DIESEL EXHAUST STANDARD - PHASE II: CRC PROJECT NO. AVFL-10b

FINAL REPORT

SwRI Project No. 03.10410

Prepared for

Coordinating Research Council, Inc.
3650 Mansell Road, Suite 140
Alpharetta, Georgia 30022

Prepared by:
E. Robert Fanick
Project Leader

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FOREWORD

This project, entitled "Diesel Exhaust Standard Phase II: CRC Project No. AVFL-10b," was performed for the Coordinating Research Council (CRC) by the Department of Engine and Emissions Research at Southwest Research Institute® (SwRI®). The period of performance was from January 12 through November 16, 2004. The project was based on SwRI Proposal 08.038784A. The Project Director for CRC was Mr. Brent Bailey. The Advanced Vehicle/Fuel/Lubricants (AVFL) Committee and Working Group were responsible for the technical oversight for this project, and Mr. King D. Eng of Shell Global Solutions (U.S.), Inc. was responsible for project supervision. The Project Manager for Southwest Research Institute was Dr. Lawrence Smith, and the Principal Investigator was Mr. E. Robert Fanick.

EXECUTIVE SUMMARY

This report describes the second phase of an effort to develop a standard diesel exhaust which may be used in the future development of diesel exhaust aftertreatment. Phase I consisted of a literature review and creation of a database of engine-out diesel emissions. To supplement limited data on light-duty diesel emissions, this second phase was initiated. The experimental effort in this second phase assessed the composition of light-duty diesel exhaust at several operating conditions and utilized that data to recommend a possible "recipe" for light-duty diesel engine exhaust.

The effort was broken down into seven tasks. The tasks included fuel selection, engine and vehicle selection, engine operating conditions, exhaust measurement procedures, experimental program, data analysis, and reporting. The fuel selected for this study was a 2007 ultra-low sulfur diesel fuel. Four vehicles, each with a minimum of 5000 accumulated miles of operation, were selected for testing in this phase. These vehicles included:

- A 2004 Chevrolet Silverado 2500HD with a 6.6 L Duramax diesel engine (300 hp at 3100 rpm and 520 ft-lbs of torque at 1800 rpm)
- 2004 Ford F-350 with a 6.0 L Powerstroke (International) V8 turbodiesel engine (325 hp at 3300 rpm and 560 lb-ft of torque at 2000 rpm)
- A 2004 Dodge Sprinter passenger van with a 2.7 L Mercedes-Benz in-line 5 cylinder engine (154 hp at 3800 rpm and 243 ft-lbs at 1600 rpm)
- A 2004 Volkswagen Jetta with a 1.9 L TDI engine (100 hp at 4000 rpm and 177 ft-lbs at 1800 rpm)

Each vehicle was tested at five steady-state engine operating conditions

- Rated speed at 75 percent torque
- Rated speed at 50 percent torque
- Peak torque speed at 50 percent torque
- Peak torque speed at 25 percent torque
- Idle.

In addition to the five steady-state modes, two transient test cycles (the Federal Test Procedure and the US06) were utilized. All four vehicles were tested for engine-out emissions only. Any existing exhaust aftertreatment systems were replaced with exhaust tubing and a damper to simulate exhaust restrictions. Regulated emissions were measured and the exhaust was characterized by speciating the volatile and semi-volatile hydrocarbons. In addition, the

particulate was characterized by analyzing the volatile organic fraction, sulfate, and ash. The data from these four vehicles were then collected and analyzed to make recommendations for a possible standard diesel exhaust formulation that could be used in catalyst performance studies.

The primary components of synthetic diesel exhaust would consist of nitrogen (N_2), oxygen (O_2), carbon dioxide (CO_2), and water (H_2O). Four other minor components (total hydrocarbons - THC, carbon monoxide - CO, the oxides of nitrogen - NO_x, and particulate) contributed smaller fractions of the total exhaust, but are the primary targets of regulations and are the focus of this study. Based on the limited data from the four vehicles in this study and the literature search in AVFL-10a, Table ES-1 presents the relative mass percentages for a synthetic diesel exhaust blend. Compressed gas cylinders of the appropriate concentration of these gases can be prepared for N_2, O_2, CO_2, CO, and NO. Water can be introduced as a liquid and evaporating it into the sample stream. Mass flow controllers can be used to accurately control the specific gas concentrations.

TABLE ES-1. STANDARD SYNTHETIC DIESEL EXHAUST MIXTURE

Component	Mass Percent
Nitrogen	~76 (balance)
Oxygen	13.3
Carbon dioxide	7.6
Water	3.1
NO_x	0.0291
Carbon monoxide	0.0162
Total hydrocarbons	0.0032
Particulate	0.0015

In the case of the THC, the composition is complicated by the presence of a large number of possible compounds. These hydrocarbons can be represented by six different compounds or groups of compounds based on their chemistry, reactivity, toxicity, and concentrations in the exhaust. These compounds or groups of compounds include:

- Ethylene
- Formaldehyde
- Semi-volatiles
- C3+ alkenes
- Aromatics
- Branched-chain C3+ alkanes.

The results from the emission tests in this study and the results from AVFL-10a indicate that the THC contribution could be simulated by a variety of component combinations depending on the

complexity desired. Table ES-2 illustrates a complex hydrocarbon mixture that would account for the reactivity, toxicity, and range of compounds present in diesel exhaust. Ethylene and formaldehyde were found to be two of the major single compounds present in diesel exhaust. The sizable semi-volatile component of diesel exhaust would be represented by tridecane, tetradecane, pentadecane, and naphthalene. The C3+ alkene component would be represented by propylene. Benzene and toluene would represent the aromatics, and the C3+ branched-chain paraffins would be represented by 2,2,4-trimethylpentane. These recommended hydrocarbons represent about 90 percent of the hydrocarbons found in diesel exhaust. Ethylene, propylene, benzene, toluene, and 2,2,4-trimethylpentane could be introduced into a synthetic mix by conventional means, while formaldehyde could be introduced as an aqueous solution along with the water component of the blend. The semi-volatiles would be more difficult to introduce, and some effort would be required to develop an appropriate technique.

TABLE ES-2. HYDROCARBONS FOR STANDARD SYNTHETIC DIESEL EXHAUST MIXTURE (COMPLEX BLEND)

Hydrocarbon	Mass Percent of Total Hydrocarbon	Mass Percent of Total Exhaust
Formaldehyde	23	0.00074
Ethylene	18	0.00058
Tridecane	9	0.00029
Tetradecane	9	0.00029
Pentadecane	9	0.00029
Naphthalene[a]	9	0.00029
Propylene[b]	11	0.00035
Benzene[c]	3.5	0.00011
Toluene[c]	3.5	0.00011
2,2,4-trimethylpentane[d]	5	0.00016

[a] Tetrahydronaphthalene or methyltetrahydronaphthalene could be substituted for naphthalene
[b] 1-Butene could be substituted for propylene
[c] One or more of the isomers of xylene (meta- or para-) could be substituted for benzene or toluene
[d] 2,2-Dimethylpropane or 3-methylpentane could be substituted for 2,2,4-trimethylpentane

As is the case with the THC, particulate is a complicated mixture of a number of different components. These components include but are not limited to soot (elemental carbon), unburned and partially burned fuel and lubricating oil components, sulfate with any associated water, and ash (metals and inorganics). Particulate in the form of carbon black could be introduced in the form of a slurry with the water component. The correct particle size for the carbon black would have to be determined by additional experimentation. It is also desirable to include an SO_2 component because of it's known impacts on catalyst efficiency. The concentration of SO_2 can be estimated based on the sulfur content of the diesel fuel. As fuel sulfur contents are lowered to ultra-low levels, it may be necessary to include an SO_2 contribution from lubricants.

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1.0 INTRODUCTION

Diesel exhaust has come under increasing public scrutiny in the United States. As a result, diesel exhaust aftertreatment has become an important technology in helping to achieve lower emission levels from diesel engines. With cooler exhaust temperatures relative to gasoline spark ignited engines, leaner operation, and higher exhaust concentrations of oxides of nitrogen (NO_x) and particulate, diesel exhaust aftertreatment cannot utilize standard gasoline aftertreatment technologies.

The development of exhaust after-treatment systems is often facilitated with laboratory bench reactors in which a gas mixture is fed to a device while the feedgas and exhaust concentrations are monitored. Synthetic gas reactors have proven useful in gasoline applications, where a simple gas mixture has sufficed. Some laboratories use these same gas reactors for the development of diesel aftertreatment, with propene as the primary hydrocarbon. Obviously, diesel exhaust gas has an inherently different composition than gasoline-derived exhaust from spark ignited engines. In addition, particulate matter is present in significant quantities. For these reasons, the development of a standardized synthetic exhaust for diesel engines is important in the evaluation of potential diesel exhaust aftertreatment technologies. To establish a standard diesel exhaust composition, it was first necessary to develop a specification based on data from a variety of diesel engines and fuels. A literature review was performed in Coordinating Research Council (CRC) Project No. AVFL-10a, and a database of diesel engine-out emissions was created.[1] This database was found to be lacking in light-duty emissions data and the need for a follow-on testing program was identified. This follow-on study was conducted by Southwest Research Institute (SwRI) to provide CRC with additional light-duty emissions data. In the follow-on study, light-duty engine-out diesel exhaust was collected and analyzed to determine the exhaust composition of four current model light-duty vehicles. These vehicles were tested at a variety of conditions to collect information in order to suggest a standard diesel exhaust composition.

2.0 WORK PLAN

2.1 Objective

The objectives of this effort were to assess the composition of light-duty diesel exhaust at several operating conditions through an experimental program using multiple, current-technology vehicles and to determine and define a synthetic formulation for light-duty engine exhaust which can be used for catalyst performance studies.

2.2 Scope of Work

This effort was broken down into seven tasks: fuel selection, engine/vehicle selection, engine operating conditions, speciated emissions procedures, experimental program, data analysis, and reporting. In Task 1, the fuel selected for this study was a 2007 ultra-low sulfur diesel fuel. In Task 2, four vehicles were selected for testing. These vehicles included:

- A 2004 Chevrolet Silverado 2500HD with a 6.6 L Duramax diesel engine (300 hp at 3100 rpm and 520 ft-lbs of torque at 1800 rpm)
- 2004 Ford F-350 with a 6.0 L Powerstroke (International) V8 turbodiesel engine (325 hp at 3300 rpm and 560 lb-ft of torque at 2000 rpm)
- A 2004 Dodge Sprinter passenger van with a 2.7 L Mercedes-Benz in-line 5 cylinder engine (154 hp at 3800 rpm and 243 ft-lbs at 1600 rpm)
- A 2004 Volkswagen Jetta with a 1.9 L TDI engine (100 hp at 4000 rpm and 177 ft-lbs at 1800 rpm)

In Task 3, five steady-state engine operating conditions:

- Rated speed at 75 percent torque
- Rated speed at 50 percent torque
- Peak torque speed at 50 percent torque
- Peak torque speed at 25 percent torque
- Idle

and two transient test cycles (Federal Test Procedure and US06) were selected to produce a range of operating conditions expected to show differences in engine-out exhaust composition, which may affect exhaust catalysts or other aftertreatment projected for use in 2007 technology systems. Task 4 involved selection of the emissions to be analyzed and the equipment and procedures needed to make these analyses. In Task 5, the four test vehicles were tested over the

steady-state modes and transient cycles selected in Task 3. Regulated emissions (total hydrocarbons - THC, carbon monoxide - CO, NO_x, and total particulate) as well as carbon dioxide (CO_2) were measured during each test. In addition, hydrocarbons were characterized by speciating the volatile and semi-volatile hydrocarbons, and the particulate was characterized by analyzing the volatile organic fraction (VOF), sulfate, and ash. The data were then collected and analyzed to determine a standard diesel exhaust formulations in Task 6.

3.0 CONDUCT OF PROGRAM

The following sections provide additional details on the completion of each of the tasks in this program. Tasks 1 through 4 are discussed in their entirety, while Sections IV and V provide additional information regarding Tasks 5 and 6, respectively.

3.1 Task 1 – Fuel Selection

Task 1 involved the selection of a test fuel for use during the emissions testing part of the program in Task 5. After discussions with the Advanced Vehicle/Fuel/Lubricants (AVFL) Committee and Working Group, the test fuel was selected to meet average United States fuel composition and properties projected for use in 2007 diesel engines according to the Code of Federal Regulations (CFR) Title 40, Part 86, Subpart B.[(2)] This fuel was obtained from Sinclair and designated EM-5038-F. Specifications for 2007 certification fuel, and commercial fuel, as well as the properties for EM-5038-F are shown in Table 1. The fuel selected for this study met the commercial fuel specifications; however, the boiling ranges were higher than the certification specifications.

TABLE 1. 2007 FUEL SPECIFICATIONS AND PROPERTIES

Property	Certification Specifications	Commercial Specifications	EM-5038-F
Cetane Number	40-50	38-58	45.4
Cetane Index	40-50	40 min.	ND[a]
Gravity, °API	32-37	30-39	34.5
Total sulfur, ppm	7-15	7-15	6.9
Aromatics, % min.	27	NA[b]	35.8
Flashpoint, °F min.	130	130	176
Boiling Point Distribution			
Initial, °F	330-390	NA	382
10 %, °F	370-430	NA	441
50 %, °F	410-480	NA	511
90 %, °F	460-520	540-630	608
End Point, °F	500-560	NA	654

[a]ND – not determined
[b]NA – Not applicable

3.2 Task 2 - Engine/Vehicle Selection

In this task, ten representative current-technology light-duty diesel vehicles with engines in the 1.9 L to 6.6 L size range were identified. Six of these ten vehicles were available at the start of the program. These vehicles included:

- 2004 Chevrolet Silverado 2500HD or 3500 with a 6.6 L Duramax diesel engine
- 2004 Dodge Ram 2500 or 3500 with a 5.9 L Cummins turbodiesel in-line 6-cylinder engine
- 2004 Ford F-250, F-350, or Excursion with a 6.0 L Powerstroke (International) V8 turbodiesel engine (325 hp at 3300 rpm and 560 lb-ft of torque at 2000 rpm)
- 2004 Dodge Sprinter passenger or cargo van with a 2.7 L Mercedes-Benz in-line 5 cylinder engine
- 2004 Volkswagen New Beetle, Golf, and Jetta with a 1.9 L engine (a redesigned version of Volkswagen's pump-injector high-pressure fuel injection system)
- 2003 Volkswagen Beetle, Golf, and Jetta with a 1.9 L in-line 4 cylinder engine (90 hp at 3750 rpm and 155 ft-lbs at 1900 rpm).

Four of the ten were expected to be available at some point during the course of the project:

- 2004 Volkswagen Passat with a 2.0 L TDI engine
- Volkswagen Touareg (expected availability in Spring 2004) with a 5.0-liter V10 turbodiesel engine
- 2005 Mercedes-Benz E320 sedan (expected availability in Spring 2004) with a 6 cyl 3.2 L engine
- 2004/2005 Jeep Liberty (expected availability in late 2004 or early 2005) with a 2.8 L VM Motori engine

These potential test vehicles were presented to the AVFL Committee and Working Group, and four of the first six vehicles were selected by the committee for testing. Initially, this group included a Chevrolet, two Dodges (Ram and Sprinter), and a Volkswagen. The four vehicles selected included two larger displacement engines (6.6 L and 5.9 L), one medium displacement engine (2.7 L), and one smaller displacement engine (1.9 L). The Ford with a 6.0 L engine, initially not included in the list of vehicles for testing, was later selected to replace the Dodge Ram because of difficulties in locating a proper test vehicle and the complication of the Dodge being available with three different engines:

- 2004½ - 325 hp at 2900 rpm and 600 ft-lbs of torque at rpm
- High output - 305 hp at 2900 rpm and 555 ft-lbs of torque at 1400 rpm
- Standard - 250 hp at 2900 rpm and 460 ft-lbs of torque at 1400 rpm

This substitution also enabled the scope of the project to include an additional vehicle/engine manufacturer into the group of selected test vehicles.

3.3 Task 3 - Engine Operating Conditions

The objective of Task 3 was to select up to five steady-state modes of operation which would reflect a range of operating conditions expected to show differences in engine-out exhaust composition that may influence exhaust catalysts or other aftertreatment devices projected for use in 2007. As a starting point, the thirteen speed/load points that had been selected to define the operating characteristics of a 1998 Mercedes-Benz 2.2 L OM 611 engine in a 1998 project conducted in the United States Army TARDEC Fuels and Lubricants Research Facility were reviewed for potential use in this program.[3] Other programs utilizing some of these test points included a 2003 CRC project (AVFL-3) to evaluate emissions from a 1999 Mercedes-Benz C220 CDI with a 2.2 L OM 611 engine.[4] Test cycles for that CRC project included Modes 5, 10, and 13 used in the TARDEC study as well as the Federal Test Procedure (FTP) and the US06. In another project for the Department of Energy (DOE), involving the characterization of exhaust from the Mercedes-Benz 2.2 L OM 611 engine, two of the test modes (Modes 6 and 11) were similar to those used in the TARDEC study except that the injection timing and exhaust gas recirculation levels were modified. This information was discussed with the AVFL Committee and Working Group. It was decided that the five steady-state modes of operation that would be utilized for testing in this study would be similar to Modes 1, 2, 8, 9, and 13 in the 1998 United States Army TARDEC Fuels and Lubricants Research Facility study.[3] Table 2 lists the specific engine operating conditions selected for this study.

TABLE 2. FIVE STEADY-STATE MODES

TARDEC Modes	Speed	Percent Torque
1	Rated	75
2	Rated	50
8	Peak Torque	50
9	Peak Torque	25
13	Idle	

In addition, two transient cycles were selected to supplement the data from the steady-state modes. The two transient cycles were the FTP, which represents city driving conditions, and the US06, an aggressive driving cycle. These two cycles are designed to simulate a wide range of driving events and are discussed in more detail below.

The FTP is typically used to evaluate light-duty vehicle exhaust emissions, and utilizes the Urban Dynamometer Driving Schedule (UDDS). The UDDS is the result of more than ten years of effort by various groups to translate the Los Angeles smog-producing driving conditions to chassis dynamometer operations, and is a non-repetitive driving cycle covering 7.5 miles in 1372 seconds with an average speed of 19.7 mph. Its maximum speed is 56.7 mph. A chassis dynamometer is employed to reproduce vehicle inertia and road load. The vehicle's exhaust is collected, diluted, and thoroughly mixed with filtered background air to a known constant volume flowrate using a positive displacement pump. A proportional sample of the dilute

exhaust is analyzed continuously or is collected in a sample bag or on a filter for analysis at the end of the test. Emissions are mathematically weighted to represent the average of several 7.5-mile trips made from hot- and cold-starts.[5]

The FTP consists of a cold-start, 505-second, cold transient phase followed immediately by an 867-second stabilized phase. A speed versus time illustration of the 505- and 867-second phases of the UDDS driving cycle is given in Figure 1. Cold-start or cold transient phase emissions result when the vehicle has not been started in 12 to 36 hours. The "stabilized" phase produces emissions from a fully warmed up or stabilized vehicle and emission control system. Following the stabilized phase, the vehicle is allowed to soak for 10 minutes with the engine turned off before proceeding with a repeat of the first 505 seconds of the test. This portion of the test, hot-start or hot transient phase represents vehicle operation after the vehicle and emission control systems have been operated during a short trip, turned off for 10 minutes, and then re-started once again. Exhaust emissions from the FTP cover the effects of vehicle and emission control system warm-up as the vehicle is operated over the cycle. The FTP is usually conducted as a three-part test with separate samples taken for the cold-transient, stabilized, and hot-transient phases. For this study, the cold-transient and stabilized phases were combined into a single test and designated a cold UDDS, and a hot-transient phase followed by a second stabilized phase were combined into a second test designated a hot UDDS.[5]

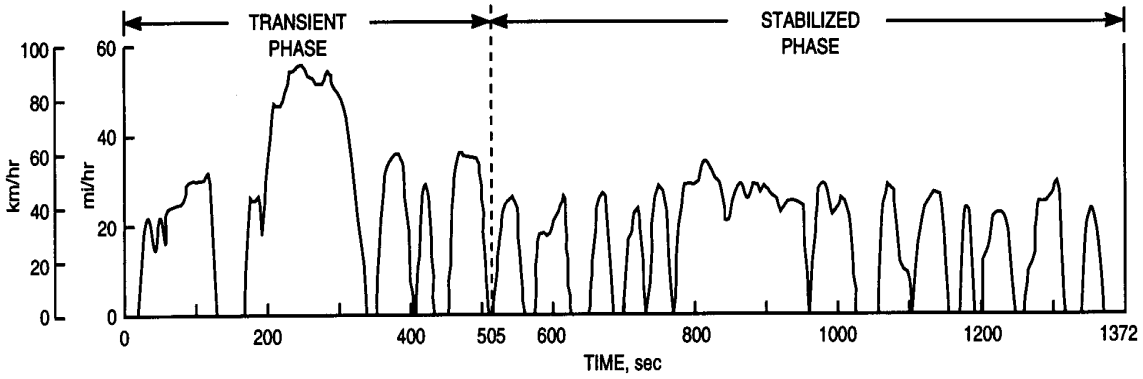


FIGURE 1. SPEED VERSUS TIME ILLUSTRATION OF 505- AND 867-SECOND PHASES OF UDDS DRIVING CYCLE

When combining the cold and hot phases to obtain a composite for the FTP, a weighted average was used. Values for the cold UDDS were weighted at 43 percent, and values from the hot UDDS were weighted at 57 percent. The composite FTP emissions results were computed using the equation:

$$Y_{wm} = 0.43 \times \left(\frac{Y_{ct}}{D_{ct}} \right) + 0.57 \times \left(\frac{Y_{ht}}{D_{ht}} \right)$$

where: Y_{wm} = Weighted mass emission rate, g/mi
Y_{ct} = Mass emission (THC, CO, or NO_x) from cold UDDS, g
Y_{ht} = Mass emission (THC, CO, or NO_x) from hot UDDS, g
D_{ct} = Distance for cold UDDS, mi
D_{ht} = Distance for hot UDDS, mi

The US06 was developed by the EPA as one of the compliance cycles in the Supplemental FTP, and represents more extreme high-speed, high-acceleration driving behavior. The US06 was designed to represent real-world driving conditions and includes speeds in excess of 80 mph and acceleration rates in excess of 10 mph/sec. The duration of this cycle is 600 seconds with an average speed of 48 mph and a total distance of 8 miles. Figure 2 shows the vehicle speed versus time for the US06 driving schedule. These two transient cycles and the five steady-state modes were selected to represent a variety of engine operating conditions to provide a wide range of components and concentrations in the engine-out exhaust.[5]

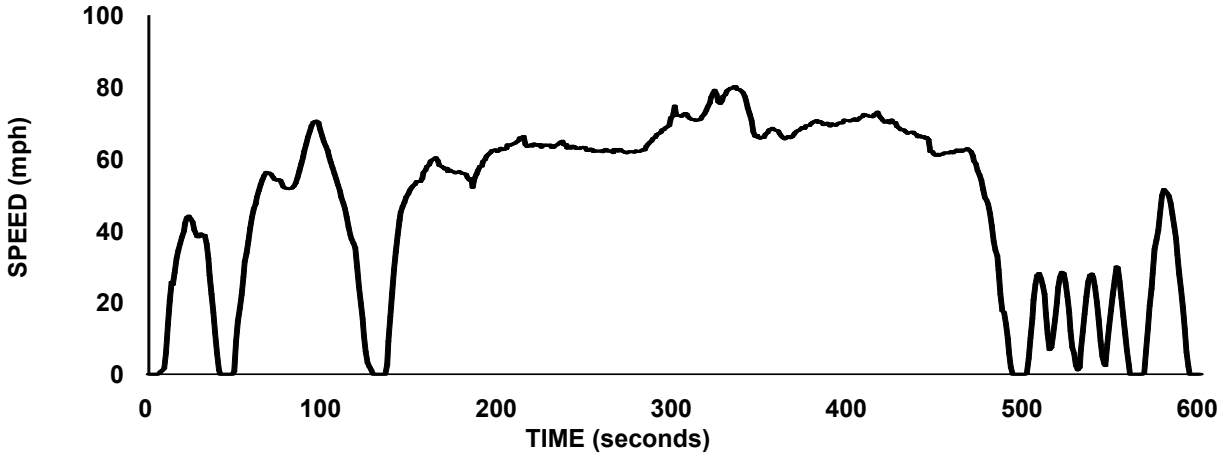


FIGURE 2. SPEED VERSUS TIME ILLUSTRATION OF US06 DRIVING CYCLE

3.4 Task 4 - Speciated Emissions Procedures

Emission measurements included regulated emissions (THC, CO, NO_x, and total particulate) as well as CO_2. These emissions were analyzed according to CFR Title 40 specifications.[2] In addition to the regulated emissions, a number of hydrocarbons were speciated and quantified to help in defining a standard exhaust composition for the hydrocarbon components.

3.4.1 Speciation of Volatile Hydrocarbon Compounds

Analytical procedures for conducting the speciation of volatile hydrocarbons (C_1 to C_{12} hydrocarbons, aldehydes, and ketones) were similar to the CRC Auto/Oil Phase II methods and were adapted for use with diesel exhaust. With these methods, exhaust emissions samples were analyzed for the presence of more than 200 different volatile exhaust species. Four gas chromatography (GC) procedures and one High Performance Liquid Chromatography (HPLC) procedure were used to identify and quantify specific compounds. One GC was used for the measurement of methane, a second for C_2-C_4 species, and a third for C_5-C_{12} species, including two ethers (methyl tertiary butyl ether - MTBE and ethyl tertiary butyl ether - ETBE). A fourth GC was used to measure 1-methylcyclopentane, benzene, toluene, and 2,3,3-trimethylpentane, which co-elute in the C_5-C_{12} method and cannot be accurately quantified by other methods. In general, all emission "sample" bags were analyzed before the "background" bags, so that

reactive exhaust compounds could be analyzed as quickly as possible. For the aldehydes and ketones, an HPLC procedure was employed. A brief description of these procedures is given below.

3.4.1.1 Methane Speciation

Methane levels were determined using proportional exhaust gas samples collected in Tedlar bags. A GC equipped with an flame ionization detector (FID) was utilized for the analyses and in accordance with Society of Automotive Engineers (SAE) J1151 procedures.[6] The GC system was equipped with a packed column to resolve methane from other hydrocarbons in the sample. Samples were introduced into a 5-mL sample loop via a diaphragm pump. For analysis, the valve was switched to the inject position, and the helium carrier gas swept the sample from the loop toward the detector through a 61 cm by 0.3 cm Porapak N column in series with a 122 cm by 0.3 cm molecular sieve 13X column. As soon as the methane peak passed into the molecular sieve column, the helium flow was reversed through the Porapak N column to vent. For quantification, sample peak areas were compared to those of external calibration standards.

3.4.1.2 C_2-C_4 Species

With the aid of a DB-WAX pre-column and a 10-port switching valve, a second GC was utilized for the separation and determination of exhaust concentrations of C_2-C_4 individual hydrocarbon species, including: ethane; ethylene; acetylene; propane; dimethylpropane; propyne; 1,3-butadiene; 2-methylpropane; 1-butyne; and cis-2-butene. Bag samples were analyzed with the system which included a Hewlett-Packard Model 5890 Series II GC with an FID, two pneumatically operated and electrically controlled valves, and two analytical columns. The carrier gas was helium. One column was utilized to separate the C_2-C_4 hydrocarbons from the higher molecular weight hydrocarbons and polar compounds. These higher molecular weight hydrocarbons (and water and alcohols) are retained on the pre-column while the C_2-C_4 hydrocarbons are passed through to the analytical column. While the C_2-C_4 hydrocarbons were separated on the analytical column, the pre-column was back-flushed with helium to prepare for the next run. The column flow was set by fine-tuning the column head pressure to give butane a retention time of 5.25 ± 0.05 minutes. The GC was calibrated daily using a CRC Auto/Oil 23-component calibration mixture. Detection limits for the procedure were on the order of 5 ppbC in dilute exhaust for all compounds.

3.4.1.3 C_5-C_{12} Species

The third GC procedure provided separation and exhaust concentrations for more than 100 C_5-C_{12} individual hydrocarbon compounds. Bag samples of dilute exhaust were analyzed using a gas chromatograph equipped with an FID. The GC system utilizes a Hewlett-Packard Model 5890 Series II GC with an FID, a pneumatically operated and electrically controlled valve, and a DB-1 fused silica open tubular (FSOT) column. The carrier gas was helium. Gaseous samples were pumped from the bag through a sample loop and then introduced into a liquid nitrogen cooled column. The column oven was then programmed to a maximum temperature of 200°C. The analog signal from the FID was sent to a networked computer system

via a buffered analog to digital converter. Column flow was set by fine-tuning the column head pressure to give propane a retention time of 5.40 ± 0.10 minutes using a temperature program. The GC was calibrated daily using a CRC Auto/Oil 23-component calibration mixture. Detection limits for the procedure are on the order of 10 ppbC in dilute exhaust for all compounds.

3.4.1.4 Benzene and Toluene

The fourth GC procedure used a separate system configured similarly to the third GC method (but utilized a DB-5 analytical column instead of a DB-1 FSOT column) to resolve individual concentrations of benzene and toluene according to the CRC Auto/Oil Phase II Protocols. Separation of benzene and toluene from co-eluting peaks was carried out by fine-tuning the column head pressure to give benzene a retention time of 22 to 23 minutes. The GC was calibrated daily using a CRC 7-component calibration mixture.

3.4.1.5 Aldehydes and Ketones

An HPLC procedure was utilized for the analysis of aldehydes and ketones. Samples were collected by bubbling dilute exhaust at a nominal flowrate of 4 L/min through chilled glass impingers containing an acetonitrile solution of 2,4-DNPH and perchloric acid. For analysis, a portion of the acetonitrile solution was injected into a liquid chromatograph equipped with a ultra-violet (UV) detector. External standards of the aldehyde and ketone DNPH derivatives were used to quantify the results. The aldehydes and ketones measured were: formaldehyde, acetaldehyde, acrolein, acetone, propionaldehyde, crotonaldehyde, isobutyraldehyde/ methylethylketone (not resolved from each other during normal operating conditions, and so split equally between the two compounds), benzaldehyde, isovaleraldehyde, valeraldehyde, o-tolualdehyde, m-tolualdehyde/p-tolualdehyde (not resolved from each other during normal operating conditions, and so reported together), hexanaldehyde, and dimethylbenzaldehyde. Detection limits for this procedure are on the order of 0.005 ppm aldehyde or ketone in dilute exhaust.

3.4.2 Speciation of Semi-Volatile Hydrocarbon Compounds

Semi-volatile vapor-phase hydrocarbon compounds in the C_{10} to C_{22} range were also included as part of the chemical characterization of the hydrocarbon compounds in the exhaust. Since no established method was available for the identification of these compounds, a method was implemented to collect these compounds in hexane as an absorbing solution. Two impingers were placed in series, and dilute exhaust sampled at a flowrate of 3.5 L/min. The absorbing solution from each impinger was combined and fifty percent (50%) of the sample was archived. The remaining sample was carefully concentrated to 500 µL with a steady stream of filtered nitrogen. At this point, 2 µL of the sample were injected into an Agilent 6890N GC/5973N MSD (gas chromatograph/mass spectrometer detector) system, with a J&W Scientific fused silica column (60m x 0.32mm i.d. with 0.25 µm film thickness) that utilized a liquid phase of dimethypolysiloxane. The GC oven temperature program was as follows:

- Hold at 40°C for 2 minutes
- Ramp at 4.5°C/min to 285°C
- Hold for 2 minutes.

The duration of each GC/MS run was 58.4 minutes. At the end of a program run, the temperature was increased to 320°C and held for 4 minutes. The splitless/split injection mode was used with helium as the carrier gas at a constant flow of 1.2 mL/min. The temperatures for the ion source and quadrupole were 230°C and 150°C, respectively. The temperatures for the injector and GC/MS interface were 265°C and 285°C, respectively, and the mass scanning range was 40 to 400 Dalton at a rate of 2.08 cycles/second. Spectral data were collected in the electron impact/positive ion (EI/PI) mode. Chromatographic data were comprised of individual ion chromatograms (plotted as the abundance of the mass to charge ratio, *m/z*, at each scan), as well as a total ion chromatogram (TIC) in which each data point was a sum for all *m/z* abundance values at each scan.

A diesel range organic standard from Ultra Scientific containing n-C10 through n-C25 was analyzed to determine the retention times for the normal alkanes. The spectra and retention times (RT) of these compounds were used for the identification of the same compounds in the actual exhaust samples. The polynuclear aromatics (PAH) such naphthalene, 1- and 2-methylnaphthalenes, phenanthrene, anthracene, fluorene, fluoranthene, and pyrene in the samples were also identified based on their spectra and retention times.

In order to identify as many components as possible in the very complex diesel engine exhaust emission samples, a representative sample was chosen for a detailed analysis. The sample that was selected had the highest concentrations based on TIC intensity. A list of target compounds was compiled from this sample, under the assumption that the highest concentrations and most complex sample yields the most comprehensive target compound list. Data from the TIC were used to identify unknown compounds with a mass spectra library search in which the best-matched library spectrum was identified. The top 30 library spectra were manually examined and the best match was selected as the tentative identification for the unknown TIC peak.

For each candidate, individual ion chromatograms for each major ion displayed in selected ion chromatogram profile were examined to ensure that these ions elute together. For example, 1,2,3,4-tetrahydro-1-methylnaphthalene has a base peak of 131 and a molecular weight peak of 146. The apex of 131 and 146 peaks should coincide in time. If the major peaks did not elute within the range of 2 scans, the ions were taken to be fragments of two different compounds and the candidate was rejected.

The first set of target compounds was identified in this manner. From this list, compounds that shared some major ions (and similar intensities for these ions) were chosen to form a list of candidates. The spectral intensity of the tentatively identified compound was determined by summing up the intensity of each ion of the compound. In some cases, TIC peaks were comprised of two or even three major components. A number of scans were noted to have

fairly complex or unique ion distributions, resulting in improbable library search identifications. Candidates from these searches contained either unlikely elemental compositions (the fractions analyzed here are thought to consist almost entirely of hydrocarbons, with trace amounts of ^{14}N, ^{16}O, and ^{32}S), or the suggested structure was too sterically or geometrically constrained to survive the combustion process. To solve these spectra within these boundaries, the scans were treated as a mixture of two or more co-eluting compounds with each component contributing to the *m/z* distribution of the scan and using the observed scan as the cumulative *m/z* distribution of the components. Major ion chromatograms for each component were checked to ensure the component's presence as well as elution in phase with the TIC peak. Candidates that were found to elute at a different time than the TIC peak were assigned to the corresponding scan; the analysis was repeated with this new scan. Similarly, ion peaks that still could not be explained were traced back to the local apex of its ion chromatogram; the scan at this new retention time was subjected to the same process. The search was repeated in this manner until a scan was completely explained (with no unidentified peaks) or was too ambiguous to explain without further study.

Target compound quantitation was performed using internal references. The C_{10}-C_{22} n-alkanes were chosen as internal references for target compound quantitation. Each internal reference concentration was calculated via an external-standard diesel-range organic standard. All tentatively identified semi-volatile hydrocarbons other than the C_{10}-C_{22} n-alkanes were then quantified against the C_{10}-C_{22} n-alkanes with the assumption that the response ratio between the internal standard and the semi-volatile hydrocarbon was 1:1 ratio. Every target compound was compared to the internal reference which eluted immediately after it. The target compound list was thus divided into 13 distinct retention time windows, with each window compared to its succeeding internal reference.

A C_{10}-C_{25} n-alkane external standard was analyzed each day along with each sequence of samples. Peak heights were recorded for each n-alkane in the TIC of each sample; these were then compared to those of the external standard to calculate internal standard concentrations in each sample. The peak heights of each identified target compound were measured as the sum of the abundance values of all major ions belonging to that target. The concentrations of these compounds were calculated based on their referenced internal concentrations.

3.4.3 Particulate Characterization

The total particulate was sampled during each test condition. In addition, a chemical characterization of the particulate was also performed. This characterization included direct filter injection/gas chromatography (DFI/GC) to determine the volatile organic composition of the particulate, the analysis of total sulfate, and the analysis of particulate-phase ash from lubricating oil and wear metals.

3.4.3.1 Direct Filter Injection/Gas Chromatography (DFI/GC)

Diesel exhaust particulate is composed of elemental carbon and organic compounds derived from the combustion of diesel fuel and lubricating oil. The DFI/GC method was used to quantitatively measure and characterize the VOF of diesel exhaust particulate collected on

Teflon® coated glass fiber (Pallflex®) filter media. This method employed a novel injection port into which a portion of the particulate filter can be placed and thermally desorbed onto a non-polar column to separate the volatile hydrocarbons according to their boiling point. Chromatograms of the VOF from the actual lubricating oil and the VOF of particulate samples were compared to determine the total percent VOF and percent VOF from the unburned oil. The difference is the remaining VOF which may be attributed to fuel and partially burned fuel and lubricating oil.

3.4.3.2 Sulfate Analysis

To accurately measure the amount of sulfate deposited on filters during emissions testing, engine exhaust was directed into a constant volume sampling dilution tunnel, where it was mixed with a flowing stream of filtered, conditioned air. In the dilution tunnel, sulfur trioxide (SO_3) reacts rapidly with water in the exhaust to form sulfuric acid aerosols. The aerosols were allowed to grow to filterable size range and were collected on filters downstream of the tunnel via probes mounted in the tunnel. Particulate sulfate salts are collected as well.

Sulfuric acid collected on the filters was converted to ammonium sulfate by exposure to ammonia vapor. The soluble sulfates were leached from the filters with a measured volume of 60% isopropanol/40% water solution (60% IPA). An aliquot of this extract was injected via an autosampler into an ion chromatograph. Anions were separated by an analytical column, and passed through a conductivity detector. The retention time on the analytical column provided identification of the anion and the intensity of the signal corresponded to the concentration detected. This method was capable of detecting sulfate at levels lower than 0.02 µg/mL.

3.4.3.3 Particulate-Phase Ash Analysis

For the determination of the metals and inorganics collected on filters, a portion of each filter was digested in a mixture of nitric and perchloric acid followed by aqua regia. The resulting solution was analyzed by ICP/MS for the individual metals and inorganics. The instrument was standardized, using NIST traceable standard reference materials. Prior to reading any sample, the standardization was also verified with a second source of NIST traceable reference material. This second source standard was from a different supplier than the standardization material. Immediately after the check sample was run, a blank sample was run to verify the zero setting of the standardization. The check sample was required to be within the control limits of 90-110 percent recovery of the certified value. The absolute value of the check blank was required to be below the reporting limit for the samples. If either condition was not met, the analysis would be terminated and the instrument re-standardized and re-checked. The check sample and check blank were re-run after every 10 samples and at the end of the run to ensure that the instrument remained in control throughout the entire run. The same control limits were used for the continuing check samples. If a check sample fell out of the control limits, then analysis was terminated, the instrument re-standardized, and all samples since the last compliant check sample were re-run. The metals and inorganics analyzed using this method included:

- Calcium (Ca)
- Chromium (Cr)
- Copper (Cu)
- Iron (Fe)
- Lead (Pb)
- Manganese (Mn)
- Phosphorus (P)
- Sulfur (S)
- Zinc (Zn).

3.5 Task 5 – Experimental Program

In this task, all emission testing of the vehicles was performed. Four vehicles were tested using the five steady-state modes and two transient cycles identified in Task 3. The four vehicles identified in Task 2 which were tested in Task 5 included:

- A 2004 Chevrolet Silverado 2500HD with a 6.6 L Duramax diesel engine (300 hp at 3100 rpm and 520 ft-lbs of torque at 1800 rpm),

- A 2004 Ford F-350 with a 6.0 L Powerstroke (International) V8 turbodiesel engine (325 hp at 3300 rpm and 560 lb-ft of torque at 2000 rpm),

- A 2004 Dodge Sprinter passenger van with a 2.7 L Mercedes-Benz in-line 5 cylinder engine (154 hp at 3800 rpm and 243 ft-lbs at 1600 rpm), and

- A 2004 Volkswagen Jetta with a 1.9 L TDI engine (100 hp at 4000 rpm and 177 ft-lbs at 1800 rpm)

The vehicles were tested with at least 5000 miles of vehicle operation prior to running the emission tests. Each vehicle was tested for engine-out emissions only. In order to accomplish this step, the existing exhaust aftertreatment systems on the Ford, Dodge, and Volkswagen were replaced with a piece of exhaust tubing utilizing a damper to simulate the exhaust restriction for each vehicle. In addition, the lubricating oil was not changed prior to testing. Three of the four vehicles (Chevrolet, Ford, and Dodge) were tested on a heavy-duty chassis dynamometer to simulate the road load conditions of these larger displacement engines and to accommodate the larger exhaust volumes and higher exhaust temperatures produced during the steady-state modes. Dilution flowrates for these vehicles were set at 2000 cfm. Conversely, the Volkswagen was tested on a 48-inch roll light-duty chassis dynamometer. Dilution flowrates for this vehicle were set at 600 cfm. All tests were performed with the test fuel selected in Task 1. Actual test results are presented in Section 4.0.

3.6. Task 6 - Data Analysis

In this task, the data collected from the experimental program were analyzed and compared with the results from the literature search in AVFL-10a. Comparisons were made to propose a possible representative gaseous exhaust formulation based on the limited experimental data from this study and from the literature search. These comparisons and discussions are presented in detail in Section 5.0.

4.0 TEST RESULTS

Regulated exhaust emissions (THC, CO, NO_x, and total particulate) and CO_2 as well as a number of speciated hydrocarbons were measured from the four light-duty diesel vehicles to help in defining a standard exhaust composition. The results for these tests are included below.

4.1 Regulated Emissions

Four vehicles were tested with the FTP, US06, and five steady-state modes. The regulated emissions for the transient cycles from each vehicle are shown in Table 3, and the regulated emissions for the five steady-state modes are presented in Table 4. Mass rates are presented in g/mi for the transient cycles, and in g/min for the steady-state modes.

TABLE 3. SUMMARY OF TRANSIENT CYCLE EMISSIONS

Transient Cycles	Emissions, g/mi				
	THC	CO	NO_x	Particulate	CO_2
Chevrolet Silverado					
Cold UDDS	0.47	2.7	6.1	0.14	825
Hot UDDS	0.45	2.0	6.1	0.12	769
Composite FTP	0.46	2.3	6.1	0.13	793
US06	0.23	1.5	6.5	0.16	833
Ford F-350					
Cold UDDS	0.69	3.3	5.5	0.13	798
Hot UDDS	0.63	2.2	3.7	0.10	720
Composite FTP	0.66	2.7	4.5	0.11	754
US06	0.31	1.4	3.7	0.07	771
Dodge Sprinter Van					
Cold UDDS	0.37	1.7	2.5	0.12	547
Hot UDDS	0.35	1.5	2.5	0.14	578
Composite FTP	0.36	1.6	2.5	0.13	565
US06	0.25	1.2	2.7	0.23	719
Volkswagen Jetta					
Cold UDDS	0.65	2.9	0.2	0.15	248
Hot UDDS	0.40	2.2	0.2	0.24	233
Composite FTP	0.51	2.5	0.2	0.20	240
US06	0.11	1.5	1.0	0.12	260

TABLE 4. SUMMARY OF STEADY-STATE MODE EMISSIONS

Steady-State Mode		Emissions, g/min				
Speed, rpm	**Percent Torque**	**THC**	**CO**	**NO_x**	**Particulate**	**CO_2**
Chevrolet Silverado						
3100	75	0.34	3.2	8.6	0.47	2107
3100	50	0.42	2.0	7.3	0.39	1046
1800	50	0.17	1.0	5.6	0.07	627
1800	25	0.35	3.4	2.1	0.07	226
Idle		0.10	0.2	0.6	0.02	54
Ford F-350						
3300	75	0.57	2.0	9.0	0.39	1977
3300	50	0.60	2.1	4.5	0.25	1407
2000	50	0.31	0.7	3.7	0.06	827
2000	25	0.35	1.2	2.0	0.06	411
Idle		0.08	0.3	0.6	0.02	74
Dodge Sprinter Van						
3800	75	0.38	3.3	3.6	0.20	1170
3800	50	0.77	4.1	2.1	0.14	788
1600	50	0.17	0.5	0.6	0.05	164
1600	25	0.18	0.5	0.3	0.03	59
Idle		0.05	0.2	0.4	0.01	32
Volkswagen Jetta						
4000	75	0.18	0.6	1.0	0.10	384
4000	50	0.16	0.6	3.7	0.08	384
1800	50	0.05	0.5	2.4	0.09	325
1800	25	0.05	0.3	1.2	0.01	162
Idle		0.04	0.2	0.1	0.01	23

4.2 Hydrocarbon Speciation Emission Results

A number of speciated hydrocarbons were measured to help define a standard exhaust composition for the hydrocarbon components in the exhaust. Emission measurements for the volatile hydrocarbons included the C_1 to C_{12} hydrocarbons and aldehydes and ketones. Measurement of the semi-volatile hydrocarbons included C_{10} C_{22} hydrocarbons. Mass rates are presented in mg/mi for the transient cycles and in mg/min for the steady-state modes. These results are reported below.

4.2.1 Volatile Hydrocarbon Compounds (C_1 to C_{12})

Over 200 compounds from methane to dodecane can be identified with this method. The transient cycle results for each vehicle are presented in detail in Appendix A for the transient cycles and Appendix B for the steady-state modes. Tables 5 and 6 present the most abundant species for each vehicle and test condition. The two or three most abundant volatile hydrocarbons are highlighted in each table.

