CRC Report No. AVFL-10c

DIESEL EXHAUST STANDARD DEVELOPMENT: Phase 3

FINAL REPORT

June 2008

COORDINATING RESEARCH COUNCIL, INC.
3650 MANSELL ROAD·SUITE 140·ALPHARETTA, GA 30022

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AVFL-10c COMMITTEE SUMMARY

In 2002, the leadership of the Advanced Vehicle / Fuel / Lubricants Committee (AVFL) of the Coordinating Research Council (CRC) leadership organized a technical session at the Spring Fuels and Lubricants Conference of the Society of Automotive Engineering (SAE). The purpose was to describe the research projects that the committee had undertaken and to solicit input on the needs and priorities of the vehicle engineering community that would help guide the direction of future AVFL-sponsored research.

While the fuels- and combustion-oriented audience offered a great diversity of opinion, they expressed the greatest need, by a significant margin, for a surrogate diesel exhaust to use in catalyst screening that was better than the current *de facto* standard of propene. Propene represents one class of light hydrocarbons, but obviously does not include the bulk of hydrocarbons, nor many of the other major components such as water and CO_2 that may affect catalyst performance. The community sought a repeatable "standard" exhaust mixture that had better fidelity in approximating real diesel exhaust. In deciding to initiate a research program in response to this need, AVFL sought to not only provide a more accurate estimate of catalyst effectiveness, but also to investigate any variation in effectiveness of a new catalyst as a function of chemical type.

In the following report, Southwest Research Institute (SwRI) describes the culmination of a three-stage process:

1. establishing the state of the literature on speciated diesel exhaust emissions (Phase 1),
2. conducting experiments to fill the key data gaps in the light duty diesel emissions literature and a proposal for a surrogate diesel exhaust composition (Phase 2),
3. testing that surrogate mixture on a series of catalysts and comparing the results to real exhaust conversion (this report, Phase 3).

Reports on all phases are available from CRC.

Optimally, one would like a single bottle of standard gas that captures all major chemistries and is indefinitely stable, but in practice this is not feasible. Diesel exhaust has been shown to contain hundreds of chemicals at generally very low levels. Furthermore, the mix of hydrocarbons varies with the exact fuel composition, the speed and load, the engine technology, and environmental conditions such as temperature. In addition, the cost of including all these chemicals would be prohibitively expensive. Consequently, the goal was to represent the mix of hydrocarbon length and chemistry through a limited number of compounds.

Two complicating factors in this process included the treatment of reactive components and heavy molecules. Reactive components such as aldehydes are potentially very important to understand but they are not stable over time and would react with other components of the mixture if stored in a single bottle, necessitating the consideration of sub-mixtures to be combined shortly before use. Maintaining the heavy molecules of the exhaust mixture in a gas

phase is another difficulty due to their propensity to condense when pressurized. However, it was desirable to minimize the number of separate sub-mixtures required to maintain stability over a reasonable time, in order to maintain the practicality of testing with the mixture. Given these concerns, the representative hydrocarbons were chosen with care.

As is described in the report, a composition and method of delivery has been developed that provides relatively good fidelity for simulating real diesel exhaust and discriminating the relative effectiveness for various chemistries. The percent HC conversion with the mixture aligns better with the real exhaust conversion in most tests when compared to propene, and provides a much richer picture of the relative conversion of different chemical classes under all conditions. Details are highlighted in the executive summary on page iii, and the conclusions are described on page 58. Furthermore, the inclusion of water, CO_2, and other non-hydrocarbon components provide much better assurance that a novel catalyst that would be deactivated by such chemicals will show low conversion.

Based on the advantages of using the mixture, it is the desire of the CRC AVFL Committee that the combustion and catalysis community begin to employ this new surrogate diesel exhaust widely in experiments with novel catalysts.

DIESEL EXHAUST STANDARD - PHASE III: CRC PROJECT NO. AVFL-10c

FINAL REPORT

SwRI Project No. 03.12264

Prepared for

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Prepared by:
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Project Leader

June 2008

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FOREWORD

This project, entitled "Diesel Exhaust Standard Phase III: CRC Project No. AVFL-10c," was performed for the Coordinating Research Council (CRC) by the Emissions Research and Development Department at Southwest Research Institute® (SwRI®). The period of performance began February 27, 2006 and extended through December 31, 2007. The project was based on SwRI Proposal 03-44162A. The Project Director for CRC was Dr. Christopher J. Tenant. The Advanced Vehicles, Fuels, and Lubricants (AVFL) Committee and Working Group were responsible for the technical oversight for this project, and Mr. Scott W. Jorgensen from General Motors 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.

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EXECUTIVE SUMMARY

This report describes the third 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. Phase II supplemented the limited data on light-duty diesel emissions from Phase I with an experimental effort to assess the composition of four light-duty vehicles at several operating conditions. In addition, a possible "recipe" for light-duty diesel engine exhaust was suggested. In Phase III, the feasibility of preparing a synthetic diesel exhaust mixture was investigated. This synthetic diesel exhaust mixture was then tested in a laboratory bench synthetic gas reactor to determine if the synthetic mixture suitably captured the nature of actual diesel exhaust. Four individual diesel catalysts were evaluated on a current-technology light-duty vehicle, and the results were compared those same diesel catalysts in the laboratory bench synthetic gas reactor.

The effort was broken down into ten tasks. These tasks included the development and preparation of a synthetic diesel exhaust mixture; aftertreatment, vehicle, and fuel selection; vehicle exhaust emission measurements; laboratory bench synthetic gas reactor measurements; data analysis; and reporting. The synthetic diesel exhaust mixture as proposed by AVFL-10b consisted of four major components (nitrogen, oxygen, carbon dioxide, and water) and three minor components (oxides of nitrogen, carbon monoxide, and hydrocarbons). Eight individual hydrocarbons were selected to represent the six compound groups that comprise the majority of the different hydrocarbon compounds in diesel exhaust. The hydrocarbons included ethylene, propylene, benzene, toluene, 2,2,4-trimethylpentane, tetradecane, tetralin, and formaldehyde. The stability of the synthetic diesel exhaust mixture was stable for an extended period of time with the exception of formaldehyde. The stability of the formaldehyde portion of the synthetic diesel exhaust mixture requires additional study. A second synthetic diesel exhaust mixture with propylene only to represent the hydrocarbons was also prepared and compared to the more complex mixture.

The vehicle was a 2005 Vauxhall Vectra with a 1.9 L engine and an automatic transmission, and the fuel was a 2007 ultra-low sulfur diesel fuel. This fuel had different properties from the fuel used to develop the proposed synthetic diesel exhaust mixture in AVFL-10b. Vehicle testing included 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 (the Federal Test Procedure and the US06). Regulated emissions were measured and the exhaust was characterized by speciating the volatile and semi-volatile hydrocarbons. Engine-out emissions were then compared to the results from AVFL-10a and 10b. Four diesel catalyst formulations:

- Platinum only with a 75 g/ft^3 loading
- 3:1 Platinum to palladium with a 75 g/ft^3 loading
- Platinum only with a 20 g/ft^3 loading
- 3:1 Platinum to palladium with a 20 g/ft^3 loading

were tested on the vehicle to determine the catalyst-out emission levels and catalyst conversion efficiencies. Core samples were then taken from each of the four catalysts and separately used on the laboratory bench synthetic gas reactor with the synthetic diesel exhaust blends. Temperatures and exhaust space velocities recorded during vehicle testing were replicated with the laboratory bench synthetic gas reactor. The evaluations included the five temperature/space velocity regimes obtained for the five steady-state conditions with two different synthetic diesel exhaust mixtures.

In a comparison of the vehicle catalyst-out emissions from the four catalyst formulations, percent reductions were determined for the transient cycles and for the same five steady-state modes. With the five steady-state conditions, significant reductions were noted for the THC and CO, but little change was observed for the NO_x. When comparing the percent reductions for the transient cycles, the THC was almost 100 percent and the CO was greater than 90 percent for the three transient cycles, while the percent reduction for the NO_x was between 12 and 25 percent for the UDDS cycles and between 1 and 7 percent for the US06. The THC and CO percent reductions were related to space velocity for steady-state Modes 1 through 4 with the percent reduction increasing with decreasing space velocity. Mode 5 (Idle) results were variable with the variation attributed to much lower exhaust temperatures for this mode. Low percent reductions for the NO_x were also observed for the steady-state modes. No specific trend related to catalyst loading or palladium content was noted for the steady-state modes.

With the vehicle, the individual hydrocarbon compounds were reduced for each catalyst formulation. Catalyst-out hydrocarbon concentrations were lower for the hot UDDS and US06 cycles than for the cold UDDS cycle; and the individual hydrocarbon concentrations decreased as the space velocity decreased for the steady-state modes. Mode 5 (Idle) results were an exception to this observation. In addition, a general trend with the transient cycles was observed toward lower percent reductions as the catalyst loading was reduced and lower percent reductions as the palladium content was increased. Percent reductions for Modes 1 through 4 were generally similar for the four catalyst formulations.

Two synthetic diesel exhaust mixtures (propylene only and an eight component hydrocarbon blend) were used to represent diesel exhaust during tests with the laboratory bench synthetic gas reactor. The laboratory bench synthetic gas reactor results were then compared to

those obtained from the steady-state vehicle emission tests. For the THC, the multiple component hydrocarbon mixture was found to be better for simulating the percent reductions from the vehicle for Modes 1 through 3, while the propylene only mixture was better at simulating the THC results for Mode 4. It should be noted that the full mixture was only less than 8 percentage numbers lower than the THC percent reductions observed for the vehicle exhaust for this mode. For the CO emissions, both mixtures were comparable for Modes 1 through 4. Neither mixture was able to reproduce the vehicle THC and CO percent reductions observed during Mode 5. In addition, no general trend was noted for the different test conditions, catalyst formulations or gas mixtures for the NO_x emissions.

The percent reductions for the individual hydrocarbons used in the synthetic diesel exhaust mixture were also compared to the hydrocarbon emissions from the steady-state vehicle emissions. In general, percent reductions for ethylene, propylene, benzene, 2,2,4-trimethylpentane, and formaldehyde increased with decreasing space velocity. Percent reductions for Modes 1 through 4 with ethylene, propylene, and benzene were similar between the vehicle-out and the laboratory bench synthetic gas reactor. Percent reductions for 2,2,4-trimethylpentane were generally lower with the laboratory bench synthetic gas reactor than with the vehicle while toluene percent reductions were generally higher with the laboratory bench synthetic gas reactor than with the vehicle. Formaldehyde had similar results to 2,2,4-trimethylpentane for Modes 2 through 4, but the percent reductions were higher for Mode 1. The percent reductions for tetralin and tetradecane were difficult to compare due to low vehicle-out emissions. These general trends appeared to be independent of the catalyst formulation and loading. While some variation in hydrocarbon components were observed for the various studies due to differences between the test fuels, the eight hydrocarbons selected to represent the hydrocarbon components in the synthetic diesel exhaust mixture were considered to be representative of the various hydrocarbon groups. Conversion efficiencies for the four catalyst formulations in actual exhaust and conversion efficiencies for with the synthetic diesel exhaust mixture were quite similar for the different hydrocarbon groups. It should be noted that the single compound propylene could not represent the changes for the various compound groups.

In general, emissions generated from steady-state vehicle tests could be represented with a laboratory bench synthetic gas reactor and a synthetic diesel exhaust mixture. Data generated with both synthetic diesel exhaust mixtures agreed quite well with the vehicle data, except for Mode 5 (Idle). The full mixture was slightly better at representing actual vehicle exhaust during most of the test conditions and the propylene only mixture tended to have higher conversion efficiencies for the THC and CO at the higher space velocities. This observation may be due to the relative light-off temperature of propylene itself and may account for the higher conversion efficiencies with propylene only at the higher space velocities. When the mixture was more complex, alternate reaction mechanisms with higher initial light-off temperatures apparently inhibited reactions which ultimately simulate actual diesel exhaust better. Therefore, the full mixture was thought to be better at simulating actual diesel exhaust.

1.0 INTRODUCTION

The exhaust from diesel engines has come under increasing public scrutiny in the United States; and as a result, diesel exhaust aftertreatment has become an important technology in helping achieve lower emission levels from diesel engines. Since diesel exhaust has 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. As a result, alternative technologies will need to be developed.

The development of exhaust aftertreatment 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 exhaust aftertreatment, with propylene 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 may be 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. The follow-on study was conducted by Southwest Research Institute (SwRI) to provide CRC with additional light-duty emissions data.[2] In that study (AVFL-10b), light-duty engine-out diesel exhaust from four current model light-duty vehicles was collected and analyzed to determine the exhaust composition.[3] These vehicles were tested at a variety of conditions to collect information in order to suggest a standard diesel exhaust composition. In the current study, the feasibility of preparing a synthetic diesel exhaust mixture was investigated, and a synthetic diesel exhaust mixture was subsequently prepared. This synthetic diesel exhaust mixture was then tested with a laboratory bench synthetic gas reactor to evaluate four diesel catalysts and the results were compared to those obtained from a vehicle equipped with these same diesel catalysts.

2.0 WORK PLAN

2.1 Objective

The objective of this study was to evaluate a standard synthetic diesel exhaust mixture and to determine if this mixture suitably captured the nature of actual diesel exhaust with respect to diesel catalyst efficiency. This evaluation involved the use of two different synthetic gas streams:

- A stable mixture of components (without particulate) which included the major hydrocarbon species found in AVFL-10b,
- A single hydrocarbon component, propylene, as suggested in the literature.

These synthetic exhaust mixtures were examined using four different diesel catalysts and compared to results with actual light-duty diesel exhaust under similar operating conditions.

2.2 Scope of Work

This effort was broken down into ten tasks:

- Feasibility for blending a synthetic mixture,
- Development of a synthetic diesel exhaust mixture,
- Aftertreatment selection,
- Engine/vehicle and fuel selection,
- Test plan design,
- Development of laboratory bench equipment,
- Emission measurement procedures,
- Experimental program,
- Data analysis,
- Reporting.

In Task 1, the feasibility for preparing, blending, and storing the various synthetic diesel exhaust gas components was evaluated. In Task 2, a synthetic diesel exhaust mixture was created using information gathered in the Task 1 feasibility study. Gas cylinders were prepared with the

desired concentrations using diluent gases such as nitrogen (N_2). In addition, other component delivery systems were assembled. In Task 3, four substantially different diesel exhaust catalyst formulations were defined and acquired. These four diesel catalysts included:

- Platinum only with a 75 g/ft^3 loading
- 3:1 Platinum to palladium with a 75 g/ft^3 loading
- Platinum only with a 20 g/ft^3 loading
- 3:1 Platinum to palladium with a 20 g/ft^3 loading

Task 4 involved the selection of a vehicle and a test fuel to produce exhaust for comparison to the synthetic diesel exhaust mixture. A 1.9 L, 2005 model year European diesel vehicle was selected for emission testing. Two test fuels were used in this study: one for degreening the catalysts prior to testing and one for emission testing the vehicle. Task 5 involved the selection of a series of steady-state and transient test conditions to evaluate the catalyst efficiency with both actual diesel exhaust and the standard synthetic diesel exhaust mixture. The five steady-state engine operating conditions were identical to those from AVFL-10b and included:

- 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, and
- Idle.

The two transient test cycles used in this study, the Federal Test Procedure (FTP) and the aggressive US06 driving cycle, were also used in the AVFL-10b study.

In Task 6, modifications were made to existing SwRI laboratory bench equipment to accommodate the various catalyst pieces and the synthetic diesel exhaust blends prepared in Task 2. Compressed gases containing various exhaust components were utilized along with mass flow controllers to introduce synthetic exhaust into core samples at the expected space velocities and exhaust temperature determined in Task 8. The emission measurements in Task 7 included the regulated emissions (total hydrocarbons, THC; carbon monoxide, CO; and NO_x) as well as carbon dioxide, CO_2. In addition, measurements for a number of individual hydrocarbons emissions were conducted. The procedures used for these measurements (C_1 to C_{12} hydrocarbons, aldehydes, ketones, and C_{10} to C_{25} hydrocarbons) were similar to the CRC Auto/Oil Phase II methods and/or to methods utilized in AVFL-10b. In addition to these procedures, a Fouirer Transform Infrared (FTIR) analyzer was used to monitor selected catalyst-in and catalyst-out gaseous components from the laboratory bench synthetic gas reactor.

In Task 8, the actual engine-out diesel exhaust was examined for each test condition selected in Task 5 using the emission measurement procedures from Task 7. The first step in Task 8 was to "degreen" the four selected catalysts. The engine-out exhaust emissions were then measured from the vehicle and compared to previous tests to confirm that the vehicle was representative of previously evaluated vehicles. Exhaust temperatures at several locations in the exhaust system and exhaust flow rates to determine the catalyst space velocity were also monitored. Each catalyst was then tested using the vehicle to determine the catalyst-out emission levels and catalyst conversion efficiencies. Core samples were then taken from each of the four catalysts and separately used for the laboratory bench testing with the synthetic diesel exhaust blends. Temperatures and exhaust space velocities recorded during vehicle testing were replicated with the laboratory bench synthetic gas reactor. The evaluations included the five temperature/space velocity regimes obtained for the five steady-state conditions.

3.0 CONDUCT OF PROGRAM

This section and the following two sections provide additional details on the completion of each of the tasks in this program. Tasks 1 through 7 are discussed in their entirety in this section, while Task 8 discussions have been expanded into the two subsequent section, Sections 4.0 and 5.0, to provide information in greater detail.

3.1 Task 1 – Feasibility for Blending a Synthetic Mixture

In Task 1, the feasibility for preparing, blending, and storing the various synthetic diesel exhaust gas components was evaluated in conjunction with input from several gas suppliers. The approach considered methods for delivering synthetic exhaust:

- Utilization of multi-component gas blends (some separation of gases is necessary to avoid destabilizing interactions)
- Utilization of individual gases (one gas per cylinder) for better stability and flexibility with in-situ blending
- Utilization of other suitable delivery systems for the introduction of individual synthetic gas components.

Table 1 summarizes properties and other considerations for a number of the different components that were either considered for use in this task or that were actually utilized.

After evaluating the three different approaches above, the final approach consisted of a combination of multi-component gases, pure gases, and liquid mixture injection with volatilization into the gas stream. The final blend, illustrated in Figure 1, consisted of fourteen different components. Oxygen (O_2) and CO_2 were injected as pure gases. Nitric oxide (NO) and CO in a balance of nitrogen (Gas Mix 1), light hydrocarbons (ethylene and propylene) in a balance of nitrogen (Gas Mix 2), and formaldehyde in a balance of nitrogen (Gas Mix 3) were injected as blends. The "heavy hydrocarbons" (a blend of five components: 2,2,4-trimethylpentane, benzene, toluene, tetradecane, and 1,2,3,4-tetrahydronaphthalene also called tetralin) were injected as a liquid mixture. These five components were combined in predetermined ratios and volatilized into the gas stream. Water (H_2O) was also injected as a pure compound. Pure N_2 was then used as a balance gas to achieve the final desired concentrations. When combined, the mixture represented the synthetic diesel exhaust proposed in AVFL-10b.

3.2 Task 2 – Development of a Synthetic Diesel Exhaust Mixture

In Task 2, a synthetic diesel exhaust mixture was created from the information gathered in the Task 1 feasibility study. The second objective of this task was to determine the stability of the multi-and individual component blends that were used to prepare the synthetic diesel exhaust mixture.

TABLE 1. SUMMARY OF PROPERTIES AND CONSIDERATIONS

Compound	MW	BP @ 1atm, °F	Melting Point, °C	Density (of liquid), g/ml	Vapor Press, psig	Specific Volume at 70°F, mL/g	Ship Pres, psig	Purity, Research Grade, mole %	Physical State at STP or as supplied	CGA	Container	Comment
Nitrogen, N_2	28.01	-195.8	–	–	–	861.5	2200	99.999	Gas	580	HP steel, 18/8 SS	asphyxiant
Oxygen, O_2	31.999	-183	–	–	–	755.4	2200	99.99	Gas	540	HP steel	explosive, avoid oils & greases, etc
Carbon dioxide, CO_2	44.01	-78.3[a]	–	–	830	547	830	99.99	liquified	320	HP Steel	asphyxiant
Water, H_2O	18.016	100	–	1.0	–	–	-	-	liquid		–	essential to life as we know it
Nitric oxide, NO	30.01	-151.7	–	–	–	811.5	500	99	Gas	660	HP steel, 18/8 SS	highly toxic, converts to NO_2 in air
Carbon monoxide, CO	28.01	-191.5	–	–	–	861.5	1500	99.8	Gas	350	HP steel, 18/8 SS	highly toxic, combustible
Formalin solution, 37%	30.03	96	–	–	–	–	–	–	aqueous	n/a	n/a	approx. 37% by weight
Formaldehyde	30.03	-19.3	–	–	–	–	–	–	Gas	n/a	–	highly toxic gas, polymerizes easily, reactive
Paraformaldehyde	–	–	–	–	–	–	–	–	solid	–	–	highly toxic gas, polymerized, reactive
Trioxane	90.08	124	12	0.99		–	–	–	liquid	–	–	flammable, toxic, corrosive, carcinogen
Ethylene	28.054	-154.7	–	–	–	861	1200	99.98	Gas	350	HP Steel	combustible
Propylene	42.079	-47.7	–	0.5139	136.6	565.6	136	99.97	liquified	510	LP	combustible
Tridecane	184.37	234	-5	0.7564	0.019	–	–	–	liquid	–	–	combustible
Tetradecane	198.39	253	5.5	0.763	0.019	–	–	–	liquid	–	–	combustible
Pentadecane	212.42	268	9.9	0.769	0.019	–	–	–	liquid	–	–	combustible
Naphthalene	128.17	218	80.2	1.0253	0.001	–	–	–	Solid	–	–	toxic, combustible; soluble in ethanol and acetonitrile
Tetralin	132.20	207.2	-31.0	0.9962	–	–	–	–	liquid	–	–	irritating to skin, eyes, and mucous membranes
2,2-dimethylpropane	72.15	9.6	–	–	7	330.8	7	99.87	liquified	510	LP	combustible
Benzene	78.11	80.1	–	0.876	1.44	–	–	–	liquid	–	–	highly toxic, combustible
Toluene	92.14	110.6	–	0.866	0.42	–	–	–	liquid	–	–	combustible

[a]sublimation
Data compiled from Matheson Gas Data Book, Matheson Gas Products, 1971; CRC Handbook of Chemistry and Physics, 75th Ed.; and The Merck Index, Tenth Edition

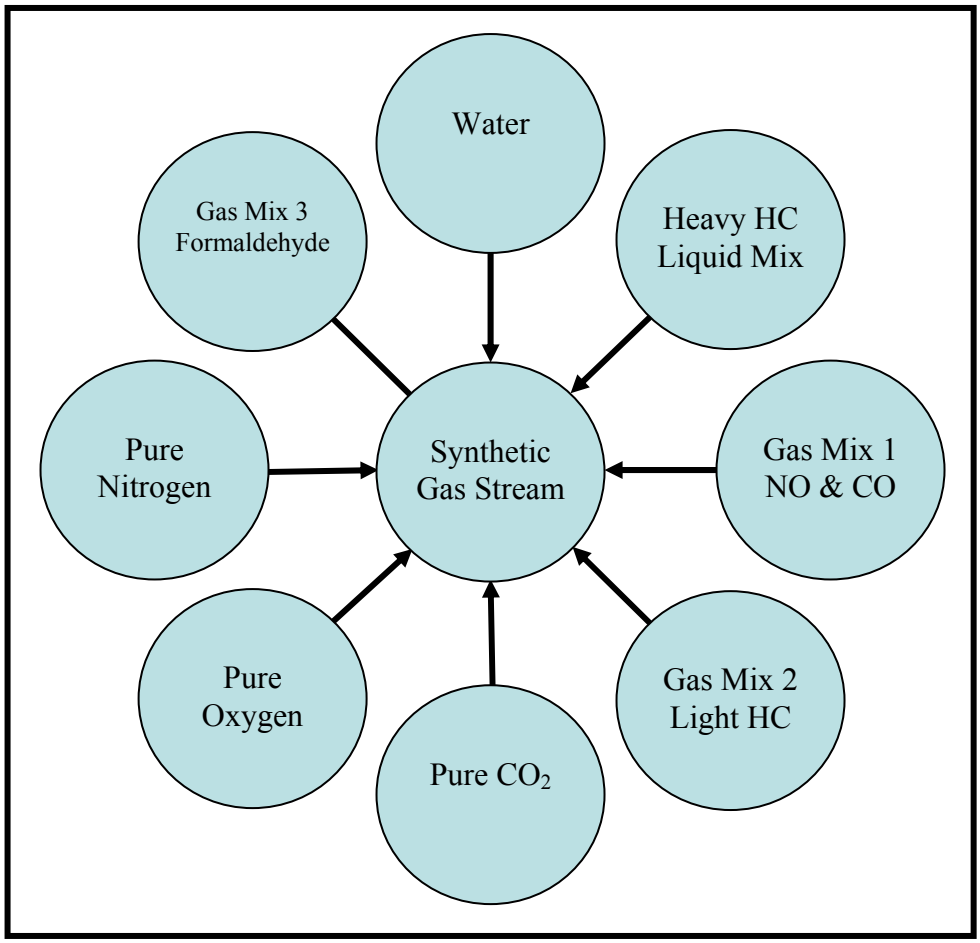

FIGURE 1. SCHEMATIC OF SYNTHETIC DIESEL EXHAUST MIXTURE

The three major components of the synthetic diesel exhaust mixture are N_2, O_2, and CO_2. These gases account for about 97 percent of the total mass of the synthetic diesel exhaust mixture. A consideration was first given in Task 1 to introduce the gases as a blend, but this approach was later changed to introducing them as pure gases. This approach allowed more flexibility in achieving the required concentrations. The use of separate gases and their blending in the laboratory bench synthetic gas reactor provided the following advantages:

- Reduced potential gas interactions
- Minimized cost by reducing the number of pre-blended gas cylinders.
- Allowed tighter control of individual concentrations in the synthetic diesel exhaust mixture.

