total HC	Pooled Standard Deviations, Sp	100 Sp/Mean, percent
Engine-out	0.42	11
Tailpipe-out	0.61	17

The results of the Phase II tests are summarized in tables 13 and 14 for engine-out and tailpipe-out, respectively. The engine-out results were fairly consistent across the five-car fleet, but there were marked car-to-car variations in the tailpipe-out results. This is probably due to differences in the exhaust emissions control systems. The ratios of tailpipe-out to engine-out (for benzene as weight percent of total HC) were averaged for the nine fuels and are given in table 15.

TABLE 13. - Engine-out benzene emissions, weight percent of total HC, Phase II

Fuel	Vol % Component					Benzene, wt % Total HC					
						Vehicle					5-Car
No.	Benzene	Toluene	Ethyl-benzene	Xylene	C_9^+ Aromatics	505	603	604	605	606	Average
8715	1	10	3	11	10	3.2	3.4	2.7	2.8	3.0	3.0
8716	1	5	1	6	10	2.2	2.7	2.8	2.3	2.1	2.4
8717	1	16	5	17	10	3.7	4.5	3.7	3.2	3.4	3.7
8718	2	5	3	17	11	4.0	4.2	3.2	3.6	4.1	3.8
8719	2	10	5	6	11	4.0	4.4	4.0	3.1	3.5	3.8
8720	2	16	1	12	12	6.1	6.6	6.0	4.4	4.2	5.5
8721	3	5	5	11	10	5.3	5.1	4.0	4.8	4.7	4.8
8722	3	10	1	17	11	4.4	5.6	5.1	5.1	4.8	5.0
8723	3	16	3	6	11	5.5	6.0	4.4	5.1	4.1	5.0
Average	2	10	3	11	11	4.3	4.7	4.0	3.8	3.8	4.1

TABLE 14. - Tailpipe-out benzene emissions, weight percent of total HC, Phase II

Fuel No.	Vol % Component					Benzene, wt % of Total HC					
						Vehicle					5-Car
	Benzene	Toluene	Ethyl-benzene	Xylene	C_9^+ Aromatics	505	603	604	605	606	Average
8715	1	10	3	11	10	4.3	2.1	2.2	2.7	3.2	2.9
8716	1	5	1	6	10	3.0	1.2	1.5	1.7	2.1	1.9
8717	1	16	5	17	10	4.2	2.9	3.6	4.8	3.4	3.8
8718	2	5	3	17	11	4.8	3.0	1.2	2.5	3.6	3.0
8719	2	10	5	6	11	5.6	2.7	2.8	3.5	3.8	3.7
8720	2	16	1	12	12	10.0	4.8	5.2	5.8	5.6	6.3
8721	3	5	5	11	10	6.4	3.6	5.4	4.9	5.1	5.1
8722	3	10	1	17	11	7.2	4.9	3.9	5.2	4.9	5.2
8723	3	16	3	6	11	7.3	4.1	4.4	5.3	5.2	5.3
Average	2	10	3	11	11	5.9	3.3	3.4	4.0	4.1	4.1

TABLE 15. - Ratio of tailpipe-out to engine-out benzene emissions, Phase II

Vehicle	Benzene wt% of HC, Tailpipe-out/ Engine-out	Exhaust Emission Control System (all have EGR, 3CL)
505	1.36	--
603	0.74	AIR
604	0.89	OX, AIR
605	1.08	AIR
606	1.07	--

Two of the three vehicles that incorporate an air injection system had decreased benzene fraction of total HC in the tailpipe-out exhaust compared to engine-out exhaust. The two vehicles that did not incorporate an air injection system had higher benzene fraction of total HC in the tailpipe-out exhaust. This implies that air injection could be a means for reducing benzene emissions. However, the mass emissions rate of benzene, averaged over the nine fuels, was nearly the same for four of the vehicles (one without air injection, three with air injection).

Vehicle 505 had substantially higher benzene emission rates than the other four vehicles. This vehicle had the highest mileage accumulation in the five-car fleet, and its higher emission rates might have been caused by catalyst deterioration as a consequence of mileage accumulation. The tailpipe-out benzene emission rates, given in table 19, show the marked difference between vehicle 505 and the other four vehicles. Emission rates of vehicle 505 also changed during the execution of this test program. The trend in HC emissions as a function of test number for car 505 is shown in figure 8. There was a large increase in HC emissions over the period of testing in this program. The other four vehicles did not show this effect (figures 9, 10, 11, 12).

TABLE 16. - Tailpipe-out benzene emission rates, mg/mi, Phase II

Fuel No.	Benzene, mg/mi Vehicle 505	603	604	605	606	5-Car Average
8715	37	11	10	14	13	27
8716	26	4	6	6	8	10
8717	23	7	12	20	10	14
8718	48	17	8	10	11	19
8719	36	6	16	9	18	17
8720	85	17	17	18	21	32
8721	61	14	20	18	26	28
8722	82	23	15	21	27	32
8723	69	13	15	15	23	27
Average	52	13	13	15	17	21

Because of the apparent effect of time (or number of tests) on the emissions characteristics of car 505, the statistical analyses performed on the results of Phase II were done both with and without the data for vehicle 505.

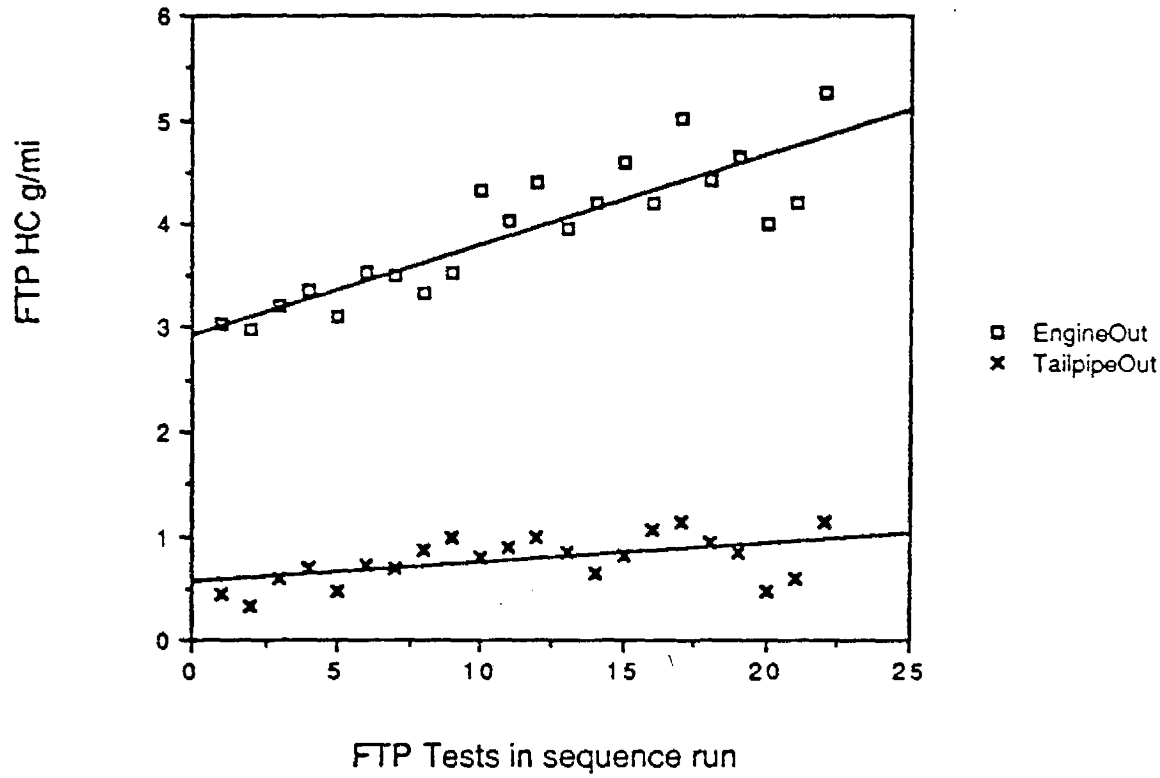


FIGURE 8. - HC emissions trend for car 505.

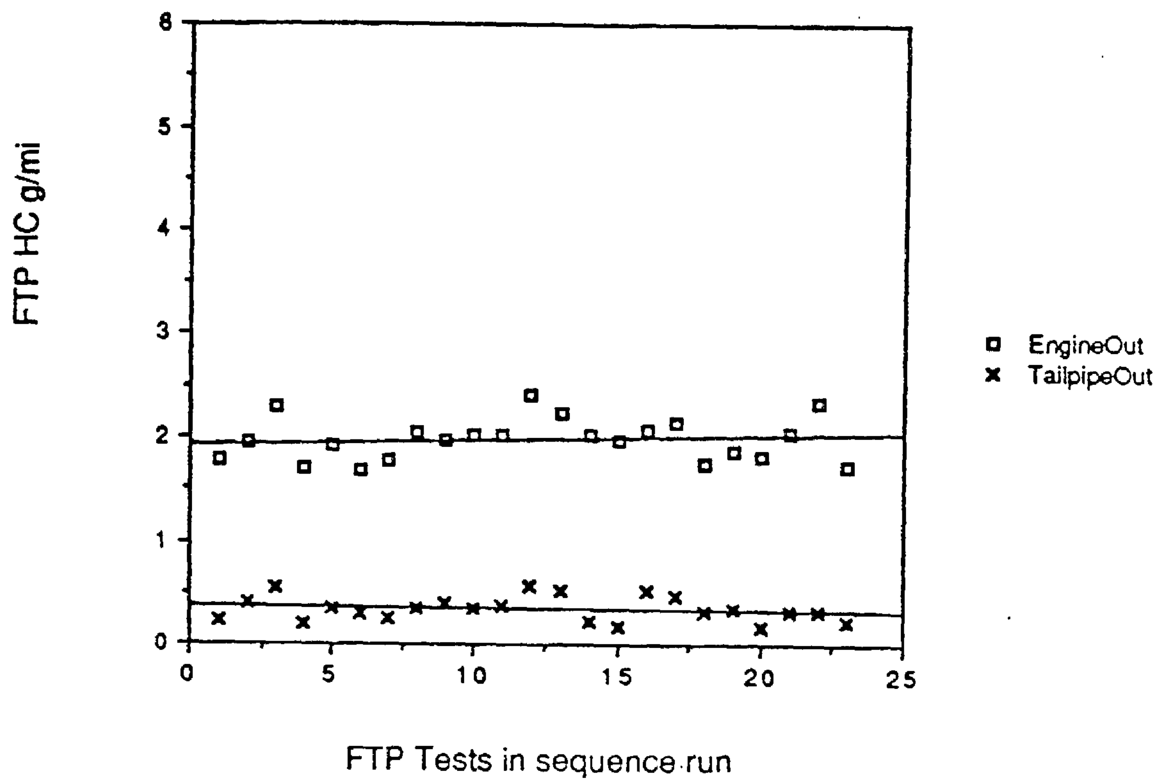


FIGURE 9. - HC emissions trend for car 603.

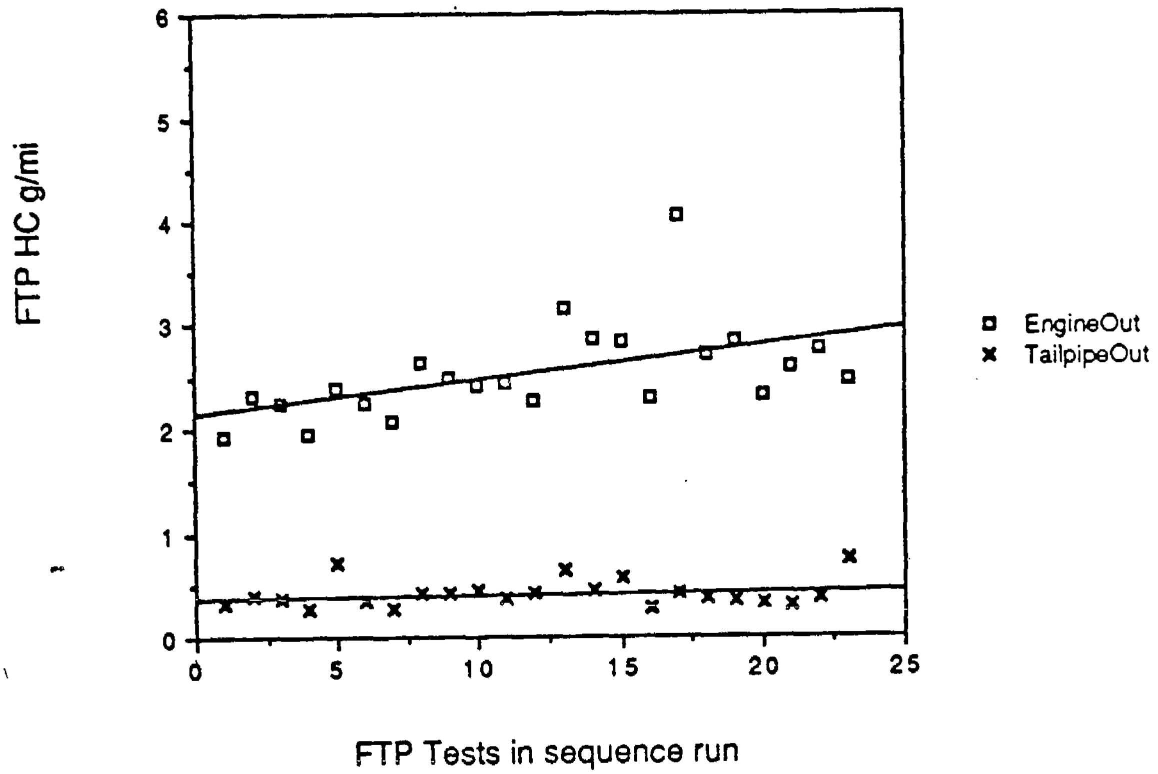


FIGURE 10. - HC emissions trend for car 604.

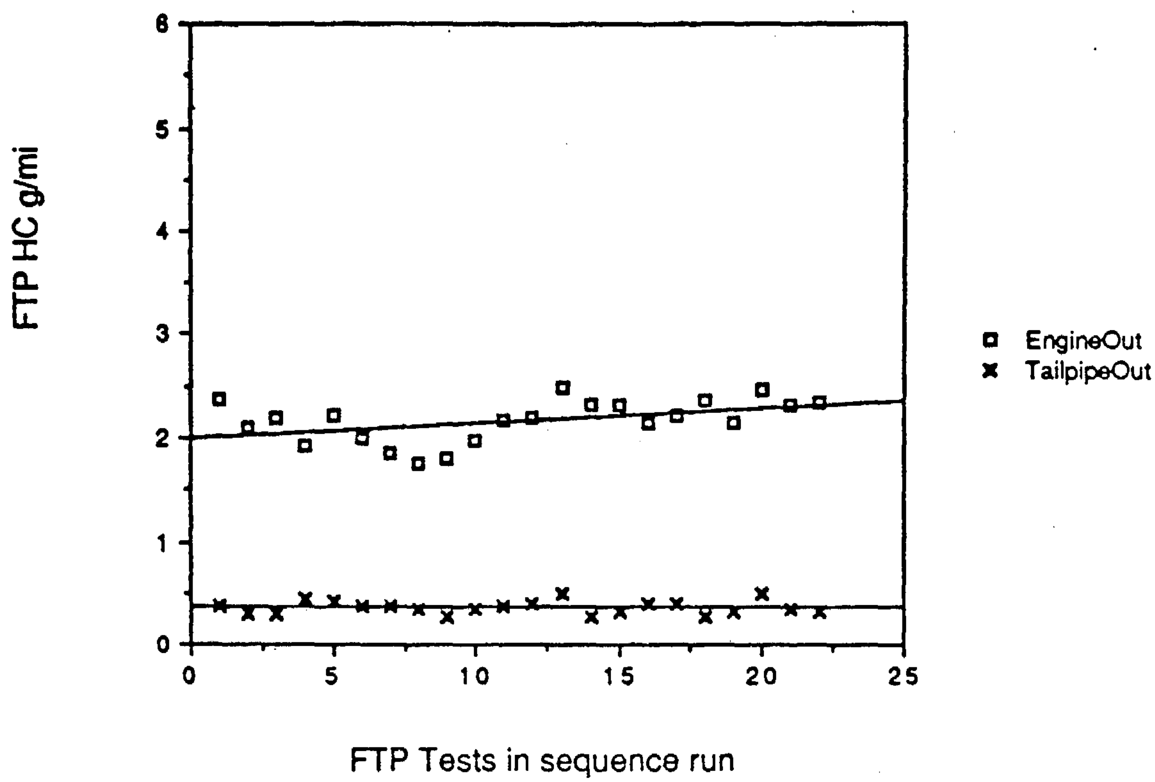


FIGURE 11. - HC emissions trend for car 605.

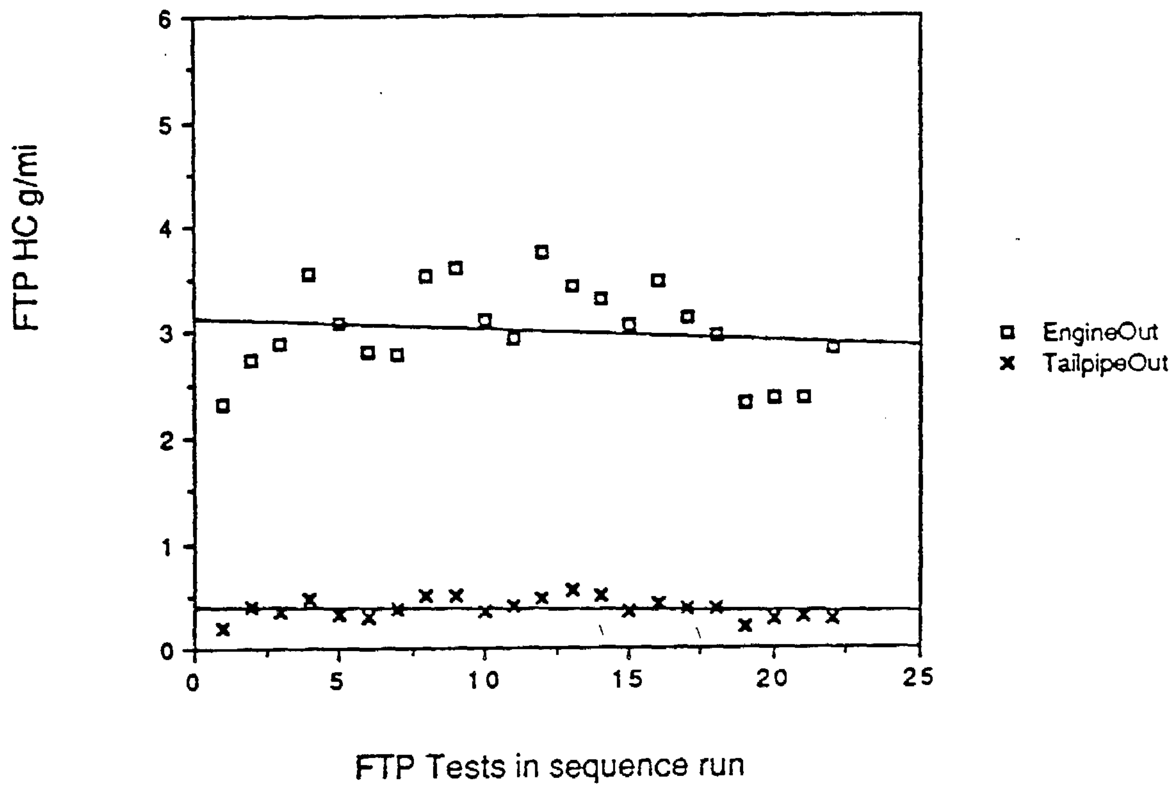


FIGURE 12. - HC emissions trend for car 606.

The results of the Phase II tests were analyzed statistically using all 60 observations:

[5 cars x (9 test fuels + 3 repeated fuels) = 5 x 12 = 60]

Separate linear and quadratic single degree of freedom effects for each of the four design components were estimated from the Phase II data, using a simple regression model. This model is of the form:

$$Y = Ym + a_1B_L + a_2B_Q + a_3T_L + a_4T_Q$$
$$+ a_5E_L + a_6E_Q + a_7X_L + a_8X_Q + \text{terms for the 5 cars}$$

where Y = benzene weight percent of total HC

Ym = fitted value of Y for a midpoint fuel

$B_L = (Bz - 2)/1$ $\quad B_Q = 3B_L^2 - 2$

$T_L = (Tol - 10)/5$ $\quad T_Q = 3T_L^2 - 2$

$E_L = (EBz - 3)/2$ $\quad E_Q = 3E_L^2 - 2$

$X_L = (Xyl - 10)/5$ $\quad X_Q = 3X_L^2 - 2$

Bz = volume percent benzene in fuel

Tol = volume percent toluene in fuel

EBz = volume percent ethylbenzene in fuel

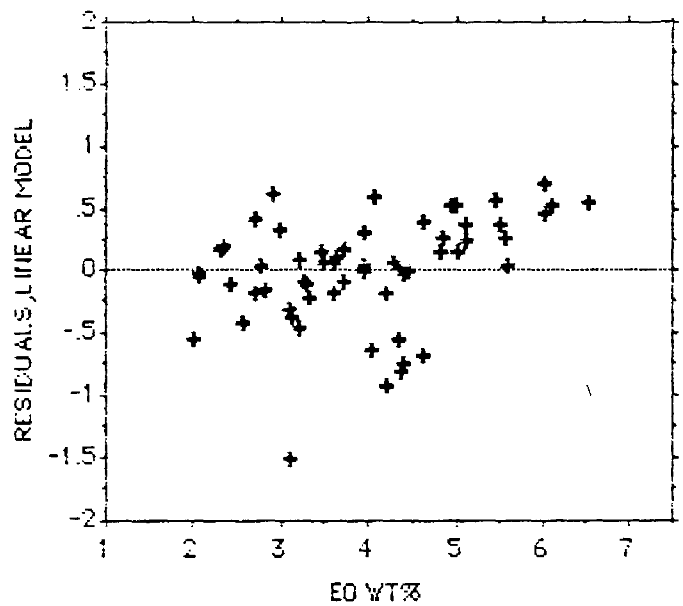
Xyl = volume percent xylenes in fuel

The subscript $_L$ denotes the linear effect terms and the subscript $_Q$ denotes the quadratic effect terms. If the targets for the fuel compositions had actually been achieved, the regression variables would be completely independent, except for the fact that replicate tests with three of the nine fuels were included in the statistical analysis. Correlation between the regression variables was acceptably low, however; the largest correlation coefficient was only 0.6. "Cars" as a class variable is included in the model to allow for the fact that each car tends to have its own emission level.

The results of the statistical analysis for engine-out and tailpipe-out benzene, weight percent of total HC, are shown in table 17. For engine-out benzene emissions, the ethylbenzene terms were not significant at the 95% level. All the other terms were significant. The root-mean-square-error, 0.42, was essentially the same as the pooled standard deviation for the replicate tests. If the fit were ideal (the mean of the replicates and exact for the non-replicated tests), the RMSE would be 0.21 and the R^2 term would be 0.965.

For tailpipe-out benzene emissions, the quadratic terms for benzene and toluene and the linear term for ethylbenzene were not statistically significant. The RMSE, 0.65, was nearly the same as the pooled standard deviation for the replicate tests. An "ideal" fit would have an RMSE of 0.31 and the R^2 term would be 0.968.

Examination of the residuals indicates a slight trend of variability increasing proportionally with benzene level (figure 13). The data were transformed into logarithms to see if this would satisfy the requirement of equal variability across the range of data. The results of the statistical analysis for the logarithmic model are given in table 18 and plots of the residuals shown in figure 14. The residuals of the logarithmic fit appear to have more uniform variability across the range of data.