TABLE 5. MOST ABUNDANT VOLATILE HYDROCARBON COMPOUNDS (TRANSIENT CYCLES)

Compound	Test Cycle		
	Cold UDDS, mg/mi	Hot UDDS, mg/mi	US06, mg/mi
Chevrolet Silverado			
Methane	7.9	10	2.1
Ethylene	41	28	18
Propylene	9.0	6.2	4.5
Acetylene	12	8.7	5.1
1-Butene	2.3	1.2	1.2
Isobutylene	1.2	0.7	1.4
2,2-Dimethylpropane	3.0	1.2	2.5
1,3-butadiene	4.4	ND[a]	2.6
Benzene	3.6	2.5	1.9
Toluene	4.1	3.1	3.0
m- & p-Xylene	1.5	1.3	0.6
Nonane	1.3	1.0	0.4
Formaldehyde	37	26	14
Acetaldehyde	13	9.1	5.1
Acrolein	3.4	2.0	0.7
Propionaldehyde	2.1	1.1	0.4
Crotonaldehyde	1.6	1.0	0.4
Isovaleraldehyde	2.7	2.5	1.0
o-Tolualdehyde	1.1	1.1	ND
m- & p-Tolualdehyde	2.4	1.3	0.8

[a]ND – None detected
NOTE: Most abundant volatile hydrocarbons indicated by shading

TABLE 5 (CONT'D). MOST ABUNDANT VOLATILE HYDROCARBON COMPOUNDS (TRANSIENT CYCLES)

Compound	Test Cycle, mg/mi		
	Cold UDDS	Hot UDDS	US06
Ford F-350			
Methane	9.6	24	ND[a]
Ethylene	53	38	15
Propylene	13	10	4.4
Acetylene	14	11	3.7
1-Butene	3.1	2.4	1.0
Isobutylene	1.9	1.4	0.8
1,3-Butadiene	0.7	2.0	ND
1-Pentene	10	6.8	1.1
2-Methyl-1-butene	5.2	3.3	0.6
Pentane	4.4	3.3	0.5
3-Methylpentane	1.4	2.1	3.1
2-Methyl-1-pentene	1.1	1.3	0.7
1-Hexene	1.1	1.3	0.7
2,2,4-Trimethylpentane	0.7	1.3	0.6
Formaldehyde	69	40	20
Acetaldehyde	22	13	5.8
Acrolein	4.5	2.0	0.2
Acetone	1.6	ND	7.3
Propionaldehyde	12	7.8	4.1
Crotonaldehyde	9.8	5.0	3.7
Benzaldehyde	1.8	1.0	0.7
Isovaleraldehyde	5.1	0.1	1.4
o-Tolualdehyde	1.8	0.7	0.8
m- & p-Tolualdehyde	7.6	3.4	2.5

[a]ND - None detected
NOTE: Most abundant volatile hydrocarbons indicated by shading

TABLE 5 (CONT'D). MOST ABUNDANT VOLATILE HYDROCARBON COMPOUNDS (TRANSIENT CYCLES)

Compound	Test Cycle, mg/mi		
	Cold UDDS	Hot UDDS	US06
Dodge Sprinter			
Methane	11	1.6	1.4
Ethylene	32	24	23
Propylene	9.4	7.5	7.8
Acetylene	7.3	5.4	3.5
1-Butene	1.8	1.6	1.7
Isobutylene	1.5	1.1	1.1
1-Pentene	1.5	0.9	1.1
2,2,4-Trimethylpentane	0.7	0.9	1.1
Formaldehyde	51	15	19
Acetaldehyde	11	5.0	6.0
Acetone	7.8	ND[a]	3.9
Propionaldehyde	2.5	Trace[b]	0.9
Crotonaldehyde	3.6	0.8	2.2
m- & p-Tolualdehyde	3.7	ND	0.8

[a]ND - None detected
[b]Trace – Compound detected but value not quantifiable
NOTE: Most abundant volatile hydrocarbons indicated by shading

TABLE 5 (CONT'D). MOST ABUNDANT VOLATILE HYDROCARBON COMPOUNDS (TRANSIENT CYCLES)

Compound	Test Cycle, mg/mi		
	Cold UDDS	Hot UDDS	US06
Volkswagen Jetta			
Methane	20	16	1.6
Ethane	2.3	1.5	0.4
Ethylene	96	64	16
Propylene	28	18	4.6
Acetylene	23	17	4.6
Isobutylene	3.1	1.9	0.6
2,2-Dimethylpropane	1.1	0.9	0.3
1-Pentene	4.8	3.2	2.1
Pentane	3.4	1.9	0.4
trans-2-Pentene	2.3	1.2	0.1
Cyclopentane	1.6	1.2	0.2
2-Methyl-1-pentene	2.2	1.4	0.4
1-Hexene	2.2	1.4	0.4
Benzene	9.8	6.2	2.0
2,2,4-Trimethylpentane	2.3	1.5	0.4
Toluene	2.9	1.4	0.6
m- & p-Xylene	2.3	1.4	0.4
1-Nonene	1.3	0.6	0.2
Formaldehyde	62	53	9.5
Acetaldehyde	29	19	3.3
Acetone	5.2	4.4	0.3
Propionaldehyde	16	11	2.1
Crotonaldehyde	11	7.0	1.0
Isobutyraldehyde	2.1	1.2	0.1
Methylethyleketone	2.1	1.2	0.1
Benzaldehyde	4.5	2.8	0.4
Isovaleraldehyde	2.2	1.1	0.7
o-Tolualdehyde	2.7	2.2	0.2
m- & p-Tolualdehyde	10	5.4	0.7
NOTE: Most abundant volatile hydrocarbons indicated by shading			

TABLE 6. MOST ABUNDANT VOLATILE HYDROCARBON COMPOUNDS (STEADY-STATE MODES)

Compound	Test Cycle, mg/min				
	Rated/75	Rated/50	PT/50	PT/25	Idle
Chevrolet Silverado					
Ethylene	62	31	7.9	51	5.4
Propylene	17	6.8	1.7	8.4	1.6
Acetylene	12	7.7	3.3	11	1.2
1-Butene	3.6	1.8	0.4	1.3	0.4
Isobutylene	4.1	1.8	0.4	0.8	0.2
2,2-Dimethylpropane	2.9	1.2	0.2	1.2	1.1
1,3-Butadiene	11	4.2	ND[a]	ND	0.5
3-Methylpentane	0.7	0.1	0.6	2.4	ND
2-Methyl-1-pentene	1.3	0.7	0.3	0.4	ND
1-Hexene	1.3	0.7	0.3	0.4	ND
Benzene	7.4	2.8	1.3	2.5	0.5
2,2,4-Trimethylpentane	1.4	0.4	0.1	0.3	Trace[b]
Toluene	5.9	2.7	2.9	3.8	ND
m- & p-Xylene	0.9	0.8	0.5	0.8	0.4
Formaldehyde	29	42	6.7	45	5.8
Acetaldehyde	14	17	2.6	17	2.2
Acrolein	0.9	2.8	ND	4.1	0.3
Propionaldehyde	0.6	2.4	0.2	1.8	0.3
Crotonaldehyde	0.5	2.0	ND	4.2	0.2
Benzaldehyde	0.8	1.4	ND	1.4	ND
o-Tolualdehyde	2.1	2.3	ND	2.8	0.3
m- & p-Tolualdehyde	0.6	1.5	ND	3.8	0.2

[a]ND - None detected
[b]Trace – Compound detected but value not quantifiable
NOTE: Most abundant volatile hydrocarbons indicated by shading

TABLE 6 (CONT'D). MOST ABUNDANT VOLATILE HYDROCARBON COMPOUNDS (STEADY-STATE MODES)

Compound	Test Cycle, mg/min				
	Rated/75	Rated/50	PT/50	PT/25	Idle
Ford F-350					
Ethylene	48	39	12	20	5.4
Propylene	20	13	4.3	4.4	1.4
Acetylene	7.6	12	3.4	6.7	2.0
1-Butene	6.3	3.8	1.2	0.9	0.2
Isobutylene	5.6	2.2	0.8	0.5	0.2
2,2-Dimethylpropane	5.7	2.8	6.2	20	4.9
1,3-Butadiene	5.5	5.3	ND[a]	ND	ND
1-Pentene	4.8	2.8	0.6	0.2	ND
2-Methyl-1-butene	2.6	0.7	0.4	0.2	ND
Pentane	1.2	0.6	1.6	4.4	0.4
4-Methyl-1-pentene	1.3	0.7	0.1	0.4	0.2
3-Methylpentane	0.8	0.3	0.9	1.3	ND
2-Methyl-1-pentene	3.1	1.6	0.8	0.4	ND
1-Hexene	3.1	1.6	0.8	0.4	ND
Benzene	3.7	4.6	1.7	2.2	ND
2,2,4-Trimethylpentane	3.3	0.6	0.7	2.7	ND
Toluene	6.1	2.9	4.3	4.7	ND
m- & p-Xylene	2.1	1.9	1.2	1.2	ND
1-Nonene	2.3	1.1	0.6	0.2	ND
1-Methyl-2-isopropylbenzene	4.4	1.0	0.2	ND	ND
Formaldehyde	10	15	9.9	36	14
Acetaldehyde	3.5	4.9	3.9	14	6.7
Acrolein	0.3	0.9	0.7	3.4	0.8
Propionaldehyde	1.0	2.3	1.4	5.2	3.0
Crotonaldehyde	1.8	2.0	1.1	4.4	2.0
m- & p-Tolualdehyde	0.4	1.3	0.7	3.6	0.8

[a]ND - None detected
NOTE: Most abundant volatile hydrocarbons indicated by shading

TABLE 6 (CONT'D). MOST ABUNDANT VOLATILE HYDROCARBON COMPOUNDS (STEADY-STATE MODES)

Compound	Test Cycle, mg/min				
	Rated/75	Rated/50	PT/50	PT/25	Idle
Dodge Sprinter					
Methane	2.1	9.3	5.5	2.3	ND[a]
Ethylene	67	89	11	14	2.8
Propylene	22	23	2.4	3.3	0.7
Acetylene	7.6	15	2.7	2.2	0.6
1-Butene	5.8	5.2	0.4	0.6	ND
Isobutylene	3.0	2.8	0.2	0.3	ND
1,3-Butadiene	18	2.6	ND	ND	ND
1-Pentene	3.3	4.7	ND	ND	ND
2-Methyl-1-butene	0.8	0.8	1.2	ND	ND
2-Methyl-1,3-butadiene	1.6	1.5	ND	ND	0.2
3-Methylpentane	1.5	3.3	0.6	1.0	0.4
2-Methyl-1-pentene	2.2	2.3	0.2	0.3	0.2
1-Hexene	2.2	2.3	0.2	0.3	0.2
Benzene	4.4	7.7	0.6	0.3	ND
2,2,4-Trimethylpentane	2.3	2.6	0.2	0.4	0.1
m- & p-Xylene	1.6	2.1	ND	ND	ND
Formaldehyde	33	60	4.6	12	2.0
Acetaldehyde	11	15	1.5	4.3	0.7
Acrolein	1.9	2.8	Trace[b]	0.8	Trace
Acetone	14	18	3.4	4.4	2.9
Propionaldehyde	3.8	5.2	0.4	0.2	ND
Crotonaldehyde	3.5	4.9	0.3	2.0	Trace
Benzaldehyde	1.4	2.2	ND	0.3	ND
m- & p-Tolualdehyde	0.6	3.9	ND	1.2	ND

[a]ND - None detected
[b]Trace – Compound detected but value not quantifiable
NOTE: Most abundant volatile hydrocarbons indicated by shading

TABLE 6 (CONT'D). MOST ABUNDANT VOLATILE HYDROCARBON COMPOUNDS (STEADY-STATE MODES)

Compound	Test Cycle, mg/min				
	Rated/75	Rated/50	PT/50	PT/25	Idle
Volkswagen Jetta					
Ethylene	13	9.5	13	6.1	5.9
Propylene	4.0	2.8	3.9	1.3	1.6
Acetylene	2.7	2.5	1.5	2.7	1.4
trans-2-Butene	1.4	0.9	0.8	0.3	0.3
Isobutylene	1.3	0.8	0.5	0.2	0.2
2,2-Dimethylpropane	0.7	0.5	0.5	0.3	0.2
1,3-Butadiene	1.9	0.8	1.4	ND[a]	ND
2-Methyl-1-pentene	0.6	0.5	0.3	0.1	0.2
1-Hexene	0.6	0.5	0.3	0.1	0.2
Benzene	0.9	0.9	1.6	0.8	0.1
2,2,4-Trimethylpentane	0.7	0.5	0.3	0.1	0.1
Toluene	0.9	0.9	1.0	0.4	Trace[b]
Formaldehyde	10	9.5	7.2	4.2	5.8
Acetaldehyde	3.5	3.3	2.0	1.4	2.1
Acrolein	1.1	0.9	1.0	0.4	0.5
Acetone	0.9	2.9	1.6	0.6	1.1
Propionaldehyde	1.7	1.5	0.8	0.6	1.2
Crotonaldehyde	0.8	0.8	0.5	0.3	0.7
m- & p-Tolualdehyde	0.5	0.5	0.4	0.2	0.6

[a]ND - None detected
[b]Trace – Compound detected but value not quantifiable
NOTE: Most abundant volatile hydrocarbons indicated by shading

4.2.2 Semi-Volatile Hydrocarbon Compounds (C_{10} to C_{22})

Results from the semi-volatile vapor-phase compounds for the transient cycles are presented in Appendix C, and results for the steady-state modes are in Appendix D. About 200 additional compounds were identified in the exhaust from the four vehicles. These hydrocarbons represent the semi-volatile compounds from C_{10} to C_{22}. Tables 7 and 8 present the most abundant species for each vehicle and test condition.

TABLE 7. MOST ABUNDANT SEMI-VOLATILE HYDROCARBON COMPOUNDS (TRANSIENT CYCLES)

Compound	Test Cycle, mg/mi		
	Cold UDDS	Hot UDDS	US06
Chevrolet Silverado			
Decane	1.4	1.5	0.6
Undecane	1.7	2.1	0.8
Naphthalene	1.2	1.0	0.4
Dodecane	2.0	2.4	0.9
Tridecane	3.0	3.9	1.4
Tetradecane	2.5	3.2	1.2
Pentadecane	3.3	3.4	1.2
Hexadecane	1.9	2.6	1.0
Heptadecane	1.4	2.2	0.8
Octadecane	0.7	1.3	0.5
Ford F-350			
Decane	2.0	2.5	1.3
Undecane	3.5	4.6	2.7
1,2,3,4-Tetrahydronaphthalene	1.3	1.7	1.1
Naphthalene	2.4	2.4	1.5
Dodecane	4.6	6.0	3.7
1,2,3,4-Tetrahydro-2-methylnaphthalene	1.0	1.3	0.9
1,2,3,4-Tetrahydro-6-methylnaphthalene	2.2	3.3	1.9
Tridecane	6.6	8.5	5.4
Tetrahydromethylnaphthalene	2.9	3.8	2.3
2-Methylnaphthalene	1.9	2.1	1.2
1,2,3,4-Tetrahydro-2,7-dimethylnaphthalene	2.4	3.2	1.9
1,2,3,4-Tetrahydro-1,5-dimethylnaphthalene	1.8	1.5	0.8
2-Methyltridecane	1.1	1.1	1.0
5-Ethyl-1,2,3,4-tetrahydronaphthalene	2.0	2.7	1.5
3-Methyltridecane	1.1	1.4	1.2
2,6,10-Trimethyldodecane	1.4	1.5	1.2
Tetradecane	5.7	7.4	4.8
1,2,3,4-Tetrahydro-5,6-dimethylnaphthalene	1.6	2.1	1.4
1,2,3,4-Tetrahydro-5,7-dimethylnaphthalene	1.2	3.9	0.8
1,8-Dimethylnaphthalene	1.5	1.8	1.1
2,5-Dimethyltridecane	1.6	1.8	1.4
Pentadecane	5.3	6.6	4.5
2,3,6-Trimethylnaphthalene	1.2	1.6	0.9
Methylpentadecane	1.4	1.7	1.4
Hexadecane	4.2	5.2	3.7
2,6,10-Trimethylpentadecane	1.0	1.1	1.0
3-Methylpentadecane	3.0	2.4	1.7
Heptadecane	3.4	4.0	3.0
2,6,10,14-Tetramethylpentadecane	1.2	1.5	1.2
Octadecane	1.9	2.2	1.6
2,6,10,14-Tetramethylhexadecane	1.0	1.3	1.0
Nonadecane	1.2	1.4	1.0

TABLE 7 (CONT'D). MOST ABUNDANT SEMI-VOLATILE HYDROCARBON COMPOUNDS (TRANSIENT CYCLES)

Compound	Test Cycle, mg/mi		
	Cold UDDS	Hot UDDS	US06
Dodge Sprinter			
Decane	0.8	1.0	0.9
Undecane	0.1	1.0	1.5
Dodecane	0.1	1.4	1.9
Tridecane	0.1	0.4	2.8
Tetradecane	0.1	0.7	2.4
Pentadecane	0.2	0.6	ND
Hexadecane	0.3	0.4	1.7
Heptadecane	0.2	0.5	1.7
Octadecane	0.2	0.5	0.8
Volkswagen Jetta			
Decane	1.6	1.1	0.4
Undecane	2.2	1.6	0.6
Naphthalene	4.1	2.8	0.8
Dodecane	2.5	1.8	0.7
1,2,3,4-Tetrahydro-6-methylnaphthalene	2.6	1.7	0.6
Tridecane	4.3	2.9	1.2
1,2,3,4-Tetrahydromethylnaphthalene	1.6	1.1	0.3
2-Methylnaphthalene	3.7	2.1	0.6
Tetradecane	3.5	2.3	1.0
1,8-Dimethylnaphthalene	2.5	1.6	0.5
Pentadecane	3.2	2.3	1.0
Hexadecane	2.7	2.0	0.8
Heptadecane	2.1	1.8	0.8
Octadecane	1.1	1.1	0.4

TABLE 8. MOST ABUNDANT SEMI-VOLATILE HYDROCARBON COMPOUNDS (STEADY-STATE MODES)

Compound	Test Cycle, mg/min				
	Rated/75	Rated/50	PT/50	PT/25	Idle
Chevrolet Silverado					
Decane	0.2	1.3	0.7	0.6	0.3
Undecane	0.3	1.7	0.9	0.7	0.5
Naphthalene	0.2	2.0	0.3	1.1	0.2
Dodecane	0.3	1.8	1.0	0.8	0.5
Tridecane	0.4	2.6	1.5	1.3	0.8
Tetradecane	0.4	2.3	1.3	1.2	0.7
Pentadecane	0.4	2.4	1.6	1.1	0.7
Hexadecane	0.3	2.2	1.1	0.9	0.5
Heptadecane	0.2	1.9	1.0	0.7	0.4
Octadecane	0.2	1.3	0.6	0.4	0.2
Ford F-350					
Decane	1.7	2.0	1.2	1.5	0.9
Undecane	2.5	3.7	2.2	2.7	1.5
Naphthalene	1.2	1.7	0.8	1.3	1.1
Dodecane	3.2	5.0	2.8	2.5	1.7
1,2,3,4-Tetrahydro-6-methylnaphthalene	1.4	2.4	1.2	1.6	0.3
Tridecane	4.3	7.3	4.0	4.9	2.3
1,2,3,4-Tetrahydro-2,7-dimethylnaphthalene	1.4	2.5	1.2	1.7	0.8
5-ethyl-1,2,3,4-tetrahydronaphthalene	1.2	2.1	1.0	1.4	0.6
2,6,10-trimethyldodecane	1.1	1.5	0.9	1.0	0.6
Tetradecane	4.0	6.8	3.6	4.5	2.0
1,2,3,4-Tetrahydro-5,6-dimethylnaphthalene	1.0	1.9	0.8	1.2	0.5
1,8-Dimethylnaphthalene	0.8	1.2	0.7	1.2	0.6
2,5-Dimethyltridecane	1.1	1.7	1.0	1.3	0.5
Pentadecane	4.0	6.2	3.4	4.2	1.8
Methylpentadecane	1.6	1.7	0.9	1.2	0.6
Hexadecane	3.5	5.1	2.9	3.6	1.4
Heptadecane	3.1	3.9	2.2	3.0	1.1
2,6,10,14-Tetramethylpentadecane	1.2	1.5	0.9	1.3	0.7
Octadecane	1.9	2.0	1.3	1.9	0.8
2,6,10,14-Tetramethylhexadecane	1.0	1.1	0.7	1.1	0.4
Nonadecane	1.3	1.2	0.8	1.1	0.4

TABLE 8. (CONT'D) MOST ABUNDANT SEMI-VOLATILE HYDROCARBON COMPOUNDS (STEADY-STATE MODES)

Compound	Test Cycle, mg/min				
	Rated/75	Rated/50	PT/50	PT/25	Idle
Dodge Sprinter					
Decane	1.0	2.2	1.2	1.5	0.8
Undecane	1.3	3.1	1.6	2.1	1.1
Naphthalene	3.1	3.8	0.8	0.9	0.3
Dodecane	1.2	3.4	1.9	2.5	1.3
1,2,3,4-Tetrahydro-6-methylnaphthalene	1.1	2.6	1.2	1.6	0.8
Tridecane	2.0	5.5	3.3	4.2	2.1
2-Methylnaphthalene	2.4	3.0	0.6	0.9	0.3
1,2,3,4-Tetrahydro-2,7-dimethylnaphthalene	1.1	1.0	1.3	1.7	0.8
Tetradecane	1.8	4.5	2.8	3.7	1.9
1,8-Dimethylnaphthalene	1.8	2.4	0.7	0.9	0.5
Pentadecane	2.1	4.4	2.8	3.5	2.3
Hexadecane	1.3	3.5	2.0	2.5	1.5
Heptadecane	0.9	2.8	1.7	1.9	1.2
Octadecane	0.5	1.3	0.6	0.6	0.5
Volkswagen Jetta					
Decane	1.2	1.2	0.2	0.6	0.4
Undecane	2.0	1.9	0.2	0.9	0.6
Naphthalene	0.5	0.5	0.7	0.5	0.4
Dodecane	2.3	2.2	0.2	1.0	0.7
Tridecane	3.8	3.6	0.4	1.7	1.1
Tetradecane	3.3	3.2	0.3	1.5	0.9
Pentadecane	3.0	3.3	0.3	1.2	0.8
Hexadecane	2.3	2.5	0.5	1.0	0.7
Heptadecane	1.7	2.1	0.8	0.8	0.6
Octadecane	0.7	0.9	0.5	0.4	0.3

4.3. Particulate Characterization

The particulate collected on filters was analyzed to determine its chemical composition. This characterization included DFI/GC to determine the volatile organic fraction of the particulate and an associated fraction of the unburned lubricating oil, total sulfate, and particulate-phase ash from the lubricating oil and/or wear metals. Mass rates for sulfate, VOF, and ash components are presented in mg/mi for the transient cycles and in mg/min for the steady-state modes. These results are summarized below.

4.3.1 Sulfate Emission Results

Particulate phase sulfate was determined from filters collected during each test. Tables 9 and 10 present the sulfate data for all four vehicles at the various test conditions.

TABLE 9. SUMMARY OF SULFATE EMISSION RESULTS FOR TRANSIENT CYCLES

Transient Cycles	Sulfate, mg/mi			
	Chevrolet	Ford	Dodge	Volkswagen
Cold UDDS	ND[a]	0.1	0.7	Trace[b]
Hot UDDS	0.3	ND	0.6	0.1
Composite	<0.2	<0.1	0.6	0.1
US06	0.1	0.3	0.6	0.1

[a]ND – None detected; below detection limit of 0.1 mg/mi
[b]Trace – Compound detected but value not quantifiable

TABLE 10. SUMMARY OF SULFATE EMISSION RESULTS FOR STEADY-STATE MODES

Steady-State Mode		Sulfate, mg/min			
Speed, rpm	Percent Torque	Chevrolet	Ford	Dodge	Volkswagen
Rated	75	12	8.1	0.5	0.2
Rated	50	0.7	0.6	ND[a]	0.1
Peak Torque	50	0.3	ND	0.1	0.2
Peak Torque	25	ND	ND	ND	Trace[b]
Idle		ND	ND	ND	Trace

[a]ND – none detected; below detection limit of 0.1 mg/min.
[b]Trace – Compound detected but value not quantifiable

4.3.2 VOF Emission Results

The VOF is a measure of partially or unburned fuel and lubricating oil components of the particulate. Total VOF is reported in Tables 11 and 12 as a percent fraction of the total particulate and as a mass rate either in mg/mi or in mg/min. In addition to the total VOF, the tables also contain a percent fraction of the VOF determined to be unburned lubricating oil and an associated mass rate for this unburned lubricating oil. This fraction was determined from a comparison of the gas chromatogram of the actual lubricating oil with one from the subject particulate sample. The difference between the total VOF and the unburned oil is the remaining VOF which may be attributed to unburned or partially burned fuel or partially burned lubricating oil.

4.3.3 Ash Emission Results

Metals and inorganics investigated included nine elements: calcium (Ca), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), phosphorus (P), sulfur (S), and zinc (Zn). Tables 13 and 14 summarize these data for each vehicle and test condition.

TABLE 11. SUMMARY OF VOF RESULTS FOR TRANSIENT CYCLES

Transient Cycles	Total VOF		Unburned Oil	
	Percent	Mg/mi	Percent	mg/mi
Chevrolet Silverado				
Cold UDDS	27	39	33	13
Hot UDDS	37	43	41	18
Composite	33	41	38	16
US06	30	48	61	29
Ford F-350				
Cold UDDS	59	79	31	24
Hot UDDS	58	58	30	17
Composite	58	67	30	20
US06	38	28	29	8
Dodge Sprinter				
Cold UDDS	25	31	29	9
Hot UDDS	21	28	24	7
Composite	23	29	26	8
US06	13	30	16	5
Volkswagen Jetta				
Cold UDDS	8	12	46	6
Hot UDDS	5	11	>90	>10
Composite	6	11	>73	>8
US06	1	2	48	1

TABLE 12. SUMMARY OF VOF EMISSION RESULTS FOR STEADY-STATE MODES

Steady-State Modes		Total VOF		Unburned Oil	
Speed, rpm	**Percent Torque**	**Percent**	**mg/min**	**Percent**	**mg/min**
Chevrolet Silverado					
3100	75	18	84	27	23
3100	50	56	217	96	208
1800	50	49	34	49	17
1800	25	45	32	30	10
Idle		58	9	9	1
Ford F-350					
3300	75	19	74	46	34
3300	50	43	108	39	42
2000	50	40	25	25	6
2000	25	57	34	20	7
Idle		85	14	7	1
Dodge Sprinter					
3800	75	10	20	7	1
3800	50	13	19	28	5
1600	50	34	16	19	3
1600	25	53	15	14	2
Idle		>90	>11	11	>1
Volkswagen Jetta					
4000	75	25	26	>90	>23
4000	50	23	18	>90	>17
1800	50	5	5	21	1
1800	25	18	3	36	1
Idle		20	2	19	<1

TABLE 13. SUMMARY OF ASH EMISSION RESULTS FOR TRANSIENT CYCLES

Metals and Inorganics	Mass Rate, mg/mi			
	Cold UDDS	Hot UDDS	Composite	US06
Chevrolet Silverado				
Calcium	2.7	1.6	2.1	12
Chromium	<0.1	<0.1	<0.1	<0.1
Copper	<0.1	<0.1	<0.1	<0.1
Iron	<0.3	<0.3	<0.3	Trace
Lead	<0.1	<0.1	<0.1	<0.1
Manganese	<0.1	<0.1	<0.1	<0.1
Phosphorus	<0.1	<0.1	<0.1	<0.1
Sulfur	<0.1	<0.1	<0.1	<0.1
Zinc	4.5	2.1	3.1	32
Ford F-350				
Calcium	3.1	3.9	3.5	1.6
Chromium	<0.1	<0.1	<0.1	<0.1
Copper	<0.1	<0.1	<0.1	<0.1
Iron	<0.3	<0.3	<0.3	Trace
Lead	<0.1	<0.1	<0.1	<0.1
Manganese	<0.1	<0.1	<0.1	<0.1
Phosphorus	<0.1	<0.1	<0.1	<0.1
Sulfur	<0.1	<0.1	<0.1	<0.3
Zinc	7.1	8.7	7.9	3.3
Dodge Sprinter				
Calcium	1.9	0.6	1.2	24
Chromium	<0.1	<0.1	<0.1	<0.1
Copper	<0.1	<0.1	<0.1	<0.1
Iron	<0.6	<0.6	<0.6	Trace
Lead	<0.1	<0.1	<0.1	<0.1
Manganese	<0.1	<0.1	<0.1	<0.1
Phosphorus	<0.2	<0.2	<0.2	<0.2
Sulfur	<0.1	<0.1	<0.1	<0.1
Zinc	4.6	1.3	2.7	6.1
Volkswagen Jetta				
Calcium	<0.5	1.5	0.9	4.0
Chromium	<0.02	<0.02	<0.02	<0.02
Copper	<0.02	<0.02	<0.02	<0.02
Iron	<0.1	<0.1	<0.1	0.2
Lead	<0.02	<0.02	<0.02	<0.02
Manganese	<0.02	<0.02	<0.02	<0.02
Phosphorus	<0.04	<0.04	<0.04	<0.04
Sulfur	<0.04	<0.04	<0.04	<0.04
Zinc	1.0	3.8	2.6	9.9

TABLE 14. SUMMARY OF ASH EMISSION RESULTS FOR STEADY-STATE MODES

Metals and Inorganics	Mass Rate, mg/min				
	Rated/75	Rated/50	PT/50	PT/25	Idle
Chevrolet Silverado					
Calcium	15	13	1.2	3.9	0.8
Chromium	<0.2	<0.2	<0.2	<0.2	<0.2
Copper	<0.2	<0.2	<0.2	<0.2	<0.2
Iron	<1	<1	Trace	Trace	<1
Lead	<0.2	<0.2	<0.2	<0.2	<0.2
Manganese	<0.2	<0.2	<0.2	<0.2	<0.2
Phosphorus	<0.3	<0.3	<0.3	<0.3	<0.3
Sulfur	0.7	Trace	<0.3	<0.3	<0.3
Zinc	30	31	2.9	8.0	1.1
Ford F-350					
Calcium	4.3	1.6	2.0	2.9	1.5
Chromium	<0.2	<0.2	<0.2	<0.2	<0.2
Copper	<0.2	<0.2	<0.2	<0.2	<0.2
Iron	Trace	<1	<1	<1	<1
Lead	<0.2	<0.2	<0.2	<0.2	<0.2
Manganese	<0.2	<0.2	<0.2	<0.2	<0.2
Phosphorus	<0.3	<0.3	<0.3	<0.3	<0.3
Sulfur	<0.3	<0.3	<0.3	<0.3	<0.3
Zinc	9.0	3.3	3.5	6.1	3.6
Dodge Sprinter					
Calcium	3.8	2.2	0.9	0.8	0.7
Chromium	<0.1	<0.1	<0.1	<0.1	<0.1
Copper	<0.1	<0.1	<0.1	<0.1	<0.1
Iron	<0.3	<0.3	<0.3	Trace	<0.3
Lead	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	<0.1	<0.1	<0.1	<0.1	<0.1
Phosphorus	<0.1	<0.1	<0.1	<0.1	<0.1
Sulfur	<0.1	<0.1	Trace	<0.1	<0.1
Zinc	8.6	4.8	2.0	1.9	1.9
Volkswagen Jetta					
Calcium	2.8	4.0	<0.3	2.8	1.2
Chromium	<0.02	<0.02	<0.02	<0.02	<0.02
Copper	<0.02	<0.02	<0.02	<0.02	0.03
Iron	Trace	<0.1	<0.1	Trace	Trace
Lead	<0.02	<0.02	<0.02	<0.02	<0.02
Manganese	<0.02	<0.02	<0.02	<0.02	<0.02
Phosphorus	<0.02	<0.02	<0.02	<0.02	<0.02
Sulfur	0.04	0.04	<0.02	<0.02	<0.02
Zinc	6.6	9.4	0.4	6.8	2.7

5.0 COMPARISON AND DISCUSSION

This section includes a discussion of the data collected during the experimental portion of this project and presents a comparison to the data collected in the AVFL-10a literature search. The data have been reviewed to assess their composition over a variety of engine operating conditions, to compare the current test results to the literature, and to determine a synthetic formulation for light-duty diesel exhaust that could be used in catalyst performance studies.

5.1 Regulated Emissions

The first comparison includes the regulated emissions which are the major components of concern in a standard synthetic diesel exhaust formulation. In this group, (THC, CO, NO_x, and particulate) only carbon monoxide is composed of a single compound. In the case of THC, an examination of the hydrocarbons present in the actual exhaust will allow the selection of a simpler mixture of individual compounds to represent this complex mixture of compounds. In the case of NO_x, the NO_x is a mixture of nitric oxide (NO) and nitrogen dioxide (NO_2), with NO being the major constituent. Particulate also consists of a variety of components including organic and elemental carbon, sulfate, and ash.

It should be noted that several assumptions have been made in combining results from the various test conditions. To simplify the results and allow comparisons to the literature data, emissions from each vehicle and test condition were combined and weighted equally. Different results may be obtained if different weightings are utilized.

5.1.1 Comparison of Transient Cycle Emissions

Table 15 shows the average regulated emission rates based on measurements for the two transient cycles used in this study. Test results for the two vehicles with the larger displacement engines (the Chevrolet and the Ford) were averaged to simplify the comparisons. The data for the Dodge were utilized to represent medium displacement engines, while data from the Volkswagen represented smaller displacement engine results. For an overall comparison, the average regulated emission results for all four vehicles are also presented in the table. In general, the regulated emissions were similar to the averaged literature data from AVFL-10a for the US06 for the large and medium displacement engines. In addition, the average particulate emissions for all four vehicles agreed closely with the averaged literature data from AVFL-10a for the US06. In contrast, the FTP cycle gave higher THC and CO emission rates in this study than those presented in the literature search average.

5.1.2 Comparison of Steady-State Emissions

Table 16 presents equally weighted modal results for each regulated emission from each vehicle and an overall average for the four vehicles. In general, emissions decreased with engine displacement. The distribution of emissions for the combined five steady-state modes was similar to the US06 result in this study and similar to the FTP data from the AVFL-10a literature search.

TABLE 15. AVERAGE REGULATED EMISSION RATES BY TRANSIENT CYCLE

Cycle	Emissions, g/mi				
	THC	CO	NO_x	Particulate	CO_2
Larger Displacement Engines[a]					
FTP	0.56	2.5	5.3	0.12	774
US06	0.27	1.5	5.1	0.12	802
Medium Displacement Engine[b]					
FTP	0.36	1.6	2.5	0.13	565
US06	0.25	1.2	2.7	0.23	719
Smaller Displacement Engine[c]					
FTP	0.51	2.5	0.2	0.20	240
US06	0.11	1.5	1.0	0.12	260
Unweighted Average of Experimental Results (All Engines)					
FTP	0.48	2.2	2.7	0.15	526
US06	0.21	1.4	2.9	0.16	594
Averaged AVFL-10a Data					
FTP	0.30	1.4	3.3	0.14	NA[d]
US06	0.26	1.5	6.5	0.14	NA

[a]Average of the data from the Chevrolet 6.6 L and the Ford 6.0 L engines
[b]Data from the 2.7 L Mercedes-Benz in-line five cylinder engine
[c]Data from the 1.9 L Volkswagen TDI engine
[d]NA-not available in the AVFL-10a report

TABLE 16. FIVE MODE AVERAGE OF STEADY-STATE EMISSIONS

Vehicle Averages	Emissions, g/min				
	THC	CO	NO_x	Particulate	CO_2
Chevrolet 6.6 L	0.28	2.0	4.8	0.20	812
Ford 6.0 L	0.38	1.3	4.0	0.16	939
Dodge 2.7 L	0.31	1.7	1.4	0.09	443
Volkswagen 1.9 L	0.10	0.4	1.7	0.06	256
Unweighted average of all four engines	0.27	1.3	3.0	0.13	612

5.2 Hydrocarbon Speciation Emission Results

The total hydrocarbon component of exhaust contains a highly complex mixture of different individual hydrocarbon types. In order to evaluate these hydrocarbons, various hydrocarbons were grouped into several categories based on the types of molecules and functional groups associated with each molecule. Paraffins were grouped as C3+ straight-chain paraffins or C3+ branched-chain paraffins. Other groupings included total C3+ alkenes, total alkynes, total aromatics, and total aldehydes. Semi-volatile hydrocarbons as determined by GC/MS were also grouped together and listed simply as semi-volatiles in Tables 17 and 18, but will be discussed in more detail in Section 5.2.2. These compound groupings were used to aid

with selection of a more generalized set of hydrocarbons for use in the development of a synthetic exhaust. A number of the hydrocarbons were present at concentrations significantly higher than most of the other hydrocarbons. These hydrocarbons (methane, ethylene, acetylene, formaldehyde, acetaldehyde, and acrolein) have been listed in Tables 17 and 18 as individual compounds and/or emphasized in the following discussions.

5.2.1 Volatile Hydrocarbon Compounds (C_1 to C_{12})

A comparison of the hydrocarbon groups shows that the basic compositions of the hydrocarbons were quite similar from test cycle to test cycle and from vehicle to vehicle, but the relative concentrations and the distribution for some of the more important compounds change with test cycle and vehicle. Tables 17 and 18 compare the actual concentrations for each group of compounds and for the individual compounds methane and ethylene in the exhaust in terms of a percentage of each in relation to the total hydrocarbons for a specific test cycle or steady-state mode. The sum of speciated compounds and compound groups was found to generally account for more than 90 percent of the total hydrocarbons measured over the various test conditions.

5.2.1.1 Comparison of Transient Cycle Emissions

A comparison of the hydrocarbon speciation results for the transient cycles shows that the relative concentrations were somewhat similar for the two driving cycles except for the Dodge Sprinter which did not produce many hydrocarbons larger than C_8. In general, ethylene and formaldehyde (a major component of the total aldehydes) were present at the highest concentrations for all four vehicles. Figure 3 compares the mass emission rates for ethylene and formaldehyde for each test cycle and with each vehicle. These two compounds were generally present in relatively equal amounts for each vehicle. These two individual compounds were also present in concentrations that were usually two to three orders of magnitude greater than the other compounds for the transient cycles and accounted for more than 30 percent of the total hydrocarbons for all vehicle and transient cycle combinations. Both compounds were found to decrease in relative concentration from the cold UDDS to the hot UDDS to the US06. The one exception to this trend was the formaldehyde emissions for the Dodge Sprinter which had slightly higher formaldehyde emissions during the US06 as compared to the hot UDDS.

With the exception of the semi-volatiles which will be discussed in a following section, the compounds or compound groups with the next highest level of relative concentrations were generally less than about 10 percent of the total hydrocarbons. For all four vehicles, these compounds or compound groups included: methane, acetylene (a major constituent of the total alkynes), the C3+ paraffins, the C3+ alkenes, and acetaldehyde (a second major constituent of the total aldehydes). These compounds or groups of compounds with ethylene and formaldehyde accounted for the majority of the hydrocarbon compounds detected. In all cases except for the Ford operating over the UDDS cycle, the C3+ branched-chain paraffins were found at higher concentrations than the C3+ straight-chain paraffins. Within the C3+ branched-chain paraffin grouping, 2,2-dimethylpropane and 2,2,4-trimethylpentane were the largest contributors to the total concentration. For the C3+ alkenes, six compounds were the largest contributors. These compounds included:

TABLE 17. COMPARISON OF HYDROCARBONS BY GROUP (TRANSIENT CYCLES)

Individual Components and Compound Groups	Mass Percent of Total Hydrocarbons		
	Cold UDDS	Hot UDDS	US06
Chevrolet Silverado			
Methane	3.2	5.1	2.1
Ethylene	17	14	17
Total Alkynes	5.0	4.3	5.1
C3+ Straight-Chain Paraffins	0.9	0.8	1.8
C3+ Branched-Chain Paraffins	3.2	2.2	6.2
C3+ Alkenes	7.8	4.7	12
Total Aromatics	4.7	4.2	5.5
Total Aldehydes	28	22	22
Semi-volatiles	28	34	12
Ford F-350			
Methane	2.1	5.9	ND[a]
Ethylene	12	9.3	6.5
Total Alkynes	3.2	2.6	1.6
C3+ Straight-Chain Paraffins	8.0	1.2	0.3
C3+ Branched-Chain Paraffins	2.0	2.7	5.4
C3+ Alkenes	8.1	7.5	4.3
Total Aromatics	0.6	0.8	0.8
Total Aldehydes	30	18	21
Semi-volatiles	34	44	29

[a]ND – None detected

TABLE 17 (CONT'D). COMPARISON OF HYDROCARBONS BY GROUP (TRANSIENT CYCLES)

Individual Components and Compound Groups	Mass Percent of Total Hydrocarbons		
	Cold UDDS	Hot UDDS	US06
Dodge Sprinter			
Methane	6.0	1.7	0.9
Ethylene	18	26	15
Total Alkynes	4.0	5.8	2.2
C3+ Straight-Chain Paraffins	1.0	2.1	2.7
C3+ Branched-Chain Paraffins	1.7	7.0	5.7
C3+ Alkenes	9.5	15	9.9
Total Aromatics	0.2	0.9	1.3
Total Aldehydes	45	22	21
Semi-volatiles	9.0	10	34
Volkswagen Jetta			
Methane	3.4	4.1	1.7
Ethylene	16	16	17
Total Alkynes	4.1	4.3	4.9
C3+ Straight-Chain Paraffins	1.0	0.7	0.6
C3+ Branched-Chain Paraffins	5.1	4.4	4.9
C3+ Alkenes	13	12	12
Total Aromatics	3.4	2.9	4.0
Total Aldehydes	28	29	20
Semi-volatiles	23	16	5.2

TABLE 18. COMPARISON OF HYDROCARBONS BY GROUP (STEADY-STATE MODES)

Individual Components and Compound Groups	Mass Percent of Total Hydrocarbons				
	Rated/75	Rated/50	PT/50	PT/25	Idle
Chevrolet Silverado					
Methane	ND[a]	ND	ND	4.3	ND
Ethylene	29	13	12	23	13
Total Alkynes	6.2	3.4	4.9	5.0	3.1
C3+ Straight-Chain Paraffins	0.9	1.1	2.9	0.7	1.6
C3+ Branched-Chain Paraffins	6.6	4.0	3.5	3.1	4.8
C3+ Alkenes	22	8.3	4.5	5.9	6.9
Total Aromatics	7.5	4.5	7.5	3.3	2.8
Total Aldehydes	23	34	14	38	23
Semi-volatiles	3.8	30	48	16	42
Ford F-350					
Methane	ND	ND	0.1	1.1	0.8
Ethylene	14	12	7.1	6.7	4.9
Total Alkynes	2.3	3.7	2.0	2.3	1.8
C3+ Straight-Chain Paraffins	1.6	1.1	2.5	2.1	0.7
C3+ Branched-Chain Paraffins	17	6.4	8.6	13	5.3
C3+ Alkenes	19	12	6.6	2.8	1.8
Total Aromatics	8.9	5.9	6.4	3.7	ND
Total Aldehydes	5.3	8.1	11	25	26
Semi-volatiles	31	49	53	41	55

[a]ND – None detected

TABLE 18 (CONT'D). COMPARISON OF HYDROCARBONS BY GROUP (STEADY-STATE MODES)

Individual Components and Compound Groups	Mass Percent of Total Hydrocarbons				
	Rated/75	Rated/50	PT/50	PT/25	Idle
Dodge Sprinter					
Methane	0.6	1.8	5.1	1.5	ND[a]
Ethylene	19	18	9.7	8.9	4.6
Total Alkynes	2.2	3.0	2.5	1.4	1.0
C3+ Straight-Chain Paraffins	0.7	0.6	0.4	2.1	1.6
C3+ Branched-Chain Paraffins	6.2	5.8	1.2	1.9	0.9
C3+ Alkenes	19	10	4.2	5.3	3.1
Total Aromatics	4.0	3.7	0.6	0.5	ND
Total Aldehydes	21	24	9.9	18	9.9
Semi-volatiles	23	30	62	56	73
Volkswagen Jetta					
Methane	ND	ND	1.0	ND	3.5
Ethylene	8.0	6.0	17	10	10
Total Alkynes	1.7	1.6	2.2	4.4	2.4
C3+ Straight-Chain Paraffins	2.0	1.5	1.1	1.0	1.0
C3+ Branched-Chain Paraffins	11	14	10	4.5	3.2
C3+ Alkenes	7.5	5.6	13	4.4	7.8
Total Aromatics	11	10	11	5.6	0.8
Total Aldehydes	12	13	19	13	22
Semi-volatiles	44	46	23	54	45

[a]ND – None detected

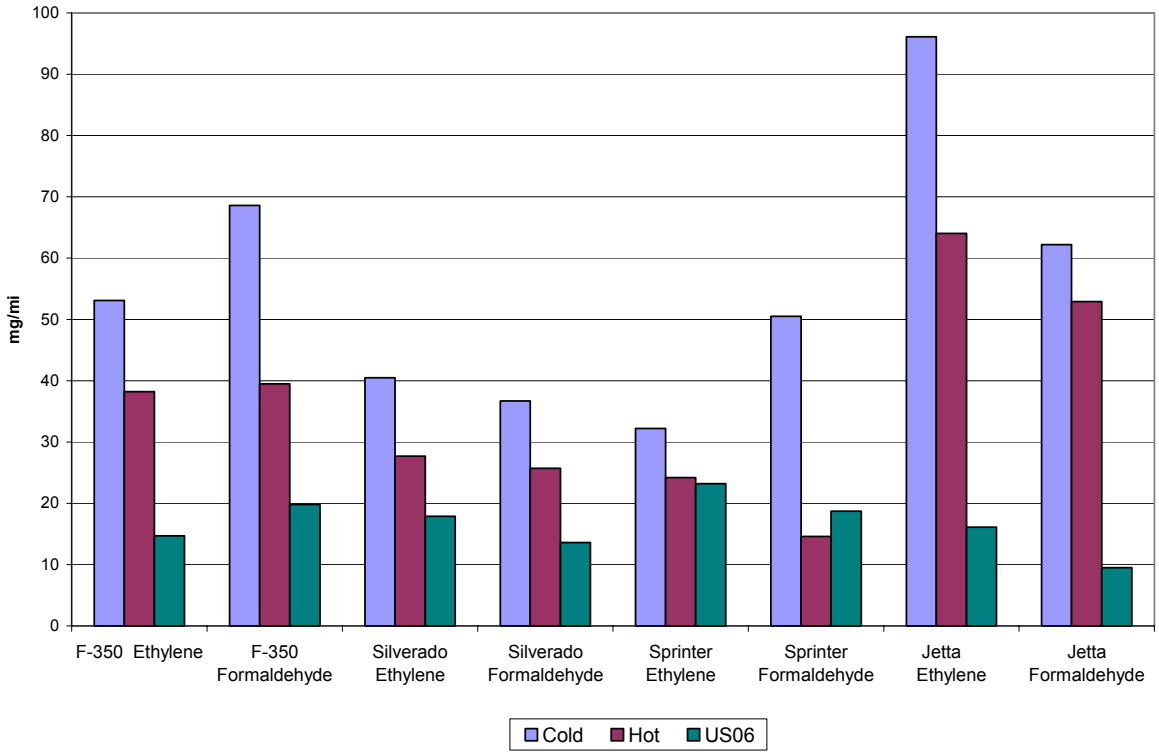


FIGURE 3. MASS EMISSION RATES FOR ETHYLENE AND FORMALDEHYDE (TRANSIENT CYCLES)

- Propylene
- 1-Butene
- Isobutylene
- 1-Pentene
- 2-Methyl-1-pentene
- 1-Hexene.

While 1-pentene was not detected in all samples, this compound was the second highest contributor to the C3+ alkenes when it was detected. It should also be noted that 1,3-butadiene was detected in significant quantities for three of the four vehicles; however, no 1,3-butadiene was detected during any of the transient cycles for the Dodge Sprinter.

The total aromatics were present at relative concentrations less than about 5 percent of the total hydrocarbons. The total aromatics were generally dominated by benzene and toluene, but the xylenes also contributed about a quarter of the total for the aromatics for the Chevrolet

Silverado and the Volkswagen Jetta. Of these xylenes, the unresolved meta- and para-isomers were the majority of the total xylenes detected.

When the individual speciation results were compared to the AVFL-10a data, the results were similar except that the average AVFL-10a data had less propane, propylene, pentene, pentane, hexane, and 2,3-dimethylpentane contributions; and more cis-2-butene, 2,3-dimethylhexane, nonene, diethylmethylbenzene, decane, undecane, and dodecane contributions. Of these compounds, only propene exhibited a large discrepancy in values between the two sets of data. Some of these differences may be attributed to the fuel, to the technology of the engines, or to the analytical methods used to determine the individual hydrocarbons. Table 19 compares the results for selected speciated hydrocarbons from the AVFL-10a data with the FTP composite results for the four vehicles in this study.

5.2.1.2 Comparison of Steady-State Emissions

As might be expected, a comparison of the hydrocarbon speciation results for the steady-state emissions showed a wider range of differences between vehicles and test conditions than with the transient cycles. In general, ethylene and formaldehyde were present at the highest concentrations for all four vehicles. Figure 4 compares the mass emission rates for ethylene and formaldehyde for each steady-state mode with each vehicle. In addition, the general trends for each vehicle will be discussed individually.

The Chevrolet Silverado produced results which were more similar to the transient cycles than any of the other vehicles. In general, ethylene and formaldehyde were present at the highest concentrations with the exception of the condition at rated speed and 75 percent torque. In this case, the ethylene accounted for 29 percent, the C3+ alkenes accounted for 22 percent, and total aldehydes were 23 percent of the hydrocarbons. Formaldehyde accounted for 58 percent of the total aldehydes or 14 percent of the total hydrocarbons for that test. With the exception of that one test condition, the ethylene and formaldehyde were the two compounds present in concentrations that were usually two to three orders of magnitude greater than the other individual compounds, and combined accounted for about 40 percent of the total hydrocarbons. Acetylene, the C3+ paraffins, the C3+ alkenes, and acetaldehyde were the majority of the remaining compounds.

For the Ford F-350, ethylene and formaldehyde were two of the major compounds. In addition, the total C3+ paraffins and the C3+ alkenes were major contributors to the total hydrocarbons. In some cases, the relative percentage of the total for these two groups was greater than for ethylene and formaldehyde. Total aromatics were a minor contributor with the total percentages less than 10 percent for three of the five test conditions.

TABLE 19. COMPARISON OF SELECTED SPECIATED HYDROCARBON EMISSIONS FOR THE FTP TEST CYCLE

COMPOUND	Emissions, mg/mi				
	Chevrolet	Ford	Dodge	Volkswagen	AVFL-10a
Ethane	0.8	0.1	1.1	1.8	1.9
Ethene (ethylene)	33	45	28	78	32
Propane	-	8.8	0.2	0.5	0.3
Propene (propylene)	7.4	11	8.3	22	-
Propyne	0.1	-	-	0.5	-
Ethyne	10	12	6.2	22	9.8
1,3-butadiene	1.9	1.5	-	1.1	1.8
Benzene	2.9	-	-	7.8	2.7
Toluene	3.5	-	0.7	2.0	2.7
Butane	0.1	-	0.3	Trace	0.6
Trans-2-butene	0.1	-	-	5.5	0.4
Isobutylene	0.9	1.6	1.3	2.4	2.2
Cis-2-butene	-	-	-	-	0.8
Pentene	0.7	8.2	1.1	3.9	-
Pentane	0.2	3.8	0.7	2.5	-
2-methyl-1-butene	-	4.1	-	10	0.6
Cyclopentene	-	0.4	-	0.7	-
Cyclopentane	-	0.7	-	1.3	0.2
2-methylpentane	-	-	0.4	0.5	0.3
Hexene	0.4	1.2	0.7	1.7	0.6
Hexane	-	0.3	0.1	1.7	-
Methylcyclopentane	-	-	-	0.1	0.1
2,3-dimethylpentane	Trace	0.2	0.7	0.2	-
2,2,4-trimethylpentane	0.4	1.0	0.8	1.9	1.6
Heptane	-	0.2	0.3	0.1	0.1
Octane	0.4	1.0	0.3	0.2	0.5
Methylcyclohexane	0.5	0.7	0.3	0.1	0.5
2,3-dimethylhexane	-	-	-	0.2	2.2
Ethyl benzene	0.4	0.9	-	0.9	0.5
Styrene	-	-	-	1.1	-
m/p-xylenes	1.4	1.4	-	1.8	2.4
o-xylene	0.7	0.2	-	0.9	1.1
Dimethyloctane	0.2	-	-	0.2	0.4
Nonene	-	-	-	0.9	1.5
Nonane	1.1	0.2	-	0.6	1.5
Propylbenzene	-	-	-	0.2	0.5
Trimethylbenzene	-	0.4	-	Trace	0.7
Methylethylbenzene	-	-	-	Trace	1.3
Diethylmethylbenzene	-	-	-	-	0.4
Tetramethylbenzene	0.6	-	-	-	0.5
Decane	1.5	2.3	0.9	1.3	2.8
Undecane	1.9	4.1	0.6	1.9	2.3
Dodecane	2.2	0.6	0.8	2.1	1.1
Unidentified C12	-	0.2	-	2.4	-

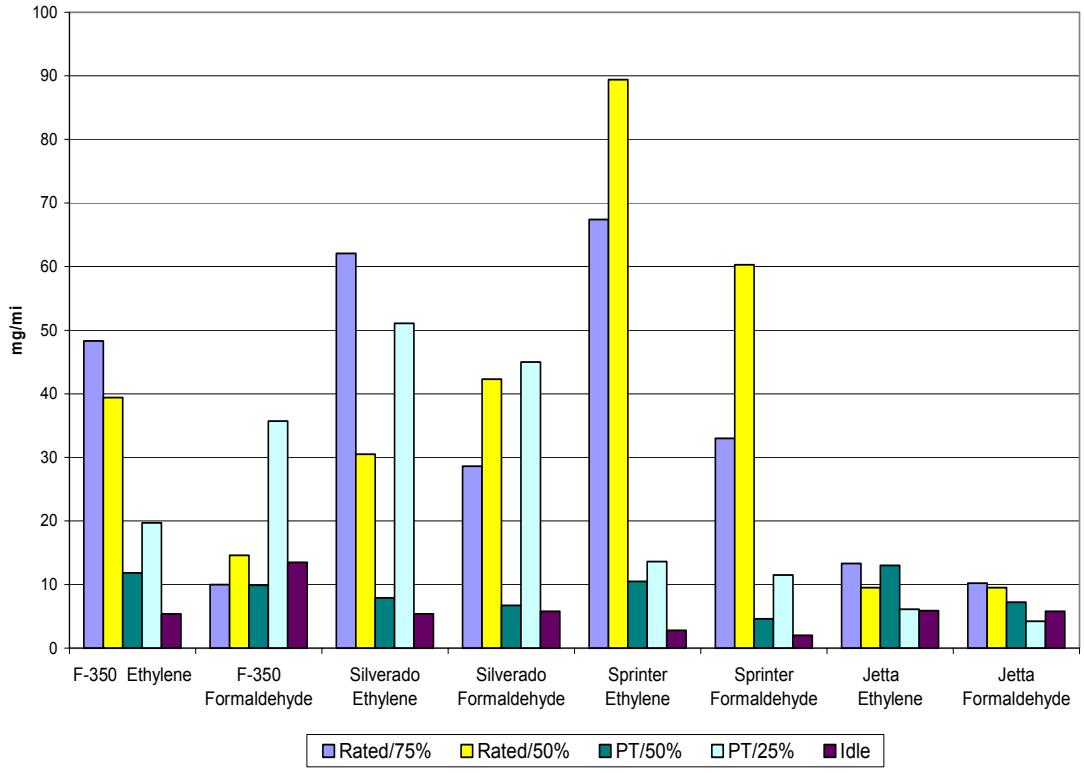


FIGURE 4. MASS EMISSION RATES FOR ETHYLENE AND FORMALDEHYDE (STEADY-STATE MODES)

For the Dodge Sprinter, ethylene, formaldehyde, and the C3+ alkenes were the major contributors to the total hydrocarbons for three of the test conditions (rated speed and 75 percent load, rated speed and 50 percent load, and peak torque speed and 50 percent load). At peak torque speed and 25 percent load and at idle, hexane was detected at a relatively high concentration compared to all of the other vehicles. Because hexane was used as the collection media for the semi-volatile hydrocarbons, this compound may have been an artifact from the contamination of the sample through the ambient air entering the constant volume sampler. If the concentration of hexane was eliminated from the hydrocarbon speciation results for these two steady-state modes, the relative percentages of the various compounds were similar to the results from the other three steady-state modes for this vehicle.