CO_2 and O_2 were initially obtained as a blend with cylinder concentrations of 19 percent CO_2 and 45.6 percent O_2, with a balance of N_2. Gas usage was high with these blended cylinders, and the relative cost of the blended mixture was also relatively high when compared to

the cost of pure CO_2 and pure O_2 cylinders. Therefore, this blend was replaced with pure gas cylinders.

The next major component of the proposed synthetic diesel exhaust mixture was water which accounted for an additional 3 percent of the mass of the mixture. Water was introduced from a reservoir using a digital liquid flow controller. The water was pumped into a heated plenum through which the main gas mixture flowed. As the water was evaporated, it was picked up in the main gas stream. The flow controller maintained the proper concentration of water in the synthetic diesel exhaust mixture.

The remaining components (CO, NO_x represented here as NO, and hydrocarbons) were considered minor components of the synthetic diesel exhaust mixture. While NO and CO were individual gases, both were obtained as a mixture in a gas cylinder with concentrations of 3480 ppm NO and 2090 ppm CO in a balance of N_2. The combination of these two gases is commonly used, and a two-year warranty on mixture stability was provided by the gas supplier. For the purpose of this study, this mixture was identified as Gas Mix 1. No problems were experienced with the stability of this mixture.

The hydrocarbons consisted of a combination of compounds representing the various types of hydrocarbon species found in diesel exhaust. Ultimately, eight individual hydrocarbons were used to represent the total hydrocarbons. While the total mass of the hydrocarbons was the smallest portion of the synthetic diesel exhaust mixture, this group was also the most complex. In AVFL-10b, the hydrocarbons were divided into five groups (semi-volatiles, olefins, aldehydes, aromatics, and branch-chained hydrocarbons), and a number of different compounds were used to represent the different groups. In this study, specific compounds were selected from each group and were ultimately introduced as both a gas blend and as a liquid heavy hydrocarbon mixture. A discussion of the selection of compounds for each group follows.

Within the total hydrocarbons, the most abundant hydrocarbon group from the AVFL-10b study was found to be the semi-volatile group. The group represented about 36 percent of the total mass of the hydrocarbons. Originally, the semi-volatile group was proposed to be comprised of four separate compounds (tridecane, tetradecane, pentadecane, and naphthalene). Tetradecane was easy to obtain; however, tridecane and pentadecane were more difficult and required a much longer lead time to acquire. As a result, the concentration of tetradecane was increased to account for the mass of all three of these straight-chain hydrocarbons. Naphthalene is a solid at room temperature and at the desired concentration in hydrocarbon mixture was not sufficiently soluble. Therefore, the aromatic portion of the semi-volatile hydrocarbons was changed to another semi-volatile component found in the AVFL-10b study, tetralin. Tetralin is a liquid at room temperature and is miscible with the other hydrocarbon carbons of interest.

Aromatics represent about 7 percent of the mass of the total hydrocarbons, and benzene and toluene were selected to represent this group of compounds. These two aromatics were blended with the semi-volatile components for introduction as liquids. Both were relatively easy to obtain; however as an alternative, xylenes could also be utilized in place of either benzene, toluene, or both.

Branched-chain hydrocarbons represented about 5 percent of the total hydrocarbon mass, and 2,2,4-trimethylpentane was ultimately chosen to represent this group. Initially, 2,2-dimethylpropane was to represent this group of hydrocarbons and was to be included in the light hydrocarbon mix, but its volatility was not sufficient to prepare a cylinder that would be stable at the desired concentrations. Another alternative, 3-methylpentane, also presented a volatility problem. As a result, a higher molecular weight compound, 2,2,4-trimethylpentane, was selected to represent this group and was included with the semi-volatile and aromatic compounds for liquid injection.

This liquid heavy hydrocarbon mixture was prepared by weighing each of the components based on the desired concentration in the synthetic diesel exhaust mixture. The mixture was introduced into the laboratory bench synthetic gas reactor with a 1 ml Hamilton Gastight® #1001 syringe connected to a Cole Palmer 74900-00-05 syringe pump. A pump rate of 0.05 ml/hr achieved the required hydrocarbon gas phase concentration from the liquid hydrocarbon mixture. The blended liquid was injected into the hot synthetic diesel exhaust stream and vaporized. Excess liquid heavy hydrocarbon mixture was stored in a glass container and kept tightly sealed to avoid evaporation of the higher volatility components.

About 29 percent of the total hydrocarbon mass includes olefins. The compounds used to represent this group were ethylene and propylene. 1-Butene was also considered, but the first two were chosen due to their volatility and stability as components in a compressed gas cylinder. The cylinder concentrations selected were 80 ppm ethylene and 33.1 ppm propylene in a balance of N_2. For the purpose of this study, this light hydrocarbon mixture was called Gas Mix 2. The mixture had a one-year warranty of mixture stability provided by the gas supplier, and no problems were experienced with this mixture.

The next component was the aldehydes. Aldehydes represent about 23 percent of the total hydrocarbon mass, and formaldehyde was chosen to represent this group. Originally, formaldehyde was to be added using a formalin solution and introduced with the water. However, commercial formalin contains approximately 10 percent methanol. The solution was not considered stable enough to use without the methanol. Two alternative sources of formaldehyde were considered: paraformaldehyde $(CH_2O)_n$ and trioxane $(C_3H_6O_3)$. Paraformaldehyde was not considered a viable option because it is a polymerized solid with an unknown molecular weight, and it would have been difficult to control the formaldehyde concentration in the synthetic diesel exhaust mixture. Trioxane, on the other hand, is a white crystalline solid which is soluble in organic solution. It decomposes to form formaldehyde at about 115ºC. An attempt was made to dissolve sufficient trioxane in the liquid hydrocarbon mixture to achieve the desired gas concentration. However, the trioxane was not sufficiently soluble. Ultimately, the method selected for the introduction of formaldehyde was from a gas cylinder at a concentration of about 100 ppm in a balance of N_2. For the purpose of this study, this mixture was called Gas Mix 3. The supplier indicated a shelf life of six months at this concentration. When running the tests, it was necessary to introduce about twice as much gas as expected to achieve the expected concentration of formaldehyde in the synthetic diesel exhaust mixture. Analysis of the cylinder after test completion showed that the formaldehyde concentration had dropped to about 34 ppm. An investigation of the feasibility and stability of using lower formaldehyde concentration blends is still needed.

One last hydrocarbon gas blend was also prepared for this study. The synthetic diesel exhaust mixture containing the complex blend of hydrocarbons was to be compared to a synthetic diesel exhaust mixture with only propylene to represent the hydrocarbon contribution. A gas cylinder containing 219 ppm propylene in a balance of N_2 was prepared by a gas supplier. This mixture is commonly used, and a two-year warranty on mixture stability was provided by the gas supplier. No problems were experienced with the stability of this mixture.

The two synthetic diesel exhaust gas mixtures with nominal component concentrations are shown in Table 2. Both mixtures contained the major components (N_2, O_2, CO_2, and H_2O) and the minor components (NO and CO). The simple mixture used only propylene to represent the exhaust hydrocarbons, and the full mixture used eight individual compounds to represent the exhaust hydrocarbons.

TABLE 2. SYNTHETIC DIESEL EXHAUST GAS MIXTURES

Component	Nominal Concentrations	
	Simple Mixture	**Full Mixture**
NO – nitric oxide	280 ppm	280 ppm
CO – carbon monoxide	165 ppm	165 ppm
O_2 – oxygen	12 %	12 %
CO_2 – carbon dioxide	5 %	5 %
C_2H_4 – ethylene	0	6 ppm
C_3H_6 – propylene	20 ppm	2.4 ppm
CH_2O – formaldehyde	0	7.0 ppm
$C_{14}H_{30}$ – tetradecane	0	1.3 ppm
$C_{10}H_{12}$ – 1,2,3,4-tetrahydronaphthalene	0	0.7 ppm
C_8H_{18} – 2,2,4-trimethylpentane	0	0.6 ppm
C_6H_6 – benzene	0	0.4 ppm
C_7H_8 – toluene	0	0.4 ppm
H_2O – water	5 %	5 %
N_2 – nitrogen	Balance	Balance

3.3 Task 3 – Aftertreatment Selection

In Task 3, four different diesel exhaust catalyst formulations were selected for the vehicle-to-bench comparisons. All four catalysts were prepared with cordierite substrates obtained from Corning. These substrates were sized to represent the space velocity of the close-coupled catalyst on the selected test vehicle (4.66-inch diameter by 3.4-inch length with 400 cell per inch and 4 mil wall thickness). With cordierite substrates, core samples were easily taken for subsequent evaluation in Task 8 with the synthetic diesel exhaust mixture. The four formulations included:

- Platinum only with a 75 g/ft^3 loading
- 3:1 Platinum to palladium with a 75 g/ft^3 loading

- Platinum only with a 20 g/ft^3 loading
- 3:1 Platinum to palladium with a 20 g/ft^3 loading

These four formulations were provided by Sűd-Chemie, Inc. The different catalyst loadings allowed a comparison of the engine and synthetic diesel exhaust mixture in terms of the various components and their effect within the catalyst.

A 2003 7.3 L DIT Navistar engine (Model B215F) was used to "degreen" the catalysts. This engine (engine family 3NVXH07.3FNB) was rated 215 hp at 2600 rpm. The exhaust system was modified to degreen the catalysts with a flow rate that simulated vehicle operation. The catalysts were degreened four at a time using a steady-state condition of 1850 rpm and 365 ft-lb. This condition was selected to maintain the catalyst inlet temperature between 400 and 450ºC. The catalysts were aged for a total of eight hours with each catalyst rotated to a different position every two hours. After degreening, each catalyst was installed on the vehicle for emission testing in Task 8.

3.4 Task 4 – Engine/Vehicle and Fuel Selection

A 2005 Vauxhall Vectra with a 1.9 L engine and an automatic transmission was selected as the test vehicle. This vehicle had three different forms of aftertreatment. The original equipment consisted of a 0.6 L, close-coupled, metal-substrate catalyst from Emitech with a loading of 110 g/ft^3 of platinum and possibly some palladium. This catalyst served to partially oxidize the exhaust to increase the CO concentration in the exhaust. The next catalyst was a 1.0 L, ceramic-substrate, catalyst with a loading of 60 g/ft^3 of platinum from Corning. This catalyst served to help light off the third aftertreatment device which is a 4.0 L, silicon carbide-substrate, catalyzed diesel particulate filter (DPF) with a 40 g/ft^3 loading of platinum. The vehicle also had an on-board diagnostic (OBD) system.

Two fuels were selected for use in this program. The first fuel (EM-5618-F) was also used in the E-66 program, but had a lower than desired aromatic content, and therefore was only used to degreen the catalyst formulations. The second fuel (EM-5989-F), a 2007 certification diesel, was used for emission testing and was considered to be closer in composition to the fuel used in the AVFL-10b project (EM-5038-F). Table 3 compares certification and commercial specifications for diesel fuel with the fuel properties for the two fuels used in this study and for the fuel used in the AVFL-10b portion of the study.

3.5 Task 5 – Test Plan Design

The objective of Task 5 was to select the engine operating conditions to be used for aftertreatment evaluation on the vehicle and subsequent simulation with the synthetic diesel exhaust mixture. Five steady-state modes of operation were selected which reflected a range of operating conditions expected to show differences in engine-out exhaust composition that may influence exhaust aftertreatment devices. These modes were identical to those used in AVFL-10b. These modes included:

TABLE 3. 2007 FUEL SPECIFICATIONS AND PROPERTIES

Property	Certification[a]	Commercial[b]	EM-5038-F[c]	EM-5618-F[d]	EM-5989-F[e]
Cetane Number	40-50	40 min.	45.4	51.1	43.0
Cetane Index	40-50	40 min.	ND[f]	48.8	44.0
IBP Distillation Range, °F	340-400	NA[g]	382	370.4	375
10%Distillation Range, °F	400-460	NA	441	429.0	403
50% Distillation Range, °F	470-540	NA	511	518.1	474
90% Distillation Range, °F	560-630	540-640	608	594.7	584
EP Distillation Range, °F	610-690	NA	654	634.4	630
Gravity, API	32-37	30-39	34.5	40.0	36.2
Total sulfur, ppm	7-15	<15	6.9	3.8	12
Aromatics, % min.	27	<35	35.8	14.4	28.6
Flashpoint, °F min.	130	130	176	ND	166
Viscosity, cs	2.0-3.2	1.9-4.1	ND	ND	2.1

[a]Federal certification grade fuel
[b]ASTM D975 specification for No. 2 Diesel Fuel Oil
[c]Fuel analysis for fuel used in AVFL-10b
[d]Fuel analysis for fuel to be used for catalyst degreening in AVFL-10c
[e]Fuel analysis for fuel to be used for emission testing in AVFL-10c
[f]ND-Not determined
[g]NA-Not applicable

- Mode 1 - Rated speed at 75 percent torque,
- Mode 2 - Rated speed at 50 percent torque,
- Mode 3- Peak torque speed at 50 percent torque,
- Mode 4 - Peak torque speed at 25 percent torque, and
- Mode 5 - 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 were 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 operation, 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.[4]

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 2. 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.[4]

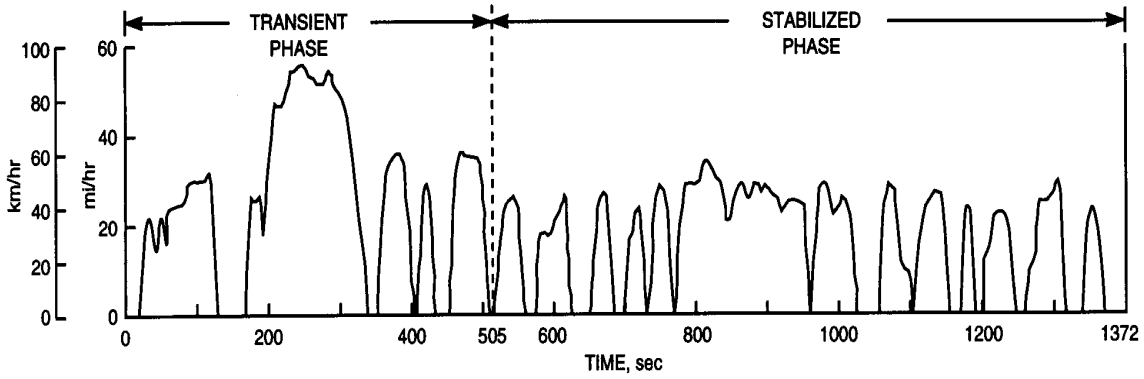

FIGURE 2. SPEED VERSUS TIME ILLUSTRATION OF 505- AND 867-SECOND PHASES OF UDDS DRIVING CYCLE

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 3 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.[4]

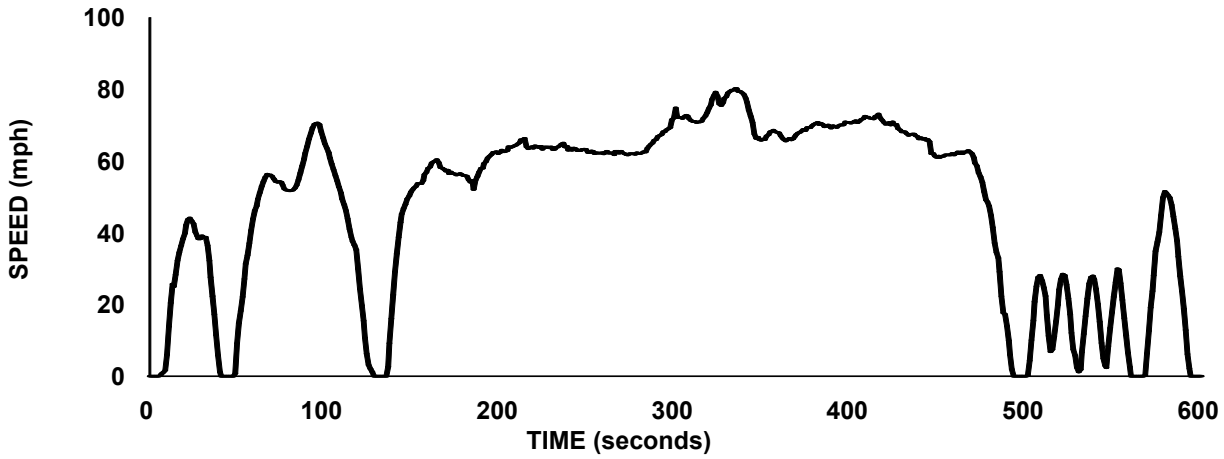

FIGURE 3. SPEED VERSUS TIME ILLUSTRATION OF US06 DRIVING CYCLE

3.6 Task 6 – Development of Laboratory Bench Equipment

In Task 6, a number of steps were taken to modify the laboratory bench equipment available at SwRI to accommodate the catalysts selected in Task 3 and the synthetic diesel exhaust mixtures prepared in Task 2. The laboratory bench synthetic gas reactor test setup consisted of three parts:

- Component addition and mixing (either as gases or liquids)
- Reactor
- Analyzers.

Compressed gases containing the various exhaust components (either as blends or as pure gases) were blended together using mass flow controllers for introduction into core samples at the space velocities and temperatures determined in Task 8. The system was also configured to permit injection of two liquid components (water and the liquid heavy hydrocarbon mixture). Two syringe infusion pumps were prepared to introduce and vaporize these liquid components into the gas stream. A custom-made gas mixing system combined and delivered the gaseous and

vaporized components at the required concentrations and flow rates. A program was written to compute the required flow rates based on the concentrations of gases in the individual cylinders and the desired concentration and flow rate for the synthetic diesel exhaust mixture. This program helped to maintain the different gas streams utilized to simulate exhaust.

The reactor was comprised of a tube and a tube furnace arrangement to heat the gas mixture to the operating temperature prior to introduction into the catalyst cores. A fully heated gas mixture was then flowed through the catalyst core. Sample probes located upstream and downstream of the catalyst core were used to extract gaseous samples for the analyzers.

The analyzers included an FTIR along with other standard analyzers for measurements of THC, CO_2, O_2, and NO_x. The FTIR was calibrated to monitor a number of gases in the catalyst-in and catalyst-out stream. Bag samples were also collected from the catalyst-in and catalyst-out stream to facilitate hydrocarbon speciation measurements similar to those used for the vehicle testing.

3.7 Task 7 – Emissions Measurement Procedures

Emission measurements included regulated emissions (THC, CO, and NO_x) as well as CO_2. For the vehicle tests, these emissions were analyzed according to CFR Title 40 specifications.[(2)] An FTIR was used as the primary analytical tool for the laboratory bench testing. In addition to the regulated emissions, a number of hydrocarbons were speciated and quantified to help define the hydrocarbon components in both the vehicle and bench tests. A detailed examination of the semi-volatiles by gas chromatography/mass spectroscopy (GC/MS) was utilized for the vehicle tests; however, the C_1 to C_{12} hydrocarbon speciation procedure was modified to include tetradecane and tetralin in the laboratory bench studies as these were the only higher molecular weight compounds included in the synthetic diesel exhaust mixture.

3.7.1 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) methods and one High Performance Liquid Chromatography (HPLC) method 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.

3.7.1.1 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.[5] 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.

3.7.1.2 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.

3.7.1.3 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. For the laboratory bench synthetic gas reactor tests, the typical GC run time was extended to allow for the elution of tetradecane and tetralin.

3.7.1.4 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.

3.7.1.5 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 2,5-dimethylbenzaldehyde. Detection limits for this procedure are on the order of 0.005 ppm aldehyde or ketone in dilute exhaust.