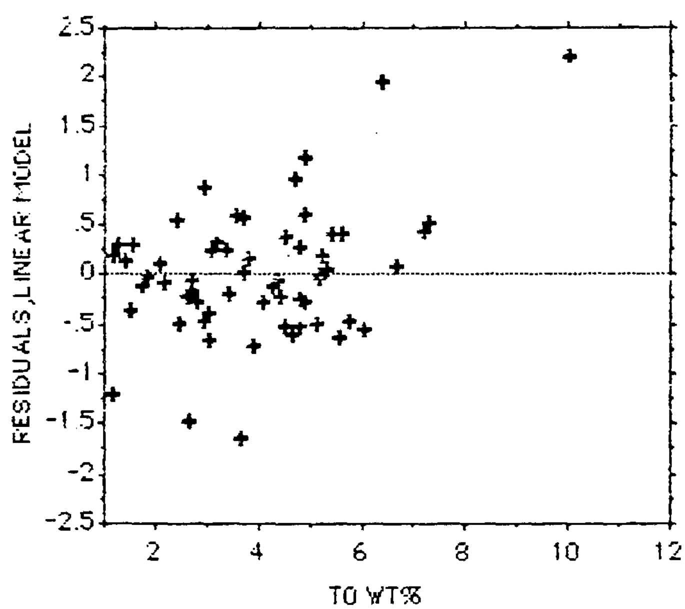


FIGURE 13. - Residual plots for Benzene, weight percent of HC: linear model

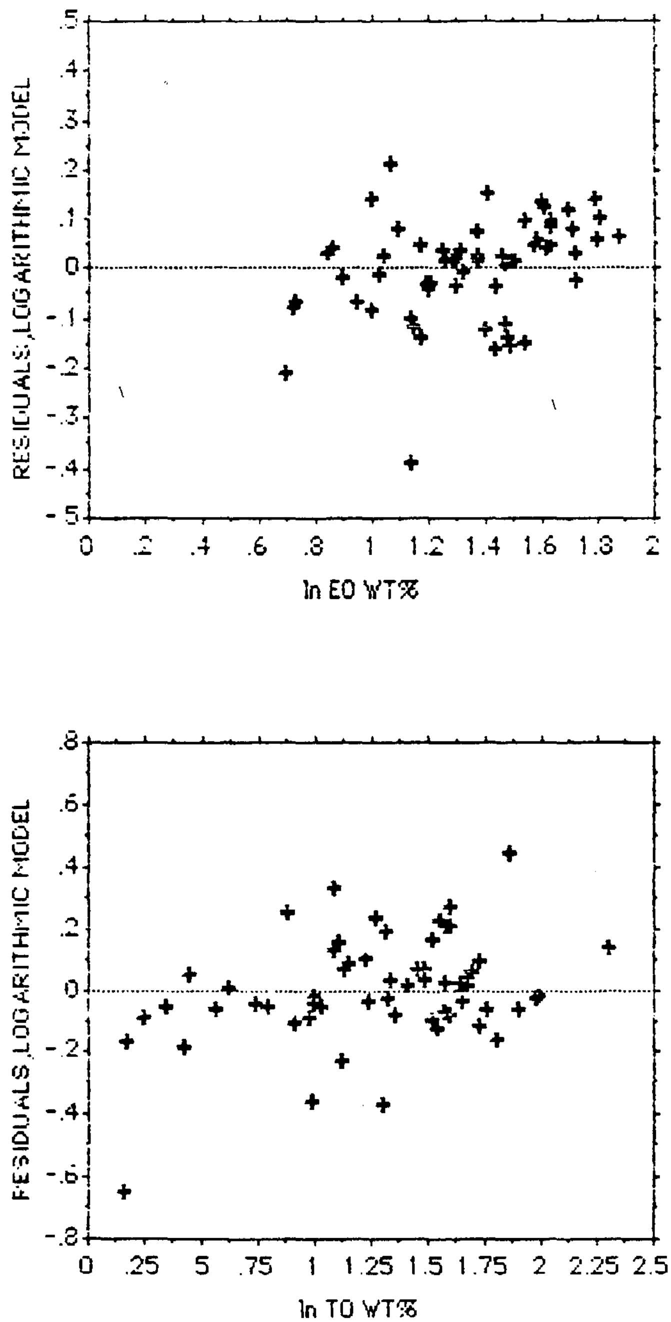


FIGURE 14. - Residual plots for Benzene, weight percent of HC: logarithmic model

TABLE 17. Statistical Analysis of Phase II Linear Model: 5 Cars

	Engine-out	Tailpipe-out
Y_M	3.884	3.849
B_L	.991	1.181
B_Q	-.105	(-.090)
T_L	.445	.776
T_Q	.090	(.108)
E_L	(.045)	(-.076)
E_Q	(.069)	.160
X_L	.332	.490
X_Q	-.087	-.219
R_2	.856	.858
RMSE	.42	.65

RMSE = root mean square error
( ) = not significant at the 95% level

The ethylbenzene terms were not significant for either engine-out or tailpipe-out benzene emission. The only quadratic terms that are significant at the 95% level are benzene (B_Q) for engine-out and xylenes (X_Q) for tailpipe -out. The R^2 values for the logarithmic model are slightly greater than those for the linear model. The antilogarithms of the fitted data were computed to enable computations of the linear RMSE's. The RMSE values were about the same as those determined for the linear models.

The approximate effects of toluene, ethylbenzene, and xylenes relative to fuel benzene are shown in table 19. These values are based on the coefficients (for the linear effect terms) in the logarithmic model. The effect of fuel benzene on benzene emissions is much greater than that of the other aromatic components in the fuel.The effects of toluene and xylenes appear to be slightly greater than those found in the Phase I results. The ethlybenzene effect is less than that found in Phase I.

TABLE 18. Statistical Analysis of Phase II, Logarithmic Model: 5 Cars

	Engine-Out	Tailpipe-Out
Y_M	1.316	1.242
B_L	.262	.316
B_Q	-.030	(-.018)
T_L	.119	.241
T_Q	(.017)	(.010)
E_L	(.014)	(.039)
L_Q	(.013)	(.035)
X_L	.096	.143
X_Q	(-.018)	-.054
R^2	.878	.871
RMSE		
Log	.10	.22
Linearized	.48	.63

TABLE 19. Effects of Aromatics in Fuel on Benzene Emissions: 5 Cars

Component	Effects Relative to Benzene	
	Engine-out	Tailpipe-out
Benzene	1.00	1.00
Toluene	0.10	0.15
Ethylbenzene	0.03	0.06
Xylenes	0.07	0.09

The analysis of the Phase II data was redone deleting vehicle 505 because it showed a drift in hydrocarbon emissions across the test period. The results of this analysis given in table 20, indicate that the terms for ethylbenzene are not statistically significant. The approximate effects of the components, relative to fuel benzene, were computed using the coefficients for the linear term effects in the logarithmic model. These are shown in table 21. The effect of fuel benzene on benzene emissions is much greater than that of the other components in the fuel.

TABLE 20. Statistical Analysis of Phase II: 4 Cars

	Engine-out		Tailpipe-out	
	Linear Model	Logarithmic Model	Linear Model	Logarithmic Model
Y_M	3.832	1.304	3.401	1.135
B_L	.952	.253	.990	.305
B_Q	(-.087)	-.026	(-.011)	(-.005)
T_L	.433	.114	.707	.256
T_Q	(.062)	(.013)	(.106)	(.011)
E_L	(-.089)	(.004)	(.038)	(.060)
E_Q	(.086)	(.018)	.144	(.038)
X_L	.322	.091	.448	.149
X_Q	(-.057)	(-.012)	-.184	-.054
R^2	.848	.872	.856	.862
RMSE	.49	.12	.62	.20
Linear RMSE	.49	.48	.62	.65

TABLE 21. Effects of Aromatics in Fuel on Benzene Emissions: 4 Cars

	Effect Relation to Benzene	
Component	Engine-out	Tailpipe- out
Benzene	1.00	1.00
Toluene	0.09	0.17
Ethylbenzene	0.01	0.10
Xylenes	0.07	0.10

In summary, the results of the Phase II test show that:

1. Benzene itself has the greatest effect on benzene exhaust emission on the basis of equal volume percent in fuel.
2. Toluene and xylenes were roughly equal in their effect on benzene emissions on the basis of equal volume percent in fuel.
3. The effect of ethylbenzene was not statistically significantly different from zero.
4. Linear and logarithmic models fitted the observed results approximately equally well. The root-mean-square-errors for both models were nearly the same as the pooled standard deviations for replicate tests.

Phase III Test Results

The tests in Phase II were conducted with 4 fuels. The purpose of these tests was to determine if the Phase II equations can be used to give reasonable estimates of benzene emissions associated with the use of commercially available fuels.

The fuels are:

Indolene, two commercial gasolines from the Los Angeles Basin, and a fuel blended at NIPER. The blended fuel consisted of an alkylate base with benzene, toluene, ethylbenzene, and xylenes at levels near their midpoint of the Phase II blends. The heavy reformate fraction was increased to about double that used in Phase II.

The observed and estimated benzene emissions are shown in table 22. The equations for the estimates are the reduced forms in which all terms that are not significant at the 95% level are excluded. The coefficients of the equations are shown in table 23.

TABLE 22. Estimated and Observed Benzene Emissions Levels for Phase III: 4 Cars

Fuel:	8724	8594	8725	8726	
Engine-out Bz wt%					Average
Observed	3.79	2.40	3.60	3.64	3.36
Linear fit	3.34	1.95	2.95	2.93	2.77
Logarithmic fit	3.26	2.19	2.88	2.86	2.78
Difference linear	.45	.55	.65	.71	.59
Difference log	.53	.31	.72	.78	.58
Tailpipe-out Bz wt%					Average
Observed	4.35	1.84	2.62	2.88	2.92
Linear fit	2.98	0.20	2.52	2.38	2.02
Logarithmic fit	3.10	1.15	2.26	2.19	2.18
Difference linear	1.37	1.64	.10	.50	.90
Difference log	1.25	.69	.36	.60	.74

TABLE 23. Regression Coefficients for Reduced Models

	Engine-out		Tailpipe-out	
	Linear	Logarithmic	Linear	Logarithmic
Y_C	3.823	1.297	3.445	1.155
B_L	.845	.223	.956	.293
B_Q				
T_L	.467	.125	.766	.267
T_Q				
E_L				
E_Q			1.58	
X_L	.204	.070	.470	.171
X_Q			-.188	-.060

The estimates for benzene levels averaged about 25% lower than the observed levels. This was not unexpected as the equations are based only on the effects of benzene, toluene, ethylbenzene, and xylenes in a base fuel containing approximately 10 volume percent of heavy reformate (C_9^+ aromatics) with a totally paraffinic alkylate constituting the balance. The fuels in Phase III contain various levels of heavy reformate (up to about 18 volume percent), naphthenes and olefins. In Phase I the heavy reformate did cause increased benzene emissions levels.

The potential contribution of naphthenes and olefins in gasoline to exhaust emissions of benzene can not be estimated from this work. However, it is possible to devise a simple model that includes the heavy reformate. This model is:

$$\text{Bz wt\% HC} = a_0 + a_1 B_L + a_2 B_Q + a_3 A_L + a_4 A_Q$$
$$+ \text{ terms for the four cars}$$

Where B_L and B_Q are the same linear and quadratic terms for fuel benzene that were used earlier and A_L and A_Q are linear and quadratic terms for total aromatics heavier than benzene.

$$A_L = \text{vol\% } C_7^+ \text{ Aromatics} - 33 \quad \text{(mean target level of } C_7^+ \text{ Aromatics} = 33)$$
$$A_Q = {A_L}^2 - 36 \quad \text{(mean of } {A_L}^2 \text{ [target of blends]} = 36)$$

The results of this analysis are given in table 24. Neither quadratic term is statistically significant, therefore, the model can be further simplified by using actual volume percent of benzene and C_9^+ aromatics, rather than the regression polynomials.. The resulting questions are:

$$\text{Engine-out wt \% Bz} = 0.23 + 0.802 \text{ Bz} + 0.058 \text{ Aro}$$
$$\text{Tailpipe-out wt \% Bz} = -1.46 + 0.968 \text{ Bz} + 0.087 \text{ Aro}$$

TABLE 24. Statistical Analysis of Phase II: Simple Model

		Engine-out		Tailpipe-out	
		Reduced	Second Reduction		Reduced
Y_0	3.763	3.819	3.760	3.264	3.337
B_L	1.181	.896	.802	1.268	.968
B_Q	-1.40	(-.075)		(-.0581)	
A_L	.046	.059	.058	.072	.087
A_Q	(.003)			(.004)	
R^2	.806	.791	.777	.749	.737
RMSE	.53	.54	.55	.77	.77

The equations were used to estimate the benzene emission for the four fuels of Phase III. The estimates, shown in table 25, are fairly close to the observed values but are consistently lower. On average, the estimates are 11% and 18% lower than the observed levels for engine-out and tailpipe-out benzene, respectively. The estimates for the two commercial fuels were about 12% lower than the observed benzene emissions.

TABLE 25. Estimated and Observed Benzene Emission Levels: Simple Model

Fuel:	8724	8594	8725	8726	
Engine-out Bz wt%					Average
Observed	3.79	2.40	3.60	3.64	3.36
Estimated	3.84	1.90	3.13	3.07	
Difference	-.05	.50	.47	.57	.37
Tailpipe-out Bz wt%					
Observed	4.35	1.84	2.62	2.88	2.92
Estimated	3.65	0.94	2.51	2.43	
Difference	.70	.90	.11	.45	.54

The presence of non-aromatic fuel components that act as benzene precursors is a possible cause of the difference between observed and estimated benzene levels. These components might be naphthenes and olefins.

The effect of total non-benzene aromatics relative to that of fuel benzene is about 0.07 and 0.09 for engine-out and tailpipe-out benzene emissions, respectively. These values are nearly the same as those reported in the literature (3, 4, 5,) and those found in Phase I of this work.

In summary, the results of the Phase III tests show that:

1. The estimates of benzene emissions using the regression equations from Phase II are consistently lower than the observed levels by about 20 to 25%.
2. A simple model that involves only two terms (benzene and total aromatics heavier than benzene) gives estimates that are closer to the observed levels, but these are still about 15% lower than observed. The improvement is attributed to the inclusion of the heavy reformate as part of the total aromatics term. The remaining discrepancy might be caused by the presence of naphthenes and olefins in the fuels.

3. The relative effect of the non-benzene aromatics on benzene emissions is about 1/12 that of fuel benzene.

CONCLUSIONS

The major conclusions derived from this work are:

1. The relative effect of benzene (in fuel) on benzene emissions is much greater than that of the other aromatic species studied.

2. All of the non-benzene aromatic components tend to increase exhaust benzene levels. The components studied -- toluene, ethylbenzene, xylenes, and heavy reformate (C_9^+) -- had an average effect of about 8% of that of benzene.

3. The effect of non-benzene aromatics relative to benzene that was found in this work agrees well with published data.

4. The ethylbenzene effect was statistically not significantly different from zero.

5. Estimates of benzene emissions using regression equations derived from from these experiments were about 12% lower than the observed levels for two commercial fuels. The discrepancy might be due to the presence of other (non-aromatic) benzene precursors, such as naphthenes and olefins, in these fuels.

These conclusions were drawn from the results of measurements of exhaust emissions from five current production vehicles. Fuel composition was varied systematically to enable discernment of the effects of the fuel components individually and together.

Exhaust sampling and analytical systems were developed for measurement of the aromatic species in both engine-out and tail-pipe out exhaust. These systems were described in detail in the Experimental Methodology section of this report. Use of these systems enabled the determination of emissions of benzene (and other aromatics) and the effects of the exhaust catalysts on emissions.

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GLOSSARY OF TERMS, ABBREVIATIONS, AND SYMBOLS

air-fuel ratio: Ratio of engine intake air to the fuel consumed.

air injection: Introduction of air into exhaust system.

alkylate: Product of chemical reaction of low molecular weight olefins with an isoparaffin for higher molecular weight isoparaffins.

aromatic: Organic compound characterized by the presence of at least one benzene ring.

benzene: A colorless volatile flammable toxic liquid aromatic hydrocarbon C_6H_6 used in organic synthesis, as a solvent and as a motor fuel.

C_6: Organic compound containing six carbon atoms.

C_8: Organic compound containing eight carbon atoms.

C_9^+: Organic compound containing nine or more carbon atoms per compound.

CVS system: Constant volume sampling system.

carbon dioxide (CO_2): A heavy colorless gas (CO_2) that does not support combustion, dissolves in water to form carbonic acid, is formed by combustion and decomposition of organic substances.

carbon monoxide (CO): A colorless, very toxic gas (CO) that burns to carbon dioxide with a blue flame and is formed as a product of the incomplete combustion carbon.

catalyst: A substance that initiates a chemical reaction and enables it to proceed under milder conditions than otherwise possible.

charcoal canister: The canister contains charcoal which is used to adsorb hydrocarbons emitted from a vehicular fuel tank.

crankcase ventilation system: Crankcase vapors are vented into the engine air induction system.

dynamometer: An apparatus for measuring mechanical power (gasoline engine or vehicle).

electronic fuel injection: Introduction of fuel into either the air induction system or individual cylinders using electronic control of the fuel valves.

elution: To remove (adsorbed material) from an adsorbent by means of a solvent or gas.

engine-out: Engine emissions sampled before exhaust catalyst.

EO: See engine-out.

ethylbenzene: A liquid aromatic hydrocarbon ($C_6H_5C_2H_5$).

evaporative emissions: Hydrocarbons which evaporate from the gasoline in the fuel tank and are vented through the charcoal canister.

exhaust gas recirculation (EGR): A portion of the engine-out exhaust is introduced into the engine air induction system.

Federal Test Procedure: Vehicular test procedure for measuring emissions from gasoline-fueled vehicles as described by the U.S. Environmental Protection Agency. Reference Code of Federal Regulations 40, Chapter 1, Subpart B, paragraph 86.101, page 470 (July 1985 edition).

gas chromatographic systems: Analytical instrumentation which is used to separate and measure hydrocarbon components contained in the fuel and exhaust emissions.

head space: Gas volume above a liquid in a closed chamber.

hydrocarbon-to-carbon (H/C) ratio: The ratio of the number of hydrogen atoms to the number of carbon atoms in an organic molecule.

hydrocarbons: An organic compound (as acetylene or benzene) containing only carbon and hydrogen and often occurring in petroleum, natural gas, coal, and bitumens.

isooctane: A liquid paraffinic (saturated) hydrocarbon (C_8H_{18}) of a branched chain structure.

isooctene: A liquid olefinic (unsaturated) hydrocarbon (C_8H_{16}) of a branched chain structure.

isomers of xylene: See mixed xylenes.

LA-4 conditioning system: An EPA-prescribed vehicle driving cycle used in vehicle preparation prior to the next day's emission test.

methane: Colorless, odorless flammable gaseous hydrocarbon (CH_4) that is a product of decomposition of organic matter in marshes and mines or of the carbonization of coal and is used as a fuel and as a raw material in chemical synthesis.

mini CVS: An exhaust sampling system used to collect engine-out (before catalyst) samples proportional to the exhaust flow during engine operation.

mixed xylenes: Mixture of three isomeric xylenes: ortho-, meta-, and para-xylene.

nitrogen oxides (NO_x): Mixture of nitric oxide and nitrogen dioxide contained in exhaust gas.

nonpolar column: Chromatographic columns which separate hydrocarbon species on a boiling point basis.

olefins: An unsaturated open-chain hydrocarbon containing at least one double bond.

ortho-, meta, and para-xylene: Three individual isomeric forms of xylenes.

oxidation catalyst: Exhaust catalyst used to oxidize carbonaceous exhaust components such as CO to CO_2.

paraffinic refinery blending stock: Mixture of paraffinic hydrocarbon components containing compounds ranging from 4 through 12 carbon atoms.

photochemical: Relating to photochemistry which deals with the effect of radiant energy in producing chemical changes.

polar column: Chromatographic columns which separate hydrocarbon species on a compound polarity basis.

precursor: A substance from which another substance is formed.

reduction catalyst: Exhaust catalyst used to reduce exhaust emissions.

reformate: Product of a refining process in which the hydrocarbon components of a naphtha are rearranged for improved volatility and octane quality.

Reid vapor pressure (RVP): The vapor pressure of a product determined in a volume of air four times the liquid volume at 100°F. RVP is an indication of the vapor-lock tendency of a motor gasoline, as well as an explosion and evaporative hazards (ASTM D 323).

specific gravity: The ratio of the density of a substance to the density of a substance (as pure water or hydrogen) taken as a standard when both densities are obtained by weighing in air.

tailpipe-out: Vehicular exhaust emissions (after catalyst) which are vented into the atmosphere.

three-way catalyst: Vehicular exhaust reduction catalyst that is operated in conjunction with an oxygen sensor which is used to control the air-to-fuel ratio of the engine.

TO: See tailpipe-out.

toluene: A liquid aromatic hydrocarbon (C_7H_8) that resembles benzene but is less volatile, flammable, and toxic, as produced commercially from light oils from coke-oven gas and coal tar and from petroleum, is used as a solvent in organic synthesis and as an antiknock agent for gasoline.

xylenes: Any of three toxic flammable oily isomeric aromatic hydrocarbons (C_8H_{10}) that are dimethyl homologues of benzene and are obtained from wood tar, coal tar, coke-oven gas, or petroleum distillates.