For the Volkswagen Jetta, total hydrocarbons were fairly evenly split between ethylene, the total C3+ paraffins, the C3+ alkenes, the total aromatics, and formaldehyde for all five test conditions. The one exception was for the total aromatics at idle, which were only a small fraction of the total hydrocarbons. At rated speed, the total C3+ paraffins, the total aromatics, and the total aldehydes were the predominant compounds, while at peak torque and idle, the relative distribution was closer to the transient cycles.

The groups comprised of multiple compounds (the total C3+ paraffins, the C3+ alkenes, and the total aromatics) were usually comprised of a select number of compounds at a much higher concentration than others. The total C3+ paraffins were mostly due to the C3+ branched-chain paraffins. Within the C3+ branched-chain paraffin group, 2,2-dimethylpropane, 3-methylpentane, and 2,2,4-trimethylpentane were the most important contributors to the total concentration. For the C3+ alkenes, a number of compounds were major contributors to this group. These compounds included:

- 1-Butene
- Isobutylene
- 1-Pentene
- 2-Methyl-1-butene
- 2-Methyl-1-pentene
- 1-Hexene.

The total aromatics were generally dominated by benzene and toluene, but the xylenes also contributed a significant portion of the total during several of the test conditions. In all but a few cases, benzene was present at a higher concentration than toluene. Ethylene, formaldehyde, total C3+ paraffins, C3+ alkenes, and total aromatics accounted for the majority of the total hydrocarbon from the steady-state modes.

5.2.2 Semi-Volatile Hydrocarbon Compounds (C_{10} to C_{22})

In general, the most abundant semi-volatile compounds were either straight-chain hydrocarbons, naphthalene, or 1,2,3,4-tetrahydronaphthalene (commonly called tetralin) with one or more alkyl groups attached at various locations on the aromatic rings. Octadecane was usually the highest molecular weight compound present with any signification contribution to the total semi-volatile compounds although a significant amount of nonadecane was detected with the Ford F-350. The Ford F-350 had the most diverse number of semi-volatile compounds with a number of di- and tri-methyl tetrahydronaphthalene compounds and a few higher molecular weight branched-chain hydrocarbons among the compounds detected. Tridecane, tetradecane, and pentadecane were generally present in the highest concentrations for the straight-chain hydrocarbons, and the aromatic naphthalene was usually present in significant quantities in the exhaust of most of the vehicles. The ratio of saturated compounds to aromatic compounds for the transient cycles and the steady-state modes was generally between 50:50 and 60:40 except for some test conditions with the Dodge Sprinter and the Volkswagen Jetta. When all vehicles and driving cycles were combined, the ratio of saturated compounds to aromatic compounds in the semi-volatiles was about 50:50.

5.3 Particulate Characterization

The total particulate was broken down into five of the major components. These components included:

- Soot (elemental carbon)
- VOF (not including unburned lubricating oil)
- Unburned lubricating oil
- Sulfate and associated water
- Ash (metals and inorganics).

A comparison of the particulate character across the engines and cycles show a variety of compositions. Data were compared by plotting pie charts for the five components of the particulate in terms of the relative composition for the total particulate. Figures in Appendix E illustrate the variations in particulate composition for each vehicle and for each test condition.

5.3.1 Comparison of Transient Cycle Emissions

In general, the soot component was the major portion of the total particulate for the transient cycle emissions for all vehicles except for the Ford F-350. Unburned lubricating oil and the remaining VOF were the next major contributors to the total particulate on a relative basis.

While VOF was not part of the AVFL-10a study, the metals and inorganics were included as part of the literature search from that study. Table 20 summarizes the FTP emissions for the metals and inorganics from the literature and from this study. A comparison of the metals and inorganics showed that calcium and zinc were the major elements detected in these samples. These two elements are generally associated with the lubricating oil additive package. Sulfur and iron were also detected at low concentrations in several of the samples. Sulfur would also be associated with the lubricating oil additive package, and the iron may have been present as a wear metal or from the exhaust system. The other elements were below the detection limit for this study.

5.3.2 Comparison of Steady-State Emissions

Steady-state emissions showed a wider range of differences for the various vehicles and test conditions than the transient cycles. In general, the majority of the particulate was also due to the soot, but there were some notable exceptions to this general statement. In addition, the particulate character changed dramatically from the more heavily loaded conditions to idle.

TABLE 20. SUMMARY OF METALS AND INORGANICS CONCENTRATIONS DURING THE FTP

Constituent	Composite Emissions, mg/mi				
	Chevrolet	Ford	Dodge	Volkswagen	AVFL-10a[a]
Zinc	3.1	7.9	2.7	2.6	1.04
Phosphorus	ND	ND	ND	ND	0.08
Sulfur	ND	ND	ND	ND	3.07
Calcium	2.1	3.5	1.2	0.9	7.52
Copper	ND	ND	ND	ND	0.11
Lead	ND	ND	ND	ND	0.05
Iron	ND	ND	ND	ND	0.21

[a]Average of metals and inorganics for an FTP from the AVFL-10a literature search

For the Chevrolet Silverado and Ford F-350, the particulate character at rated speed and 75 percent load was similar to the particulate from transient cycle emissions. At the lower load conditions and at idle, the unburned lubricating oil increased until it was a major contributor to the particulate. For the Dodge Sprinter, the majority of the particulate character under steady-state conditions was due to soot for all conditions except idle. With the Volkswagen Jetta, the particulate character was also similar to the transient cycle emissions for three of the steady-state conditions. Peak torque and 50 percent load had larger contributions of VOF.

6.0 SUMMARY AND CONCLUSIONS

In the AVFL-10a study, a database was compiled which contained data from 72 different studies, most of which were published between 1999 and 2003 (See pg. 4 of AVFL-10a). Most of the data represented composite results from either transient cycles or from multiple, steady-state points. As a result, it was not possible to define a standard synthetic diesel exhaust composition that was related to a full matrix of speed and load conditions, especially for light-duty vehicle emissions. Nevertheless, these data were used to define a possible standard synthetic diesel exhaust. The proposed blend from AVFL-10a consisted primarily of nitrogen (N_2), oxygen (O_2), CO_2, water (H_2O), CO, and NO. The hydrocarbons, which were a minor portion of the proposed blend, were suggested to be composed of ethylene, undecane, and formaldehyde in a ratio of about 4:3:2 for the three compounds on a mass basis.

This study (AVFL-10b) was performed to measure the exhaust composition from four current technology vehicles, to compare those results to the previous data in AVFL-10a, and to propose a standard synthetic diesel exhaust composition based on this additional data. The goal was to recommend a synthetic mixture which could provide aftertreatment manufacturers with the ability to determine a good indication of effectiveness and durability of their aftertreatment systems. When the relative concentrations of the major components (N_2, O_2, CO_2, and H_2O) are considered, nitrogen composes about 78 percent of the air by volume and O_2 is about 21 percent by volume. After combustion, the concentration of O_2 goes to between 10 and 12 percent by volume, and the CO_2 increases to about 5 percent by volume. Water is formed as part of the combustion process, and the percent water is related to how much fuel is consumed and the concentration of the CO_2 in the exhaust. On a mass basis, water is about 40 percent of the mass of the CO_2 in the exhaust, but the concentration on a volume basis is roughly equal to the CO_2. These are the major components of the exhaust and in total account for 99+ percent of an exhaust mixture.

The remaining fraction is composed of the regulated exhaust emissions and consists of four different compounds or groups of compounds. These four include total hydrocarbons (THC), CO, NO_x, and particulate. Carbon monoxide is the only component of this group that is a single compound and is formed as a product of partial combustion. The NO_x is composed of two principle oxides (NO and NO_2) and its concentration is related to a number of complex factors that include temperature, pressure, and stoichiometry of the combustion. In exhaust, the majority of the NO_x is in the form of NO which converts to NO_2 over time in the presence of oxygen. Particulate is a complex mix of particles and condensed semi-volatiles. It is composed primarily of carbon and hydrogen; however, particulate also contains sulfate/sulfuric acid, water, absorbed or condensed hydrocarbons, and inorganic ash components. As a result, the particulate component may be the most difficult to simulate in synthetic exhaust. Finally, the fourth group, THC, is composed of unburned or partially burned fuel and oil and is present at relatively low concentrations. This group of compounds is also complex in terms of numbers and types of compounds, but it may be possible to simulate the total by carefully selecting representative compounds based on the chemical properties of the hydrocarbons detected in diesel exhaust. These hydrocarbons along with the particulate account for only a very small fraction of total exhaust; and yet, they represent the most interesting challenges to a manufacturer in terms of

conversion and durability of an aftertreatment system. Appendix F illustrates the relative mass emission rates for the NO_x, CO, THC, and particulate for each test condition and vehicle.

6.1. Synthetic Blend Selection Process

In a limited study of four current technology vehicles, emissions were measured under five steady-state modes and two transient cycles. Based on these results and on data from AVFL-10a, a recommended synthetic mixture for the regulated emissions (NO_x, CO, THC, and particulate) has been proposed for review by the AVFL Committee and Working Group. If the mass rates for the regulated emissions from the various operating conditions obtained during AVFL-10b are combined by averaging the four vehicles (unweighted for engine size or vehicle population) to determine the relative fraction of each for the two transient cycles and the combined steady-state modes, then the relative percent for each component can be determined (Table 21). It should be noted that the results for the US06 and the combined steady-state modes were similar while the THC and CO results were higher and the NO_x results lower for the FTP than either of the other cycles. By averaging the results for each operating condition, a combined relative fraction for the four components can be obtained. In the AVFL-10a study, the relative overall fractions were about 75 percent for NO_x and about 20 percent for CO. In this study, the overall NO_x was lower (about 58 percent) and CO fraction was higher (about 33 percent) on a relative basis. The data generated in this study are thought to be the most appropriate for a proposed synthetic blend as they represent modern light-duty vehicles, while the data from the AVFL-10a study were from older model sources and contained limited light-duty content. Assuming an overall mass fraction for the regulated emissions of 0.05 percent, the individual mass percentages for each of the regulated emissions would be 0.0291 percent NO_x, 0.0162 percent CO, 0.0032 percent total hydrocarbons, and 0.0015 percent particulate.

TABLE 21. RELATIVE MASS PERCENT FOR REGULATED EMISSIONS

Operating Condition	Emissions, relative mass percent			
	THC	CO	NO_x	Particulate
FTP	8.7	39.8	48.8	2.7
US06	4.5	30.0	62.1	3.4
Steady-State	5.7	27.7	63.8	2.8
Average	6.3	32.5	58.2	3.0
AVFL-10a	3.4	20.1	74.9	1.7

When considering a selection of compounds to represent the hydrocarbon component, the process consisted of first determining the hydrocarbons that were present in exhaust (AVFL-10a and AVFL-10b). The second step was to consider hydrocarbon components that would:

- Cover the range of compounds typically present in diesel exhaust as determined by AVFL-10a and -10b
- Represent the types of compounds and major components present in the engine-out exhaust

- Have a potentially adverse affect on aftertreatment devices
- Be representative of the toxic component
- Be representative of the reactivity of the mixture
- Be prevalent and interesting in terms of affect on aftertreatment.

Several hundred individual hydrocarbon compounds were detected in the exhaust during the course of these studies. Two individual compounds (ethylene and formaldehyde) were present in concentrations that were usually two to three orders of magnitude greater than the other individual compounds for the transient cycles and accounted for more than 30 percent of the total hydrocarbons. To simplify the selection process, the remainder of the components was grouped by their structure and chemical properties. These groupings included:

- Semi-volatiles
- Total alkynes which included acetylene as the major contributor
- C3+ straight-chain paraffins
- C3+ branched-chain paraffins
- C3+ alkenes
- Total aromatics
- Total aldehydes which did not include the contribution from formaldehyde.

Each compound or group of compounds was considered based on the six criteria listed above. It should be noted that methane was excluded from the categories above because methane was primarily important during the transient cycles; and methane, while being a greenhouse gas, is usually excluded from most regulations for on-road vehicles.

When considering a composition for the hydrocarbons in a synthetic blend, several approaches can be taken. The simplest approach is to select the two most common individual species. In this case, the composition of the hydrocarbons would be primarily ethylene and formaldehyde. If contributions from other groups of hydrocarbons previously listed are considered, the composition would change based on the addition of each additional group. Table 22 presents a break down of the various combinations for a synthetic hydrocarbon mixture based on the sequential addition of four additional compound groups and their relative contribution in percent of the total. This table includes five different combinations with each combination increasing in complexity so as to represent the various groups of compounds present in the exhaust. When these six compounds or compound groups are included, they include representative compounds that account for more than 90 percent of the total hydrocarbons present in the exhaust.

TABLE 22. RECOMMENDED HYDROCARBON COMPOSITIONS FOR SYNTHETIC EXHAUST WITH INCREASING COMPLEXITY

Component	Relative Percent of Hydrocarbon				
	Blend 1	Blend 2	Blend 3	Blend 4	Blend 5
Transient Cycles					
Ethylene	46	27	24	22	21
Formaldehyde	54	33	28	26	25
Semi-Volatiles		40	35	32	30
C3+ Alkenes			13	12	11
Total Aromatics				8	7
Total C3+ Branched-Chain Paraffins					5
Steady-State Modes					
Ethylene	60	18	16	15	14
Formaldehyde	40	27	24	23	21
Semi-Volatiles		55	49	46	42
C3+ Alkenes			11	10	10
Total Aromatics				6	8
Total C3+ Branched-Chain Paraffins					6

The semi-volatile hydrocarbons represent the next most significant portion of the total hydrocarbons after formaldehyde and ethylene. If the semi-volatiles are included in the hydrocarbon composition, then the blend could include a mixture of equal amounts of tridecane, tetradecane, pentadecane and naphthalene. If C3+ alkenes are added, the blend could include one or more of the following: propylene, 1-butene, isobutylene, 1-pentene, 2-methyl-1-butene, 2-methyl-1-pentene, 1-hexene. For the aromatic contribution, benzene or toluene would be the most representative of the actual exhaust. Finally, the branched-chain hydrocarbons could be represented by 2,2-dimethylpropane, 3-methylpentane, or 2,2,4-trimethylpentane. The other two groups combined (total alkynes and aldehydes minus formaldehyde) only contribute a small fraction (about 5 percent of the total hydrocarbons) and could be represented by an appropriate increase in the concentrations of formaldehyde and ethylene.

6.2. Recommended Complex Standard Synthetic Diesel Exhaust Mixture

For the sake of practicality, a standard synthetic diesel exhaust mixture would need to be fairly simple in composition. The major components (N_2, O_2, CO_2, and H_2O) would account for about 99+ percent of the total blend. The minor components (THC, CO, NO_x, and particulate) would compose the remainder of the blend. Table 23 presents the relative concentrations for a synthetic blend based on the literature search from AVFL-10a and measurements in AVFL-10b. Data from the transient and steady-state modes form AVFL-10b have been weighted equally to obtain representative mass concentrations.

TABLE 23. STANDARD SYNTHETIC DIESEL EXHAUST MIXTURE

Component	Mass Percent
Nitrogen	~76 (balance)
Oxygen	13.3
Carbon dioxide	7.6
Water	3.1
NO_x	0.0291
Carbon monoxide	0.0162
Total hydrocarbons	0.0032
Particulate	0.0015

Within the minor components, a blend with multiple hydrocarbon components would be a challenge to prepare; however, a blend with a variety of components would provide a better representation of diesel exhaust and a more realistic challenge to potential aftertreatment systems. If the composition of each of the components in the most complex blend of hydrocarbons in Table 22 (Blend 5) is averaged for the steady-state and transient conditions and if representative compounds are selected for each group of compounds, a blend could be represented by a combination of:

- Ethylene (18 mass percent)
- Formaldehyde (23 mass percent)
- Tridecane, tetradecane, pentadecane, and naphthalene to represent the semi-volatiles (36 mass percent)
- Propylene or 1-butene to represent the C3+ alkenes (11 mass percent)
- Benzene and toluene to represent the aromatics (7 mass percent)
- 2,2,4-Trimethylpentane, 3-methylpentane, or 2,2-dimethylpropane to represent the C3+ alkanes (5 mass percent).

Table 24 presents a recommended hydrocarbon blend to represent the hydrocarbon components in a synthetic diesel mix. Depending on a researcher's objectives, other components might also be included or the concentrations changed to represent a specific test condition or a specific vehicle. At this point, no special considerations have been made as to the cost, the stability of the compounds as compressed gases, or the ability to prepare such a synthetic blend. These considerations are left for additional study. The selected blend would represent about 90 percent of the hydrocarbons found in diesel exhaust.

TABLE 24. HYDROCARBONS FOR STANDARD SYNTHETIC DIESEL EXHAUST MIXTURE (COMPLEX BLEND)

Hydrocarbon	Mass Percent of Total Hydrocarbon	Mass Percent of Total Exhaust
Formaldehyde	23	0.00074
Ethylene	18	0.00058
Tridecane	9	0.00029
Tetradecane	9	0.00029
Pentadecane	9	0.00029
Naphthalene[a]	9	0.00029
Propylene[b]	11	0.00035
Benzene[c]	3.5	0.00011
Toluene[c]	3.5	0.00011
2,2,4-trimethylpentane[d]	5	0.00016

[a] Tetrahydronaphthalene or methyltetrahydronaphthalene could be substituted for naphthalene
[b] 1-Butene could be substituted for propylene
[c] One or more of the isomers of xylene (meta- or para-) could be substituted for benzene and/or toluene
[d] 2,2-Dimethylpropane or 3-methylpentane could be substituted for 2,2,4-trimethylpentane

6.3. Approach to Simplify Complex Synthetic Diesel Exhaust Mixture

The complex mixture of hydrocarbons could be further simplified by considering the overlap of similar properties of compounds such as toxicity, reactivity, and hydrocarbon type. For example, the semi-volatile naphthalene is also an aromatic and an air toxic and could be used to represent the volatile aromatics, and ethylene is also an alkene and could represent the higher molecular weight alkenes. One of the straight-chain semi-volatiles could also be selected to represent the other two similar straight-chain semi-volatiles, as well as the C3+ alkanes. This simplification would result in the four component diesel exhaust blend shown in Table 25. These four compounds not only represent the various different compound groups found in diesel exhaust, but also the reactivity of the lower molecular weight hydrocarbons (ethylene and formaldehyde), the toxic components of the exhaust (formaldehyde and naphthalene), and the wide range of the molecular weights and reactivities of the hydro-carbons in diesel exhaust (ethylene and tetradecane). This simplified blend of hydrocarbons could be utilized to represent the more complex mixture presented in Table 24.

TABLE 25. SIMPLIFIED HYDROCARBON MIXTURE FOR STANDARD SYNTHETIC DIESEL EXHAUST BLEND

Hydrocarbon	Mass Percent of Total Hydrocarbon	Mass Percent of Regulated Emissions[a]	Mass Percent of Total Exhaust[b]
Ethylene[c]	29	1.82	0.00091
Tetradecane[d]	32	2.02	0.00101
Formaldehyde	23	1.45	0.00073
Naphthalene[e]	16	1.01	0.00051

[a] Based on average for total hydrocarbons in Table 21 relative mass percent of 6.3
[b] Based on a total mass fraction of 0.05 percent for the regulated emissions
[c] Ethylene to represent its own contribution and C3+ alkenes
[d] Tetradecane selected to represent the non-naphthalene semi-volatiles and C3+ alkanes
[e] Naphthalene to represent a portion of the semi-volatiles and total volatile aromatics

6.4 Other Considerations

In addition to the above considerations, several other components are present in diesel exhaust. The selection of additional components may be desired for specific aftertreatment technologies. Some of these additional components could include SO_2 and hydrogen which were not measured in the study, VOF which includes unburned lubricating oil, sulfate which can poison aftertreatment systems, and ash (metals and other inorganics). The SO_2 component is of particular importance because of its known impacts on catalyst efficiency. The concentration of SO_2 can be estimated based on the sulfur content of the diesel fuel. As fuel sulfur contents are lowered to ultra-low levels, it may be necessary to include an SO_2 contribution from the lubricant. Particulate in the form of carbon black could be introduced in the form of a slurry with water. The correct particle size for the carbon black would have to be determined by additional experimentation. The other particulate components could possibly be added to contribute additional sulfur, phosphorus, and other ash components.

6.5 Recommendations for Preparation of a Synthetic Diesel Exhaust Blend

Once all the representative gases of the synthetic exhaust mixture have been selected, blending the gaseous portion of a synthetic gas mixture should be a straight forward exercise. SwRI has a Universal Synthetic Gas Reactor® (USGR®) which is capable of simulating gasoline exhaust through computer-controlled mass flow controllers. A similar system could be prepared for blending a standard diesel exhaust mixture. Compressed gas cylinders of high concentration gases (N_2, O_2, CO_2, CO, and NO) could be readily combined through the use of mass flow controllers to obtain the specified gas concentration for the majority of the blend. Blends of ethylene and many of the other lower molecular weight hydrocarbons could also be introduced in the same manner by blending them in nitrogen. Water, formaldehyde in the form of an aqueous solution, and possibly particulate in the form of a slurry of carbon black in water could be introduced using a custom-built evaporator with the flow rate controlled by a carefully metered peristaltic pump or with a liquid mass flow controller. The introduction of semi-volatile compounds (tridecane, tetradecane, pentadecane and naphthalene which are liquids or solids at

room temperature) would need to be addressed. All have relatively low vapor pressures and pressurized gas cylinders may not be able to maintain concentrations high enough to be effective. If these compounds are combined to form a liquid, the injection rate of the mixture into the exhaust stream may be difficult to control. In any case, the introduction of these compounds would be a considerable challenge. SwRI has been able to introduce diesel fuel into an exhaust blend at known rates with a syringe pump used for medical applications using micro flow controllers. It is thought, that with the USGR, the various individual components could be introduced, and a consistent and repeatable synthetic exhaust gas mixture could be supplied as a method to evaluate potential aftertreatment systems.

REFERENCES

1. Merritt, P.M., "Diesel Exhaust Standard Phase I: CRC Project No. AVFL-10a," prepared for the Coordinating Research Council, Inc., August 2003.

2. Code of Federal Regulations, Title 40 Protection of Environment, Chapter I-Environmental Protection Agency, Subchapter C-Air Programs, Part 86-Control of Emissions from New and In-Use Highway Vehicles and Engines, Subpart D-Emission Regulations New Light-Duty Vehicles and New Light-Duty Trucks and New Otto-Cycle Complete Heavy-duty Vehicles; Test Procedures, Published by Office of Federal Register National Archives and Records Administration, Revised as of July 1, 2001.

3. Whitney, K.A., "Comparison of Steady-State Exhaust Emissions from Alternative Diesel Fuel Blends," Prepared for U.S. Army TARDEC Fuels and Lubricants Research Facility (SwRI), May 1998.

4. Shaw, K.A., "Evaluation of Emission Characteristics Downstream of Diesel Oxidation Catalyst Technology," prepared for the Coordinating Research Council, Inc., June 2003.

5. Code of Federal Regulations, Title 40 Protection of Environment, Chapter I-Environmental Protection Agency, Subchapter C-Air Programs, Part 86-Control of Emissions from New and In-Use Highway Vehicles and Engines, Subpart AA-Reporting and Recordkeeping Requirements for Part 86, Appendix I to Part 86-Urban Dynamometer Schedules, Published by Office of Federal Register National Archives and Records Administration, Revised as of July 1, 2001.

6. 1996 SAE Handbook, Volume 1-Materials, Fuels, Emissions, and Noise, Section 13-Emissions, Methane Measurement Using Gas Chromatography-SAE J1151 Dec 91, SAE Recommended Practice, ISBN 1-56091-809-8, ISSN 0362-8205, Library of Congress Catalog Card Number 25-16527, Published by Society of Automotive Engineers, Inc., 1996.

APPENDIX A

VOLATILE HYDROCARBON SPECIATION DATA FOR TRANSIENT CYCLES

TABLE A-1. HYDROCARBON SPECIATION FOR CHEVROLET SILVERADO (TRANSIENT CYCLES)				
COMPOUND	**mg/mile**			
	Cold	**Hot**	**Composite**	**US06**
METHANE	7.9	10.4	9.3	2.1
ETHANE	0.9	0.8	0.8	0.3
ETHYLENE	40.5	27.7	33.2	17.9
PROPANE				
PROPYLENE	9.0	6.2	7.4	4.5
ACETYLENE	11.9	8.7	10.1	5.1
PROPADIENE				
BUTANE	0.2	0.1	0.1	0.6
TRANS-2-BUTENE	0.3		0.1	0.2
1-BUTENE	2.3	1.2	1.7	1.2
2-METHYLPROPENE (ISOBUTYLENE)	1.2	0.7	0.9	1.4
2,2-DIMETHYLPROPANE (NEOPENTANE)	3.0	1.2	2.0	2.5
PROPYNE	0.3		0.1	0.2
1,3-BUTADIENE	4.4		1.9	2.6
2-METHYLPROPANE (ISOBUTANE)	0.1	trace	0.1	0.3
1-BUTYNE				
METHANOL				
CIS-2-BUTENE				0.2
3-METHYL-1-BUTENE				
ETHANOL				
2-METHYLBUTANE (ISOPENTANE)				
2-BUTYNE				
1-PENTENE	0.7	0.6	0.7	0.5
2-METHYL-1-BUTENE				
PENTANE	0.2	0.2	0.2	0.8
UNIDENTIFIED C5 OLEFINS				
2-METHYL-1,3-BUTADIENE				0.2
TRANS-2-PENTENE				
3,3-DIMETHYL-1-BUTENE				
CIS-2-PENTENE				
2-METHYL-2-BUTENE				
TERT-BUTANOL				
CYCLOPENTADIENE				
2,2-DIMETHYLBUTANE				
CYCLOPENTENE				
4-METHYL-1-PENTENE				0.2
3-METHYL-1-PENTENE				
CYCLOPENTANE				
2,3-DIMETHYLBUTANE	0.8	0.8	0.8	0.6
MTBE				
4-METHYL-CIS-2-PENTENE				
2-METHYLPENTANE				
4-METHYL-TRANS-2-PENTENE				

TABLE A-1. (CONT'D) HYDROCARBON SPECIATION FOR CHEVROLET SILVERADO (TRANSIENT CYCLES)				
COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
3-METHYLPENTANE				0.4
2-METHYL-1-PENTENE	0.4	0.3	0.4	0.4
1-HEXENE	0.4	0.3	0.4	0.4
HEXANE				
UNIDENTIFIED C6 OLEFINS	1.2		0.5	
TRANS-3-HEXENE				
CIS-3-HEXENE				
DI-ISOPROPYL ETHER				
TRANS-2-HEXENE				
3-METHYL-TRANS-2-PENTENE				
2-METHYL-2-PENTENE				
3-METHYLCYCLOPENTENE				
CIS-2-HEXENE				
ETBE				
3-METHYL-CIS-2-PENTENE				
2,2-DIMETHYLPENTANE, NOTE A				
METHYLCYCLOPENTANE, NOTE A				
2,4-DIMETHYLPENTANE				
2,2,3-TRIMETHYLBUTANE				0.2
3,4-DIMETHYL-1-PENTENE				
1-METHYLCYCLOPENTENE				
BENZENE	3.6	2.5	2.9	1.9
3-METHYL-1-HEXENE				
3,3-DIMETHYLPENTANE				
CYCLOHEXANE				
2-METHYLHEXANE				
2,3-DIMETHYLPENTANE		trace	trace	trace
1,1-DIMETHYLCYCLOPENTANE				
TERT-AMYL METHYL ETHER				
CYCLOHEXENE				
3-METHYLHEXANE				
CIS-1,3-DIMETHYLCYCLOPENTANE				0.2
3-ETHYLPENTANE				
TRANS-1,2-DIMETHYLCYCLOPENTANE				
TRANS-1,3-DIMETHYLCYCLOPENTANE				
1-HEPTENE				
2,2,4-TRIMETHYLPENTANE	0.5	0.3	0.4	0.8
2-METHYL-1-HEXENE				
TRANS-3-HEPTENE				
HEPTANE				
CIS-3-HEPTENE				
UNIDENTIFIED C7				
2-METHYL-2-HEXENE				

TABLE A-1. (CONT'D) HYDROCARBON SPECIATION FOR CHEVROLET SILVERADO (TRANSIENT CYCLES)				
COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
3-METHYL-TRANS-3-HEXENE				
TRANS-2-HEPTENE				
3-ETHYL-CIS-2-PENTENE				
2,4,4-TRIMETHYL-1-PENTENE				
2,3-DIMETHYL-2-PENTENE				
CIS-2-HEPTENE				
METHYLCYCLOHEXANE	0.4	0.6	0.5	0.2
CIS-1,2-DIMETHYLCYCLOPENTANE				
2,2-DIMETHYLHEXANE				
1,1,3-TRIMETHYLCYCLOPENTANE				
2,4,4-TRIMETHYL-2-PENTENE				
2,2,3-TRIMETHYLPENTANE				
2,5-DIMETHYLHEXANE				
ETHYLCYCLOPENTANE				
2,4-DIMETHYLHEXANE	0.5		0.2	0.2
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE				
3,3-DIMETHYLHEXANE				
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE				
2,3,4-TRIMETHYLPENTANE		0.4	0.2	0.3
2,3,3-TRIMETHYLPENTANE	0.3		0.1	0.1
TOLUENE	4.1	3.1	3.5	3.0
2,3-DIMETHYLHEXANE				
1,1,2-TRIMETHYLCYCLOPENTANE				
2-METHYLHEPTANE				
3,4-DIMETHYLHEXANE, NOTE B				
4-METHYLHEPTANE				
3-METHYLHEPTANE				
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE				
CIS-1,3-DIMETHYLCYCLOHEXANE				
TRANS-1,4-DIMETHYLCYCLOHEXANE				
3-ETHYLHEXANE				
2,2,5-TRIMETHYLHEXANE				
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE				
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.5	0.5	0.5	0.3
1,1-DIMETHYLCYCLOHEXANE				
TRANS-1-METHYL-2-ETHYLCYCLOPENTANE				
1-METHYL-1-ETHYL-CYCLOPENTANE				
2,4,4-TRIMETHYLHEXANE				
2,2,4-TRIMETHYLHEXANE				
TRANS-1,2-DIMETHYLCYCLOHEXANE				
1-OCTENE				

TABLE A-1. (CONT'D) HYDROCARBON SPECIATION FOR CHEVROLET SILVERADO (TRANSIENT CYCLES)

COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
TRANS-4-OCTENE				
OCTANE	0.5	0.4	0.4	0.1
UNIDENTIFIED C8				
TRANS-2-OCTENE				
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C				
CIS-2-OCTENE				
ISOPROPYLCYCLOPENTANE				
2,2-DIMETHYLHEPTANE				
2,3,5-TRIMETHYLHEXANE				
CIS-1-METHYL-2-ETHYLCYCLOPENTANE				
2,4-DIMETHYLHEPTANE				
4,4-DIMETHYLHEPTANE				
CIS-1,2-DIMETHYLCYCLOHEXANE				
ETHYLCYCLOHEXANE				
2,6-DIMETHYLHEPTANE, NOTE D	0.5	0.5	0.5	0.2
1,1,3-TRIMETHYLCYCLOHEXANE				
2,5-DIMETHYLHEPTANE, NOTE E				
3,3-DIMETHYLHEPTANE				
3,5-DIMETHYLHEPTANE, NOTE E				
ETHYLBENZENE	0.4	0.4	0.4	
2,3,4-TRIMETHYLHEXANE				
2,3-DIMETHYLHEPTANE				
m-& p-XYLENE	1.5	1.3	1.4	0.6
4-METHYLOCTANE				
3,4-DIMETHYLHEPTANE				
4-ETHYLHEPTANE				
2-METHYLOCTANE				
3-METHYLOCTANE				
STYRENE				
o-XYLENE	0.9	0.6	0.7	0.3
1-NONENE		0.4	0.3	0.3
TRANS-3-NONENE				
CIS-3-NONENE				
NONANE	1.3	1.0	1.1	0.4
TRANS-2-NONENE				
ISOPROPYLBENZENE (CUMENE)				
2,2-DIMETHYLOCTANE				
2,4-DIMETHYLOCTANE		0.4	0.2	
n-PROPYLBENZENE				
1-METHYL-3-ETHYLBENZENE				
1-METHYL-4-ETHYLBENZENE				
1,3,5-TRIMETHYLBENZENE				
1-METHYL-2-ETHYLBENZENE				

TABLE A-1. (CONT'D) HYDROCARBON SPECIATION FOR CHEVROLET SILVERADO (TRANSIENT CYCLES)				
COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
1,2,4-TRIMETHYLBENZENE				
TERT-BUTYLBENZENE				
1-DECENE				
DECANE, NOTE F				
ISOBUTYLBENZENE, NOTE F				
1,3,-DIMETHYL-5-ETHYLBENZENE				
METHYLPROPYLBENZENE (sec butylbenzene)				
1-METHYL-3-ISOPROPYLBENZENE				
1,2,3-TRIMETHYLBENZENE				
1-METHYL-4-ISOPROPYLBENZENE				
INDAN				
1-METHYL-2-ISOPROPYLBENZENE				
1,3-DIETHYLBENZENE				
1,4-DIETHYLBENZENE				
1-METHYL-3-N-PROPYLBENZENE				
1-METHYL-4-N-PROPYLBENZENE, NOTE G				
1,2 DIETHYLBENZENE				
1-METHYL-2-N-PROPYLBENZENE				
1,4-DIMETHYL-2-ETHYLBENZENE				
1,3-DIMETHYL-4-ETHYLBENZENE				
1,2-DIMETHYL-4-ETHYLBENZENE				
1,3-DIMETHYL-2-ETHYLBENZENE				
UNDECANE				
1,2-DIMETHYL-3-ETHYLBENZENE				
1,2,4,5-TETRAMETHYLBENZENE				
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)				
3,4 DIMETHYLCUMENE				
1,2,3,5-TETRAMETHYLBENZENE	0.9	0.4	0.6	
TERT-1-BUT-2-METHYLBENZENE		0.4	0.2	
1,2,3,4-TETRAMETHYLBENZENE				
N-PENT-BENZENE				
TERT-1-BUT-3,5-DIMETHYLBENZENE				
TERT-1-BUTYL-4-ETHYLBENZENE				
NAPHTHALENE				
DODECANE				
1,3,5-TRIETHYLBENZENE				
1,2,4-TRIETHYLBENZENE				
HEXYLBENZENE				
UNIDENTIFIED C9-C12+				0.1
FORMALDEHYDE	36.7	25.7	30.4	13.6
ACETALDEHYDE	13.1	9.1	10.8	5.1

TABLE A-1. (CONT'D) HYDROCARBON SPECIATION FOR CHEVROLET SILVERADO (TRANSIENT CYCLES)				
COMPOUND	**mg/mile**			
	Cold	**Hot**	**Composite**	**US06**
ACROLEIN	3.4	2.0	2.6	0.7
ACETONE	1.3	0.3	0.7	
PROPIONALDEHYDE	2.1	1.1	1.5	0.4
CROTONALDEHYDE	1.6	1.0	1.2	0.4
ISOBUTYRALDEHYDE, NOTE H	0.6	0.4	0.5	0.1
METHYL ETHYL KETONE, NOTE H	0.6	0.4	0.5	0.1
BENZALDEHYDE	0.9	0.6	0.7	0.3
ISOVALERALDEHYDE	2.7	2.5	2.6	1.0
VALERALDEHYDE	0.6	0.4	0.5	trace
O-TOLUALDEHYDE	1.1	1.1	1.1	
M/P-TOLUALDEHYDE	2.4	1.3	1.8	0.8
HEXANALDEHYDE	0.4	0.3	0.4	0.2
DIMETHYLBENZALDEHYDE	0.3		0.1	

A - 2,2-Dimethylpentane and methylcyclopentane co-elute. GC peak area split equally between the two compounds.
B - 3-Methyl-3-ethyl-pentane co-elutes with reported compound. Not reported separately.
C - Cis-1,4-Dimethylcyclohexane co-elutes with reported compound. Not reported separately.
D - Propylcyclopentane co-elutes with reported compound. Not reported separately.
E - 2,5-Dimethylheptane and 3,5-dimethylheptane co-elute. GC peak area split equally between the two compounds.
F - Decane and isobutylbenzene co-elute. GC peak area split equally between the two compounds.
G - n-Butylbenzene co-elutes with reported compound. Not reported separately.
H - Isobutyraldehyde and methyl ethyl ketone co-elute. LC peak area split equally between the two compounds.

TABLE A-2. HYDROCARBON SPECIATION FOR FORD F350 (TRANSIENT CYCLES)				
	mg/mile			
COMPOUND	Cold	Hot	Composite	US06
METHANE	9.6	24.2	17.9	
ETHANE	0.1		0.1	
ETHYLENE	53.1	38.2	44.6	14.7
PROPANE	20.1	0.2	8.8	
PROPYLENE	12.6	9.6	10.9	4.4
ACETYLENE	14.4	10.8	12.3	3.7
PROPADIENE				
BUTANE				
TRANS-2-BUTENE				
1-BUTENE	3.1	2.4	2.7	1.0
2-METHYLPROPENE (ISOBUTYLENE)	1.9	1.4	1.6	0.8
2,2-DIMETHYLPROPANE (NEOPENTANE)				
PROPYNE				
1,3-BUTADIENE	0.7	2.0	1.5	
2-METHYLPROPANE (ISOBUTANE)				
1-BUTYNE				
METHANOL				
CIS-2-BUTENE				
3-METHYL-1-BUTENE				
ETHANOL				
2-METHYLBUTANE (ISOPENTANE)				
2-BUTYNE				
1-PENTENE	10.0	6.8	8.2	1.1
2-METHYL-1-BUTENE	5.2	3.3	4.1	0.6
PENTANE	4.4	3.3	3.8	0.5
UNIDENTIFIED C5 OLEFINS				
2-METHYL-1,3-BUTADIENE				
TRANS-2-PENTENE	1.0	0.7	0.8	
3,3-DIMETHYL-1-BUTENE				
CIS-2-PENTENE				
2-METHYL-2-BUTENE				
TERT-BUTANOL				
CYCLOPENTADIENE				
2,2-DIMETHYLBUTANE				
CYCLOPENTENE	0.3	0.4	0.4	0.1
4-METHYL-1-PENTENE		0.8	0.4	0.2
3-METHYL-1-PENTENE				
CYCLOPENTANE	0.6	0.9	0.7	0.1
2,3-DIMETHYLBUTANE		0.6	0.3	0.9
MTBE				
4-METHYL-CIS-2-PENTENE				
2-METHYLPENTANE				3.5
4-METHYL-TRANS-2-PENTENE				
3-METHYLPENTANE	1.4	2.1	1.8	3.1

TABLE A-2. (CONT'D) HYDROCARBON SPECIATION FOR FORD F350 (TRANSIENT CYCLES)				
	mg/mile			
COMPOUND	Cold	Hot	Composite	US06
2-METHYL-1-PENTENE	1.1	1.3	1.2	0.7
1-HEXENE	1.1	1.3	1.2	0.7
HEXANE	0.7		0.3	
UNIDENTIFIED C6 OLEFINS	3.4	1.0	2.0	0.6
TRANS-3-HEXENE				
CIS-3-HEXENE				0.1
DI-ISOPROPYL ETHER				
TRANS-2-HEXENE				
3-METHYL-TRANS-2-PENTENE				
2-METHYL-2-PENTENE				
3-METHYLCYCLOPENTENE				
CIS-2-HEXENE				
ETBE				
3-METHYL-CIS-2-PENTENE				
2,2-DIMETHYLPENTANE, NOTE A				
METHYLCYCLOPENTANE, NOTE A				
2,4-DIMETHYLPENTANE				
2,2,3-TRIMETHYLBUTANE				
3,4-DIMETHYL-1-PENTENE				
1-METHYLCYCLOPENTENE				
BENZENE				
3-METHYL-1-HEXENE		1.0	0.6	
3,3-DIMETHYLPENTANE				
CYCLOHEXANE				
2-METHYLHEXANE				
2,3-DIMETHYLPENTANE	0.2	0.1	0.2	0.1
1,1-DIMETHYLCYCLOPENTANE				
TERT-AMYL METHYL ETHER				
CYCLOHEXENE				
3-METHYLHEXANE	trace		trace	
CIS-1,3-DIMETHYLCYCLOPENTANE	0.4	0.9	0.7	0.3
3-ETHYLPENTANE				
TRANS-1,2-DIMETHYLCYCLOPENTANE				
TRANS-1,3-DIMETHYLCYCLOPENTANE				
1-HEPTENE				
2,2,4-TRIMETHYLPENTANE	0.7	1.3	1.0	0.6
2-METHYL-1-HEXENE				
TRANS-3-HEPTENE				
HEPTANE	0.1	0.2	0.2	trace
CIS-3-HEPTENE				
UNIDENTIFIED C7				0.1
2-METHYL-2-HEXENE				
3-METHYL-TRANS-3-HEXENE				
TRANS-2-HEPTENE				

TABLE A-2. (CONT'D) HYDROCARBON SPECIATION FOR FORD F350 (TRANSIENT CYCLES)

COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
3-ETHYL-CIS-2-PENTENE				
2,4,4-TRIMETHYL-1-PENTENE				
2,3-DIMETHYL-2-PENTENE				
CIS-2-HEPTENE				
METHYLCYCLOHEXANE	0.6	0.7	0.7	0.3
CIS-1,2-DIMETHYLCYCLOPENTANE				
2,2-DIMETHYLHEXANE				
1,1,3-TRIMETHYLCYCLOPENTANE				
2,4,4-TRIMETHYL-2-PENTENE				
2,2,3-TRIMETHYLPENTANE				
2,5-DIMETHYLHEXANE				
ETHYLCYCLOPENTANE				
2,4-DIMETHYLHEXANE	0.3	0.1	0.1	0.3
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE				
3,3-DIMETHYLHEXANE				
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE				
2,3,4-TRIMETHYLPENTANE	0.1	0.5	0.3	0.1
2,3,3-TRIMETHYLPENTANE				
TOLUENE				
2,3-DIMETHYLHEXANE				
1,1,2-TRIMETHYLCYCLOPENTANE				
2-METHYLHEPTANE				
3,4-DIMETHYLHEXANE, NOTE B				
4-METHYLHEPTANE				
3-METHYLHEPTANE				
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE				
CIS-1,3-DIMETHYLCYCLOHEXANE				
TRANS-1,4-DIMETHYLCYCLOHEXANE				
3-ETHYLHEXANE				
2,2,5-TRIMETHYLHEXANE				
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE				
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.8	1.1	1.0	0.6
1,1-DIMETHYLCYCLOHEXANE				
TRANS-1-METHYL-2-ETHYLCYCLOPENTANE				
1-METHYL-1-ETHYL-CYCLOPENTANE				
2,4,4-TRIMETHYLHEXANE				
2,2,4-TRIMETHYLHEXANE				
TRANS-1,2-DIMETHYLCYCLOHEXANE		0.7	0.4	0.2
1-OCTENE				
TRANS-4-OCTENE				
OCTANE	0.8	1.1	1.0	0.2
UNIDENTIFIED C8				0.2
TRANS-2-OCTENE				
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C				
CIS-2-OCTENE				

TABLE A-2. (CONT'D) HYDROCARBON SPECIATION FOR FORD F350 (TRANSIENT CYCLES)				
	mg/mile			
COMPOUND	Cold	Hot	Composite	US06
ISOPROPYLCYCLOPENTANE				
2,2-DIMETHYLHEPTANE				
2,3,5-TRIMETHYLHEXANE				
CIS-1-METHYL-2-ETHYLCYCLOPENTANE				
2,4-DIMETHYLHEPTANE				
4,4-DIMETHYLHEPTANE				
CIS-1,2-DIMETHYLCYCLOHEXANE				
ETHYLCYCLOHEXANE				
2,6-DIMETHYLHEPTANE, NOTE D	0.6	0.7	0.7	0.3
1,1,3-TRIMETHYLCYCLOHEXANE				
2,5-DIMETHYLHEPTANE, NOTE E		0.2	0.1	0.1
3,3-DIMETHYLHEPTANE				
3,5-DIMETHYLHEPTANE, NOTE E		0.2	0.1	0.1
ETHYLBENZENE	0.8	1.1	0.9	0.5
2,3,4-TRIMETHYLHEXANE				
2,3-DIMETHYLHEPTANE				
m-& p-XYLENE	0.9	1.8	1.4	0.9
4-METHYLOCTANE				
3,4-DIMETHYLHEPTANE				
4-ETHYLHEPTANE				
2-METHYLOCTANE				
3-METHYLOCTANE				
STYRENE				
o-XYLENE		0.3	0.2	0.4
1-NONENE				
TRANS-3-NONENE				
CIS-3-NONENE				
NONANE		0.3	0.2	
TRANS-2-NONENE				
ISOPROPYLBENZENE (CUMENE)				
2,2-DIMETHYLOCTANE				
2,4-DIMETHYLOCTANE				
n-PROPYLBENZENE				
1-METHYL-3-ETHYLBENZENE				
1-METHYL-4-ETHYLBENZENE				
1,3,5-TRIMETHYLBENZENE	0.9		0.4	
1-METHYL-2-ETHYLBENZENE				
1,2,4-TRIMETHYLBENZENE				
TERT-BUTYLBENZENE				
1-DECENE				
DECANE, NOTE F				
ISOBUTYLBENZENE, NOTE F				
1,3,-DIMETHYL-5-ETHYLBENZENE				
METHYLPROPYLBENZENE (sec butylbenzene)				
1-METHYL-3-ISOPROPYLBENZENE				

TABLE A-2. (CONT'D) HYDROCARBON SPECIATION FOR FORD F350 (TRANSIENT CYCLES)

COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
1,2,3-TRIMETHYLBENZENE				
1-METHYL-4-ISOPROPYLBENZENE				
INDAN				
1-METHYL-2-ISOPROPYLBENZENE				
1,3-DIETHYLBENZENE				
1,4-DIETHYLBENZENE				
1-METHYL-3-N-PROPYLBENZENE				
1-METHYL-4-N-PROPYLBENZENE, NOTE G				
1,2 DIETHYLBENZENE				
1-METHYL-2-N-PROPYLBENZENE				
1,4-DIMETHYL-2-ETHYLBENZENE				
1,3-DIMETHYL-4-ETHYLBENZENE				
1,2-DIMETHYL-4-ETHYLBENZENE				
1,3-DIMETHYL-2-ETHYLBENZENE				
UNDECANE				
1,2-DIMETHYL-3-ETHYLBENZENE				
1,2,4,5-TETRAMETHYLBENZENE				
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)				
3,4 DIMETHYLCUMENE				
1,2,3,5-TETRAMETHYLBENZENE				
TERT-1-BUT-2-METHYLBENZENE				
1,2,3,4-TETRAMETHYLBENZENE				
N-PENT-BENZENE				
TERT-1-BUT-3,5-DIMETHYLBENZENE				
TERT-1-BUTYL-4-ETHYLBENZENE				
NAPHTHALENE				
DODECANE	1.3		0.6	
1,3,5-TRIETHYLBENZENE				
1,2,4-TRIETHYLBENZENE				
HEXYLBENZENE				
UNIDENTIFIED C9-C12+		0.3	0.2	0.9
FORMALDEHYDE	68.6	39.5	52.0	19.8
ACETALDEHYDE	21.9	13.4	17.0	5.8
ACROLEIN	4.5	2.0	3.0	0.2
ACETONE	1.6		0.7	7.3
PROPIONALDEHYDE	11.8	7.8	9.5	4.1
CROTONALDEHYDE	9.8	5.0	7.1	3.7
ISOBUTYRALDEHYDE, NOTE H	0.9	0.4	0.6	0.3
METHYL ETHYL KETONE, NOTE H	0.9	0.4	0.6	0.3
BENZALDEHYDE	1.8	1.0	1.3	0.7
ISOVALERALDEHYDE				
VALERALDEHYDE				

TABLE A-2. (CONT'D) HYDROCARBON SPECIATION FOR FORD F350 (TRANSIENT CYCLES)				
	mg/mile			
COMPOUND	Cold	Hot	Composite	US06
O-TOLUALDEHYDE				
DIMETHYLBENZALDEHYDE				

A - 2,2-Dimethylpentane and methylcyclopentane co-elute. GC peak area split equally between the two compounds.
B - 3-Methyl-3-ethyl-pentane co-elutes with reported compound. Not reported separately.
C - Cis-1,4-Dimethylcyclohexane co-elutes with reported compound. Not reported separately.
D - Propylcyclopentane co-elutes with reported compound. Not reported separately.
E - 2,5-Dimethylheptane and 3,5-dimethylheptane co-elute. GC peak area split equally between the two compounds.
F - Decane and isobutylbenzene co-elute. GC peak area split equally between the two compounds.
G - n-Butylbenzene co-elutes with reported compound. Not reported separately.
H - Isobutyraldehyde and methyl ethyl ketone co-elute. LC peak area split equally between the two compounds.