3.7.2 Speciation of Semi-Volatile Hydrocarbon Compounds

A speciation of the semi-volatile vapor-phase hydrocarbon compounds in the C_{10} to C_{25} range was included as part of the characterization of the hydrocarbon compounds in the vehicle exhaust. For this study, samples were collected using glass cartridges (2.5 in. o.d. x 5 in. length) packed with 20 grams of XAD-2 resin. Stainless steel screens, Teflon O-rings, and stainless steel lock rings were used to hold the XAD-2 resin in place. Figure 4 shows the XAD-2 glass cartridges.

The dilute exhaust was sampled at a flow rate of 3.5 L/min. After sampling, the entire glass cartridge was inserted into a one-liter Soxhlet extractor. Prior to the extraction, 36 µL of a mixture of deuterated semi-volatile internal standards with concentrations ranging from 6.0 to 100 ng/µL was spiked into each glass cartridge. The internal standard mix consisted of deuterated n-alkanes (C_{10} to C_{22}), deuterated PAHs such as biphenyl-d10, naphthalene-d8, 2-methylnaphthalene-d10, 1,8-dimethylnaphthalene-d12, phenanthrene-d10, and pyrene-d10. Concentrations of the internal standard paralleled concentrations expected for the semi-volatile types in the samples. For example, n-tetradecane-d30, naphthalene-d8, and pyrene-d10 were at concentrations of 100 ng/µL, 60 ng/µL, and 6.0 ng/µL, respectively.

FIGURE 4. XAD-2 GLASS CARTRIDGE FOR SAMPLING SEMI-VOLATILE HYDROCARBONS

The entire glass cartridge was extracted with dichlormethane (DCM) for eight hours with at least three cycles per hour. The DCM extract was concentrated to about 20 mL using a rotary evaporator. At this point, the extract was evenly split, 50% was put away in a freezer as reserve, and 50% was carefully blown down to 200 µL with a steady stream of filtered nitrogen.

A calibration standard consisted of 28 deuterated internal standards and 110 target semi-volatile hydrocarbons was first analyzed to establish retention time and relative response factor on an Agilent 6890N GC/5973N MSD (gas chromatograph/mass spectrometer detector) system. The GC column was a J&W Scientific fused silica column (30 m x 0.25 mm i.d. with 0.25 µm film thickness) that utilized a stationary phase of 95% dimethypolysiloxane and 5% phenylpolysiloxane. The GC oven temperature program was as follows:

- Hold at 40^{o}C for 1.5 minutes
- Ramp at 6^{o}C/min to 320^{o}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^{o}C and held for 4 minutes. The splitless/split injection mode was used with helium as the carrier gas and held at a constant flow of 1.2 mL/min. The temperatures for the ion source and quadrupole were 230^{o}C and 150^{o}C, respectively. The temperatures for the injector and GC/MS interface were 265^{o}C and 285^{o}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.

Actual exhaust sample extracts were analyzed in a manner similar to the calibration standards. The RRF (relative response factor) established in the calibration standard run for each target compound was used for target compound determination in the real emission samples. Only the 29 most dominant semi-volatile hydrocarbons were quantified and reported.

3.8 Task 8 – Experimental Program

In Task 8, the actual experimental work with the vehicle and diesel catalysts was performed. After selection of the vehicle and test fuel in Task 4, the actual engine-out diesel exhaust was examined for each test condition selected in Task 5 (five steady-state modes and two transient cycles) using the emission measurement procedures from Task 7. The engine-out exhaust concentrations were compared to previous tests to determine if this test vehicle was representative of vehicles previously evaluated. Exhaust temperatures at several locations in the exhaust system, exhaust flow rates to determine the catalyst space velocity, and exhaust compositions were then determined for each test condition. Each degreened catalyst from Task 3 was installed on the test vehicle for evaluation using the same five steady-state modes and two transient cycles used in the engine-out experiments. Conversion efficiencies were determined for each catalyst and test cycle for comparison with the bench tests.

After completing the vehicle testing, core samples from each of the four catalysts were taken. The temperatures and space velocities from the vehicle testing with the five steady-state modes were reproduced with the laboratory bench synthetic gas reactor. Temperatures and space velocities determined for each of the steady-state conditions are presented in Table 4. Each catalyst was tested with the synthetic diesel exhaust mixture containing the complex mix of hydrocarbons and with the synthetic diesel exhaust mixture containing the single hydrocarbon component propylene. Pre- and post-catalyst emissions were recorded. The catalyst cores were one inch in diameter, but the length of the cores were adjusted between 0.5 and 3 inches to accommodate the wide range of space velocities for the various steady-state conditions, the flow rate limitations of the reactor, and the analyzer flow requirements. Data for actual diesel exhaust and for the synthetic diesel exhaust mixtures were then compared. Test results for the vehicle evaluations are presented in Section 4, while the laboratory bench synthetic gas reactor evaluations are presented in Section 5.0.

TABLE 4. TEST CONDITIONS

Speed, rpm	Load, %	Space Velocity, hr^{-1}	Catalyst Inlet Temperature, °C	Catalyst Core Dimensions, in.
4000	75	370,800	497	1 × 0.5
4000	50	344,300	411	1 × 0.5
2000	50	171,100	387	1 × 1
2000	25	94,700	342	1 × 2
Idle		51,800	179	1 × 3

3.9 Task 9 - Data Analysis

In this task, the data collected from the experimental program were analyzed to compare catalyst performance for each catalyst piece with actual diesel exhaust to that with the synthetic exhaust mixtures. The data analysis included comparisons of conversion efficiencies for both the regulated emissions and the speciated hydrocarbon compounds. Individual components utilized in the synthetic diesel exhaust mixture were also monitored in actual vehicle exhaust for comparison. Any deviations between actual and synthetic exhaust for specific engine operating conditions or for a specific class of compounds were noted. These comparisons and discussions are presented in detail in Section 5.0.

4.0 VEHICLE TEST RESULTS

Regulated exhaust emissions (THC, CO, and NO_x) and CO_2 as well as a number of hydrocarbon species were measured from the vehicle for both engine-out and for four catalyst-out test conditions. Mass rates are presented in g/mi (or mg/mi) for the transient cycles, and in g/min or (mg/min) for the steady-state modes. The results for the vehicle tests conducted in Task 8 are included below. The results for the laboratory bench synthetic gas reactor tests conducted in Task 8 can be found in Section 5.0.

4.1 Regulated Emissions

4.1.1 Comparison Between Projects

The 1.9 L Vauxhall Vectra was tested both without exhaust aftertreatment (engine-out) and with the four catalyst pieces selected for this study. The test conditions included the FTP, the US06, and five steady-state modes. Tables 5 (transient tests) and 6 (steady-state tests) present the average engine-out vehicle emission rates generated during Task 8 from this study along with the data from the AVFL-10a literature search and the vehicle testing in AVFL-10b for comparison purposes. To simplify the results and allow comparisons to the literature data, emissions from the five steady-state test condition were combined and weighted equally. Results for the cold- and hot-UDDS cycles were also combined to determine a composite result for this cycle. Different results may be obtained if different weighting factors are utilized.

For the transient cycles, the FTP THC and CO emission rates were higher than those for the US06, while the NO_x emissions were higher with the US06. The Vauxhall THC and CO emission rates for both transient cycles were also consistent with the AVFL-10a data, while the Vauxhall NO_x emissions were approximately one third of those obtained in the AVFL-10a study. The Vauxhall transient NO_x emission rates were observed to fall between those observed for the small and medium displacement engines tested in the AVFL-10b study. For the steady-state modes, the Vauxhall emission rates for all regulated emissions decreased from Modes 1 through Mode 5. Most modal emission results fell between those obtained for the medium and smaller displacements engines in AVFL-10b except for NO_x which was closer to the larger displacement engines. Overall, the emissions from the Vauxhall engine were considered to be representative of the data obtained in the two previous AVFL-10 programs and representative of typical diesel exhaust.

4.1.2 Comparison of Engine-Out and Catalyst-Out Emissions

The engine-out and catalyst-out regulated emissions for the transient cycles are shown in Table 7. Table 8 presents the engine-out and catalyst-out regulated emissions for the five steady-state modes. When each of the four catalysts was installed, a significant change in the THC and CO emissions was observed, but little change was observed for the NO_x. These observations; however, were expected for the four oxidation catalysts evaluated in this study.

TABLE 5. COMPARISON OF ENGINE-OUT TRANSIENT CYCLE EMISSION RATES FROM AVFL-10a, AVFL-10b, AND AVFL-10c

Cycle	Emissions, g/mi				
	THC	CO	NO_x	Particulate	CO_2
Larger Displacement Engines[a], AVFL-10b					
FTP Composite	0.56	2.5	5.3	0.12	774
US06	0.27	1.5	5.1	0.12	802
Medium Displacement Engine[b], AVFL-10b					
FTP Composite	0.36	1.6	2.5	0.13	565
US06	0.25	1.2	2.7	0.23	719
Smaller Displacement Engine[c], AVFL-10b					
FTP Composite	0.51	2.5	0.2	0.20	240
US06	0.11	1.5	1.0	0.12	260
Average for All Engines, AVFL-10b					
FTP Composite	0.48	2.2	2.7	0.15	526
US06	0.21	1.4	2.9	0.16	594
Averaged from AVFL-10a Data					
FTP Composite	0.30	1.4	3.3	0.14	NA[d]
US06	0.26	1.5	6.5	0.14	NA
Vauxhall 1.9 L Engine Data from AVFL-10c Data (Engine Out)					
FTP Composite	0.35	1.9	1.1	ND[e]	345
US06	0.11	0.9	2.1	ND	324

[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
[e]ND-not determined in AVFL-10c

TABLE 6. COMPARISON OF ENGINE-OUT STEADY-STATE EMISSION RATES FROM AVFL-10b AND AVFL-10c

Unweighted Averages for the Five Steady-State Modes	Emissions, g/min				
	THC	CO	NO_x	Particulate	CO_2
Chevrolet 6.6 L, AVFL-10b	0.28	2.0	4.8	0.20	812
Ford 6.0 L, AVFL-10b	0.38	1.3	4.0	0.16	939
Dodge 2.7 L, AVFL-10b	0.31	1.7	1.4	0.09	443
Volkswagen 1.9 L, AVFL-10b	0.10	0.4	1.7	0.06	256
Average of all Engines, AVFL-10b	0.27	1.3	3.0	0.13	612
Vauxhall 1.9 L, AVFL-10c	0.16	0.6	4.0	ND[a]	456

[a]ND-not determined for AVFL-10c

TABLE 7. SUMMARY OF TRANSIENT CYCLE EMISSIONS

Test	Emissions, g/mi				
	THC	NMHC	CO	NO_x	CO_2
Engine Out Emissions					
Cold-Start and Stabilize	0.39	0.38	2.2	1.0	368
Hot-Start and Stabilize	0.32	0.31	1.7	1.1	330
Composite	0.35	0.34	1.9	1.1	345
US06	0.11	0.11	0.9	2.1	324
Platinum Only (75 g/ft^3)					
Cold-Start and Stabilize	0.00	0.00	0.1	0.8	360
Hot-Start and Stabilize	0.00	0.00	0.0	0.9	326
Composite	0.00	0.00	0.1	0.8	339
US06	0.00	0.00	0.0	2.1	305
3:1 Ratio of Platinum to Palladium (75 g/ft^3)					
Cold-Start and Stabilize	0.01	0.00	0.2	0.8	368
Hot-Start and Stabilize	0.00	0.00	0.0	0.8	330
Composite	0.01	0.00	0.1	0.8	345
US06	0.00	0.00	0.0	2.1	314
Platinum Only (20 g/ft^3)					
Cold-Start and Stabilize	0.01	0.00	0.2	0.9	367
Hot-Start and Stabilize	0.00	0.00	0.0	0.9	326
Composite	0.00	0.00	0.1	0.9	345
US06	0.00	0.00	0.0	2.0	314
3:1 Ratio of Platinum to Palladium (20 g/ft^3)					
Cold-Start and Stabilize	0.03	0.02	0.2	0.8	364
Hot-Start and Stabilize	0.00	0.00	0.0	1.0	326
Composite	0.01	0.01	0.1	0.9	342
US06	0.01	0.01	0.0	2.2	308

As a means of comparing results for the four catalysts and various test cycles, percent reductions of each emission were determined for each of the catalysts. Tables 9 and 10 present reduction percentages for the individual transient cycles and for the five steady-state modes. With the hot UDDS and US06 cycles, the percent reductions for THC and CO were almost 100 percent. The cold UDDS produced THC and CO percent reductions between 91 and 98 percent for the four catalyst formulations, except for an almost 100 percent reduction of the THC with the platinum only formulation with a 75 g/ft^3 loading. Percent reductions for NO_x were between 12 and 25 percent for the UDDS cycles. Percent reductions for NO_x were even lower for the US06 cycle (typically between 1 and 7 percent) with the 3:1 Pt/Pd formulation with a 20 g/ft^3 loading producing a 2 percent increase in NO_x. A very slight trend toward decreasing percent reduction with decreasing catalyst loading and with the use of palladium in the catalyst was noted, but this trend was not considered significant in terms of the overall reduction in emissions.

TABLE 8. SUMMARY OF STEADY-STATE MODE EMISSIONS

Test Condition			Emission, g/min				
Mode	**Speed, rpm**	**Load, %**	**THC**	**NMHC**	**CO**	**NO_x**	**CO_2**
Engine Out Emissions							
1	4000	75	0.22	0.22	1.0	9.4	927
2	4000	50	0.29	0.29	0.8	6.8	705
3	2000	50	0.10	0.10	0.3	3.3	396
4	2000	25	0.10	0.10	0.6	0.5	223
5	Idle		0.08	0.08	0.3	0.2	28
Platinum Only (75 g/ft^3)							
1	4000	75	0.05	0.05	0.1	9.5	902
2	4000	50	0.08	0.08	0.1	6.5	674
3	2000	50	0.01	0.01	0.0	3.4	392
4	2000	25	0.00	0.00	0.0	0.5	217
5	Idle		0.01	0.01	0.2	0.2	27
3:1 Ratio of Platinum to Palladium (75 g/ft^3)							
1	4000	75	0.05	0.05	0.1	9.7	928
2	4000	50	0.08	0.08	0.1	7.1	735
3	2000	50	0.01	0.01	0.0	3.4	397
4	2000	25	0.00	0.00	0.0	0.5	229
5	Idle		0.01	0.01	0.3	0.2	27
Platinum Only (20 g/ft^3)							
1	4000	75	0.04	0.04	0.1	9.3	920
2	4000	50	0.07	0.07	0.1	6.8	718
3	2000	50	0.01	0.01	0.0	3.4	397
4	2000	25	0.00	0.00	0.0	0.5	223
5	Idle		0.01	0.01	0.2	0.19	28
3:1 Ratio of Platinum to Palladium (20 g/ft^3)							
1	4000	75	0.05	0.05	0.1	9.3	918
2	4000	50	0.08	0.08	0.1	6.4	690
3	2000	50	0.01	0.01	0.0	3.3	391
4	2000	25	0.00	0.00	0.0	0.5	230
5	Idle		0.01	0.01	0.3	0.2	28

With the steady-state modes, more variation was noted for the different modes. The THC and CO percent reductions for the four catalyst pieces ranged from 72 to 100 percent, while the NO_x reductions were between -11 and 17 percent. (Note: A negative percent reduction indicates an increase in the emission.) For THC and CO emissions, the percent reduction increased from Modes 1 through 4 except for the THC in Mode 1. In this case, Mode 1 produced a higher percent reduction than Mode 2. Mode 5 (idle) did not seem to follow a general trend when compared to the other four modes, but the percent reduction in THC was greater than 88 percent while the percent reduction for CO was less than 26 percent for all four catalyst formulations.

TABLE 9. PERCENT REDUCTION FOR THE TRANSIENT CYCLES

Test Condition	Engine Out	Pt Only (75 g/ft^3)	% Reduction	Pt/Pd (75 g/ft^3)	% Reduction	Pt Only (20 g/ft^3)	% Reduction	Pt/Pd (20 g/ft^3)	% Reduction
THC Emissions, g/mi									
Cold UDDS	0.39	0.00	100	0.01	97	0.01	98	0.03	93
Hot UDDS	0.32	0.00	100	0.00	100	0.00	100	0.00	100
US06	0.11	0.00	100	0.00	100	0.00	100	0.01	95
NMHC Emissions, g/mi									
Cold UDDS	0.38	0.00	100	0.00	100	0.00	100	0.02	95
Hot UDDS	0.31	0.00	100	0.00	100	0.00	100	0.00	100
US06	0.11	0.00	100	0.00	100	0.00	100	0.01	95
CO Emissions, g/mi									
Cold UDDS	2.17	0.11	94	0.15	93	0.19	91	0.19	91
Hot UDDS	1.67	0.00	100	0.00	100	0.00	100	0.01	99
US06	0.89	0.01	99	0.02	98	0.10	88	0.02	97
NO_x Emissions, g/mi									
Cold UDDS	1.01	0.77	24	0.76	25	0.85	16	0.80	21
Hot UDDS	1.08	0.86	21	0.85	22	0.86	20	0.95	12
US06	2.13	2.11	1	2.11	1	1.98	7	2.18	(2)[a]

[a] Values in parenthesis indicates an increase in emissions (negative percent reduction)

TABLE 10. PERCENT REDUCTION FOR STEADY-STATE MODES

Modes	Test Condition	Engine Out	Pt Only (75 g/ft^3)	Percent Reduction	Pt/Pd (75 g/ft^3)	Percent Reduction	Pt Only (20 g/ft^3)	Percent Reduction	Pt/Pd (20 g/ft^3)	Percent Reduction
THC Emissions, g/min										
1	Rated/75 %	0.22	0.05	77	0.05	77	0.04	82	0.05	77
2	Rated/50 %	0.29	0.08	72	0.08	72	0.07	76	0.08	72
3	PT/50 %	0.10	0.01	90	0.01	90	0.01	90	0.01	90
4	PT/25%	0.10	0.00	100	0.00	100	0.00	100	0.00	100
5	Idle	0.08	0.01	88	0.01	88	0.01	88	0.01	88
NMHC Emissions, g/min										
1	Rated/75 %	0.22	0.05	77	0.05	77	0.04	82	0.05	77
2	Rated/50 %	0.29	0.08	72	0.08	72	0.07	76	0.08	72
3	PT/50 %	0.10	0.01	90	0.01	90	0.01	90	0.01	90
4	PT/25%	0.10	0.00	100	0.00	100	0.00	100	0.00	100
5	Idle	0.08	0.01	88	0.01	88	0.01	88	0.01	88
CO Emissions, g/min										
1	Rated/75 %	1.00	0.09	91	0.10	90	0.09	91	0.09	91
2	Rated/50 %	0.80	0.06	93	0.07	91	0.06	93	0.07	91
3	PT/50 %	0.30	0.01	97	0.01	97	0.01	97	0.01	97
4	PT/25%	0.62	0.00	100	0.00	100	0.00	98	0.0	100
5	Idle	0.31	0.22	26	0.25	19	0.24	23	0.26	16
NO_x Emissions, g/min										
1	Rated/75 %	9.71	9.53	(1)[a]	9.74	(3)	9.50	(1)	9.29	2
2	Rated/50 %	6.77	6.50	4	7.11	(5)	6.82	(1)	6.43	5
3	PT/50 %	3.30	3.43	(4)	3.43	(4)	3.43	(4)	3.34	(1)
4	PT/25%	0.53	0.53	0	0.59	(11)	0.68	(2)	0.51	4
5	Idle	0.23	0.20	13	0.20	13	0.19	17	0.21	9

[a] Values in parenthesis indicates an increase in emissions (negative percent reduction)

No specific trend related to catalyst loading or palladium content was noted for the steady-state modes.

4.2 Hydrocarbon Speciation Emission Results

Eight individual hydrocarbons were used to represent the total hydrocarbons in the synthetic diesel exhaust mixture. The most abundant hydrocarbon group from the AVFL-10b study was the semi-volatile group. The group represented about 36 percent of the total mass of the hydrocarbons. Within the semi-volatile group, tetradecane was used to represent the mass of the straight-chain hydrocarbons within this group, and tetralin was used for the aromatic portion. About 29 percent of the total hydrocarbon mass was from the olefins. The compounds used to represent this group were ethylene and propylene. The next most abundant component was the aldehydes and ketones. This group represented about 23 percent of the total hydrocarbon mass, and formaldehyde was chosen to represent this group. Aromatics represented about 7 percent of the mass of the total hydrocarbons, and benzene and toluene were selected to represent this group of compounds. Branched-chain hydrocarbons represented about 5 percent of the total mass hydrocarbon mass, and 2,2,4-trimethylpentane was ultimately chosen to represent this group.

A number of hydrocarbon species were measured to determine the engine-out and catalyst-out emission rates and conversion efficiencies for each of the four catalyst formulations. Hydrocarbon compounds included both volatile hydrocarbons (C_1 to C_{12} hydrocarbons, aldehydes, ketones) and semi-volatile hydrocarbons (C_{10} to C_{25} hydrocarbons). The transient cycle results are presented in Appendix A, and the steady-state results are in Appendix B. Table 11 summarizes the predominant hydrocarbon compounds observed for the transient cycles, and Table 12 presents the predominant hydrocarbons observed for the steady-state modes. Shaded compounds in the tables indicate the eight hydrocarbons actually used in the synthetic diesel exhaust mixture (ethylene, propylene, 2,2,4-trimethylpentane, benzene, toluene, formaldehyde, tetradecane, and tetralin) evaluated in Task 8. In general, the predominant compounds observed in this program were similar to those observed in the AVFL-10b study.