APPENDIX A

ANALYSES OF PHASE II FUELS

APPENDIX A

Fuel No.	Benzene NIPER	Benzene Chevron	Toluene NIPER	Toluene Chevron	EthylBenzene NIPER	EthylBenzene Chevron	Xylenes NIPER	Xylenes Chevron	Total Aromatics NIPER	Total Aromatics Chevron	H/C NIPER	H/C Chevron	Spec. Gravity NIPER	Spec. Gravity Chevron	RON	MON	$\frac{R + M}{2}$
8715	1.2	1.1	10.1	10.0	2.8	3.1	10.8	11.2	35.3	35.7	1.85	1.86	.749	.752	102	93	97.4
8716	1.1	1.1	5.1	5.1	0.9	1.1	5.7	6.2	229	23.4	1.99	1.99	.731	.733	100	93	96.3
8717	1.0	0.9	15.9	15.2	5.1	5.5	16.7	16.9	49.2	49.4	1.70	1.70	.772	.774	104	93	98.6
8718	2.1	1.9	5.2	4.8	2.9	3.3	17.0	16.2	37.9	37.1	1.83	1.84	.754	.755	102	94	97.8
8719	2.1	2.0	10.2	10.5	5.1	5.5	5.9	6.5	34.1	35.4	1.85	1.85	.749	.751	102	93	97.4
8720	2.2	2.2	16.1	16.1	0.9	1.2	12.0	13.0	43.5	45.8	1.75	1.71	.768	.772	104	93	98.4
8721	3.4	3.0	5.2	5.4	5.0	5.6	11.2	11.9	35.3	36.4	1.85	1.83	.754	.754	102	94	98.0
8722	3.4	3.3	10.4	9.9	0.9	1.2	16.6	16.7	42.0	42.3	1.77	1.75	.765	.765	103	93	97.8
8723	3.2	2.0	15.5	15.2	2.7	3.3	5.6	6.5	37.8	39.2	1.80	1.80	.762	.757	103	93	97.8

APPENDIX B

TAILPIPE-OUT EMISSIONS

NIPER, ARB Benzene, Phase 1, Tailpipe-Out

			HC grams/mile				CO grams/mile				NOx grams/mile				Methane grams/mile				mpg
Car	Fuel	Test	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	FTP
505	8603	5907	1.09	0.26	0.27	0.44	10.13	3.17	2.31	4.38	0.55	0.42	0.52	0.48	0.13	0.11	0.06	0.10	21.5
505	8635	5913	0.85	0.16	0.22	0.32	10.58	0.86	2.44	3.31	0.60	0.53	0.61	0.57	0.18	0.20	0.06	0.16	21.7
505	8636	5939	2.44	0.21	0.38	0.72	22.73	1.36	2.01	5.98	0.54	0.55	0.59	0.56	0.25	0.06	0.05	0.10	21.3
505	8637	5919	1.93	0.25	0.26	0.60	17.63	2.17	1.33	5.16	0.60	0.50	0.62	0.55	0.21	0.08	0.05	0.10	21.3
505	8638	5924	2.28	0.24	0.34	0.69	20.16	2.23	1.67	5.78	0.48	0.51	0.63	0.54	0.21	0.09	0.05	0.10	20.9
505	8639	5931	1.44	0.21	0.23	0.47	13.28	1.34	0.70	3.62	0.69	0.58	0.76	0.65	0.14	0.07	0.04	0.08	21.0
603	8603	5904	0.56	0.13	0.10	0.21	4.07	0.19	0.30	1.03	0.36	0.09	0.09	0.15	0.04	0.00	0.01	0.01	23.8
603	8603	5929	1.05	0.10	0.09	0.29	4.97	0.38	0.10	1.26	0.43	0.08	0.10	0.16	0.05	0.00	0.01	0.02	23.8
603	8635	5911	1.53	0.09	0.09	0.39	6.51	0.36	0.32	1.63	0.39	0.12	0.17	0.19	0.07	0.00	0.01	0.02	23.9
603	8636	5915	2.19	0.11	0.13	0.54	6.40	0.32	0.27	1.54	0.33	0.09	0.10	0.14	0.08	0.00	0.01	0.02	24.1
603	8637	5920	0.55	0.10	0.09	0.19	1.74	0.20	0.22	0.53	0.31	0.12	0.07	0.14	0.03	0.00	0.01	0.01	24.3
603	8638	5925	1.21	0.12	0.10	0.34	3.93	0.41	0.29	1.10	0.45	0.05	0.07	0.14	0.05	0.00	0.01	0.01	24.2
603	8639	5952	0.82	0.12	0.09	0.25	5.95	0.79	0.36	1.74	0.42	0.07	0.07	0.14	0.05	0.00	0.01	0.01	23.3
604	8603	5905	0.68	0.21	0.24	0.32	4.41	0.07	1.10	1.26	0.55	0.47	0.44	0.48	0.08	0.04	0.03	0.04	23.6
604	8603	5930	0.80	0.18	0.32	0.34	3.63	0.01	2.38	1.36	0.55	0.54	0.74	0.59	0.08	0.04	0.05	0.05	22.5
604	8635	5910	1.03	0.21	0.24	0.39	5.45	0.33	1.42	1.69	0.99	0.56	0.50	0.63	0.11	0.04	0.04	0.05	21.6
604	8636	5917	1.02	0.18	0.22	0.37	4.53	0.32	0.99	1.37	0.54	0.52	0.49	0.52	0.10	0.03	0.04	0.05	22.7
604	8637	5922	0.47	0.18	0.25	0.26	1.94	0.17	2.34	1.13	0.59	0.43	0.45	0.47	0.07	0.03	0.04	0.04	22.7
604	8638	5927	0.91	0.68	0.66	0.72	6.42	0.44	3.34	2.50	0.49	0.50	0.55	0.51	0.09	0.04	0.05	0.05	22.5
604	8639	5959	0.61	0.17	0.21	0.28	2.30	0.16	0.69	0.75	0.61	0.46	0.53	0.51	0.03	0.00	0.00	0.00	21.2
605	8603	5953	1.33	0.13	0.13	0.38	17.36	0.19	1.91	4.24	0.93	0.52	0.88	0.71	0.15	0.01	0.03	0.04	24.8
605	8635	5912	1.38	0.11	0.13	0.38	13.08	0.08	1.83	3.25	1.37	0.44	0.74	0.72	0.12	0.02	0.03	0.04	24.4
605	8636	5916	0.91	0.12	0.15	0.29	8.86	0.10	1.77	2.32	1.14	0.42	0.66	0.63	0.09	0.02	0.03	0.04	24.9
605	8637	5921	0.95	0.12	0.13	0.30	11.50	0.05	1.87	2.93	0.98	0.36	0.71	0.58	0.12	0.02	0.03	0.04	25.4
605	8638	5926	1.11	0.28	0.29	0.45	8.97	0.02	2.24	2.45	1.36	0.42	0.76	0.70	0.09	0.02	0.03	0.04	25.5
605	8639	5932	1.55	0.15	0.13	0.43	11.72	0.07	1.06	2.76	1.47	0.41	0.75	0.72	0.15	0.02	0.03	0.05	25.1
606	8603	5908	0.43	0.13	0.13	0.19	2.65	0.50	0.86	1.05	0.53	0.23	0.33	0.32	0.05	0.02	0.03	0.03	18.4
606	8635	5909	1.23	0.15	0.24	0.39	5.09	0.31	3.03	2.01	0.77	0.22	0.37	0.37	0.08	0.01	0.05	0.04	17.4
606	8636	5938	0.84	0.12	0.19	0.29	3.37	0.55	2.56	1.68	0.90	0.33	0.37	0.46	0.06	0.02	0.04	0.03	17.3
606	8637	5923	1.12	0.16	0.14	0.35	4.48	0.72	1.06	1.59	0.70	0.23	0.25	0.33	0.06	0.03	0.03	0.04	19.0
606	8638	5928	1.28	0.19	0.38	0.47	3.92	1.85	3.69	2.78	0.77	0.23	0.35	0.37	0.07	0.03	0.05	0.04	17.9
606	8639	5933	0.86	0.17	0.23	0.33	3.42	0.83	2.72	1.88	0.74	0.27	0.31	0.38	0.06	0.02	0.04	0.04	17.8

NIPER, ARB Benzene, Phase 1, Tailpipe-Out

Car	Fuel	Test	Benzene mg/mile				Toluene mg/mile				Ethyl BZ mg/mile				Xylenes mg/mile				m,pXylene mg/mi				oXylene mg/mile			
			c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
505	8603	5907	4	1	1	2	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
505	8635	5913	75	1	6	18	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
505	8636	5939	29	1	3	7	288	9	27	72	5	0	0	1	3	0	0	1	3	0	0	1	0	0	0	0
505	8637	5919	20	1	2	5	10	0	0	2	115	6	5	28	0	0	0	0	0	0	0	0	0	0	0	0
505	8638	5924	20	2	3	6	19	0	3	5	2	0	0	0	328	28	30	91	6	0	0	1	322	28	30	89
505	8639	5931	14	1	1	4	10	0	1	2	1	0	0	0	28	4	7	10	6	0	0	1	22	4	7	9
603	8603	5904	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
603	8603	5929	2	0	0	0	3	0	0	1	0	0	0	0	2	0	3	1	0	0	0	0	2	0	3	1
603	8635	5911	97	0	1	21	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
603	8636	5915	14	0	0	3	251	6	7	56	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
603	8637	5920	3	0	0	1	7	0	0	1	48	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
603	8638	5925	6	0	0	1	9	0	0	2	0	0	0	0	161	21	9	47	3	0	0	1	159	21	9	46
603	8639	5952	5	0	0	1	4	0	0	1	0	0	0	0	15	0	0	3	5	0	0	1	10	0	0	2
604	8603	5905	4	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
604	8603	5930	3	0	1	1	2	0	0	0	0	0	0	0	5	0	0	1	0	0	0	0	5	0	0	1
604	8635	5910	52	2	7	13	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
604	8636	5917	10	0	1	3	110	0	11	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
604	8637	5922	6	0	2	2	6	0	1	2	30	1	11	10	0	0	0	0	0	0	0	0	0	0	0	0
604	8638	5927	12	1	3	4	14	0	3	4	0	0	0	0	110	50	43	61	2	0	0	0	108	50	43	60
604	8639	5959	6	0	0	1	7	0	0	1	0	0	0	0	14	0	0	3	6	0	0	1	8	0	0	2
605	8603	5953	5	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
605	8635	5912	73	0	1	15	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
605	8636	5916	8	0	0	2	128	4	3	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
605	8637	5921	10	0	0	2	6	0	0	1	71	2	3	17	0	0	0	0	0	0	0	0	0	0	0	0
605	8638	5926	7	0	1	2	7	0	0	1	0	0	0	0	111	28	22	44	2	0	0	0	109	28	22	43
605	8639	5932	14	0	0	3	8	0	0	2	2	0	0	0	28	3	4	9	5	0	0	1	22	3	4	7
606	8603	5908	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
606	8635	5909	65	0	3	14	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
606	8636	5938	10	0	3	3	96	1	7	22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
606	8637	5923	7	0	0	1	8	0	0	2	82	6	3	21	0	0	0	0	0	0	0	0	0	0	0	0
606	8638	5928	8	0	3	3	10	0	2	3	0	0	0	0	169	42	23	63	3	0	0	1	166	42	23	63
606	8639	5933	8	0	2	2	5	0	1	1	0	0	0	0	12	0	3	3	1	0	0	0	11	0	3	3

NIPER, ARB Benzene, Phase 1, Tailpipe-Out

			HC Reduction %				CO Reduction %				NOx Reduction %			
Car	Fuel	Test	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
505	8603	5907	69	91	90	86	50	76	79	69	59	53	62	58
505	8635	5913	77	94	91	89	49	92	79	75	56	49	60	54
505	8636	5939	56	93	86	80	51	89	81	69	55	46	62	53
505	8637	5919	55	92	91	81	34	83	87	65	55	47	60	54
505	8638	5924	52	92	88	79	38	84	85	66	66	50	62	58
505	8639	5931	60	93	92	85	24	90	88	70	60	50	60	56
603	8603	5904	68	93	93	88	70	99	97	92	81	90	94	89
603	8603	5929	47	94	94	83	68	97	99	90	78	91	94	88
603	8635	5911	47	95	94	80	64	97	97	88	82	90	91	88
603	8636	5915	52	94	92	77	61	97	97	88	84	90	94	90
603	8637	5920	68	94	94	89	86	98	98	96	83	87	95	89
603	8638	5925	56	94	93	82	76	97	97	92	81	95	96	91
603	8639	5952	59	94	94	86	64	95	97	88	82	94	96	91
604	8603	5905	65	90	85	84	61	99	87	87	72	74	80	76
604	8603	5930	63	92	87	85	67	100	76	87	72	72	63	69
604	8635	5910	66	91	86	83	67	97	85	86	63	72	80	72
604	8636	5917	63	92	87	84	69	97	88	87	72	70	79	73
604	8637	5922	77	91	86	87	82	98	77	89	70	75	77	75
604	8638	5927	64	74	65	70	58	96	71	80	72	73	75	74
604	8639	5959	71	93	86	87	79	99	92	93	68	77	76	75
605	8603	5953	55	93	92	81	37	97	76	63	66	60	67	64
605	8635	5912	66	94	93	84	35	99	78	67	60	64	70	65
605	8636	5916	71	94	91	86	58	98	78	77	59	64	74	66
605	8637	5921	72	93	93	86	48	99	78	72	62	65	69	66
605	8638	5926	55	85	82	76	55	100	75	76	60	69	73	68
605	8639	5932	55	92	93	80	37	99	87	71	58	66	74	66
606	8603	5908	78	95	93	92	80	97	93	92	83	88	89	87
606	8635	5909	59	94	90	86	69	98	80	87	76	88	88	85
606	8636	5938	70	96	93	90	77	96	82	89	78	87	90	85
606	8637	5923	65	95	94	88	69	95	91	88	75	86	90	84
606	8638	5928	72	95	87	87	76	88	75	82	78	89	88	86
606	8639	5933	71	95	91	89	75	95	80	87	77	88	90	86

NIPER, ARB Benzene, Phase 1, Tailpipe-Out

			Benzene Red. %				Toluene Red. %				Ethyl BZ Red. %				Xylene Red. %				m,pXylene Red.%				oXylene Red. %			
Car	Fuel	Test	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
505	8603	5907	54	87	87	78	70	100	100	91	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
505	8635	5913	64	99	96	89	75	100	100	92	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
505	8636	5939	53	98	87	80	46	97	90	78	50	100	100	85	28	100	100	60	2	100	100	49	100	100	100	100
505	8637	5919	34	95	90	75	42	100	100	85	51	96	97	83	100	100	100	100	100	100	100	100	100	100	100	100
505	8638	5924	53	93	86	78	62	100	92	88	74	100	100	81	31	89	87	69	100	100	100	63	32	89	87	70
505	8639	5931	51	96	96	84	74	100	94	90	84	100	100	96	50	89	83	78	56	100	100	90	48	85	77	73
603	8603	5904	74	100	100	94	81	100	100	95	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
603	8603	5929	66	100	100	92	67	100	100	89	100	100	100	100	80	100	59	86	100	100	100	100	80	100	59	86
603	8635	5911	43	100	99	80	64	100	100	87	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
603	8636	5915	62	100	100	90	53	97	95	76	89	100	100	96	100	100	100	100	100	100	100	100	100	100	100	100
603	8637	5920	83	100	100	96	55	100	100	89	39	100	100	85	100	100	100	100	100	100	100	100	100	100	100	100
603	8638	5925	73	100	97	93	76	100	100	94	100	100	100	100	38	86	93	72	48	100	100	85	37	86	93	72
603	8639	5952	74	100	100	94	79	100	100	95	100	100	100	100	58	100	100	89	70	100	100	91	48	100	100	88
604	8603	5905	55	100	94	86	85	100	100	96	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
604	8603	5930	63	100	81	85	69	100	100	94	100	100	100	100	55	100	100	91	100	100	100	100	49	100	100	90
604	8635	5910	67	99	93	89	68	100	100	91	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
604	8636	5917	69	100	94	91	60	100	92	87	100	100	100	88	100	100	100	100	100	100	100	100	100	100	100	100
604	8637	5922	72	100	84	89	55	100	87	85	70	99	88	89	100	100	100	100	100	100	100	100	100	100	100	100
604	8638	5927	52	95	81	80	62	100	86	87	100	100	100	100	57	80	73	73	54	100	100	89	57	80	73	73
604	8639	5959	75	100	98	94	70	100	100	93	100	100	100	100	54	100	100	90	42	100	100	87	60	100	100	92
605	8603	5953	60	100	100	81	80	100	100	92	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
605	8635	5912	67	100	99	88	74	100	100	86	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
605	8636	5916	68	100	97	91	62	98	98	86	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
605	8637	5921	63	100	98	84	64	100	100	89	66	97	97	85	100	100	100	100	100	100	100	100	100	100	100	100
605	8638	5926	66	100	95	88	74	100	100	93	100	100	100	100	53	81	83	73	58	100	100	88	53	81	82	73
605	8639	5932	57	100	100	81	61	100	100	87	59	100	100	85	48	90	88	77	53	100	100	86	47	88	85	75
606	8603	5908	79	100	100	94	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
606	8635	5909	59	100	97	90	71	100	100	93	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
606	8636	5938	68	100	89	90	65	100	97	92	94	100	100	99	100	100	100	100	100	100	100	100	100	100	100	100
606	8637	5923	62	100	99	91	35	100	100	86	57	97	97	88	100	100	100	100	100	100	100	100	100	100	100	100
606	8638	5928	71	98	84	88	73	100	94	92	100	100	100	100	67	87	92	82	71	100	100	92	67	87	92	82
606	8639	5933	66	100	89	89	76	100	94	93	100	100	100	100	63	100	91	92	100	100	100	98	65	100	89	91

NIPER, ARB Benzene, Phase 1, Tailpipe-Out

Car	Fuel	Test	Fuel Components vol pct BZ	TOL	EBZ	XYL	REF	FTP mpg	Emissions FTP g/mile HC	CO	NOx	Meth	FTP mg/mile BZ	TOL	EBZ	XYL	Emissions wt pct of HC BZ	TOL	EBZ	XYL	g/gal BZ
505	8603	5907	0.0	0.1	0.0	0.1	0.0	21.5	0.44	4.38	0.48	0.10	2	1	0	0	0.38	0.16	0.00	0.00	0.04
505	8635	5913	5.1	0.2	0.0	0.1	0.0	21.7	0.32	3.31	0.57	0.16	18	1	0	0	5.46	0.22	0.00	0.00	0.38
505	8636	5939	0.0	11.2	0.0	0.1	0.0	21.3	0.72	5.98	0.56	0.10	7	72	1	1	1.01	9.97	0.15	0.09	0.16
505	8637	5919	0.0	0.1	5.4	0.0	0.0	21.3	0.60	5.16	0.55	0.10	5	2	28	0	0.85	0.34	4.66	0.00	0.11
505	8638	5924	0.0	0.1	0.0	10.7	0.0	20.9	0.69	5.78	0.54	0.10	6	5	0	91	0.82	0.67	0.07	13.10	0.12
505	8639	5931	0.0	0.1	0.0	1.0	10.1	21.0	0.47	3.62	0.65	0.08	4	2	0	10	0.77	0.53	0.05	2.10	0.08
603	8603	5904	0.0	0.1	0.0	0.1	0.0	23.8	0.21	1.03	0.15	0.01	0	0	0	0	0.17	0.16	0.00	0.00	0.01
603	8603	5929	0.0	0.1	0.0	0.1	0.0	23.8	0.29	1.26	0.16	0.02	0	1	0	1	0.17	0.21	0.00	0.45	0.01
603	8635	5911	5.1	0.2	0.0	0.1	0.0	23.9	0.39	1.63	0.19	0.02	21	1	0	0	5.29	0.14	0.00	0.00	0.49
603	8636	5915	0.0	11.2	0.0	0.1	0.0	24.1	0.54	1.54	0.14	0.02	3	56	0	0	0.53	10.42	0.03	0.00	0.07
603	8637	5920	0.0	0.1	5.4	0.0	0.0	24.3	0.19	0.53	0.14	0.01	1	1	10	0	0.29	0.75	5.16	0.00	0.01
603	8638	5925	0.0	0.1	0.0	10.7	0.0	24.2	0.34	1.10	0.14	0.01	1	2	0	47	0.38	0.56	0.00	13.77	0.03
603	8639	5952	0.0	0.1	0.0	1.0	10.1	23.3	0.25	1.74	0.14	0.01	1	1	0	3	0.38	0.32	0.00	1.24	0.02
604	8603	5905	0.0	0.1	0.0	0.1	0.0	23.6	0.32	1.26	0.48	0.04	1	0	0	0	0.27	0.08	0.00	0.00	0.02
604	8603	5930	0.0	0.1	0.0	0.1	0.0	22.5	0.34	1.36	0.59	0.05	1	0	0	1	0.27	0.12	0.00	0.33	0.02
604	8635	5910	5.1	0.2	0.0	0.1	0.0	21.6	0.39	1.69	0.63	0.05	13	0	0	0	3.46	0.13	0.00	0.00	0.29
604	8636	5917	0.0	11.2	0.0	0.1	0.0	22.7	0.37	1.37	0.52	0.05	3	26	0	0	0.69	7.09	0.02	0.00	0.06
604	8637	5922	0.0	0.1	5.4	0.0	0.0	22.7	0.26	1.13	0.47	0.04	2	2	10	0	0.66	0.65	3.79	0.00	0.04
604	8638	5927	0.0	0.1	0.0	10.7	0.0	22.5	0.72	2.50	0.51	0.05	4	4	0	61	0.56	0.52	0.00	8.41	0.09
604	8639	5959	0.0	0.1	0.0	1.0	10.1	21.2	0.28	0.75	0.51	0.00	1	1	0	3	0.48	0.49	0.00	1.04	0.03
605	8603	5953	0.0	0.1	0.0	0.1	0.0	24.8	0.38	4.24	0.71	0.04	1	0	0	0	0.28	0.11	0.00	0.00	0.03
605	8635	5912	5.1	0.2	0.0	0.1	0.0	24.4	0.38	3.25	0.72	0.04	15	1	0	0	4.03	0.17	0.00	0.00	0.37
605	8636	5916	0.0	11.2	0.0	0.1	0.0	24.9	0.29	2.32	0.63	0.04	2	29	0	0	0.61	9.94	0.00	0.00	0.04
605	8637	5921	0.0	0.1	5.4	0.0	0.0	25.4	0.30	2.93	0.58	0.04	2	1	17	0	0.73	0.42	5.60	0.00	0.06
605	8638	5926	0.0	0.1	0.0	10.7	0.0	25.5	0.45	2.45	0.70	0.04	2	1	0	44	0.36	0.31	0.00	9.58	0.04
605	8639	5932	0.0	0.1	0.0	1.0	10.1	25.1	0.43	2.76	0.72	0.05	3	2	0	9	0.69	0.40	0.09	1.98	0.07
606	8603	5908	0.0	0.1	0.0	0.1	0.0	18.4	0.19	1.05	0.32	0.03	0	0	0	0	0.17	0.00	0.00	0.00	0.01
606	8635	5909	5.1	0.2	0.0	0.1	0.0	17.4	0.39	2.01	0.37	0.04	14	0	0	0	3.56	0.10	0.00	0.00	0.24
606	8636	5938	0.0	11.2	0.0	0.1	0.0	17.3	0.29	1.68	0.46	0.03	3	22	0	0	0.96	7.79	0.04	0.00	0.05
606	8637	5923	0.0	0.1	5.4	0.0	0.0	19.0	0.35	1.59	0.33	0.04	1	2	21	0	0.42	0.47	5.93	0.00	0.03
606	8638	5928	0.0	0.1	0.0	10.7	0.0	17.9	0.47	2.78	0.37	0.04	3	3	0	63	0.60	0.55	0.00	13.57	0.05
606	8639	5933	0.0	0.1	0.0	1.0	10.1	17.8	0.33	1.88	0.38	0.04	2	1	0	3	0.63	0.37	0.00	0.97	0.04