TABLE A-3. HYDROCARBON SPECIATION FOR DODGE SPRINTER (TRANSIENT CYCLES)

COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
METHANE	10.8	1.6	5.6	1.4
ETHANE	1.8	0.6	1.1	0.1
ETHYLENE	32.2	24.2	27.6	23.2
PROPANE	0.4	0.1	0.2	Trace
PROPYLENE	9.4	7.5	8.3	7.8
ACETYLENE	7.3	5.4	6.2	3.5
PROPADIENE				
BUTANE	0.2	0.3	0.3	0.9
TRANS-2-BUTENE				
1-BUTENE	1.8	1.6	1.7	1.7
2-METHYLPROPENE (ISOBUTYLENE)	1.5	1.1	1.3	1.1
2,2-DIMETHYLPROPANE (NEOPENTANE)		0.8	0.5	2.1
PROPYNE				
1,3-BUTADIENE				
2-METHYLPROPANE (ISOBUTANE)		0.5	0.3	1.3
1-BUTYNE				
METHANOL				
CIS-2-BUTENE				
3-METHYL-1-BUTENE				
ETHANOL				
2-METHYLBUTANE (ISOPENTANE)				
2-BUTYNE				
1-PENTENE	1.5	0.9	1.1	1.1
2-METHYL-1-BUTENE				0.3
PENTANE	0.6	0.8	0.7	0.8
UNIDENTIFIED C5 OLEFINS				
2-METHYL-1,3-BUTADIENE				0.2
TRANS-2-PENTENE	1.1	1.0	1.0	
3,3-DIMETHYL-1-BUTENE				
CIS-2-PENTENE				
2-METHYL-2-BUTENE				0.4
TERT-BUTANOL				
CYCLOPENTADIENE	0.6		0.2	
2,2-DIMETHYLBUTANE				0.4
CYCLOPENTENE				0.2
4-METHYL-1-PENTENE				0.4
3-METHYL-1-PENTENE				
CYCLOPENTANE				
2,3-DIMETHYLBUTANE				0.5
MTBE				
4-METHYL-CIS-2-PENTENE				
2-METHYLPENTANE		0.6	0.4	0.5
4-METHYL-TRANS-2-PENTENE				
3-METHYLPENTANE	0.9	0.5	0.7	0.8

TABLE A-3. (CONT'D) HYDROCARBON SPECIATION FOR DODGE SPRINTER (TRANSIENT CYCLES)

COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
2-METHYL-1-PENTENE	0.6	0.8	0.7	1.0
1-HEXENE	0.6	0.8	0.7	1.0
HEXANE		0.2	0.1	2.2
UNIDENTIFIED C6 OLEFINS				0.3
TRANS-3-HEXENE				
CIS-3-HEXENE				
DI-ISOPROPYL ETHER				
TRANS-2-HEXENE				0.2
3-METHYL-TRANS-2-PENTENE				
2-METHYL-2-PENTENE				
3-METHYLCYCLOPENTENE				
CIS-2-HEXENE				
ETBE				
3-METHYL-CIS-2-PENTENE				0.2
2,2-DIMETHYLPENTANE, NOTE A				
METHYLCYCLOPENTANE, NOTE A				
2,4-DIMETHYLPENTANE				
2,2,3-TRIMETHYLBUTANE				
3,4-DIMETHYL-1-PENTENE				
1-METHYLCYCLOPENTENE				
BENZENE				0.5
3-METHYL-1-HEXENE				
3,3-DIMETHYLPENTANE				
CYCLOHEXANE				
2-METHYLHEXANE				
2,3-DIMETHYLPENTANE	0.7	0.7	0.7	0.5
1,1-DIMETHYLCYCLOPENTANE				
TERT-AMYL METHYL ETHER				
CYCLOHEXENE				
3-METHYLHEXANE				
CIS-1,3-DIMETHYLCYCLOPENTANE				
3-ETHYLPENTANE				
TRANS-1,2-DIMETHYLCYCLOPENTANE				
TRANS-1,3-DIMETHYLCYCLOPENTANE				
1-HEPTENE				
2,2,4-TRIMETHYLPENTANE	0.7	0.9	0.8	1.1
2-METHYL-1-HEXENE				
TRANS-3-HEPTENE				
HEPTANE	0.7		0.3	0.4
CIS-3-HEPTENE				
UNIDENTIFIED C7				
2-METHYL-2-HEXENE				
3-METHYL-TRANS-3-HEXENE				
TRANS-2-HEPTENE				
3-ETHYL-CIS-2-PENTENE				

TABLE A-3.(CONT'D) HYDROCARBON SPECIATION FOR DODGE SPRINTER (TRANSIENT CYCLES)

COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
2,4,4-TRIMETHYL-1-PENTENE				
2,3-DIMETHYL-2-PENTENE				
CIS-2-HEPTENE				
METHYLCYCLOHEXANE		0.5	0.3	
CIS-1,2-DIMETHYLCYCLOPENTANE				
2,2-DIMETHYLHEXANE				
1,1,3-TRIMETHYLCYCLOPENTANE				
2,4,4-TRIMETHYL-2-PENTENE				
2,2,3-TRIMETHYLPENTANE				
2,5-DIMETHYLHEXANE				
ETHYLCYCLOPENTANE				
2,4-DIMETHYLHEXANE		0.7	0.4	0.5
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE				
3,3-DIMETHYLHEXANE				
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE				
2,3,4-TRIMETHYLPENTANE				0.3
2,3,3-TRIMETHYLPENTANE				
TOLUENE	0.4	0.9	0.7	0.7
2,3-DIMETHYLHEXANE				
1,1,2-TRIMETHYLCYCLOPENTANE				
2-METHYLHEPTANE				
3,4-DIMETHYLHEXANE, NOTE B				
4-METHYLHEPTANE				
3-METHYLHEPTANE				
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE				
CIS-1,3-DIMETHYLCYCLOHEXANE				
TRANS-1,4-DIMETHYLCYCLOHEXANE				
3-ETHYLHEXANE		0.6	0.3	
2,2,5-TRIMETHYLHEXANE				
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE				
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.8	0.7	0.8	0.8
1,1-DIMETHYLCYCLOHEXANE				
TRANS-1-METHYL-2-ETHYLCYCLOPENTANE				
1-METHYL-1-ETHYL-CYCLOPENTANE				
2,4,4-TRIMETHYLHEXANE				
2,2,4-TRIMETHYLHEXANE				
TRANS-1,2-DIMETHYLCYCLOHEXANE				
1-OCTENE				
TRANS-4-OCTENE				
OCTANE		0.6	0.3	
UNIDENTIFIED C8				
TRANS-2-OCTENE				
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C				
CIS-2-OCTENE				
ISOPROPYLCYCLOPENTANE				

TABLE A-3.(CONT'D) HYDROCARBON SPECIATION FOR DODGE SPRINTER (TRANSIENT CYCLES)

COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
2,2-DIMETHYLHEPTANE				
2,3,5-TRIMETHYLHEXANE				
CIS-1-METHYL-2-ETHYLCYCLOPENTANE				
2,4-DIMETHYLHEPTANE				
4,4-DIMETHYLHEPTANE				
CIS-1,2-DIMETHYLCYCLOHEXANE				
ETHYLCYCLOHEXANE				
2,6-DIMETHYLHEPTANE, NOTE D				
1,1,3-TRIMETHYLCYCLOHEXANE				
2,5-DIMETHYLHEPTANE, NOTE E				
3,3-DIMETHYLHEPTANE				
3,5-DIMETHYLHEPTANE, NOTE E				
ETHYLBENZENE				0.3
2,3,4-TRIMETHYLHEXANE				
2,3-DIMETHYLHEPTANE				
m-& p-XYLENE				0.4
4-METHYLOCTANE				
3,4-DIMETHYLHEPTANE				
4-ETHYLHEPTANE				
2-METHYLOCTANE				
3-METHYLOCTANE				
STYRENE				
o-XYLENE				
1-NONENE				
TRANS-3-NONENE				
CIS-3-NONENE				
NONANE				
TRANS-2-NONENE				
ISOPROPYLBENZENE (CUMENE)				
2,2-DIMETHYLOCTANE				
2,4-DIMETHYLOCTANE				
n-PROPYLBENZENE				
1-METHYL-3-ETHYLBENZENE				
1-METHYL-4-ETHYLBENZENE				
1,3,5-TRIMETHYLBENZENE				
1-METHYL-2-ETHYLBENZENE				
1,2,4-TRIMETHYLBENZENE				
TERT-BUTYLBENZENE				
1-DECENE				
DECANE, NOTE F				
ISOBUTYLBENZENE, NOTE F				
1,3,-DIMETHYL-5-ETHYLBENZENE				
METHYLPROPYLBENZENE (sec butylbenzene)				
1-METHYL-3-ISOPROPYLBENZENE				
1,2,3-TRIMETHYLBENZENE				

TABLE A-3.(CONT'D) HYDROCARBON SPECIATION FOR DODGE SPRINTER (TRANSIENT CYCLES)

COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
1-METHYL-4-ISOPROPYLBENZENE				
INDAN				
1-METHYL-2-ISOPROPYLBENZENE				
1,3-DIETHYLBENZENE				
1,4-DIETHYLBENZENE				
1-METHYL-3-N-PROPYLBENZENE				
1-METHYL-4-N-PROPYLBENZENE, NOTE G				
1,2 DIETHYLBENZENE				
1-METHYL-2-N-PROPYLBENZENE				
1,4-DIMETHYL-2-ETHYLBENZENE				
1,3-DIMETHYL-4-ETHYLBENZENE				
1,2-DIMETHYL-4-ETHYLBENZENE				
1,3-DIMETHYL-2-ETHYLBENZENE				
UNDECANE				
1,2-DIMETHYL-3-ETHYLBENZENE				
1,2,4,5-TETRAMETHYLBENZENE				
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)				
3,4 DIMETHYLCUMENE				
1,2,3,5-TETRAMETHYLBENZENE				
TERT-1-BUT-2-METHYLBENZENE				
1,2,3,4-TETRAMETHYLBENZENE				
N-PENT-BENZENE				
TERT-1-BUT-3,5-DIMETHYLBENZENE				
TERT-1-BUTYL-4-ETHYLBENZENE				
NAPHTHALENE				
DODECANE				
1,3,5-TRIETHYLBENZENE				
1,2,4-TRIETHYLBENZENE				
HEXYLBENZENE				
UNIDENTIFIED C9-C12+				
FORMALDEHYDE	50.5	14.6	30.0	18.7
ACETALDEHYDE	10.7	5.0	7.4	6.0
ACROLEIN	1.3		0.6	0.4
ACETONE	7.8		3.4	3.9
PROPIONALDEHYDE	2.5	0.0	1.1	0.9
CROTONALDEHYDE	3.6	0.8	2.0	2.2
ISOBUTYRALDEHYDE, NOTE H	trace		trace	
METHYL ETHYL KETONE, NOTE H	trace		trace	
BENZALDEHYDE	0.2		0.1	Trace
ISOVALERALDEHYDE	0.2		0.1	0.1
VALERALDEHYDE				0.2
O-TOLUALDEHYDE	0.8		0.3	Trace
M/P-TOLUALDEHYDE	3.7		1.6	0.8

TABLE A-3.(CONT'D) HYDROCARBON SPECIATION FOR DODGE SPRINTER (TRANSIENT CYCLES)				
COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
HEXANALDEHYDE				
DIMETHYLBENZALDEHYDE				

A - 2,2-Dimethylpentane and methylcyclopentane co-elute. GC peak area split equally between the two compounds.
B - 3-Methyl-3-ethyl-pentane co-elutes with reported compound. Not reported separately.
C - Cis-1,4-Dimethylcyclohexane co-elutes with reported compound. Not reported separately.
D - Propylcyclopentane co-elutes with reported compound. Not reported separately.
E - 2,5-Dimethylheptane and 3,5-dimethylheptane co-elute. GC peak area split equally between the two compounds.
F - Decane and isobutylbenzene co-elute. GC peak area split equally between the two compounds.
G - n-Butylbenzene co-elutes with reported compound. Not reported separately.
H - Isobutyraldehyde and methyl ethyl ketone co-elute. LC peak area split equally between the two compounds.

TABLE A-4. HYDROCARBON SPECIATION FOR VOLKSWAGEN JETTA (TRANSIENT CYCLES)				
COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
METHANE	20.1	16.2	17.9	1.6
ETHANE	2.3	1.5	1.8	0.4
ETHYLENE	96.1	64.0	77.8	16.1
PROPANE	0.8	0.2	0.5	
PROPYLENE	28.2	18.1	22.4	4.6
ACETYLENE	23.1	16.8	19.5	4.6
PROPADIENE				
BUTANE		0.1	0.0	
TRANS-2-BUTENE	7.2	4.3	5.5	1.1
1-BUTENE				
2-METHYLPROPENE (ISOBUTYLENE)	3.1	1.9	2.4	0.6
2,2-DIMETHYLPROPANE (NEOPENTANE)	1.1	0.9	1.0	0.3
PROPYNE	0.8	0.4	0.5	0.1
1,3-BUTADIENE	2.0	0.3	1.1	0.5
2-METHYLPROPANE (ISOBUTANE)	0.1	0.2	0.2	0.0
1-BUTYNE				
METHANOL				
CIS-2-BUTENE				
3-METHYL-1-BUTENE				
ETHANOL				
2-METHYLBUTANE (ISOPENTANE)				
2-BUTYNE				
1-PENTENE	4.8	3.2	3.9	2.1
2-METHYL-1-BUTENE	12.1	9.1	10.4	0.4
PENTANE	3.4	1.9	2.5	0.4
UNIDENTIFIED C5 OLEFINS				
2-METHYL-1,3-BUTADIENE	1.2	0.6	0.9	0.2
TRANS-2-PENTENE	2.3	1.2	1.7	0.1
3,3-DIMETHYL-1-BUTENE	1.0	0.5	0.7	
CIS-2-PENTENE	0.3	0.1	0.2	0.1
2-METHYL-2-BUTENE	0.3	0.3	0.3	0.1
TERT-BUTANOL				
CYCLOPENTADIENE	1.3	0.9	1.1	
2,2-DIMETHYLBUTANE				0.1
CYCLOPENTENE	0.9	0.6	0.7	0.2
4-METHYL-1-PENTENE	1.0	0.6	0.7	0.1
3-METHYL-1-PENTENE				
CYCLOPENTANE	1.6	1.2	1.3	0.2
2,3-DIMETHYLBUTANE	1.2	0.7	0.9	0.2
MTBE				
4-METHYL-CIS-2-PENTENE				
2-METHYLPENTANE	0.5	0.6	0.5	0.1
4-METHYL-TRANS-2-PENTENE				
3-METHYLPENTANE	0.7	0.6	0.7	0.2

TABLE A-4.(CONT'D) HYDROCARBON SPECIATION FOR VOLKSWAGEN JETTA (TRANSIENT CYCLES)				
COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
2-METHYL-1-PENTENE	2.2	1.4	1.7	0.4
1-HEXENE	2.2	1.4	1.7	0.4
HEXANE				
UNIDENTIFIED C6 OLEFINS	7.5	1.9	4.3	0.8
TRANS-3-HEXENE				
CIS-3-HEXENE				
DI-ISOPROPYL ETHER				
TRANS-2-HEXENE	0.9	0.3	0.6	0.1
3-METHYL-TRANS-2-PENTENE				
2-METHYL-2-PENTENE	0.3		0.1	
3-METHYLCYCLOPENTENE				
CIS-2-HEXENE	0.4	0.2	0.3	
ETBE				
3-METHYL-CIS-2-PENTENE				
2,2-DIMETHYLPENTANE, NOTE A	0.1	0.2	0.1	
METHYLCYCLOPENTANE, NOTE A	0.1	0.2	0.1	
2,4-DIMETHYLPENTANE	0.1	0.1	0.1	
2,2,3-TRIMETHYLBUTANE	0.1		0.0	
3,4-DIMETHYL-1-PENTENE				
1-METHYLCYCLOPENTENE	0.6		0.3	
BENZENE	9.8	6.2	7.8	2.0
3-METHYL-1-HEXENE				
3,3-DIMETHYLPENTANE		0.0	0.0	
CYCLOHEXANE				
2-METHYLHEXANE				
2,3-DIMETHYLPENTANE	0.2	0.2	0.2	0.0
1,1-DIMETHYLCYCLOPENTANE				
TERT-AMYL METHYL ETHER				
CYCLOHEXENE				
3-METHYLHEXANE	1.1	0.6	0.8	0.1
CIS-1,3-DIMETHYLCYCLOPENTANE				
3-ETHYLPENTANE	0.3	0.2	0.2	0.0
TRANS-1,2-DIMETHYLCYCLOPENTANE				
TRANS-1,3-DIMETHYLCYCLOPENTANE				
1-HEPTENE				
2,2,4-TRIMETHYLPENTANE	2.3	1.5	1.9	0.4
2-METHYL-1-HEXENE				
TRANS-3-HEPTENE				
HEPTANE	0.3		0.1	
CIS-3-HEPTENE				
UNIDENTIFIED C7	3.5	2.2	2.7	0.3
2-METHYL-2-HEXENE				
3-METHYL-TRANS-3-HEXENE				
TRANS-2-HEPTENE	0.3	0.2	0.2	0.1
3-ETHYL-CIS-2-PENTENE				

TABLE A-4.(CONT'D) HYDROCARBON SPECIATION FOR VOLKSWAGEN JETTA (TRANSIENT CYCLES)				
COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
2,4,4-TRIMETHYL-1-PENTENE	0.2		0.1	
2,3-DIMETHYL-2-PENTENE				
CIS-2-HEPTENE	0.3	0.2	0.2	0.0
METHYLCYCLOHEXANE	0.6	0.3	0.4	0.1
CIS-1,2-DIMETHYLCYCLOPENTANE				
2,2-DIMETHYLHEXANE				
1,1,3-TRIMETHYLCYCLOPENTANE				
2,4,4-TRIMETHYL-2-PENTENE	0.4	0.3	0.4	0.1
2,2,3-TRIMETHYLPENTANE				
2,5-DIMETHYLHEXANE				
ETHYLCYCLOPENTANE				
2,4-DIMETHYLHEXANE	0.8	0.5	0.6	0.2
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE				
3,3-DIMETHYLHEXANE				
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE	0.3	0.1	0.2	
2,3,4-TRIMETHYLPENTANE	0.9	0.4	0.6	0.1
2,3,3-TRIMETHYLPENTANE				
TOLUENE	2.9	1.4	2.0	0.6
2,3-DIMETHYLHEXANE				
1,1,2-TRIMETHYLCYCLOPENTANE				
2-METHYLHEPTANE	0.3	0.1	0.2	0.0
3,4-DIMETHYLHEXANE, NOTE B				
4-METHYLHEPTANE	0.1	0.1	0.1	0.0
3-METHYLHEPTANE				
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE	0.7	0.4	0.6	0.2
CIS-1,3-DIMETHYLCYCLOHEXANE				
TRANS-1,4-DIMETHYLCYCLOHEXANE				
3-ETHYLHEXANE	0.3	0.2	0.2	0.1
2,2,5-TRIMETHYLHEXANE	0.2	0.1	0.2	0.0
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE				
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	2.0	1.3	1.6	0.3
1,1-DIMETHYLCYCLOHEXANE				
TRANS-1-METHYL-2-ETHYLCYCLOPENTANE				
1-METHYL-1-ETHYL-CYCLOPENTANE				
2,4,4-TRIMETHYLHEXANE				
2,2,4-TRIMETHYLHEXANE				
TRANS-1,2-DIMETHYLCYCLOHEXANE	0.3	0.2	0.2	0.1
1-OCTENE				
TRANS-4-OCTENE				
OCTANE	0.3	0.2	0.2	0.1
UNIDENTIFIED C8	0.3		0.1	
TRANS-2-OCTENE				
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C				
CIS-2-OCTENE				
ISOPROPYLCYCLOPENTANE				

TABLE A-4.(CONT'D) HYDROCARBON SPECIATION FOR VOLKSWAGEN JETTA (TRANSIENT CYCLES)				
COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
2,2-DIMETHYLHEPTANE				
2,3,5-TRIMETHYLHEXANE	0.4		0.2	
CIS-1-METHYL-2-ETHYLCYCLOPENTANE	0.4		0.2	
2,4-DIMETHYLHEPTANE				
4,4-DIMETHYLHEPTANE	0.2		0.1	
CIS-1,2-DIMETHYLCYCLOHEXANE				
ETHYLCYCLOHEXANE				
2,6-DIMETHYLHEPTANE, NOTE D	0.4	0.2	0.3	0.1
1,1,3-TRIMETHYLCYCLOHEXANE				
2,5-DIMETHYLHEPTANE, NOTE E	0.1	0.0	0.1	0.0
3,3-DIMETHYLHEPTANE				
3,5-DIMETHYLHEPTANE, NOTE E	0.1	0.0	0.1	0.0
ETHYLBENZENE	1.1	0.7	0.9	0.2
2,3,4-TRIMETHYLHEXANE				
2,3-DIMETHYLHEPTANE				
m-& p-XYLENE	2.3	1.4	1.8	0.4
4-METHYLOCTANE				
3,4-DIMETHYLHEPTANE				
4-ETHYLHEPTANE				
2-METHYLOCTANE	0.3	0.2	0.2	0.1
3-METHYLOCTANE	0.1	0.1	0.1	
STYRENE	1.7	0.6	1.1	0.2
o-XYLENE	1.1	0.7	0.9	0.2
1-NONENE	1.3	0.6	0.9	0.2
TRANS-3-NONENE				
CIS-3-NONENE				
NONANE	0.8	0.5	0.6	0.1
TRANS-2-NONENE				
ISOPROPYLBENZENE (CUMENE)				
2,2-DIMETHYLOCTANE				
2,4-DIMETHYLOCTANE	0.2	0.2	0.2	0.1
n-PROPYLBENZENE	0.3	0.1	0.2	
1-METHYL-3-ETHYLBENZENE				
1-METHYL-4-ETHYLBENZENE	0.1		0.0	
1,3,5-TRIMETHYLBENZENE	0.1		0.0	
1-METHYL-2-ETHYLBENZENE				0.0
1,2,4-TRIMETHYLBENZENE	0.1		0.0	0.0
TERT-BUTYLBENZENE				
1-DECENE				
DECANE, NOTE F				
ISOBUTYLBENZENE, NOTE F				
1,3,-DIMETHYL-5-ETHYLBENZENE				
METHYLPROPYLBENZENE (sec butylbenzene)				
1-METHYL-3-ISOPROPYLBENZENE				
1,2,3-TRIMETHYLBENZENE	0.4	0.2	0.3	0.1

TABLE A-4.(CONT'D) HYDROCARBON SPECIATION FOR VOLKSWAGEN JETTA (TRANSIENT CYCLES)				
COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
1-METHYL-4-ISOPROPYLBENZENE				
INDAN				
1-METHYL-2-ISOPROPYLBENZENE				
1,3-DIETHYLBENZENE				
1,4-DIETHYLBENZENE				
1-METHYL-3-N-PROPYLBENZENE				
1-METHYL-4-N-PROPYLBENZENE, NOTE G				
1,2 DIETHYLBENZENE	0.3	0.1	0.2	0.0
1-METHYL-2-N-PROPYLBENZENE				
1,4-DIMETHYL-2-ETHYLBENZENE				
1,3-DIMETHYL-4-ETHYLBENZENE				
1,2-DIMETHYL-4-ETHYLBENZENE				
1,3-DIMETHYL-2-ETHYLBENZENE				
UNDECANE				
1,2-DIMETHYL-3-ETHYLBENZENE				
1,2,4,5-TETRAMETHYLBENZENE				0.1
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)				
3,4 DIMETHYLCUMENE				
1,2,3,5-TETRAMETHYLBENZENE				
TERT-1-BUT-2-METHYLBENZENE				
1,2,3,4-TETRAMETHYLBENZENE				
N-PENT-BENZENE				
TERT-1-BUT-3,5-DIMETHYLBENZENE				0.1
TERT-1-BUTYL-4-ETHYLBENZENE				
NAPHTHALENE				
DODECANE				
1,3,5-TRIETHYLBENZENE				
1,2,4-TRIETHYLBENZENE				
HEXYLBENZENE				
UNIDENTIFIED C9-C12+	2.3	2.5	2.4	0.7
FORMALDEHYDE	62.2	52.9	56.9	9.5
ACETALDEHYDE	28.9	18.8	23.1	3.3
ACROLEIN	11.2	6.7	8.6	0.8
ACETONE	5.2	4.4	4.8	0.3
PROPIONALDEHYDE	15.7	10.6	12.8	2.1
CROTONALDEHYDE	10.5	7.0	8.5	1.0
ISOBUTYRALDEHYDE, NOTE H	2.1	1.2	1.6	0.1
METHYL ETHYL KETONE, NOTE H	2.1	1.2	1.6	0.1
BENZALDEHYDE	4.5	2.8	3.5	0.4
ISOVALERALDEHYDE	2.2	1.1	1.6	0.7
VALERALDEHYDE	2.7	1.5	2.1	0.3
O-TOLUALDEHYDE	2.7	2.2	2.4	0.2
M/P-TOLUALDEHYDE	10.1	5.4	7.4	0.7

TABLE A-4.(CONT'D) HYDROCARBON SPECIATION FOR VOLKSWAGEN JETTA (TRANSIENT CYCLES)				
COMPOUND	mg/mile			
	Cold	Hot	Composite	US06
HEXANALDEHYDE	1.3		0.6	
DIMETHYLBENZALDEHYDE	1.6	0.9	1.2	0.0

A - 2,2-Dimethylpentane and methylcyclopentane co-elute. GC peak area split equally between the two compounds.
B - 3-Methyl-3-ethyl-pentane co-elutes with reported compound. Not reported separately.
C - Cis-1,4-Dimethylcyclohexane co-elutes with reported compound. Not reported separately.
D - Propylcyclopentane co-elutes with reported compound. Not reported separately.
E - 2,5-Dimethylheptane and 3,5-dimethylheptane co-elute. GC peak area split equally between the two compounds.
F - Decane and isobutylbenzene co-elute. GC peak area split equally between the two compounds.
G - n-Butylbenzene co-elutes with reported compound. Not reported separately.
H - Isobutyraldehyde and methyl ethyl ketone co-elute. LC peak area split equally between the two compounds.

APPENDIX B

VOLATILE HYDROCARBON SPECIATION DATA FOR STEADY-STATE MODES

TABLE B-1. HYDROCARBON SPECIATION FOR CHEVROLET SILVERADO (STEADY-STATE MODES)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
METHANE				9.5	
ETHANE	0.4	0.4	0.3	0.6	0.2
ETHYLENE	62.1	30.5	7.9	51.1	5.4
PROPANE			trace		
PROPYLENE	17.3	6.8	1.7	8.4	1.6
ACETYLENE	12.4	7.7	3.3	10.8	1.2
PROPADIENE					
BUTANE	0.8	0.2		0.2	0.2
TRANS-2-BUTENE	0.6	0.3			
1-BUTENE	3.6	1.8	0.4	1.3	0.4
2-METHYLPROPENE (ISOBUTYLENE)	4.1	1.8	0.4	0.8	0.2
2,2-DIMETHYLPROPANE (NEOPENTANE)	2.9	1.2	0.2	1.2	1.1
PROPYNE	0.6	0.3		0.4	0.1
1,3-BUTADIENE	10.6	4.2			0.5
2-METHYLPROPANE (ISOBUTANE)	0.3	0.1		0.1	trace
1-BUTYNE					
METHANOL					
CIS-2-BUTENE	0.5	0.3			
3-METHYL-1-BUTENE					
ETHANOL					
2-METHYLBUTANE (ISOPENTANE)					
2-BUTYNE					
1-PENTENE	1.7	0.8		0.4	
2-METHYL-1-BUTENE	0.7	0.5			
PENTANE	1.1	0.5	0.2	0.8	
UNIDENTIFIED C5 OLEFINS	0.5	0.3		0.3	
2-METHYL-1,3-BUTADIENE	0.2	0.1		0.4	
TRANS-2-PENTENE	0.3				
3,3-DIMETHYL-1-BUTENE					
CIS-2-PENTENE					
2-METHYL-2-BUTENE					
TERT-BUTANOL					
CYCLOPENTADIENE					
2,2-DIMETHYLBUTANE	0.2				
CYCLOPENTENE	0.4	0.2		0.3	
4-METHYL-1-PENTENE	0.4	0.2			
3-METHYL-1-PENTENE					
CYCLOPENTANE	1.7	0.6		0.4	
2,3-DIMETHYLBUTANE	0.4	0.1	0.1	0.2	
MTBE					
4-METHYL-CIS-2-PENTENE					
2-METHYLPENTANE			trace		
4-METHYL-TRANS-2-PENTENE					
3-METHYLPENTANE	0.7	0.1	0.6	2.4	
2-METHYL-1-PENTENE	1.3	0.7	0.3	0.4	
1-HEXENE	1.3	0.7	0.3	0.4	
HEXANE			1.4	0.3	0.2

TABLE B-1. (CONT'D) HYDROCARBON SPECIATION FOR CHEVROLET SILVERADO (STEADY-STATE MODES)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
UNIDENTIFIED C6	3.2	1.9		0.2	0.1
TRANS-3-HEXENE					
CIS-3-HEXENE					
DI-ISOPROPYL ETHER					
TRANS-2-HEXENE					
3-METHYL-TRANS-2-PENTENE					
2-METHYL-2-PENTENE					
3-METHYLCYCLOPENTENE					
CIS-2-HEXENE					
ETBE					
3-METHYL-CIS-2-PENTENE					
2,2-DIMETHYLPENTANE, NOTE A	trace	trace	trace	trace	
METHYLCYCLOPENTANE, NOTE A	trace	trace	trace	trace	
2,4-DIMETHYLPENTANE					
2,2,3-TRIMETHYLBUTANE				trace	0.1
3,4-DIMETHYL-1-PENTENE	0.2	0.4			
1-METHYLCYCLOPENTENE					
BENZENE	7.4	2.8	1.3	2.5	0.5
3-METHYL-1-HEXENE	0.2				
3,3-DIMETHYLPENTANE					
CYCLOHEXANE	0.2				
2-METHYLHEXANE					
2,3-DIMETHYLPENTANE	trace				
1,1-DIMETHYLCYCLOPENTANE					
TERT-AMYL METHYL ETHER					
CYCLOHEXENE	0.3	0.1			
3-METHYLHEXANE					
CIS-1,3-DIMETHYLCYCLOPENTANE	0.4	0.4			
3-ETHYLPENTANE					
TRANS-1,2-DIMETHYLCYCLOPENTANE					
TRANS-1,3-DIMETHYLCYCLOPENTANE					
1-HEPTENE					
2,2,4-TRIMETHYLPENTANE	1.4	0.4	0.1	0.3	trace
2-METHYL-1-HEXENE					
TRANS-3-HEPTENE					
HEPTANE					
CIS-3-HEPTENE					
UNIDENTIFIED C7	0.2				
2-METHYL-2-HEXENE					
3-METHYL-TRANS-3-HEXENE					
TRANS-2-HEPTENE					
3-ETHYL-CIS-2-PENTENE					
2,4,4-TRIMETHYL-1-PENTENE					
2,3-DIMETHYL-2-PENTENE					
CIS-2-HEPTENE					
METHYLCYCLOHEXANE		0.2	0.3	0.4	0.1
CIS-1,2-DIMETHYLCYCLOPENTANE					
2,2-DIMETHYLHEXANE					

TABLE B-1. (CONT'D) HYDROCARBON SPECIATION FOR CHEVROLET SILVERADO (STEADY-STATE MODES)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
1,1,3-TRIMETHYLCYCLOPENTANE					
2,4,4-TRIMETHYL-2-PENTENE					
2,2,3-TRIMETHYLPENTANE					
2,5-DIMETHYLHEXANE					
ETHYLCYCLOPENTANE					
2,4-DIMETHYLHEXANE	0.6		0.1	0.1	
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE					
3,3-DIMETHYLHEXANE					
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE					
2,3,4-TRIMETHYLPENTANE	0.2	0.2		0.1	trace
2,3,3-TRIMETHYLPENTANE	0.2	0.1	0.2	0.4	
TOLUENE	5.9	2.7	2.9	3.8	
2,3-DIMETHYLHEXANE	0.3	0.2			0.3
1,1,2-TRIMETHYLCYCLOPENTANE					
2-METHYLHEPTANE					
3,4-DIMETHYLHEXANE, NOTE B					
4-METHYLHEPTANE					
3-METHYLHEPTANE					
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE					
CIS-1,3-DIMETHYLCYCLOHEXANE					
TRANS-1,4-DIMETHYLCYCLOHEXANE					
3-ETHYLHEXANE		0.2			
2,2,5-TRIMETHYLHEXANE				0.2	
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE					
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.7	0.4		0.2	
1,1-DIMETHYLCYCLOHEXANE					
TRANS-1-METHYL-2-ETHYLCYCLOPENTANE					
1-METHYL-1-ETHYL-CYCLOPENTANE					
2,4,4-TRIMETHYLHEXANE					
2,2,4-TRIMETHYLHEXANE					
TRANS-1,2-DIMETHYLCYCLOHEXANE		0.1			
1-OCTENE					
TRANS-4-OCTENE					
OCTANE		0.2			0.2
UNIDENTIFIED C8		0.3			
TRANS-2-OCTENE					
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C					
CIS-2-OCTENE					
ISOPROPYLCYCLOPENTANE					
2,2-DIMETHYLHEPTANE					
2,3,5-TRIMETHYLHEXANE					
CIS-1-METHYL-2-ETHYLCYCLOPENTANE					
2,4-DIMETHYLHEPTANE					
4,4-DIMETHYLHEPTANE					
CIS-1,2-DIMETHYLCYCLOHEXANE					
ETHYLCYCLOHEXANE					
2,6-DIMETHYLHEPTANE, NOTE D		0.3	0.3	0.2	0.2
1,1,3-TRIMETHYLCYCLOHEXANE					

TABLE B-1. (CONT'D) HYDROCARBON SPECIATION FOR CHEVROLET SILVERADO (STEADY-STATE MODES)					
COMPOUND	**mg/min**				
	3000/75	**3000/50**	**1800/50**	**1800/25**	**Idle**
2,5-DIMETHYLHEPTANE, NOTE E					
3,3-DIMETHYLHEPTANE					
3,5-DIMETHYLHEPTANE, NOTE E					
ETHYLBENZENE	0.2	0.2			0.1
2,3,4-TRIMETHYLHEXANE					
2,3-DIMETHYLHEPTANE					
m-& p-XYLENE	0.9	0.8	0.5	0.8	0.4
4-METHYLOCTANE					
3,4-DIMETHYLHEPTANE					
4-ETHYLHEPTANE					
2-METHYLOCTANE		0.2			
3-METHYLOCTANE					
STYRENE	0.7	0.2			
o-XYLENE	0.4	0.4	0.4	0.4	0.2
1-NONENE	0.6	0.3			
TRANS-3-NONENE					
CIS-3-NONENE					
NONANE		0.6	0.4	0.3	
TRANS-2-NONENE					
ISOPROPYLBENZENE (CUMENE)					
2,2-DIMETHYLOCTANE					
2,4-DIMETHYLOCTANE		0.1			
n-PROPYLBENZENE		0.2			
1-METHYL-3-ETHYLBENZENE		0.4			
1-METHYL-4-ETHYLBENZENE	0.2	0.3			
1,3,5-TRIMETHYLBENZENE		0.2			
1-METHYL-2-ETHYLBENZENE		0.3			
1,2,4-TRIMETHYLBENZENE		0.6			
TERT-BUTYLBENZENE					
1-DECENE					
DECANE, NOTE F		0.1			
ISOBUTYLBENZENE, NOTE F		0.1			
1,3,-DIMETHYL-5-ETHYLBENZENE					
METHYLPROPYLBENZENE (sec butylbenzene)					
1-METHYL-3-ISOPROPYLBENZENE					
1,2,3-TRIMETHYLBENZENE					
1-METHYL-4-ISOPROPYLBENZENE					
INDAN					
1-METHYL-2-ISOPROPYLBENZENE		0.2			
1,3-DIETHYLBENZENE					
1,4-DIETHYLBENZENE					
1-METHYL-3-N-PROPYLBENZENE					
1-METHYL-4-N-PROPYLBENZENE, NOTE G					
1,2 DIETHYLBENZENE		0.2			
1-METHYL-2-N-PROPYLBENZENE					
1,4-DIMETHYL-2-ETHYLBENZENE					
1,3-DIMETHYL-4-ETHYLBENZENE					
1,2-DIMETHYL-4-ETHYLBENZENE					

TABLE B-1. (CONT'D) HYDROCARBON SPECIATION FOR CHEVROLET SILVERADO (STEADY-STATE MODES)					
COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
1,3-DIMETHYL-2-ETHYLBENZENE					
UNDECANE		1.0			
1,2-DIMETHYL-3-ETHYLBENZENE					
1,2,4,5-TETRAMETHYLBENZENE		0.4			
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)					
3,4 DIMETHYLCUMENE					
1,2,3,5-TETRAMETHYLBENZENE		0.3			
TERT-1-BUT-2-METHYLBENZENE					
1,2,3,4-TETRAMETHYLBENZENE					
N-PENT-BENZENE					
TERT-1-BUT-3,5-DIMETHYLBENZENE					
TERT-1-BUTYL-4-ETHYLBENZENE		0.3			
NAPHTHALENE					
DODECANE					
1,3,5-TRIETHYLBENZENE					
1,2,4-TRIETHYLBENZENE					
HEXYLBENZENE					
UNIDENTIFIED C9-C12+		2.6	0.4	0.2	
FORMALDEHYDE	28.6	42.3	6.7	45.0	5.8
ACETALDEHYDE	13.6	17.4	2.6	16.9	2.2
ACROLEIN	0.9	2.8		4.1	0.3
ACETONE		4.0		1.8	
PROPIONALDEHYDE	0.6	2.4	0.1	1.8	0.3
CROTONALDEHYDE	0.5	2.0		4.2	0.2
ISOBUTYRALDEHYDE, NOTE H	0.3	0.8		0.5	0.1
METHYL ETHYL KETONE, NOTE H	0.3	0.8		0.5	0.1
BENZALDEHYDE	0.8	1.4		1.4	
ISOVALERALDEHYDE	0.9	1.2		0.5	
VALERALDEHYDE	0.1	0.8		0.5	trace
O-TOLUALDEHYDE	2.1	2.3		2.8	0.3
M/P-TOLUALDEHYDE	0.6	1.5		3.8	0.2
HEXANALDEHYDE	0.2	1.0		trace	trace
DIMETHYLBENZALDEHYDE					
SUM	201.1	161.8	33.2	185.0	22.7

A - 2,2-Dimethylpentane and methylcyclopentane co-elute. GC peak area split equally between the two compounds.
B - 3-Methyl-3-ethyl-pentane co-elutes with reported compound. Not reported separately.
C - Cis-1,4-Dimethylcyclohexane co-elutes with reported compound. Not reported separately.
D - Propylcyclopentane co-elutes with reported compound. Not reported separately.
E - 2,5-Dimethylheptane and 3,5-dimethylheptane co-elute. GC peak area split equally between the two compounds.
F - Decane and isobutylbenzene co-elute. GC peak area split equally between the two compounds.
G - n-Butylbenzene co-elutes with reported compound. Not reported separately.
H - Isobutyraldehyde and methyl ethyl ketone co-elute. LC peak area split equally between the two compounds.

TABLE B-2. HYDROCARBON SPECIATION FOR FORD F350 (STEADY-STATE MODES)					
COMPOUND	mg/min				
	3300/75	3300/50	2000/50	2000/25	Idle
METHANE			0.1	3.2	0.9
ETHANE	0.2	0.2		0.4	0.1
ETHYLENE	48.3	39.4	11.8	19.7	5.4
PROPANE	0.8		trace	0.9	0.3
PROPYLENE	19.9	12.6	4.3	4.4	1.4
ACETYLENE	7.6	11.9	3.4	6.7	2.0
PROPADIENE					
BUTANE	0.3		0.6		
TRANS-2-BUTENE	0.8	0.6	0.1		
1-BUTENE	6.3	3.8	1.2	0.9	0.2
2-METHYLPROPENE (ISOBUTYLENE)	5.6	2.2	0.8	0.5	0.2
2,2-DIMETHYLPROPANE (NEOPENTANE)	5.7	2.8	6.2	20.1	4.9
PROPYNE	0.4	0.5		0.1	
1,3-BUTADIENE	5.5	5.3			
2-METHYLPROPANE (ISOBUTANE)	trace		0.1	4.3	0.6
1-BUTYNE					
METHANOL					
CIS-2-BUTENE	0.7	0.4			
3-METHYL-1-BUTENE					
ETHANOL					
2-METHYLBUTANE (ISOPENTANE)					
2-BUTYNE					
1-PENTENE	4.8	2.8	0.6	0.2	
2-METHYL-1-BUTENE	2.6	0.7	0.4	0.2	
PENTANE	1.2	0.6	1.6	4.4	0.4
UNIDENTIFIED C5 OLEFINS	3.7	1.5			
2-METHYL-1,3-BUTADIENE	1.3	0.8	0.2	0.2	
TRANS-2-PENTENE	0.4	0.2	0.1		
3,3-DIMETHYL-1-BUTENE					
CIS-2-PENTENE	0.2	0.2	0.2		
2-METHYL-2-BUTENE					
TERT-BUTANOL					
CYCLOPENTADIENE					
2,2-DIMETHYLBUTANE	0.4	0.2	trace	0.1	
CYCLOPENTENE	0.3	0.4	0.1		
4-METHYL-1-PENTENE	1.3	0.7	0.1	0.4	0.2
3-METHYL-1-PENTENE					
CYCLOPENTANE	1.8	0.7			
2,3-DIMETHYLBUTANE	0.4		0.3	1.1	
MTBE					
4-METHYL-CIS-2-PENTENE					
2-METHYLPENTANE	0.1		0.1	0.6	
4-METHYL-TRANS-2-PENTENE					
3-METHYLPENTANE	0.8	0.3	0.9	1.3	
2-METHYL-1-PENTENE	3.1	1.6	0.8	0.4	
1-HEXENE	3.1	1.6	0.8	0.4	
HEXANE			0.8		

TABLE B-2. (CONT'D) HYDROCARBON SPECIATION FOR FORD F350 (STEADY-STATE MODES)

COMPOUND	mg/min				
	3300/75	3300/50	2000/50	2000/25	Idle
UNIDENTIFIED C6 OLEFINS	2.2	1.5			
TRANS-3-HEXENE					
CIS-3-HEXENE					
DI-ISOPROPYL ETHER					
TRANS-2-HEXENE	1.0	0.4	0.2		
3-METHYL-TRANS-2-PENTENE					
2-METHYL-2-PENTENE	0.2				
3-METHYLCYCLOPENTENE					
CIS-2-HEXENE	0.2	0.1			
ETBE					
3-METHYL-CIS-2-PENTENE					
2,2-DIMETHYLPENTANE, NOTE A	0.1		trace		
METHYLCYCLOPENTANE, NOTE A	0.1		trace		
2,4-DIMETHYLPENTANE	0.2		0.1	0.3	
2,2,3-TRIMETHYLBUTANE					
3,4-DIMETHYL-1-PENTENE	0.4				
1-METHYLCYCLOPENTENE					
BENZENE	3.7	4.6	1.7	2.2	
3-METHYL-1-HEXENE					
3,3-DIMETHYLPENTANE					
CYCLOHEXANE		0.2		0.3	0.1
2-METHYLHEXANE					
2,3-DIMETHYLPENTANE			0.1	0.1	
1,1-DIMETHYLCYCLOPENTANE					
TERT-AMYL METHYL ETHER					
CYCLOHEXENE		0.6			
3-METHYLHEXANE	0.6			trace	
CIS-1,3-DIMETHYLCYCLOPENTANE	0.9	0.8	0.3	0.2	
3-ETHYLPENTANE	0.4				
TRANS-1,2-DIMETHYLCYCLOPENTANE					
TRANS-1,3-DIMETHYLCYCLOPENTANE					
1-HEPTENE					
2,2,4-TRIMETHYLPENTANE	3.3	0.6	0.7	2.7	
2-METHYL-1-HEXENE					
TRANS-3-HEPTENE	0.3				
HEPTANE	0.3	trace	0.1	0.1	
CIS-3-HEPTENE					
UNIDENTIFIED C7	2.3	0.8	0.3	0.2	
2-METHYL-2-HEXENE					
3-METHYL-TRANS-3-HEXENE					
TRANS-2-HEPTENE	0.5	0.2			
3-ETHYL-CIS-2-PENTENE					
2,4,4-TRIMETHYL-1-PENTENE	0.2	0.1			
2,3-DIMETHYL-2-PENTENE					
CIS-2-HEPTENE	0.4	0.2			
METHYLCYCLOHEXANE	0.4	0.3	0.2	0.3	trace
CIS-1,2-DIMETHYLCYCLOPENTANE					

TABLE B-2. (CONT'D) HYDROCARBON SPECIATION FOR FORD F350 (STEADY-STATE MODES)

COMPOUND	mg/min				
	3300/75	3300/50	2000/50	2000/25	Idle
2,2-DIMETHYLHEXANE					
1,1,3-TRIMETHYLCYCLOPENTANE					
2,4,4-TRIMETHYL-2-PENTENE	0.6				
2,2,3-TRIMETHYLPENTANE	1.2				
2,5-DIMETHYLHEXANE					
ETHYLCYCLOPENTANE					
2,4-DIMETHYLHEXANE	0.2	0.6	0.2		
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE					
3,3-DIMETHYLHEXANE					
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE					
2,3,4-TRIMETHYLPENTANE	0.7	0.5	0.2	0.7	trace
2,3,3-TRIMETHYLPENTANE		0.4		1.9	
TOLUENE	6.1	2.9	4.3	4.7	
2,3-DIMETHYLHEXANE					
1,1,2-TRIMETHYLCYCLOPENTANE					
2-METHYLHEPTANE	0.3	0.2			
3,4-DIMETHYLHEXANE, NOTE B					
4-METHYLHEPTANE	0.3	0.2	0.2	0.1	
3-METHYLHEPTANE	0.5	0.2			
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE					
CIS-1,3-DIMETHYLCYCLOHEXANE					
TRANS-1,4-DIMETHYLCYCLOHEXANE					
3-ETHYLHEXANE	0.6	0.2		0.1	
2,2,5-TRIMETHYLHEXANE	0.9	0.1	trace	0.1	
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE					
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	3.2	1.4	0.6	0.2	
1,1-DIMETHYLCYCLOHEXANE					
TRANS-1-METHYL-2-ETHYLCYCLOPENTANE					
1-METHYL-1-ETHYL-CYCLOPENTANE					
2,4,4-TRIMETHYLHEXANE					
2,2,4-TRIMETHYLHEXANE					
TRANS-1,2-DIMETHYLCYCLOHEXANE		0.3	0.1	0.1	0.2
1-OCTENE					
TRANS-4-OCTENE					
OCTANE	0.9	0.4	0.3	0.3	0.1
UNIDENTIFIED C8	2.7	0.5	0.3		
TRANS-2-OCTENE					
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C					
CIS-2-OCTENE	0.1		0.4		
ISOPROPYLCYCLOPENTANE					
2,2-DIMETHYLHEPTANE					
2,3,5-TRIMETHYLHEXANE	0.3				
CIS-1-METHYL-2-ETHYLCYCLOPENTANE	0.5	0.6			
2,4-DIMETHYLHEPTANE					
4,4-DIMETHYLHEPTANE		0.2			
CIS-1,2-DIMETHYLCYCLOHEXANE					
ETHYLCYCLOHEXANE					
2,6-DIMETHYLHEPTANE, NOTE D	0.6	0.6	0.3	0.4	0.1

TABLE B-2. (CONT'D) HYDROCARBON SPECIATION FOR FORD F350 (STEADY-STATE MODES)

COMPOUND	mg/min				
	3300/75	3300/50	2000/50	2000/25	Idle
1,1,3-TRIMETHYLCYCLOHEXANE					
2,5-DIMETHYLHEPTANE, NOTE E	0.3	0.1	0.1	0.1	
3,3-DIMETHYLHEPTANE					
3,5-DIMETHYLHEPTANE, NOTE E		0.1	0.1	0.1	
ETHYLBENZENE	0.6	0.8	0.4	0.5	
2,3,4-TRIMETHYLHEXANE					
2,3-DIMETHYLHEPTANE					
m-& p-XYLENE	2.1	1.9	1.2	1.2	
4-METHYLOCTANE					
3,4-DIMETHYLHEPTANE					
4-ETHYLHEPTANE					
2-METHYLOCTANE	0.7	0.4	0.2	0.3	
3-METHYLOCTANE	0.3	0.2	0.1	0.2	
STYRENE	1.0	0.8	0.2	0.2	
o-XYLENE	1.4	1.0	0.6	0.6	
1-NONENE	2.3	1.1	0.6	0.2	
TRANS-3-NONENE					
CIS-3-NONENE					
NONANE	1.5	1.1	0.8	0.6	
TRANS-2-NONENE					
ISOPROPYLBENZENE (CUMENE)					
2,2-DIMETHYLOCTANE	0.3				
2,4-DIMETHYLOCTANE	0.5	0.3	0.2	0.2	
n-PROPYLBENZENE	1.3	0.8	0.4		
1-METHYL-3-ETHYLBENZENE	1.5	1.0			
1-METHYL-4-ETHYLBENZENE	0.7	0.5	0.1	0.1	
1,3,5-TRIMETHYLBENZENE	0.8	0.5	0.1	0.1	
1-METHYL-2-ETHYLBENZENE	1.3	0.5			
1,2,4-TRIMETHYLBENZENE	1.1	0.2	0.3		
TERT-BUTYLBENZENE					
1-DECENE					
DECANE, NOTE F	0.5	0.6			
ISOBUTYLBENZENE, NOTE F	0.5	0.6			
1,3,-DIMETHYL-5-ETHYLBENZENE					
METHYLPROPYLBENZENE (sec butylbenzene)	0.2				
1-METHYL-3-ISOPROPYLBENZENE	0.5				
1,2,3-TRIMETHYLBENZENE	0.6				
1-METHYL-4-ISOPROPYLBENZENE	0.3				
INDAN					
1-METHYL-2-ISOPROPYLBENZENE	4.4	1.0	0.2		
1,3-DIETHYLBENZENE					
1,4-DIETHYLBENZENE	0.2			0.1	
1-METHYL-3-N-PROPYLBENZENE					
1-METHYL-4-N-PROPYLBENZENE, NOTE G					
1,2 DIETHYLBENZENE	0.9	0.7	0.4	0.3	
1-METHYL-2-N-PROPYLBENZENE	0.3				
1,4-DIMETHYL-2-ETHYLBENZENE					
1,3-DIMETHYL-4-ETHYLBENZENE	0.6				

TABLE B-2. (CONT'D) HYDROCARBON SPECIATION FOR FORD F350 (STEADY-STATE MODES)

COMPOUND	mg/min				
	3300/75	3300/50	2000/50	2000/25	Idle
1,2-DIMETHYL-4-ETHYLBENZENE					
1,3-DIMETHYL-2-ETHYLBENZENE					
UNDECANE		0.5	0.2		
1,2-DIMETHYL-3-ETHYLBENZENE					
1,2,4,5-TETRAMETHYLBENZENE		0.3	0.1		
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)					
3,4 DIMETHYLCUMENE					
1,2,3,5-TETRAMETHYLBENZENE	0.4		0.3	0.4	
TERT-1-BUT-2-METHYLBENZENE	0.1	0.5	0.3	0.4	
1,2,3,4-TETRAMETHYLBENZENE					
N-PENT-BENZENE		0.4			
TERT-1-BUT-3,5-DIMETHYLBENZENE					
TERT-1-BUTYL-4-ETHYLBENZENE	0.2		0.1	0.1	
NAPHTHALENE	0.1	0.7			
DODECANE		0.4			
1,3,5-TRIETHYLBENZENE					
1,2,4-TRIETHYLBENZENE					
HEXYLBENZENE					
UNIDENTIFIED C9-C12+	25.3	6.3	2.4	1.8	
FORMALDEHYDE	10.0	14.6	9.9	35.7	13.5
ACETALDEHYDE	3.5	4.9	3.9	13.5	6.7
ACROLEIN	0.3	0.9	0.7	3.4	0.8
ACETONE					1.0
PROPIONALDEHYDE	1.0	2.3	1.4	5.2	3.0
CROTONALDEHYDE	1.8	2.0	1.1	4.4	2.0
ISOBUTYRALDEHYDE, NOTE H	0.3	0.2	0.2	0.6	0.3
METHYL ETHYL KETONE, NOTE H	0.3	0.2	0.2	0.6	0.3
BENZALDEHYDE		0.1		0.8	
ISOVALERALDEHYDE		trace	trace	3.3	0.3
VALERALDEHYDE	trace	0.1	0.1	1.0	0.4
O-TOLUALDEHYDE		0.2	trace	0.8	
M/P-TOLUALDEHYDE	0.4	1.3	0.7	3.6	0.8
HEXANALDEHYDE		trace		0.3	trace
DIMETHYLBENZALDEHYDE	0.8				
SUMMED SPECIATION HYDROCARBONS	236.3	161.8	73.7	166.6	46.3

A - 2,2-Dimethylpentane and methylcyclopentane co-elute. GC peak area split equally between the two compounds.
B - 3-Methyl-3-ethyl-pentane co-elutes with reported compound. Not reported separately.
C - Cis-1,4-Dimethylcyclohexane co-elutes with reported compound. Not reported separately.
D - Propylcyclopentane co-elutes with reported compound. Not reported separately.
E - 2,5-Dimethylheptane and 3,5-dimethylheptane co-elute. GC peak area split equally between the two compounds.
F - Decane and isobutylbenzene co-elute. GC peak area split equally between the two compounds.
G - n-Butylbenzene co-elutes with reported compound. Not reported separately.
H - Isobutyraldehyde and methyl ethyl ketone co-elute. LC peak area split equally between the two compounds.