Ethylene, propylene, and formaldehyde were present at the highest concentrations in the engine-out exhaust. With each catalyst formulation, the total and individual hydrocarbon compounds were reduced; but ethylene, propylene, and formaldehyde remained as the major components of the exhaust. Catalyst-out hydrocarbon concentrations were lower with the hot UDDS and US06 cycles than with the cold UDDS cycle. For the steady-state modes, the hydrocarbon concentrations decreased as the space velocity through the catalysts decreased (highest hydrocarbons and space velocity with Mode 1 and lowest with Mode 5). No significant amounts of semi-volatiles were detected in the engine-out emissions with the transient cycles, but eight semi-volatiles were detected in the engine-out emissions with the steady-state modes. Overall, the eight most abundant semi-volatile compounds observed during testing were:

- Tridecane
- Tetradecane
- Pentadecane

TABLE 11. PREDOMINANT HYDROCARBON COMPOUNDS (TRANSIENT CYCLES)

Compound	Test Cycle, mg/mi		
	Cold UDDS	Hot UDDS	US06
Engine-Out (No Catalyst)			
Methane	9.0	8.7	ND[a]
Ethylene	56	43	11
Propane	1.9	0.2	trace[b]
Propylene	15	11	3.3
Propadiene	10	7.7	trace
1-Butene	3.8	2.9	0.9
Isobutylene	2.4	1.8	0.7
1,3-Butadiene	6.2	5.0	1.1
2-Methylpropane	0.6	0.6	1.8
2-Methylbutane	1.2	1.0	0.2
Pentane	1.6	1.3	0.1
3-Methylpentane	2.5	1.9	1.0
2-Methyl-1-pentene	1.4	0.9	0.4
1-Hexene	1.4	0.9	0.4
Benzene	4.6	4.0	1.1
2,2,4-Trimethylpentane	trace	trace	0.4
Heptane	1.5	1.3	ND
Toluene	2.9	3.2	1.4
Cis-1-Methyl-3-ethylcyclopentane	1.1	0.7	0.3
m- & p-xylene	1.2	0.7	0.2
1,2-Diethylbenzene	1.7	1.8	0.5
1,2,3,5-Tetramethylbenzene	3.8	3.4	0.8
Tetradecane	ND	ND	ND
Tetralin	ND	ND	trace
Formaldehyde	57	40	10
Acetaldehyde	13	19	3.6
Acrolein	5.5	0.7	1.4
Acetone	4.2	5.9	1.4
Propionaldehyde	2.2	3.5	0.6
Crotonaldehyde	1.8	2.6	0.5
Benzaldehyde	5.5	6.6	1.3
Isovaleraldehyde	1.3	0.7	0.2
Valeraldehyde	1.2	0.7	trace
o-Tolualdehyde	1.2	0.6	0.3
m- & p-Tolualdehyde	4.4	2.7	0.3

[a]ND - None detected
[b]trace – Compound detected but value not quantifiable
NOTE: THE EIGHT COMPOUNDS FROM THE SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

TABLE 11 (CONT'D). PREDOMINANT HYDROCARBON COMPOUNDS (TRANSIENT CYCLES)

Compound	Test Cycle, mg/mi		
	Cold UDDS	Hot UDDS	US06
Platinum Only (75 g/ft^3)			
Methane	9.5	5.1	0.6
Ethylene	2.6	0.2	0.4
Propane	3.1	0.1	trace[b]
Propylene	0.7	0.6	0.1
Benzene	ND	ND	0.2
2,2,4-Trimethylpentane	trace	trace	trace
Toluene	ND	ND	0.8
Tetradecane	ND	ND	0.4
Tetralin	ND	ND	ND
Formaldehyde	2.5	0.3	0.7
Acetaldehyde	1.1	0.1	0.2
Acetone	0.4	1.3	1.6
3:1 Ratio of Platinum to Palladium (75 g/ft^3)			
Methane	11	7.4	0.1
Ethane	3.0	0.7	0.1
Ethylene	6.2	0.5	1.1
Propylene	1.3	0.1	0.2
Benzene	ND	ND	0.1
2,2,4-Trimethylpentane	trace	trace	trace
Tolulene	ND	ND	0.5
Tetradecane	ND	ND	ND
Tetralin	ND	ND	ND
Formaldehyde	5.1	0.1	1.4
Acetaldehyde	3.1	ND	0.5
Acetone	1.4	ND	0.2

[a]ND - None detected
[b]trace – Compound detected but value not quantifiable
NOTE: THE EIGHT COMPOUNDS FROM THE SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

TABLE 11 (CONT'D). PREDOMINANT HYDROCARBON COMPOUNDS (TRANSIENT CYCLES)

Compound	Test Cycle, mg/mi		
	Cold UDDS	Hot UDDS	US06
Platinum Only (20 g/ft^3)			
Methane	9.8	1.3	0.3
Ethane	6.4	0.4	trace[b]
Ethylene	5.2	0.3	0.5
Propylene	1.4	ND[a]	0.2
Isobutylene	1.9	1.4	0.8
Benzene	ND	ND	0.1
2,2,4-Trimethylpentane	trace	trace	trace
Toluene	ND	ND	0.9
Tetradecane	ND	ND	0.3
Tetralin	ND	ND	trace
Formaldehyde	5.8	0.6	1.1
Acetaldehyde	3.3	0.3	0.5
Acetone	1.0	0.3	trace
3:1 Ratio of Platinum to Palladium (20 g/ft^3)			
Methane	8.6	7.6	0.1
Ethane	2.3	0.3	trace
Ethylene	18	1.6	1.2
Propylene	3.1	ND	0.2
Hexane	1.1	0.2	ND
Benzene	ND	ND	0.1
2,2,4-Trimethylpentane	ND	ND	0.1
Toluene	ND	ND	0.5
Pentamethylbenzene	ND	ND	2.1
Tetradecane	ND	ND	ND
Tetracosane	1.0	ND	ND
Pentacosane	1.2	ND	ND
Tetralin	ND	ND	ND
Formaldehyde	8.3	3.1	2.4
Acetaldehyde	4.4	1.1	0.7
Acetone	1.8	0.7	0.1
Propionaldehyde	1.1	0.1	0.2

[a]ND - None detected
[b]trace – Compound detected but value not quantifiable
NOTE: THE EIGHT COMPOUNDS FROM THE SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

TABLE 12. PREDOMINANT HYDROCARBON COMPOUNDS (STEADY-STATE MODES)

Compound	Test Cycle, mg/min				
	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
	Rated/75	Rated/50	PT/50	PT/25	Idle
Engine Out (No Catalyst)					
Ethylene	49	23	5.8	9.0	6.8
Propane	6.6	trace[a]	trace	trace	0.1
Propylene	17	8.8	2.5	2.1	1.7
1-Butene	3.9	2.7	0.8	0.5	0.4
Isobutylene	2.8	2.0	0.6	0.4	0.3
1,3-Butadiene	6.7	2.5	0.6	0.8	0.6
3-Methylpentane	1.9	1.4	0.3	0.5	0.8
2-Methyl-1-pentene	1.0	1.1	0.4	0.2	0.2
1-Hexene	1.0	1.1	0.4	0.2	0.2
Benzene	3.8	1.8	0.5	0.8	0.4
2,2,4-Trimethylpentane	1.1	1.4	0.5	0.2	0.1
Toluene	3.2	2.1	1.0	0.1	0.7
cis-1-methyl-3-ethylcyclopentane	0.3	1.1	0.4	0.2	0.1
1-Methyl-4-n-propylbenzene	0.5	1.3	0.5	0.4	0.5
1,3-Dimethyl-4-ethylbenzene	trace	1.6	0.5	0.3	0.1
1,2,4,5-Tetramethylbenzene	0.6	3.5	1.9	1.5	0.7
Tridecane	ND[b]	2.7	trace	0.1	ND
Tetradecane	ND	3.4	ND	ND	ND
Pentadecane	ND	2.1	trace	trace	ND
Hexadecane	ND	1.7	ND	ND	ND
Heptadecane	trace	1.2	trace	trace	ND
Tetralin	trace	0.3	trace	trace	ND
Methyltetralin	ND	1.8	ND	ND	ND
1-Methyldecalin	ND	1.7	trace	0.1	Trace
Formaldehyde	16	26	5.6	7.2	7.5
Acetaldehyde	2.0	8.0	1.8	2.6	2.7
Acrolein	0.9	3.3	0.5	0.8	0.9
Acetone	0.4	1.8	0.2	0.7	0.8
Propionaldehyde	0.1	1.2	0.2	0.4	0.4
Benzaldehyde	0.9	3.0	0.4	2.0	1.2
m- & p-Tolualdehyde	0.6	1.9	ND	0.1	0.7

[a]trace – Compound detected but value not quantifiable
[b]ND - None detected
NOTE: THE EIGHT COMPOUNDS FROM THE SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

TABLE 12 (CONT'D). PREDOMINANT HYDROCARBON COMPOUNDS (STEADY-STATE MODES)

Compound	Test Cycle, mg/min				
	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
	Rated/75	Rated/50	PT/50	PT/25	Idle
Platinum Only (75 g/ft^3)					
Ethylene	5.3	2.6	0.4	0.1	6.4
Propylene	2.1	0.8	0.1	trace[a]	1.4
Benzene	0.6	0.3	0.1	ND	0.1
2,2,4-Trimethylpentane	0.4	0.1	0.1	trace	Trace
Toluene	1.0	0.5	0.5	0.2	ND
Tridecane	0.5	1.3	0.5	0.3	ND
Tetradecane	1.0	1.9	1.5	1.1	0.2
Pentadecane	0.4	1.1	0.5	0.2	ND
Hexadecane	0.5	1.0	0.8	0.4	Trace
Tetralin	0.1	0.2	trace	ND	ND
Formaldehyde	7.5	5.0	0.7	0.1	7.2
Acetaldehyde	1.9	1.4	trace	ND	3.3
Acetone	2.4	2.4	2.4	2.5	1.9
Propionaldehyde	0.6	0.4	ND	ND	4.5
3:1 Ratio of Platinum to Palladium (75 g/ft^3)					
Ethylene	6.1	3.6	0.6	0.3	6.2
Propylene	2.2	1.0	0.2	trace	0.5
Benzene	0.6	0.3	0.2	trace	0.2
2,2,4-Trimethylpentane	0.5	0.3	0.1	0.1	0.1
Toluene	0.8	0.6	0.5	ND	ND
Tridecane	0.5	1.3	0.4	0.2	Trace
Tetradecane	1.2	2.0	1.1	0.8	0.2
Pentadecane	0.4	1.1	0.4	0.3	ND
Hexadecane	0.6	1.0	0.7	0.5	0.1
Tetralin	0.1	0.4	trace	0.2	ND
Formaldehyde	7.5	5.7	1.3	0.7	7.1
Acetaldehyde	2.4	2.0	0.4	0.1	3.8
Acetone	0.5	0.4	0.1	ND	1.1
Propionaldehyde	1.1	0.8	0.1	ND	1.6

[a]trace – Compound detected but value not quantifiable
[b]ND - None detected
NOTE: THE EIGHT COMPOUNDS FROM THE SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

TABLE 12 (CONT'D). PREDOMINANT HYDROCARBON COMPOUNDS (STEADY-STATE MODES)

Compound	Test Cycle, mg/min				
	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5
	Rated/75	Rated/50	PT/50	PT/25	Idle
Platinum Only (20 g/ft^3)					
Methane	ND[b]	ND	ND	1.2	ND
Ethylene	4.8	2.6	0.4	0.1	6.5
Propylene	1.9	0.8	0.1	ND	1.7
Benzene	0.5	0.3	trace	ND	0.2
2,2,4-Trimethylpentane	0.4	0.2	trace	trace	Trace
Toluene	1.1	0.8	0.6	ND	ND
Tridecane	0.6	1.2	0.4	0.2	ND
Tetradecane	1.2	1.8	0.9	0.7	0.2
Pentadecane	0.4	1.0	0.4	0.2	Trace
Hexadecane	0.7	1.0	0.7	0.4	0.1
Tetralin	0.1	0.3	0.1	trace	ND
Formaldehyde	9.0	5.5	1.4	0.4	8.6
Acetaldehyde	2.8	2.1	0.3	0.1	4.0
Propionaldehyde	0.6	0.4	0.1	trace	1.3
3:1 Ratio of Platinum to Palladium (20 g/ft^3)					
Methane	ND	ND	ND	1.8	ND
Ethylene	6.2	3.9	0.8	0.4	6.0
Propylene	2.0	0.8	0.1	ND	0.5
Benzene	0.5	0.3	0.1	0.2	0.2
2,2,4-Trimethylpentane	ND	ND	ND	ND	ND
Toluene	0.6	0.5	0.5	ND	ND
Tridecane	0.6	1.1	0.3	0.2	ND
Tetradecane	0.7	1.3	0.5	0.5	ND
Pentamethylbenzene	8.6	0.4	1.5	9.0	ND
Tetralin	trace	0.1	trace	trace	0.1
Methyltetralin	1.3	0.4	0.4	1.2	ND
Formaldehyde	1.3	ND	ND	ND	ND

[a]trace – Compound detected but value not quantifiable
[b]ND - None detected
NOTE: THE EIGHT COMPOUNDS FROM THE SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

- Hexadecane
- Heptadecane
- Tetralin
- Methyltetralin
- 1-Methyldecalin.

Most of the steady-state semi-volatiles for the engine-out exhaust were present in Mode 2 (Rated speed and 50 percent load); however, catalyst-out emissions were relatively consistent across the five steady-state modes and across the four catalyst formulations.

As was done for the regulated emissions, percent reductions for individual hydrocarbon species were determined for each test condition and with each catalyst. Tables 13 through 20 show the percent reductions for the individual transient cycles and for the five steady-state modes. Appendix C presents the hydrocarbon percent reductions for the transient cycles and steady-state modes.

For the various hydrocarbons, there was a general trend toward lower percent reductions as the catalyst loading was reduced, and the 3:1 platinum to palladium catalysts usually had slightly lower percent reductions than the platinum only catalysts with the same loading. The cold UDDS generally had lower percent reductions especially for the lower molecular weight hydrocarbons than the hot UDDS. Methane actually increased when passing through the catalysts during the cold UDDS and had the lowest hydrocarbon percent reduction of any of the hydrocarbons during the hot UDDS. Overall, hydrocarbon percent reductions were lower for the US06 cycle than for either of the UDDS cycles. For four of the five steady-state modes, there was little differentiation between the four catalysts. Percent reductions were generally similar for the four catalyst pieces. Mode 5 (Idle) on the other hand had the lowest percent reductions (especially for ethylene, propylene, and formaldehyde) and gave the most variety in results among the four catalysts pieces. In general, the eight hydrocarbons that were selected for the synthetic diesel exhaust mixture were found to be representative of the total hydrocarbons and of the various hydrocarbons groups that they were selected to represent.

TABLE 13. PERCENT REDUCTION FOR PREDOMINANT COMPOUNDS FROM COLD UDDS CYCLE

Test Condition	Emission Rates in mg/mi								
	Engine Out	Pt Only, 75 g/ft^3	% Reduction	Pt/Pd, 75 g/ft^3	% Reduction	Pt Only, 20 g/ft^3	% Reduction	Pt/Pd, 20 g/ft^3	% Reduction
Methane	9.0	9.5	(6)[a]	10.6	(18)	9.8	(9)	8.6	4
Ethane	0.8	0.7	6	3.0	(286)	6.4	(734)	2.3	(198)
Ethylene	55.7	2.6	95	6.2	89	5.2	91	18.4	67
Propane	1.9	3.1	(62)	ND[b]	100	0.2	92	0.3	84
Propylene	14.9	0.7	96	1.3	91	1.4	90	3.1	79
Propadiene	10.1	trace[c]	DEC[d]	trace	DEC	ND	100	ND	100
1-Butene	3.8	0.1	96	0.2	95	0.2	95	0.3	91
Isobutylene	2.4	ND	100	ND	100	0.2	93	0.4	84
1,3-Butadiene	6.2	0.2	97	0.3	96	0.2	97	ND	100
2-Methylbutane	1.2	ND	100	ND	100	ND	100	ND	100
Pentane	1.6	0.3	79	0.3	80	0.4	75	ND	100
3-Methylpentane	2.5	0.5	79	0.3	86	ND	100	ND	100
2-Methyl-1-pentene	1.4	ND	100	ND	100	ND	100	ND	100
1-Hexene	1.4	ND	100	ND	100	ND	100	ND	100
Benzene	4.6	ND	100	ND	100	ND	100	ND	100
2,2,4-Trimethylpentane	ND	ND	NC[e]	ND	NC	ND	NC	ND	NC
Heptane	1.5	ND	100	ND	100	ND	100	trace	DEC
Toluene	2.9	ND	100	ND	100	ND	100	ND	100
cis-1-Methyl-3-ethylcyclopentane	1.1	ND	100	ND	100	ND	100	ND	100
m- & p-xylene	1.2	ND	100	ND	100	ND	100	ND	100
1,2-Diethylbenzene	1.7	ND	100	ND	100	ND	100	ND	100
1,2,3,5-Tetramethylbenzene	3.8	ND	100	ND	100	ND	100	ND	100
Tetradecane	ND	ND	NC	ND	NC	ND	NC	ND	NC
Tetralin	ND	ND	NC	ND	NC	ND	NC	ND	NC

TABLE 13. (CONT'D) PERCENT REDUCTION FOR PREDOMINANT COMPOUNDS FROM COLD UDDS CYCLE

Test Condition	Emission Rates in mg/mi								
	Engine Out	Pt Only, 75 g/ft^3	% Reduction	Pt/Pd, 75 g/ft^3	% Reduction	Pt Only, 20 g/ft^3	% Reduction	Pt/Pd, 20 g/ft^3	% Reduction
Formaldehyde	56.8	2.5	96	5.1	91	5.8	90	8.3	85
Acetaldehyde	12.9	1.1	92	3.1	76	3.3	75	4.4	66
Acrolein	5.5	ND[b]	100	0.1	97	0.1	98	0.2	97
Acetone	4.2	0.4	91	1.4	67	1.0	76	1.8	58
Propionaldehyde	2.2	trace[c]	DEC[d]	0.7	69	0.8	63	1.1	51
Crotonaldehyde	1.8	0.1	94	0.2	92	0.2	91	0.2	88
Benzaldehyde	5.5	0.1	99	trace	DEC	trace	DEC	Trace	DEC
Isovaleraldehyde	1.3	0.1	95	trace	DEC	trace	DEC	0.1	93
Valeraldehyde	1.2	0.1	90	0.1	90	0.2	86	0.1	95
o-Tolualdehyde	1.2	0.1	95	ND	100	ND	100	ND	100
m- & p-Tolualdehyde	4.4	ND	100	ND	100	ND	100	ND	100

[a] Values in parenthesis indicate an increase in concentration (negative percent reduction)
[b] ND – None detected at the limit of detection
[c] trace – Trace amount detected, but value not quantifiable
[d] DEC – Decrease in emissions, percent reduction usually greater than 90 percent, but actual value cannot be calculated due to unquantifiable trace amount detected in catalyst-out exhaust
[e] NC – No change from the engine-out results
NOTE: THE EIGHT COMPOUNDS FROM THE SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

TABLE 14. PERCENT REDUCTION FOR PREDOMINANT COMPOUNDS FROM HOT UDDS CYCLE

Test Condition	Emission Rates in mg/mi								
	Engine Out	Pt Only, 75 g/ft^3	% Reduction	Pt/Pd, 75 g/ft^3	% Reduction	Pt Only, 20 g/ft^3	% Reduction	Pt/Pd, 20 g/ft^3	% Reduction
Methane	8.7	5.1	42	7.4	15	1.3	85	7.6	13
Ethylene	42.6	0.2	100	0.5	99	0.3	99	1.6	96
Propylene	11.4	ND[a]	100	0.1	99	ND	100	ND	100
Propadiene	7.7	trace[b]	DEC[c]	trace	DEC	ND	100	ND	100
1-Butene	2.9	ND	100	ND	100	ND	100	ND	100
Isobutylene	1.8	ND	100	ND	100	ND	100	ND	100
1,3-Butadiene	5.0	ND	100	ND	100	ND	100	ND	100
Pentane	1.3	trace	DEC	0.1	96	0.3	73	ND	100
3-Methylpentane	1.9	0.7	63	0.8	57	ND	100	ND	100
Benzene	4.0	ND	100	ND	100	ND	100	ND	100
2,2,4-Trimethylpentane	ND	ND	NC[d]	ND	NC	ND	NC	ND	NC
Heptane	1.3	ND	100	ND	100	ND	100	ND	100
Toluene	3.2	ND	100	ND	100	ND	100	ND	100
1,2-Diethylbenzene	1.8	ND	100	ND	100	ND	100	ND	100
1,2,3,5-Tetramethylbenzene	3.4	ND	100	ND	100	ND	100	ND	100
Tetradecane	ND	ND	NC	ND	NC	ND	NC	ND	NC
Tetralin	ND	ND	NC	ND	NC	ND	NC	ND	NC
Formaldehyde	40.3	0.3	99	0.1	100	0.6	98	3.1	92
Acetaldehyde	18.7	0.1	100	ND	100	0.3	99	1.1	94
Acetone	5.9	1.3	78	ND	100	0.3	95	0.7	87
Propionaldehyde	3.5	trace	DEC	ND	100	0.1	96	0.1	98
Crotonaldehyde	2.6	trace	DEC	ND	100	0.1	98	ND	100
Benzaldehyde	6.6	trace	DEC	ND	100	ND	100	ND	100
m- & p-Tolualdehyde	2.7	ND	100	ND	100	ND	100	ND	100

[a] ND – None detected at the limit of detection
[b] trace – Trace amount detected, but value not quantifiable
[c] DEC – Decrease in emissions, percent reduction usually greater than 90 percent, but actual value cannot be calculated due to unquantifiable trace amount detected in catalyst-out exhaust
[d] NC – No change from the engine-out results
NOTE: HYDROCARBONS IN SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

TABLE 15. PERCENT REDUCTION FOR PREDOMINANT COMPOUNDS FROM US06 CYCLE

Test Condition	Emission Rates in mg/mi								
	Engine Out	Pt Only, 75 g/ft^3	% Reduction	Pt/Pd, 75 g/ft^3	% Reduction	Pt Only, 20 g/ft^3	% Reduction	Pt/Pd, 20 g/ft^3	% Reduction
Ethylene	10.6	0.4	97	1.1	90	0.5	95	1.2	88
Propylene	3.3	0.1	96	0.2	94	0.2	95	0.2	95
1,3-Butadiene	1.1	ND[a]	100	ND	100	ND	100	ND	100
2-Methylpropane	1.8	trace[b]	DEC[c]	0.1	97	ND	100	ND	100
3-Methylpentane	1.0	0.5	50	0.3	68	0.9	12	0.4	60
Benzene	1.1	0.2	85	0.1	88	0.1	91	0.1	92
2,2,4-Trimethylpentane	0.4	Trace	DEC	ND	100	trace	DEC	0.1	64
Toluene	1.4	0.8	42	0.5	65	0.9	36	0.5	64
Tetradecane	ND	0.4	INC	ND	NC[d]	ND	NC	0.3	INC
Tetralin	trace	ND	DEC	ND	DEC	ND	DEC	trace	NC
Formaldehyde	10.1	0.7	94	1.4	87	1.1	89	2.4	76
Acetaldehyde	3.6	0.2	95	0.5	86	0.5	87	0.7	80
Acrolein	1.4	ND	100	0.1	94	0.1	95	trace	DEC
Acetone	1.4	1.6	(20)[e]	0.2	89	trace	DEC	0.1	90
Benzaldehyde	1.3	Trace	DEC	ND	100	ND	100	ND	100

[a] ND – None detected at the limit of detection
[b] trace – Trace amount detected, but value not quantifiable
[c] DEC – Decrease in emissions, percent reduction usually greater than 90 percent, but actual value cannot be calculated due to unquantifiable trace amount detected in catalyst-out exhaust
[d] NC – No change from the engine-out results
[e] Values in parenthesis indicate an increase in concentration (negative percent reduction)
NOTE: HYDROCARBONS IN SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