NIPER, ARB Benzene, Phase 2, Tailpipe-Out

			HC grams/mile				CO grams/mile				NOx grams/mile				Methane grams/mile				mpg
Car	Fuel	Test	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	FTP
505	8715	7055	2.20	0.48	0.55	0.85	21.69	8.77	7.19	10.99	0.39	0.36	0.33	0.36	0.19	0.13	0.10	0.13	21.2
505	8716	7042	1.98	0.53	0.41	0.80	16.29	10.55	6.02	10.51	0.66	0.54	0.52	0.56	0.16	0.17	0.09	0.15	19.5
505	8716	7048	2.33	0.47	0.54	0.88	22.42	8.26	7.87	11.08	0.60	0.44	0.50	0.49	0.21	0.13	0.11	0.14	19.9
505	8717	7112	1.67	0.17	0.18	0.48	14.57	2.89	2.07	5.07	0.35	0.55	0.50	0.50	0.10	0.02	0.01	0.04	22.7
505	8717	7120	2.21	0.17	0.21	0.60	23.71	3.31	3.07	7.44	0.34	0.65	0.68	0.59	0.15	0.03	0.04	0.06	22.2
505	8718	7049	2.23	0.68	0.64	0.99	17.86	12.88	8.58	12.74	0.68	0.41	0.45	0.48	0.16	0.18	0.08	0.15	20.7
505	8719	7082	1.87	0.33	0.28	0.64	17.11	7.50	3.53	8.40	0.58	0.42	0.46	0.46	0.04	0.10	0.06	0.08	21.2
505	8720	7107	1.65	0.56	0.78	0.85	14.29	13.80	11.80	13.35	0.44	0.41	0.48	0.43	0.09	0.12	0.08	0.10	20.1
505	8721	7088	2.35	0.35	0.56	0.82	24.31	6.95	7.59	10.70	0.53	0.36	0.38	0.40	0.00	0.12	0.09	0.09	20.2
505	8721	7094	2.57	0.64	0.75	1.07	11.16	13.18	10.06	11.91	0.40	0.38	0.24	0.35	0.16	0.17	0.10	0.15	22.9
505	8722	7097	2.99	0.65	0.67	1.14	24.16	11.99	8.64	13.58	0.54	0.56	0.40	0.51	0.23	0.17	0.11	0.17	22.2
505	8723	7104	2.03	0.59	0.81	0.95	9.12	11.10	11.50	10.80	0.51	0.43	0.43	0.44	0.14	0.14	0.10	0.13	20.7
505	8724	7144	2.72	0.76	0.66	1.14	20.76	13.77	7.98	13.61	0.57	0.44	0.37	0.45	0.15	0.16	0.08	0.14	20.0
603	8715	7058	2.15	0.10	0.06	0.51	6.98	0.33	0.26	1.69	0.36	0.08	0.06	0.13	0.06	0.00	0.01	0.02	27.4
603	8716	7039	0.94	0.22	0.16	0.35	4.94	0.41	0.30	1.32	0.48	0.15	0.13	0.22	0.06	0.02	0.02	0.03	23.3
603	8716	7045	1.14	0.17	0.13	0.36	5.13	0.34	0.46	1.37	0.48	0.12	0.09	0.19	0.05	0.00	0.01	0.01	24.2
603	8717	7113	0.58	0.10	0.04	0.18	5.29	1.07	0.78	1.86	0.44	0.06	0.04	0.13	0.03	0.00	0.00	0.00	26.9
603	8717	7116	1.22	0.10	0.05	0.32	7.18	0.99	0.76	2.20	0.41	0.06	0.04	0.12	0.04	0.00	0.00	0.01	25.6
603	8718	7052	2.27	0.15	0.09	0.57	7.31	0.48	0.69	1.95	0.35	0.11	0.08	0.15	0.07	0.00	0.01	0.02	24.0
603	8719	7080	0.67	0.11	0.07	0.21	6.30	0.36	0.56	1.64	0.33	0.12	0.07	0.15	0.03	0.00	0.00	0.00	24.1
603	8720	7109	1.23	0.12	0.12	0.35	7.67	0.44	0.43	1.93	0.37	0.12	0.04	0.15	0.03	0.00	0.01	0.00	27.3
603	8721	7089	0.58	0.07	0.10	0.18	5.39	0.36	0.53	1.44	0.39	0.06	0.04	0.12	0.01	0.00	0.00	0.00	25.1
603	8721	7095	2.00	0.10	0.21	0.52	6.86	0.47	0.45	1.78	0.45	0.06	0.08	0.14	0.05	0.00	0.01	0.01	27.8
603	8722	7096	1.94	0.11	0.06	0.47	7.37	0.24	0.66	1.82	0.36	0.13	0.12	0.17	0.06	0.00	0.00	0.02	27.0
603	8723	7102	1.05	0.10	0.15	0.31	5.33	0.40	0.38	1.41	0.35	0.12	0.08	0.16	0.04	0.00	0.02	0.01	27.1
603	8724	7124	0.87	0.25	0.06	0.32	10.46	1.34	0.55	3.00	0.35	0.06	0.04	0.11	0.06	0.04	0.00	0.03	26.6
604	8715	7056	1.24	0.23	0.26	0.45	4.11	0.24	1.02	1.26	0.68	0.39	0.44	0.47	0.07	0.03	0.03	0.04	23.4
604	8716	7041	0.76	0.28	0.26	0.37	3.15	0.18	0.55	0.90	0.85	0.56	0.67	0.65	0.06	0.04	0.03	0.04	22.0
604	8716	7044	0.93	0.27	0.30	0.42	4.73	0.19	1.22	1.41	0.80	0.58	0.65	0.65	0.08	0.03	0.03	0.04	21.3
604	8717	7114	0.93	0.13	0.15	0.30	6.14	0.36	2.04	2.01	0.66	0.46	0.51	0.51	0.05	0.01	0.01	0.02	24.4
604	8717	7115	1.25	0.12	0.18	0.37	5.47	0.16	2.27	1.83	0.62	0.40	0.51	0.48	0.06	0.00	0.01	0.01	24.2
604	8718	7051	1.78	0.34	0.32	0.64	6.06	0.24	0.86	1.61	0.63	0.39	0.41	0.45	0.10	0.03	0.03	0.05	23.7
604	8719	7084	1.76	0.21	0.31	0.56	5.99	0.12	1.20	1.62	0.72	0.42	0.42	0.48	0.09	0.02	0.03	0.04	24.3
604	8720	7110	0.94	0.11	0.25	0.32	3.73	0.16	1.12	1.16	0.71	0.45	0.57	0.54	0.04	0.01	0.02	0.02	24.3
604	8721	7087	0.71	0.16	0.19	0.28	6.28	0.08	0.85	1.57	0.64	0.47	0.45	0.50	0.02	0.03	0.03	0.03	24.4
604	8721	7092	1.28	0.13	0.36	0.43	4.41	0.12	0.65	1.15	0.40	0.25	0.32	0.30	0.10	0.02	0.03	0.04	26.2
604	8722	7098	1.11	0.17	0.23	0.38	5.21	0.08	1.57	1.54	0.54	0.30	0.42	0.38	0.07	0.04	0.03	0.04	25.6
604	8723	7103	0.96	0.16	0.24	0.35	5.38	0.24	1.48	1.64	0.56	0.31	0.40	0.39	0.06	0.01	0.01	0.02	25.4
604	8724	7122	2.65	0.30	0.19	0.75	6.66	0.83	0.48	1.93	0.37	0.35	0.37	0.36	0.22	0.03	0.03	0.07	27.0

NIPER, ARB Benzene, Phase 2, Tailpipe-Out

			HC grams/mile				CO grams/mile				NOx grams/mile				Methane grams/mile				mpg
Car	Fuel	Test	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	FTP
605	8715	7057	1.96	0.13	0.09	0.50	16.84	0.01	0.28	3.58	0.93	0.28	0.32	0.43	0.16	0.01	0.02	0.04	27.3
605	8716	7040	1.04	0.17	0.15	0.35	8.66	0.03	0.14	1.85	1.11	0.32	0.46	0.52	0.10	0.01	0.02	0.03	27.3
605	8716	7046	1.08	0.17	0.16	0.36	13.45	0.05	2.74	3.57	1.15	0.41	0.50	0.58	0.12	0.01	0.02	0.03	24.8
605	8717	7121	2.07	0.10	0.05	0.49	15.65	0.12	2.39	3.94	0.78	0.17	0.26	0.32	0.13	0.00	0.01	0.03	27.0
605	8717	7125	1.39	0.07	0.05	0.34	20.66	0.16	1.51	4.75	0.81	0.18	0.27	0.34	0.13	0.00	0.01	0.02	27.5
605	8718	7050	1.21	0.19	0.19	0.40	13.01	0.07	0.44	2.84	1.19	0.31	0.84	0.63	0.12	0.01	0.01	0.04	26.3
605	8719	7090	0.98	0.08	0.11	0.27	16.28	0.08	1.21	3.72	1.09	0.25	0.56	0.51	0.13	0.00	0.03	0.04	24.4
605	8720	7117	1.24	0.08	0.08	0.32	15.50	0.20	2.82	4.07	2.95	0.20	0.33	0.80	0.13	0.00	0.01	0.03	26.1
605	8721	7093	1.23	0.09	0.08	0.32	13.52	0.04	2.01	3.35	1.00	0.25	0.44	0.45	0.11	0.01	0.02	0.03	26.1
605	8721	7099	1.52	0.10	0.09	0.39	14.35	0.12	1.04	3.30	1.09	0.24	0.35	0.45	0.13	0.01	0.02	0.04	28.7
605	8722	7101	1.39	0.14	0.13	0.40	20.33	0.05	2.40	4.86	0.90	0.25	0.39	0.42	0.15	0.02	0.02	0.05	26.5
605	8723	7108	1.06	0.08	0.09	0.28	11.29	0.12	2.64	3.11	1.16	0.29	0.30	0.47	0.11	0.00	0.01	0.02	26.3
605	8724	7128	1.19	0.11	0.05	0.32	12.47	0.48	0.83	3.04	0.77	0.12	0.26	0.29	0.11	0.00	0.00	0.02	26.3
606	8715	7054	1.26	0.20	0.14	0.40	5.47	1.23	1.66	2.23	0.86	0.19	0.23	0.34	0.06	0.00	0.02	0.02	20.0
606	8716	7047	1.58	0.20	0.24	0.50	6.04	0.46	1.79	1.98	1.06	0.26	0.30	0.44	0.08	0.01	0.04	0.04	19.5
606	8716	7053	0.83	0.27	0.15	0.35	4.10	2.12	1.65	2.40	0.81	0.27	0.18	0.36	0.06	0.04	0.04	0.04	19.2
606	8717	7119	1.44	0.13	0.07	0.38	8.08	0.60	1.04	2.26	1.10	0.23	0.26	0.42	0.05	0.01	0.01	0.02	21.1
606	8717	7126	0.72	0.07	0.05	0.20	5.39	0.32	0.56	1.43	1.00	0.18	0.23	0.36	0.03	0.00	0.01	0.01	22.3
606	8718	7130	1.14	0.09	0.06	0.30	5.98	0.32	0.44	1.52	1.05	0.17	0.22	0.36	0.07	0.00	0.01	0.02	21.6
606	8719	7085	1.22	0.26	0.28	0.46	5.50	1.00	2.71	2.39	0.95	0.22	0.28	0.39	0.07	0.03	0.03	0.04	19.3
606	8720	7118	1.51	0.08	0.09	0.38	6.53	0.87	1.70	2.26	1.02	0.22	0.28	0.40	0.05	0.01	0.02	0.02	20.0
606	8721	7091	2.23	0.10	0.13	0.55	5.66	0.36	1.03	1.63	1.04	0.20	0.17	0.36	0.05	0.00	0.02	0.02	20.3
606	8721	7100	2.02	0.10	0.12	0.50	7.36	0.44	1.58	2.18	0.73	0.18	0.23	0.31	0.09	0.05	0.01	0.05	20.1
606	8722	7105	1.24	0.09	0.12	0.34	5.50	0.59	1.61	1.88	1.13	0.18	0.23	0.39	0.04	0.00	0.02	0.01	20.2
606	8723	7111	1.53	0.13	0.18	0.43	6.89	0.91	2.14	2.48	1.29	0.30	0.34	0.51	0.07	0.01	0.02	0.03	19.6
606	8724	7127	0.86	0.12	0.08	0.26	4.74	0.36	0.89	1.41	0.83	0.17	0.25	0.33	0.04	0.00	0.00	0.00	21.9

NIPER, ARB Benzene, Phase 2, Tailpipe-out

Car	Fuel	Test	Benzene mg/mile				Toluene mg/mile				Ethyl BZ mg/mile				Xylenes mg/mile				m,pXylene mg/mi				oXylene mg/mile			
			c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
505	8715	7055	75	25	31	37	221	22	65	75	65	5	19	21	203	19	56	67	103	10	29	34	100	9	27	33
505	8716	7042	49	16	19	24	109	8	26	34	25	0	5	7	106	10	22	33	52	6	11	17	54	4	11	16
505	8716	7048	59	16	22	27	125	9	31	39	30	0	6	8	127	14	26	40	62	8	14	21	65	6	12	20
505	8717	7112	61	8	3	18	249	11	15	61	91	10	5	25	249	35	15	74	130	16	8	37	119	19	7	36
505	8717	7120	89	8	21	28	320	8	34	79	109	11	9	31	299	34	27	87	154	16	14	44	145	18	13	43
505	8718	7049	92	39	31	48	141	24	36	51	74	0	13	19	307	21	61	91	158	6	32	45	149	15	28	46
505	8719	7082	86	24	21	36	215	13	39	62	107	4	13	28	125	13	22	39	60	6	11	18	65	8	12	20
505	8720	7107	112	78	78	85	371	85	188	172	36	9	15	16	252	66	108	116	128	32	57	59	124	33	51	57
505	8721	7088	131	25	37	50	166	12	36	50	138	10	21	39	278	29	46	85	140	14	25	43	138	16	22	42
505	8721	7094	144	53	51	72	161	28	46	60	133	16	30	44	265	36	62	90	132	18	32	45	133	18	30	45
505	8722	7097	164	67	49	82	321	49	68	110	42	14	8	18	436	54	82	140	222	31	42	73	214	23	40	67
505	8723	7104	124	57	53	69	317	55	108	123	68	9	20	24	119	22	39	47	58	11	20	23	61	11	20	24
505	8724	7144	95	62	44	64	375	74	103	145	233	32	27	72	377	84	87	146	201	50	45	80	177	34	42	66
603	8715	7058	51	0	1	11	259	1	1	55	71	0	0	15	219	14	2	53	111	8	2	28	107	7	0	26
603	8716	7039	19	0	1	4	53	0	0	11	17	0	0	4	66	0	0	14	34	0	0	7	32	0	0	7
603	8716	7045	21	0	1	5	66	0	1	14	16	0	0	3	68	3	0	16	34	0	0	7	34	3	0	8
603	8717	7113	20	2	2	6	86	4	4	21	27	0	0	5	76	11	6	23	39	7	4	13	36	4	2	10
603	8717	7116	38	0	1	8	254	8	4	57	82	5	3	20	214	18	11	56	112	9	4	29	102	9	7	28
603	8718	7052	81	0	1	17	164	0	1	34	78	0	0	16	350	15	4	81	183	8	2	42	168	7	3	39
603	8719	7080	27	0	1	6	76	0	2	16	33	0	0	7	39	0	3	9	19	0	3	5	20	0	0	4
603	8720	7109	70	2	5	17	316	12	15	75	25	0	4	6	177	20	20	52	92	11	9	27	85	9	11	25
603	8721	7089	22	0	2	5	37	3	7	11	28	0	2	6	58	11	13	21	32	5	9	12	27	6	4	10
603	8721	7095	105	4	0	24	137	4	0	30	108	16	0	31	198	23	6	54	101	11	3	27	97	12	3	27
603	8722	7096	107	2	1	23	277	3	1	59	28	0	0	6	307	27	10	80	147	14	6	39	160	14	4	41
603	8723	7102	56	1	3	13	180	4	6	41	36	0	0	7	67	13	10	23	33	8	7	13	34	4	3	10
603	8724	7124	38	15	1	16	111	19	3	33	35	7	0	11	105	23	5	35	49	10	2	16	56	13	3	19
604	8715	7056	34	2	6	10	126	5	10	31	40	0	4	9	125	16	12	38	64	9	6	19	62	7	6	18
604	8716	7041	18	1	3	5	38	0	4	9	0	0	0	0	48	0	4	11	20	0	0	4	28	0	4	7
604	8716	7044	22	1	5	7	48	0	7	12	10	0	0	2	45	0	10	12	22	0	7	6	23	0	3	6
604	8717	7114	41	2	7	11	150	5	12	37	48	7	6	15	130	16	13	39	69	8	7	21	61	8	6	18
604	8717	7115	45	2	9	13	209	4	16	49	68	4	5	17	176	15	15	48	93	8	8	25	83	7	7	23
604	8718	7051	23	2	6	8	109	3	9	26	55	0	5	13	260	18	21	69	134	10	11	36	126	8	10	33
604	8719	7084	61	1	9	16	194	3	15	46	87	11	8	26	92	45	13	46	52	30	7	29	40	15	5	17
604	8720	7110	60	2	12	17	208	10	17	53	19	0	0	4	124	24	7	40	65	13	2	21	59	11	5	19
604	8721	7087	45	1	10	12	49	1	11	13	21	0	11	7	54	17	17	25	29	13	9	15	25	4	8	10
604	8721	7092	110	0	18	28	151	0	17	36	125	2	17	32	241	10	35	64	123	4	17	32	118	6	17	32
604	8722	7098	56	1	11	15	113	3	17	29	16	0	4	4	153	21	23	48	78	12	12	25	75	9	11	23
604	8723	7103	52	2	13	15	129	6	24	36	28	0	8	8	49	0	11	13	25	0	6	7	24	0	5	6
604	8724	7122	126	10	9	34	290	11	12	69	88	6	3	22	263	22	11	69	126	9	6	32	137	13	5	36

NIPER, ARB Benzene, Phase 2, Tailpipe-Out

			Benzene mg/mile				Toluene mg/mile				Ethyl BZ mg/mile				Xylenes mg/mile				m,pXylene mg/mi				oXylene mg/mile			
Car	Fuel	Test	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
605	8715	7057	64	0	1	14	201	2	0	43	54	0	0	11	175	17	0	45	90	9	0	23	85	8	0	22
605	8716	7040	25	0	0	5	51	0	0	11	14	0	0	3	55	0	0	11	29	0	0	6	26	0	0	5
605	8716	7046	30	0	1	7	49	0	1	10	11	0	0	2	52	0	0	11	26	0	0	5	26	0	0	5
605	8717	7121	115	0	2	24	278	8	9	64	76	8	4	21	228	29	13	65	118	13	8	33	110	16	5	32
605	8717	7125	76	0	1	16	206	4	2	45	55	0	0	11	171	14	2	43	88	5	0	21	83	8	2	22
605	8718	7050	47	0	1	10	69	0	0	14	37	0	0	8	166	11	0	40	86	5	0	21	80	5	0	19
605	8719	7090	41	0	4	9	106	2	3	24	51	0	0	10	65	5	5	18	33	5	4	11	33	0	1	7
605	8720	7117	85	0	3	18	211	5	5	47	21	0	0	4	132	11	7	35	68	5	4	18	64	6	3	17
605	8721	7093	70	0	1	15	72	0	1	15	63	0	0	13	129	3	3	29	64	0	3	14	64	3	0	15
605	8721	7099	80	7	1	20	91	17	1	28	72	8	0	19	142	28	2	44	73	17	2	24	69	11	0	20
605	8722	7101	93	1	3	21	136	4	3	31	19	0	0	4	173	19	8	48	89	10	5	24	85	10	4	24
605	8723	7108	68	1	2	15	151	3	5	34	29	0	0	6	59	0	1	13	29	0	1	6	31	0	0	6
605	8724	7128	69	1	0	15	141	13	2	36	50	10	0	16	149	42	9	55	69	16	4	24	80	27	5	32
606	8715	7054	42	3	10	13	121	2	12	30	34	0	0	7	106	0	9	24	54	0	4	12	52	0	4	12
606	8716	7047	36	0	5	9	81	0	2	18	18	0	0	4	79	0	0	16	39	0	0	8	40	0	0	8
606	8716	7053	22	6	3	8	39	4	2	11	10	0	0	2	43	3	0	10	21	0	0	4	22	3	0	6
606	8717	7119	53	1	2	12	225	8	3	51	66	5	2	17	188	18	10	51	98	9	5	26	90	9	6	25
606	8717	7126	35	0	1	8	96	2	3	21	28	0	0	6	81	10	9	24	42	4	3	12	39	5	6	12
606	8718	7130	51	0	1	11	75	1	0	16	34	0	0	7	152	17	4	41	78	8	2	21	74	9	2	21
606	8719	7085	65	4	9	18	169	5	9	40	77	8	2	21	89	17	7	29	43	8	4	14	46	9	4	15
606	8720	7118	94	0	6	21	329	4	7	72	26	0	0	5	174	13	7	45	91	8	3	23	83	6	4	21
606	8721	7091	122	0	5	26	154	3	4	34	130	15	0	34	246	30	9	69	123	14	3	33	123	17	5	35
606	8721	7100	106	10	1	27	138	10	1	34	110	5	0	25	223	23	6	60	108	10	2	28	115	13	4	31
606	8722	7105	69	1	7	17	138	3	6	31	22	0	0	5	170	15	3	43	87	8	3	23	82	6	0	20
606	8723	7111	90	1	13	23	221	4	16	52	46	0	4	11	87	11	9	26	42	7	4	13	45	4	4	13
606	8724	7127	39	0	2	9	116	3	5	27	39	0	0	8	106	9	15	31	50	3	6	13	57	7	9	18

NIPER, ARB Benzene, Phase 2, Tailpipe-Out

			HC Reduction %				CO Reduction %				NOx Reduction %			
Car	Fuel	Test	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
505	8715	7055	56	88	82	78	12	62	63	51	73	66	73	70
505	8716	7042	61	89	86	81	16	55	65	50	69	64	71	67
505	8716	7048	56	88	84	78	3	60	58	46	68	64	70	67
505	8717	7112	67	96	94	88	24	85	83	70	81	65	73	71
505	8717	7120	62	96	94	86	17	81	79	61	82	57	66	65
505	8718	7049	57	84	83	77	20	53	58	48	65	67	75	69
505	8719	7082	64	92	92	85	6	63	76	54	71	66	72	69
505	8720	7107	68	88	82	82	24	51	50	46	77	68	74	72
505	8721	7088	61	92	86	82	17	67	63	52	72	71	77	73
505	8721	7094	51	85	78	75	46	47	47	47	72	62	81	70
505	8722	7097	63	85	82	77	34	50	58	47	74	55	75	66
505	8723	7104	60	87	78	79	46	55	49	52	76	64	75	71
505	8724	7144	57	86	85	78	25	53	60	49	74	68	82	74
603	8715	7058	47	95	96	77	63	98	97	88	75	91	93	87
603	8716	7039	59	89	91	83	72	97	97	91	80	87	93	87
603	8716	7045	55	92	92	82	69	98	96	90	78	90	94	88
603	8717	7113	74	95	97	90	49	93	93	87	82	95	98	92
603	8717	7116	59	95	97	85	65	94	94	86	83	96	98	93
603	8718	7052	44	93	94	77	63	97	94	88	82	88	95	88
603	8719	7080	70	95	96	89	67	98	95	90	85	90	95	90
603	8720	7109	53	94	90	81	62	97	96	88	81	90	97	89
603	8721	7089	73	97	94	91	69	98	95	91	82	95	97	92
603	8721	7095	43	94	87	75	61	97	96	88	74	94	94	88
603	8722	7096	43	94	97	78	60	98	95	88	80	88	91	87
603	8723	7102	51	94	89	82	68	97	96	90	82	88	92	87
603	8724	7124	78	89	96	86	35	94	95	84	83	94	97	92
604	8715	7056	67	92	88	84	72	98	88	89	62	75	75	72
604	8716	7041	68	90	87	85	72	99	94	92	58	72	73	70
604	8716	7044	62	88	84	82	65	99	87	88	65	74	72	72
604	8717	7114	68	95	93	88	59	97	80	84	65	76	77	74
604	8717	7115	64	96	91	87	64	99	77	85	68	79	76	76
604	8718	7051	59	89	86	80	65	98	90	87	59	74	75	71
604	8719	7084	50	93	84	80	58	99	85	86	60	75	75	72
604	8720	7110	62	96	85	86	69	99	88	90	70	80	74	76
604	8721	7087	71	94	88	88	57	99	89	86	65	73	73	71
604	8721	7092	87	95	80	89	84	99	92	91	65	81	74	76
604	8722	7098	66	94	88	86	63	99	82	86	70	82	78	78
604	8723	7103	81	94	87	88	80	98	83	88	57	81	80	77
604	8724	7122	36	87	89	70	89	95	96	92	46	69	76	69

NIPER, ARB Benzene, Phase 2, Tailpipe-Out

			HC Reduction %				CO Reduction %				NOx Reduction %			
Car	Fuel	Test	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
605	8715	7057	62	93	95	80	31	100	96	66	61	71	83	72
605	8716	7040	64	90	91	82	61	100	98	81	61	72	77	70
605	8716	7046	68	91	91	84	20	99	71	63	63	70	82	72
605	8717	7121	59	94	97	80	17	98	74	61	72	86	89	83
605	8717	7125	65	96	98	85	14	98	83	57	73	87	89	83
605	8718	7050	66	89	91	82	41	99	94	72	61	74	66	67
605	8719	7090	71	96	95	88	7	99	90	64	67	83	81	77
605	8720	7117	68	95	95	85	27	97	70	63	6	87	87	62
605	8721	7093	67	95	96	86	26	99	78	66	67	82	83	78
605	8721	7099	61	95	94	82	47	98	85	70	58	78	82	73
605	8722	7101	64	92	93	82	21	99	76	58	70	81	84	79
605	8723	7108	74	96	96	88	35	98	71	69	64	79	87	77
605	8724	7128	71	94	98	87	33	94	91	71	80	92	90	87
606	8715	7054	63	94	94	86	65	92	86	85	91	91	91	91
606	8716	7047	65	94	92	86	64	97	85	86	74	89	90	85
606	8716	7053	75	92	95	89	71	86	87	83	72	89	93	86
606	8717	7119	66	95	97	87	56	96	92	85	69	88	92	84
606	8717	7126	72	97	98	91	64	98	95	89	72	91	92	86
606	8718	7130	63	96	97	87	59	98	96	89	69	91	92	85
606	8719	7085	72	93	91	88	66	94	82	85	74	90	92	87
606	8720	7118	63	97	96	88	61	94	86	85	72	90	91	85
606	8721	7091	58	97	95	84	65	98	92	89	71	91	95	87
606	8721	7100	55	97	95	85	54	97	87	85	79	92	93	89
606	8722	7105	65	97	96	89	62	96	88	87	70	92	93	87
606	8723	7111	64	96	94	88	59	94	84	84	69	89	90	84
606	8724	7127	67	95	96	89	66	97	93	89	74	91	91	86