TABLE B-3. HYDROCARBON SPECIATION FOR DODGE SPRINTER (STEADY-STATE MODES)

COMPOUND	mg/min				
	3800/75	3800/50	1600/50	1600/25	Idle
METHANE	2.1	9.3	5.5	2.3	
ETHANE	0.7	1.2	0.5	0.4	0.4
ETHYLENE	67.4	89.4	10.5	13.6	2.8
PROPANE	0.3	0.3	0.2	0.8	0.5
PROPYLENE	22.3	22.7	2.4	3.3	0.7
ACETYLENE	7.6	14.9	2.7	2.2	0.6
PROPADIENE					
BUTANE	0.7	0.2		2.1	0.5
TRANS-2-BUTENE	0.7	0.4			
1-BUTENE	5.8	5.2	0.4	0.6	
2-METHYLPROPENE (ISOBUTYLENE)	3.0	2.8	0.2	0.3	
2,2-DIMETHYLPROPANE (NEOPENTANE)	1.6	0.4			
PROPYNE					
1,3-BUTADIENE	17.9	2.6			
2-METHYLPROPANE (ISOBUTANE)	0.6	0.2			
1-BUTYNE					
METHANOL					
CIS-2-BUTENE	0.5	0.4			
3-METHYL-1-BUTENE					
ETHANOL					
2-METHYLBUTANE (ISOPENTANE)	0.6	0.5			
2-BUTYNE					
1-PENTENE	3.3	4.7			
2-METHYL-1-BUTENE	0.8	0.8	1.2		
PENTANE	0.4				
UNIDENTIFIED C5 OLEFINS					
2-METHYL-1,3-BUTADIENE	1.6	1.5			0.2
TRANS-2-PENTENE	0.2	0.2		trace	
3,3-DIMETHYL-1-BUTENE					
CIS-2-PENTENE	0.2	0.2			
2-METHYL-2-BUTENE	0.3	0.2		0.4	
TERT-BUTANOL					
CYCLOPENTADIENE	0.6	0.4			
2,2-DIMETHYLBUTANE	0.7	0.6		0.2	
CYCLOPENTENE	0.8	0.8			
4-METHYL-1-PENTENE	0.9	0.8			
3-METHYL-1-PENTENE					
CYCLOPENTANE					
2,3-DIMETHYLBUTANE	1.4	1.6			
MTBE					
4-METHYL-CIS-2-PENTENE					
2-METHYLPENTANE	0.6	0.9			
4-METHYL-TRANS-2-PENTENE					
3-METHYLPENTANE	1.5	3.3	0.6	1.0	0.4
2-METHYL-1-PENTENE	2.2	2.3	0.2	0.3	0.2
1-HEXENE	2.2	2.3	0.2	0.3	0.2
HEXANE				21.1*	5.9*

TABLE B-3. (CONT'D) HYDROCARBON SPECIATION FOR DODGE SPRINTER (STEADY-STATE MODES)

COMPOUND	mg/min				
	3800/75	3800/50	1600/50	1600/25	Idle
UNIDENTIFIED C6 OLEFINS	2.9	2.7		0.7	
TRANS-3-HEXENE					
CIS-3-HEXENE					
DI-ISOPROPYL ETHER					
TRANS-2-HEXENE	0.7	0.7			
3-METHYL-TRANS-2-PENTENE					
2-METHYL-2-PENTENE	0.3	0.3			
3-METHYLCYCLOPENTENE					
CIS-2-HEXENE					
ETBE					
3-METHYL-CIS-2-PENTENE				2.7	0.7
2,2-DIMETHYLPENTANE, NOTE A	0.1	0.4			
METHYLCYCLOPENTANE, NOTE A	0.1	0.4			
2,4-DIMETHYLPENTANE	0.4	0.3			
2,2,3-TRIMETHYLBUTANE					
3,4-DIMETHYL-1-PENTENE	0.2	0.4			
1-METHYLCYCLOPENTENE					
BENZENE	4.4	7.7	0.6	0.3	
3-METHYL-1-HEXENE					
3,3-DIMETHYLPENTANE		0.2			
CYCLOHEXANE					
2-METHYLHEXANE		0.3			
2,3-DIMETHYLPENTANE					
1,1-DIMETHYLCYCLOPENTANE	0.9	0.8			
TERT-AMYL METHYL ETHER					
CYCLOHEXENE					
3-METHYLHEXANE					
CIS-1,3-DIMETHYLCYCLOPENTANE	0.2	1.0			
3-ETHYLPENTANE		0.3			
TRANS-1,2-DIMETHYLCYCLOPENTANE					
TRANS-1,3-DIMETHYLCYCLOPENTANE					
1-HEPTENE					
2,2,4-TRIMETHYLPENTANE	2.3	2.6	0.2	0.4	0.1
2-METHYL-1-HEXENE					
TRANS-3-HEPTENE					
HEPTANE		0.3			
CIS-3-HEPTENE					
UNIDENTIFIED C7	0.4	0.9			
2-METHYL-2-HEXENE					
3-METHYL-TRANS-3-HEXENE					
TRANS-2-HEPTENE	0.2	0.4			
3-ETHYL-CIS-2-PENTENE					
2,4,4-TRIMETHYL-1-PENTENE					
2,3-DIMETHYL-2-PENTENE					
CIS-2-HEPTENE	0.3	0.3			
METHYLCYCLOHEXANE	0.3	0.6	0.2	0.2	
CIS-1,2-DIMETHYLCYCLOPENTANE					

TABLE B-3. (CONT'D) HYDROCARBON SPECIATION FOR DODGE SPRINTER (STEADY-STATE MODES)					
COMPOUND	mg/min				
	3800/75	3800/50	1600/50	1600/25	Idle
2,2-DIMETHYLHEXANE					
1,1,3-TRIMETHYLCYCLOPENTANE					
2,4,4-TRIMETHYL-2-PENTENE	0.2	0.2			
2,2,3-TRIMETHYLPENTANE		0.7			
2,5-DIMETHYLHEXANE					
ETHYLCYCLOPENTANE					
2,4-DIMETHYLHEXANE	0.9	0.3			
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE					
3,3-DIMETHYLHEXANE					
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE					
2,3,4-TRIMETHYLPENTANE	0.2	0.5			
2,3,3-TRIMETHYLPENTANE					
TOLUENE	3.4	2.5			
2,3-DIMETHYLHEXANE					
1,1,2-TRIMETHYLCYCLOPENTANE					
2-METHYLHEPTANE	0.3	0.2			
3,4-DIMETHYLHEXANE, NOTE B	0.3	0.3			
4-METHYLHEPTANE					
3-METHYLHEPTANE					
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE	0.2	0.3			
CIS-1,3-DIMETHYLCYCLOHEXANE					
TRANS-1,4-DIMETHYLCYCLOHEXANE					
3-ETHYLHEXANE	0.3	0.3			
2,2,5-TRIMETHYLHEXANE	0.2	0.3			
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE					
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	1.6	2.0	0.2	0.3	
1,1-DIMETHYLCYCLOHEXANE					
TRANS-1-METHYL-2-ETHYLCYCLOPENTANE					
1-METHYL-1-ETHYL-CYCLOPENTANE					
2,4,4-TRIMETHYLHEXANE					
2,2,4-TRIMETHYLHEXANE					
TRANS-1,2-DIMETHYLCYCLOHEXANE	0.2	0.6			
1-OCTENE					
TRANS-4-OCTENE					
OCTANE	0.2	0.5	0.2	0.3	
UNIDENTIFIED C8		0.3			
TRANS-2-OCTENE					
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C					
CIS-2-OCTENE					
ISOPROPYLCYCLOPENTANE					
2,2-DIMETHYLHEPTANE					
2,3,5-TRIMETHYLHEXANE		0.3			
CIS-1-METHYL-2-ETHYLCYCLOPENTANE		0.5			
2,4-DIMETHYLHEPTANE					
4,4-DIMETHYLHEPTANE					
CIS-1,2-DIMETHYLCYCLOHEXANE					
ETHYLCYCLOHEXANE					

TABLE B-3. (CONT'D) HYDROCARBON SPECIATION FOR DODGE SPRINTER (STEADY-STATE MODES)

COMPOUND	mg/min				
	3800/75	3800/50	1600/50	1600/25	Idle
2,6-DIMETHYLHEPTANE, NOTE D	0.3	0.5		0.3	
1,1,3-TRIMETHYLCYCLOHEXANE					
2,5-DIMETHYLHEPTANE, NOTE E		0.1			
3,3-DIMETHYLHEPTANE					
3,5-DIMETHYLHEPTANE, NOTE E		0.1			
ETHYLBENZENE	0.7	1.0		0.2	
2,3,4-TRIMETHYLHEXANE					
2,3-DIMETHYLHEPTANE					
m-& p-XYLENE	1.6	2.1			
4-METHYLOCTANE					
3,4-DIMETHYLHEPTANE					
4-ETHYLHEPTANE					
2-METHYLOCTANE		0.4			
3-METHYLOCTANE					
STYRENE	0.8	1.8			
o-XYLENE	1.0	1.1			
1-NONENE	1.1	1.6			
TRANS-3-NONENE					
CIS-3-NONENE					
NONANE	0.7	1.0			
TRANS-2-NONENE					
ISOPROPYLBENZENE (CUMENE)		0.2			
2,2-DIMETHYLOCTANE					
2,4-DIMETHYLOCTANE		0.4			
n-PROPYLBENZENE	0.2	0.6			
1-METHYL-3-ETHYLBENZENE		0.5			
1-METHYL-4-ETHYLBENZENE	0.2	0.2			
1,3,5-TRIMETHYLBENZENE	0.2	0.2			
1-METHYL-2-ETHYLBENZENE					
1,2,4-TRIMETHYLBENZENE		0.3			
TERT-BUTYLBENZENE					
1-DECENE					
DECANE, NOTE F	0.3				
ISOBUTYLBENZENE, NOTE F	0.3				
1,3,-DIMETHYL-5-ETHYLBENZENE					
METHYLPROPYLBENZENE (sec butylbenzene)					
1-METHYL-3-ISOPROPYLBENZENE	0.2				
1,2,3-TRIMETHYLBENZENE					
1-METHYL-4-ISOPROPYLBENZENE	0.2				
INDAN					
1-METHYL-2-ISOPROPYLBENZENE	0.3				
1,3-DIETHYLBENZENE					
1,4-DIETHYLBENZENE					
1-METHYL-3-N-PROPYLBENZENE					
1-METHYL-4-N-PROPYLBENZENE, NOTE G					
1,2 DIETHYLBENZENE	0.3				
1-METHYL-2-N-PROPYLBENZENE					
1,4-DIMETHYL-2-ETHYLBENZENE					

TABLE B-3. (CONT'D) HYDROCARBON SPECIATION FOR DODGE SPRINTER (STEADY-STATE MODES)					
COMPOUND	mg/min				
	3800/75	3800/50	1600/50	1600/25	Idle
1,3-DIMETHYL-4-ETHYLBENZENE					
1,2-DIMETHYL-4-ETHYLBENZENE		0.2			
1,3-DIMETHYL-2-ETHYLBENZENE					
UNDECANE					
1,2-DIMETHYL-3-ETHYLBENZENE					
1,2,4,5-TETRAMETHYLBENZENE					
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)					
3,4 DIMETHYLCUMENE					
1,2,3,5-TETRAMETHYLBENZENE					
TERT-1-BUT-2-METHYLBENZENE				0.2	
1,2,3,4-TETRAMETHYLBENZENE					
N-PENT-BENZENE	0.2				
TERT-1-BUT-3,5-DIMETHYLBENZENE		0.4			
TERT-1-BUTYL-4-ETHYLBENZENE					
NAPHTHALENE					
DODECANE		0.5			
1,3,5-TRIETHYLBENZENE					
1,2,4-TRIETHYLBENZENE					
HEXYLBENZENE					
UNIDENTIFIED C9-C12+	2.6	3.3			
FORMALDEHYDE	33.0	60.3	4.6	11.5	2.0
ACETALDEHYDE	10.7	15.2	1.5	4.3	0.7
ACROLEIN	1.9	2.8	trace	0.8	0.0
ACETONE	14.4	17.6	3.4	4.4	2.9
PROPIONALDEHYDE	3.8	5.2	0.4	0.2	
CROTONALDEHYDE	3.5	4.9	0.3	2.0	trace
ISOBUTYRALDEHYDE, NOTE H	0.5	1.2	0.2	0.5	0.2
METHYL ETHYL KETONE, NOTE H	0.5	1.2	0.2	0.5	0.2
BENZALDEHYDE	1.4	2.2		0.3	
ISOVALERALDEHYDE	0.8	0.9	0.1	0.5	
VALERALDEHYDE	0.6	1.4		0.4	
O-TOLUALDEHYDE	0.8	1.2		0.2	
M/P-TOLUALDEHYDE	0.6	3.9		1.2	
HEXANALDEHYDE	0.3	0.6		0.2	
DIMETHYLBENZALDEHYDE	0.7	1.1	0.1	0.3	
SUMMED SPECIATION HYDROCARBONS	255.6	337.8	36.7	60.8	13.1
*High values; appears to be due to contamination.					

A - 2,2-Dimethylpentane and methylcyclopentane co-elute. GC peak area split equally between the two compounds.
B - 3-Methyl-3-ethyl-pentane co-elutes with reported compound. Not reported separately.
C - Cis-1,4-Dimethylcyclohexane co-elutes with reported compound. Not reported separately.
D - Propylcyclopentane co-elutes with reported compound. Not reported separately.
E - 2,5-Dimethylheptane and 3,5-dimethylheptane co-elute. GC peak area split equally between the two compounds.
F - Decane and isobutylbenzene co-elute. GC peak area split equally between the two compounds.
G - n-Butylbenzene co-elutes with reported compound. Not reported separately.
H - Isobutyraldehyde and methyl ethyl ketone co-elute. LC peak area split equally between the two compounds.

TABLE B-4. HYDROCARBON SPECIATION FOR VOLKSWAGEN JETTA (STEADY-STATE MODES)					
COMPOUND	mg/min				
	4000/75	4000/50	1800/50	1800/25	Idle
METHANE			0.7		2.0
ETHANE	trace	trace	0.1	0.1	0.1
ETHYLENE	13.3	9.5	13.0	6.1	5.9
PROPANE	2.2	trace	trace		
PROPYLENE	4.0	2.8	3.9	1.3	1.6
ACETYLENE	2.7	2.5	1.5	2.7	1.4
PROPADIENE					
BUTANE			trace		trace
TRANS-2-BUTENE	1.4	0.9	0.8	0.3	0.3
1-BUTENE					
2-METHYLPROPENE (ISOBUTYLENE)	1.3	0.8	0.5	0.2	0.2
2,2-DIMETHYLPROPANE (NEOPENTANE)	0.7	0.5	0.5	0.3	0.2
PROPYNE	0.1	0.1	0.1	0.1	
1,3-BUTADIENE	1.9	0.8	1.4		
2-METHYLPROPANE (ISOBUTANE)	trace	trace	trace	trace	trace
1-BUTYNE					
METHANOL					
CIS-2-BUTENE					
3-METHYL-1-BUTENE					
ETHANOL					
2-METHYLBUTANE (ISOPENTANE)					
2-BUTYNE					
1-PENTENE	0.3	0.7	0.4	0.1	
2-METHYL-1-BUTENE		0.1			
PENTANE	trace	0.2	0.2	0.1	0.3
UNIDENTIFIED C5 OLEFINS	0.4	0.2	0.3	0.2	1.5
2-METHYL-1,3-BUTADIENE	0.1				0.2
TRANS-2-PENTENE	0.1	0.1	0.4	0.1	0.1
3,3-DIMETHYL-1-BUTENE			trace		trace
CIS-2-PENTENE	trace				
2-METHYL-2-BUTENE	0.1				
TERT-BUTANOL					
CYCLOPENTADIENE					trace
2,2-DIMETHYLBUTANE	0.1	trace	0.1	trace	trace
CYCLOPENTENE	0.1		trace		trace
4-METHYL-1-PENTENE	0.1	0.1	0.1	trace	
3-METHYL-1-PENTENE					
CYCLOPENTANE	0.2	0.1	0.1		0.1
2,3-DIMETHYLBUTANE	0.1	0.1	trace	0.1	trace
MTBE					
4-METHYL-CIS-2-PENTENE					
2-METHYLPENTANE	trace	trace	trace		
4-METHYL-TRANS-2-PENTENE					
3-METHYLPENTANE	0.2	0.2	0.1	trace	0.4
2-METHYL-1-PENTENE	0.6	0.5	0.3	0.1	0.2
1-HEXENE	0.6	0.5	0.3	0.1	0.2
HEXANE				trace	0.1

TABLE B-4. (CONT'D) HYDROCARBON SPECIATION FOR VOLKSWAGEN JETTA (STEADY-STATE MODES)

COMPOUND	mg/min				
	4000/75	4000/50	1800/50	1800/25	Idle
UNIDENTIFIED C6 OLEFINS	1.2	0.8	0.4	0.4	trace
TRANS-3-HEXENE					
CIS-3-HEXENE					
DI-ISOPROPYL ETHER					
TRANS-2-HEXENE	0.1	0.1	0.1		
3-METHYL-TRANS-2-PENTENE					
2-METHYL-2-PENTENE			trace		
3-METHYLCYCLOPENTENE	trace	trace			
CIS-2-HEXENE					
ETBE		0.2			
3-METHYL-CIS-2-PENTENE	0.2		0.1	0.1	0.1
2,2-DIMETHYLPENTANE, NOTE A					
METHYLCYCLOPENTANE, NOTE A					
2,4-DIMETHYLPENTANE	0.1	trace	0.1	trace	0.1
2,2,3-TRIMETHYLBUTANE					
3,4-DIMETHYL-1-PENTENE					
1-METHYLCYCLOPENTENE					
BENZENE	0.9	0.9	1.6	0.8	0.1
3-METHYL-1-HEXENE					
3,3-DIMETHYLPENTANE					
CYCLOHEXANE					
2-METHYLHEXANE					
2,3-DIMETHYLPENTANE	0.0	0.1	0.1		
1,1-DIMETHYLCYCLOPENTANE					
TERT-AMYL METHYL ETHER					
CYCLOHEXENE					
3-METHYLHEXANE	0.3	0.2	trace	trace	0.1
CIS-1,3-DIMETHYLCYCLOPENTANE					
3-ETHYLPENTANE	0.1	trace	trace		
TRANS-1,2-DIMETHYLCYCLOPENTANE					
TRANS-1,3-DIMETHYLCYCLOPENTANE					
1-HEPTENE					
2,2,4-TRIMETHYLPENTANE	0.7	0.5	0.3	0.1	0.1
2-METHYL-1-HEXENE					
TRANS-3-HEPTENE					
HEPTANE					
CIS-3-HEPTENE					
UNIDENTIFIED C7	0.3	0.1	0.1	0.1	0.1
2-METHYL-2-HEXENE					
3-METHYL-TRANS-3-HEXENE					
TRANS-2-HEPTENE	0.1	trace	trace		
3-ETHYL-CIS-2-PENTENE			trace		
2,4,4-TRIMETHYL-1-PENTENE	0.1	trace	trace		
2,3-DIMETHYL-2-PENTENE					
CIS-2-HEPTENE	0.1	trace	0.1		
METHYLCYCLOHEXANE	0.2	0.2		0.1	0.1
CIS-1,2-DIMETHYLCYCLOPENTANE					

TABLE B-4. (CONT'D) HYDROCARBON SPECIATION FOR VOLKSWAGEN JETTA (STEADY-STATE MODES)					
COMPOUND	mg/min				
	4000/75	4000/50	1800/50	1800/25	Idle
2,2-DIMETHYLHEXANE					
1,1,3-TRIMETHYLCYCLOPENTANE					
2,4,4-TRIMETHYL-2-PENTENE	0.1	0.1	0.2		
2,2,3-TRIMETHYLPENTANE					0.1
2,5-DIMETHYLHEXANE					
ETHYLCYCLOPENTANE					
2,4-DIMETHYLHEXANE	0.2	0.2	0.2	0.1	
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE					
3,3-DIMETHYLHEXANE					
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE					
2,3,4-TRIMETHYLPENTANE	0.1	0.1	0.0	trace	trace
2,3,3-TRIMETHYLPENTANE					
TOLUENE	0.9	0.9	1.0	0.4	trace
2,3-DIMETHYLHEXANE					
1,1,2-TRIMETHYLCYCLOPENTANE					
2-METHYLHEPTANE		trace			
3,4-DIMETHYLHEXANE, NOTE B	0.1	0.1			
4-METHYLHEPTANE	0.1			trace	
3-METHYLHEPTANE					
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE	0.4	0.4	0.3	0.2	trace
CIS-1,3-DIMETHYLCYCLOHEXANE					
TRANS-1,4-DIMETHYLCYCLOHEXANE					
3-ETHYLHEXANE	0.1				
2,2,5-TRIMETHYLHEXANE	0.1				
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE					
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.6	0.3	0.3	0.1	0.2
1,1-DIMETHYLCYCLOHEXANE					
TRANS-1-METHYL-2-ETHYLCYCLOPENTANE					
1-METHYL-1-ETHYL-CYCLOPENTANE					
2,4,4-TRIMETHYLHEXANE					
2,2,4-TRIMETHYLHEXANE					
TRANS-1,2-DIMETHYLCYCLOHEXANE	0.1	0.1			
1-OCTENE					
TRANS-4-OCTENE					
OCTANE	0.2	0.1	0.2	0.1	trace
UNIDENTIFIED C8	0.1	trace	trace		
TRANS-2-OCTENE	trace				
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C					
CIS-2-OCTENE	0.1	0.1	0.1		
ISOPROPYLCYCLOPENTANE					
2,2-DIMETHYLHEPTANE					
2,3,5-TRIMETHYLHEXANE		trace			
CIS-1-METHYL-2-ETHYLCYCLOPENTANE	0.2	0.1			
2,4-DIMETHYLHEPTANE		trace			
4,4-DIMETHYLHEPTANE	0.3	trace	0.1		
CIS-1,2-DIMETHYLCYCLOHEXANE					
ETHYLCYCLOHEXANE					

TABLE B-4. (CONT'D) HYDROCARBON SPECIATION FOR VOLKSWAGEN JETTA (STEADY-STATE MODES)					
COMPOUND	mg/min				
	4000/75	4000/50	1800/50	1800/25	Idle
2,6-DIMETHYLHEPTANE, NOTE D 1,1,3-TRIMETHYLCYCLOHEXANE	0.2	0.2		0.1	0.1
2,5-DIMETHYLHEPTANE, NOTE E	trace	trace		trace	trace
3,3-DIMETHYLHEPTANE		trace			
3,5-DIMETHYLHEPTANE, NOTE E	trace			trace	trace
ETHYLBENZENE	0.2	0.2	0.1	trace	trace
2,3,4-TRIMETHYLHEXANE					
2,3-DIMETHYLHEPTANE					
m-& p-XYLENE	0.3	0.4	0.2	0.3	0.1
4-METHYLOCTANE					
3,4-DIMETHYLHEPTANE					
4-ETHYLHEPTANE					
2-METHYLOCTANE	0.1	0.1		0.1	
3-METHYLOCTANE	0.2	0.2	trace	0.1	
STYRENE	0.1	0.2	0.3	0.1	
o-XYLENE	0.5	0.5	0.1	0.1	trace
1-NONENE	0.4	0.4	0.3	0.1	
TRANS-3-NONENE					
CIS-3-NONENE					
NONANE	0.6	0.5	0.1	0.2	trace
TRANS-2-NONENE					
ISOPROPYLBENZENE (CUMENE)					
2,2-DIMETHYLOCTANE					
2,4-DIMETHYLOCTANE	0.2	0.1	trace	0.1	
n-PROPYLBENZENE	0.4	0.3	0.1	trace	
1-METHYL-3-ETHYLBENZENE	0.3	0.3	trace		
1-METHYL-4-ETHYLBENZENE	0.3	0.2	0.1	0.1	
1,3,5-TRIMETHYLBENZENE	0.4	0.4	0.1	0.1	
1-METHYL-2-ETHYLBENZENE	0.5	0.7	0.3	trace	
1,2,4-TRIMETHYLBENZENE	0.2	1.1	0.4	0.1	
TERT-BUTYLBENZENE					
1-DECENE					
DECANE, NOTE F	0.2	0.3	0.1	trace	
ISOBUTYLBENZENE, NOTE F	0.2	0.3	0.1	trace	
1,3,-DIMETHYL-5-ETHYLBENZENE					
METHYLPROPYLBENZENE (sec butylbenzene)	0.2	0.1	0.1		
1-METHYL-3-ISOPROPYLBENZENE	0.3	0.1	0.3	0.1	
1,2,3-TRIMETHYLBENZENE	0.1	0.2	0.1	trace	0.1
1-METHYL-4-ISOPROPYLBENZENE	0.1	0.1	0.2	trace	
INDAN					
1-METHYL-2-ISOPROPYLBENZENE	2.0	0.8	0.6	0.2	
1,3-DIETHYLBENZENE					
1,4-DIETHYLBENZENE	0.3		0.1		
1-METHYL-3-N-PROPYLBENZENE	1.5	1.2	0.6	0.1	
1-METHYL-4-N-PROPYLBENZENE, NOTE G	1.2	1.2	0.6	0.1	
1,2 DIETHYLBENZENE	1.2	1.2	0.4	0.1	
1-METHYL-2-N-PROPYLBENZENE	1.0	1.0	0.5	0.1	

TABLE B-4. (CONT'D) HYDROCARBON SPECIATION FOR VOLKSWAGEN JETTA (STEADY-STATE MODES)					
COMPOUND	mg/min				
	4000/75	4000/50	1800/50	1800/25	Idle
1,4-DIMETHYL-2-ETHYLBENZENE	0.1				
1,3-DIMETHYL-4-ETHYLBENZENE	1.9	2.0	0.6	0.3	
1,2-DIMETHYL-4-ETHYLBENZENE	2.9	1.1			
1,3-DIMETHYL-2-ETHYLBENZENE					
UNDECANE	trace	0.5	trace	0.1	
1,2-DIMETHYL-3-ETHYLBENZENE					
1,2,4,5-TETRAMETHYLBENZENE	0.1	0.2		0.1	
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)					
3,4 DIMETHYLCUMENE					
1,2,3,5-TETRAMETHYLBENZENE	trace				
TERT-1-BUT-2-METHYLBENZENE					
1,2,3,4-TETRAMETHYLBENZENE					
N-PENT-BENZENE					
TERT-1-BUT-3,5-DIMETHYLBENZENE	0.2				
TERT-1-BUTYL-4-ETHYLBENZENE					
NAPHTHALENE	0.1	0.3	0.1	0.1	
DODECANE		0.8	0.1	0.2	
1,3,5-TRIETHYLBENZENE					
1,2,4-TRIETHYLBENZENE					
HEXYLBENZENE					
UNIDENTIFIED C9-C12+	11.3	16.7	4.9	1.1	0.2
FORMALDEHYDE	10.2	9.5	7.2	4.2	5.8
ACETALDEHYDE	3.5	3.3	2.0	1.4	2.1
ACROLEIN	1.1	0.9	1.0	0.4	0.5
ACETONE	0.9	2.9	1.6	0.6	1.1
PROPIONALDEHYDE	1.7	1.5	0.8	0.6	1.2
CROTONALDEHYDE	0.8	0.8	0.5	0.3	0.7
ISOBUTYRALDEHYDE, NOTE H	0.3	0.2	trace	trace	0.1
METHYL ETHYL KETONE, NOTE H	0.3	0.2	trace	trace	0.1
BENZALDEHYDE	0.1	0.2	0.4	0.1	0.1
ISOVALERALDEHYDE	0.6	0.1	trace		0.1
VALERALDEHYDE	0.4	0.5	0.1	trace	0.2
O-TOLUALDEHYDE	0.2	0.1	0.1	0.1	0.1
M/P-TOLUALDEHYDE	0.5	0.5	0.4	0.2	0.6
HEXANALDEHYDE	0.2	0.3			trace
DIMETHYLBENZALDEHYDE					
SUMMED SPECIATION HYDROCARBONS	89.0	80.9	55.3	25.7	28.7

A - 2,2-Dimethylpentane and methylcyclopentane co-elute. GC peak area split equally between the two compounds.
B - 3-Methyl-3-ethyl-pentane co-elutes with reported compound. Not reported separately.
C - Cis-1,4-Dimethylcyclohexane co-elutes with reported compound. Not reported separately.
D - Propylcyclopentane co-elutes with reported compound. Not reported separately.
E - 2,5-Dimethylheptane and 3,5-dimethylheptane co-elute. GC peak area split equally between the two compounds.
F - Decane and isobutylbenzene co-elute. GC peak area split equally between the two compounds.
G - n-Butylbenzene co-elutes with reported compound. Not reported separately.
H - Isobutyraldehyde and methyl ethyl ketone co-elute. LC peak area split equally between the two compounds.

APPENDIX C

SEMI-VOLATILE HYDROCARBON SPECIATION DATA FOR TRANSIENT CYCLES

TABLE C-1. CHEVROLET SILVERADO SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
p-Xylene	0.6	0.5	trace
Styrene	0.9	0.6	0.4
Benzene, 1,2-dimethyl-	0.4	0.3	0.1
Nonane	0.7	0.7	0.3
Benzene, propyl-	0.2	0.2	ND
Benzaldehyde	0.8	0.5	0.4
Benzene, 1-ethyl-2-methyl-	0.2	0.4	ND
Benzene, 1-ethyl-3-methyl-	0.1	0.1	ND
Benzene, 1,3,5-trimethyl-	0.2	0.4	ND
Indane	0.3	0.3	0.1
Benzofuran	0.4	0.2	0.2
Decane	1.4	1.5	0.6
Benzene, 1-methyl-3-(1-methylethyl)-	0.2	0.2	0.1
Benzene, trimethyl-	0.3	0.4	0.1
Benzene, 1,2,4,5-tetramethyl-	1.1	0.7	0.2
Indene	0.3	0.2	0.1
Benzene, 1-methyl-3-propyl-	0.3	0.3	0.1
Benzene, tetramethyl-	0.2	0.2	0.1
Naphthalene, decahydro-, trans-	0.2	0.3	0.1
Benzaldehyde, 4-methyl	0.4	0.3	0.2
Benzene, 1-methyl-2-propyl-	0.2	0.2	0.1
Benzene, ethyl-dimethyl-	0.2	0.2	0.1
Benzene, 1-ethyl-3,5-dimethyl-	0.3	0.3	0.1
Thiophene, 2-pentyl	0.1	0.1	0.1
Benzene, ethyl-dimethyl-	0.2	0.2	0.1
Undecane	1.7	2.1	0.8
5-Undecene, (E)-	0.1	0.2	0.1
Benzene, 1-methyl-4-(1-methylpropyl)-	0.3	0.3	0.1
Naphthalene, decahydro-2-methyl-	0.4	0.4	0.2
Benzene, 1,2,3,5-tetramethyl-	0.2	0.2	0.1
trans-Decalin, 2-methyl-	0.3	0.3	0.1
Benzene, (2-methyl-1-propenyl)-	0.3	0.3	0.1
Benzene, methyl-(2-methylpropyl)-	0.2	0.2	0.1
3-Buten-2-ol, 4-phenyl-	0.2	0.2	0.1
Naphthalene, decahydro-1-methyl-	0.1	0.1	0.1
Decane, 3,7-dimethyl-	0.2	0.3	0.1
Naphthalene, 1,2,3,4-tetrahydro-	0.6	0.6	0.2
Benzene, 1-methyl-4-(2-methylpropyl)-	0.1	0.2	0.1
Undecane, 3-methyl-	0.1	0.2	0.1
Naphthalene, decahydro-2,3-dimethyl-	0.2	0.3	0.1
Benzene, methyl-(1-methylpropyl)-	0.2	0.2	0.1
Napthalene, decahydro-dimethyl-	0.2	0.2	0.1
Benzene, 1-methyl-1-butenyl-	0.1	0.1	trace
Naphthalene, decahydro-1,2-dimethyl-	0.2	0.2	0.1

TABLE C-1. (CONT'D) CHEVROLET SILVERADO SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
Naphthalene	1.2	1.0	0.4
Benzene, (1,1-dimethyl-2-propenyl)-	0.1	0.1	trace
1H-Indene, dihydro-dimethyl-	0.1	0.1	trace
Benzene, methyl-(1-methylpropyl)-	0.1	trace	trace
Naphthalene, decahydro-dimethyl-	0.1	0.1	trace
Dodecane	2.0	2.4	0.9
Benzene, 2,4-dimethyl-1-(1-methylethyl)-	0.1	0.1	trace
1H-Indene, 2,3-dihydro-1,1-dimethyl-	0.1	0.2	trace
Naphthalene, decahydro-2,6-dimethyl-	0.1	0.1	trace
Naphthalene, decahydro-1,5-dimethyl-	0.1	0.2	0.1
Undecane, 2,6-dimethyl-	0.5	0.7	0.2
Benzaldehyde, 3,4-dimethyl-	0.1	trace	trace
Naphthalene, 1,2,3,4-tetrahydro-2-methyl-	0.5	0.6	0.2
cis-anti-cis-Tricyclo[7.3.0.0(2,6)]-7-dodecene	0.1	0.1	trace
Benzene, (1-ethyl-1-methylpropyl)-	0.1	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-1-methyl-	0.3	0.4	0.1
Naphthalene, 2-ethyldecahydro-	0.1	0.2	0.1
2-Ethyl-2,3-dihydro-1H-indene	0.1	0.1	trace
Benzene, 1,3,5-trimethyl-2-propyl-	trace	0.1	trace
3,5-Dodecadiene, 2-methyl-	0.1	0.2	0.1
Ethyl-dihydro-1H-indene	0.1	0.1	trace
Cyclohexane, hexyl-	0.2	0.2	0.1
Naphthalene, ethyldecahydro-	0.1	0.1	trace
3-Dodecene, (Z)-	0.1	0.2	0.1
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	0.1	0.1	trace
Naphthalene, tetrahydro-dimethyl-	0.1	0.1	trace
Benzene, dimethyl-(1-methylpropyl)-	trace	trace	trace
Benzene, (1,3-dimethylbutyl)-	0.2	0.3	0.1
Dodecane, 5-methyl-	0.1	0.1	trace
1H-Indene, 2,3-dihydro-4,7-dimethyl-	0.1	0.2	trace
Dodecane, 4-methyl-	0.1	0.1	0.1
Benzene, (1-methylpentyl)-	0.1	0.1	trace
Benzene, C6-	0.1	0.1	trace
Benzene, hexyl-	0.1	0.1	trace
Undecane, 2,3-dimethyl-	0.3	0.4	0.1
1H-Indene, 2,3-dihydro-1,3-dimethyl-	0.1	0.2	trace
Dodecane, 3-methyl-	0.2	0.3	0.1
Naphthalene, 1,2,3,4-tetrahydro-6-methyl-	0.7	1.4	0.3
Undecane, 3,6-dimethyl-	0.3	0.5	0.2
Naphthalene, ethyltetrahydro-	trace	trace	trace
Naphthalene, 1,2-dihydo-2-methyl-	0.1	0.1	trace
Naphthalene, ethyl-tetrahydro-	ND	trace	ND
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	0.1	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	trace	0.1	trace

TABLE C-1. (CONT'D) CHEVROLET SILVERADO SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
6-Tridecene, 7-methyl-	0.1	0.2	0.1
1,1'-Bicyclohexyl, 2-methyl-, cis-	0.2	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,8-dimethyl-	0.1	0.1	0.1
Tridecane	3.0	3.9	1.3
Naphthalene, tetrahydromethyl-	0.7	0.8	0.3
Naphthalene, 2-methyl-	0.8	0.7	0.3
Thiophene, 2-heptyl-	0.1	0.1	trace
Cyclohexane, (2-ethyl-1-methyl-1-butenyl)-	0.1	0.1	trace
Naphthalene, 6-ethyl-1,2,3,4-tetrahydro-	0.1	0.1	ND
C2-Naphthalene, 1,2,3,4-tetrahydro-	0.1	0.1	0.1
Tridecane, 7-methyl-	0.1	0.2	trace
1,12-Tridecadiene	0.2	0.1	0.1
3,5-Decadiene, 2,2-dimethyl-, (Z,Z)-	0.1	0.1	trace
1H-Indene, 2,3-dihydro-4,5,7-trimethyl-	trace	trace	trace
Benzene, 1-methyl-3-hexyl-	trace	trace	trace
1,2,3-Trimethylindene	0.1	0.1	trace
Tridecane, 3-methyl-	0.3	0.4	0.1
Naphthalene, 1-methyl-	0.5	0.4	0.2
Naphthalene, 1,2,3,4-tetrahydro-1,1,6-trimethyl-	trace	trace	trace
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	1.2	1.3	0.5
Benzene, cyclohexyl-	0.2	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,4-dimethyl-	0.3	0.4	0.1
Naphthalene, 1,2,3,4-tetrahydro-1-propyl-	0.1	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-1,5-dimethyl-	0.4	0.5	0.2
Heptylcyclohexane	0.3	0.4	0.2
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	0.3	0.4	0.2
Naphthalene, 1,2,3,4-tetrahydro-2,6-dimethyl-	0.4	0.5	0.2
Benzene, 1-methyl-3-hexyl-	0.1	0.1	0.1
Tridecane, 4-methyl-	0.4	0.3	0.2
Tridecane, 2-methyl-	0.3	0.5	0.1
Naphthalene, tetrahydro-dimethyl-	0.2	0.2	0.1
Naphthalene, 5-ethyl-1,2,3,4-tetrahydro-	0.5	0.6	0.3
tert-Butyl-bicyclo(4,3,0)non-3,7-diene	0.1	0.1	trace
Tridecane, 3-methyl-	0.2	0.3	0.1
Dimethyl-cyclopentylbenzene	0.1	0.1	trace
1-Methyl-2-n-hexylbenzene	0.1	0.1	trace
Dodecane, 2,6,10-trimethyl-	0.7	0.7	0.3
trans-8-tert-Butyl-bicyclo(4,3,0)non-3,7-diene	0.1	0.1	0.1
1,4-Dimethyl-2-cyclopentylbenzene	0.1	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,5,8-trimethyl-	0.1	0.1	trace
Biphenyl	0.3	0.2	0.1
Acenaphthylene, 1,2,2a,3,4,5-hexahydro-	0.1	0.1	trace
2-Methyl-Z-4-tetradecene	0.2	0.2	0.1
Thiophene, 2-octyl-	trace	trace	trace

TABLE C-1. (CONT'D) CHEVROLET SILVERADO SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
Tetradecane	2.5	3.2	1.2
Naphthalene, 1,2,3,4-tetrahydro-5,6-dimethyl-	0.8	0.9	0.3
Naphthalene, 2-ethyl-	0.3	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	0.4	0.4	0.1
Naphthalene, 1-ethyl-	0.1	0.1	trace
Thiophene, 2-octyl-	0.1	0.1	trace
Naphthalene, 2,7-dimethyl-	0.5	0.4	0.1
C3-Naphthalene, tetrahydro-	0.1	0.2	trace
Benzene, (2,4-cyclopentadien-1-ylidenyl)-	trace	trace	trace
Benzene, 1-cyclohexyl-3-methyl-	0.1	0.1	trace
Naphthalene, 1,8-dimethyl-	0.9	0.7	0.1
Naphthalene, 1,7-dimethyl-	0.4	0.3	0.1
Naphthalene, 1,2,3,4-tetrahydro-6,7-dimethyl-	0.3	0.2	0.1
Naphthalene, tetrahydrodimethyl-	0.2	0.2	0.1
Naphthalene, 2-ethenyl-	0.1	0.1	trace
Naphthalene, 1,4-dimethyl-	0.1	0.2	trace
2,5,8-Trimethyl-1,2,3,4-tetrahydronaphthalene	0.3	0.3	0.1
Cyclohexane, octyl-	0.3	0.3	0.1
Naphthalene, tetrahydrotrimethyl-	0.2	0.3	0.1
Naphthalene, dimethyl-	0.1	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-2,5,8-trimethyl-	0.1	0.2	trace
Tetradecane, 4-methyl-	0.2	0.3	0.1
Tridecane, 2,5-dimethyl-	0.7	0.9	0.2
Naphthalene, dimethyl-	0.1	0.1	trace
Tetradecane, 3-methyl-	0.6	0.5	0.2
1,1'-Biphenyl, 3-methyl-	0.3	0.3	0.1
Pentadecane	3.3	3.4	1.2
Naphthalene, 2-(1-methylethyl)-	0.3	0.3	0.1
Dibenzofuran	0.1	0.1	trace
Naphthalene, trimethyl-	0.1	0.2	0.1
Naphthalene, 2,3,6-trimethyl-	0.3	0.3	0.1
Pentadecane, methyl-	0.1	0.2	0.1
n-Nonylcyclohexane	0.2	0.3	0.1
Naphthalene, 1,6,7-trimethyl-	0.2	0.2	0.1
Naphthalene, trimethyl-	0.1	0.2	0.1
Pentadecane, 2-methyl-	0.1	0.3	0.1
Pentadecane, methyl-	0.3	0.6	0.2
Benzene, nonyl-	0.1	0.1	trace
Hexane, 2-phenyl-3-propyl-	trace	0.1	trace
Fluorene	trace	trace	trace
Hexadecane	1.9	2.6	1.0
Benzene, 1-methyl-3-(phenylmethyl)-	0.1	0.1	trace
1, 1'-Biphenyl, 2-methyl-	0.2	0.2	0.1
Naphthalene, 1,2,3,4-tetramethyl-	0.1	0.1	trace

TABLE C-1. (CONT'D) CHEVROLET SILVERADO SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
Pentadecane, 2,6,10-trimethyl-	0.5	0.6	0.2
Pentadecane, 3-methyl-	0.3	0.3	0.1
Cyclohexane, decyl-	0.1	0.1	0.1
Dodecane, 4,9-dipropyl-	0.3	0.7	0.1
Azulene, 7-ethyl-1,4-dimethyl-	0.1	0.1	0.1
Heptadecane	1.4	2.2	0.8
Azulene, ethyldimethyl-	0.1	0.1	0.1
1-Heptadecene	0.2	0.2	0.1
Pentadecane, 2,6,10,14-tetramethyl-	0.7	0.8	0.4
4,4'-Dimethylbiphenyl	0.1	0.1	0.1
1,1'-Biphenyl, 2,4'-dimethyl-	0.1	0.1	trace
2,2'-Dimethylbiphenyl	0.1	0.1	trace
Heptadecane, 4-methyl-	0.3	0.3	0.1
Dodecane, 4,9-dipropyl-	0.2	0.3	0.1
1,2,3,4,5,6,7,8-Octahydro-1-methylphenanthrene	0.0	trace	trace
Cyclohexane, undecyl-	0.2	0.3	0.1
Phenanthrene, 1,2,3,4-tetrahydro-	0.1	0.1	0.1
Phenanthrene	0.1	0.1	0.1
Octadecane	0.7	1.3	0.5
Hexadecane, 2,6,10,14-tetramethyl-	0.4	0.5	0.2
Phenanthrene, 9,10-dihydro-1-methyl-	trace	trace	trace
Benzene, 1-methyl-3-[(4-methylphenyl)methyl]-	trace	trace	trace
10,11-Dihydro-5H-dibenzo(a,d)cycloheptene	trace	trace	trace
Benzene, 1-methyl-2-(2-phenylethenyl)-	trace	trace	trace
Dodecylcyclohexane	0.1	0.1	trace
Nonadecane	0.4	0.8	0.3
Phenanthrene, 4-methyl-	0.1	0.1	trace
Phenanthrene, 2-methyl-	0.1	0.1	0.1
1,2,5,6-Tetramethylacenaphthylene	trace	trace	trace
Eicosane	0.2	0.4	0.1
2,7-dimethyl phenanthrene	trace	trace	trace
Heneicosane	0.2	0.2	0.1
Pyrene	trace	trace	trace
Docosane	0.2	0.1	0.1

TABLE C-2. DODGE SPRINTER SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
p-Xylene	ND	1.0	0.1
Styrene	ND	0.2	0.8
Benzene, 1,2-dimethyl-	ND	0.5	trace
Nonane	0.2	0.4	0.4
Benzene, propyl-	ND	0.3	0.1
Benzaldehyde	ND	0.1	0.6
Benzene, 1-ethyl-2-methyl-	ND	0.8	0.0
Benzene, 1-ethyl-3-methyl-	ND	0.6	0.1
Benzene, 1,3,5-trimethyl-	ND	1.5	0.1
Indane	ND	0.1	0.4
Benzofuran	ND	ND	0.3
Decane	0.8	1.0	0.9
Benzene, 1-methyl-3-(1-methylethyl)-	ND	trace	0.1
Benzene, trimethyl-	ND	0.2	0.3
Benzene, 1,2,4,5-tetramethyl-	ND	trace	0.1
Indene	ND	trace	0.3
Benzene, 1-methyl-3-propyl-	ND	0.1	0.3
Benzene, tetramethyl-	ND	0.1	0.2
Naphthalene, decahydro-, trans-	ND	0.1	0.2
Benzaldehyde, 4-methyl	5.1	trace	0.5
Benzene, 1-methyl-2-propyl-	ND	trace	0.1
Benzene, ethyl-dimethyl-	ND	0.1	0.2
Benzene, 1-ethyl-3,5-dimethyl-	1.2	0.1	0.3
Thiophene, 2-pentyl	ND	trace	0.1
Benzene, ethyl-dimethyl-	ND	0.1	0.2
Undecane	0.1	1.0	1.5
5-Undecene, (E)-	ND	0.1	0.1
Benzene, 1-methyl-4-(1-methylpropyl)-	ND	trace	0.3
Naphthalene, decahydro-2-methyl-	ND	0.1	0.3
Benzene, 1,2,3,5-tetramethyl-	ND	0.1	0.2
trans-Decalin, 2-methyl-	ND	trace	0.3
Benzene, (2-methyl-1-propenyl)-	ND	trace	0.3
Benzene, methyl-(2-methylpropyl)-	ND	trace	0.2
3-Buten-2-ol, 4-phenyl-	ND	trace	0.2
Naphthalene, decahydro-1-methyl-	ND	ND	ND
Decane, 3,7-dimethyl-	ND	0.1	0.2
Naphthalene, 1,2,3,4-tetrahydro-	ND	ND	0.6
Benzene, 1-methyl-4-(2-methylpropyl)-	ND	ND	0.2
Undecane, 3-methyl-	ND	0.1	0.1
Naphthalene, decahydro-2,3-dimethyl-	ND	ND	0.2
Benzene, methyl-(1-methylpropyl)-	ND	trace	0.2
Napthalene, decahydro-dimethyl-	ND	ND	ND
Benzene, 1-methyl-1-butenyl-	trace	trace	0.1
Naphthalene, decahydro-1,2-dimethyl-	ND	ND	0.1