TABLE 16. PERCENT REDUCTION FOR PREDOMINANT COMPOUNDS FROM STEADY-STATE MODE 1, RATED SPEED AND 75 PERCENT TORQUE

Test Condition	Emission Rates in mg/min								
	Engine Out	Pt Only, 75 g/ft^3	% Reduction	Pt/Pd, 75 g/ft^3	% Reduction	Pt Only, 20 g/ft^3	% Reduction	Pt/Pd, 20 g/ft^3	% Reduction
Ethylene	48.8	5.3	89	6.1	88	4.8	90	6.2	87
Propylene	16.8	2.1	88	2.2	87	1.9	89	1.9	88
1-Butene	3.9	0.7	83	0.7	81	0.6	84	0.6	84
Isobutylene	2.8	0.5	81	0.5	81	0.5	83	0.5	83
1,3-Butadiene	6.7	0.3	95	0.3	96	0.3	95	0.2	97
3-Methylpentane	1.9	0.5	71	0.8	57	0.4	81	0.2	92
2-Methyl-1-pentene	1.0	0.3	66	0.3	69	0.3	71	0.3	73
1-Hexene	1.0	0.3	66	0.3	69	0.3	71	0.3	73
Benzene	3.8	0.6	85	0.6	85	0.5	88	0.5	86
2,2,4-Trimethylpentane	1.1	0.4	64	0.5	54	0.3	69	ND[a]	100
Toluene	3.2	1.0	67	0.8	74	1.1	66	0.6	81
Tetradecane	ND	1.0	INC[b]	1.2	INC	1.2	INC	0.7	INC
Tetralin	trace	0.1	INC	0.1	INC	0.1	INC	trace[c]	NC[d]
Formaldehyde	16.4	7.5	55	7.4	55	9.0	45	7.6	53
Acetaldehyde	11.8	1.9	84	2.4	80	2.7	77	2.1	83

[a] ND – None detected at the limit of detection
[b] INC – Increase in emissions, percent reduction could not be calculated because compound not detected in the engine-out exhaust, but measurable amounts detected in the catalyst-out exhaust
[c] trace – Trace amount detected, but value not quantifiable
[d] NC – No change from the engine-out results
NOTE: HYDROCARBONS IN SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

TABLE 17. PERCENT REDUCTION FOR PREDOMINANT COMPOUNDS FROM STEADY-STATE MODE 2, RATED SPEED AND 50 PERCENT TORQUE

Test Condition	Emission Rates in mg/min								
	Engine Out	Pt Only, 75 g/ft^3	% Reduction	Pt/Pd, 75 g/ft^3	% Reduction	Pt Only, 20 g/ft^3	% Reduction	Pt/Pd, 20 g/ft^3	% Reduction
Ethylene	22.9	2.6	89	3.6	84	2.6	89	3.9	83
Propylene	8.8	0.8	91	1.0	89	0.8	90	0.8	91
1-Butene	2.7	0.3	89	0.3	88	0.3	89	0.3	90
Isobutylene	2.0	0.3	87	0.3	86	0.3	87	0.2	88
1,3-Butadiene	2.5	0.1	94	0.2	91	0.2	93	0.1	95
3-Methylpentane	1.4	0.2	89	0.4	69	0.3	81	0.2	86
2-Methyl-1-pentene	1.1	0.2	84	0.1	88	0.2	83	0.1	92
1-Hexene	1.1	0.2	84	0.1	88	0.2	83	0.1	92
Benzene	1.8	0.3	85	0.3	81	0.3	85	0.3	81
2,2,4-Trimethylpentane	1.4	0.1	91	0.3	78	0.1	89	ND[a]	100
Toluene	2.1	0.5	75	0.6	73	0.8	65	0.5	75
cis-1-Methyl-3-ethylcyclopentane	1.1	0.2	86	0.1	87	0.2	85	0.1	89
1-Methyl-4-n-propylbenzene	1.3	ND	100	ND	100	ND	100	0.1	93
1,3-Dimethyl-4-ethylbenzene	1.6	ND	100	ND	100	ND	100	ND	100
Tetradecane	3.4	1.9	44	2.0	41	1.8	47	1.3	62
Tetralin	0.3	0.2	33	0.4	(33)[b]	0.3	NC	0.1	67
Formaldehyde	25.6	5.0	81	5.7	78	5.5	79	ND	100
Acetaldehyde	8.0	1.4	82	2.0	75	2.1	79	ND	100
Acrolein	3.3	ND	100	0.8	77	0.5	84	ND	100
Acetone	1.8	2.4	(29)	0.4	77	ND	100	ND	100
Propionaldehyde	1.2	0.4	69	0.8	34	0.4	64	ND	100
Benzaldehyde	3.0	0.1	96	0.2	94	trace[c]	DEC[d]	ND	100
m- & p-Tolualdehyde	11.1	ND	100	0.7	93	ND	100	ND	100

[a] ND – None detected at the limit of detection

[b] Values in parenthesis indicate an increase in concentration (negative percent reduction)

[c] trace – Trace amount detected, but value not quantifiable

[d] DEC – Decrease in emissions, percent reduction usually greater than 90 percent, but actual value cannot be calculated due to unquantifiable trace amount detected in catalyst-out exhaust

NOTE: HYDROCARBONS IN SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

TABLE 18. PERCENT REDUCTION FOR PREDOMINANT COMPOUNDS FROM STEADY-STATE MODE 3, PEAK TORQUE SPEED AND 50 PERCENT TORQUE

Test Condition	Emission Rates in mg/min								
	Engine Out	Pt Only, 75 g/ft^3	% Reduction	Pt/Pd, 75 g/ft^3	% Reduction	Pt Only, 20 g/ft^3	% Reduction	Pt/Pd, 20 g/ft^3	% Reduction
Ethylene	5.8	0.4	94	0.6	90	0.4	94	0.8	87
Propylene	2.5	0.1	95	0.1	95	0.1	96	0.1	95
Benzene	0.5	0.1	79	0.1	78	trace[a]	DEC[b]	0.1	84
2,2,4-Trimethylpentane	0.5	0.1	90	0.1	73	ND[c]	100	ND	100
Toluene	1.0	0.5	48	0.5	55	0.6	40	0.5	54
Tetradecane	ND	1.5	INC[d]	1.1	INC	0.9	INC	0.5	INC
Tetralin	0.1	ND	100	ND	100	ND	100	ND	100
Formaldehyde	5.6	0.7	87	1.3	77	1.4	75	ND	100
Acetaldehyde	1.8	Trace	DEC	0.4	79	0.3	81	ND	100

[a] trace – Trace amount detected, but value not quantifiable

[b] DEC – Decrease in emissions, percent reduction usually greater than 90 percent, but actual value cannot be calculated due to unquantifiable trace amount detected in catalyst-out exhaust

[c] ND – None detected at the limit of detection

[d] INC – Increase in emissions, percent reduction could not be calculated because compound not detected in the engine-out exhaust, but measurable amounts detected in the catalyst-out exhaust

NOTE: HYDROCARBONS IN SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

TABLE 19. PERCENT REDUCTION FOR PREDOMINANT COMPOUNDS FROM STEADY-STATE MODE 4, PEAK TORQUE SPEED AND 25 PERCENT TORQUE

Test Condition	Emission Rates in mg/min								
	Engine Out	Pt Only, 75 g/ft^3	% Reduction	Pt/Pd, 75 g/ft^3	% Reduction	Pt Only, 20 g/ft^3	% Reduction	Pt/Pd, 20 g/ft^3	% Reduction
Methane	0.2	0.6	(200)[a]	ND[b]	100	1.2	(501)	1.8	(801)
Ethylene	9.0	0.1	99	0.3	97	0.1	99	0.4	95
Propylene	2.1	trace[c]	DEC[d]	trace	DEC	ND	100	ND	100
Benzene	0.8	ND	100	trace	DEC	ND	100	0.2	73
2,2,4-Trimethylpentane	0.2	ND	100	0.1	46	ND	100	ND	100
Toluene	0.1	0.2	(16)	ND	100	ND	100	ND	100
Tetradecane	ND	1.1	INC[d]	0.8	INC	0.7	INC	0.5	INC
Tetralin	trace	ND	DEC	0.2	INC	Trace	NC[e]	Trace	NC
Formaldehyde	7.2	0.1	98	0.7	91	0.4	95	ND	100
Acetaldehyde	2.6	ND	100	0.1	98	0.1	95	ND	100
Benzaldehyde	2.0	0.1	96	ND	100	ND	100	ND	100

[a] Values in parenthesis indicate an increase in concentration (negative percent reduction)
[b] ND – None detected at the limit of detection
[c] trace – Trace amount detected, but value not quantifiable
[d] DEC – Decrease in emissions, percent reduction usually greater than 90 percent, but actual value cannot be calculated due to unquantifiable trace amount detected in catalyst-out exhaust
[d] INC – Increase in emissions, percent reduction could not be calculated because compound not detected in the engine-out exhaust, but measurable amounts detected in the catalyst-out exhaust
[e] NC – No change from engine-out results
NOTE: HYDROCARBONS IN SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

TABLE 20. PERCENT REDUCTION FOR PREDOMINANT COMPOUNDS FROM STEADY-STATE MODE 5, IDLE

Test Condition	Emission Rates in mg/min								
	Engine Out	Pt Only, 75 g/ft^3	% Reduction	Pt/Pd, 75 g/ft^3	% Reduction	Pt Only, 20 g/ft^3	% Reduction	Pt/Pd, 20 g/ft^3	% Reduction
Ethylene	6.8	6.4	6	6.2	9	6.5	4	5.9	12
Propylene	1.7	1.4	16	0.5	70	1.7	4	0.5	73
Benzene	0.4	0.1	67	0.2	48	0.2	56	0.2	48
2,2,4-Trimethylpentane	0.1	ND[a]	100	0.1	24	ND	100	ND	100
Toluene	0.7	ND	100	ND	100	ND	100	ND	100
Tetradecane	ND	0.2	INC[b]	0.2	INC	0.2	INC	ND	NC[c]
Tetralin	ND	ND	NC	ND	NC	ND	NC	trace[d]	INC
Formaldehyde	7.5	7.2	4	7.1	5	8.6	(15)[e]	ND	100
Acetaldehyde	2.7	3.3	(25)	3.8	(42)	4.0	(50)	ND	100
Benzaldehyde	1.2	Trace	DEC	ND	100	ND	100	ND	100

[a] ND – None detected at the limit of detection
[b] INC – Increase in emissions, percent reduction could not be calculated because compound not detected in the engine-out exhaust, but measurable amounts detected in the catalyst-out exhaust
[c] NC – No change for the engine-out results
[d] trace – Trace amount detected, but value not quantifiable
[e] Values in parenthesis indicate an increase in concentration (negative percent reduction)
NOTE: HYDROCARBONS IN SYNTHETIC DIESEL EXHAUST MIXTURE INDICATED BY SHADING

5.0 COMPARISON AND DISCUSSION

This section includes a discussion of the data collected during the laboratory bench synthetic gas reactor experiments in Task 8 and a comparison to the data collected from vehicle testing in AVFL-10b and AVFL-10c. The results from testing the four different diesel catalysts with the two synthetic diesel exhaust mixtures were compared. These results determined the ability of the synthetic diesel exhaust mixtures to represent actual diesel exhaust.

5.1 Regulated Emissions with Laboratory Bench Synthetic Gas Reactor

The five steady-state modes used in the vehicle testing were simulated with a SwRI laboratory bench synthetic gas reactor. As a means of comparing results for the four catalysts and various test cycles, percent reductions for each of the regulated emissions were determined for each of the catalysts. Table 21 presents reduction percentages for the five steady-state modes with the test vehicle and compares those results to the results obtained with the full hydrocarbon synthetic diesel exhaust mixture and the propylene only mixture.

Table 22 shows the vehicle and laboratory bench synthetic gas reactor catalyst inlet and outlet temperatures for the five steady-state modes with each of the four catalyst formulations. The catalyst inlet temperatures for Modes 1 through 4 were above the catalyst light-off temperatures, and all catalysts had high conversion efficiencies. Mode 5 was close to or below the catalyst light-off temperatures for each of the formulations. When the general trends for the percent reductions were compared, the percent reductions increased from Mode 1 through Mode 4 for the THC and CO emissions with a few exceptions regardless of the synthetic diesel exhaust mixture (full or propylene only) or the catalyst composition. These conversion efficiencies were generally found to be lower with higher exhaust space velocities, which increased from Mode 4 through Mode 1. For the NO_x emissions, no general trend was noted for the different test conditions, catalyst formulations or gas mixtures.

When the percent reductions for the regulated emissions from the vehicle exhaust were compared to those from the two synthetic diesel exhaust mixtures, some general trends were observed. For THC emissions with Modes 1 through 3, the propylene only mixture produced higher percent reductions than the actual vehicle exhaust while the percent reductions for the full mixture was much closer to the actual vehicle exhaust. For Mode 4 with the THC, the propylene only mixture was better at simulating the percent reductions; however, the percent reductions with the full mixture were only between 5 and 8 percentage numbers lower than the vehicle emission results. The most variation was observed for Mode 5 (Idle). Neither mixture reproduced the vehicle's THC emission reductions, and both mixtures were significantly lower in terms of percent reductions for all four catalyst formulations. For CO emissions with Modes 1 through 4, both synthetic diesel exhaust mixtures produced percent reductions which were comparable to the vehicle exhaust. With Mode 5, the results once again showed the most variation. For the platinum only catalysts, both synthetic diesel exhaust mixtures were significantly higher than the vehicle exhaust (23 to 26 percent reductions in CO emissions for the vehicle and 82 to 93 percent reductions in CO for the two synthetic gas mixtures). The 3:1 Pt/Pd

TABLE 21. PERCENT REDUCTION FOR STEADY-STATE MODES

Modes	Test Condition	Percent Reduction											
		Pt Only, 75 g/ft^3			3:1 Pt/Pd, 75 g/ft^3			Pt Only, 20 g/ft^3			3:1 Pt/Pd, 20 g/ft^3		
		Vehicle	Full Mix	Propylene	Vehicle	Full Mix	Propylene	Vehicle	Full Mix	Propylene	Vehicle	Full Mix	Propylene
THC													
1	Rated/75 %	77	84	93	77	84	91	82	83	91	77	83	90
2	Rated/50 %	72	84	92	72	82	90	76	85	91	72	81	87
3	PT/50 %	90	90	99	90	90	96	90	91	96	90	89	95
4	PT/25%	100	95	99	100	92	99	100	95	99	100	94	100
5	Idle	88	72	78	88	50	60	88	76	63	88	65	59
CO													
1	Rated/75 %	91	92		90	89	89	91	91	90	91	88	90
2	Rated/50 %	93	92	92	91	89	88	93	89	90	91	88	87
3	PT/50 %	97	98	98	97	99	97	97	99	99	97	98	97
4	PT/25%	100	100	100	100	100	100	98	100	100	100	100	100
5	Idle	26	90	90	19	22	23	23	93	82	16	1	11
NO_x													
1	Rated/75 %	(1)[a]	5	0	(3)	1	1	(1)	(1)	0	2	1	1
2	Rated/50 %	4	3	0	(5)	2	(1)	(1)	(1)	1	5	1	1
3	PT/50 %	(4)	1	0	(4)	1	1	(4)	2	2	(1)	1	0
4	PT/25%	0	2	2	(11)	2	1	(2)	2	0	4	2	0
5	Idle	13	1	3	13	(1)	(2)	17	1	2	9	0	2

[a] Values in parenthesis indicate an increase in concentration (negative percent reduction)

TABLE 22. COMPARISON OF VEHICLE AND LABORATORY BENCH SYNTHETIC GAS REACTOR CATALYST TEMPERATURES

Mode	Test Condition	Vehicle, °F		Bench Reactor Inlet, °F	
		Inlet	Outlet	Full Mix	Propylene Only
Engine-Out					
1	Rated/75 %	498	--[a]	--	--
2	Rated/50 %	414	--	--	--
3	PT/50 %	363	--	--	--
4	PT/25%	284	--	--	--
5	Idle	101	--	--	--
Pt Only, 75 g/ft^3					
1	Rated/75 %	472	501	499	500
2	Rated/50 %	383	405	408	413
3	PT/50 %	356	384	386	390
4	PT/25%	299	335	344	341
5	Idle	123	131	178	175
3:1 Pt/Pd, 75 g/ft^3					
1	Rated/75 %	472	499	505	499
2	Rated/50 %	395	421	410	410
3	PT/50 %	356	384	388	385
4	PT/25%	311	347	340	339
5	Idle	96	118	183	178
Pt Only, 20 g/ft^3					
1	Rated/75 %	470	500	498	499
2	Rated/50 %	397	422	411	410
3	PT/50 %	358	388	388	391
4	PT/25%	300	335	343	338
5	Idle	123	132	180	181
3:1 Pt/Pd, 20 g/ft^3					
1	Rated/75 %	468	487	500	498
2	Rated/50 %	384	400	411	411
3	PT/50 %	360	391	385	388
4	PT/25%	306	345	345	339
5	Idle	121	131	182	180

[a] No temperatures taken for this test condition

catalyst with a 75 g/ft^3 loading produced similar results for the vehicle and the two synthetic diesel exhaust mixtures, while the 20 g/ft^3 loading vehicle results were better simulated by the propylene only mixture. For the NO_x emissions, both mixtures were similar for Modes 1 though 4; but the overall percent reductions were low in all cases. At Idle (Mode 5), neither mixture was able to simulate the vehicle emission results.

5.2 Hydrocarbon Speciation Emission Results

The total hydrocarbon component of exhaust contains a highly complex mixture of different individual hydrocarbon types. This section first compares the composition of individual hydrocarbon results for this study with those obtained in AVFL-10b; and secondly, compares the percent reductions between the vehicle and laboratory bench synthetic gas reactor tests for each of the eight individual hydrocarbons and the compound groups used in the synthetic diesel exhaust mixture.

5.2.1 Comparison Between Projects

A comparison of the hydrocarbon groups from engine-out emissions for the four vehicles in AFVL-10b and the Vauxhall from this project showed some similarities and some differences between the various hydrocarbon groups. Tables 23 and 24 compare the results for the transient cycles and steady-state modes, respectively, for these projects (AVFL-10b and 10c). Since ethylene and propylene were usually present at the highest concentrations, these two compounds have been presented as individual compounds in the tables. Methane was also presented as an individual compound. 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. While propylene and formaldehyde were usually two of the highest contributors to the C3+ alkenes and total aldehydes, respectively; all aldehydes and ketones were grouped together to simplify the comparisons while the propylene and C3+ alkenes were reported separately. It should be noted that in Tables 23 and 24, propylene was also included in the C3+ alkanes values and therefore the total mass percentage will be greater than 100 percent. Semi-volatile hydrocarbons as determined by GC/MS were also grouped together and listed simply as semi-volatiles.

In general, there was a large vehicle to vehicle variation in the mass percentages for each compound group. In some cases the Vauxhall results agreed more closely with the larger displacement Chevrolet, Ford, and Dodge engines; and in other cases, they agreed more closely with the smaller displacement Volkswagen engine. In general, the Vauxhall results fell within the range of the results obtained for the AVFL-10b test engines. There were two exceptions, however, total alkynes and semi-volatiles. In these two cases, the magnitude of the total alkynes and semi-volatiles was much less for the Vauxhall than in the previous tests in AVFL-10b. While the source of these differences was unclear, the aromatic content of the fuel used in this project was about 20 percent lower than the fuel used in AVFL-10b (35.8 percent versus 28.6 percent). This difference in the aromatics may have had some impact on the relative magnitude of the total alkynes and semi-volatile hydrocarbons.