NIPER, ARB Benzene, Phase 2, Tailpipe-Out

			Benzene Red. %				Toluene Red. %				Ethyl BZ Red. %				Xylene Red. %				m,pXylene Red.%				oXylene Red. %			
Car	Fuel	Test	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
505	8715	7055	54	80	70	71	57	95	80	82	58	96	80	83	54	95	80	81	55	95	80	81	54	95	80	81
505	8716	7042	40	83	75	73	62	97	85	85	59	100	86	87	58	95	86	83	58	94	86	83	58	96	87	84
505	8716	7048	53	83	74	73	56	96	84	83	50	100	87	84	53	93	86	81	52	92	85	80	53	94	87	81
505	8717	7112	66	95	97	88	71	98	97	90	70	95	97	88	68	93	96	86	67	94	96	87	69	93	96	86
505	8717	7120	58	94	84	82	61	99	93	86	62	94	95	85	59	93	93	83	59	93	94	83	58	92	92	82
505	8718	7049	55	78	78	73	60	92	86	82	59	100	89	87	58	96	88	84	58	98	88	85	57	95	88	84
505	8719	7082	48	87	86	78	52	97	90	86	52	98	94	87	50	95	90	84	51	95	90	85	50	94	90	84
505	8720	7107	65	72	70	70	70	92	82	85	71	92	85	86	66	91	83	83	67	91	83	84	66	91	83	83
505	8721	7088	56	89	82	79	61	96	86	84	59	96	90	84	57	93	88	82	57	94	87	82	56	93	88	81
505	8721	7094	49	77	73	69	50	89	78	76	51	92	83	79	48	91	77	76	48	91	80	77	47	90	71	75
505	8722	7097	19	71	77	63	18	89	85	75	25	80	87	72	15	90	85	74	14	89	85	74	15	91	85	74
505	8723	7104	56	77	74	72	57	92	81	81	60	94	84	83	56	91	81	80	56	91	80	80	56	91	81	81
505	8724	7144	57	67	72	66	58	89	84	80	46	89	93	79	58	87	87	79	53	84	88	78	63	89	86	80
603	8715	7058	56	100	99	86	49	99	99	78	50	100	100	80	49	92	98	75	49	92	96	75	48	93	100	76
603	8716	7039	69	100	98	93	60	100	100	91	54	100	100	93	53	100	100	88	56	100	100	88	50	100	100	88
603	8716	7045	48	100	98	91	58	100	99	88	56	100	100	89	55	98	100	87	56	100	100	88	55	96	100	85
603	8717	7113	80	98	97	93	74	98	98	92	74	100	100	93	72	95	96	90	72	94	96	89	72	96	97	90
603	8717	7116	65	100	98	91	47	97	99	82	46	94	96	80	47	93	95	79	47	93	96	80	47	92	93	78
603	8718	7052	49	100	99	83	48	100	99	81	48	100	100	81	43	95	98	77	43	95	99	77	43	95	98	77
603	8719	7080	73	100	99	93	69	100	99	93	70	100	100	93	72	100	97	93	72	100	94	92	72	100	100	94
603	8720	7109	57	99	94	86	46	97	94	82	53	100	87	86	49	92	87	79	49	92	89	79	49	93	86	79
603	8721	7089	68	100	98	95	75	98	93	92	72	100	98	93	70	95	91	89	70	95	89	88	71	94	94	89
603	8721	7095	46	96	100	80	43	96	100	78	38	81	100	70	38	86	96	72	39	87	97	73	38	85	96	71
603	8722	7096	43	98	99	81	31	99	99	76	41	100	100	84	29	88	95	70	30	88	95	71	28	88	96	69
603	8723	7102	57	99	96	88	43	98	97	84	49	100	100	88	45	88	88	77	46	84	82	74	44	91	94	80
603	8724	7124	73	84	99	83	71	92	98	86	63	91	100	85	60	89	96	83	61	91	96	84	59	88	96	82
604	8715	7056	21	98	92	87	45	98	95	88	44	100	95	89	45	94	95	85	45	94	95	85	46	95	95	86
604	8716	7041	72	98	94	92	72	100	97	94	100	100	100	100	64	100	96	92	71	100	100	94	58	100	93	90
604	8716	7044	69	98	91	90	65	100	94	91	62	100	100	93	65	100	90	90	67	100	87	90	62	100	94	91
604	8717	7114	64	98	91	88	65	99	96	90	68	95	94	89	69	96	96	89	68	96	95	89	70	96	96	90
604	8717	7115	65	98	89	88	60	99	95	88	61	97	95	88	63	96	95	88	62	96	95	87	64	96	95	88
604	8718	7051	68	98	93	93	56	99	94	87	56	100	94	88	56	93	94	80	56	96	94	85	56	71	94	73
604	8719	7084	58	99	89	86	51	99	93	85	58	93	93	84	62	77	90	76	57	69	89	70	68	86	92	82
604	8720	7110	61	99	89	88	59	98	95	89	65	100	100	92	61	94	97	88	61	93	98	88	62	94	96	88
604	8721	7087	57	99	88	89	72	100	90	92	80	100	87	94	77	94	89	90	76	91	88	88	79	97	90	92
604	8721	7092	10	100	82	78	57	100	84	81	56	99	81	82	53	97	82	81	53	98	82	81	53	97	82	81
604	8722	7098	66	100	90	89	66	99	92	90	65	100	90	91	66	95	92	88	66	95	92	88	66	96	92	88
604	8723	7103	61	98	87	87	61	98	91	89	54	100	86	89	54	100	90	90	53	100	89	89	55	100	92	90
604	8724	7122	12	87	87	62	34	95	91	71	39	93	92	73	42	90	92	72	40	91	91	72	43	90	92	73

NIPER, ARB Benzene, Phase 2, Tailpipe-Out

			Benzene Red. %				Toluene Red. %				Ethyl BZ Red. %				Xylene Red. %				m,pXylene Red.%				oXylene Red. %			
Car	Fuel	Test	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
605	8715	7057	53	100	98	80	63	99	100	83	67	100	100	86	66	90	100	81	66	89	100	81	67	90	100	82
605	8716	7040	64	100	99	89	67	100	100	90	80	100	100	91	69	100	100	90	70	100	100	90	68	100	100	90
605	8716	7046	62	100	97	87	74	100	99	91	74	100	100	89	75	100	100	91	74	100	100	90	76	100	100	92
605	8717	7121	22	100	97	68	61	97	97	81	70	91	95	83	67	88	95	80	67	89	93	80	67	86	96	80
605	8717	7125	41	100	99	79	61	99	99	86	69	100	100	90	64	94	99	85	64	96	100	86	64	93	98	85
605	8718	7050	63	100	99	88	68	100	100	90	70	100	100	89	68	95	100	87	68	95	100	87	68	95	100	87
605	8719	7090	38	100	95	87	58	99	98	89	60	100	100	91	57	95	96	86	56	91	94	83	59	100	98	89
605	8720	7117	48	100	96	81	67	98	98	87	67	100	100	90	70	94	96	86	69	95	95	86	71	94	97	86
605	8721	7093	61	100	99	87	67	100	99	89	69	100	100	89	67	98	98	88	67	100	97	88	67	97	100	87
605	8721	7099	53	91	98	79	59	83	99	77	61	91	100	82	62	83	98	78	61	81	97	77	63	87	100	80
605	8722	7101	53	99	97	82	68	98	99	88	73	100	100	90	70	93	97	85	70	93	97	85	70	92	97	85
605	8723	7108	67	99	98	88	77	99	99	91	79	100	100	93	76	100	99	91	76	100	98	91	76	100	100	91
605	8724	7128	55	99	100	83	72	95	99	88	72	88	100	85	72	82	96	82	71	86	96	83	72	80	96	81
606	8715	7054	59	97	86	85	64	99	95	90	70	100	100	92	68	100	96	91	68	100	96	91	68	100	96	91
606	8716	7047	61	100	92	88	68	100	99	91	70	100	100	92	72	100	100	93	71	100	100	92	73	100	100	93
606	8716	7053	72	90	95	87	80	98	99	94	78	100	100	95	81	99	100	95	81	100	100	96	81	97	100	94
606	8717	7119	59	99	98	88	65	98	99	88	71	96	98	89	70	95	97	88	70	96	97	88	71	95	97	88
606	8717	7126	63	100	98	91	72	99	99	93	76	100	100	95	74	97	97	92	75	97	98	92	74	97	95	91
606	8718	7130	59	100	99	89	60	99	100	89	63	100	100	91	64	95	99	88	64	95	99	88	64	94	98	87
606	8719	7085	56	97	92	87	61	99	97	90	68	96	99	90	67	92	96	87	67	94	96	88	66	90	97	86
606	8720	7118	46	100	94	84	54	99	98	86	61	100	100	90	65	97	98	89	63	96	98	88	66	97	97	89
606	8721	7091	54	100	96	84	57	99	98	84	60	92	100	82	60	91	97	82	60	92	97	82	60	90	96	81
606	8721	7100	49	92	100	81	53	94	99	83	58	97	100	86	56	93	97	83	58	94	98	84	55	93	95	81
606	8722	7105	59	99	95	89	63	99	98	90	58	100	100	90	68	97	99	91	68	96	98	90	69	97	100	91
606	8723	7111	58	99	91	84	67	99	96	90	70	100	96	91	67	95	95	88	67	93	95	87	68	96	95	89
606	8724	7127	64	99	98	90	67	99	98	91	65	100	100	92	70	97	95	90	71	98	95	91	68	96	94	89

NIPER, ARB Benzene, Phase 2, Tailpipe-Out

			Fuel Components vol pct					FTP	Emissions FTP g/mile				FTP mg/mile				Emissions wt pct of HC				g/gal
Car	Fuel	Test	BZ	TOL	EBZ	XYL	REF	mpg	HC	CO	NOx	Meth	BZ	TOL	EBZ	XYL	BZ	TOL	EBZ	XYL	BZ
505	8715	7055	1.2	10.1	2.8	10.8	10.4	21.2	0.85	10.99	0.36	0.13	37	75	21	67	4.31	8.74	2.49	7.85	0.78
505	8716	7042	1.1	5.1	0.9	5.7	10.1	19.5	0.80	10.51	0.56	0.15	24	34	7	33	2.97	4.20	0.84	4.15	0.46
505	8716	7048	1.1	5.1	0.9	5.7	10.1	19.9	0.88	11.08	0.49	0.14	27	39	8	40	3.04	4.44	0.90	4.62	0.53
505	8717	7112	1.0	15.9	5.1	16.7	10.5	22.7	0.48	5.07	0.50	0.04	18	61	25	74	3.67	12.62	5.20	15.23	0.40
505	8717	7120	1.0	15.9	5.1	16.7	10.5	22.2	0.60	7.44	0.59	0.06	28	79	31	87	4.69	13.12	5.12	14.37	0.63
505	8718	7049	2.1	5.2	2.9	17.0	10.7	20.7	0.99	12.74	0.48	0.15	48	51	19	91	4.81	5.16	1.88	9.17	0.99
505	8719	7082	2.1	10.2	5.1	5.9	10.8	21.2	0.64	8.40	0.46	0.08	36	62	28	39	5.63	9.73	4.35	6.10	0.76
505	8720	7107	2.2	16.1	0.9	12.0	12.3	20.1	0.85	13.35	0.43	0.10	85	172	16	116	10.02	20.31	1.93	13.65	1.71
505	8721	7088	3.4	5.2	5.0	11.2	10.5	20.2	0.82	10.70	0.40	0.09	50	50	39	85	6.07	6.14	4.77	10.39	1.01
505	8721	7094	3.4	5.2	5.0	11.2	10.5	22.9	1.07	11.91	0.35	0.15	72	60	44	90	6.70	5.65	4.15	8.46	1.64
505	8722	7097	3.4	10.4	0.9	16.6	10.7	22.2	1.14	13.58	0.51	0.17	82	110	18	140	7.21	9.68	1.58	12.33	1.82
505	8723	7104	3.2	15.5	2.7	5.6	10.8	20.7	0.95	10.80	0.44	0.13	69	123	24	47	7.33	13.01	2.58	4.94	1.44
505	8724	7144	1.1	11.6	3.4	13.2	18.5	20.0	1.14	13.61	0.45	0.14	64	145	72	146	5.64	12.74	6.36	12.81	1.29
603	8715	7058	1.2	10.1	2.8	10.8	10.4	27.4	0.51	1.69	0.13	0.02	11	55	15	53	2.09	10.67	2.84	10.36	0.30
603	8716	7039	1.1	5.1	0.9	5.7	10.1	23.3	0.35	1.32	0.22	0.03	4	11	4	14	1.19	3.15	1.01	3.91	0.10
603	8716	7045	1.1	5.1	0.9	5.7	10.1	24.2	0.36	1.37	0.19	0.01	5	14	3	16	1.29	3.90	0.94	4.30	0.11
603	8717	7113	1.0	15.9	5.1	16.7	10.5	26.9	0.18	1.86	0.13	0.00	6	21	5	23	3.10	11.59	3.03	12.84	0.15
603	8717	7116	1.0	15.9	5.1	16.7	10.5	25.6	0.32	2.20	0.12	0.01	8	57	20	56	2.65	18.17	6.47	17.89	0.21
603	8718	7052	2.1	5.2	2.9	17.0	10.7	24.0	0.57	1.95	0.15	0.02	17	34	16	81	2.97	6.00	2.81	14.22	0.41
603	8719	7080	2.1	10.2	5.1	5.9	10.8	24.1	0.21	1.64	0.15	0.00	6	16	7	9	2.71	7.48	3.15	4.17	0.14
603	8720	7109	2.2	16.1	0.9	12.0	12.3	27.3	0.35	1.93	0.15	0.00	17	75	6	52	4.84	21.70	1.80	15.03	0.46
603	8721	7089	3.4	5.2	5.0	11.2	10.5	25.1	0.18	1.44	0.12	0.00	5	11	6	21	2.69	6.06	3.39	11.74	0.12
603	8721	7095	3.4	5.2	5.0	11.2	10.5	27.8	0.52	1.78	0.14	0.01	24	30	31	54	4.56	5.81	5.86	10.44	0.66
603	8722	7096	3.4	10.4	0.9	16.6	10.7	27.0	0.47	1.82	0.17	0.02	23	59	6	80	4.92	12.47	1.20	16.94	0.63
603	8723	7102	3.2	15.5	2.7	5.6	10.8	27.1	0.31	1.41	0.16	0.01	13	41	7	23	4.11	13.08	2.35	7.36	0.35
603	8724	7124	1.1	11.6	3.4	13.2	18.5	26.6	0.32	3.00	0.11	0.03	16	33	11	35	4.95	10.23	3.29	10.71	0.43
604	8715	7056	1.2	10.1	2.8	10.8	10.4	23.4	0.45	1.26	0.47	0.04	10	31	9	38	2.21	7.03	2.09	8.41	0.23
604	8716	7041	1.1	5.1	0.9	5.7	10.1	22.0	0.37	0.90	0.65	0.04	5	9	0	11	1.42	2.37	0.00	3.00	0.12
604	8716	7044	1.1	5.1	0.9	5.7	10.1	21.3	0.42	1.41	0.65	0.04	7	12	2	12	1.57	2.84	0.50	2.89	0.14
604	8717	7114	1.0	15.9	5.1	16.7	10.5	24.4	0.30	2.01	0.51	0.02	11	37	15	39	3.73	12.16	5.00	12.93	0.27
604	8717	7115	1.0	15.9	5.1	16.7	10.5	24.2	0.37	1.83	0.48	0.01	13	49	17	48	3.41	13.36	4.75	13.14	0.30
604	8718	7051	2.1	5.2	2.9	17.0	10.7	23.7	0.64	1.61	0.45	0.05	8	26	13	69	1.18	4.16	1.98	10.86	0.18
604	8719	7084	2.1	10.2	5.1	5.9	10.8	24.3	0.56	1.62	0.48	0.04	16	46	26	46	2.80	8.14	4.60	8.23	0.38
604	8720	7110	2.2	16.1	0.9	12.0	12.3	24.3	0.32	1.16	0.54	0.02	17	53	4	40	5.16	16.49	1.19	12.44	0.40
604	8721	7087	3.4	5.2	5.0	11.2	10.5	24.4	0.28	1.57	0.50	0.03	12	13	7	25	4.41	4.74	2.57	8.93	0.30
604	8721	7092	3.4	5.2	5.0	11.2	10.5	26.2	0.43	1.15	0.30	0.04	28	36	32	64	6.41	8.35	7.36	14.99	0.72
604	8722	7098	3.4	10.4	0.9	16.6	10.7	25.6	0.38	1.54	0.38	0.04	15	29	4	48	3.91	7.78	1.15	12.80	0.38
604	8723	7103	3.2	15.5	2.7	5.6	10.8	25.4	0.35	1.64	0.39	0.02	15	36	8	13	4.44	10.36	2.32	3.80	0.39
604	8724	7122	1.1	11.6	3.4	13.2	18.5	27.0	0.75	1.93	0.36	0.07	34	69	22	69	4.49	9.14	2.90	9.11	0.91

NIPER, ARB Benzene, Phase 2, Tailpipe-Out

			Fuel Components vol pct					FTP	Emissions FTP g/mile				FTP mg/mile				Emissions wt pct of HC				g/gal
Car	Fuel	Test	BZ	TOL	EBZ	XYL	REF	mpg	HC	CO	NOx	Meth	BZ	TOL	EBZ	XYL	BZ	TOL	EBZ	XYL	BZ
605	8715	7057	1.2	10.1	2.8	10.8	10.4	27.3	0.50	3.58	0.43	0.04	14	43	11	45	2.72	8.54	2.25	9.02	0.37
605	8716	7040	1.1	5.1	0.9	5.7	10.1	27.3	0.35	1.85	0.52	0.03	5	11	3	11	1.52	3.06	0.86	3.27	0.14
605	8716	7046	1.1	5.1	0.9	5.7	10.1	24.8	0.36	3.57	0.58	0.03	7	10	2	11	1.85	2.93	0.66	3.00	0.16
605	8717	7121	1.0	15.9	5.1	16.7	10.5	27.0	0.49	3.94	0.32	0.03	24	64	21	65	4.93	12.96	4.21	13.27	0.66
605	8717	7125	1.0	15.9	5.1	16.7	10.5	27.5	0.34	4.75	0.34	0.02	16	45	11	43	4.72	13.31	3.37	12.77	0.44
605	8718	7050	2.1	5.2	2.9	17.0	10.7	26.3	0.40	2.84	0.63	0.04	10	14	8	40	2.48	3.56	1.88	9.87	0.26
605	8719	7090	2.1	10.2	5.1	5.9	10.8	24.4	0.27	3.72	0.51	0.04	9	24	10	18	3.46	8.64	3.80	6.46	0.23
605	8720	7117	2.2	16.1	0.9	12.0	12.3	26.1	0.32	4.07	0.80	0.03	18	47	4	35	5.79	14.96	1.34	11.06	0.48
605	8721	7093	3.4	5.2	5.0	11.2	10.5	26.1	0.32	3.35	0.45	0.03	15	15	13	29	4.56	4.68	4.04	8.99	0.38
605	8721	7099	3.4	5.2	5.0	11.2	10.5	28.7	0.39	3.30	0.45	0.04	20	28	19	44	5.26	7.23	4.89	11.50	0.58
605	8722	7101	3.4	10.4	0.9	16.6	10.7	26.5	0.40	4.86	0.42	0.05	21	31	4	48	5.20	7.75	0.96	12.07	0.55
605	8723	7108	3.2	15.5	2.7	5.6	10.8	26.3	0.28	3.11	0.47	0.02	15	34	6	13	5.33	12.00	2.13	4.47	0.40
605	8724	7128	1.1	11.6	3.4	13.2	18.5	26.3	0.32	3.04	0.29	0.02	15	36	16	55	4.64	11.53	4.92	17.54	0.38
606	8715	7054	1.2	10.1	2.8	10.8	10.4	20.0	0.40	2.23	0.34	0.02	13	30	7	24	3.18	7.34	1.77	6.03	0.26
606	8716	7047	1.1	5.1	0.9	5.7	10.1	19.5	0.50	1.98	0.44	0.04	9	18	4	16	1.76	3.50	0.76	3.28	0.17
606	8716	7053	1.1	5.1	0.9	5.7	10.1	19.2	0.35	2.40	0.36	0.04	8	11	2	10	2.42	3.02	0.60	2.92	0.16
606	8717	7119	1.0	15.9	5.1	16.7	10.5	21.1	0.38	2.26	0.42	0.02	12	51	17	51	3.08	13.29	4.41	13.23	0.25
606	8717	7126	1.0	15.9	5.1	16.7	10.5	22.3	0.20	1.43	0.36	0.01	8	21	6	24	3.75	10.73	2.87	12.02	0.17
606	8718	7130	2.1	5.2	2.9	17.0	10.7	21.6	0.30	1.52	0.36	0.02	11	16	7	41	3.57	5.36	2.32	13.85	0.23
606	8719	7085	2.1	10.2	5.1	5.9	10.8	19.3	0.46	2.39	0.39	0.04	18	40	21	29	3.82	8.68	4.49	6.28	0.34
606	8720	7118	2.2	16.1	0.9	12.0	12.3	20.0	0.38	2.26	0.40	0.02	21	72	5	45	5.61	18.97	1.43	11.83	0.42
606	8721	7091	3.4	5.2	5.0	11.2	10.5	20.3	0.55	1.63	0.36	0.02	26	34	34	69	4.81	6.21	6.26	12.53	0.54
606	8721	7100	3.4	5.2	5.0	11.2	10.5	20.1	0.50	2.18	0.31	0.05	27	34	25	60	5.46	6.79	5.04	11.88	0.55
606	8722	7105	3.4	10.4	0.9	16.6	10.7	20.2	0.34	1.88	0.39	0.01	17	31	5	43	4.92	9.30	1.35	12.87	0.34
606	8723	7111	3.2	15.5	2.7	5.6	10.8	19.6	0.43	2.48	0.51	0.03	23	52	11	26	5.22	11.99	2.43	6.05	0.44
606	8724	7127	1.1	11.6	3.4	13.2	18.5	21.9	0.26	1.41	0.33	0.00	9	27	8	31	3.32	10.23	3.05	11.75	0.19