TABLE C-2. (CONT'D) DODGE SPRINTER SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
Naphthalene	0.6	0.1	1.0
Benzene, (1,1-dimethyl-2-propenyl)-	ND	trace	0.1
1H-Indene, dihydro-dimethyl-	ND	ND	0.1
Benzene, methyl-(1-methylpropyl)-	ND	ND	trace
Naphthalene, decahydro-dimethyl-	ND	ND	0.1
Dodecane	0.1	1.4	1.9
Benzene, 2,4-dimethyl-1-(1-methylethyl)-	ND	trace	0.1
1H-Indene, 2,3-dihydro-1,1-dimethyl-	ND	ND	0.1
Naphthalene, decahydro-2,6-dimethyl-	ND	trace	0.1
Naphthalene, decahydro-1,5-dimethyl-	ND	ND	0.1
Undecane, 2,6-dimethyl-	ND	0.1	0.5
Benzaldehyde, 3,4-dimethyl-	0.4	ND	0.1
Naphthalene, 1,2,3,4-tetrahydro-2-methyl-	ND	trace	0.5
cis-anti-cis-Tricyclo[7.3.0.0(2,6)]-7-dodecene	ND	ND	0.1
Benzene, (1-ethyl-1-methylpropyl)-	ND	ND	0.1
Naphthalene, 1,2,3,4-tetrahydro-1-methyl-	ND	ND	0.4
Naphthalene, 2-ethyldecahydro-	ND	trace	0.1
2-Ethyl-2,3-dihydro-1H-indene	ND	ND	0.1
Benzene, 1,3,5-trimethyl-2-propyl-	ND	ND	0.1
3,5-Dodecadiene, 2-methyl-	ND	ND	ND
Ethyl-dihydro-1H-indene	ND	ND	0.1
Cyclohexane, hexyl-	ND	ND	0.1
Naphthalene, ethyldecahydro-	ND	trace	0.1
3-Dodecene, (Z)-	ND	ND	0.1
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	ND	ND	0.1
Naphthalene, tetrahydro-dimethyl-	ND	ND	0.1
Benzene, dimethyl-(1-methylpropyl)-	ND	ND	trace
Benzene, (1,3-dimethylbutyl)-	ND	ND	0.2
Dodecane, 5-methyl-	ND	ND	0.1
1H-Indene, 2,3-dihydro-4,7-dimethyl-	ND	trace	0.1
Dodecane, 4-methyl-	ND	trace	0.1
Benzene, (1-methylpentyl)-	ND	ND	0.1
Benzene, C6-	ND	ND	0.1
Benzene, hexyl-	ND	ND	0.1
Undecane, 2,3-dimethyl-	ND	0.1	0.3
1H-Indene, 2,3-dihydro-1,3-dimethyl-	ND	ND	0.1
Dodecane, 3-methyl-	ND	ND	0.4
Naphthalene, 1,2,3,4-tetrahydro-6-methyl-	ND	ND	0.8
Undecane, 3,6-dimethyl-	ND	trace	0.4
Naphthalene, ethyltetrahydro-	ND	ND	trace
Naphthalene, 1,2-dihydo-2-methyl-	ND	ND	0.1
Naphthalene, ethyl-tetrahydro-	ND	ND	ND
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	ND	ND	0.1
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	ND	ND	0.1

TABLE C-2. (CONT'D) DODGE SPRINTER SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
6-Tridecene, 7-methyl-	ND	ND	0.1
1,1'-Bicyclohexyl, 2-methyl-, cis-	ND	ND	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,8-dimethyl-	ND	ND	0.1
Tridecane	0.1	0.4	2.8
Naphthalene, tetrahydromethyl-	trace	trace	0.8
Naphthalene, 2-methyl-	trace	trace	1.0
Thiophene, 2-heptyl-	ND	ND	0.1
Cyclohexane, (2-ethyl-1-methyl-1-butenyl)-	ND	ND	0.1
Naphthalene, 6-ethyl-1,2,3,4-tetrahydro-	ND	ND	trace
C2-Naphthalene, 1,2,3,4-tetrahydro-	ND	ND	0.1
Tridecane, 7-methyl-	ND	ND	0.1
1,12-Tridecadiene	ND	ND	ND
3,5-Decadiene, 2,2-dimethyl-, (Z,Z)-	ND	ND	0.1
1H-Indene, 2,3-dihydro-4,5,7-trimethyl-	ND	ND	trace
Benzene, 1-methyl-3-hexyl-	ND	ND	0.1
1,2,3-Trimethylindene	ND	ND	0.1
Tridecane, 3-methyl-	ND	ND	0.4
Naphthalene, 1-methyl-	0.1	trace	0.7
Naphthalene, 1,2,3,4-tetrahydro-1,1,6-trimethyl-	ND	ND	trace
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	ND	trace	1.2
Benzene, cyclohexyl-	ND	ND	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,4-dimethyl-	ND	ND	0.3
Naphthalene, 1,2,3,4-tetrahydro-1-propyl-	ND	ND	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,5-dimethyl-	ND	ND	0.4
Heptylcyclohexane	ND	trace	0.2
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	ND	ND	0.3
Naphthalene, 1,2,3,4-tetrahydro-2,6-dimethyl-	ND	ND	0.3
Benzene, 1-methyl-3-hexyl-	ND	ND	0.1
Tridecane, 4-methyl-	0.8	0.4	0.2
Tridecane, 2-methyl-	ND	0.0	0.3
Naphthalene, tetrahydro-dimethyl-	ND	ND	0.2
Naphthalene, 5-ethyl-1,2,3,4-tetrahydro-	ND	ND	0.5
tert-Butyl-bicyclo(4,3,0)non-3,7-diene	ND	ND	0.1
Tridecane, 3-methyl-	ND	trace	0.2
Dimethyl-cyclopentylbenzene	ND	ND	0.1
1-Methyl-2-n-hexylbenzene	ND	ND	0.1
Dodecane, 2,6,10-trimethyl-	0.9	0.4	0.5
trans-8-tert-Butyl-bicyclo(4,3,0)non-3,7-diene	ND	ND	0.1
1,4-Dimethyl-2-cyclopentylbenzene	ND	ND	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,5,8-trimethyl-	ND	ND	0.1
Biphenyl	0.1	trace	0.2
Acenaphthylene, 1,2,2a,3,4,5-hexahydro-	ND	ND	0.1
2-Methyl-Z-4-tetradecene	ND	ND	0.1
Thiophene, 2-octyl-	ND	ND	trace

TABLE C-2. (CONT'D) DODGE SPRINTER SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
Tetradecane	0.1	0.7	2.4
Naphthalene, 1,2,3,4-tetrahydro-5,6-dimethyl-	trace	ND	0.4
Naphthalene, 2-ethyl-	ND	ND	0.2
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	trace	trace	0.3
Naphthalene, 1-ethyl-	ND	ND	0.1
Thiophene, 2-octyl-	ND	ND	0.1
Naphthalene, 2,7-dimethyl-	ND	ND	0.4
C3-Naphthalene, tetrahydro-	ND	ND	0.1
Benzene, (2,4-cyclopentadien-1-ylidenyl)-	ND	ND	trace
Benzene, 1-cyclohexyl-3-methyl-	ND	ND	0.1
Naphthalene, 1,8-dimethyl-	0.1	ND	0.9
Naphthalene, 1,7-dimethyl-	trace	ND	0.4
Naphthalene, 1,2,3,4-tetrahydro-6,7-dimethyl-	ND	ND	0.2
Naphthalene, tetrahydrodimethyl-	ND	ND	0.1
Naphthalene, 2-ethenyl-	ND	ND	0.1
Naphthalene, 1,4-dimethyl-	ND	ND	0.1
2,5,8-Trimethyl-1,2,3,4-tetrahydronaphthalene	ND	trace	0.2
Cyclohexane, octyl-	ND	ND	0.2
Naphthalene, tetrahydrotrimethyl-	ND	ND	0.2
Naphthalene, dimethyl-	0.0	ND	0.1
Naphthalene, 1,2,3,4-tetrahydro-2,5,8-trimethyl-	ND	ND	0.1
Tetradecane, 4-methyl-	ND	ND	0.2
Tridecane, 2,5-dimethyl-	ND	ND	0.6
Naphthalene, dimethyl-	ND	ND	0.1
Tetradecane, 3-methyl-	ND	ND	0.3
1,1'-Biphenyl, 3-methyl-	trace	ND	0.3
Pentadecane	0.2	0.6	ND
Naphthalene, 2-(1-methylethyl)-	0.1	trace	0.3
Dibenzofuran	0.1	trace	0.1
Naphthalene, trimethyl-	trace	trace	0.2
Naphthalene, 2,3,6-trimethyl-	0.1	trace	0.3
Pentadecane, methyl-	ND	ND	0.2
n-Nonylcyclohexane	ND	ND	0.2
Naphthalene, 1,6,7-trimethyl-	ND	trace	0.2
Naphthalene, trimethyl-	ND	trace	0.2
Pentadecane, 2-methyl-	ND	ND	0.2
Pentadecane, methyl-	ND	ND	0.4
Benzene, nonyl-	0.3	0.1	ND
Hexane, 2-phenyl-3-propyl-	ND	ND	trace
Fluorene	0.1	trace	trace
Hexadecane	0.3	0.4	1.7
Benzene, 1-methyl-3-(phenylmethyl)-	0.1	ND	0.1
1, 1'-Biphenyl, 2-methyl-	0.2	ND	0.2
Naphthalene, 1,2,3,4-tetramethyl-	ND	ND	0.1

TABLE C-2. (CONT'D) DODGE SPRINTER SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
Pentadecane, 2,6,10-trimethyl-	ND	0.1	0.6
Pentadecane, 3-methyl-	ND	ND	0.5
Cyclohexane, decyl-	ND	ND	0.1
Dodecane, 4,9-dipropyl-	ND	ND	0.3
Azulene, 7-ethyl-1,4-dimethyl-	trace	trace	0.1
Heptadecane	0.2	0.5	1.7
Azulene, ethyldimethyl-	0.1	trace	0.1
1-Heptadecene	ND	trace	0.2
Pentadecane, 2,6,10,14-tetramethyl-	ND	0.2	0.7
4,4'-Dimethylbiphenyl	0.4	trace	0.1
1,1'-Biphenyl, 2,4'-dimethyl-	ND	ND	0.1
2,2'-Dimethylbiphenyl	ND	ND	0.1
Heptadecane, 4-methyl-	ND	ND	0.2
Dodecane, 4,9-dipropyl-	ND	ND	0.2
1,2,3,4,5,6,7,8-Octahydro-1-methylphenanthrene	ND	ND	ND
Cyclohexane, undecyl-	ND	0.1	0.2
Phenanthrene, 1,2,3,4-tetrahydro-	0.3	ND	0.1
Phenanthrene	1.0	0.1	0.1
Octadecane	0.2	0.4	0.8
Hexadecane, 2,6,10,14-tetramethyl-	ND	0.3	0.6
Phenanthrene, 9,10-dihydro-1-methyl-	ND	ND	ND
Benzene, 1-methyl-3-[(4-methylphenyl)methyl]-	ND	ND	ND
10,11-Dihydro-5H-dibenzo(a,d)cycloheptene	ND	ND	ND
Benzene, 1-methyl-2-(2-phenylethenyl)-	ND	trace	trace
Dodecylcyclohexane	ND	trace	0.1
Nonadecane	0.1	0.6	0.7
Phenanthrene, 4-methyl-	0.7	0.1	0.1
Phenanthrene, 2-methyl-	0.6	0.1	0.1
1,2,5,6-Tetramethylacenaphthylene	ND	ND	ND
Eicosane	0.1	0.5	0.4
2,7-dimethyl phenanthrene	0.1	trace	0.1
Heneicosane	0.1	0.5	0.2
Pyrene	trace	trace	trace
Docosane	0.2	0.6	0.1

TABLE C-3. FORD F350 SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
p-Xylene	ND	ND	0.9
Styrene	1.6	1.6	1.2
Benzene, 1,2-dimethyl-	ND	ND	0.7
Nonane	1.3	1.4	0.6
Benzene, propyl-	0.0	0.3	0.2
Benzaldehyde	0.8	1.0	0.4
Benzene, 1-ethyl-2-methyl-	ND	0.3	trace
Benzene, 1-ethyl-3-methyl-	ND	0.1	0.2
Benzene, 1,3,5-trimethyl-	ND	0.3	0.3
Indane	0.5	0.5	0.3
Benzofuran	0.4	0.4	0.3
Decane	2.0	2.5	1.3
Benzene, 1-methyl-3-(1-methylethyl)-	0.3	0.4	0.2
Benzene, trimethyl-	0.4	0.7	0.4
Benzene, 1,2,4,5-tetramethyl-	0.1	0.1	0.1
Indene	0.6	0.7	0.4
Benzene, 1-methyl-3-propyl-	0.5	0.8	0.5
Benzene, tetramethyl-	0.3	0.4	0.3
Naphthalene, decahydro-, trans-	0.4	0.6	0.4
Benzaldehyde, 4-methyl	0.8	0.9	0.4
Benzene, 1-methyl-2-propyl-	0.3	0.3	0.3
Benzene, ethyl-dimethyl-	0.3	0.5	0.3
Benzene, 1-ethyl-3,5-dimethyl-	0.5	0.7	0.3
Thiophene, 2-pentyl	0.3	0.4	0.3
Benzene, ethyl-dimethyl-	0.4	0.5	0.3
Undecane	3.5	4.6	2.7
5-Undecene, (E)-	0.4	0.5	0.3
Benzene, 1-methyl-4-(1-methylpropyl)-	0.6	0.7	0.5
Naphthalene, decahydro-2-methyl-	0.7	1.0	0.7
Benzene, 1,2,3,5-tetramethyl-	0.3	0.5	0.3
trans-Decalin, 2-methyl-	0.7	0.9	0.6
Benzene, (2-methyl-1-propenyl)-	0.6	0.9	0.6
Benzene, methyl-(2-methylpropyl)-	0.4	0.5	0.4
3-Buten-2-ol, 4-phenyl-	0.5	0.7	0.5
Naphthalene, decahydro-1-methyl-	0.2	0.3	0.2
Decane, 3,7-dimethyl-	0.6	0.8	0.6
Naphthalene, 1,2,3,4-tetrahydro-	1.3	1.7	1.1
Benzene, 1-methyl-4-(2-methylpropyl)-	0.3	0.5	0.3
Undecane, 3-methyl-	0.4	0.5	0.4
Naphthalene, decahydro-2,3-dimethyl-	0.4	0.6	0.4
Benzene, methyl-(1-methylpropyl)-	0.4	0.6	0.4
Napthalene, decahydro-dimethyl-	0.3	0.4	0.3
Benzene, 1-methyl-1-butenyl-	0.2	0.2	0.1
Naphthalene, decahydro-1,2-dimethyl-	0.3	0.4	0.3

TABLE C-3. (CONT'D) FORD F350 SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
Naphthalene	2.4	2.4	1.5
Benzene, (1,1-dimethyl-2-propenyl)-	0.3	0.4	0.3
1H-Indene, dihydro-dimethyl-	0.2	0.3	0.2
Benzene, methyl-(1-methylpropyl)-	0.1	0.1	0.1
Naphthalene, decahydro-dimethyl-	0.4	0.4	0.3
Dodecane	4.6	6.0	3.7
Benzene, 2,4-dimethyl-1-(1-methylethyl)-	0.2	0.2	0.2
1H-Indene, 2,3-dihydro-1,1-dimethyl-	0.2	0.3	0.2
Naphthalene, decahydro-2,6-dimethyl-	0.1	0.3	0.2
Naphthalene, decahydro-1,5-dimethyl-	0.7	0.7	0.4
Undecane, 2,6-dimethyl-	1.0	1.4	0.9
Benzaldehyde, 3,4-dimethyl-	0.1	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-2-methyl-	1.0	1.3	0.9
cis-anti-cis-Tricyclo[7.3.0.0(2,6)]-7-dodecene	0.2	0.9	0.1
Benzene, (1-ethyl-1-methylpropyl)-	0.2	0.3	0.2
Naphthalene, 1,2,3,4-tetrahydro-1-methyl-	0.8	1.0	0.6
Naphthalene, 2-ethyldecahydro-	0.3	0.4	0.2
2-Ethyl-2,3-dihydro-1H-indene	0.1	0.2	0.1
Benzene, 1,3,5-trimethyl-2-propyl-	0.2	0.2	0.1
3,5-Dodecadiene, 2-methyl-	0.3	0.4	0.3
Ethyl-dihydro-1H-indene	0.1	0.2	0.1
Cyclohexane, hexyl-	0.4	0.5	0.3
Naphthalene, ethyldecahydro-	0.2	0.2	0.1
3-Dodecene, (Z)-	0.2	0.5	0.3
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	0.2	0.2	0.1
Naphthalene, tetrahydro-dimethyl-	0.2	0.2	0.2
Benzene, dimethyl-(1-methylpropyl)-	0.1	0.1	0.1
Benzene, (1,3-dimethylbutyl)-	0.6	0.9	0.8
Dodecane, 5-methyl-	0.2	0.4	0.2
1H-Indene, 2,3-dihydro-4,7-dimethyl-	0.5	0.7	0.4
Dodecane, 4-methyl-	0.3	0.4	0.3
Benzene, (1-methylpentyl)-	0.2	0.2	0.1
Benzene, C6-	0.2	0.3	0.2
Benzene, hexyl-	0.1	0.2	0.1
Undecane, 2,3-dimethyl-	0.9	1.2	0.7
1H-Indene, 2,3-dihydro-1,3-dimethyl-	0.3	0.4	0.3
Dodecane, 3-methyl-	0.5	0.7	0.4
Naphthalene, 1,2,3,4-tetrahydro-6-methyl-	2.2	3.3	1.9
Undecane, 3,6-dimethyl-	0.9	1.2	0.8
Naphthalene, ethyltetrahydro-	trace	0.1	trace
Naphthalene, 1,2-dihydo-2-methyl-	0.2	0.2	0.1
Naphthalene, ethyl-tetrahydro-	trace	trace	trace
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	0.2	0.3	0.2
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	0.1	0.1	0.1

TABLE C-3. (CONT'D) FORD F350 SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
6-Tridecene, 7-methyl-	0.4	0.5	0.5
1,1'-Bicyclohexyl, 2-methyl-, cis-	0.4	0.5	0.4
Naphthalene, 1,2,3,4-tetrahydro-1,8-dimethyl-	0.3	0.4	0.3
Tridecane	6.6	8.5	5.4
Naphthalene, tetrahydromethyl-	2.9	3.8	2.3
Naphthalene, 2-methyl-	1.9	2.1	1.2
Thiophene, 2-heptyl-	0.1	0.2	0.1
Cyclohexane, (2-ethyl-1-methyl-1-butenyl)-	0.2	0.2	0.1
Naphthalene, 6-ethyl-1,2,3,4-tetrahydro-	0.1	0.2	0.1
C2-Naphthalene, 1,2,3,4-tetrahydro-	0.3	0.4	0.2
Tridecane, 7-methyl-	0.2	0.5	0.3
1,12-Tridecadiene	trace	ND	ND
3,5-Decadiene, 2,2-dimethyl-, (Z,Z)-	0.3	0.6	0.3
1H-Indene, 2,3-dihydro-4,5,7-trimethyl-	0.1	0.1	trace
Benzene, 1-methyl-3-hexyl-	0.1	0.1	0.1
1,2,3-Trimethylindene	0.2	0.3	0.2
Tridecane, 3-methyl-	0.8	1.2	0.6
Naphthalene, 1-methyl-	1.2	1.3	0.7
Naphthalene, 1,2,3,4-tetrahydro-1,1,6-trimethyl-	0.2	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	2.4	3.2	1.8
Benzene, cyclohexyl-	0.5	0.6	0.4
Naphthalene, 1,2,3,4-tetrahydro-1,4-dimethyl-	0.6	1.1	0.5
Naphthalene, 1,2,3,4-tetrahydro-1-propyl-	0.2	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,5-dimethyl-	1.0	1.5	0.8
Heptylcyclohexane	0.8	1.2	0.8
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	0.8	1.0	0.6
Naphthalene, 1,2,3,4-tetrahydro-2,6-dimethyl-	0.8	1.1	0.6
Benzene, 1-methyl-3-hexyl-	0.4	0.5	0.3
Tridecane, 4-methyl-	0.7	0.8	0.5
Tridecane, 2-methyl-	1.1	1.1	1.0
Naphthalene, tetrahydro-dimethyl-	0.5	0.7	0.4
Naphthalene, 5-ethyl-1,2,3,4-tetrahydro-	2.0	2.7	1.5
tert-Butyl-bicyclo(4,3,0)non-3,7-diene	0.2	0.2	0.2
Tridecane, 3-methyl-	1.1	1.4	1.2
Dimethyl-cyclopentylbenzene	0.2	0.3	0.2
1-Methyl-2-n-hexylbenzene	0.2	0.2	0.1
Dodecane, 2,6,10-trimethyl-	1.4	1.5	1.2
trans-8-tert-Butyl-bicyclo(4,3,0)non-3,7-diene	0.5	0.6	0.4
1,4-Dimethyl-2-cyclopentylbenzene	0.5	0.3	0.3
Naphthalene, 1,2,3,4-tetrahydro-1,5,8-trimethyl-	0.2	0.4	0.2
Biphenyl	0.5	0.6	0.4
Acenaphthylene, 1,2,2a,3,4,5-hexahydro-	0.2	0.2	0.1
2-Methyl-Z-4-tetradecene	0.4	0.5	0.4
Thiophene, 2-octyl-	0.1	0.1	0.1

TABLE C-3. (CONT'D) FORD F350 SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
Tetradecane	5.7	7.4	4.8
Naphthalene, 1,2,3,4-tetrahydro-5,6-dimethyl-	1.6	2.1	1.4
Naphthalene, 2-ethyl-	0.4	0.5	0.3
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	1.2	3.9	0.8
Naphthalene, 1-ethyl-	0.3	0.4	0.2
Thiophene, 2-octyl-	0.2	0.3	0.2
Naphthalene, 2,7-dimethyl-	0.8	0.9	0.6
C3-Naphthalene, tetrahydro-	0.3	0.4	0.2
Benzene, (2,4-cyclopentadien-1-ylidenyl)-	0.1	0.1	trace
Benzene, 1-cyclohexyl-3-methyl-	0.2	0.3	0.2
Naphthalene, 1,8-dimethyl-	1.5	1.8	1.1
Naphthalene, 1,7-dimethyl-	0.6	0.7	0.4
Naphthalene, 1,2,3,4-tetrahydro-6,7-dimethyl-	0.3	0.4	0.3
Naphthalene, tetrahydrodimethyl-	0.5	0.7	0.4
Naphthalene, 2-ethenyl-	0.2	0.2	0.1
Naphthalene, 1,4-dimethyl-	0.4	0.4	0.3
2,5,8-Trimethyl-1,2,3,4-tetrahydronaphthalene	0.4	0.5	0.3
Cyclohexane, octyl-	0.4	0.5	0.4
Naphthalene, tetrahydrotrimethyl-	0.5	0.6	0.4
Naphthalene, dimethyl-	0.3	0.4	0.3
Naphthalene, 1,2,3,4-tetrahydro-2,5,8-trimethyl-	0.5	0.6	0.4
Tetradecane, 4-methyl-	0.4	0.5	0.4
Tridecane, 2,5-dimethyl-	1.6	1.8	1.4
Naphthalene, dimethyl-	0.4	0.4	0.3
Tetradecane, 3-methyl-	0.8	1.0	0.8
1,1'-Biphenyl, 3-methyl-	0.6	0.6	0.4
Pentadecane	5.3	6.6	4.5
Naphthalene, 2-(1-methylethyl)-	0.6	0.7	0.4
Dibenzofuran	0.2	0.2	0.1
Naphthalene, trimethyl-	0.5	0.7	0.3
Naphthalene, 2,3,6-trimethyl-	1.2	1.6	0.9
Pentadecane, methyl-	0.3	0.4	0.2
n-Nonylcyclohexane	0.5	0.7	0.4
Naphthalene, 1,6,7-trimethyl-	0.5	0.6	0.4
Naphthalene, trimethyl-	0.6	0.9	0.6
Pentadecane, 2-methyl-	0.6	0.6	0.5
Pentadecane, methyl-	1.4	1.7	1.4
Benzene, nonyl-	0.3	0.3	0.2
Hexane, 2-phenyl-3-propyl-	0.1	0.1	0.1
Fluorene	0.2	0.2	0.1
Hexadecane	4.2	5.2	3.7
Benzene, 1-methyl-3-(phenylmethyl)-	0.3	0.3	0.2
1, 1'-Biphenyl, 2-methyl-	0.5	0.6	0.4
Naphthalene, 1,2,3,4-tetramethyl-	0.1	0.2	0.1

TABLE C-3. (CONT'D) FORD F350 SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
Pentadecane, 2,6,10-trimethyl-	1.0	1.1	1.0
Pentadecane, 3-methyl-	3.0	2.4	1.7
Cyclohexane, decyl-	0.2	0.3	0.3
Dodecane, 4,9-dipropyl-	0.8	0.6	0.6
Azulene, 7-ethyl-1,4-dimethyl-	0.3	0.3	0.2
Heptadecane	3.4	4.0	3.0
Azulene, ethyldimethyl-	0.3	0.4	0.3
1-Heptadecene	0.3	0.4	0.3
Pentadecane, 2,6,10,14-tetramethyl-	1.2	1.5	1.2
4,4'-Dimethylbiphenyl	0.3	0.3	0.2
1,1'-Biphenyl, 2,4'-dimethyl-	0.1	0.1	0.1
2,2'-Dimethylbiphenyl	0.1	0.2	0.1
Heptadecane, 4-methyl-	0.5	0.6	0.7
Dodecane, 4,9-dipropyl-	0.9	1.1	1.0
1,2,3,4,5,6,7,8-Octahydro-1-methylphenanthrene	0.1	0.1	trace
Cyclohexane, undecyl-	0.4	0.5	0.3
Phenanthrene, 1,2,3,4-tetrahydro-	0.1	0.2	0.1
Phenanthrene	0.3	0.3	0.3
Octadecane	1.9	2.2	1.6
Hexadecane, 2,6,10,14-tetramethyl-	1.0	1.3	1.0
Phenanthrene, 9,10-dihydro-1-methyl-	0.1	0.1	0.1
Benzene, 1-methyl-3-[(4-methylphenyl)methyl]-	0.1	0.1	trace
10,11-Dihydro-5H-dibenzo(a,d)cycloheptene	0.1	0.1	0.1
Benzene, 1-methyl-2-(2-phenylethenyl)-	0.1	0.1	0.1
Dodecylcyclohexane	0.1	0.1	0.1
Nonadecane	1.2	1.4	1.0
Phenanthrene, 4-methyl-	0.2	0.2	0.2
Phenanthrene, 2-methyl-	0.2	0.2	0.2
1,2,5,6-Tetramethylacenaphthylene	trace	0.1	trace
Eicosane	0.6	0.8	0.5
2,7-dimethyl phenanthrene	0.1	0.1	0.2
Heneicosane	0.4	0.6	0.5
Pyrene	0.2	0.1	0.1
Docosane	0.3	0.4	0.2

TABLE C-4. VOLKSWAGEN JETTA SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
p-Xylene	1.4	0.9	0.2
Styrene	3.4	2.4	0.6
Benzene, 1,2-dimethyl-	0.9	0.6	0.1
Nonane	0.8	0.6	0.2
Benzene, propyl-	0.6	0.4	trace
Benzaldehyde	2.7	1.8	0.4
Benzene, 1-ethyl-2-methyl-	0.9	0.5	ND
Benzene, 1-ethyl-3-methyl-	0.5	0.3	ND
Benzene, 1,3,5-trimethyl-	1.3	0.7	ND
Indane	1.4	0.9	0.2
Benzofuran	1.2	0.8	0.2
Decane	1.6	1.1	0.4
Benzene, 1-methyl-3-(1-methylethyl)-	0.3	0.2	0.1
Benzene, trimethyl-	0.6	0.4	0.1
Benzene, 1,2,4,5-tetramethyl-	0.2	0.1	trace
Indene	1.7	1.1	0.3
Benzene, 1-methyl-3-propyl-	0.7	0.4	0.1
Benzene, tetramethyl-	0.4	0.3	0.1
Naphthalene, decahydro-, trans-	0.3	0.2	0.1
Benzaldehyde, 4-methyl	2.0	1.2	0.3
Benzene, 1-methyl-2-propyl-	0.4	0.2	0.1
Benzene, ethyl-dimethyl-	0.4	0.3	0.1
Benzene, 1-ethyl-3,5-dimethyl-	0.9	0.5	0.1
Thiophene, 2-pentyl	0.2	0.1	trace
Benzene, ethyl-dimethyl-	0.4	0.3	0.1
Undecane	2.2	1.6	0.6
5-Undecene, (E)-	0.2	0.2	0.1
Benzene, 1-methyl-4-(1-methylpropyl)-	0.6	0.4	0.1
Naphthalene, decahydro-2-methyl-	0.5	0.4	0.1
Benzene, 1,2,3,5-tetramethyl-	0.3	0.2	0.1
trans-Decalin, 2-methyl-	0.4	0.3	0.1
Benzene, (2-methyl-1-propenyl)-	0.6	0.4	0.1
Benzene, methyl-(2-methylpropyl)-	0.4	0.3	0.1
3-Buten-2-ol, 4-phenyl-	0.4	0.3	0.1
Naphthalene, decahydro-1-methyl-	0.2	0.1	ND
Decane, 3,7-dimethyl-	0.3	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-	1.1	0.7	0.3
Benzene, 1-methyl-4-(2-methylpropyl)-	0.3	0.2	0.1
Undecane, 3-methyl-	0.2	0.1	0.1
Naphthalene, decahydro-2,3-dimethyl-	0.3	0.2	0.1
Benzene, methyl-(1-methylpropyl)-	0.4	0.3	0.1
Napthalene, decahydro-dimethyl-	0.2	0.2	ND
Benzene, 1-methyl-1-butenyl-	0.2	0.1	trace
Naphthalene, decahydro-1,2-dimethyl-	0.3	0.2	0.1

TABLE C-4. (CONT'D) VOLKSWAGEN JETTA SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
Naphthalene	4.1	2.8	0.8
Benzene, (1,1-dimethyl-2-propenyl)-	0.3	0.2	0.1
1H-Indene, dihydro-dimethyl-	0.2	0.1	trace
Benzene, methyl-(1-methylpropyl)-	0.1	0.1	trace
Naphthalene, decahydro-dimethyl-	0.1	0.1	ND
Dodecane	2.5	1.8	0.7
Benzene, 2,4-dimethyl-1-(1-methylethyl)-	0.2	0.1	trace
1H-Indene, 2,3-dihydro-1,1-dimethyl-	0.3	0.2	0.1
Naphthalene, decahydro-2,6-dimethyl-	0.2	0.1	0.0
Naphthalene, decahydro-1,5-dimethyl-	0.2	0.1	0.1
Undecane, 2,6-dimethyl-	0.8	0.6	0.2
Benzaldehyde, 3,4-dimethyl-	0.3	0.2	trace
Naphthalene, 1,2,3,4-tetrahydro-2-methyl-	1.1	0.7	0.2
cis-anti-cis-Tricyclo[7.3.0.0(2,6)]-7-dodecene	0.3	0.1	0.1
Benzene, (1-ethyl-1-methylpropyl)-	0.2	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-1-methyl-	0.8	0.5	0.2
Naphthalene, 2-ethyldecahydro-	0.2	0.1	0.1
2-Ethyl-2,3-dihydro-1H-indene	0.2	0.1	trace
Benzene, 1,3,5-trimethyl-2-propyl-	0.1	0.1	trace
3,5-Dodecadiene, 2-methyl-	0.2	0.2	0.1
Ethyl-dihydro-1H-indene	0.1	0.1	trace
Cyclohexane, hexyl-	0.3	0.2	0.1
Naphthalene, ethyldecahydro-	0.1	0.1	trace
3-Dodecene, (Z)-	0.3	0.1	0.1
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	0.2	0.1	trace
Naphthalene, tetrahydro-dimethyl-	0.2	0.1	trace
Benzene, dimethyl-(1-methylpropyl)-	0.1	trace	trace
Benzene, (1,3-dimethylbutyl)-	0.3	0.2	0.1
Dodecane, 5-methyl-	0.2	0.1	trace
1H-Indene, 2,3-dihydro-4,7-dimethyl-	0.3	0.2	0.1
Dodecane, 4-methyl-	0.2	0.1	trace
Benzene, (1-methylpentyl)-	0.1	0.1	trace
Benzene, C6-	0.2	0.2	trace
Benzene, hexyl-	0.2	0.1	trace
Undecane, 2,3-dimethyl-	0.5	0.3	0.1
1H-Indene, 2,3-dihydro-1,3-dimethyl-	0.3	0.2	0.1
Dodecane, 3-methyl-	0.3	0.2	0.2
Naphthalene, 1,2,3,4-tetrahydro-6-methyl-	1.6	1.0	0.3
Undecane, 3,6-dimethyl-	0.5	0.3	0.1
Naphthalene, ethyltetrahydro-	trace	trace	trace
Naphthalene, 1,2-dihydo-2-methyl-	0.5	0.3	0.1
Naphthalene, ethyl-tetrahydro-	trace	trace	trace
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	0.2	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	0.1	0.1	trace

TABLE C-4. (CONT'D) VOLKSWAGEN JETTA SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
6-Tridecene, 7-methyl-	0.2	0.1	trace
1,1'-Bicyclohexyl, 2-methyl-, cis-	0.3	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,8-dimethyl-	0.3	0.2	trace
Tridecane	4.3	2.9	1.2
Naphthalene, tetrahydromethyl-	1.6	1.1	0.3
Naphthalene, 2-methyl-	3.6	2.2	0.6
Thiophene, 2-heptyl-	0.1	0.1	trace
Cyclohexane, (2-ethyl-1-methyl-1-butenyl)-	0.2	0.1	ND
Naphthalene, 6-ethyl-1,2,3,4-tetrahydro-	0.1	0.1	trace
C2-Naphthalene, 1,2,3,4-tetrahydro-	0.2	0.2	trace
Tridecane, 7-methyl-	0.1	0.1	trace
1,12-Tridecadiene	0.8	ND	trace
3,5-Decadiene, 2,2-dimethyl-, (Z,Z)-	0.1	0.1	trace
1H-Indene, 2,3-dihydro-4,5,7-trimethyl-	0.1	trace	trace
Benzene, 1-methyl-3-hexyl-	0.1	0.1	trace
1,2,3-Trimethylindene	0.6	0.3	0.1
Tridecane, 3-methyl-	0.5	0.4	0.2
Naphthalene, 1-methyl-	2.3	1.4	0.4
Naphthalene, 1,2,3,4-tetrahydro-1,1,6-trimethyl-	0.1	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	0.9	0.5	0.2
Benzene, cyclohexyl-	0.4	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,4-dimethyl-	0.6	0.4	0.1
Naphthalene, 1,2,3,4-tetrahydro-1-propyl-	0.2	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-1,5-dimethyl-	0.8	0.5	0.2
Heptylcyclohexane	0.5	0.4	0.1
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	0.7	0.4	0.1
Naphthalene, 1,2,3,4-tetrahydro-2,6-dimethyl-	0.7	0.5	0.2
Benzene, 1-methyl-3-hexyl-	0.2	0.1	trace
Tridecane, 4-methyl-	0.4	0.3	0.1
Tridecane, 2-methyl-	0.4	0.3	0.1
Naphthalene, tetrahydro-dimethyl-	0.3	0.2	0.1
Naphthalene, 5-ethyl-1,2,3,4-tetrahydro-	1.1	0.7	0.3
tert-Butyl-bicyclo(4,3,0)non-3,7-diene	0.2	0.1	trace
Tridecane, 3-methyl-	0.4	0.2	0.1
Dimethyl-cyclopentylbenzene	0.2	0.1	trace
1-Methyl-2-n-hexylbenzene	0.2	0.1	trace
Dodecane, 2,6,10-trimethyl-	0.9	0.6	0.2
trans-8-tert-Butyl-bicyclo(4,3,0)non-3,7-diene	0.3	0.2	0.1
1,4-Dimethyl-2-cyclopentylbenzene	0.3	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-1,5,8-trimethyl-	0.2	0.1	trace
Biphenyl	0.8	0.5	0.1
Acenaphthylene, 1,2,2a,3,4,5-hexahydro-	0.1	0.1	trace
2-Methyl-Z-4-tetradecene	0.3	0.2	0.1
Thiophene, 2-octyl-	0.1	trace	trace

TABLE C-4. (CONT'D) VOLKSWAGEN JETTA SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
Tetradecane	3.5	2.3	1.0
Naphthalene, 1,2,3,4-tetrahydro-5,6-dimethyl-	1.2	0.9	0.3
Naphthalene, 2-ethyl-	0.7	0.5	0.1
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	0.6	0.3	0.1
Naphthalene, 1-ethyl-	0.4	0.3	0.1
Thiophene, 2-octyl-	0.1	0.1	0.0
Naphthalene, 2,7-dimethyl-	1.2	0.8	0.2
C3-Naphthalene, tetrahydro-	0.2	0.1	trace
Benzene, (2,4-cyclopentadien-1-ylidenyl)-	0.1	0.1	trace
Benzene, 1-cyclohexyl-3-methyl-	0.2	0.1	trace
Naphthalene, 1,8-dimethyl-	2.5	1.6	0.5
Naphthalene, 1,7-dimethyl-	1.1	0.7	0.2
Naphthalene, 1,2,3,4-tetrahydro-6,7-dimethyl-	0.3	0.2	0.1
Naphthalene, tetrahydrodimethyl-	0.3	0.2	0.1
Naphthalene, 2-ethenyl-	0.6	0.4	0.1
Naphthalene, 1,4-dimethyl-	0.6	0.4	0.1
2,5,8-Trimethyl-1,2,3,4-tetrahydronaphthalene	0.4	0.2	0.1
Cyclohexane, octyl-	0.3	0.2	0.1
Naphthalene, tetrahydrotrimethyl-	0.3	0.2	0.1
Naphthalene, dimethyl-	0.2	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-2,5,8-trimethyl-	0.2	0.2	trace
Tetradecane, 4-methyl-	0.3	0.2	0.1
Tridecane, 2,5-dimethyl-	0.7	0.5	0.2
Naphthalene, dimethyl-	0.4	0.3	0.1
Tetradecane, 3-methyl-	0.6	0.4	0.1
1,1'-Biphenyl, 3-methyl-	0.8	0.5	0.2
Pentadecane	3.2	2.3	1.0
Naphthalene, 2-(1-methylethyl)-	1.2	0.7	0.1
Dibenzofuran	0.4	0.3	0.1
Naphthalene, trimethyl-	0.5	0.4	0.1
Naphthalene, 2,3,6-trimethyl-	1.1	0.7	0.2
Pentadecane, methyl-	0.3	0.1	0.1
n-Nonylcyclohexane	0.3	0.2	0.1
Naphthalene, 1,6,7-trimethyl-	0.7	0.4	0.2
Naphthalene, trimethyl-	0.6	0.3	0.1
Pentadecane, 2-methyl-	0.3	0.2	0.1
Pentadecane, methyl-	0.5	0.3	0.2
Benzene, nonyl-	0.2	0.1	0.1
Hexane, 2-phenyl-3-propyl-	0.1	0.1	trace
Fluorene	0.1	0.1	trace
Hexadecane	2.7	2.0	0.8
Benzene, 1-methyl-3-(phenylmethyl)-	0.3	0.2	0.1
1, 1'-Biphenyl, 2-methyl-	0.6	0.4	0.2
Naphthalene, 1,2,3,4-tetramethyl-	0.1	0.1	trace

TABLE C-4. (CONT'D) VOLKSWAGEN JETTA SEMI-VOLATILE (TRANSIENT CYCLES)			
Compound	mg/mi		
	Cold	Hot	US06
Pentadecane, 2,6,10-trimethyl-	0.8	0.5	0.3
Pentadecane, 3-methyl-	0.6	0.6	0.3
Cyclohexane, decyl-	0.2	0.1	0.1
Dodecane, 4,9-dipropyl-	0.4	0.5	0.2
Azulene, 7-ethyl-1,4-dimethyl-	0.3	0.2	0.1
Heptadecane	2.1	1.8	0.8
Azulene, ethyldimethyl-	0.3	0.2	0.1
1-Heptadecene	0.3	0.2	0.1
Pentadecane, 2,6,10,14-tetramethyl-	1.0	0.8	0.4
4,4'-Dimethylbiphenyl	0.4	0.3	0.1
1,1'-Biphenyl, 2,4'-dimethyl-	0.2	0.1	0.1
2,2'-Dimethylbiphenyl	0.2	0.1	0.1
Heptadecane, 4-methyl-	0.3	0.3	0.1
Dodecane, 4,9-dipropyl-	0.3	0.3	0.1
1,2,3,4,5,6,7,8-Octahydro-1-methylphenanthrene	0.1	0.1	trace
Cyclohexane, undecyl-	0.3	0.3	0.1
Phenanthrene, 1,2,3,4-tetrahydro-	0.3	0.2	0.1
Phenanthrene	0.6	0.5	0.2
Octadecane	1.1	1.1	0.4
Hexadecane, 2,6,10,14-tetramethyl-	0.7	0.7	0.3
Phenanthrene, 9,10-dihydro-1-methyl-	0.1	0.1	trace
Benzene, 1-methyl-3-[(4-methylphenyl)methyl]-	0.1	0.1	trace
10,11-Dihydro-5H-dibenzo(a,d)cycloheptene	0.1	0.1	trace
Benzene, 1-methyl-2-(2-phenylethenyl)-	0.1	0.1	trace
Dodecylcyclohexane	0.1	0.1	trace
Nonadecane	0.6	0.7	0.2
Phenanthrene, 4-methyl-	0.2	0.2	0.1
Phenanthrene, 2-methyl-	0.3	0.3	0.1
1,2,5,6-Tetramethylacenaphthylene	trace	trace	trace
Eicosane	0.3	0.4	0.1
2,7-dimethyl phenanthrene	0.1	0.1	trace
Heneicosane	0.2	0.2	trace
Pyrene	0.1	trace	trace
Docosane	0.1	0.2	trace

APPENDIX D

SEMI-VOLATILE HYDROCARBON SPECIATION DATA FOR STEADY-STATE MODES

TABLE D-1. CHEVROLET SILVERADO SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
p-Xylene	0.3	0.8	0.2	0.3	0.2
Styrene	0.3	1.3	0.2	0.8	0.1
Benzene, 1,2-dimethyl-	ND	0.3	0.1	0.2	0.1
Nonane	0.2	0.7	0.3	0.2	0.2
Benzene, propyl-	ND	0.3	0.2	0.3	0.1
Benzaldehyde	0.4	1.9	0.2	1.3	0.1
Benzene, 1-ethyl-2-methyl-	ND	0.4	0.3	0.5	0.2
Benzene, 1-ethyl-3-methyl-	ND	0.3	0.2	0.4	0.1
Benzene, 1,3,5-trimethyl-	ND	0.6	0.6	0.9	0.2
Indane	ND	0.5	0.1	0.4	0.1
Benzofuran	0.1	0.7	0.1	0.6	0.1
Decane	0.2	1.3	0.7	0.6	0.3
Benzene, 1-methyl-3-(1-methylethyl)-	trace	0.2	0.1	0.1	trace
Benzene, trimethyl-	ND	0.3	0.1	0.2	0.1
Benzene, 1,2,4,5-tetramethyl-	0.1	0.1	trace	trace	trace
Indene	trace	0.4	trace	0.3	0.1
Benzene, 1-methyl-3-propyl-	trace	0.3	0.1	0.1	0.1
Benzene, tetramethyl-	trace	0.2	0.1	0.1	0.1
Naphthalene, decahydro-, trans-	trace	0.2	0.1	0.1	0.1
Benzaldehyde, 4-methyl	0.1	0.8	0.1	0.4	0.1
Benzene, 1-methyl-2-propyl-	ND	0.2	0.1	0.1	trace
Benzene, ethyl-dimethyl-	trace	0.2	0.1	0.1	0.1
Benzene, 1-ethyl-3,5-dimethyl-	trace	0.4	0.1	0.2	0.1
Thiophene, 2-pentyl	ND	0.1	0.1	0.1	trace
Benzene, ethyl-dimethyl-	trace	0.2	0.1	0.1	0.1
Undecane	0.3	1.7	0.9	0.7	0.5
5-Undecene, (E)-	trace	0.2	0.1	0.1	trace
Benzene, 1-methyl-4-(1-methylpropyl)-	trace	0.3	0.1	0.1	0.1
Naphthalene, decahydro-2-methyl-	trace	0.4	0.2	0.2	0.1
Benzene, 1,2,3,5-tetramethyl-	trace	0.2	0.1	0.1	0.1
trans-Decalin, 2-methyl-	ND	0.3	0.1	0.1	0.1
Benzene, (2-methyl-1-propenyl)-	trace	0.3	0.1	0.1	0.1
Benzene, methyl-(2-methylpropyl)-	trace	0.2	0.1	0.1	trace
3-Buten-2-ol, 4-phenyl-	trace	0.2	0.1	0.1	0.1
Naphthalene, decahydro-1-methyl-	ND	0.1	0.1	0.1	trace
Decane, 3,7-dimethyl-	0.1	0.2	0.1	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-	0.1	0.5	0.2	0.2	0.1
Benzene, 1-methyl-4-(2-methylpropyl)-	ND	0.2	0.1	0.1	trace
Undecane, 3-methyl-	trace	0.1	0.1	0.1	trace
Naphthalene, decahydro-2,3-dimethyl-	ND	0.2	0.1	0.1	0.1
Benzene, methyl-(1-methylpropyl)-	trace	0.2	0.1	0.1	0.1
Napthalene, decahydro-dimethyl-	ND	0.1	0.1	0.1	0.1
Benzene, 1-methyl-1-butenyl-	ND	0.1	trace	trace	trace
Naphthalene, decahydro-1,2-dimethyl-	ND	0.1	0.1	0.1	trace

TABLE D-1. (CONT'D) CHEVROLET SILVERADO SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
Naphthalene	0.2	2.0	0.3	1.1	0.2
Benzene, (1,1-dimethyl-2-propenyl)-	trace	0.1	trace	0.1	0.0
1H-Indene, dihydro-dimethyl-	ND	0.1	trace	trace	trace
Benzene, methyl-(1-methylpropyl)-	ND	trace	trace	trace	trace
Naphthalene, decahydro-dimethyl-	ND	trace	trace	trace	trace
Dodecane	0.3	1.8	1.0	0.8	0.5
Benzene, 2,4-dimethyl-1-(1-methylethyl)-	ND	0.1	trace	trace	trace
1H-Indene, 2,3-dihydro-1,1-dimethyl-	trace	0.1	0.1	0.1	trace
Naphthalene, decahydro-2,6-dimethyl-	ND	0.1	trace	trace	trace
Naphthalene, decahydro-1,5-dimethyl-	ND	0.1	0.1	0.1	trace
Undecane, 2,6-dimethyl-	0.1	0.5	0.3	0.2	0.1
Benzaldehyde, 3,4-dimethyl-	ND	0.1	trace	trace	trace
Naphthalene, 1,2,3,4-tetrahydro-2-methyl-	trace	0.4	0.2	0.2	0.1
cis-anti-cis-Tricyclo[7.3.0.0(2,6)]-7-dodecene	ND	0.2	trace	0.1	trace
Benzene, (1-ethyl-1-methylpropyl)-	ND	0.1	0.1	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-1-methyl-	trace	0.3	0.2	0.2	0.1
Naphthalene, 2-ethyldecahydro-	ND	0.1	0.1	0.1	trace
2-Ethyl-2,3-dihydro-1H-indene	ND	0.2	trace	trace	trace
Benzene, 1,3,5-trimethyl-2-propyl-	ND	0.1	trace	trace	trace
3,5-Dodecadiene, 2-methyl-	ND	0.1	0.1	0.1	trace
Ethyl-dihydro-1H-indene	ND	0.1	trace	trace	trace
Cyclohexane, hexyl-	trace	0.2	0.1	0.1	trace
Naphthalene, ethyldecahydro-	ND	0.1	trace	trace	trace
3-Dodecene, (Z)-	ND	0.1	0.1	0.1	trace
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	ND	0.1	trace	trace	trace
Naphthalene, tetrahydro-dimethyl-	ND	0.1	trace	trace	trace
Benzene, dimethyl-(1-methylpropyl)-	ND	trace	trace	trace	trace
Benzene, (1,3-dimethylbutyl)-	ND	0.2	0.1	0.1	0.1
Dodecane, 5-methyl-	ND	0.1	trace	trace	trace
1H-Indene, 2,3-dihydro-4,7-dimethyl-	trace	0.1	0.1	0.1	trace
Dodecane, 4-methyl-	ND	0.1	0.1	0.1	trace
Benzene, (1-methylpentyl)-	ND	0.1	trace	trace	trace
Benzene, C6-	ND	0.1	trace	trace	trace
Benzene, hexyl-	ND	0.1	trace	trace	trace
Undecane, 2,3-dimethyl-	trace	0.3	0.2	0.2	0.1
1H-Indene, 2,3-dihydro-1,3-dimethyl-	ND	0.1	0.1	0.1	trace
Dodecane, 3-methyl-	trace	0.2	0.1	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-6-methyl-	0.1	1.0	0.3	0.3	0.2
Undecane, 3,6-dimethyl-	trace	0.3	0.2	0.2	0.1
Naphthalene, ethyltetrahydro-	ND	trace	trace	trace	trace
Naphthalene, 1,2-dihydo-2-methyl-	ND	trace	trace	trace	trace
Naphthalene, ethyl-tetrahydro-	ND	ND	0.0	ND	ND
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	ND	0.1	trace	trace	trace
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	ND	trace	trace	trace	trace