5.2.2 Comparison of Vehicle and Laboratory Bench Synthetic Gas Reactor

A comparison was also made between the Vauxhall catalyst-out emission results and those obtained with the laboratory bench synthetic gas reactor. Table 25 compares the vehicle and laboratory bench synthetic gas reactor percent reductions for the eight individual hydrocarbons used in the synthetic diesel exhaust mixture. When the general trends for the

TABLE 23. COMPARISON OF ENGINE-OUT HYDROCARBONS BY GROUP (TRANSIENT CYCLES)

Individual Compounds and Compound Groups	Mass Percent of Total Hydrocarbons				
	Chevrolet	Ford	Dodge	Volkswagen	Vauxhall
Cold UDDS					
Methane	3.2	2.1	6.0	3.4	3.4
Ethylene	17	12	18	16	21
Propylene	9.0	13	9.4	28	15
Total Alkynes	5.0	3.2	4.0	4.1	0.6
C3+ Straight-Chain Paraffins	0.9	8.0	1.0	1.0	2.4
C3+ Branched-Chain Paraffins	3.2	2.0	1.7	5.1	7.0
C3+ Alkenes	7.8	8.1	9.5	13	17
Total Aromatics	4.7	0.6	0.2	3.4	6.9
Total Aldehydes	28	30	45	28	42
Semi-volatiles	28	34	9.0	23	trace[a]
Hot UDDS					
Methane	5.1	5.9	1.7	4.1	4.5
Ethylene	14	9.3	26	16	22
Propylene	6.2	10	7.5	18	11
Total Alkynes	4.3	2.6	5.8	4.3	0.2
C3+ Straight-Chain Paraffins	0.8	1.2	2.1	0.7	1.7
C3+ Branched-Chain Paraffins	2.2	2.7	7.0	4.4	5.9
C3+ Alkenes	4.7	7.5	15	12	18
Total Aromatics	4.2	0.8	0.9	2.9	8.4
Total Aldehydes	22	18	22	29	40
Semi-volatiles	34	44	10	16	trace
US06					
Methane	2.1	ND[b]	0.9	1.7	ND
Ethylene	17	6.5	15	17	22
Propylene	4.5	4.4	7.8	4.6	3.3
Total Alkynes	5.1	1.6	2.2	4.9	0.4
C3+ Straight-Chain Paraffins	1.8	0.3	2.7	0.6	0.3
C3+ Branched-Chain Paraffins	6.2	5.4	5.7	4.9	12
C3+ Alkenes	12	4.3	9.9	12	15
Total Aromatics	5.5	0.8	1.3	4.0	12
Total Aldehydes	22	21	21	20	41
Semi-volatiles	12	29	34	5.2	trace

[a]Trace –Compound detected but value not quantifiable
[b]ND-None detected

TABLE 24. COMPARISON OF ENGINE-OUT HYDROCARBONS BY GROUP (STEADY-STATE MODES)

Individual Compounds and Compound Groups	Mass Percent of Total Hydrocarbons				
	Chevrolet	Ford	Dodge	Volkswagen	Vauxhall
Rated Speed at 75 Percent Load					
Methane	ND[a]	ND	0.6	ND	0.1
Ethylene	29	14	19	8.0	30
Propylene	17	20	22	4.0	17
Total Alkynes	6.2	2.3	2.2	1.7	0.1
C3+ Straight-Chain Paraffins	0.9	1.6	0.7	2.0	4.5
C3+ Branched-Chain Paraffins	6.6	17	6.2	11	6.9
C3+ Alkenes	22	19	19	7.5	22
Total Aromatics	7.5	8.9	4.0	11	5.6
Total Aldehydes	23	5.3	21	12	30
Semi-volatiles	3.8	31	23	44	trace[b]
Rated Speed at 50 Percent Load					
Methane	ND	ND	1.8	ND	ND
Ethylene	13	12	18	6.0	15
Propylene	6.8	13	23	2.8	8.8
Total Alkynes	3.4	3.7	3.0	1.6	0.1
C3+ Straight-Chain Paraffins	1.1	1.1	0.6	1.5	1.0
C3+ Branched-Chain Paraffins	4.0	6.4	5.8	14	12
C3+ Alkenes	8.3	12	10	5.6	16
Total Aromatics	4.5	5.9	3.7	10	17
Total Aldehydes	34	8.1	24	13	30
Semi-volatiles	30	49	30	46	12
Peak Torque Speed at 50 Percent Load					
Methane	ND	0.1	5.1	1.0	ND
Ethylene	12	7.1	9.7	17	16
Propylene	1.7	4.3	2.4	3.9	2.5
Total Alkynes	4.9	2.0	2.5	2.2	0.2
C3+ Straight-Chain Paraffins	2.9	2.5	0.4	1.1	1.1
C3+ Branched-Chain Paraffins	3.5	8.6	1.2	10	16
C3+ Alkenes	4.5	6.6	4.2	13	18
Total Aromatics	7.5	6.4	0.6	11	22
Total Aldehydes	14	11	9.9	19	25
Semi-volatiles	48	53	62	23	0.6

[a]ND-None detected
[b]Trace –Compound detected but value not quantifiable

TABLE 24 (CONT'D). COMPARISON OF ENGINE-OUT HYDROCARBONS BY GROUP (STEADY-STATE MODES)

Individual Compounds and Compound Groups	Mass Percent of Total Hydrocarbons				
	Chevrolet	Ford	Dodge	Volkswagen	Vauxhall
Peak Torque Speed at 25 Percent Load					
Methane	4.3	1.1	1.5	ND[a]	0.5
Ethylene	23	6.7	8.9	10	22
Propylene	8.4	4.4	3.3	1.3	2.1
Total Alkynes	5.0	2.3	1.4	4.4	0.1
C3+ Straight-Chain Paraffins	0.7	2.1	2.1	1.0	1.7
C3+ Branched-Chain Paraffins	3.1	13	1.9	4.5	18
C3+ Alkenes	5.9	2.8	5.3	4.4	12
Total Aromatics	3.3	3.7	0.5	5.6	8.4
Total Aldehydes	38	25	18	13	36
Semi-volatiles	16	41	56	54	0.6
Idle					
Methane	ND	0.8	ND	3.5	0.6
Ethylene	13	4.9	4.6	10	20
Propylene	1.6	1.4	0.7	1.6	1.7
Total Alkynes	3.1	1.8	1.0	2.4	0.2
C3+ Straight-Chain Paraffins	1.6	0.7	1.6	1.0	1.0
C3+ Branched-Chain Paraffins	4.8	5.3	0.9	3.2	15
C3+ Alkenes	6.9	1.8	3.1	7.8	11
Total Aromatics	2.8	ND	ND	0.8	11
Total Aldehydes	23	26	9.9	22	42
Semi-volatiles	42	55	73	45	0.1

[a]ND-None detected

percent reductions were compared for these individual hydrocarbons from the vehicle and laboratory bench synthetic gas reactor, the percent reductions were found to increase from Mode 1 through 4 for ethylene, propylene, benzene, 2,2,4-trimethylpentane, and formaldehyde with few exceptions. The conversion efficiencies were found to be generally lower as the space velocity through the catalyst increased. The trends for toluene, tetralin, and tetradecane were less apparent. Mode 5 (Idle) produced the most variation in results for the five test conditions.

Percent reductions for Modes 1 through 4 were similar between the vehicle-out and the laboratory bench synthetic gas reactor for ethylene, propylene, and benzene. For these same four modes, percent reductions for 2,2,4-trimethylpentane were generally lower than the vehicle-out emissions and percent reductions for toluene were generally higher than the vehicle-out emissions. Formaldehyde had similar results to 2,2,4-trimethylpentane (lower percent reductions than the vehicle-out emissions) for Modes 2 through 4, but the percent reductions were higher for Mode 1. The results for tetralin and tetradecane were difficult to compare because of their low concentrations in the vehicle emissions. No apparent trends related to catalyst formulation and

TABLE 25. INDIVIDUAL HYDROCARBON PERCENT REDUCTION FOR STEADY-STATE MODES

Modes	Test Condition	Percent Reductions							
		Pt Only, 75 g/ft^3		3:1 Pt/Pd, 75 g/ft^3		Pt Only, 20 g/ft^3		3:1 Pt/Pd, 20 g/ft^3	
		Vehicle	Full Mix	Vehicle	Full Mix	Vehicle	Full Mix	Vehicle	Full Mix
Ethylene									
1	Rated/75 %	89	81	88	71	90	79	87	70
2	Rated/50 %	89	80	84	66	89	75	83	64
3	PT/50 %	94	92	90	89	94	93	87	84
4	PT/25%	99	98	97	87	99	99	95	92
5	Idle	6	27	9	1	4	24	12	(1)[a]
Propylene									
1	Rated/75 %	88	82	87	76	89	80	88	76
2	Rated/50 %	91	82	89	78	90	78	91	75
3	PT/50 %	95	93	95	93	96	94	95	94
4	PT/25%	DEC[b]	99	DEC	98	100	99	100	99
5	Idle	16	53	70	100	4	100	73	16
Benzene									
1	Rated/75 %	85	77	85	74	88	78	86	73
2	Rated/50 %	85	75	81	69	85	79	81	73
3	PT/50 %	79	90	78	86	DEC	88	84	88
4	PT/25%	100	96	DEC	86	100	96	73	90
5	Idle	67	60	48	53	56	46	48	16
2,2,4-Trimethylpentane									
1	Rated/75 %	64	58	54	54	69	54	100	56
2	Rated/50 %	91	56	78	ND[c]	89	51	100	84
3	PT/50 %	90	73	73	65	100	71	100	68
4	PT/25%	100	81	46	67	100	81	100	70
5	Idle	100	41	24	50	100	21	100	23

[a]Values in parenthesis indicate an increase in concentration (negative percent reduction)
[b]DEC - Decrease in emissions, percent reduction usually greater than 90 percent, but actual value cannot be calculated due to unquantifiable trace amount detected in catalyst-out exhaust
[c]ND- Not determined for this sample due to instrument problems

TABLE 25 (CONT'D). INDIVIDUAL HYDROCARBON PERCENT REDUCTION FOR STEADY-STATE MODES

Modes	Test Condition	Percent Reductions							
		Pt Only, 75 g/ft^3		3:1 Pt/Pd, 75 g/ft^3		Pt Only, 20 g/ft^3		3:1 Pt/Pd, 20 g/ft^3	
		Vehicle	Full Mix	Vehicle	Full Mix	Vehicle	Full Mix	Vehicle	Full Mix
Toluene									
1	Rated/75 %	67	79	74	76	66	79	81	77
2	Rated/50 %	75	77	73	77	65	80	75	78
3	PT/50 %	48	90	55	89	40	88	54	90
4	PT/25%	(16)[a]	97	100	95	100	96	100	96
5	Idle	100	75	100	60	100	68	100	32
Tetralin									
1	Rated/75 %	INC[d]	83	INC	84	INC	77	NC	85
2	Rated/50 %	33	77	(33)	63	NC[e]	87	67	77
3	PT/50 %	100	91	100	81	100	87	100	76
4	PT/25%	DEC[b]	90	INC	88	NC	99	NC	99
5	Idle	NC	97	NC	95	NC	99	INC	90
Tetradecane									
1	Rated/75 %	INC	29	INC	66	INC	17	INC	61
2	Rated/50 %	44	ND[c]	41	ND	47	ND	62	ND
3	PT/50 %	INC	45	INC	ND	INC	ND	INC	30
4	PT/25%	INC	57	INC	64	INC	75	INC	21
5	Idle	INC	37	INC	44	INC	41	NC	31
Formaldehyde									
1	Rated/75 %	55	71	55	74	45	69	53	66
2	Rated/50 %	81	68	78	63	79	62	100	57
3	PT/50 %	87	83	77	84	75	84	100	82
4	PT/25%	98	94	91	75	95	95	100	87
5	Idle	4	5	5	1	(15)	(1)	100	(1)

[a] Values in parenthesis indicate an increase in concentration (negative percent reduction)
[b]DEC – Decrease in emissions, percent reduction usually greater than 90 percent, but actual value cannot be calculated due to unquantifiable trace amount detected in catalyst-out exhaust
[c] ND – Not determined for this sample due to instrument problems
[d] INC – Increase in emissions, percent reduction could not be calculated because compound not detected in the engine-out exhaust, but measurable amounts detected in the catalyst-out exhaust
[e] NC – No change for the engine-out results

loading were observed. The most variation in results for the vehicle to laboratory bench synthetic gas reactor comparison was observed for Mode 5 (Idle). None of the vehicle individual hydrocarbons results were reproduced with the laboratory bench synthetic gas reactor. These Mode 5 (Idle) differences are thought to be related to the much lower exhaust temperatures observed for this test condition.

5.2.3 Comparison by Compound Groups

Eight individual hydrocarbons were used to represent the total hydrocarbons in the synthetic diesel exhaust mixture. The most abundant hydrocarbon group from the AVFL-10b study was the semi-volatile group. The group represented about 36 percent of the total mass of the hydrocarbons. Within the semi-volatile group, tetradecane was used to represent the mass of the straight-chain hydrocarbons within this group, and tetralin was used for the aromatic portion. About 29 percent of the total hydrocarbon mass was from the olefins. The compounds used to represent this group were ethylene and propylene with propylene representing the C3+ alkenes. The next most abundant component was the aldehydes and ketones. This group represented about 23 percent of the total hydrocarbon mass, and formaldehyde was chosen to represent this group. Aromatics represented about 7 percent of the mass of the total hydrocarbons, and benzene and toluene were selected to represent this group of compounds. Branched-chain hydrocarbons represented about 5 percent of the total mass hydrocarbon mass, and 2,2,4-trimethylpentane was ultimately chosen to represent this group.

A comparison of the individual compounds representing the six compound groups to the total of each type of compound within each group was made between the Vauxhall catalyst-out emission results and those obtained with the laboratory bench synthetic gas reactor. Table 26 compares the vehicle and laboratory bench synthetic gas reactor percent reductions for seven of the eight compound groups (Note: Semi-volatile exhaust concentrations from the Vauxhall were lower than expected, so no comparison could be made.) When the general trends for the percent reductions were compared, the results were similar to the comparisons with the individual compounds. The percent reductions were generally found to increase from Mode 1 through Mode 4 with the exception of some compounds with Mode 3. Mode 5 (Idle) produced the most variation in results for the five test conditions. Percent reductions were similar for ethylene and propylene. Benzene, toluene, and the sum of benzene and toluene were generally similar except for Mode 3. The full mixture was also better able to represent the C3+ branched-chain paraffins and the total aldehyde results with the lightly loaded catalyst formulations.

5.3 Light-Off Experiment

In addition to the steady-state testing discussed above, several experiments were performed to determine the catalyst light-off performance with each of the synthetic diesel exhaust mixtures (full and propylene only). These light-off tests simulated some of the conditions which took place during the transient cycles. Two light-off tests were performed using the 3:1 platinum to palladium catalyst with the 20 g/ft loading and a space velocity similar to Mode 2 (50 percent load at rated speed). For these experiments, the furnace temperature was ramped from 100 to 450°C at 10°C per minute. The results are shown in Figure 5 for propylene only.

TABLE 26. COMPARISON OF PERCENT REDUCTION FOR HYDROCARBON GROUPS

Modes	Test Condition	Percent Reductions							
		Pt Only, 75 g/ft^3		3:1 Pt/Pd, 75 g/ft^3		Pt Only, 20 g/ft^3		3:1 Pt/Pd, 20 g/ft^3	
		Vehicle	Full Mix	Vehicle	Full Mix	Vehicle	Full Mix	Vehicle	Full Mix
Ethylene									
1	Rated/75 %	89	81	88	71	90	79	87	70
2	Rated/50 %	89	80	84	66	89	75	83	64
3	PT/50 %	94	92	90	89	94	93	87	84
4	PT/25%	99	98	97	87	99	99	95	92
5	Idle	6	27	9	1	4	24	12	(1)[a]
C3+ Alkenes as Represented by Propylene									
1	Rated/75 %	86	82	86	76	87	80	89	76
2	Rated/50 %	91	82	90	78	90	78	92	75
3	PT/50 %	94	93	96	93	94	94	94	94
4	PT/25%	97	99	99	98	99	99	99	99
5	Idle	42	53	80	100	31	100	82	16
Total Aromatics as Represented by Benzene									
1	Rated/75 %	71	77	71	74	66	78	(23)	73
2	Rated/50 %	88	75	89	69	88	79	91	73
3	PT/50 %	85	90	85	86	79	88	68	88
4	PT/25%	85	96	73	86	79	96	(220)	90
5	Idle	96	60	93	53	90	46	84	16
Total Aromatics as Represented by Toluene									
1	Rated/75 %	71	79	71	76	66	79	(23)	77
2	Rated/50 %	88	77	89	77	88	80	91	78
3	PT/50 %	85	90	85	89	79	88	68	90
4	PT/25%	85	97	73	95	79	96	(220)	96
5	Idle	96	75	93	60	90	68	84	32
Total Aromatics as Represented by Benzene and Toluene									
1	Rated/75 %	77	78	80	75	78	79	84	75
2	Rated/50 %	79	76	77	74	74	80	78	76
3	PT/50 %	57	90	62	88	56	88	63	89
4	PT/25%	83	96	95	91	100	96	77	94
5	Idle	87	68	80	56	83	57	80	25

[a]Values in parenthesis indicate an increase in concentration (negative percent reduction)

TABLE 26 (CONT'D). COMPARISON OF PERCENT REDUCTION FOR HYDROCARBON GROUPS

Modes	Test Condition	Percent Reductions							
		Pt Only, 75 g/ft^3		3:1 Pt/Pd, 75 g/ft^3		Pt Only, 20 g/ft^3		3:1 Pt/Pd, 20 g/ft^3	
		Vehicle	Full Mix	Vehicle	Full Mix	Vehicle	Full Mix	Vehicle	Full Mix
C3+ Branched-Chain Paraffins as Represented by 2,2,4-Trimethylpentane									
1	Rated/75 %	41	58	35	54	31	54	59	56
2	Rated/50 %	70	56	69	ND[c]	71	51	79	84
3	PT/50 %	20	73	26	65	35	71	61	68
4	PT/25%	57	81	51	67	61	81	67	70
5	Idle	70	41	55	50	58	21	74	23
Total Aldehydes and Ketones as Represented by Formaldehyde									
1	Rated/75 %	70	82	70	76	69	80	95	76
2	Rated/50 %	78	82	74	78	80	78	100	75
3	PT/50 %	62	93	78	93	71	94	99	94
4	PT/25%	79	99	95	98	95	99	99	99
5	Idle	(22)[a]	53	(2)	100	(9)	100	100	16

[a]Values in parenthesis indicate an increase in concentration (negative percent reduction)

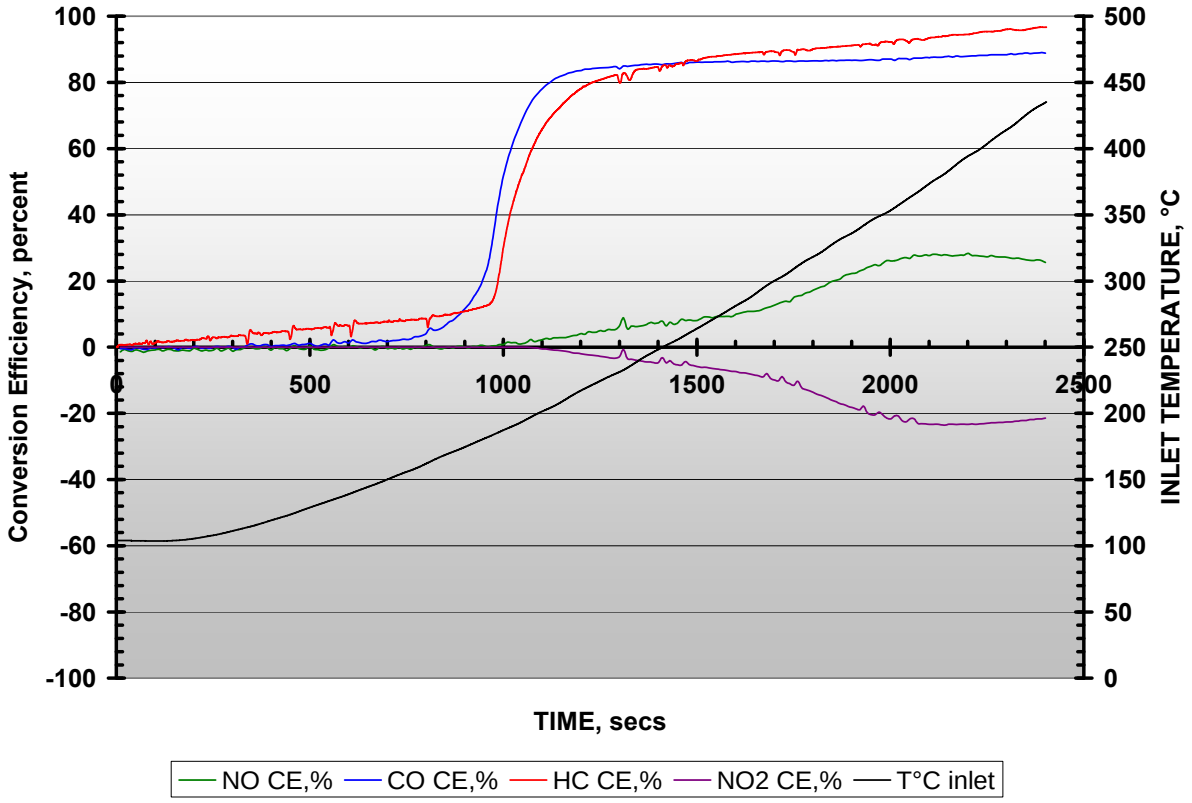

FIGURE 5. LIGHT-OFF RESULTS FOR PROPYLENE ONLY MIXTURE

For the purpose of these experiments, the light-off temperature was defined as the temperature when 50 percent conversion efficiency was obtained. With the propylene only mixture, the light-off temperature was between 187 to 188°C for THC and CO. The NO_x never achieved 50 percent conversion efficiency, but conversion from NO to NO_2 began at about the same temperature as the THC and CO conversion reached 50 percent. Since the NO oxidation began at about the same temperature as CO light-off, the initial reaction was probably between NO and CO rather than NO and O_2. No net change was noted for the total NO_x, so these results agreed with the vehicle transient cycle results. In addition, nitrogen dioxide (NO_2) and ammonia (NH_3) were monitored in the catalyst inlet and outlet. No NO_2 or NH_3 were detected for the inlet or outlet.

With the full mixture, similar results were obtained except the light-off temperature for CO was shifted to about 216°C. In this case, the liquid hydrocarbon mixture did not evaporate well at lower temperatures due to the higher boiling points for some of the compounds. As a result, the THC could not be quantified. Once the catalyst temperatures were greater than the boiling points for the various heavy-hydrocarbons, the final conversion efficiencies were similar to the propylene only mixture. The NO light-off also began at a higher temperature for the full gas mixture with a zero net change in the total NO_x. As with the propylene only, no NO_2 or NH_3 were detected for the catalyst inlet or outlet. In addition, formaldehyde was monitored in the catalyst inlet and outlet with the full mixture. Formaldehyde began to be reduced at about 300°C, and 50 percent conversion efficiency was obtained at about 425°C. Figure 6 shows the light-off results for the full mixture.

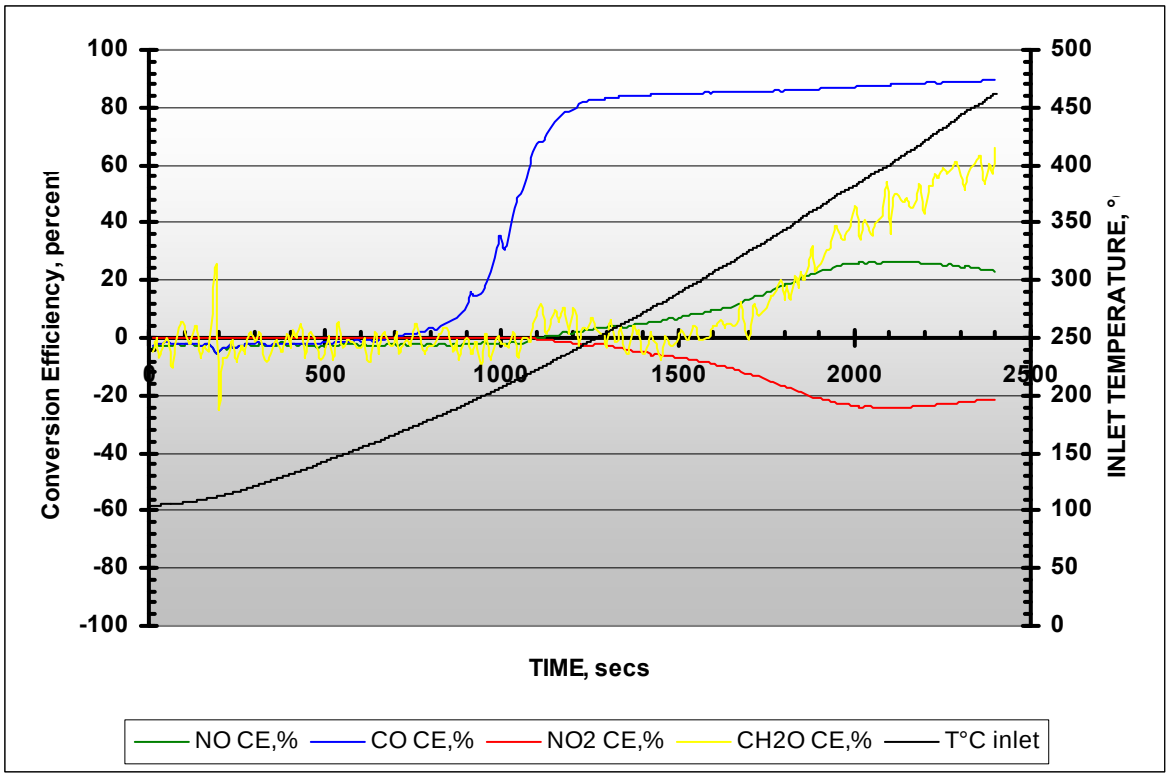

FIGURE 6. LIGHT-OFF RESULTS FOR FULL MIXTURE

6.0 REVIEW, SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This section reviews the three AVFL-10 studies, summarizes the results of this study, and attempts to draw some conclusions from the results.