NIPER, ARB Benzene, Phase 3, Tailpipe-Out

			HC grams/mile				CO grams/mile				NOx grams/mile				Methane grams/mile				mpg
Car	Fuel	Test	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	FTP
505	8594	7016	1.13	0.57	0.64	0.70	11.22	8.08	7.54	8.59	0.59	0.46	0.47	0.49	0.09	0.13	0.08	0.11	20.7
505	8725	7020	1.80	0.63	0.62	0.87	16.69	10.41	9.58	11.48	0.57	0.39	0.47	0.45	0.11	0.11	0.07	0.10	22.7
505	8726	7027	2.08	0.63	0.87	1.00	24.82	10.56	11.38	13.76	0.61	0.41	0.52	0.48	0.16	0.13	0.10	0.13	22.5
603	8594	7015	0.98	0.19	0.18	0.35	5.38	0.32	1.01	1.56	0.54	0.18	0.20	0.26	0.05	0.00	0.02	0.02	23.0
603	8725	7021	1.25	0.19	0.17	0.40	5.18	0.50	0.99	1.61	0.47	0.13	0.09	0.19	0.05	0.00	0.02	0.02	27.0
603	8726	7129	0.69	0.10	0.08	0.21	5.60	1.82	1.29	2.45	0.41	0.06	0.07	0.14	0.05	0.02	0.02	0.02	28.0
604	8594	7017	0.72	0.31	0.38	0.42	3.49	0.11	1.19	1.11	0.60	0.38	0.54	0.47	0.07	0.04	0.04	0.05	23.1
604	8725	7022	0.72	0.26	0.47	0.41	3.78	0.12	2.34	1.48	0.65	0.44	0.47	0.49	0.05	0.03	0.03	0.04	23.9
604	8726	7026	0.70	0.34	0.48	0.45	3.44	0.12	1.35	1.15	0.56	0.36	0.49	0.44	0.05	0.03	0.03	0.03	25.7
605	8594	7018	1.02	0.19	0.17	0.36	17.07	0.16	2.52	4.31	0.84	0.18	0.36	0.37	0.14	0.02	0.03	0.05	25.6
605	8725	7019	0.92	0.22	0.16	0.35	12.31	0.66	1.70	3.36	1.00	0.19	0.30	0.39	0.10	0.01	0.02	0.03	26.8
605	8726	7028	0.68	0.17	0.18	0.28	10.20	0.22	3.74	3.25	1.08	0.21	0.42	0.45	0.08	0.01	0.03	0.03	25.3
606	8594	7146	0.70	0.18	0.16	0.28	4.94	0.85	1.65	1.93	1.05	0.22	0.30	0.41	0.05	0.01	0.03	0.02	19.3
606	8725	7025	0.72	0.25	0.36	0.38	4.27	0.58	2.52	1.88	0.81	0.31	0.53	0.48	0.05	0.02	0.04	0.03	20.6
606	8726	7043	1.31	0.31	0.25	0.49	5.93	1.89	1.07	2.46	1.17	0.40	0.39	0.55	0.06	0.02	0.03	0.03	20.1

NIPER, ARB Benzene, Phase 3, Tailpipe-Out

			Benzene mg/mile				Toluene mg/mile				Ethyl BZ mg/mile				Xylenes mg/mile				m,pXylene mg/mi				oXylene mg/mile			
Car	Fuel	Test	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
505	8594	7016	27	22	20	22	84	16	40	37	23	0	6	6	49	8	21	20	36	8	16	16	12	0	5	4
505	8725	7020	64	36	30	40	128	30	39	53	28	0	10	9	149	23	42	54	109	16	31	39	40	7	11	15
505	8726	7027	84	41	45	51	141	28	56	59	35	0	10	10	162	21	54	59	121	14	39	43	41	7	14	16
603	8594	7015	17	0	2	4	83	0	2	18	20	0	0	4	44	0	0	9	33	0	0	7	11	0	0	2
603	8725	7021	35	0	3	8	89	0	3	19	21	0	0	4	98	7	6	26	75	7	6	21	24	0	0	5
603	8726	7129	30	2	2	8	65	4	2	16	16	0	0	3	75	16	2	24	54	10	2	17	21	6	0	7
604	8594	7017	17	1	7	6	50	1	14	15	15	0	1	3	31	0	9	9	22	0	7	7	8	0	2	2
604	8725	7022	25	1	14	10	42	1	19	14	2	0	4	2	51	0	23	17	38	0	17	12	14	0	6	5
604	8726	7026	25	1	13	9	38	0	17	13	10	0	6	4	44	0	21	15	33	0	15	11	11	0	6	4
605	8594	7018	40	0	3	9	74	0	3	16	17	0	0	3	40	0	0	8	30	0	0	6	10	0	0	2
605	8725	7019	46	0	2	10	55	0	2	12	13	0	0	3	68	7	6	20	50	7	6	16	18	0	0	4
605	8726	7028	38	0	5	9	37	0	3	8	9	0	0	2	42	0	4	10	31	0	4	7	11	0	0	2
606	8594	7146	21	1	5	6	48	0	4	11	6	0	0	1	29	0	0	6	22	0	0	5	7	0	0	1
606	8725	7025	33	1	17	12	42	0	16	13	10	0	3	3	50	0	17	15	36	0	13	11	13	0	5	4
606	8726	7043	46	4	7	13	84	4	6	20	16	0	0	3	93	7	5	23	69	7	5	18	24	0	0	5

NIPER, ARB Benzene, Phase 3, Tailpipe-Out

			HC Reduction %				CO Reduction %				NOx Reduction %			
Car	Fuel	Test	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
505	8594	7016	67	85	80	80	35	58	55	53	63	60	67	63
505	8725	7020	54	81	79	74	36	50	47	46	61	59	66	62
505	8726	7027	50	81	73	72	12	49	21	33	59	61	64	61
603	8594	7015	59	91	90	83	69	98	92	90	72	84	88	82
603	8725	7021	50	90	89	79	66	97	91	88	74	89	92	85
603	8726	7129	65	95	95	88	67	89	89	84	78	95	94	90
604	8594	7017	74	89	82	84	72	99	85	89	66	74	69	71
604	8725	7022	71	91	76	83	67	99	73	86	61	72	72	70
604	8726	7026	72	87	75	81	68	99	83	88	66	76	72	73
605	8594	7018	64	88	88	80	5	98	69	56	69	85	82	79
605	8725	7019	63	87	89	80	47	91	79	69	60	86	87	79
605	8726	7028	72	89	89	84	54	97	63	71	66	87	84	80
606	8594	7146	73	94	93	90	66	94	86	86	74	91	91	86
606	8725	7025	68	92	86	86	67	96	80	86	73	86	84	82
606	8726	7043	69	92	90	86	63	88	90	83	73	86	88	83

NIPER, ARB Benzene, Phase 3, Tailpipe-Out

			Benzene Red. %				Toluene Red. %				Ethyl BZ Red. %				Xylene Red. %				m,pXylene Red.%				oXylene Red. %			
Car	Fuel	Test	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
505	8594	7016	66	73	73	71	71	95	85	87	72	100	91	92	67	95	84	87	67	93	84	86	67	100	84	89
505	8725	7020	53	70	72	66	57	87	82	78	56	100	81	85	54	91	83	80	55	92	83	80	50	88	82	77
505	8726	7027	51	71	64	64	55	89	76	77	52	100	83	68	50	83	78	70	51	76	78	67	48	89	76	75
603	8594	7015	75	100	96	93	62	100	99	90	69	100	100	91	62	100	100	91	63	100	100	91	58	100	100	90
603	8725	7021	62	99	95	88	55	100	98	87	54	100	100	88	55	96	95	85	55	94	93	83	55	100	100	88
603	8726	7129	65	98	97	90	64	97	98	90	63	100	100	92	60	91	98	86	61	93	98	87	59	87	100	83
604	8594	7017	76	98	87	91	79	100	92	93	79	100	98	95	79	100	92	93	79	100	91	94	76	100	93	93
604	8725	7022	72	99	82	90	75	100	86	92	95	100	87	96	76	100	86	92	76	100	86	92	74	100	85	92
604	8726	7026	74	99	84	90	77	100	87	92	75	100	81	91	77	100	86	92	77	100	87	92	77	100	84	92
605	8594	7018	40	100	92	78	68	100	98	89	75	100	100	92	68	100	100	90	68	100	100	90	68	100	100	90
605	8725	7019	49	100	96	83	68	100	98	90	78	100	100	92	71	94	95	87	72	92	93	86	66	100	100	89
605	8726	7028	58	100	92	86	77	100	97	93	76	100	100	94	77	100	97	93	78	100	96	93	76	100	100	93
606	8594	7146	67	98	87	89	79	100	98	95	88	100	100	98	75	100	100	95	75	100	100	95	77	100	100	96
606	8725	7025	66	99	82	88	76	100	91	93	75	100	92	93	76	100	92	94	77	100	92	94	75	100	92	94
606	8726	7043	63	96	90	87	72	99	97	92	79	100	100	95	75	98	98	92	75	97	97	92	74	100	100	94

NIPER, ARB Benzene, Phase 3, Tailpipe-Out

			Fuel Components vol pct					FTP	Emissions FTP g/mile				FTP mg/mile				Emissions wt pct of HC				g/gal
Car	Fuel	Test	BZ	TOL	EBZ	XYL	REF	mpg	HC	CO	NOx	Meth	BZ	TOL	EBZ	XYL	BZ	TOL	EBZ	XYL	BZ
505	8594	7016	0.4	7.3	1.7	3.5	10.7	20.7	0.70	8.59	0.49	0.11	22	37	6	20	3.16	5.26	0.91	2.87	0.46
505	8725	7020	1.5	6.0	1.2	8.0	13.8	22.7	0.87	11.48	0.45	0.10	40	53	9	54	4.58	6.06	0.98	6.24	0.90
505	8726	7027	1.5	6.0	1.3	7.5	13.3	22.5	1.00	13.76	0.48	0.13	51	59	10	59	5.07	5.91	0.99	5.90	1.14
603	8594	7015	0.4	7.3	1.7	3.5	10.7	23.0	0.35	1.56	0.26	0.02	4	18	4	9	1.15	5.00	1.20	2.58	0.09
603	8725	7021	1.5	6.0	1.2	8.0	13.8	27.0	0.40	1.61	0.19	0.02	8	19	4	26	2.03	4.77	1.06	6.42	0.22
603	8726	7129	1.5	6.0	1.3	7.5	13.3	28.0	0.21	2.45	0.14	0.02	8	16	3	24	3.50	7.50	1.57	11.30	0.21
604	8594	7017	0.4	7.3	1.7	3.5	10.7	23.1	0.42	1.11	0.47	0.05	6	15	3	9	1.46	3.60	0.81	2.12	0.14
604	8725	7022	1.5	6.0	1.2	8.0	13.8	23.9	0.41	1.48	0.49	0.04	10	14	2	17	2.32	3.46	0.39	4.09	0.23
604	8726	7026	1.5	6.0	1.3	7.5	13.3	25.7	0.45	1.15	0.44	0.03	9	13	4	15	2.06	2.75	0.83	3.30	0.24
605	8594	7018	0.4	7.3	1.7	3.5	10.7	25.6	0.36	4.31	0.37	0.05	9	16	3	8	2.49	4.44	0.97	2.32	0.23
605	8725	7019	1.5	6.0	1.2	8.0	13.8	26.8	0.35	3.36	0.39	0.03	10	12	3	20	2.91	3.48	0.80	5.70	0.27
605	8726	7028	1.5	6.0	1.3	7.5	13.3	25.3	0.28	3.25	0.45	0.03	9	8	2	10	3.22	3.00	0.67	3.45	0.23
606	8594	7146	0.4	7.3	1.7	3.5	10.7	19.3	0.28	1.93	0.41	0.02	6	11	1	6	2.27	3.94	0.46	2.13	0.12
606	8725	7025	1.5	6.0	1.2	8.0	13.8	20.6	0.38	1.88	0.48	0.03	12	13	3	15	3.24	3.47	0.79	4.00	0.25
606	8726	7043	1.5	6.0	1.3	7.5	13.3	20.1	0.49	2.46	0.55	0.03	13	20	3	23	2.73	4.08	0.63	4.75	0.27

APPENDIX C

ENGINE-OUT EMISSIONS

NIPER, ARB Benzene Precursors, Phase 1, Engine-Out

			HC grams/mile				CO grams/mile				NOx grams/mile				Methane grams/mile				mpg
Car	Fuel	Test	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	FTP
505	8603	5907	3.50	2.94	2.83	3.03	20.12	13.45	10.84	14.12	1.33	0.90	1.39	1.13	0.22	0.20	0.15	0.19	21.5
505	8635	5913	3.66	2.90	2.63	2.98	20.74	11.28	11.61	13.33	1.36	1.03	1.55	1.24	0.31	0.19	0.16	0.21	21.7
505	8636	5939	5.61	3.09	2.77	3.53	46.49	12.74	10.58	19.15	1.21	1.01	1.55	1.20	0.50	0.19	0.13	0.24	21.3
505	8637	5919	4.26	2.93	2.93	3.20	26.58	12.69	10.39	14.94	1.33	0.94	1.57	1.19	0.34	0.16	0.14	0.19	21.3
505	8638	5924	4.78	3.06	2.84	3.35	32.68	14.15	11.03	17.13	1.42	1.01	1.63	1.27	0.36	0.18	0.13	0.20	20.9
505	8639	5931	3.60	3.01	2.90	3.10	17.45	12.87	5.91	11.93	1.72	1.18	1.90	1.49	0.24	0.16	0.13	0.17	21.0
603	8603	5904	1.75	1.90	1.54	1.77	13.53	13.68	10.26	12.70	1.88	0.92	1.53	1.29	0.15	0.20	0.14	0.17	23.8
603	8603	5929	1.99	1.75	1.36	1.69	15.49	13.33	9.80	12.80	1.93	0.92	1.63	1.32	0.15	0.16	0.12	0.15	23.8
603	8635	5911	2.91	1.80	1.53	1.95	18.21	12.86	10.26	13.27	2.24	1.21	1.93	1.62	0.19	0.20	0.15	0.18	23.9
603	8636	5915	4.55	1.83	1.53	2.30	16.41	12.78	10.07	12.78	2.13	0.95	1.54	1.35	0.20	0.18	0.14	0.17	24.1
603	8637	5920	1.71	1.81	1.49	1.70	12.06	13.04	10.64	12.17	1.83	0.91	1.55	1.28	0.13	0.16	0.12	0.15	24.3
603	8638	5925	2.73	1.81	1.52	1.92	16.38	13.68	10.31	13.31	2.35	1.06	1.89	1.55	0.16	0.16	0.12	0.15	24.2
603	8639	5952	1.99	1.85	1.53	1.79	16.74	14.54	10.95	14.01	2.33	1.15	1.87	1.59	0.13	0.13	0.10	0.12	23.3
604	8603	5905	1.96	2.09	1.61	1.93	11.33	10.09	8.32	9.86	1.95	1.81	2.25	1.96	0.17	0.17	0.13	0.16	23.6
604	8603	5930	2.13	2.25	2.37	2.25	10.89	10.28	9.94	10.32	1.97	1.89	1.98	1.93	0.14	0.13	0.11	0.13	22.5
604	8635	5910	3.06	2.34	1.74	2.32	16.69	11.03	9.31	11.73	2.64	2.04	2.47	2.28	0.24	0.18	0.13	0.18	21.6
604	8636	5917	2.77	2.36	1.67	2.25	14.41	10.45	8.24	10.66	1.96	1.76	2.27	1.94	0.20	0.20	0.14	0.18	22.7
604	8637	5922	2.06	2.01	1.79	1.96	10.97	9.72	10.21	10.11	1.96	1.71	1.99	1.84	0.13	0.12	0.12	0.12	22.7
604	8638	5927	2.56	2.59	1.88	2.39	15.44	11.44	11.58	12.32	1.77	1.88	2.19	1.94	0.16	0.15	0.12	0.14	22.5
604	8639	5959	2.10	2.35	1.55	2.08	11.03	11.68	8.25	10.60	1.94	2.02	2.24	2.06	0.11	0.09	0.07	0.09	21.2
605	8603	5953	2.93	1.78	1.66	1.99	27.69	6.59	8.13	11.41	2.75	1.29	2.64	1.97	0.24	0.07	0.07	0.10	24.8
605	8635	5912	4.06	2.03	1.69	2.36	20.14	6.64	8.37	9.91	3.38	1.24	2.49	2.03	0.27	0.15	0.10	0.16	24.4
605	8636	5916	3.15	1.89	1.75	2.11	20.93	6.78	8.12	9.99	2.76	1.17	2.53	1.87	0.19	0.14	0.11	0.14	24.9
605	8637	5921	3.45	1.82	1.98	2.20	22.04	6.50	8.56	10.30	2.59	1.02	2.28	1.70	0.28	0.11	0.09	0.14	25.4
605	8638	5926	2.49	1.84	1.67	1.92	20.12	6.69	8.87	10.02	3.43	1.33	2.86	2.17	0.19	0.12	0.10	0.13	25.5
605	8639	5932	3.45	1.91	1.84	2.21	18.47	6.52	7.93	9.39	3.49	1.20	2.88	2.14	0.30	0.12	0.10	0.15	25.1
606	8603	5908	1.99	2.69	1.92	2.33	13.02	14.32	12.36	13.51	3.04	1.85	2.91	2.39	0.15	0.18	0.14	0.16	18.4
606	8635	5909	3.02	2.80	2.46	2.75	16.22	14.80	15.39	15.25	3.20	1.79	3.06	2.42	0.18	0.19	0.15	0.18	17.4
606	8636	5938	2.75	3.00	2.49	2.81	14.78	15.28	14.26	14.90	4.01	2.50	3.57	3.10	0.15	0.18	0.14	0.16	17.3
606	8637	5923	3.16	3.08	2.31	2.89	14.33	14.02	11.54	13.41	2.84	1.65	2.45	2.11	0.15	0.16	0.12	0.15	19.0
606	8638	5928	4.61	3.51	2.87	3.56	16.30	15.97	15.01	15.77	3.51	2.13	2.97	2.64	0.17	0.18	0.14	0.17	17.9
606	8639	5933	2.97	3.40	2.58	3.09	13.88	15.04	13.96	14.50	3.27	2.15	3.08	2.64	0.15	0.16	0.13	0.15	17.8

NIPER, ARB Benzene Precursors, Phase 1, Engine-Out

			Benzene mg/mile				Toluene mg/mile				Ethyl BZ mg/mile				Xylenes mg/mile				m,pXylene mg/mi				oXylene mg/mile			
Car	Fuel	Test	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
505	8603	5907	10	7	7	7	11	6	8	8	0	0	0	0	1	6	1	4	0	0	0	0	1	6	1	4
505	8635	5913	206	158	150	166	14	8	7	9	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0
505	8636	5939	62	32	28	37	535	283	274	333	11	5	8	7	4	0	2	2	3	0	2	1	1	0	0	0
505	8637	5919	31	17	18	20	17	12	13	13	234	144	139	161	0	0	0	0	0	0	0	0	0	0	0	0
505	8638	5924	42	23	20	27	50	36	32	38	9	0	2	3	475	259	235	297	0	4	4	3	475	255	231	294
505	8639	5931	29	21	20	22	40	22	21	25	7	7	5	6	55	42	39	44	13	12	10	12	43	30	29	32
603	8603	5904	7	6	6	6	8	4	8	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
603	8603	5929	7	6	6	6	9	4	7	6	0	0	0	0	11	10	8	9	0	0	0	0	11	10	8	9
603	8635	5911	171	88	78	103	8	3	5	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
603	8636	5915	37	26	23	27	528	168	139	233	6	5	0	4	3	0	5	2	3	0	5	2	0	0	0	0
603	8637	5920	16	15	15	15	15	11	14	13	78	71	51	67	0	0	0	0	0	0	0	0	0	0	0	0
603	8638	5925	21	19	16	19	39	30	29	32	3	3	3	3	258	155	121	167	5	3	3	3	253	152	118	163
603	8639	5952	18	16	15	16	19	13	15	15	16	6	4	8	36	29	23	29	16	11	9	12	20	18	14	17
604	8603	5905	8	6	5	6	8	6	4	6	0	0	0	0	1	4	2	3	0	0	0	0	1	4	2	3
604	8603	5930	8	6	6	6	7	6	8	7	0	0	0	0	12	14	8	12	1	0	0	0	11	14	8	12
604	8635	5910	157	120	92	120	8	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
604	8636	5917	34	26	22	27	272	203	150	203	0	0	2	1	9	0	0	2	9	0	0	2	0	0	0	0
604	8637	5922	19	16	13	16	14	11	11	12	101	91	91	93	0	0	0	0	0	0	0	0	0	0	0	0
604	8638	5927	26	21	18	21	36	31	24	30	7	7	1	5	259	253	163	229	5	5	3	5	254	248	160	224
604	8639	5959	24	23	17	21	22	21	14	19	2	2	1	2	30	33	22	29	10	10	7	9	20	22	15	20
605	8603	5953	13	3	4	6	10	3	4	5	0	0	0	0	6	0	1	2	4	0	0	1	2	0	1	1
605	8635	5912	219	108	91	126	12	2	4	5	0	0	0	0	2	0	0	0	1	0	0	0	1	0	0	0
605	8636	5916	26	18	17	19	339	176	173	208	4	4	3	4	2	0	0	0	2	0	0	0	0	0	0	0
605	8637	5921	28	10	10	14	17	7	15	11	209	79	107	114	0	0	0	0	0	0	0	0	0	0	0	0
605	8638	5926	22	12	11	14	26	17	19	19	2	0	1	1	238	153	128	163	4	3	2	3	234	150	126	161
605	8639	5932	33	11	12	16	21	11	12	14	5	2	3	3	53	35	30	37	11	7	6	7	42	28	24	30
606	8603	5908	7	5	5	6	12	7	5	7	0	0	0	0	0	3	0	1	0	0	0	0	0	3	0	1
606	8635	5909	160	143	132	143	7	5	6	6	0	0	0	0	2	0	1	1	2	0	1	1	0	0	0	0
606	8636	5938	30	28	25	27	275	293	236	274	8	7	6	7	2	0	3	1	2	0	2	1	0	0	1	0
606	8637	5923	18	16	14	16	12	10	14	12	192	179	134	170	0	0	0	0	0	0	0	0	0	0	0	0
606	8638	5928	28	22	20	23	39	31	26	31	7	2	4	3	512	325	283	352	9	6	5	7	503	319	278	346
606	8639	5933	22	20	18	20	19	18	15	17	9	0	0	2	31	45	34	39	0	9	7	6	31	36	26	32