TABLE D-1 (CONT'D)CHEVROLET SILVERADO SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
6-Tridecene, 7-methyl-	ND	0.1	trace	0.1	trace
1,1'-Bicyclohexyl, 2-methyl-, cis-	ND	0.1	0.1	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-1,8-dimethyl-	trace	0.1	0.1	0.1	trace
Tridecane	0.4	2.6	1.5	1.3	0.8
Naphthalene, tetrahydromethyl-	0.1	0.6	0.3	0.3	0.2
Naphthalene, 2-methyl-	0.1	1.0	0.2	0.6	0.2
Thiophene, 2-heptyl-	ND	trace	trace	trace	trace
Cyclohexane, (2-ethyl-1-methyl-1-butenyl)-	ND	trace	trace	trace	trace
Naphthalene, 6-ethyl-1,2,3,4-tetrahydro-	ND	trace	trace	trace	trace
C2-Naphthalene, 1,2,3,4-tetrahydro-	ND	0.1	0.1	0.1	trace
Tridecane, 7-methyl-	ND	0.1	trace	trace	trace
1,12-Tridecadiene	ND	0.4	trace	trace	trace
3,5-Decadiene, 2,2-dimethyl-, (Z,Z)-	ND	trace	trace	trace	trace
1H-Indene, 2,3-dihydro-4,5,7-trimethyl-	ND	trace	trace	trace	trace
Benzene, 1-methyl-3-hexyl-	ND	0.1	trace	trace	trace
1,2,3-Trimethylindene	ND	trace	trace	trace	trace
Tridecane, 3-methyl-	trace	0.3	0.1	0.2	0.1
Naphthalene, 1-methyl-	0.1	0.6	0.1	0.4	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,1,6-trimethyl-	ND	trace	trace	trace	trace
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	0.1	1.0	0.2	0.5	0.1
Benzene, cyclohexyl-	trace	0.2	0.1	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-1,4-dimethyl-	trace	0.3	0.1	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-1-propyl-	ND	0.1	trace	trace	trace
Naphthalene, 1,2,3,4-tetrahydro-1,5-dimethyl-	trace	0.4	0.2	0.2	0.1
Heptylcyclohexane	trace	0.3	0.2	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	trace	0.3	0.1	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-2,6-dimethyl-	ND	0.3	0.2	0.2	0.1
Benzene, 1-methyl-3-hexyl-	ND	0.1	0.0	0.0	trace
Tridecane, 4-methyl-	ND	0.2	0.1	0.1	0.1
Tridecane, 2-methyl-	trace	0.2	0.1	0.1	0.1
Naphthalene, tetrahydro-dimethyl-	ND	0.1	0.1	0.1	trace
Naphthalene, 5-ethyl-1,2,3,4-tetrahydro-	0.1	0.5	0.2	0.2	0.2
tert-Butyl-bicyclo(4,3,0)non-3,7-diene	ND	0.1	trace	trace	trace
Tridecane, 3-methyl-	trace	0.2	0.1	0.1	0.1
Dimethyl-cyclopentylbenzene	ND	0.1	trace	trace	trace
1-Methyl-2-n-hexylbenzene	ND	0.1	trace	trace	trace
Dodecane, 2,6,10-trimethyl-	ND	0.4	0.3	0.3	0.2
trans-8-tert-Butyl-bicyclo(4,3,0)non-3,7-diene	ND	0.1	0.1	0.1	trace
1,4-Dimethyl-2-cyclopentylbenzene	ND	0.1	0.1	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-1,5,8-trimethyl-	ND	0.1	trace	trace	trace
Biphenyl	trace	0.3	0.1	0.2	trace
Acenaphthylene, 1,2,2a,3,4,5-hexahydro-	ND	0.1	trace	trace	trace
2-Methyl-Z-4-tetradecene	ND	0.1	0.1	0.1	trace
Thiophene, 2-octyl-	ND	trace	trace	trace	trace

TABLE D-1. (CONT'D) CHEVROLET SILVERADO SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
Tetradecane	0.4	2.3	1.3	1.2	0.7
Naphthalene, 1,2,3,4-tetrahydro-5,6-dimethyl-	0.1	0.6	0.3	0.3	0.2
Naphthalene, 2-ethyl-	trace	0.2	0.1	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	trace	0.2	0.2	0.1	0.1
Naphthalene, 1-ethyl-	trace	0.1	trace	0.1	trace
Thiophene, 2-octyl-	ND	trace	trace	trace	trace
Naphthalene, 2,7-dimethyl-	trace	0.3	0.1	0.2	0.1
C3-Naphthalene, tetrahydro-	ND	0.1	0.1	0.1	trace
Benzene, (2,4-cyclopentadien-1-ylidenyl)-	ND	trace	trace	trace	trace
Benzene, 1-cyclohexyl-3-methyl-	ND	0.1	0.1	trace	trace
Naphthalene, 1,8-dimethyl-	0.1	0.7	0.3	0.4	0.2
Naphthalene, 1,7-dimethyl-	trace	0.3	0.1	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-6,7-dimethyl-	trace	0.2	0.1	0.1	trace
Naphthalene, tetrahydrodimethyl-	ND	0.1	0.1	0.1	trace
Naphthalene, 2-ethenyl-	ND	0.2	trace	0.1	trace
Naphthalene, 1,4-dimethyl-	ND	0.2	0.1	0.1	trace
2,5,8-Trimethyl-1,2,3,4-tetrahydronaphthalene	trace	0.2	0.1	0.1	0.1
Cyclohexane, octyl-	trace	0.2	0.1	0.1	trace
Naphthalene, tetrahydrotrimethyl-	ND	0.1	0.1	0.1	trace
Naphthalene, dimethyl-	ND	0.1	trace	trace	trace
Naphthalene, 1,2,3,4-tetrahydro-2,5,8-trimethyl-	trace	0.1	0.1	trace	trace
Tetradecane, 4-methyl-	ND	0.2	0.1	0.1	0.1
Tridecane, 2,5-dimethyl-	0.1	0.5	0.3	0.2	0.1
Naphthalene, dimethyl-	ND	0.1	0.0	0.1	trace
Tetradecane, 3-methyl-	ND	0.3	0.2	0.2	0.1
1,1'-Biphenyl, 3-methyl-	trace	0.3	0.1	0.1	0.1
Pentadecane	0.4	2.4	1.6	1.1	0.7
Naphthalene, 2-(1-methylethyl)-	ND	0.5	0.1	0.2	0.1
Dibenzofuran	trace	0.2	trace	0.1	trace
Naphthalene, trimethyl-	trace	0.2	0.1	0.1	trace
Naphthalene, 2,3,6-trimethyl-	trace	0.3	0.1	0.2	0.1
Pentadecane, methyl-	ND	0.2	0.1	0.1	0.1
n-Nonylcyclohexane	trace	0.2	0.1	0.1	0.1
Naphthalene, 1,6,7-trimethyl-	ND	0.2	0.1	0.1	0.1
Naphthalene, trimethyl-	ND	0.2	0.1	0.1	trace
Pentadecane, 2-methyl-	ND	0.2	0.1	0.1	0.1
Pentadecane, methyl-	ND	0.4	0.2	0.2	0.1
Benzene, nonyl-	ND	0.1	0.1	0.1	trace
Hexane, 2-phenyl-3-propyl-	ND	trace	trace	trace	trace
Fluorene	ND	trace	trace	trace	trace
Hexadecane	0.3	2.2	1.1	0.9	0.5
Benzene, 1-methyl-3-(phenylmethyl)-	ND	0.1	trace	0.1	trace
1, 1'-Biphenyl, 2-methyl-	trace	0.2	0.1	0.1	0.1
Naphthalene, 1,2,3,4-tetramethyl-	ND	trace	trace	trace	trace

TABLE D-1. (CONT'D) CHEVROLET SILVERADO SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
Pentadecane, 2,6,10-trimethyl-	0.1	0.6	0.3	0.2	0.1
Pentadecane, 3-methyl-	ND	0.4	0.2	0.2	trace
Cyclohexane, decyl-	trace	0.1	0.1	0.1	trace
Dodecane, 4,9-dipropyl-	ND	0.3	0.2	0.1	0.2
Azulene, 7-ethyl-1,4-dimethyl-	ND	0.1	0.1	0.1	trace
Heptadecane	0.2	1.9	1.0	0.7	0.4
Azulene, ethyldimethyl-	ND	0.1	0.1	0.1	trace
1-Heptadecene	trace	0.3	0.1	0.1	0.1
Pentadecane, 2,6,10,14-tetramethyl-	0.1	1.0	0.4	0.3	0.2
4,4'-Dimethylbiphenyl	ND	0.2	0.1	0.1	trace
1,1'-Biphenyl, 2,4'-dimethyl-	ND	0.1	trace	trace	trace
2,2'-Dimethylbiphenyl	ND	0.1	trace	trace	trace
Heptadecane, 4-methyl-	ND	0.3	0.1	0.1	trace
Dodecane, 4,9-dipropyl-	ND	0.4	0.2	0.1	0.1
1,2,3,4,5,6,7,8-Octahydro-1-methylphenanthrene	ND	0.1	trace	trace	trace
Cyclohexane, undecyl-	trace	0.3	0.1	0.1	trace
Phenanthrene, 1,2,3,4-tetrahydro-	ND	0.1	trace	trace	trace
Phenanthrene	trace	0.3	0.1	0.1	trace
Octadecane	0.2	1.3	0.6	0.4	0.2
Hexadecane, 2,6,10,14-tetramethyl-	ND	0.8	0.4	0.3	0.1
Phenanthrene, 9,10-dihydro-1-methyl-	ND	trace	trace	trace	trace
Benzene, 1-methyl-3-[(4-methylphenyl)methyl]-	ND	trace	trace	trace	trace
10,11-Dihydro-5H-dibenzo(a,d)cycloheptene	ND	0.1	trace	trace	trace
Benzene, 1-methyl-2-(2-phenylethenyl)-	ND	0.1	trace	trace	trace
Dodecylcyclohexane	ND	0.1	0.1	trace	trace
Nonadecane	0.1	0.7	0.4	0.2	0.1
Phenanthrene, 4-methyl-	ND	0.1	0.1	trace	trace
Phenanthrene, 2-methyl-	ND	0.1	0.1	trace	trace
1,2,5,6-Tetramethylacenaphthylene	ND	trace	ND	trace	ND
Eicosane	0.1	0.3	0.2	0.1	trace
2,7-dimethyl phenanthrene	ND	0.1	trace	trace	trace
Heneicosane	0.1	0.2	0.1	0.1	trace
Pyrene	ND	trace	trace	trace	trace
Docosane	0.1	0.2	0.1	0.1	trace

TABLE D-2. DODGE SPRINTER SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3800/75	3800/50	1600/50	1600/25	Idle
p-Xylene	1.5	1.6	0.5	0.6	0.3
Styrene	2.6	2.9	0.5	0.6	0.2
Benzene, 1,2-dimethyl-	0.9	1.0	0.3	0.4	0.2
Nonane	0.6	1.1	0.5	0.7	0.3
Benzene, propyl-	0.7	0.8	0.3	0.3	0.2
Benzaldehyde	2.4	2.8	0.4	0.5	0.1
Benzene, 1-ethyl-2-methyl-	1.0	1.1	0.4	0.4	0.3
Benzene, 1-ethyl-3-methyl-	0.6	0.8	0.3	0.4	0.2
Benzene, 1,3,5-trimethyl-	1.4	2.0	0.7	0.9	0.5
Indane	1.4	1.3	0.2	0.2	0.1
Benzofuran	0.9	1.2	0.2	0.2	0.1
Decane	1.0	2.2	1.2	1.5	0.8
Benzene, 1-methyl-3-(1-methylethyl)-	0.2	0.4	0.1	0.2	0.1
Benzene, trimethyl-	0.5	0.7	0.2	0.3	0.2
Benzene, 1,2,4,5-tetramethyl-	0.1	0.2	0.1	0.1	trace
Indene	1.0	1.3	0.2	0.2	0.1
Benzene, 1-methyl-3-propyl-	0.5	0.7	0.3	0.3	0.2
Benzene, tetramethyl-	0.3	0.5	0.2	0.2	0.1
Naphthalene, decahydro-, trans-	0.2	0.4	0.2	0.3	0.2
Benzaldehyde, 4-methyl	1.5	1.7	0.2	0.3	0.1
Benzene, 1-methyl-2-propyl-	0.3	0.4	0.2	0.2	0.1
Benzene, ethyl-dimethyl-	0.3	0.4	0.2	0.2	0.1
Benzene, 1-ethyl-3,5-dimethyl-	0.6	0.9	0.2	0.3	0.1
Thiophene, 2-pentyl	0.1	0.2	0.1	0.1	0.1
Benzene, ethyl-dimethyl-	0.3	0.5	0.2	0.2	0.1
Undecane	1.3	3.1	1.6	2.1	1.0
5-Undecene, (E)-	0.1	0.3	0.1	0.2	0.1
Benzene, 1-methyl-4-(1-methylpropyl)-	0.4	0.7	0.2	0.3	0.1
Naphthalene, decahydro-2-methyl-	0.3	0.7	0.4	0.4	0.2
Benzene, 1,2,3,5-tetramethyl-	0.2	0.4	0.2	0.2	0.1
trans-Decalin, 2-methyl-	0.2	0.6	0.3	0.4	0.2
Benzene, (2-methyl-1-propenyl)-	0.3	0.6	0.2	0.3	0.2
Benzene, methyl-(2-methylpropyl)-	0.2	0.4	0.1	0.2	0.1
3-Buten-2-ol, 4-phenyl-	0.3	0.5	0.2	0.2	0.1
Naphthalene, decahydro-1-methyl-	0.1	0.2	0.1	0.1	0.1
Decane, 3,7-dimethyl-	0.2	0.4	0.2	0.3	0.1
Naphthalene, 1,2,3,4-tetrahydro-	0.7	1.3	0.5	0.7	0.3
Benzene, 1-methyl-4-(2-methylpropyl)-	0.2	0.4	0.1	0.2	0.1
Undecane, 3-methyl-	trace	0.1	trace	0.1	ND
Naphthalene, decahydro-2,3-dimethyl-	0.1	0.4	0.2	0.2	0.1
Benzene, methyl-(1-methylpropyl)-	0.2	0.5	0.2	0.2	0.1
Napthalene, decahydro-dimethyl-	ND	0.3	0.2	0.2	0.1
Benzene, 1-methyl-1-butenyl-	0.1	0.2	0.1	0.1	trace
Naphthalene, decahydro-1,2-dimethyl-	0.1	0.4	0.2	0.3	0.1

TABLE D-2. DODGE SPRINTER SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3800/75	3800/50	1600/50	1600/25	Idle
Naphthalene	3.1	3.8	0.8	0.9	0.3
Benzene, (1,1-dimethyl-2-propenyl)-	0.1	0.3	0.1	0.1	0.1
1H-Indene, dihydro-dimethyl-	0.1	0.2	0.1	0.1	trace
Benzene, methyl-(1-methylpropyl)-	0.1	0.1	trace	0.1	trace
Naphthalene, decahydro-dimethyl-	0.1	0.2	0.1	0.1	0.1
Dodecane	1.2	3.4	1.8	2.5	1.3
Benzene, 2,4-dimethyl-1-(1-methylethyl)-	0.1	0.2	0.1	0.1	0.1
1H-Indene, 2,3-dihydro-1,1-dimethyl-	0.1	0.3	0.1	0.2	0.1
Naphthalene, decahydro-2,6-dimethyl-	0.1	0.2	0.1	0.1	trace
Naphthalene, decahydro-1,5-dimethyl-	0.1	0.2	0.1	0.2	0.1
Undecane, 2,6-dimethyl-	0.4	1.1	0.6	0.7	0.4
Benzaldehyde, 3,4-dimethyl-	0.2	0.3	trace	0.1	ND
Naphthalene, 1,2,3,4-tetrahydro-2-methyl-	0.6	1.2	0.5	0.6	0.3
cis-anti-cis-Tricyclo[7.3.0.0(2,6)]-7-dodecene	0.1	0.4	0.1	0.1	0.1
Benzene, (1-ethyl-1-methylpropyl)-	0.1	0.3	0.1	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-1-methyl-	0.4	0.9	0.4	0.5	0.2
Naphthalene, 2-ethyldecahydro-	0.1	0.2	0.1	0.2	0.1
2-Ethyl-2,3-dihydro-1H-indene	0.1	0.2	0.1	0.1	0.1
Benzene, 1,3,5-trimethyl-2-propyl-	0.1	0.2	0.1	0.1	trace
3,5-Dodecadiene, 2-methyl-	0.1	0.3	0.2	0.3	0.2
Ethyl-dihydro-1H-indene	0.1	0.2	0.1	0.1	0.1
Cyclohexane, hexyl-	0.1	0.3	0.2	0.2	0.1
Naphthalene, ethyldecahydro-	trace	0.1	0.1	0.1	0.1
3-Dodecene, (Z)-	ND	0.2	0.1	0.1	trace
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	0.1	0.2	0.1	0.1	0.1
Naphthalene, tetrahydro-dimethyl-	0.1	0.2	0.1	0.1	0.1
Benzene, dimethyl-(1-methylpropyl)-	trace	0.1	trace	trace	trace
Benzene, (1,3-dimethylbutyl)-	0.1	0.4	0.2	0.3	0.2
Dodecane, 5-methyl-	0.1	0.2	0.1	0.1	0.1
1H-Indene, 2,3-dihydro-4,7-dimethyl-	0.1	0.3	0.1	0.2	0.1
Dodecane, 4-methyl-	0.1	0.2	0.1	0.2	0.1
Benzene, (1-methylpentyl)-	0.1	0.1	0.1	0.1	trace
Benzene, C6-	0.1	0.3	0.1	0.1	0.1
Benzene, hexyl-	0.1	0.2	0.1	0.1	trace
Undecane, 2,3-dimethyl-	0.2	0.6	0.3	0.4	0.2
1H-Indene, 2,3-dihydro-1,3-dimethyl-	0.1	0.3	0.1	0.2	0.4
Dodecane, 3-methyl-	0.1	0.3	0.2	0.3	0.1
Naphthalene, 1,2,3,4-tetrahydro-6-methyl-	1.1	2.6	1.2	1.6	0.8
Undecane, 3,6-dimethyl-	0.2	0.7	0.4	0.5	0.3
Naphthalene, ethyltetrahydro-	trace	trace	trace	trace	trace
Naphthalene, 1,2-dihydo-2-methyl-	0.1	0.2	trace	0.1	trace
Naphthalene, ethyl-tetrahydro-	trace	trace	trace	trace	trace
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	0.1	0.2	0.1	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	0.1	0.1	0.1	0.1	trace

TABLE D-2. DODGE SPRINTER SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3800/75	3800/50	1600/50	1600/25	Idle
6-Tridecene, 7-methyl-	0.1	0.2	0.1	0.2	0.1
1,1'-Bicyclohexyl, 2-methyl-, cis-	0.1	0.4	0.1	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,8-dimethyl-	0.1	0.3	0.1	0.2	0.1
Tridecane	2.0	5.5	3.2	4.2	2.1
Naphthalene, tetrahydromethyl-	0.8	2.0	0.8	1.2	0.5
Naphthalene, 2-methyl-	2.4	3.0	0.6	0.9	0.3
Thiophene, 2-heptyl-	0.0	0.1	0.1	0.1	trace
Cyclohexane, (2-ethyl-1-methyl-1-butenyl)-	0.1	0.2	0.1	0.1	0.1
Naphthalene, 6-ethyl-1,2,3,4-tetrahydro-	trace	0.1	0.1	0.1	trace
C2-Naphthalene, 1,2,3,4-tetrahydro-	0.1	0.3	0.1	0.2	0.1
Tridecane, 7-methyl-	trace	0.2	0.1	0.2	0.1
1,12-Tridecadiene	ND	ND	0.1	0.1	trace
3,5-Decadiene, 2,2-dimethyl-, (Z,Z)-	0.1	0.2	0.1	0.1	0.1
1H-Indene, 2,3-dihydro-4,5,7-trimethyl-	trace	0.1	trace	trace	trace
Benzene, 1-methyl-3-hexyl-	trace	0.1	trace	0.1	trace
1,2,3-Trimethylindene	0.2	0.3	trace	0.1	trace
Tridecane, 3-methyl-	0.2	0.9	0.4	0.6	0.2
Naphthalene, 1-methyl-	1.5	2.0	0.4	0.6	0.2
Naphthalene, 1,2,3,4-tetrahydro-1,1,6-trimethyl-	trace	0.1	0.1	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	1.1	1.0	1.3	1.7	0.8
Benzene, cyclohexyl-	0.2	0.3	0.2	0.3	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,4-dimethyl-	0.3	0.7	0.4	0.5	0.2
Naphthalene, 1,2,3,4-tetrahydro-1-propyl-	0.1	0.2	0.1	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,5-dimethyl-	0.4	0.9	0.5	0.7	0.3
Heptylcyclohexane	0.2	0.6	0.4	0.5	0.2
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	0.4	0.8	0.4	0.5	0.2
Naphthalene, 1,2,3,4-tetrahydro-2,6-dimethyl-	0.4	0.9	0.5	0.6	0.3
Benzene, 1-methyl-3-hexyl-	0.1	0.2	0.1	0.1	0.1
Tridecane, 4-methyl-	0.4	0.6	0.3	0.4	0.2
Tridecane, 2-methyl-	0.2	0.6	0.3	0.5	0.2
Naphthalene, tetrahydro-dimethyl-	0.2	0.4	0.2	0.2	0.1
Naphthalene, 5-ethyl-1,2,3,4-tetrahydro-	0.4	1.2	0.6	0.8	0.4
tert-Butyl-bicyclo(4,3,0)non-3,7-diene	0.1	0.2	0.1	0.1	trace
Tridecane, 3-methyl-	ND	ND	ND	ND	ND
Dimethyl-cyclopentylbenzene	0.1	0.3	0.1	0.2	0.1
1-Methyl-2-n-hexylbenzene	0.1	0.2	0.1	0.1	trace
Dodecane, 2,6,10-trimethyl-	0.6	1.1	0.6	0.8	0.4
trans-8-tert-Butyl-bicyclo(4,3,0)non-3,7-diene	0.1	0.3	0.1	0.2	0.1
1,4-Dimethyl-2-cyclopentylbenzene	0.1	0.3	0.1	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,5,8-trimethyl-	0.1	0.2	0.1	0.1	0.1
Biphenyl	0.5	0.7	0.2	0.3	0.1
Acenaphthylene, 1,2,2a,3,4,5-hexahydro-	0.1	0.2	0.1	0.1	0.1
2-Methyl-Z-4-tetradecene	0.1	0.3	0.2	0.2	0.1
Thiophene, 2-octyl-	trace	0.1	0.1	0.1	trace

TABLE D-2. DODGE SPRINTER SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3800/75	3800/50	1600/50	1600/25	Idle
Tetradecane	1.8	4.5	2.8	3.7	1.9
Naphthalene, 1,2,3,4-tetrahydro-5,6-dimethyl-	0.6	1.4	0.8	1.0	0.6
Naphthalene, 2-ethyl-	0.5	0.6	0.2	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	0.3	0.7	0.4	0.5	0.2
Naphthalene, 1-ethyl-	0.3	0.4	0.1	0.1	trace
Thiophene, 2-octyl-	trace	0.1	trace	0.1	trace
Naphthalene, 2,7-dimethyl-	0.8	1.1	0.3	0.5	0.2
C3-Naphthalene, tetrahydro-	0.1	0.3	0.1	0.2	0.1
Benzene, (2,4-cyclopentadien-1-ylidenyl)-	0.1	0.1	trace	trace	ND
Benzene, 1-cyclohexyl-3-methyl-	0.1	0.3	0.1	0.2	0.1
Naphthalene, 1,8-dimethyl-	1.9	2.4	0.7	0.9	0.5
Naphthalene, 1,7-dimethyl-	0.7	1.0	0.3	0.4	0.2
Naphthalene, 1,2,3,4-tetrahydro-6,7-dimethyl-	0.2	0.4	0.2	0.3	0.2
Naphthalene, tetrahydrodimethyl-	0.1	0.3	0.2	0.2	0.1
Naphthalene, 2-ethenyl-	0.4	0.5	0.1	0.1	trace
Naphthalene, 1,4-dimethyl-	0.2	0.6	0.1	0.2	0.1
2,5,8-Trimethyl-1,2,3,4-tetrahydronaphthalene	0.2	0.5	0.2	0.3	0.2
Cyclohexane, octyl-	trace	0.2	0.1	0.2	0.0
Naphthalene, tetrahydrotrimethyl-	0.1	0.4	0.2	0.3	0.2
Naphthalene, dimethyl-	0.2	0.2	0.1	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-2,5,8-trimethyl-	0.1	0.3	0.2	0.2	0.1
Tetradecane, 4-methyl-	0.1	0.3	0.1	0.2	0.1
Tridecane, 2,5-dimethyl-	0.4	1.0	0.6	0.8	0.5
Naphthalene, dimethyl-	0.3	0.4	0.1	0.1	0.1
Tetradecane, 3-methyl-	0.1	0.5	0.2	0.3	0.1
1,1'-Biphenyl, 3-methyl-	0.6	0.8	0.2	0.3	0.2
Pentadecane	2.1	4.4	2.8	3.5	2.3
Naphthalene, 2-(1-methylethyl)-	0.7	1.1	0.3	0.3	0.1
Dibenzofuran	0.2	0.4	0.1	0.1	trace
Naphthalene, trimethyl-	0.2	0.6	0.2	0.3	0.1
Naphthalene, 2,3,6-trimethyl-	0.5	1.1	0.3	0.4	0.2
Pentadecane, methyl-	ND	ND	ND	ND	ND
n-Nonylcyclohexane	0.1	0.5	0.3	0.3	0.2
Naphthalene, 1,6,7-trimethyl-	0.3	0.6	0.2	0.3	0.2
Naphthalene, trimethyl-	0.2	0.5	0.2	0.2	0.1
Pentadecane, 2-methyl-	0.1	0.3	0.1	0.2	0.1
Pentadecane, methyl-	ND	ND	ND	ND	ND
Benzene, nonyl-	0.2	0.3	0.1	0.2	0.1
Hexane, 2-phenyl-3-propyl-	trace	0.1	trace	0.1	trace
Fluorene	0.1	0.1	trace	trace	trace
Hexadecane	1.3	3.5	2.0	2.5	1.5
Benzene, 1-methyl-3-(phenylmethyl)-	0.1	0.4	0.1	0.2	0.1
1, 1'-Biphenyl, 2-methyl-	0.3	0.6	0.3	0.3	0.2
Naphthalene, 1,2,3,4-tetramethyl-	0.1	0.2	0.1	0.1	trace

TABLE D-2. DODGE SPRINTER SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3800/75	3800/50	1600/50	1600/25	Idle
Pentadecane, 2,6,10-trimethyl-	0.4	1.1	0.7	0.7	0.5
Pentadecane, 3-methyl-	0.4	0.6	0.4	0.5	0.4
Cyclohexane, decyl-	0.1	0.2	0.2	0.1	0.1
Dodecane, 4,9-dipropyl-	0.2	0.7	0.4	0.6	0.4
Azulene, 7-ethyl-1,4-dimethyl-	0.1	0.3	0.2	0.2	0.1
Heptadecane	0.9	2.8	1.7	1.9	1.2
Azulene, ethyldimethyl-	0.1	0.4	0.2	0.1	0.1
1-Heptadecene	0.1	0.3	0.2	0.2	0.1
Pentadecane, 2,6,10,14-tetramethyl-	0.3	1.1	0.5	0.6	0.2
4,4'-Dimethylbiphenyl	0.1	0.4	0.2	0.2	0.1
1,1'-Biphenyl, 2,4'-dimethyl-	0.1	0.2	0.1	0.1	0.1
2,2'-Dimethylbiphenyl	0.1	0.2	0.1	0.1	0.1
Heptadecane, 4-methyl-	0.2	0.3	0.3	0.2	0.2
Dodecane, 4,9-dipropyl-	trace	0.4	0.1	0.1	0.1
1,2,3,4,5,6,7,8-Octahydro-1-methylphenanthrene	ND	0.1	trace	0.1	trace
Cyclohexane, undecyl-	0.1	0.4	0.2	0.3	0.1
Phenanthrene, 1,2,3,4-tetrahydro-	0.1	0.3	0.1	0.1	0.1
Phenanthrene	0.4	0.6	0.2	0.1	0.1
Octadecane	0.5	1.3	0.6	0.6	0.5
Hexadecane, 2,6,10,14-tetramethyl-	0.5	1.1	0.7	0.6	0.5
Phenanthrene, 9,10-dihydro-1-methyl-	trace	0.1	0.1	trace	trace
Benzene, 1-methyl-3-[(4-methylphenyl)methyl]-	ND	0.1	trace	trace	trace
10,11-Dihydro-5H-dibenzo(a,d)cycloheptene	trace	0.1	0.1	trace	0.0
Benzene, 1-methyl-2-(2-phenylethenyl)-	trace	0.1	0.1	0.1	0.0
Dodecylcyclohexane	ND	ND	ND	ND	ND
Nonadecane	0.2	0.7	0.3	0.3	0.3
Phenanthrene, 4-methyl-	0.1	0.2	0.1	0.1	0.1
Phenanthrene, 2-methyl-	0.1	0.3	0.1	0.1	0.1
1,2,5,6-Tetramethylacenaphthylene	ND	0.1	trace	trace	ND
Eicosane	ND	0.1	ND	ND	trace
2,7-dimethyl phenanthrene	0.1	0.1	0.1	0.1	0.1
Heneicosane	ND	ND	ND	ND	ND
Pyrene	trace	trace	trace	trace	trace
Docosane	ND	ND	ND	ND	ND

TABLE D-3. FORD F350 SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3300/75	3300/50	2000/50	2000/25	Idle
p-Xylene	1.3	0.7	0.5	0.5	0.8
Styrene	1.0	0.8	0.4	1.0	0.7
Benzene, 1,2-dimethyl-	0.9	0.5	0.3	0.4	0.6
Nonane	1.5	1.2	0.8	1.0	0.7
Benzene, propyl-	0.3	0.3	trace	trace	ND
Benzaldehyde	0.5	0.6	0.3	0.7	0.6
Benzene, 1-ethyl-2-methyl-	0.4	0.5	ND	0.0	ND
Benzene, 1-ethyl-3-methyl-	0.0	0.2	ND	ND	ND
Benzene, 1,3,5-trimethyl-	0.7	0.4	ND	ND	ND
Indane	0.2	0.2	0.1	0.3	0.2
Benzofuran	0.1	0.2	0.1	0.2	0.1
Decane	1.7	2.0	1.2	1.5	0.9
Benzene, 1-methyl-3-(1-methylethyl)-	0.2	0.3	0.2	0.2	0.1
Benzene, trimethyl-	0.3	0.4	0.2	0.3	0.2
Benzene, 1,2,4,5-tetramethyl-	0.1	0.2	0.1	0.1	trace
Indene	0.2	0.3	0.1	0.3	0.2
Benzene, 1-methyl-3-propyl-	0.4	0.5	0.3	0.4	0.3
Benzene, tetramethyl-	0.2	0.4	0.2	0.2	0.2
Naphthalene, decahydro-, trans-	0.3	0.5	0.3	0.3	0.2
Benzaldehyde, 4-methyl	0.2	0.4	0.2	0.5	0.5
Benzene, 1-methyl-2-propyl-	0.2	0.2	0.1	0.2	0.1
Benzene, ethyl-dimethyl-	0.2	0.4	0.2	0.3	0.2
Benzene, 1-ethyl-3,5-dimethyl-	0.3	0.5	0.3	0.4	0.3
Thiophene, 2-pentyl	0.2	0.3	0.2	0.2	0.1
Benzene, ethyl-dimethyl-	0.3	0.4	0.2	0.3	0.2
Undecane	2.5	3.7	2.2	2.7	1.5
5-Undecene, (E)-	0.2	0.4	0.2	0.2	0.2
Benzene, 1-methyl-4-(1-methylpropyl)-	0.3	0.5	0.3	0.3	0.2
Naphthalene, decahydro-2-methyl-	0.5	0.8	0.5	0.5	0.3
Benzene, 1,2,3,5-tetramethyl-	0.2	0.4	0.2	0.2	0.2
trans-Decalin, 2-methyl-	0.5	0.7	0.4	0.4	0.3
Benzene, (2-methyl-1-propenyl)-	0.4	0.7	0.4	0.4	0.3
Benzene, methyl-(2-methylpropyl)-	0.3	0.4	0.2	0.3	0.2
3-Buten-2-ol, 4-phenyl-	0.3	0.6	0.3	0.3	0.3
Naphthalene, decahydro-1-methyl-	0.2	0.2	0.2	0.1	0.1
Decane, 3,7-dimethyl-	0.4	0.6	0.4	0.3	0.3
Naphthalene, 1,2,3,4-tetrahydro-	0.8	1.3	0.8	0.8	0.6
Benzene, 1-methyl-4-(2-methylpropyl)-	0.2	0.4	0.2	0.2	0.2
Undecane, 3-methyl-	0.3	0.4	0.2	0.2	0.2
Naphthalene, decahydro-2,3-dimethyl-	0.4	0.5	0.3	0.3	0.2
Benzene, methyl-(1-methylpropyl)-	0.3	0.4	0.2	0.2	0.2
Napthalene, decahydro-dimethyl-	0.3	0.4	0.3	0.2	0.1
Benzene, 1-methyl-1-butenyl-	0.1	0.2	0.1	0.1	0.1
Naphthalene, decahydro-1,2-dimethyl-	0.3	0.4	0.2	0.2	0.2

TABLE D-3. (CONT'D) FORD F350 SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3300/75	3300/50	2000/50	2000/25	Idle
Naphthalene	1.2	1.7	0.8	1.3	1.1
Benzene, (1,1-dimethyl-2-propenyl)-	0.2	0.3	0.2	0.2	0.1
1H-Indene, dihydro-dimethyl-	0.1	0.3	0.1	0.1	0.1
Benzene, methyl-(1-methylpropyl)-	trace	0.1	trace	trace	trace
Naphthalene, decahydro-dimethyl-	0.1	0.3	0.2	0.2	0.1
Dodecane	3.2	5.0	2.8	2.5	1.7
Benzene, 2,4-dimethyl-1-(1-methylethyl)-	0.1	0.2	0.1	0.1	0.1
1H-Indene, 2,3-dihydro-1,1-dimethyl-	0.2	0.2	0.1	0.2	0.1
Naphthalene, decahydro-2,6-dimethyl-	0.1	0.3	0.1	0.2	0.1
Naphthalene, decahydro-1,5-dimethyl-	0.4	0.6	0.3	0.5	0.2
Undecane, 2,6-dimethyl-	0.7	1.2	0.7	1.0	0.4
Benzaldehyde, 3,4-dimethyl-	0.1	trace	trace	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-2-methyl-	0.6	1.0	0.5	0.8	0.4
cis-anti-cis-Tricyclo[7.3.0.0(2,6)]-7-dodecene	0.1	0.2	0.1	0.2	0.1
Benzene, (1-ethyl-1-methylpropyl)-	0.1	0.3	0.1	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-1-methyl-	0.4	0.7	0.4	0.6	0.3
Naphthalene, 2-ethyldecahydro-	0.2	0.3	0.2	0.2	0.1
2-Ethyl-2,3-dihydro-1H-indene	0.1	0.2	0.1	0.1	0.1
Benzene, 1,3,5-trimethyl-2-propyl-	0.1	0.1	0.1	0.1	trace
3,5-Dodecadiene, 2-methyl-	0.2	0.4	0.3	0.4	0.1
Ethyl-dihydro-1H-indene	0.1	0.2	0.1	0.1	0.1
Cyclohexane, hexyl-	0.2	0.4	0.2	0.2	0.1
Naphthalene, ethyldecahydro-	0.1	0.2	0.1	0.1	0.1
3-Dodecene, (Z)-	0.2	0.3	0.2	0.3	0.1
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	0.1	0.2	0.1	0.2	0.1
Naphthalene, tetrahydro-dimethyl-	0.1	0.2	0.1	0.1	0.1
Benzene, dimethyl-(1-methylpropyl)-	0.1	0.1	trace	0.1	trace
Benzene, (1,3-dimethylbutyl)-	0.4	0.7	0.4	0.5	0.2
Dodecane, 5-methyl-	0.2	0.3	0.2	0.2	0.1
1H-Indene, 2,3-dihydro-4,7-dimethyl-	0.3	0.5	0.3	0.4	0.2
Dodecane, 4-methyl-	0.2	0.3	0.2	0.2	0.1
Benzene, (1-methylpentyl)-	0.1	0.2	0.1	0.1	0.1
Benzene, C6-	0.1	0.3	0.1	0.2	0.1
Benzene, hexyl-	0.1	0.2	0.1	0.2	0.1
Undecane, 2,3-dimethyl-	0.5	0.9	0.6	0.6	0.3
1H-Indene, 2,3-dihydro-1,3-dimethyl-	0.1	0.2	0.2	0.2	0.1
Dodecane, 3-methyl-	0.3	0.6	0.3	0.4	0.2
Naphthalene, 1,2,3,4-tetrahydro-6-methyl-	1.4	2.4	1.2	1.6	0.8
Undecane, 3,6-dimethyl-	0.5	1.0	0.5	0.7	0.3
Naphthalene, ethyltetrahydro-	0.1	0.1	trace	0.1	trace
Naphthalene, 1,2-dihydo-2-methyl-	0.1	0.1	trace	0.1	trace
Naphthalene, ethyl-tetrahydro-	trace	trace	trace	trace	ND
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	0.1	0.2	0.1	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	0.1	0.1	0.1	0.1	trace

TABLE D-3. (CONT'D) FORD F350 SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3300/75	3300/50	2000/50	2000/25	Idle
6-Tridecene, 7-methyl-	0.3	0.4	0.3	0.3	0.2
1,1'-Bicyclohexyl, 2-methyl-, cis-	0.3	0.4	0.2	0.3	0.2
Naphthalene, 1,2,3,4-tetrahydro-1,8-dimethyl-	0.2	0.3	0.2	0.2	0.2
Tridecane	4.3	7.3	4.0	4.9	2.3
Naphthalene, tetrahydromethyl-	1.7	3.0	1.5	2.1	1.0
Naphthalene, 2-methyl-	0.7	1.3	0.7	1.3	0.9
Thiophene, 2-heptyl-	0.1	0.2	0.1	0.1	0.1
Cyclohexane, (2-ethyl-1-methyl-1-butenyl)-	0.1	0.1	0.1	0.1	0.1
Naphthalene, 6-ethyl-1,2,3,4-tetrahydro-	0.1	0.1	0.1	0.1	0.1
C2-Naphthalene, 1,2,3,4-tetrahydro-	0.1	0.3	0.1	0.2	0.1
Tridecane, 7-methyl-	0.2	0.5	0.3	0.8	0.1
1,12-Tridecadiene	0.1	0.4	0.3	0.2	trace
3,5-Decadiene, 2,2-dimethyl-, (Z,Z)-	0.2	0.5	0.3	0.4	0.1
1H-Indene, 2,3-dihydro-4,5,7-trimethyl-	0.1	0.1	trace	0.1	trace
Benzene, 1-methyl-3-hexyl-	0.1	0.1	0.1	0.1	trace
1,2,3-Trimethylindene	0.1	0.1	0.1	0.2	trace
Tridecane, 3-methyl-	0.4	1.1	0.6	0.9	0.3
Naphthalene, 1-methyl-	0.5	0.8	0.4	0.8	0.5
Naphthalene, 1,2,3,4-tetrahydro-1,1,6-trimethyl-	0.1	0.1	trace	0.1	0.0
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	1.4	2.5	1.2	1.7	0.8
Benzene, cyclohexyl-	0.2	0.4	0.3	0.3	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,4-dimethyl-	0.4	0.7	0.3	0.5	0.2
Naphthalene, 1,2,3,4-tetrahydro-1-propyl-	0.1	0.2	0.1	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,5-dimethyl-	0.6	1.0	0.5	0.7	0.4
Heptylcyclohexane	0.6	1.0	0.6	0.6	0.2
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	0.7	1.2	0.4	0.9	0.3
Naphthalene, 1,2,3,4-tetrahydro-2,6-dimethyl-	0.5	0.8	0.4	0.6	0.2
Benzene, 1-methyl-3-hexyl-	0.2	0.4	0.2	0.3	0.2
Tridecane, 4-methyl-	0.6	0.7	0.4	0.5	0.3
Tridecane, 2-methyl-	0.6	1.0	0.6	0.9	0.3
Naphthalene, tetrahydro-dimethyl-	0.3	0.5	0.4	0.3	0.2
Naphthalene, 5-ethyl-1,2,3,4-tetrahydro-	1.2	2.1	1.0	1.4	0.6
tert-Butyl-bicyclo(4,3,0)non-3,7-diene	0.1	0.2	0.1	0.2	0.1
Tridecane, 3-methyl-	0.8	1.1	0.7	0.9	0.4
Dimethyl-cyclopentylbenzene	0.1	0.2	0.1	0.1	0.1
1-Methyl-2-n-hexylbenzene	0.1	0.2	0.1	0.1	0.1
Dodecane, 2,6,10-trimethyl-	1.1	1.5	0.9	1.0	0.6
trans-8-tert-Butyl-bicyclo(4,3,0)non-3,7-diene	0.3	0.5	0.3	0.4	0.2
1,4-Dimethyl-2-cyclopentylbenzene	0.3	0.4	0.2	0.3	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,5,8-trimethyl-	0.1	0.3	0.1	0.2	0.1
Biphenyl	0.2	0.4	0.2	0.4	0.2
Acenaphthylene, 1,2,2a,3,4,5-hexahydro-	0.1	0.2	0.1	0.1	0.1
2-Methyl-Z-4-tetradecene	0.3	0.5	0.3	0.5	0.2
Thiophene, 2-octyl-	0.1	0.1	trace	0.1	trace

TABLE D-3. (CONT'D) FORD F350 SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3300/75	3300/50	2000/50	2000/25	Idle
Tetradecane	4.0	6.8	3.6	4.5	2.0
Naphthalene, 1,2,3,4-tetrahydro-5,6-dimethyl-	1.0	1.9	0.8	1.2	0.5
Naphthalene, 2-ethyl-	0.2	0.3	0.2	0.3	0.2
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	0.7	1.1	0.6	0.8	0.3
Naphthalene, 1-ethyl-	0.3	0.1	0.1	0.1	0.1
Thiophene, 2-octyl-	0.1	0.2	0.1	0.2	0.1
Naphthalene, 2,7-dimethyl-	0.4	0.7	0.4	0.6	0.4
C3-Naphthalene, tetrahydro-	0.2	0.3	0.1	0.2	0.1
Benzene, (2,4-cyclopentadien-1-ylidenyl)-	trace	trace	trace	trace	trace
Benzene, 1-cyclohexyl-3-methyl-	0.2	0.3	0.1	0.3	0.1
Naphthalene, 1,8-dimethyl-	0.8	1.2	0.7	1.2	0.6
Naphthalene, 1,7-dimethyl-	0.3	0.5	0.3	0.5	0.2
Naphthalene, 1,2,3,4-tetrahydro-6,7-dimethyl-	0.2	0.3	0.2	0.2	0.1
Naphthalene, tetrahydrodimethyl-	0.3	0.5	0.3	0.4	0.2
Naphthalene, 2-ethenyl-	0.1	0.1	0.1	0.1	0.1
Naphthalene, 1,4-dimethyl-	0.2	0.3	0.2	0.3	0.2
2,5,8-Trimethyl-1,2,3,4-tetrahydronaphthalene	0.3	0.4	0.2	0.3	0.1
Cyclohexane, octyl-	0.3	0.4	0.3	0.3	0.1
Naphthalene, tetrahydrotrimethyl-	0.3	0.5	0.2	0.4	0.2
Naphthalene, dimethyl-	0.3	0.2	0.1	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-2,5,8-trimethyl-	0.1	0.5	0.1	0.2	0.1
Tetradecane, 4-methyl-	0.2	0.5	0.2	0.3	0.1
Tridecane, 2,5-dimethyl-	1.1	1.7	1.0	1.3	0.5
Naphthalene, dimethyl-	0.2	0.3	0.2	0.3	0.2
Tetradecane, 3-methyl-	0.6	0.9	0.5	0.6	0.3
1,1'-Biphenyl, 3-methyl-	0.3	0.5	0.3	0.5	0.2
Pentadecane	4.0	6.2	3.4	4.2	1.8
Naphthalene, 2-(1-methylethyl)-	0.3	0.5	0.3	0.6	0.3
Dibenzofuran	0.1	0.1	0.1	0.1	0.1
Naphthalene, trimethyl-	0.2	0.4	0.2	0.3	0.2
Naphthalene, 2,3,6-trimethyl-	0.7	1.1	0.6	1.0	0.5
Pentadecane, methyl-	0.2	0.4	0.2	0.3	0.1
n-Nonylcyclohexane	0.3	0.6	0.3	0.4	0.2
Naphthalene, 1,6,7-trimethyl-	0.2	0.4	0.2	0.4	0.2
Naphthalene, trimethyl-	0.3	0.6	0.3	0.6	0.3
Pentadecane, 2-methyl-	0.4	0.6	0.4	0.5	0.2
Pentadecane, methyl-	1.6	1.7	0.9	1.2	0.6
Benzene, nonyl-	0.2	0.3	0.2	0.2	0.1
Hexane, 2-phenyl-3-propyl-	0.1	0.1	0.1	0.1	trace
Fluorene	0.1	0.1	0.1	0.1	0.1
Hexadecane	3.5	5.1	2.9	3.6	1.4
Benzene, 1-methyl-3-(phenylmethyl)-	0.2	0.2	0.1	0.2	0.1
1, 1'-Biphenyl, 2-methyl-	0.3	0.4	0.2	0.3	0.1
Naphthalene, 1,2,3,4-tetramethyl-	0.1	0.1	0.1	0.1	0.1

TABLE D-3. (CONT'D) FORD F350 SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	3300/75	3300/50	2000/50	2000/25	Idle
Pentadecane, 2,6,10-trimethyl-	0.8	1.0	0.5	1.1	0.3
Pentadecane, 3-methyl-	0.9	2.6	1.4	1.5	0.6
Cyclohexane, decyl-	0.2	0.3	0.1	0.2	0.1
Dodecane, 4,9-dipropyl-	0.4	0.7	0.6	0.7	0.2
Azulene, 7-ethyl-1,4-dimethyl-	0.2	0.3	0.1	0.2	0.1
Heptadecane	3.1	3.9	2.2	3.0	1.1
Azulene, ethyldimethyl-	0.2	0.4	0.2	0.3	0.1
1-Heptadecene	0.3	0.4	0.2	0.3	0.2
Pentadecane, 2,6,10,14-tetramethyl-	1.2	1.5	0.9	1.3	0.7
4,4'-Dimethylbiphenyl	0.2	0.2	0.1	0.2	0.1
1,1'-Biphenyl, 2,4'-dimethyl-	0.1	0.1	0.1	0.1	trace
2,2'-Dimethylbiphenyl	0.1	0.1	0.1	0.1	0.1
Heptadecane, 4-methyl-	0.5	0.7	0.4	0.6	0.2
Dodecane, 4,9-dipropyl-	1.0	1.2	0.7	1.1	0.4
1,2,3,4,5,6,7,8-Octahydro-1-methylphenanthrene	0.1	0.1	trace	trace	trace
Cyclohexane, undecyl-	0.3	0.4	0.3	0.4	0.1
Phenanthrene, 1,2,3,4-tetrahydro-	0.1	0.1	0.1	0.1	0.1
Phenanthrene	0.2	0.3	0.2	0.5	0.7
Octadecane	1.9	2.0	1.3	1.9	0.8
Hexadecane, 2,6,10,14-tetramethyl-	1.0	1.1	0.7	1.1	0.4
Phenanthrene, 9,10-dihydro-1-methyl-	0.1	0.1	0.1	0.1	trace
Benzene, 1-methyl-3-[(4-methylphenyl)methyl]-	trace	trace	trace	trace	trace
10,11-Dihydro-5H-dibenzo(a,d)cycloheptene	0.1	0.1	trace	0.1	trace
Benzene, 1-methyl-2-(2-phenylethenyl)-	0.1	0.1	0.1	0.1	trace
Dodecylcyclohexane	0.2	0.1	0.1	0.1	trace
Nonadecane	1.3	1.2	0.8	1.1	0.4
Phenanthrene, 4-methyl-	0.2	0.1	0.1	0.2	0.1
Phenanthrene, 2-methyl-	0.1	0.2	0.1	0.2	0.1
1,2,5,6-Tetramethylacenaphthylene	ND	trace	trace	trace	ND
Eicosane	0.9	0.6	0.5	0.6	0.2
2,7-dimethyl phenanthrene	0.1	0.1	0.1	0.1	trace
Heneicosane	0.7	0.4	0.3	0.4	0.2
Pyrene	0.2	0.1	0.1	0.2	0.1
Docosane	0.6	0.3	0.2	0.2	0.2