6.1 AVFL-10a

In the AVFL-10a study, a database was compiled which contained data from 72 different studies published between 1999 and 2003. These data represented composite results from either transient cycles or from multiple, steady-state points; however, most of the data was from heavy-duty applications rather than light-duty vehicle emissions. A proposed blend for a synthetic diesel exhaust mixture from AVFL-10a consisted primarily of N_2, O_2, CO_2, H_2O, CO, and NO. The hydrocarbons, which were a minor portion of the proposed blend, were composed of ethylene, undecane, and formaldehyde in a ratio of about 4:3:2 for the three compounds on a mass basis. As a result of this study, it was also determined that there was insufficient data available for light-duty vehicles. The AVFL-10b was then performed to provide additional light-duty vehicle data.

6.2 AVFL-10b

In AVFL-10b, a study was performed to measure the exhaust composition from four current technology vehicles (2004 models), to compare those results with the previous data from AVFL-10a, and to propose a standard synthetic diesel exhaust composition based on these additional data. The proposed synthetic diesel exhaust mixture from this study was to be formulated to provide aftertreatment manufacturers with the ability to determine a good indication of effectiveness and durability of their aftertreatment systems, and was ultimately determined to be similar to the one proposed in AVFL-10a. When the relative concentrations of the major components (N_2, O_2, CO_2, and H_2O) were considered, the composition consisted of about 76 percent by mass N_2, about 13 percent by mass O_2, about 7.6 percent by mass CO_2, and about 3 percent by mass H_2O. These major components would account for more than 99 percent of a synthetic diesel exhaust mixture. Table 27 presents the relative concentrations for a synthetic blend based on the literature search from AVFL-10a and on vehicle measurements made in AVFL-10b. Data from the transient and steady-state modes from AVFL-10b were weighted equally to obtain representative mass concentrations.

TABLE 27. PROPOSED 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

The remaining fraction of a synthetic diesel exhaust mixture was to be composed of the currently regulated exhaust emissions and consisted of three different compounds or groups of compounds. These three included THC, CO, and NO_x. CO was the only one of this group that consisted of a single compound. The NO_x was composed of two principle oxides (NO and NO_2), but only NO has been utilized to represent NO_x in the blend formulations. The THC was composed of unburned or partially burned fuel and oil at relatively low concentrations. This group of compounds was very complex in terms of numbers and types of compounds; however, it poses the most interesting challenges to a aftertreatment manufacturer in terms of conversion and durability of the aftertreatment system. Several hundred individual hydrocarbon compounds were detected in the exhaust during the course of these studies. Three individual compounds (ethylene, propylene, and formaldehyde) were present in concentrations that were usually two to three orders of magnitude greater than the other individual compounds and accounted for more than 50 percent of the total hydrocarbons. For consideration as a blend component, 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
- Total aromatics.

Because of the potential complexity of preparing a detailed blend of hydrocarbon components, a graduated approach was proposed with the hydrocarbon composition increasing in complexity. Table 28 presents various combinations for a synthetic hydrocarbon mixture based on the sequential addition of additional compound groups and their relative contribution in percent of the total. This table includes five different combinations with each combination increasing in complexity. When all six compounds or compound groups were included, they represented more than 90 percent of the total hydrocarbons present in the exhaust.

The semi-volatile hydrocarbons were proposed to be represented by a mixture of equal amounts of tridecane, tetradecane, pentadecane and naphthalene or tetralin. The C3+ alkenes were proposed to be represented by propylene or 1-butene. For the aromatic contribution, benzene or toluene were determined to be the most representative of the actual exhaust, but the isomers of xylene were also considered. Finally, the branched-chain hydrocarbons were proposed to be represented by either 2,2-dimethylpropane, 3-methylpentane, or 2,2,4-trimethylpentane.

TABLE 28. AVFL-10b HYDROCARBON COMPOSITIONS FOR SYNTHETIC EXHAUST WITH INCREASING COMPLEXITY

Component	Relative Mass 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

6.3 AVFL-10c and a Comparison of Results for the AVFL-10 Programs

In AVFL-10c, the feasibility of preparing a synthetic diesel exhaust mixture was investigated. A mixture was subsequently prepared and used in conjunction with a laboratory bench synthetic gas reactor to evaluate four diesel catalysts. These results were then compared to those obtained from a vehicle equipped with these same catalysts.

A 2005 Vauxhall Vectra with a 1.9 L engine and an automatic transmission was selected as the test vehicle in AVFL-10c. This vehicle had multiple forms of aftertreatment; but for simplicity, the AVFL-10c committee selected the use of a single oxidation catalyst with four different catalyst formulations for use in this study. The catalyst formulations included:

- Platinum only with a 75 g/ft^3 loading
- 3:1 Platinum to palladium with a 75 g/ft^3 loading
- Platinum only with a 20 g/ft^3 loading
- 3:1 Platinum to palladium with a 20 g/ft^3 loading

The Vauxhall's engine-out exhaust data was compared to data from the previous two studies, and the regulated emissions fell within the previously observed results even though the fuels were different between the different studies. When the hydrocarbon speciation results were compared to those obtained in the two previous studies, there was a general similarity in the results except that the magnitude of the total alkynes and semi-volatiles were much less for the Vauxhall than

for previously studied vehicles. The origin of the differences was unclear, but differences in composition of the test fuels were considered as a possible source. Overall, exhaust emissions from the Vauxhall were considered to be representative of the data from the previous two projects and representative of typical diesel exhaust.

The next step in the AVFL-10c study was to determine the catalyst-out emissions from the four catalyst formulations. Percent reductions were determined for the transient cycles and for the same five steady-state modes that were used in AVFL-10b. Significant reductions were noted for the THC and CO, but little change was observed for the NO_x. When comparing the percent reductions for the transient cycles, the THC was almost 100 percent and the CO was greater than 90 percent for the three transient cycles, while the percent reduction for the NO_x was between 12 and 25 percent for the UDDS cycles and between 1 and 7 percent for the US06. The THC and CO percent reductions were related to space velocity for steady-state Modes 1 through 4 with the percent reduction increasing with decreasing space velocity. Mode 5 (Idle) results were variable with the variation attributed to much lower exhaust temperatures for this mode. Low percent reductions for the NO_x were also observed for the steady-state modes. No specific trend related to catalyst loading or palladium content was noted for the steady-state modes.

For the individual hydrocarbons, ethylene, propylene, and formaldehyde were present at the highest concentrations in the engine-out exhaust. With each catalyst formulation, the individual hydrocarbon compounds were reduced; but ethylene, propylene, and formaldehyde remained as the major components. Catalyst-out hydrocarbon concentrations were lower for the hot UDDS and US06 cycles than for the cold UDDS cycle; and as was the case for the total hydrocarbons, the individual hydrocarbon concentrations decreased as the space velocity decreased (highest hydrocarbons and space velocity with Mode 1 and lowest hydrocarbons and space velocity with Mode 4) for the steady-state modes. Once again, Mode 5 (Idle) results were an exception to this observation. In addition, a general trend with the transient cycles was observed toward lower percent reductions as the catalyst loading was reduced and lower percent reductions as the palladium content was increased. Percent reductions for Modes 1 through 4 were generally similar for the four catalyst formulations. While some variation in hydrocarbon components were observed for the various studies, the eight hydrocarbons selected earlier in the study to represent the hydrocarbon components in the synthetic diesel exhaust mixture were considered to be representative of the total hydrocarbons and of the various hydrocarbon groups that they were selected to represent.

6.4 Comparison of AVFL-10c Vehicle and Laboratory Bench Synthetic Gas Reactor

Two synthetic diesel exhaust mixtures (propylene only to represent THC and an eight component hydrocarbon blend to represent THC) were utilized to represent diesel exhaust during tests with the laboratory bench synthetic gas reactor. These laboratory bench synthetic gas reactor results were then compared to those obtained from the steady-state vehicle emission tests. For the THC, the multiple component hydrocarbon mixture was found to be better for simulating the percent reductions from the vehicle for Modes 1 through 3, while the propylene only mixture was better at simulating the THC results for Mode 4. It should be noted that the full mixture was only less than 8 percentage numbers lower than the THC percent reductions observed for the vehicle exhaust for this mode. For the CO emissions, both mixtures were comparable for Modes

1 through 4. Neither mixture was able to reproduce the vehicle THC and CO percent reductions observed during Mode 5. In addition, no general trend was noted for the different test conditions, catalyst formulations or gas mixtures for the NO_x emissions.

The percent reductions for the individual hydrocarbons used in the synthetic diesel exhaust mixture were also compared to the hydrocarbon emissions from the steady-state vehicle emissions. In general, percent reductions for ethylene, propylene, benzene, 2,2,4-trimethylpentane, and formaldehyde increased with decreasing space velocity. Percent reductions for Modes 1 through 4 with ethylene, propylene, and benzene were similar between the vehicle-out and the laboratory bench synthetic gas reactor. Percent reductions for 2,2,4-trimethylpentane were found to be generally lower with the laboratory bench synthetic gas reactor than with the vehicle while toluene percent reductions were generally higher with the laboratory bench synthetic gas reactor than with the vehicle. Formaldehyde had similar results to 2,2,4-trimethylpentane (lower percent reductions for the laboratory bench synthetic gas reactor than for the vehicle) for Modes 2 through 4, but the percent reductions were higher for Mode 1. The percent reductions for tetralin and tetradecane were difficult to compare due to low vehicle-out emissions. These general trends appeared to be independent of the catalyst formulation and loading.

6.5 Conclusions

In general, it was found that emissions generated from steady-state vehicle tests could be represented with a laboratory bench synthetic gas reactor and a synthetic diesel exhaust mixture. Data generated with both synthetic diesel exhaust mixtures evaluated in this study (the full blend of eight hydrocarbons and propylene only) agreed quite well with the vehicle data, except for Mode 5 (Idle). The full synthetic diesel exhaust mixture was found to be slightly better at representing actual vehicle exhaust during most of the test conditions as the propylene only mixture tended to have higher conversion efficiencies for the THC and CO at the higher space velocities. This observation may be due to the relatively low light-off temperature of propylene itself. With a lower relative light-off temperature compared to other compounds within the mixture, reactions involving the conversion of CO to CO_2 and THC (propylene) to CO_2 may proceed at a lower temperature due to the single component concentration and the expected exotherms produced. Heat produced by the oxidation of the propylene would rapidly increase the internal catalyst temperatures and initiate other reactions within the catalyst bed. This simplified approach may account for the higher conversion efficiencies with propylene only at the higher space velocities. When the mixture was more complex, alternate reaction mechanisms with relatively higher initial light-off temperatures may inhibit the reactions which ultimately simulate actual diesel exhaust better. Therefore, the full mixture was thought to be better at simulating actual diesel exhaust. This same observation was also seen when comparing the different hydrocarbon groups. The full synthetic diesel exhaust mixture was better able to represent the conversion efficiencies of the different hydrocarbon groups than propylene only.

Mode 5 (Idle) test conditions produced the most variability of the five steady-state modes evaluated. One possible explanation of the variability may be due to the relatively low exhaust temperature for this condition. With the exhaust temperature at or near the light-off temperature a small shift either way in the exhaust temperature or the composition of the exhaust may change

the results significantly. Therefore, this test condition, Mode 5 (Idle), was found to be very difficult to simulate, and the results obtained from the synthetic diesel exhaust mixture were not very representative of the actual engine exhaust for this condition only. In general, however, the synthetic diesel exhaust mixture was capable of simulating actual engine-out diesel exhaust for the other test conditions.

A listing of the generalized conclusions from this study follows:

- Vauxhall engine-out regulated emissions were found to be typical of light-duty diesel engines even though the test fuel was different from previous studies

- Composition of the Vauxhall engine-out hydrocarbon emissions were typical of light-duty diesel engine exhaust emissions except for lower relative concentrations of total alkynes and semi-volatile components; this difference may have been due to the composition of the test fuel

- Steady-state laboratory bench synthetic gas reactor tests can be performed using both a simple gas mixture (propylene-only) and a full eight component synthetic diesel exhaust mixture. Both were found to generally reproduce regulated emission results from a test vehicle with the propylene only mixture tending to over estimate conversion efficiencies during some modes of operation.

- Percent reductions for the THC and CO emissions could be simulated relatively well for Modes 1 through 4, but Mode 5 (Idle) reductions could not be effectively reproduced

- Propylene only mixture represented only light hydrocarbons, and did not show any results for the other hydrocarbons

- Conversion efficiencies tended to increase with lower space velocity (with higher exhaust temperatures)

- While reasonable agreement was obtained for the THC and CO conversion efficiencies, NO_x conversion efficiencies were much more variable

- Reasonable agreement was obtained for conversion efficiencies of individual hydrocarbons ethylene, propylene, and benzene for Modes 1 through 4, while laboratory bench synthetic gas reactor efficiencies were generally lower for 2,2,4-trimethylpentane and higher for toluene. Formaldehyde laboratory bench synthetic gas reactor efficiencies were lower for Modes 2 through 4 and higher for Mode 1 than for the vehicle. Because of the low engine-out concentrations, tetralin and tetradecane were difficult to evaluate.

- Reasonable agreement was obtained for conversion efficiencies of the C3+ alkenes and total aromatics; catalysts with lower loading were better represented by the full mixture

- Incorporating formaldehyde in the mixture in a reliable manner remains a challenge.

- Conversion efficiencies for the different hydrocarbon groups were better represented by the full synthetic diesel exhaust mixture as compared to propylene only

- Propylene only mixture was observed to have a lower light-off temperature than the full gas mixture.

- Light-off tests could not readily be performed with the full gas mixture due to the relatively high boiling points of the hydrocarbon tetralin and tetradecane.

- Full eight component gas mixture captures possible water and CO effects which are not captured with the propylene only mixture. This observation is most directly seen through a comparison of the different groups of compounds and may be partially responsible for the better simulation of actual diesel exhaust.

6.6 Recommendations

One of the complications in this study was trying to find a simple set of representative hydrocarbon components for the synthetic diesel exhaust mixture. While some components could be introduced easily, others such as formaldehyde, tetralin, and tetradecane were much more difficult. Incorporating formaldehyde into the mixture in a reliable manner was a challenge for this study. Both paraformaldehdye and trioxane were considered as possible sources of formaldehyde, but these proved to be impractical as a reliable means of introducing formaldehyde. High concentrations (greater than 100 ppm) of formaldehyde in a compressed gas cylinder were not considered to be stable. Low concentrations, while more stable, required higher volumes of gas to obtain the proper mass in the exhaust stream. The 100 ppm formaldehyde concentration used in this study was not found to be stable. While formaldehyde, the most predominant of the exhaust aldehydes, was chosen to represent the total aldehydes and the total aldehydes are a major portion of the total mass of the hydrocarbons, additional experiments are suggested to determine if another aldehyde could be used in place of formaldehyde or if formaldehyde could be eliminated from the mixture without a significant change in conversion efficiencies. If the absence of formaldehyde does not affect the catalyst conversion efficiencies, then the synthetic diesel exhaust mixture could be simplified. Acetaldehyde, the second most abundant aldehyde in exhaust, or another aldehyde with better stability or solubility may be another alternative to the use of formaldehyde.

In this study, the semi-volatile components were represented by tetralin and tetradecane. These two compounds were introduced as liquids and evaporated into the gas stream. Variable results with the laboratory bench synthetic gas reactor were obtained at test conditions where the catalyst inlet temperature was below the boiling point of these two compounds (Mode 5). Both of these compounds had boiling points above 200°C (207°C for tetralin and 254°C for tetradecane). As a result, these two compounds were difficult to introduce into the gas stream at

low exhaust temperatures. While not as representative as tetralin or tetradecane, lower molecular weight compounds such as decane, undecane, or dodecane would more likely evaporate into the gas stream and are suggested as components for future studies.

In summary, the recommendations for further study are:

- Synthetic diesel exhaust gas mixtures with multiple hydrocarbons provided similar results to the vehicle emissions and equivalent or better than a propylene only mixture; but more work needs to be done to refine the mixture.

- Higher molecular weight hydrocarbons should probably be included in the full gas mixture, but the boiling points of the selected compounds should be lower. It is suggested that liquid hydrocarbons with boiling points higher than the catalyst light-off temperature not be used. A boiling point upper limit of 150°C is suggested.

- Determine if the effect of formaldehyde on catalyst activity can be duplicated with another aldehyde or if it can be eliminated from the hydrocarbon mixture without adversely affecting the results. If formaldehyde cannot be replaced, addition study is needed to determine a more reliable method of addition.

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. Fanick, E.R., Diesel Exhaust Standard Phase II: CRC Project No. AVFL-10b," prepared for the Coordinating Research Council, Inc., August 2005.

4. 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.

5. 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

HYDROCARBON SPECIATION DATA FOR TRANSIENT CYCLES

TABLE A-1. TRANSIENT CYCLE SUMMARY FOR ENGINE-OUT EMISSIONS

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
METHANE	9.0	8.7	8.8	
ETHANE	0.8	0.4	0.6	
ETHYLENE	55.7	42.6	48.2	10.6
PROPANE	1.9	0.2	0.9	
PROPYLENE	14.9	11.4	12.9	3.3
ACETYLENE				
PROPADIENE	10.1	7.7	8.7	
BUTANE	0.1	trace	0.1	
TRANS-2-BUTENE	0.6	0.4	0.5	0.1
1-BUTENE	3.8	2.9	3.3	0.9
2-METHYLPROPENE (ISOBUTYLENE)	2.4	1.8	2.1	0.7
2,2-DIMETHYLPROPANE (NEOPENTANE)				
PROPYNE	0.2	0.4	0.3	0.2
1,3-BUTADIENE	6.2	5.0	5.5	1.1
2-METHYLPROPANE (ISOBUTANE)	0.6	0.6	0.6	1.8
1-BUTYNE				
METHANOL				
CIS-2-BUTENE	0.4	0.3	0.3	0.1
3-METHYL-1-BUTENE				
ETHANOL				
2-METHYLBUTANE (ISOPENTANE)	1.2	1.0	1.1	0.2
2-BUTYNE				
1-PENTENE				
2-METHYL-1-BUTENE				
PENTANE	1.6	1.3	1.4	0.1
UNIDENTIFIED C5 OLEFINS				
2-METHYL-1,3-BUTADIENE	0.3	0.4	0.4	trace
TRANS-2-PENTENE	1.0	0.7	0.8	
3,3-DIMETHYL-1-BUTENE	0.3	0.3	0.3	
CIS-2-PENTENE				
2-METHYL-2-BUTENE	0.2	0.3	0.2	
TERT-BUTANOL				
CYCLOPENTADIENE	0.5	0.3	0.4	
2,2-DIMETHYLBUTANE	1.0	0.6	0.8	
CYCLOPENTENE	0.3	0.2	0.3	
4-METHYL-1-PENTENE				0.2
3-METHYL-1-PENTENE				
CYCLOPENTANE	0.7	0.6	0.6	0.2
2,3-DIMETHYLBUTANE	0.1	0.5	0.3	
MTBE				
4-METHYL-CIS-2-PENTENE				
2-METHYLPENTANE				
4-METHYL-TRANS-2-PENTENE				
3-METHYLPENTANE	2.5	1.9	2.1	1.0
2-METHYL-1-PENTENE	1.4	0.9	1.1	0.4
1-HEXENE	1.4	0.9	1.1	0.4
HEXANE				trace

TABLE A-1 (CONT'D). TRANSIENT CYCLE SUMMARY FOR ENGINE-OUT EMISSIONS

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
UNIDENTIFIED C6 OLEFINS	0.8	0.5	0.6	0.5
TRANS-3-HEXENE				
CIS-3-HEXENE				
DI-ISOPROPYL ETHER				
TRANS-2-HEXENE	0.2	0.2	0.2	0.1
3-METHYL-TRANS-2-PENTENE				
2-METHYL-2-PENTENE				
3-METHYLCYCLOPENTENE				
CIS-2-HEXENE				
ETBE				
3-METHYL-CIS-2-PENTENE	trace	trace	trace	
2,2-DIMETHYLPENTANE, NOTE A	0.2	0.2	0.2	0.1
METHYLCYCLOPENTANE, NOTE A				
2,4-DIMETHYLPENTANE				
2,2,3-TRIMETHYLBUTANE				
3,4-DIMETHYL-1-PENTENE	0.5	0.3	0.4	
1-METHYLCYCLOPENTENE				
BENZENE	4.6	4.0	4.2	1.1
3-METHYL-1-HEXENE				
3,3-DIMETHYLPENTANE	0.4	0.3	0.3	0.2
CYCLOHEXANE				
2-METHYLHEXANE	0.3	0.3	0.3	
2,3-DIMETHYLPENTANE	0.5	0.4	0.5	0.2
1,1-DIMETHYLCYCLOPENTANE				
TERT-AMYL METHYL ETHER				
CYCLOHEXENE				
3-METHYLHEXANE	0.4	0.4	0.4	0.1
CIS-1,3-DIMETHYLCYCLOPENTANE	0.5	0.4	0.4	0.1
3-ETHYLPENTANE				
TRANS-1,2-DIMETHYLCYCLOPENTANE				
TRANS-1,3-DIMETHYLCYCLOPENTANE				
1-HEPTENE				
2,2,4-TRIMETHYLPENTANE				0.4
2-METHYL-1-HEXENE				
TRANS-3-HEPTENE	0.2	0.2	0.2	
HEPTANE	1.5	1.3	1.4	
CIS-3-HEPTENE				
UNIDENTIFIED C7	0.7	0.5	0.6	0.1
2-METHYL-2-HEXENE				
3-METHYL-TRANS-3-HEXENE				
TRANS-2-HEPTENE	0.2	0.2	0.2	0.1
3-ETHYL-CIS-2-PENTENE				
2,4,4-TRIMETHYL-1-PENTENE				
2,3-DIMETHYL-2-PENTENE				
CIS-2-HEPTENE				
METHYLCYCLOHEXANE	0.2	0.2	0.2	0.1
CIS-1,2-DIMETHYLCYCLOPENTANE				