NIPER, ARB Benzene Precursors, Phase 1, Engine-Out

			Fuel Components vol pct					FTP	Emissions FTP g/mile				FTP mg/mile				Emissions wt pct of HC				g/gal
Car	Fuel	Test	BZ	TOL	EBZ	XYL	REF	mpg	HC	CO	NOx	Meth	BZ	TOL	EBZ	XYL	BZ	TOL	EBZ	XYL	BZ
505	8603	5907	0.0	0.1	0.0	0.1	0.0	21.5	3.03	14.12	1.13	0.19	7	8	0	4	0.25	0.26	0.00	0.12	0.16
505	8635	5913	5.1	0.2	0.0	0.1	0.0	21.7	2.98	13.33	1.24	0.21	166	9	0	0	5.56	0.30	0.00	0.02	3.59
505	8636	5939	0.0	11.2	0.0	0.1	0.0	21.3	3.53	19.15	1.20	0.24	37	333	7	2	1.05	9.44	0.21	0.04	0.79
505	8637	5919	0.0	0.1	5.4	0.0	0.0	21.3	3.20	14.94	1.19	0.19	20	13	161	0	0.64	0.42	5.04	0.00	0.43
505	8638	5924	0.0	0.1	0.0	10.7	0.0	20.9	3.35	17.13	1.27	0.20	27	38	3	297	0.79	1.13	0.08	8.86	0.56
505	8639	5931	0.0	0.1	0.0	1.0	10.1	21.0	3.10	11.93	1.49	0.17	22	25	6	44	0.71	0.81	0.21	1.42	0.47
603	8603	5904	0.0	0.1	0.0	0.1	0.0	23.8	1.77	12.70	1.29	0.17	6	6	0	0	0.35	0.35	0.00	0.00	0.15
603	8603	5929	0.0	0.1	0.0	0.1	0.0	23.8	1.69	12.80	1.32	0.15	6	6	0	9	0.36	0.34	0.00	0.56	0.15
603	8635	5911	5.1	0.2	0.0	0.1	0.0	23.9	1.95	13.27	1.62	0.18	103	4	0	0	5.25	0.22	0.00	0.00	2.45
603	8636	5915	0.0	11.2	0.0	0.1	0.0	24.1	2.30	12.78	1.35	0.17	27	233	4	2	1.18	10.12	0.18	0.09	0.65
603	8637	5920	0.0	0.1	5.4	0.0	0.0	24.3	1.70	12.17	1.28	0.15	15	13	67	0	0.89	0.75	3.94	0.00	0.37
603	8638	5925	0.0	0.1	0.0	10.7	0.0	24.2	1.92	13.31	1.55	0.15	19	32	3	167	0.97	1.66	0.14	8.70	0.45
603	8639	5952	0.0	0.1	0.0	1.0	10.1	23.3	1.79	14.01	1.59	0.12	16	15	8	29	0.89	0.84	0.43	1.61	0.37
604	8603	5905	0.0	0.1	0.0	0.1	0.0	23.6	1.93	9.86	1.96	0.16	6	6	0	3	0.31	0.32	0.00	0.14	0.14
604	8603	5930	0.0	0.1	0.0	0.1	0.0	22.5	2.25	10.32	1.93	0.13	6	7	0	12	0.28	0.30	0.00	0.52	0.14
604	8635	5910	5.1	0.2	0.0	0.1	0.0	21.6	2.32	11.73	2.28	0.18	120	5	0	0	5.15	0.23	0.00	0.00	2.58
604	8636	5917	0.0	11.2	0.0	0.1	0.0	22.7	2.25	10.66	1.94	0.18	27	203	1	2	1.18	8.98	0.03	0.08	0.61
604	8637	5922	0.0	0.1	5.4	0.0	0.0	22.7	1.96	10.11	1.84	0.12	16	12	93	0	0.81	0.59	4.76	0.00	0.36
604	8638	5927	0.0	0.1	0.0	10.7	0.0	22.5	2.39	12.32	1.94	0.14	21	30	5	229	0.88	1.25	0.21	9.60	0.47
604	8639	5959	0.0	0.1	0.0	1.0	10.1	21.2	2.08	10.60	2.06	0.09	21	19	2	29	1.03	0.92	0.08	1.41	0.45
605	8603	5953	0.0	0.1	0.0	0.1	0.0	24.8	1.99	11.41	1.97	0.10	6	5	0	2	0.28	0.26	0.00	0.08	0.14
605	8635	5912	5.1	0.2	0.0	0.1	0.0	24.4	2.36	9.91	2.03	0.16	126	5	0	0	5.36	0.19	0.00	0.02	3.08
605	8636	5916	0.0	11.2	0.0	0.1	0.0	24.9	2.11	9.99	1.87	0.14	19	208	4	0	0.91	9.88	0.18	0.02	0.48
605	8637	5921	0.0	0.1	5.4	0.0	0.0	25.4	2.20	10.30	1.70	0.14	14	11	114	0	0.63	0.51	5.17	0.00	0.35
605	8638	5926	0.0	0.1	0.0	10.7	0.0	25.5	1.92	10.02	2.17	0.13	14	19	1	163	0.71	1.01	0.04	8.49	0.35
605	8639	5932	0.0	0.1	0.0	1.0	10.1	25.1	2.21	9.39	2.14	0.15	16	14	3	37	0.72	0.61	0.13	1.69	0.40
606	8603	5908	0.0	0.1	0.0	0.1	0.0	18.4	2.33	13.51	2.39	0.16	6	7	0	1	0.24	0.30	0.00	0.06	0.10
606	8635	5909	5.1	0.2	0.0	0.1	0.0	17.4	2.75	15.25	2.42	0.18	143	6	0	1	5.20	0.21	0.00	0.03	2.49
606	8636	5938	0.0	11.2	0.0	0.1	0.0	17.3	2.81	14.90	3.10	0.16	27	274	7	1	0.98	9.74	0.25	0.05	0.48
606	8637	5923	0.0	0.1	5.4	0.0	0.0	19.0	2.89	13.41	2.11	0.15	16	12	170	0	0.55	0.41	5.88	0.00	0.30
606	8638	5928	0.0	0.1	0.0	10.7	0.0	17.9	3.56	15.77	2.64	0.17	23	31	3	352	0.64	0.88	0.09	9.90	0.41
606	8639	5933	0.0	0.1	0.0	1.0	10.1	17.8	3.09	14.50	2.64	0.15	20	17	2	39	0.63	0.56	0.06	1.26	0.35

NIPER, ARB Benzene Precursors, Phase 2, Engine-Out

			HC grams/mile				CO grams/mile				NOx grams/mile				Methane grams/mile				mpg
Car	Fuel	Test	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	FTP
505	8715	7055	4.96	3.98	3.10	3.94	24.70	22.98	19.36	22.34	1.43	1.07	1.24	1.19	0.27	0.17	0.13	0.18	21.2
505	8716	7042	5.03	4.76	2.98	4.33	19.47	23.55	17.06	20.93	2.17	1.48	1.79	1.71	0.23	0.17	0.12	0.17	19.5
505	8716	7048	5.32	3.78	3.50	4.02	23.22	20.54	18.56	20.54	1.86	1.23	1.69	1.49	0.10	0.16	0.15	0.14	19.9
505	8717	7112	5.11	4.09	2.98	4.00	19.15	18.71	11.92	16.94	1.85	1.56	1.86	1.70	0.16	0.12	0.08	0.12	22.7
505	8717	7120	5.76	3.92	3.58	4.20	28.66	17.89	14.26	19.12	1.84	1.49	2.01	1.71	0.22	0.09	0.08	0.12	22.2
505	8718	7049	5.21	4.37	3.82	4.39	22.34	27.57	20.39	24.53	1.90	1.23	1.82	1.53	0.26	0.21	0.20	0.22	20.7
505	8719	7082	5.18	4.13	3.58	4.20	18.24	20.26	14.78	18.35	2.01	1.26	1.65	1.52	0.20	0.16	0.10	0.15	21.2
505	8720	7107	5.24	4.58	4.32	4.65	18.73	28.04	23.67	24.93	1.96	1.27	1.85	1.57	0.15	0.14	0.12	0.14	20.1
505	8721	7088	6.02	4.38	3.96	4.60	29.19	20.94	20.43	22.50	1.88	1.26	1.65	1.49	0.26	0.14	0.12	0.16	20.2
505	8721	7094	5.25	4.19	3.38	4.19	20.67	24.67	19.04	22.31	1.44	1.00	1.25	1.16	0.23	0.19	0.15	0.19	22.9
505	8722	7097	8.18	4.40	3.78	5.01	36.65	24.18	20.75	25.81	2.10	1.23	1.61	1.52	0.38	0.18	0.17	0.22	22.2
505	8723	7104	5.02	4.52	3.74	4.41	16.85	24.70	22.50	22.49	2.08	1.20	1.69	1.52	0.19	0.15	0.13	0.15	20.7
505	8724	7144	6.30	5.30	4.38	5.25	27.85	29.57	20.18	26.59	2.17	1.37	2.09	1.74	0.24	0.20	0.14	0.19	20.0
603	8715	7058	4.08	1.94	1.42	2.24	19.11	14.55	9.71	14.16	1.42	0.96	0.92	1.04	0.15	0.12	0.08	0.12	27.4
603	8716	7039	2.31	2.03	1.82	2.03	17.34	16.22	11.75	15.23	2.41	1.19	1.80	1.61	0.10	0.10	0.15	0.11	23.3
603	8716	7045	2.52	2.04	1.58	2.02	16.67	14.99	11.09	14.26	2.22	1.23	1.47	1.50	0.11	0.12	0.09	0.11	24.2
603	8717	7113	2.25	1.82	1.52	1.83	10.43	16.18	11.84	13.81	2.43	1.14	1.60	1.53	0.09	0.08	0.06	0.08	26.9
603	8717	7116	2.95	1.86	1.72	2.04	20.74	15.98	13.11	16.17	2.47	1.31	1.90	1.71	0.10	0.08	0.07	0.08	25.6
603	8718	7052	4.06	2.17	1.71	2.43	19.84	16.24	12.37	15.92	1.90	0.99	1.50	1.32	0.13	0.10	0.08	0.10	24.0
603	8719	7080	2.21	2.14	1.67	2.03	18.94	16.42	11.64	15.63	2.28	1.17	1.53	1.50	0.09	0.12	0.08	0.10	24.1
603	8720	7109	2.60	1.91	1.25	1.87	20.24	16.53	10.55	15.66	1.94	1.21	1.08	1.33	0.07	0.05	0.04	0.05	27.3
603	8721	7089	2.17	2.13	1.56	1.98	17.36	16.58	11.22	15.28	2.16	1.18	1.46	1.46	0.12	0.15	0.10	0.13	25.1
603	8721	7095	3.52	1.73	1.68	2.08	17.81	13.99	12.42	14.35	1.76	1.00	1.20	1.21	0.12	0.08	0.05	0.08	27.8
603	8722	7096	3.43	1.79	1.83	2.14	18.46	14.73	13.24	15.09	1.83	1.03	1.36	1.29	0.09	0.08	0.08	0.08	27.0
603	8723	7102	2.14	1.77	1.45	1.76	16.76	15.39	10.65	14.38	1.92	1.05	1.02	1.22	0.07	0.05	0.02	0.05	27.1
603	8724	7124	3.87	2.19	1.51	2.35	16.12	24.25	11.35	19.06	2.10	1.08	1.50	1.40	0.15	0.11	0.06	0.10	26.6
604	8715	7056	3.74	2.91	2.10	2.87	14.64	11.28	8.68	11.27	1.76	1.56	1.81	1.67	0.02	0.09	0.04	0.06	23.4
604	8716	7041	2.37	2.68	2.05	2.44	11.15	12.67	9.16	11.39	2.02	2.03	2.48	2.15	0.11	0.11	0.08	0.10	22.0
604	8716	7044	2.43	2.36	1.93	2.26	13.35	12.47	9.29	11.78	2.28	2.25	2.32	2.28	0.13	0.09	0.12	0.10	21.3
604	8717	7114	2.95	2.72	2.10	2.60	15.16	12.97	10.19	12.66	1.89	1.89	2.25	1.99	0.10	0.07	0.05	0.07	24.4
604	8717	7115	3.50	2.93	1.92	2.77	15.04	12.81	9.94	12.49	1.92	1.88	2.15	1.96	0.11	0.07	0.05	0.07	24.2
604	8718	7051	4.39	3.08	2.37	3.16	17.30	12.28	8.97	12.41	1.56	1.50	1.62	1.54	0.00	0.10	0.07	0.07	23.7
604	8719	7084	3.54	3.00	2.01	2.84	14.25	11.81	8.20	11.32	1.80	1.67	1.66	1.69	0.14	0.06	0.07	0.08	24.3
604	8720	7110	2.50	2.59	1.69	2.32	12.06	12.09	9.10	11.27	2.37	2.19	2.20	2.23	0.08	0.06	0.05	0.06	24.3
604	8721	7087	2.42	2.66	1.52	2.30	14.47	11.28	7.73	10.97	1.84	1.77	1.67	1.76	0.08	0.09	0.06	0.08	24.4
604	8721	7092	10.10	2.83	1.80	4.05	27.82	10.69	7.72	13.41	1.15	1.35	1.26	1.29	0.06	0.12	0.12	0.11	26.2
604	8722	7098	3.23	2.94	1.89	2.71	14.17	11.16	8.91	11.16	1.79	1.67	1.92	1.76	0.03	0.12	0.09	0.09	25.6
604	8723	7103	5.07	2.49	1.79	2.83	27.49	11.19	8.73	13.88	1.29	1.68	1.97	1.68	0.09	0.06	0.04	0.06	25.4
604	8724	7122	4.15	2.24	1.67	2.48	59.23	17.27	11.57	24.35	0.68	1.12	1.55	1.15	0.23	0.07	0.06	0.10	27.0

NIPER, ARB Benzene Precursors, Phase 2, Engine-Out

Car	Fuel	Test	HC grams/mile cold	HC stab	HC hot	HC FTP	CO grams/mile cold	CO stab	CO hot	CO FTP	NOx grams/mile cold	NOx stab	NOx hot	NOx FTP	Methane grams/mile cold	Methane stab	Methane hot	Methane FTP	mpg FTP
605	8715	7057	5.17	1.79	1.76	2.49	24.42	6.68	6.77	10.40	2.36	0.98	1.82	1.50	0.27	0.05	0.04	0.09	27.3
605	8716	7040	2.87	1.79	1.66	1.98	22.00	6.73	6.18	9.74	2.86	1.14	2.00	1.74	0.16	0.05	0.04	0.07	27.3
605	8716	7046	3.36	1.85	1.89	2.17	16.77	7.09	9.48	9.76	3.13	1.36	2.69	2.09	0.20	0.05	0.05	0.08	24.8
605	8717	7121	5.08	1.78	1.80	2.46	18.74	7.07	9.16	10.05	2.79	1.28	2.36	1.89	0.28	0.07	0.05	0.11	27.0
605	8717	7125	3.94	1.85	1.99	2.32	23.89	7.25	8.84	11.11	2.99	1.38	2.52	2.02	0.20	0.03	0.04	0.07	27.5
605	8718	7050	3.54	1.73	2.05	2.20	21.92	7.01	7.62	10.26	3.03	1.16	2.46	1.90	0.22	0.05	0.04	0.08	26.3
605	8719	7090	3.40	2.03	2.11	2.33	17.52	6.79	11.88	10.39	3.27	1.48	2.91	2.24	0.05	0.05	0.05	0.05	24.4
605	8720	7117	3.84	1.74	1.68	2.16	21.10	7.71	9.50	10.96	3.13	1.50	2.57	2.12	0.20	0.04	0.04	0.07	26.1
605	8721	7093	3.74	1.92	2.08	2.33	18.30	6.96	9.20	9.90	3.01	1.40	2.59	2.06	0.17	0.04	0.05	0.07	26.1
605	8721	7099	3.84	1.80	1.54	2.15	26.90	6.50	7.15	10.87	2.61	1.09	1.93	1.63	0.23	0.04	0.03	0.07	28.7
605	8722	7101	3.86	1.75	1.87	2.22	25.80	6.88	9.86	11.59	3.02	1.32	2.49	1.99	0.01	0.01	0.03	0.02	26.5
605	8723	7108	4.13	1.82	2.04	2.36	17.36	7.41	9.22	9.95	3.26	1.37	2.36	2.03	0.21	0.05	0.04	0.08	26.3
605	8724	7128	4.08	1.88	1.96	2.35	18.50	8.30	8.86	10.55	3.78	1.45	2.56	2.23	0.22	0.03	0.04	0.07	26.3
606	8715	7054	3.37	3.12	2.29	2.94	15.44	15.75	12.14	14.70	9.83	1.98	2.60	3.78	0.10	0.12	0.14	0.12	20.0
606	8716	7047	4.51	3.55	3.06	3.61	16.72	15.09	11.64	14.48	4.04	2.33	3.00	2.87	0.13	0.10	0.09	0.10	19.5
606	8716	7053	3.35	3.22	2.76	3.12	14.04	15.65	12.53	14.45	2.92	2.42	2.70	2.60	0.10	0.11	0.09	0.10	19.2
606	8717	7119	4.28	2.70	2.51	2.97	18.34	14.16	13.04	14.71	3.56	1.99	3.24	2.65	0.10	0.06	0.05	0.06	21.1
606	8717	7126	2.54	2.39	1.99	2.31	14.98	13.31	11.17	13.07	3.59	2.12	2.92	2.64	0.07	0.06	0.05	0.06	22.3
606	8718	7130	3.07	2.29	1.99	2.37	14.70	13.72	11.18	13.23	3.36	1.90	2.58	2.39	0.09	0.07	0.04	0.06	21.6
606	8719	7085	4.38	3.94	2.93	3.75	16.16	16.28	14.79	15.85	3.65	2.24	3.48	2.87	0.10	0.08	0.08	0.09	19.3
606	8720	7118	4.04	3.17	2.35	3.13	16.54	15.77	12.49	15.04	3.61	2.16	3.00	2.69	0.09	0.07	0.06	0.07	20.0
606	8721	7091	5.28	3.09	2.66	3.42	16.12	14.67	13.16	14.56	3.64	2.08	3.27	2.73	0.08	0.04	0.05	0.05	20.3
606	8721	7100	4.50	3.21	2.59	3.31	15.86	14.89	12.57	14.46	3.56	2.24	3.24	2.79	0.11	0.06	0.10	0.08	20.1
606	8722	7105	3.53	3.03	2.82	3.07	14.60	15.69	13.23	14.79	3.71	2.25	3.37	2.86	0.08	0.04	0.10	0.06	20.2
606	8723	7111	4.28	3.49	2.86	3.48	16.89	16.06	13.50	15.53	4.23	2.62	3.36	3.15	0.01	0.12	0.10	0.09	19.6
606	8724	7127	2.59	2.37	2.24	2.38	14.06	13.29	12.33	13.19	3.24	1.83	2.91	2.41	0.08	0.05	0.05	0.06	21.9

NIPER, ARB Benzene Precursors, Phase 2, Engine-Out

Car	Fuel	Test	Benzene mg/mile c	s	h	FTP	Toluene mg/mile c	s	h	FTP	Ethyl BZ mg/mile c	s	h	FTP	Xylenes mg/mile c	s	h	FTP	m,pXylene mg/mi c	s	h	FTP	oXylene mg/mile c	s	h	FTP
505	8715	7055	163	128	101	128	517	403	319	404	155	123	94	122	443	355	275	351	227	180	141	179	216	174	135	172
505	8716	7042	82	95	76	87	282	220	177	221	62	54	38	51	252	203	158	201	123	99	77	98	129	103	81	102
505	8716	7048	126	94	86	98	285	212	195	222	61	48	47	50	268	198	188	210	131	98	92	103	138	100	95	107
505	8717	7112	177	155	117	149	864	615	455	622	299	208	151	211	780	535	379	543	395	278	197	280	385	257	182	263
505	8717	7120	214	141	130	153	828	527	499	581	285	184	171	201	727	476	387	504	377	246	217	265	350	230	170	239
505	8718	7049	206	176	144	174	355	280	249	287	182	137	118	141	725	573	502	585	379	297	260	304	346	276	242	281
505	8719	7082	167	176	146	166	447	465	393	442	220	230	198	219	251	256	225	247	123	126	108	121	128	130	116	126
505	8720	7107	319	282	261	284	1223	1120	1035	1118	122	117	104	114	747	717	631	700	384	367	326	360	363	349	305	340
505	8721	7088	298	221	204	232	422	286	260	307	339	234	201	246	640	437	374	462	324	222	194	236	316	215	180	226
505	8721	7094	282	228	188	228	319	251	211	255	270	203	174	209	506	383	266	376	254	193	161	197	252	190	105	179
505	8722	7097	202	233	213	221	390	455	449	440	56	69	64	65	511	548	554	542	259	288	282	281	252	259	271	261
505	8723	7104	282	251	202	244	747	663	555	651	170	150	127	148	268	244	203	238	130	117	98	115	138	126	105	123
505	8724	7144	220	187	158	186	888	682	641	714	434	298	373	347	896	623	668	693	425	322	366	356	471	302	302	337
603	8715	7058	115	70	53	75	505	201	145	248	141	62	42	73	427	182	124	217	219	94	64	112	208	88	60	105
603	8716	7039	61	59	53	57	134	133	101	125	37	63	36	50	141	114	97	115	78	61	50	62	64	53	46	54
603	8716	7045	41	59	47	52	156	124	92	122	37	31	23	30	152	120	87	117	76	61	45	60	76	58	42	58
603	8717	7113	100	84	74	85	336	268	224	270	101	85	67	83	269	228	179	223	142	120	94	117	127	108	85	106
603	8717	7116	108	84	82	88	482	282	261	318	153	94	79	102	403	251	209	271	211	132	111	142	192	119	98	128
603	8718	7052	160	92	79	102	315	158	122	181	150	75	53	84	615	323	228	357	321	167	119	185	294	156	110	172
603	8719	7080	99	90	77	88	246	228	183	219	110	111	81	102	137	133	112	128	68	67	57	64	69	66	55	63
603	8720	7109	162	124	90	122	582	413	269	408	54	47	29	44	347	262	158	251	180	136	83	130	167	126	76	121
603	8721	7089	69	107	82	92	148	149	107	138	98	104	72	94	197	210	147	190	104	110	77	100	93	100	70	90
603	8721	7095	195	94	99	116	241	115	109	139	173	85	75	101	320	170	149	195	165	87	77	100	156	83	72	95
603	8722	7096	187	100	109	120	403	210	213	251	46	32	30	34	430	227	222	268	209	118	115	136	221	110	108	132
603	8723	7102	129	107	86	106	315	253	213	255	70	61	48	59	122	100	80	99	61	51	40	50	61	49	40	49
603	8724	7124	139	94	68	96	381	231	158	242	95	71	48	69	264	210	138	202	128	102	67	98	136	108	71	104
604	8715	7056	44	96	69	78	229	292	210	256	72	92	67	81	229	287	219	256	115	145	110	129	114	142	109	127
604	8716	7041	63	74	55	66	132	149	118	137	27	34	27	31	134	151	111	137	68	76	55	68	66	75	56	68
604	8716	7044	72	70	54	66	139	136	107	129	27	31	24	29	127	131	106	123	66	66	54	63	61	65	52	61
604	8717	7114	113	97	78	95	428	394	304	376	148	139	104	131	417	388	291	367	214	198	149	188	203	190	142	179
604	8717	7115	128	108	77	103	521	422	299	409	175	154	103	144	478	418	280	392	246	213	145	201	231	205	135	191
604	8718	7051	70	121	91	102	250	210	154	203	126	105	78	102	588	262	350	354	302	234	178	233	286	28	172	121
604	8719	7084	144	116	83	113	398	308	206	299	209	169	115	162	246	201	133	191	120	98	65	94	125	103	67	98
604	8720	7110	152	151	110	140	510	553	364	493	53	56	37	50	320	377	233	326	166	192	120	167	154	185	113	159
604	8721	7087	104	131	81	112	174	190	111	165	106	148	80	121	237	296	158	247	120	150	81	125	118	147	77	122
604	8721	7092	123	143	97	126	350	177	106	193	285	172	93	173	512	359	193	345	262	176	96	172	250	183	97	173
604	8722	7098	162	148	106	139	330	316	218	292	47	52	36	47	450	441	297	404	227	222	151	203	223	219	146	200
604	8723	7103	134	131	99	123	330	332	266	313	61	79	61	71	106	142	116	127	53	69	57	62	53	73	60	65
604	8724	7122	143	79	69	89	440	217	137	241	144	74	43	80	453	230	132	249	211	105	62	115	242	125	70	134