TABLE D-4. VOLKSWAGEN JETTA SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	4000/75	4000/50	1800/50	1800/25	Idle
p-Xylene	0.4	0.4	0.3	0.3	0.2
Styrene	0.2	0.2	0.8	0.3	0.2
Benzene, 1,2-dimethyl-	0.3	0.3	0.2	0.2	0.1
Nonane	0.6	0.6	0.1	0.2	0.2
Benzene, propyl-	0.3	0.2	0.1	0.1	0.1
Benzaldehyde	0.3	0.3	0.7	0.2	0.2
Benzene, 1-ethyl-2-methyl-	0.4	0.4	0.2	0.2	0.2
Benzene, 1-ethyl-3-methyl-	0.3	0.3	0.1	0.1	0.1
Benzene, 1,3,5-trimethyl-	0.8	0.8	0.3	0.4	0.4
Indane	0.1	0.1	0.3	0.1	0.1
Benzofuran	0.1	0.1	0.2	0.1	0.1
Decane	1.2	1.2	0.2	0.6	0.4
Benzene, 1-methyl-3-(1-methylethyl)-	0.2	0.1	trace	0.1	0.1
Benzene, trimethyl-	0.3	0.3	0.1	0.1	0.1
Benzene, 1,2,4,5-tetramethyl-	0.1	0.1	trace	trace	trace
Indene	0.1	0.1	0.2	0.1	0.1
Benzene, 1-methyl-3-propyl-	0.3	0.3	0.1	0.1	0.1
Benzene, tetramethyl-	0.2	0.2	0.0	0.1	0.1
Naphthalene, decahydro-, trans-	0.3	0.2	0.0	0.1	0.1
Benzaldehyde, 4-methyl	0.2	0.2	0.2	0.1	0.2
Benzene, 1-methyl-2-propyl-	0.2	0.2	0.0	0.1	0.1
Benzene, ethyl-dimethyl-	0.2	0.2	0.0	0.1	0.1
Benzene, 1-ethyl-3,5-dimethyl-	0.3	0.2	0.1	0.1	0.1
Thiophene, 2-pentyl	0.2	0.1	0.0	0.1	trace
Benzene, ethyl-dimethyl-	0.2	0.2	0.0	0.1	0.1
Undecane	2.0	1.9	0.2	0.9	0.6
5-Undecene, (E)-	0.2	0.2	trace	0.1	0.1
Benzene, 1-methyl-4-(1-methylpropyl)-	0.3	0.3	0.1	0.1	0.1
Naphthalene, decahydro-2-methyl-	0.4	0.4	trace	0.2	0.1
Benzene, 1,2,3,5-tetramethyl-	0.2	0.2	trace	0.1	0.1
trans-Decalin, 2-methyl-	0.4	0.3	trace	0.2	0.1
Benzene, (2-methyl-1-propenyl)-	0.3	0.3	trace	0.1	0.1
Benzene, methyl-(2-methylpropyl)-	0.2	0.2	trace	0.1	0.1
3-Buten-2-ol, 4-phenyl-	0.2	0.2	trace	0.1	0.1
Naphthalene, decahydro-1-methyl-	0.1	0.1	trace	0.1	0.1
Decane, 3,7-dimethyl-	0.3	0.2	trace	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-	0.6	0.6	0.1	0.3	0.2
Benzene, 1-methyl-4-(2-methylpropyl)-	0.2	0.2	trace	0.1	0.1
Undecane, 3-methyl-	0.2	0.2	trace	0.1	trace
Naphthalene, decahydro-2,3-dimethyl-	0.2	0.2	trace	0.1	0.1
Benzene, methyl-(1-methylpropyl)-	0.2	0.2	trace	0.1	0.1
Napthalene, decahydro-dimethyl-	0.2	0.2	trace	0.1	0.1
Benzene, 1-methyl-1-butenyl-	0.1	0.1	trace	trace	trace
Naphthalene, decahydro-1,2-dimethyl-	0.2	0.2	trace	0.1	0.1

TABLE D-4. (CONT'D) VOLKSWAGEN JETTA SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	4000/75	4000/50	1800/50	1800/25	Idle
Naphthalene	0.5	0.5	0.7	0.5	0.4
Benzene, (1,1-dimethyl-2-propenyl)-	0.1	0.1	trace	0.1	trace
1H-Indene, dihydro-dimethyl-	0.1	0.1	trace	trace	trace
Benzene, methyl-(1-methylpropyl)-	trace	trace	trace	trace	trace
Naphthalene, decahydro-dimethyl-	0.1	0.1	ND	trace	trace
Dodecane	2.3	2.2	0.2	1.0	0.7
Benzene, 2,4-dimethyl-1-(1-methylethyl)-	0.1	0.1	trace	trace	trace
1H-Indene, 2,3-dihydro-1,1-dimethyl-	0.2	0.1	trace	0.1	0.1
Naphthalene, decahydro-2,6-dimethyl-	0.2	0.1	trace	trace	trace
Naphthalene, decahydro-1,5-dimethyl-	0.2	0.2	trace	0.1	0.1
Undecane, 2,6-dimethyl-	0.7	0.7	0.1	0.3	0.2
Benzaldehyde, 3,4-dimethyl-	trace	trace	trace	trace	trace
Naphthalene, 1,2,3,4-tetrahydro-2-methyl-	0.6	0.5	0.1	0.2	0.2
cis-anti-cis-Tricyclo[7.3.0.0(2,6)]-7-dodecene	0.1	0.1	trace	trace	trace
Benzene, (1-ethyl-1-methylpropyl)-	0.1	0.1	trace	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-1-methyl-	0.4	0.4	0.1	0.2	0.1
Naphthalene, 2-ethyldecahydro-	0.2	0.2	trace	0.1	trace
2-Ethyl-2,3-dihydro-1H-indene	0.1	0.1	trace	trace	trace
Benzene, 1,3,5-trimethyl-2-propyl-	0.1	0.1	trace	trace	trace
3,5-Dodecadiene, 2-methyl-	0.2	0.2	trace	0.1	0.1
Ethyl-dihydro-1H-indene	0.1	0.1	trace	trace	trace
Cyclohexane, hexyl-	0.2	0.2	trace	0.1	0.1
Naphthalene, ethyldecahydro-	0.1	0.1	trace	trace	trace
3-Dodecene, (Z)-	0.2	0.2	trace	0.1	0.1
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	0.1	0.1	trace	trace	trace
Naphthalene, tetrahydro-dimethyl-	0.1	0.1	trace	trace	trace
Benzene, dimethyl-(1-methylpropyl)-	trace	trace	trace	trace	trace
Benzene, (1,3-dimethylbutyl)-	0.3	0.3	trace	0.1	0.1
Dodecane, 5-methyl-	0.1	0.1	trace	trace	trace
1H-Indene, 2,3-dihydro-4,7-dimethyl-	0.2	0.2	trace	0.1	trace
Dodecane, 4-methyl-	0.2	0.2	trace	0.1	trace
Benzene, (1-methylpentyl)-	0.1	0.1	trace	trace	trace
Benzene, C6-	0.1	0.1	trace	trace	trace
Benzene, hexyl-	0.1	0.1	trace	trace	trace
Undecane, 2,3-dimethyl-	0.4	0.4	trace	0.2	0.1
1H-Indene, 2,3-dihydro-1,3-dimethyl-	0.2	0.2	trace	0.1	0.1
Dodecane, 3-methyl-	0.3	0.3	trace	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-6-methyl-	0.9	1.3	0.1	0.5	0.4
Undecane, 3,6-dimethyl-	0.5	0.4	trace	0.2	0.1
Naphthalene, ethyltetrahydro-	trace	trace	ND	trace	trace
Naphthalene, 1,2-dihydo-2-methyl-	trace	trace	0.0	trace	trace
Naphthalene, ethyl-tetrahydro-	trace	trace	ND	trace	ND
Benzene, 1,4-dimethyl-2-(2-methylpropyl)-	0.1	0.1	trace	trace	trace
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	0.1	0.1	ND	trace	trace

TABLE D-4. (CONT'D) VOLKSWAGEN JETTA SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	4000/75	4000/50	1800/50	1800/25	Idle
6-Tridecene, 7-methyl-	0.2	0.1	trace	0.1	trace
1,1'-Bicyclohexyl, 2-methyl-, cis-	0.2	0.2	trace	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,8-dimethyl-	0.2	0.2	trace	0.1	trace
Tridecane	3.8	3.6	0.4	1.7	1.1
Naphthalene, tetrahydromethyl-	0.9	0.9	0.1	0.4	0.3
Naphthalene, 2-methyl-	0.6	0.6	0.4	0.3	0.4
Thiophene, 2-heptyl-	0.1	0.1	trace	trace	trace
Cyclohexane, (2-ethyl-1-methyl-1-butenyl)-	0.1	0.1	trace	trace	trace
Naphthalene, 6-ethyl-1,2,3,4-tetrahydro-	trace	trace	trace	trace	trace
C2-Naphthalene, 1,2,3,4-tetrahydro-	0.2	0.1	trace	0.1	trace
Tridecane, 7-methyl-	0.1	0.1	trace	0.1	trace
1,12-Tridecadiene	0.1	0.1	ND	trace	ND
3,5-Decadiene, 2,2-dimethyl-, (Z,Z)-	0.2	0.1	ND	trace	trace
1H-Indene, 2,3-dihydro-4,5,7-trimethyl-	trace	trace	trace	trace	trace
Benzene, 1-methyl-3-hexyl-	trace	0.1	trace	trace	trace
1,2,3-Trimethylindene	trace	trace	trace	trace	trace
Tridecane, 3-methyl-	0.5	0.4	0.1	0.2	0.1
Naphthalene, 1-methyl-	0.4	0.3	0.3	0.2	0.2
Naphthalene, 1,2,3,4-tetrahydro-1,1,6-trimethyl-	0.0	0.0	0.0	trace	trace
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	1.3	0.5	0.2	0.2	0.4
Benzene, cyclohexyl-	0.2	0.2	trace	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-1,4-dimethyl-	0.4	0.3	trace	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-1-propyl-	0.1	0.1	trace	trace	trace
Naphthalene, 1,2,3,4-tetrahydro-1,5-dimethyl-	0.5	0.5	trace	0.2	0.2
Heptylcyclohexane	0.5	0.4	trace	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-2,7-dimethyl-	0.4	0.4	trace	0.2	0.1
Naphthalene, 1,2,3,4-tetrahydro-2,6-dimethyl-	0.5	0.4	trace	0.2	0.1
Benzene, 1-methyl-3-hexyl-	0.1	0.1	trace	0.1	trace
Tridecane, 4-methyl-	0.4	0.4	0.1	0.2	0.2
Tridecane, 2-methyl-	0.4	0.4	0.1	0.2	0.1
Naphthalene, tetrahydro-dimethyl-	0.2	0.2	trace	0.1	0.1
Naphthalene, 5-ethyl-1,2,3,4-tetrahydro-	0.6	0.6	0.1	0.3	0.2
tert-Butyl-bicyclo(4,3,0)non-3,7-diene	0.1	0.1	trace	trace	trace
Tridecane, 3-methyl-	0.3	0.3	trace	0.2	0.1
Dimethyl-cyclopentylbenzene	0.1	0.1	trace	0.1	trace
1-Methyl-2-n-hexylbenzene	0.1	0.1	trace	trace	trace
Dodecane, 2,6,10-trimethyl-	0.8	0.8	0.1	0.4	0.3
trans-8-tert-Butyl-bicyclo(4,3,0)non-3,7-diene	0.2	0.1	trace	0.1	trace
1,4-Dimethyl-2-cyclopentylbenzene	0.1	0.2	trace	0.1	trace
Naphthalene, 1,2,3,4-tetrahydro-1,5,8-trimethyl-	0.1	0.1	trace	trace	trace
Biphenyl	0.2	0.2	0.1	0.1	0.1
Acenaphthylene, 1,2,2a,3,4,5-hexahydro-	0.1	0.1	trace	trace	trace
2-Methyl-Z-4-tetradecene	0.2	0.2	trace	0.1	trace
Thiophene, 2-octyl-	0.1	0.1	trace	trace	trace

TABLE D-4. (CONT'D) VOLKSWAGEN JETTA SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	4000/75	4000/50	1800/50	1800/25	Idle
Tetradecane	3.3	3.2	0.3	1.5	0.9
Naphthalene, 1,2,3,4-tetrahydro-5,6-dimethyl-	0.8	0.8	0.1	0.3	0.3
Naphthalene, 2-ethyl-	0.2	0.2	0.1	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-5,7-dimethyl-	0.3	0.3	trace	0.1	0.1
Naphthalene, 1-ethyl-	0.1	0.1	0.1	trace	trace
Thiophene, 2-octyl-	0.1	0.1	trace	trace	trace
Naphthalene, 2,7-dimethyl-	0.3	0.3	0.1	0.1	0.1
C3-Naphthalene, tetrahydro-	0.1	0.1	0.0	0.1	trace
Benzene, (2,4-cyclopentadien-1-ylidenyl)-	trace	trace	trace	trace	trace
Benzene, 1-cyclohexyl-3-methyl-	0.1	0.1	0.0	0.1	trace
Naphthalene, 1,8-dimethyl-	0.6	0.6	0.2	0.3	0.3
Naphthalene, 1,7-dimethyl-	0.3	0.3	0.1	0.1	0.1
Naphthalene, 1,2,3,4-tetrahydro-6,7-dimethyl-	0.2	0.2	trace	0.1	0.1
Naphthalene, tetrahydrodimethyl-	0.2	0.2	trace	0.1	0.1
Naphthalene, 2-ethenyl-	trace	trace	0.1	trace	trace
Naphthalene, 1,4-dimethyl-	0.1	0.2	trace	0.1	0.1
2,5,8-Trimethyl-1,2,3,4-tetrahydronaphthalene	0.3	0.3	trace	0.1	0.1
Cyclohexane, octyl-	0.2	0.3	trace	0.1	0.1
Naphthalene, tetrahydrotrimethyl-	0.2	0.3	trace	0.1	0.1
Naphthalene, dimethyl-	0.1	0.1	trace	trace	trace
Naphthalene, 1,2,3,4-tetrahydro-2,5,8-trimethyl-	0.1	0.2	trace	0.1	0.1
Tetradecane, 4-methyl-	0.2	0.3	trace	0.1	0.1
Tridecane, 2,5-dimethyl-	0.7	0.7	0.1	0.3	0.2
Naphthalene, dimethyl-	0.1	0.1	0.1	trace	trace
Tetradecane, 3-methyl-	0.5	0.5	trace	0.2	0.1
1,1'-Biphenyl, 3-methyl-	0.2	0.2	0.1	0.1	0.1
Pentadecane	3.0	3.3	0.3	1.2	0.8
Naphthalene, 2-(1-methylethyl)-	0.2	0.2	0.1	0.1	0.1
Dibenzofuran	0.1	0.1	trace	trace	trace
Naphthalene, trimethyl-	0.2	0.2	trace	0.1	0.1
Naphthalene, 2,3,6-trimethyl-	0.4	0.4	0.1	0.2	0.1
Pentadecane, methyl-	0.2	0.2	trace	0.1	0.1
n-Nonylcyclohexane	0.3	0.3	trace	0.1	0.1
Naphthalene, 1,6,7-trimethyl-	0.2	0.2	trace	0.1	0.1
Naphthalene, trimethyl-	0.2	0.2	trace	0.1	0.1
Pentadecane, 2-methyl-	0.2	0.2	trace	0.1	0.1
Pentadecane, methyl-	0.4	0.4	0.1	0.2	0.1
Benzene, nonyl-	0.2	0.2	trace	0.1	trace
Hexane, 2-phenyl-3-propyl-	0.1	0.1	trace	trace	trace
Fluorene	trace	trace	trace	trace	trace
Hexadecane	2.3	2.5	0.5	1.0	0.7
Benzene, 1-methyl-3-(phenylmethyl)-	0.1	0.1	trace	0.1	trace
1, 1'-Biphenyl, 2-methyl-	0.2	0.2	trace	0.1	0.1
Naphthalene, 1,2,3,4-tetramethyl-	0.1	0.1	trace	trace	trace

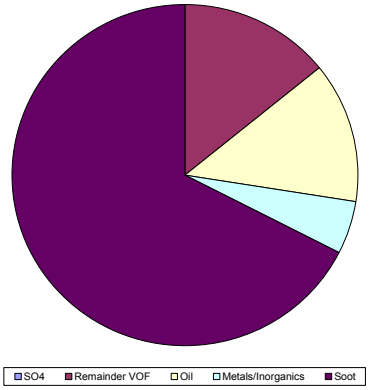
TABLE D-4. (CONT'D) VOLKSWAGEN JETTA SEMI-VOLATILE (STEADY-STATE MODES)					
Compound	mg/min				
	4000/75	4000/50	1800/50	1800/25	Idle
Pentadecane, 2,6,10-trimethyl-	0.6	0.6	0.2	0.3	0.2
Pentadecane, 3-methyl-	0.4	0.4	0.1	0.2	0.1
Cyclohexane, decyl-	0.1	0.1	trace	0.1	trace
Dodecane, 4,9-dipropyl-	0.3	0.4	0.1	0.2	0.1
Azulene, 7-ethyl-1,4-dimethyl-	0.1	0.1	trace	0.1	trace
Heptadecane	1.7	2.1	0.8	0.8	0.6
Azulene, ethyldimethyl-	0.1	0.1	trace	0.1	trace
1-Heptadecene	0.2	0.2	0.1	0.1	0.1
Pentadecane, 2,6,10,14-tetramethyl-	0.6	0.8	0.3	0.3	0.2
4,4'-Dimethylbiphenyl	0.1	0.1	trace	trace	trace
1,1'-Biphenyl, 2,4'-dimethyl-	0.1	0.1	trace	trace	trace
2,2'-Dimethylbiphenyl	0.1	0.1	trace	trace	trace
Heptadecane, 4-methyl-	0.2	0.2	0.1	0.1	0.1
Dodecane, 4,9-dipropyl-	0.2	0.3	0.1	0.1	0.1
1,2,3,4,5,6,7,8-Octahydro-1-methylphenanthrene	trace	trace	trace	trace	trace
Cyclohexane, undecyl-	0.2	0.2	0.1	0.1	0.1
Phenanthrene, 1,2,3,4-tetrahydro-	0.1	0.1	trace	trace	trace
Phenanthrene	0.2	0.2	0.1	0.1	trace
Octadecane	0.7	0.9	0.5	0.4	0.3
Hexadecane, 2,6,10,14-tetramethyl-	0.5	0.6	0.4	0.3	0.2
Phenanthrene, 9,10-dihydro-1-methyl-	trace	trace	trace	trace	trace
Benzene, 1-methyl-3-[(4-methylphenyl)methyl]-	trace	trace	trace	trace	trace
10,11-Dihydro-5H-dibenzo(a,d)cycloheptene	trace	trace	trace	trace	trace
Benzene, 1-methyl-2-(2-phenylethenyl)-	trace	trace	trace	trace	trace
Dodecylcyclohexane	0.1	0.1	0.1	trace	trace
Nonadecane	0.4	0.5	0.4	0.3	0.2
Phenanthrene, 4-methyl-	0.1	0.1	0.1	trace	trace
Phenanthrene, 2-methyl-	0.1	0.1	0.1	trace	trace
1,2,5,6-Tetramethylacenaphthylene	trace	ND	trace	trace	trace
Eicosane	0.2	0.2	0.2	0.2	0.1
2,7-dimethyl phenanthrene	trace	trace	trace	trace	trace
Heneicosane	0.1	0.1	0.1	0.1	0.1
Pyrene	trace	trace	trace	trace	trace
Docosane	0.1	0.1	0.1	0.1	0.1

APPENDIX E

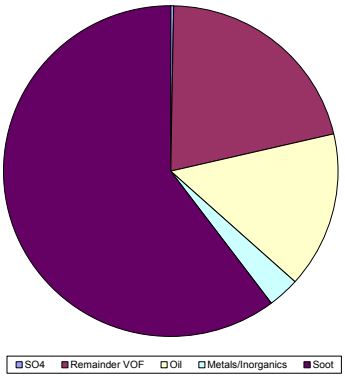
PARTICULATE CHARACTERIZATION

APPENDIX E – PARTICULATE COMPOSITION

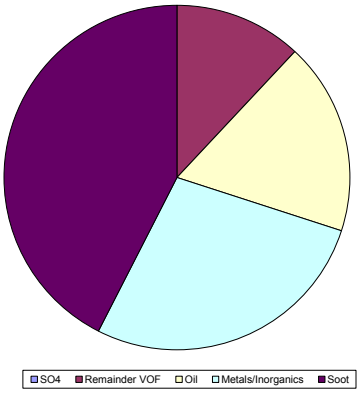
Silverado Cold UDDS



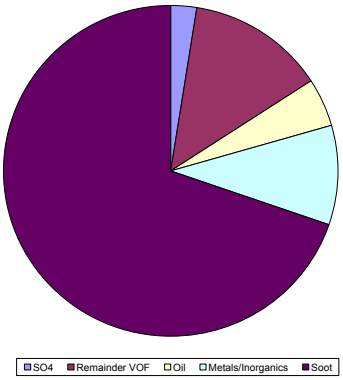
Silverado Hot UDDS



Silverado US06

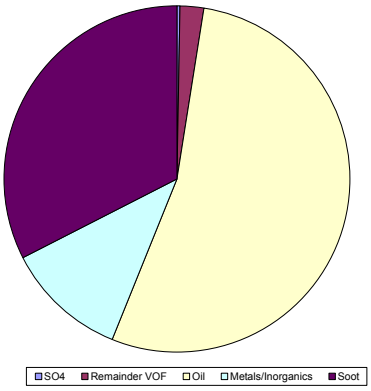


Silverado 3100/75%

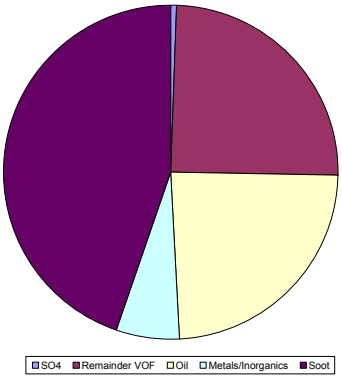


APPENDIX E – PARTICULATE COMPOSITION

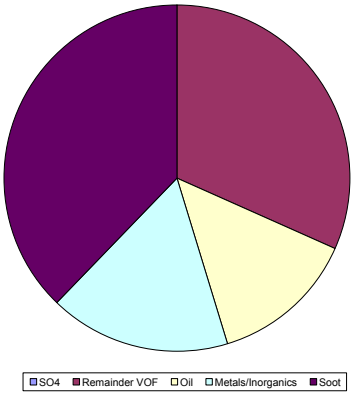
Silverado 3100/50%



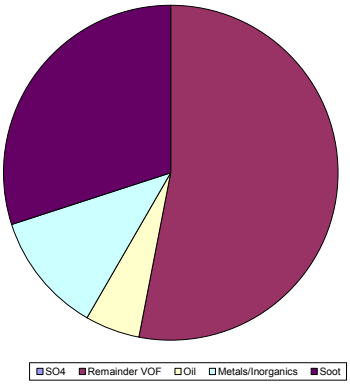
Silverado 1800/50%



Silverado 1800/25%

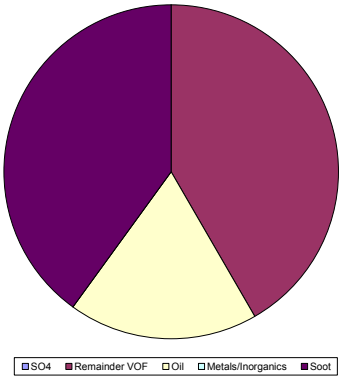


Silverado Idle

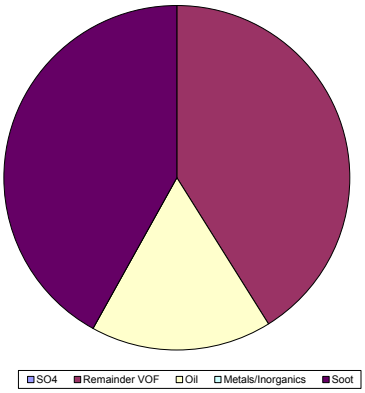


APPENDIX E – PARTICULATE COMPOSITION

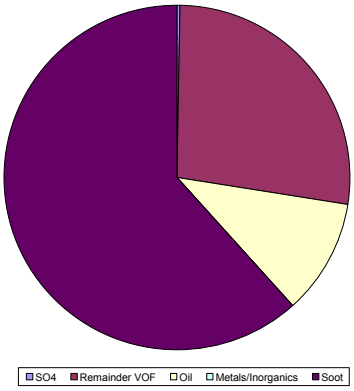
F-350 Cold UDDS



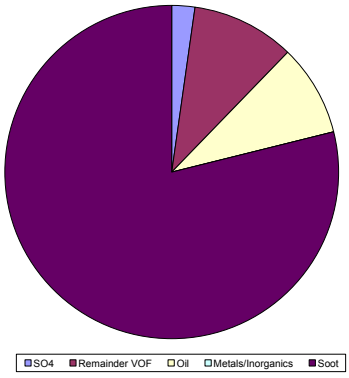
F-350 Hot UDDS



F-350 US06

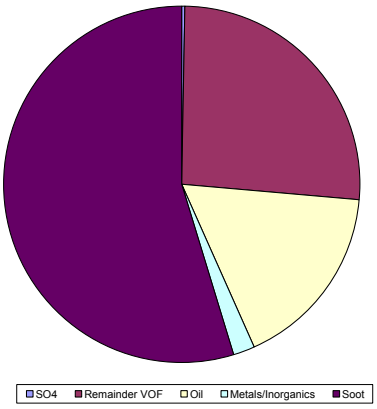


F-350 3300/75%

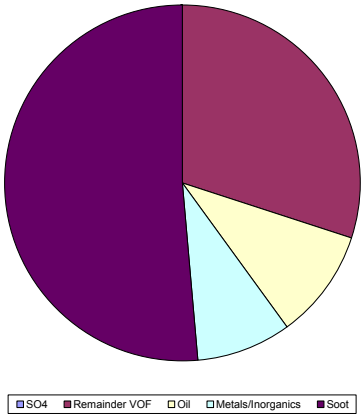


APPENDIX E – PARTICULATE COMPOSITION

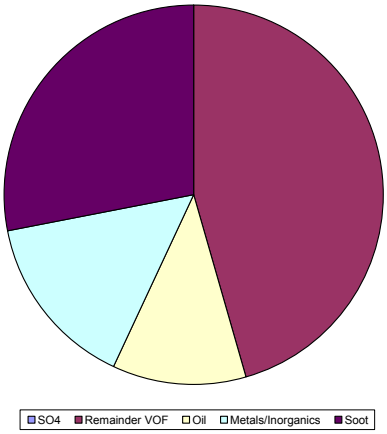
F-350 3300/50%



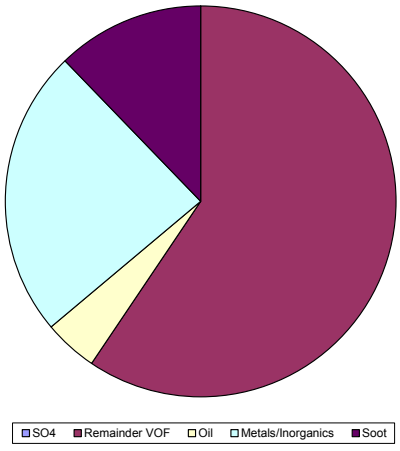
F-350 2000/50%



F-350 2000/25%

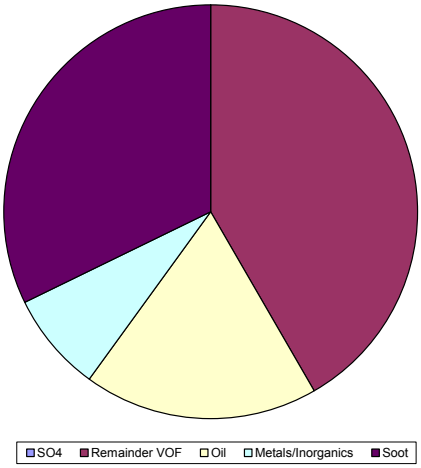


F-350 Idle

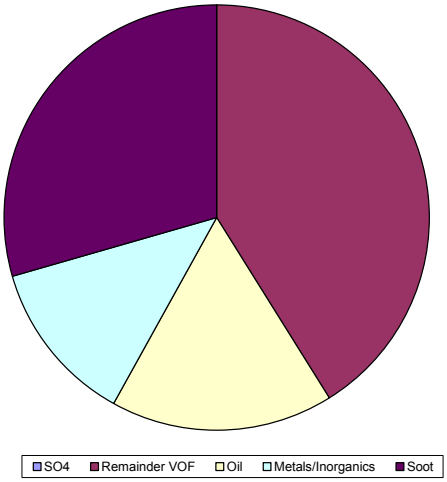


APPENDIX E – PARTICULATE COMPOSITION

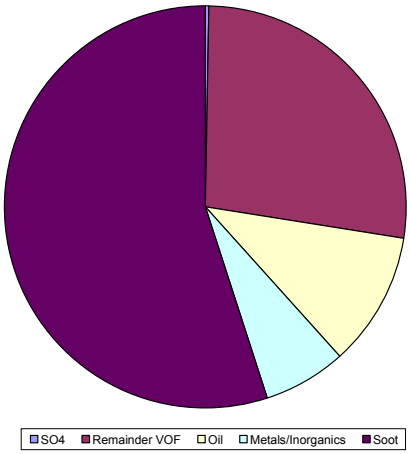
F-350 Cold UDDS



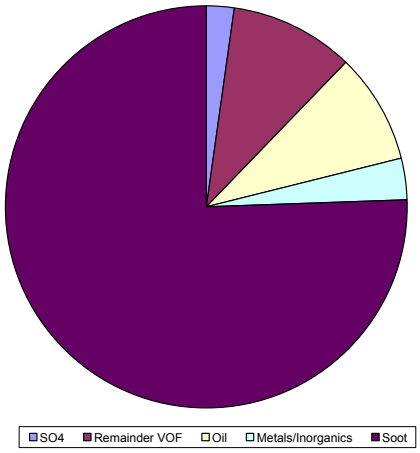
F-350 Hot UDDS



F-350 US06

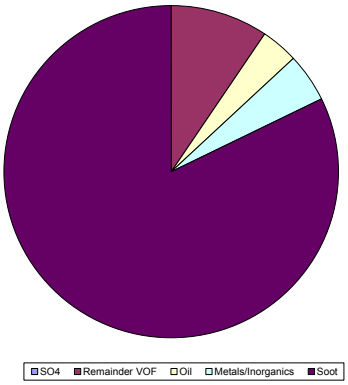


F-350 3300/75%

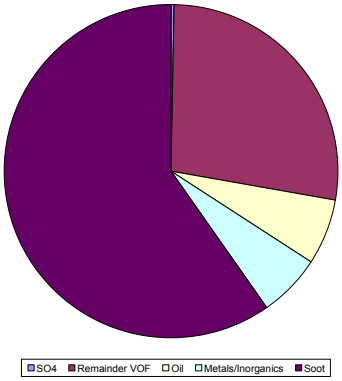


APPENDIX E – PARTICULATE COMPOSITION

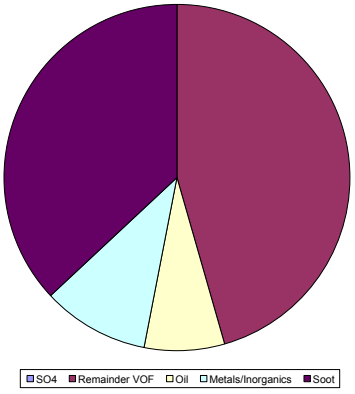
Sprinter 4000/50%



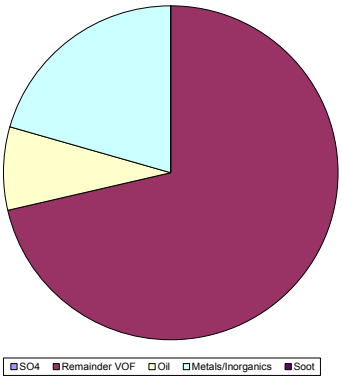
Sprinter 1800/50%



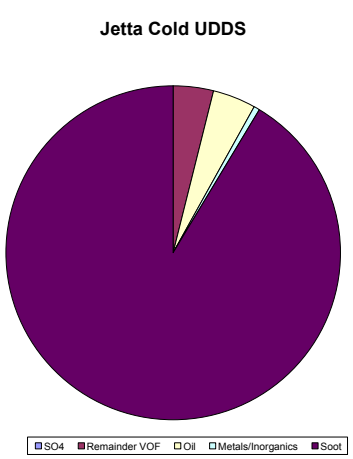
Sprinter 1800/25%

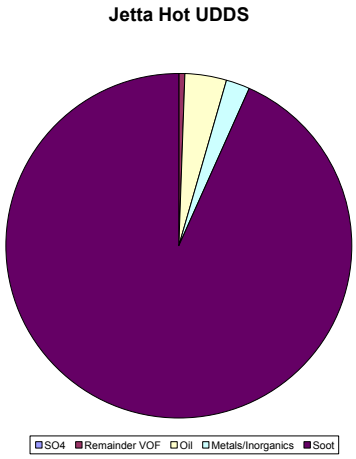


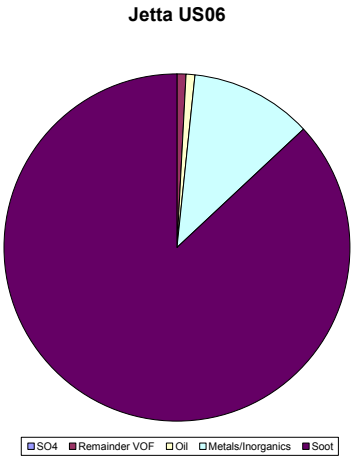
Sprinter Idle

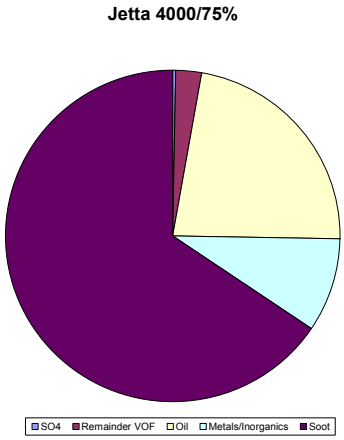


APPENDIX E – PARTICULATE COMPOSITION

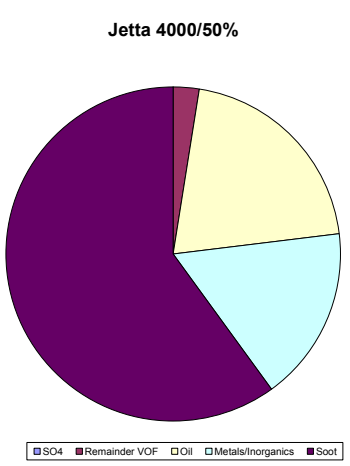


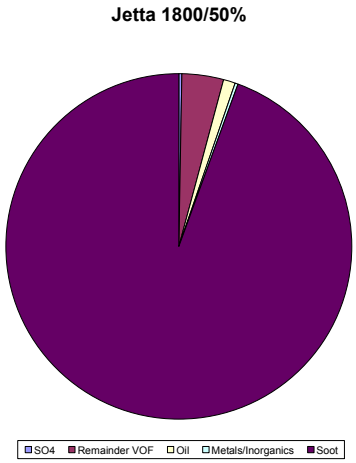


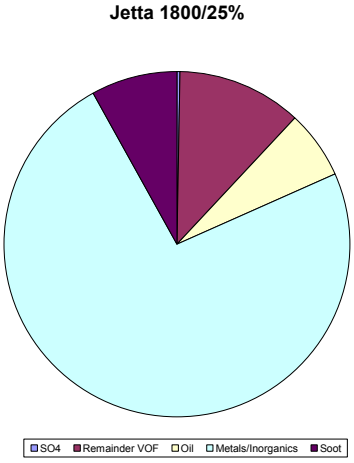


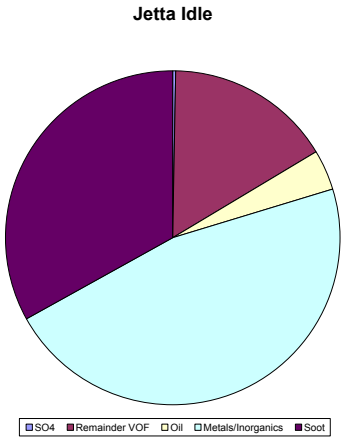


APPENDIX E – PARTICULATE COMPOSITION





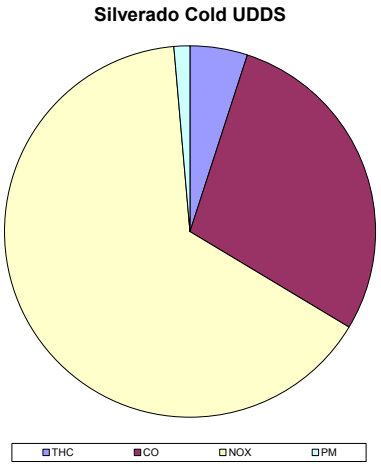


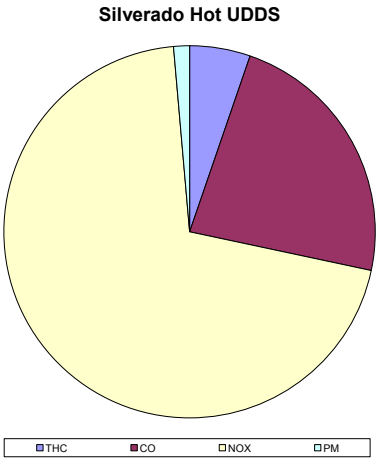


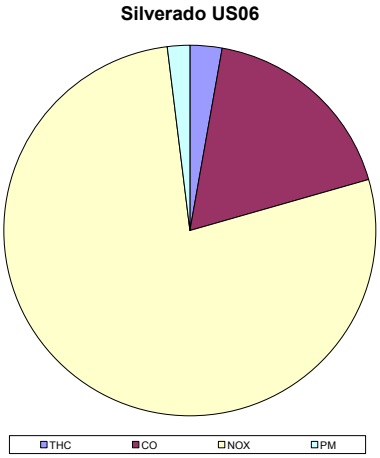
APPENDIX F

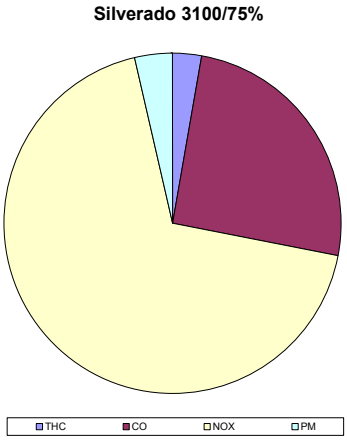
RELATIVE MASS EMISSION RATES FOR REGULATED EMISSIONS

APPENDIX F – RELATIVE MASS EMISSION RATES

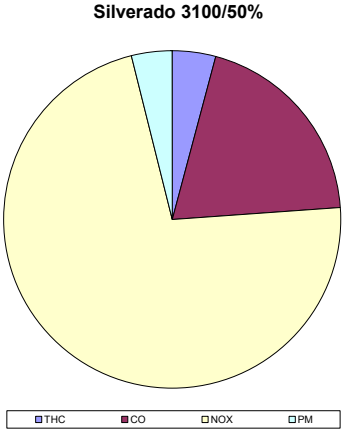


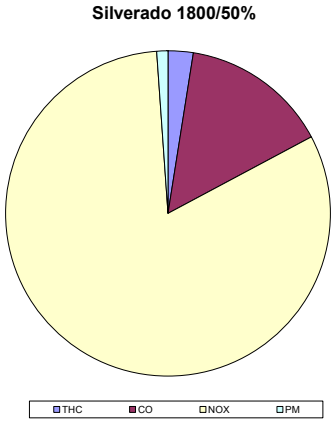


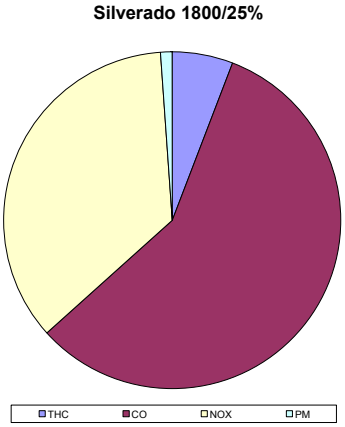


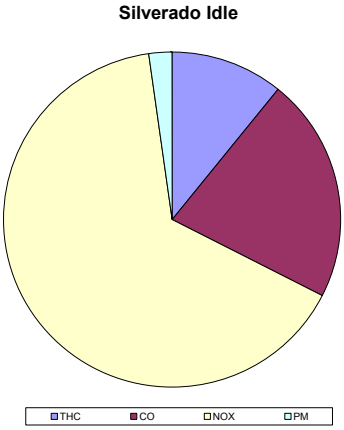


APPENDIX F – RELATIVE MASS EMISSION RATES

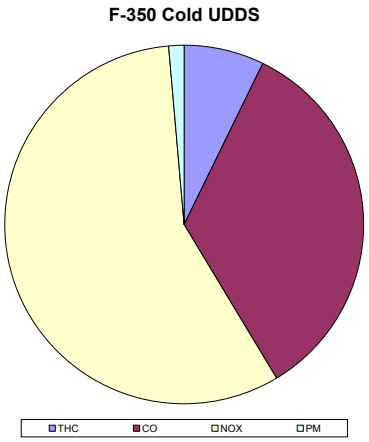


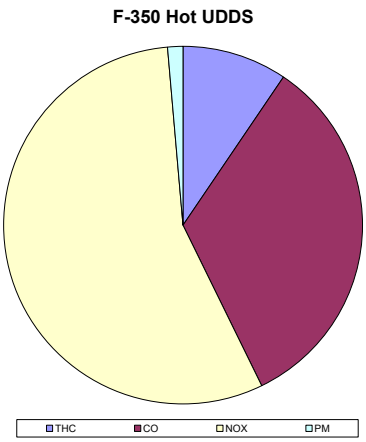


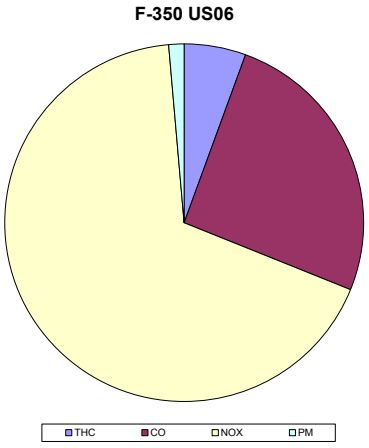


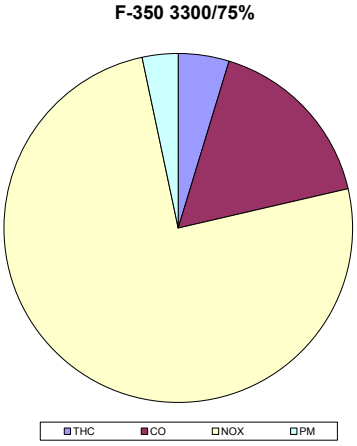


APPENDIX F – RELATIVE MASS EMISSION RATES

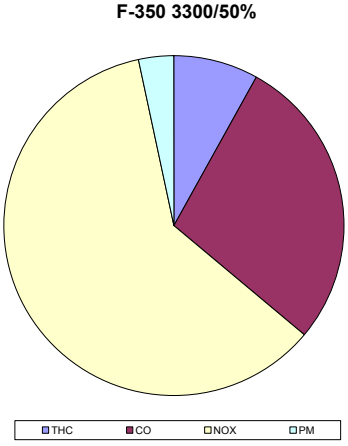


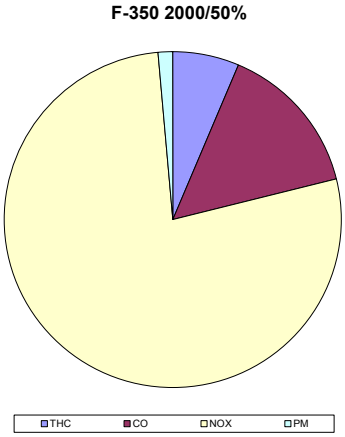


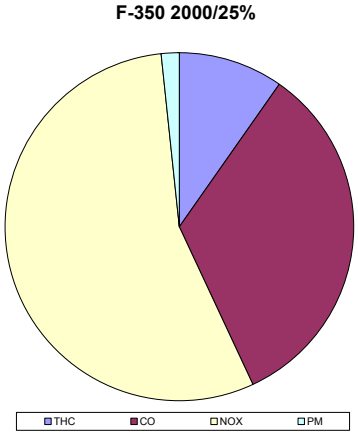


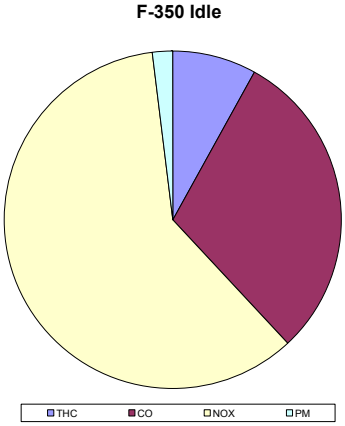


APPENDIX F – RELATIVE MASS EMISSION RATES

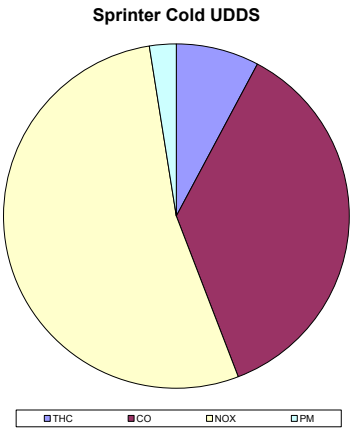


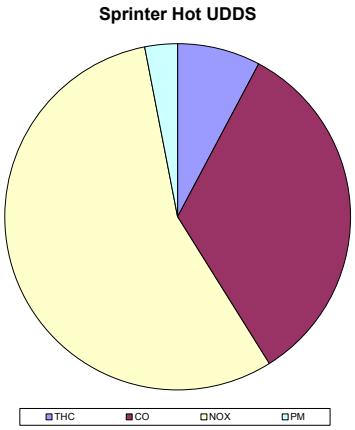


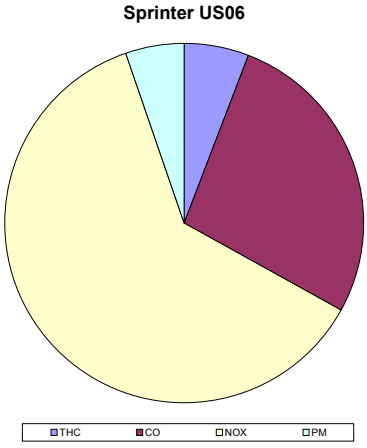


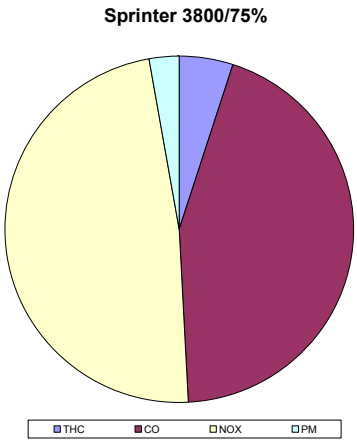


APPENDIX F – RELATIVE MASS EMISSION RATES









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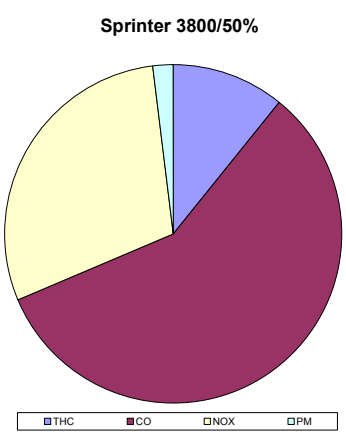
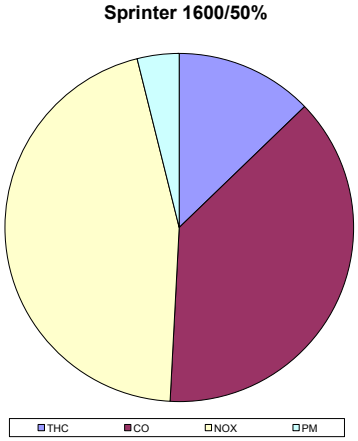
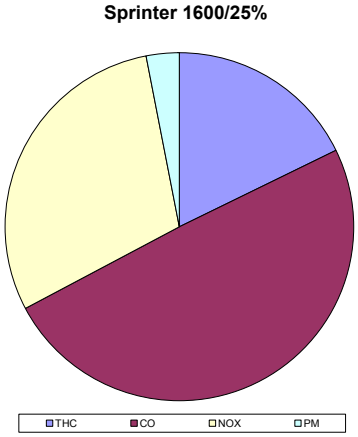
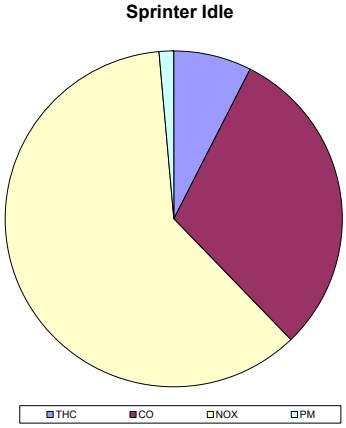
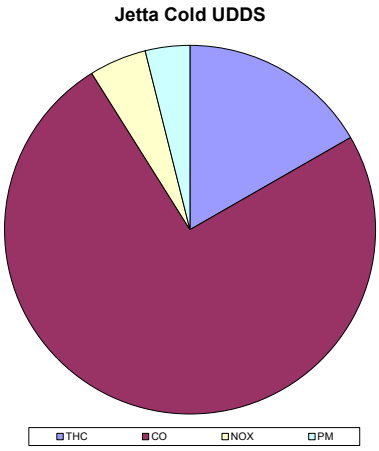


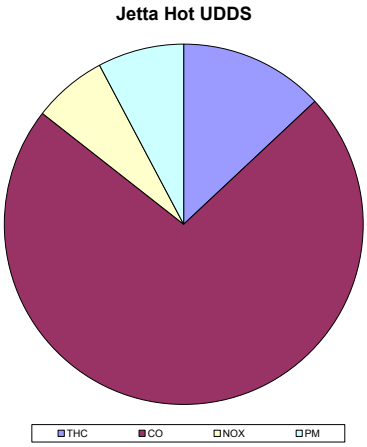


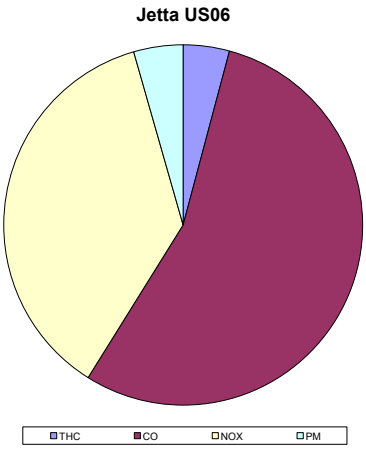


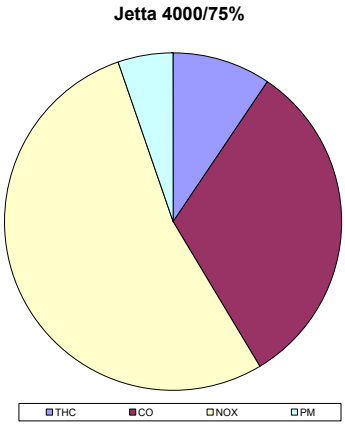


APPENDIX F – RELATIVE MASS EMISSION RATES









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