NIPER, ARB Benzene Precursors, Phase 2, Engine-Out

Car	Fuel	Test	Benzene mg/mile				Toluene mg/mile				Ethyl BZ mg/mile				Xylenes mg/mile				m,pXylene mg/mi				oXylene mg/mile			
			c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
605	8715	7057	138	54	47	69	547	171	176	250	166	56	54	78	521	165	175	242	262	84	87	122	259	82	87	120
605	8716	7040	70	43	34	46	157	99	88	108	71	27	20	34	177	101	100	117	97	52	51	61	80	50	49	56
605	8716	7046	78	45	43	51	188	103	103	121	43	24	0	21	208	101	81	118	101	50	26	54	108	51	55	64
605	8717	7121	148	58	59	77	705	243	253	341	257	89	86	123	690	236	236	329	355	121	121	169	335	115	115	160
605	8717	7125	130	63	64	77	524	264	285	323	180	91	95	110	482	246	253	296	248	127	131	153	233	119	122	143
605	8718	7050	128	67	68	80	214	117	130	141	122	52	67	71	522	226	287	304	270	116	148	157	252	109	139	147
605	8719	7090	66	72	81	73	254	202	215	216	126	113	104	113	153	118	128	128	75	60	62	64	78	58	66	64
605	8720	7117	164	76	78	94	636	285	283	357	62	40	31	42	439	205	183	247	221	104	93	125	218	101	90	122
605	8721	7093	181	96	108	117	218	112	124	137	201	97	104	121	386	191	206	235	194	95	103	118	193	95	103	117
605	8721	7099	171	80	72	96	219	102	92	124	187	87	77	104	373	170	149	206	187	86	76	104	186	83	73	102
605	8722	7101	196	92	94	114	430	198	204	247	69	32	29	39	576	260	261	325	295	132	133	166	281	128	128	160
605	8723	7108	206	97	103	121	662	273	328	368	142	64	70	81	248	107	127	141	119	52	61	68	129	55	66	73
605	8724	7128	153	67	71	86	500	238	255	297	179	87	90	107	528	241	252	303	240	109	115	138	289	132	136	165
606	8715	7054	100	94	69	88	338	307	226	291	113	94	68	91	333	294	216	280	170	148	109	142	163	146	107	139
606	8716	7047	93	74	63	75	253	188	164	195	61	43	39	46	281	211	187	219	134	101	90	105	146	110	98	114
606	8716	7053	79	60	61	64	199	188	152	180	46	42	38	42	229	206	178	203	111	99	86	98	118	107	93	105
606	8717	7119	131	90	85	97	650	381	365	432	231	138	128	155	631	371	350	419	323	190	180	215	308	181	170	204
606	8717	7126	94	81	70	81	345	310	257	303	117	113	90	108	317	310	251	295	164	157	127	150	153	153	124	145
606	8718	7130	124	95	81	97	189	147	119	148	92	74	59	74	424	336	269	336	217	172	136	172	207	164	133	164
606	8719	7085	148	139	107	132	438	414	297	387	240	234	170	217	266	216	193	220	130	121	91	115	136	94	102	105
606	8720	7118	173	131	101	131	712	517	399	525	68	52	42	52	492	394	315	393	246	196	156	195	246	198	160	197
606	8721	7091	263	153	132	170	356	186	151	211	324	182	118	194	610	346	269	379	306	171	132	188	305	175	137	191
606	8721	7100	206	139	114	146	293	187	151	199	263	181	142	187	512	353	215	348	255	174	134	180	256	179	80	168
606	8722	7105	169	149	132	149	372	321	280	320	52	44	42	45	536	467	412	466	268	232	205	232	268	234	207	234
606	8723	7111	213	109	148	141	675	547	421	539	153	124	98	123	268	215	180	217	127	103	83	102	141	113	97	114
606	8724	7127	107	88	83	90	353	285	276	297	111	93	90	96	349	303	274	304	170	137	123	140	179	165	152	164

NIPER, ARB Benzene Precursors, Phase 2, Engine-Out

			Fuel Components vol pct					FTP	Emissions FTP g/mile				FTP mg/mile				Emissions wt pct of HC				g/gal
Car	Fuel	Test	BZ	TOL	EBZ	XYL	REF	mpg	HC	CO	NOx	Meth	BZ	TOL	EBZ	XYL	BZ	TOL	EBZ	XYL	BZ
505	8715	7055	1.2	10.1	2.8	10.8	10.4	21.2	3.94	22.34	1.19	0.18	128	404	122	351	3.24	10.24	3.09	8.91	2.71
505	8716	7042	1.1	5.1	0.9	5.7	10.1	19.5	4.33	20.93	1.71	0.17	87	221	51	201	2.01	5.11	1.18	4.63	1.69
505	8716	7048	1.1	5.1	0.9	5.7	10.1	19.9	4.02	20.54	1.49	0.14	98	222	50	210	2.44	5.52	1.26	5.22	1.95
505	8717	7112	1.0	15.9	5.1	16.7	10.5	22.7	4.00	16.94	1.70	0.12	149	622	211	543	3.74	15.57	5.28	13.58	3.40
505	8717	7120	1.0	15.9	5.1	16.7	10.5	22.2	4.20	19.12	1.71	0.12	153	581	201	504	3.64	13.83	4.78	11.98	3.40
505	8718	7049	2.1	5.2	2.9	17.0	10.7	20.7	4.39	24.53	1.53	0.22	174	287	141	585	3.96	6.53	3.21	13.32	3.59
505	8719	7082	2.1	10.2	5.1	5.9	10.8	21.2	4.20	18.35	1.52	0.15	166	442	219	247	3.96	10.53	5.23	5.87	3.53
505	8720	7107	2.2	16.1	0.9	12.0	12.3	20.1	4.65	24.93	1.57	0.14	284	1118	114	700	6.11	24.05	2.46	15.05	5.71
505	8721	7088	3.4	5.2	5.0	11.2	10.5	20.2	4.60	22.50	1.49	0.16	232	307	246	462	5.05	6.67	5.35	10.03	4.70
505	8721	7094	3.4	5.2	5.0	11.2	10.5	22.9	4.19	22.31	1.16	0.19	228	255	209	376	5.46	6.08	5.00	8.99	5.24
505	8722	7097	3.4	10.4	0.9	16.6	10.7	22.2	5.01	25.81	1.52	0.22	221	440	65	542	4.41	8.79	1.30	10.82	4.91
505	8723	7104	3.2	15.5	2.7	5.6	10.8	20.7	4.41	22.49	1.52	0.15	244	651	148	238	5.53	14.75	3.35	5.38	5.05
505	8724	7144	1.1	11.6	3.4	13.2	18.5	20.0	5.25	26.59	1.74	0.19	186	714	347	693	3.54	13.59	6.61	13.19	3.73
603	8715	7058	1.2	10.1	2.8	10.8	10.4	27.4	2.24	14.16	1.04	0.12	75	248	73	217	3.35	11.09	3.25	9.69	2.06
603	8716	7039	1.1	5.1	0.9	5.7	10.1	23.3	2.03	15.23	1.61	0.11	57	125	50	115	2.83	6.14	2.47	5.67	1.34
603	8716	7045	1.1	5.1	0.9	5.7	10.1	24.2	2.02	14.26	1.50	0.11	52	122	30	117	2.58	6.04	1.48	5.82	1.26
603	8717	7113	1.0	15.9	5.1	16.7	10.5	26.9	1.83	13.81	1.53	0.08	85	270	83	223	4.64	14.78	4.57	12.21	2.28
603	8717	7116	1.0	15.9	5.1	16.7	10.5	25.6	2.04	16.17	1.71	0.08	88	318	102	271	4.32	15.54	4.99	13.25	2.26
603	8718	7052	2.1	5.2	2.9	17.0	10.7	24.0	2.43	15.92	1.32	0.10	102	181	84	357	4.21	7.42	3.47	14.67	2.45
603	8719	7080	2.1	10.2	5.1	5.9	10.8	24.1	2.03	15.63	1.50	0.10	88	219	102	128	4.36	10.82	5.05	6.31	2.13
603	8720	7109	2.2	16.1	0.9	12.0	12.3	27.3	1.87	15.66	1.33	0.05	122	408	44	251	6.55	21.84	2.33	13.44	3.34
603	8721	7089	3.4	5.2	5.0	11.2	10.5	25.1	1.98	15.28	1.46	0.13	92	138	94	190	4.65	6.93	4.75	9.57	2.31
603	8721	7095	3.4	5.2	5.0	11.2	10.5	27.8	2.08	14.35	1.21	0.08	116	139	101	195	5.58	6.70	4.84	9.39	3.24
603	8722	7096	3.4	10.4	0.9	16.6	10.7	27.0	2.14	15.09	1.29	0.08	120	251	34	268	5.62	11.72	1.61	12.52	3.25
603	8723	7102	3.2	15.5	2.7	5.6	10.8	27.1	1.76	14.38	1.22	0.05	106	255	59	99	6.04	14.52	3.39	5.64	2.87
603	8724	7124	1.1	11.6	3.4	13.2	18.5	26.6	2.35	19.06	1.40	0.10	96	242	69	202	4.10	10.32	2.96	8.60	2.56
604	8715	7056	1.2	10.1	2.8	10.8	10.4	23.4	2.87	11.27	1.67	0.06	78	256	81	256	2.71	8.95	2.83	8.94	1.82
604	8716	7041	1.1	5.1	0.9	5.7	10.1	22.0	2.44	11.39	2.15	0.10	66	137	31	137	2.72	5.62	1.25	5.60	1.46
604	8716	7044	1.1	5.1	0.9	5.7	10.1	21.3	2.26	11.78	2.28	0.10	66	129	29	123	2.92	5.70	1.26	5.45	1.40
604	8717	7114	1.0	15.9	5.1	16.7	10.5	24.4	2.60	12.66	1.99	0.07	95	376	131	367	3.66	14.47	5.04	14.13	2.32
604	8717	7115	1.0	15.9	5.1	16.7	10.5	24.2	2.77	12.49	1.96	0.07	103	409	144	392	3.73	14.75	5.21	14.16	2.50
604	8718	7051	2.1	5.2	2.9	17.0	10.7	23.7	3.16	12.41	1.54	0.07	102	203	102	354	3.24	6.42	3.23	11.20	2.42
604	8719	7084	2.1	10.2	5.1	5.9	10.8	24.3	2.84	11.32	1.69	0.08	113	299	162	191	3.96	10.53	5.71	6.74	2.74
604	8720	7110	2.2	16.1	0.9	12.0	12.3	24.3	2.32	11.27	2.23	0.06	140	493	50	326	6.02	21.21	2.16	14.03	3.40
604	8721	7087	3.4	5.2	5.0	11.2	10.5	24.4	2.30	10.97	1.76	0.08	112	165	121	247	4.88	7.19	5.27	10.72	2.74
604	8721	7092	3.4	5.2	5.0	11.2	10.5	26.2	4.05	13.41	1.29	0.11	126	193	173	345	3.12	4.77	4.29	8.52	3.31
604	8722	7098	3.4	10.4	0.9	16.6	10.7	25.6	2.71	11.16	1.76	0.09	139	292	47	404	5.14	10.77	1.72	14.88	3.58
604	8723	7103	3.2	15.5	2.7	5.6	10.8	25.4	2.83	13.88	1.68	0.06	123	313	71	127	4.35	11.07	2.49	4.50	3.12
604	8724	7122	1.1	11.6	3.4	13.2	18.5	27.0	2.48	24.35	1.15	0.10	89	241	80	249	3.61	9.73	3.23	10.06	2.41

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			Fuel Components vol pct					FTP	Emissions FTP g/mile				FTP mg/mile				Emissions wt pct of HC				g/gal
Car	Fuel	Test	BZ	TOL	EBZ	XYL	REF	mpg	HC	CO	NOx	Meth	BZ	TOL	EBZ	XYL	BZ	TOL	EBZ	XYL	BZ
605	8715	7057	1.2	10.1	2.8	10.8	10.4	27.3	2.49	10.40	1.50	0.09	69	250	78	242	2.79	10.07	3.14	9.73	1.90
605	8716	7040	1.1	5.1	0.9	5.7	10.1	27.3	1.98	9.74	1.74	0.07	46	108	34	117	2.33	5.49	1.73	5.91	1.26
605	8716	7046	1.1	5.1	0.9	5.7	10.1	24.8	2.17	9.76	2.09	0.08	51	121	21	118	2.36	5.55	0.98	5.42	1.27
605	8717	7121	1.0	15.9	5.1	16.7	10.5	27.0	2.46	10.05	1.89	0.11	77	341	123	329	3.12	13.82	4.97	13.36	2.08
605	8717	7125	1.0	15.9	5.1	16.7	10.5	27.5	2.32	11.11	2.02	0.07	77	323	110	296	3.31	13.93	4.75	12.77	2.11
605	8718	7050	2.1	5.2	2.9	17.0	10.7	26.3	2.20	10.26	1.90	0.08	80	141	71	304	3.63	6.40	3.22	13.83	2.09
605	8719	7090	2.1	10.2	5.1	5.9	10.8	24.4	2.33	10.39	2.24	0.05	73	216	113	128	3.14	9.27	4.86	5.48	1.78
605	8720	7117	2.2	16.1	0.9	12.0	12.3	26.1	2.16	10.96	2.12	0.07	94	357	42	247	4.38	16.54	1.96	11.45	2.46
605	8721	7093	3.4	5.2	5.0	11.2	10.5	26.1	2.33	9.90	2.06	0.07	117	137	121	235	5.01	5.86	5.17	10.07	3.05
605	8721	7099	3.4	5.2	5.0	11.2	10.5	28.7	2.15	10.87	1.63	0.07	96	124	104	206	4.49	5.75	4.86	9.59	2.77
605	8722	7101	3.4	10.4	0.9	16.6	10.7	26.5	2.22	11.59	1.99	0.02	114	247	39	325	5.13	11.15	1.75	14.68	3.01
605	8723	7108	3.2	15.5	2.7	5.6	10.8	26.3	2.36	9.95	2.03	0.08	121	368	81	141	5.13	15.61	3.46	6.01	3.18
605	8724	7128	1.1	11.6	3.4	13.2	18.5	26.3	2.35	10.55	2.23	0.07	86	297	107	303	3.65	12.60	4.53	12.87	2.26
606	8715	7054	1.2	10.1	2.8	10.8	10.4	20.0	2.94	14.70	3.78	0.12	88	291	91	280	3.00	9.89	3.08	9.53	1.77
606	8716	7047	1.1	5.1	0.9	5.7	10.1	19.5	3.61	14.48	2.87	0.10	75	195	46	219	2.08	5.39	1.27	6.07	1.46
606	8716	7053	1.1	5.1	0.9	5.7	10.1	19.2	3.12	14.45	2.60	0.10	64	180	42	203	2.06	5.78	1.34	6.51	1.23
606	8717	7119	1.0	15.9	5.1	16.7	10.5	21.1	2.97	14.71	2.65	0.06	97	432	155	419	3.28	14.54	5.20	14.09	2.05
606	8717	7126	1.0	15.9	5.1	16.7	10.5	22.3	2.31	13.07	2.64	0.06	81	303	108	295	3.50	13.12	4.66	12.80	1.80
606	8718	7130	2.1	5.2	2.9	17.0	10.7	21.6	2.37	13.23	2.39	0.06	97	148	74	336	4.09	6.24	3.11	14.18	2.09
606	8719	7085	2.1	10.2	5.1	5.9	10.8	19.3	3.75	15.85	2.87	0.09	132	387	217	220	3.52	10.30	5.79	5.86	2.55
606	8720	7118	2.2	16.1	0.9	12.0	12.3	20.0	3.13	15.04	2.69	0.07	131	525	52	393	4.21	16.80	1.68	12.56	2.63
606	8721	7091	3.4	5.2	5.0	11.2	10.5	20.3	3.42	14.56	2.73	0.05	170	211	194	379	4.96	6.18	5.66	11.08	3.45
606	8721	7100	3.4	5.2	5.0	11.2	10.5	20.1	3.31	14.46	2.79	0.08	146	199	187	348	4.41	6.01	5.66	10.52	2.94
606	8722	7105	3.4	10.4	0.9	16.6	10.7	20.2	3.07	14.79	2.86	0.06	149	320	45	466	4.84	10.42	1.47	15.16	3.01
606	8723	7111	3.2	15.5	2.7	5.6	10.8	19.6	3.48	15.53	3.15	0.09	141	539	123	217	4.06	15.51	3.54	6.23	2.77
606	8724	7127	1.1	11.6	3.4	13.2	18.5	21.9	2.38	13.19	2.41	0.06	90	297	96	304	3.80	12.47	4.02	12.79	1.99

NIPER, ARB Benzene, Phase 3, Engine-Out

			HC grams/mile				CO grams/mile				NOx grams/mile				Methane grams/mile				mpg
Car	Fuel	Test	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	cold	stab	hot	FTP	FTP
505	8594	7016	3.42	3.71	3.21	3.51	17.27	19.37	16.71	18.20	1.59	1.17	1.44	1.33	0.13	0.17	0.17	0.16	20.7
505	8725	7020	3.91	3.32	2.94	3.34	26.18	20.63	18.12	21.09	1.46	0.95	1.38	1.18	0.14	0.11	0.14	0.12	22.7
505	8726	7027	4.15	3.42	3.25	3.52	28.12	20.81	14.42	20.56	1.49	1.04	1.43	1.24	0.22	0.14	0.13	0.15	22.5
603	8594	7015	2.37	2.03	1.82	2.05	17.62	15.96	12.69	15.41	1.92	1.12	1.69	1.44	0.12	0.10	0.13	0.11	23.0
603	8725	7021	2.48	1.98	1.57	1.97	15.28	14.49	10.98	13.68	1.78	1.17	1.15	1.29	0.08	0.07	0.05	0.07	27.0
603	8726	7129	1.99	1.80	1.44	1.74	17.20	17.05	12.18	15.75	1.83	1.17	1.29	1.34	0.10	0.08	0.06	0.08	28.0
604	8594	7017	2.77	2.86	2.11	2.64	12.36	10.83	8.10	10.40	1.78	1.49	1.75	1.62	0.11	0.09	0.06	0.09	23.1
604	8725	7022	2.46	2.79	1.94	2.49	11.40	10.61	8.60	10.22	1.67	1.56	1.70	1.62	0.08	0.06	0.02	0.05	23.9
604	8726	7026	2.48	2.67	1.94	2.43	10.64	10.69	8.04	9.95	1.62	1.54	1.75	1.61	0.09	0.07	0.08	0.07	25.7
605	8594	7018	2.85	1.63	1.46	1.84	17.92	7.27	8.26	9.75	2.69	1.20	2.00	1.73	0.19	0.05	0.07	0.09	25.6
605	8725	7019	2.49	1.61	1.45	1.75	23.36	7.58	8.03	10.98	2.51	1.37	2.42	1.89	0.12	0.01	0.02	0.04	26.8
605	8726	7028	2.44	1.60	1.73	1.81	22.34	7.46	10.13	11.26	3.16	1.58	2.62	2.19	0.13	0.05	0.11	0.08	25.3
606	8594	7146	2.56	3.22	2.36	2.84	14.70	15.29	11.60	14.14	3.99	2.38	3.17	2.93	0.09	0.08	0.06	0.08	19.3
606	8725	7025	2.23	3.14	2.54	2.78	12.76	14.99	12.70	13.90	3.04	2.23	3.31	2.69	0.03	0.00	0.05	0.02	20.6
606	8726	7043	4.27	3.74	2.59	3.53	15.92	16.14	10.78	14.62	4.39	2.79	3.20	3.22	0.10	0.08	0.06	0.08	20.1

NIPER, ARB Benzene, Phase 3, Engine-Out

			Benzene mg/mile				Toluene mg/mile				Ethyl BZ mg/mile				Xylenes mg/mile				m,pXylene mg/mi				oXylene mg/mile			
Car	Fuel	Test	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP	c	s	h	FTP
505	8594	7016	80	81	72	78	291	306	269	293	80	81	69	78	148	158	136	150	111	120	103	114	37	38	33	36
505	8725	7020	134	117	107	118	301	233	218	243	64	54	52	55	324	256	244	267	245	194	184	202	79	62	60	65
505	8726	7027	170	138	124	141	312	243	233	254	72	0	57	31	325	119	242	196	247	57	183	132	79	62	59	64
603	8594	7015	66	58	55	59	216	187	155	184	66	46	40	49	115	102	84	100	89	78	62	76	27	24	22	24
603	8725	7021	91	68	59	70	197	144	115	147	45	37	27	36	219	171	125	168	166	129	95	127	53	42	30	41
603	8726	7129	86	75	66	75	177	158	129	154	44	45	30	41	189	181	134	170	138	135	99	126	51	46	34	44
604	8594	7017	70	71	54	66	236	241	174	222	70	75	54	68	143	144	108	134	108	110	79	101	35	34	30	33
604	8725	7022	89	101	76	92	170	197	135	174	41	47	33	42	212	241	167	215	159	181	125	161	53	60	41	54
604	8726	7026	97	99	80	93	164	181	130	163	40	46	33	41	194	210	152	191	146	159	114	144	48	52	37	47
605	8594	7018	66	36	34	41	228	134	125	151	67	38	36	44	127	72	68	82	96	55	51	62	31	17	16	20
605	8725	7019	91	53	50	60	175	113	103	123	59	27	25	33	232	127	121	147	180	96	92	112	53	31	29	35
605	8726	7028	90	60	58	66	159	111	117	123	38	28	31	31	184	119	134	137	139	91	101	104	45	28	33	33
606	8594	7146	63	62	43	57	223	269	186	237	53	59	49	55	116	155	105	133	85	107	77	94	31	48	28	39
606	8725	7025	98	110	94	103	175	219	171	197	40	49	42	45	210	289	222	254	157	216	166	190	52	74	56	64
606	8726	7043	124	102	76	99	295	246	170	235	75	68	42	63	373	324	219	305	279	242	163	227	94	82	56	77

NIPER, ARB Benzene, Phase 3, Engine-Out

			Fuel Components vol pct					FTP	Emissions FTP g/mile				FTP mg/mile				Emissions wt pct of HC				g/gal
Car	Fuel	Test	BZ	TOL	EBZ	XYL	REF	mpg	HC	CO	NOx	Meth	BZ	TOL	EBZ	XYL	BZ	TOL	EBZ	XYL	BZ
505	8594	7016	0.4	7.3	1.7	3.5	10.7	20.7	3.51	18.20	1.33	0.16	78	293	78	150	2.23	8.34	2.21	4.27	1.62
505	8725	7020	1.5	6.0	1.2	8.0	13.8	22.7	3.34	21.09	1.18	0.12	118	243	55	267	3.54	7.29	1.66	8.00	2.67
505	8726	7027	1.5	6.0	1.3	7.5	13.3	22.5	3.52	20.56	1.24	0.15	141	254	31	196	4.00	7.22	0.88	5.56	3.17
603	8594	7015	0.4	7.3	1.7	3.5	10.7	23.0	2.05	15.41	1.44	0.11	59	184	49	100	2.88	8.99	2.38	4.88	1.36
603	8725	7021	1.5	6.0	1.2	8.0	13.8	27.0	1.97	13.68	1.29	0.07	70	147	36	168	3.56	7.46	1.82	8.53	1.89
603	8726	7129	1.5	6.0	1.3	7.5	13.3	28.0	1.74	15.75	1.34	0.08	75	154	41	170	4.28	8.82	2.33	9.74	2.09
604	8594	7017	0.4	7.3	1.7	3.5	10.7	23.1	2.64	10.40	1.62	0.09	66	222	68	134	2.50	8.40	2.58	5.08	1.53
604	8725	7022	1.5	6.0	1.2	8.0	13.8	23.9	2.49	10.22	1.62	0.05	92	174	42	215	3.68	7.00	1.69	8.64	2.19
604	8726	7026	1.5	6.0	1.3	7.5	13.3	25.7	2.43	9.95	1.61	0.07	93	163	41	191	3.84	6.72	1.68	7.86	2.40
605	8594	7018	0.4	7.3	1.7	3.5	10.7	25.6	1.84	9.75	1.73	0.09	41	151	44	82	2.25	8.23	2.37	4.48	1.06
605	8725	7019	1.5	6.0	1.2	8.0	13.8	26.8	1.75	10.98	1.89	0.04	60	123	33	147	3.44	7.03	1.90	8.42	1.61
605	8726	7028	1.5	6.0	1.3	7.5	13.3	25.3	1.81	11.26	2.19	0.08	66	123	31	137	3.63	6.78	1.73	7.56	1.66
606	8594	7146	0.4	7.3	1.7	3.5	10.7	19.3	2.84	14.14	2.93	0.08	57	237	55	133	1.99	8.32	1.94	4.67	1.10
606	8725	7025	1.5	6.0	1.2	8.0	13.8	20.6	2.78	13.90	2.69	0.02	103	197	45	254	3.71	7.06	1.63	9.13	2.13
606	8726	7043	1.5	6.0	1.3	7.5	13.3	20.1	3.53	14.62	3.22	0.08	99	235	63	305	2.81	6.65	1.77	8.64	1.99