TABLE A-1 (CONT'D). TRANSIENT CYCLE SUMMARY FOR ENGINE-OUT EMISSIONS

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
2,2-DIMETHYLHEXANE				
1,1,3-TRIMETHYLCYCLOPENTANE				
2,4,4-TRIMETHYL-2-PENTENE				
2,2,3-TRIMETHYLPENTANE	0.5	0.4	0.4	0.2
2,5-DIMETHYLHEXANE				
ETHYLCYCLOPENTANE				
2,4-DIMETHYLHEXANE				
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	0.2
2,3,3-TRIMETHYLPENTANE				
TOLUENE	2.9	3.2	3.1	1.4
2,3-DIMETHYLHEXANE				
1,1,2-TRIMETHYLCYCLOPENTANE				
2-METHYLHEPTANE	0.2		0.1	
3,4-DIMETHYLHEXANE, NOTE B				
4-METHYLHEPTANE				
3-METHYLHEPTANE				
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE	0.2		0.1	
CIS-1,3-DIMETHYLCYCLOHEXANE				
TRANS-1,4-DIMETHYLCYCLOHEXANE				
3-ETHYLHEXANE	0.2		0.1	
2,2,5-TRIMETHYLHEXANE	0.4	0.2	0.3	0.1
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE				
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	1.1	0.7	0.9	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	0.5		0.2	
1-OCTENE				
TRANS-4-OCTENE				
OCTANE	0.4		0.2	
UNIDENTIFIED C8	0.2		0.1	
TRANS-2-OCTENE	0.2		0.1	
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C				
CIS-2-OCTENE				
ISOPROPYLCYCLOPENTANE				
2,2-DIMETHYLHEPTANE				
2,3,5-TRIMETHYLHEXANE	0.5		0.2	
CIS-1-METHYL-2-ETHYLCYCLOPENTANE				
2,4-DIMETHYLHEPTANE				
4,4-DIMETHYLHEPTANE				
CIS-1,2-DIMETHYLCYCLOHEXANE				
ETHYLCYCLOHEXANE				

TABLE A-1 (CONT'D). TRANSIENT CYCLE SUMMARY FOR ENGINE-OUT EMISSIONS

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
2,6-DIMETHYLHEPTANE, NOTE D	0.4	0.3	0.3	0.1
1,1,3-TRIMETHYLCYCLOHEXANE				
2,5-DIMETHYLHEPTANE, NOTE E				
3,3-DIMETHYLHEPTANE				
3,5-DIMETHYLHEPTANE, NOTE E				
ETHYLBENZENE	0.5	0.3	0.4	0.1
2,3,4-TRIMETHYLHEXANE				
2,3-DIMETHYLHEPTANE				
m-& p-XYLENE	1.2	0.7	0.9	0.2
4-METHYLOCTANE				
3,4-DIMETHYLHEPTANE				
4-ETHYLHEPTANE				
2-METHYLOCTANE	0.3		0.1	0.1
3-METHYLOCTANE				0.1
STYRENE				
o-XYLENE	0.6	0.4	0.5	0.1
1-NONENE	0.3	0.2	0.3	
TRANS-3-NONENE				
CIS-3-NONENE				
NONANE	0.5	0.4	0.4	
TRANS-2-NONENE				
ISOPROPYLBENZENE (CUMENE)	0.2	0.2	0.2	
2,2-DIMETHYLOCTANE				
2,4-DIMETHYLOCTANE	0.2	0.2	0.2	0.1
n-PROPYLBENZENE	0.2		0.1	
1-METHYL-3-ETHYLBENZENE				
1-METHYL-4-ETHYLBENZENE				
1,3,5-TRIMETHYLBENZENE				
1-METHYL-2-ETHYLBENZENE				
1,2,4-TRIMETHYLBENZENE	0.3	0.3	0.3	0.1
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	0.3	0.3	0.3	0.3
1-METHYL-4-ISOPROPYLBENZENE				
INDAN				0.2
1-METHYL-2-ISOPROPYLBENZENE				0.1
1,3-DIETHYLBENZENE				
1,4-DIETHYLBENZENE	0.3	0.2	0.2	
1-METHYL-3-N-PROPYLBENZENE				
1-METHYL-4-N-PROPYLBENZENE, NOTE G				
1,2 DIETHYLBENZENE	1.7	1.8	1.8	0.5
1-METHYL-2-N-PROPYLBENZENE				0.3

TABLE A-1 (CONT'D). TRANSIENT CYCLE SUMMARY FOR ENGINE-OUT EMISSIONS

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
1,4-DIMETHYL-2-ETHYLBENZENE				
1,3-DIMETHYL-4-ETHYLBENZENE				
1,2-DIMETHYL-4-ETHYLBENZENE		0.6	0.4	0.2
1,3-DIMETHYL-2-ETHYLBENZENE	1.0	0.3	0.6	0.1
UNDECANE	0.4	0.2	0.3	
1,2-DIMETHYL-3-ETHYLBENZENE				
1,2,4,5-TETRAMETHYLBENZENE				
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)				
3,4 DIMETHYLCUMENE				
1,2,3,5-TETRAMETHYLBENZENE	3.8	3.4	3.6	0.8
TERT-1-BUT-2-METHYLBENZENE	0.4	0.2	0.3	0.1
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				0.1
1,2,4-TRIETHYLBENZENE	0.3	0.4	0.3	0.1
HEXYLBENZENE				
UNIDENTIFIED C9-C12+	3.8	1.2	2.3	0.2
FORMALDEHYDE	56.8	40.3	47.4	10.1
ACETALDEHYDE	12.9	18.7	16.2	3.6
ACROLEIN	5.5	0.7	2.8	1.4
ACETONE	4.2	5.9	5.1	1.4
PROPIONALDEHYDE	2.2	3.5	2.9	0.6
CROTONALDEHYDE	1.8	2.6	2.3	0.5
ISOBUTYRALDEHYDE, NOTE H	0.6	0.7	0.7	0.1
METHYL ETHYL KETONE, NOTE H	0.6	0.7	0.7	0.1
BENZALDEHYDE	5.5	6.6	6.1	1.3
ISOVALERALDEHYDE	1.3	0.7	1.0	0.2
VALERALDEHYDE	1.2	0.7	0.9	trace
O-TOLUALDEHYDE	1.2	0.6	0.9	0.3
M/P-TOLUALDEHYDE	4.4	2.7	3.4	0.8
HEXANALDEHYDE	0.1	0.3	0.2	
DIMETHYLBENZALDEHYDE	0.7		0.3	0.2

SUMMED SPECIATION HYDROCARBONS	253.7	202.6	224.6	50.4

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. TRANSIENT CYCLE SUMMARY FOR PLATINUM ONLY (70g/ft^3)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
METHANE	9.5	5.1	7.0	0.6
ETHANE	0.7	0.5	0.6	
ETHYLENE	2.6	0.2	1.2	0.4
PROPANE	3.1	0.1	1.4	trace
PROPYLENE	0.7		0.3	0.1
ACETYLENE				
PROPADIENE	trace	trace	trace	
BUTANE	0.1	0.1	0.1	trace
TRANS-2-BUTENE				
1-BUTENE	0.1		0.1	
2-METHYLPROPENE (ISOBUTYLENE)				
2,2-DIMETHYLPROPANE (NEOPENTANE)				
PROPYNE	0.8	0.7	0.7	0.3
1,3-BUTADIENE	0.2		0.1	
2-METHYLPROPANE (ISOBUTANE)	0.5		0.2	trace
1-BUTYNE				
METHANOL				
CIS-2-BUTENE				
3-METHYL-1-BUTENE				
ETHANOL				
2-METHYLBUTANE (ISOPENTANE)				
2-BUTYNE				
1-PENTENE				
2-METHYL-1-BUTENE				
PENTANE	0.3	trace	0.1	
UNIDENTIFIED C5 OLEFINS				
2-METHYL-1,3-BUTADIENE				
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				
3-METHYL-1-PENTENE				
CYCLOPENTANE				
2,3-DIMETHYLBUTANE		0.2	0.1	
MTBE				
4-METHYL-CIS-2-PENTENE				
2-METHYLPENTANE		trace	trace	trace
4-METHYL-TRANS-2-PENTENE				
3-METHYLPENTANE	0.5	0.7	0.6	0.5
2-METHYL-1-PENTENE				trace
1-HEXENE				trace
HEXANE				

TABLE A-2 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM ONLY ($70g/ft^3$)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
UNIDENTIFIED C6 OLEFINS		0.2	0.1	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	0.2	0.2	0.2	0.1
2,2-DIMETHYLPENTANE, NOTE A				
METHYLCYCLOPENTANE, NOTE A				
2,4-DIMETHYLPENTANE				
2,2,3-TRIMETHYLBUTANE				
3,4-DIMETHYL-1-PENTENE				
1-METHYLCYCLOPENTENE				
BENZENE				0.2
3-METHYL-1-HEXENE				
3,3-DIMETHYLPENTANE	trace		trace	trace
CYCLOHEXANE				
2-METHYLHEXANE				
2,3-DIMETHYLPENTANE	trace		trace	trace
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				trace
2-METHYL-1-HEXENE				
TRANS-3-HEPTENE				
HEPTANE				
CIS-3-HEPTENE				
UNIDENTIFIED C7				
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				
CIS-1,2-DIMETHYLCYCLOPENTANE				

TABLE A-2 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM ONLY (70g/ft^3)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
2,2-DIMETHYLHEXANE				
1,1,3-TRIMETHYLCYCLOPENTANE				
2,4,4-TRIMETHYL-2-PENTENE				
2,2,3-TRIMETHYLPENTANE				
2,5-DIMETHYLHEXANE				
ETHYLCYCLOPENTANE				
2,4-DIMETHYLHEXANE				
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE				
3,3-DIMETHYLHEXANE				
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE				
2,3,4-TRIMETHYLPENTANE				
2,3,3-TRIMETHYLPENTANE				
TOLUENE				0.8
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				
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				
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				

TABLE A-2 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM ONLY (70g/ft^3)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
2,6-DIMETHYLHEPTANE, NOTE D				
1,1,3-TRIMETHYLCYCLOHEXANE				
2,5-DIMETHYLHEPTANE, NOTE E	0.3		0.1	
3,3-DIMETHYLHEPTANE				
3,5-DIMETHYLHEPTANE, NOTE E	0.3		0.1	
ETHYLBENZENE				
2,3,4-TRIMETHYLHEXANE				
2,3-DIMETHYLHEPTANE				
m-& p-XYLENE				
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				
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				

TABLE A-2 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM ONLY (70g/ft^3)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
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	2.5	0.3	1.3	0.7
ACETALDEHYDE	1.1	0.1	0.5	0.2
ACROLEIN				
ACETONE	0.4	1.3	0.9	1.6
PROPIONALDEHYDE	trace	trace	trace	trace
CROTONALDEHYDE	0.1	trace	trace	trace
ISOBUTYRALDEHYDE, NOTE H	0.1		trace	
METHYL ETHYL KETONE, NOTE H	0.1		trace	
BENZALDEHYDE	0.1	trace	trace	trace
ISOVALERALDEHYDE	0.1	trace	trace	
VALERALDEHYDE	0.1	0.2	0.2	0.1
O-TOLUALDEHYDE	0.1		trace	
M/P-TOLUALDEHYDE				
HEXANALDEHYDE				
DIMETHYLBENZALDEHYDE				
SUMMED SPECIATION HYDROCARBONS	24.4	9.7	15.9	5.6

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. TRANSIENT CYCLE SUMMARY FOR 3:1 PLATINUM TO PALLADIUM ($70g/ft^3$)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
METHANE	10.6	7.4	8.8	0.1
ETHANE	3.0	0.7	1.7	0.1
ETHYLENE	6.2	0.5	2.9	1.1
PROPANE		0.2	0.1	
PROPYLENE	1.3	0.1	0.6	0.2
ACETYLENE				
PROPADIENE	trace	trace	trace	trace
BUTANE	0.1	trace	0.1	
TRANS-2-BUTENE	0.1		0.1	
1-BUTENE	0.2		0.1	0.1
2-METHYLPROPENE (ISOBUTYLENE)				0.1
2,2-DIMETHYLPROPANE (NEOPENTANE)				
PROPYNE	0.6	0.1	0.3	0.1
1,3-BUTADIENE	0.3		0.1	
2-METHYLPROPANE (ISOBUTANE)	0.4		0.2	0.1
1-BUTYNE				
METHANOL				
CIS-2-BUTENE				
3-METHYL-1-BUTENE				
ETHANOL				
2-METHYLBUTANE (ISOPENTANE)				
2-BUTYNE				
1-PENTENE				
2-METHYL-1-BUTENE				
PENTANE	0.3	0.1	0.2	
UNIDENTIFIED C5 OLEFINS				
2-METHYL-1,3-BUTADIENE				
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				
3-METHYL-1-PENTENE				
CYCLOPENTANE				
2,3-DIMETHYLBUTANE				
MTBE				
4-METHYL-CIS-2-PENTENE				
2-METHYLPENTANE	0.2	0.2	0.2	0.1
4-METHYL-TRANS-2-PENTENE				
3-METHYLPENTANE	0.3	0.8	0.6	0.3
2-METHYL-1-PENTENE				
1-HEXENE				
HEXANE				

TABLE A-3 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM TO PALLADIUM (70g/ft^3)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
UNIDENTIFIED C6 OLEFINS				0.3
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				0.1
2,2-DIMETHYLPENTANE, NOTE A				
METHYLCYCLOPENTANE, NOTE A				
2,4-DIMETHYLPENTANE				
2,2,3-TRIMETHYLBUTANE				
3,4-DIMETHYL-1-PENTENE				
1-METHYLCYCLOPENTENE				
BENZENE				0.1
3-METHYL-1-HEXENE				
3,3-DIMETHYLPENTANE				
CYCLOHEXANE				
2-METHYLHEXANE				
2,3-DIMETHYLPENTANE				
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				
2-METHYL-1-HEXENE				
TRANS-3-HEPTENE				
HEPTANE				
CIS-3-HEPTENE				
UNIDENTIFIED C7				
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				
CIS-1,2-DIMETHYLCYCLOPENTANE				

TABLE A-3 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM TO PALLADIUM (70g/ft^3)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
2,2-DIMETHYLHEXANE				
1,1,3-TRIMETHYLCYCLOPENTANE				
2,4,4-TRIMETHYL-2-PENTENE				
2,2,3-TRIMETHYLPENTANE				
2,5-DIMETHYLHEXANE				
ETHYLCYCLOPENTANE				
2,4-DIMETHYLHEXANE				
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE				
3,3-DIMETHYLHEXANE				
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE				
2,3,4-TRIMETHYLPENTANE				
2,3,3-TRIMETHYLPENTANE				
TOLUENE				0.5
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				
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				
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				

TABLE A-3 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM TO PALLADIUM (70g/ft^3)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
2,6-DIMETHYLHEPTANE, NOTE D				
1,1,3-TRIMETHYLCYCLOHEXANE				
2,5-DIMETHYLHEPTANE, NOTE E				
3,3-DIMETHYLHEPTANE				
3,5-DIMETHYLHEPTANE, NOTE E				
ETHYLBENZENE				
2,3,4-TRIMETHYLHEXANE				
2,3-DIMETHYLHEPTANE				
m-& p-XYLENE				
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				
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				

TABLE A-3 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM TO PALLADIUM (70g/ft^3)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
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	5.1	0.1	2.3	1.4
ACETALDEHYDE	3.1		1.3	0.5
ACROLEIN	0.1		0.1	0.1
ACETONE	1.4		0.6	0.2
PROPIONALDEHYDE	0.7		0.3	0.1
CROTONALDEHYDE	0.2		0.1	
ISOBUTYRALDEHYDE, NOTE H	0.1		0.1	trace
METHYL ETHYL KETONE, NOTE H	0.1		0.1	trace
BENZALDEHYDE	trace		trace	
ISOVALERALDEHYDE	trace		trace	
VALERALDEHYDE	0.1		0.1	trace
O-TOLUALDEHYDE				
M/P-TOLUALDEHYDE				
HEXANALDEHYDE	trace		trace	
DIMETHYLBENZALDEHYDE				
SUMMED SPECIATION HYDROCARBONS	35	10	21	5

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. TRANSIENT CYCLE SUMMARY FOR PLATINUM ONLY (20g/ft^3)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
METHANE	9.8	1.3	5.0	0.3
ETHANE	6.4	0.4	3.0	trace
ETHYLENE	5.2	0.3	2.4	0.5
PROPANE	0.2		0.1	
PROPYLENE	1.4		0.6	0.2
ACETYLENE				
PROPADIENE				trace
BUTANE	trace	trace	trace	
TRANS-2-BUTENE	0.2		0.1	
1-BUTENE	0.2		0.1	0.1
2-METHYLPROPENE (ISOBUTYLENE)	0.2		0.1	
2,2-DIMETHYLPROPANE (NEOPENTANE)				
PROPYNE	0.3	0.2	0.3	0.2
1,3-BUTADIENE	0.2		0.1	
2-METHYLPROPANE (ISOBUTANE)	0.6		0.2	
1-BUTYNE				
METHANOL				
CIS-2-BUTENE				
3-METHYL-1-BUTENE				
ETHANOL				
2-METHYLBUTANE (ISOPENTANE)				
2-BUTYNE				
1-PENTENE				
2-METHYL-1-BUTENE				
PENTANE	0.4	0.3	0.4	
UNIDENTIFIED C5 OLEFINS				
2-METHYL-1,3-BUTADIENE	0.4		0.2	
TRANS-2-PENTENE	0.6	0.3	0.4	
3,3-DIMETHYL-1-BUTENE				
CIS-2-PENTENE				
2-METHYL-2-BUTENE				
TERT-BUTANOL				
CYCLOPENTADIENE				
2,2-DIMETHYLBUTANE				
CYCLOPENTENE				
4-METHYL-1-PENTENE				
3-METHYL-1-PENTENE				
CYCLOPENTANE				
2,3-DIMETHYLBUTANE				
MTBE				
4-METHYL-CIS-2-PENTENE				
2-METHYLPENTANE				0.1
4-METHYL-TRANS-2-PENTENE				
3-METHYLPENTANE				0.9
2-METHYL-1-PENTENE				
1-HEXENE				
HEXANE		0.2	0.1	

TABLE A-4 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM ONLY ($20g/ft^3$)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
UNIDENTIFIED C6 OLEFINS	0.5	0.9	0.7	
TRANS-3-HEXENE				
CIS-3-HEXENE				
DI-ISOPROPYL ETHER				
TRANS-2-HEXENE				0.1
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				0.1
3-METHYL-1-HEXENE				
3,3-DIMETHYLPENTANE				0.1
CYCLOHEXANE				
2-METHYLHEXANE				
2,3-DIMETHYLPENTANE				
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				trace
2-METHYL-1-HEXENE				
TRANS-3-HEPTENE				
HEPTANE				
CIS-3-HEPTENE				
UNIDENTIFIED C7				
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				
CIS-1,2-DIMETHYLCYCLOPENTANE				

TABLE A-4 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM ONLY ($20g/ft^3$)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
2,2-DIMETHYLHEXANE				
1,1,3-TRIMETHYLCYCLOPENTANE				
2,4,4-TRIMETHYL-2-PENTENE				
2,2,3-TRIMETHYLPENTANE				
2,5-DIMETHYLHEXANE				
ETHYLCYCLOPENTANE				
2,4-DIMETHYLHEXANE				
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE				
3,3-DIMETHYLHEXANE				
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE				
2,3,4-TRIMETHYLPENTANE				
2,3,3-TRIMETHYLPENTANE				
TOLUENE				0.9
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				
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				
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				

TABLE A-4 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM ONLY ($20g/ft^3$)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
2,6-DIMETHYLHEPTANE, NOTE D				
1,1,3-TRIMETHYLCYCLOHEXANE				
2,5-DIMETHYLHEPTANE, NOTE E				
3,3-DIMETHYLHEPTANE				
3,5-DIMETHYLHEPTANE, NOTE E				
ETHYLBENZENE				
2,3,4-TRIMETHYLHEXANE				
2,3-DIMETHYLHEPTANE				
m-& p-XYLENE				
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				
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				

TABLE A-4 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM ONLY ($20g/ft^3$)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
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	5.8	0.6	2.8	1.1
ACETALDEHYDE	3.3	0.3	1.6	0.5
ACROLEIN	0.1		trace	0.1
ACETONE	1.0	0.3	0.6	trace
PROPIONALDEHYDE	0.8	0.1	0.4	0.1
CROTONALDEHYDE	0.2	0.1	0.1	0.1
ISOBUTYRALDEHYDE, NOTE H	0.1	trace	0.1	
METHYL ETHYL KETONE, NOTE H	0.1	trace	0.1	
BENZALDEHYDE	trace		trace	
ISOVALERALDEHYDE	trace		trace	
VALERALDEHYDE	0.2	trace	0.1	
O-TOLUALDEHYDE				
M/P-TOLUALDEHYDE				
HEXANALDEHYDE	trace		trace	
DIMETHYLBENZALDEHYDE				
SUMMED SPECIATION HYDROCARBONS	38	5	19	5

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-5. TRANSIENT CYCLE SUMMARY FOR 3:1 PLATINUM TO PALLADIUM ($20g/ft^3$)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
METHANE	8.6	7.6	8.0	0.1
ETHANE	2.3	0.3	1.1	
ETHYLENE	18.4	1.6	8.8	1.2
PROPANE	0.3	trace	0.2	
PROPYLENE	3.1		1.3	0.2
ACETYLENE				
PROPADIENE				
BUTANE	trace	trace	trace	trace
TRANS-2-BUTENE				
1-BUTENE	0.3		0.1	0.1
2-METHYLPROPENE (ISOBUTYLENE)	0.4		0.2	0.1
2,2-DIMETHYLPROPANE (NEOPENTANE)				
PROPYNE	0.6	0.1	0.3	0.1
1,3-BUTADIENE				
2-METHYLPROPANE (ISOBUTANE)	0.7		0.3	
1-BUTYNE				
METHANOL				
CIS-2-BUTENE				
3-METHYL-1-BUTENE				
ETHANOL				
2-METHYLBUTANE (ISOPENTANE)				
2-BUTYNE				
1-PENTENE				
2-METHYL-1-BUTENE				
PENTANE				
UNIDENTIFIED C5 OLEFINS				
2-METHYL-1,3-BUTADIENE				
TRANS-2-PENTENE	0.7		0.3	
3,3-DIMETHYL-1-BUTENE				
CIS-2-PENTENE				
2-METHYL-2-BUTENE				
TERT-BUTANOL				
CYCLOPENTADIENE				
2,2-DIMETHYLBUTANE				
CYCLOPENTENE				
4-METHYL-1-PENTENE				
3-METHYL-1-PENTENE				
CYCLOPENTANE				
2,3-DIMETHYLBUTANE				
MTBE				
4-METHYL-CIS-2-PENTENE				
2-METHYLPENTANE				
4-METHYL-TRANS-2-PENTENE				
3-METHYLPENTANE				0.4
2-METHYL-1-PENTENE				
1-HEXENE				
HEXANE	1.1	0.2	0.6	

TABLE A-5 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM TO PALLADIUM (20g/ft^3)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
UNIDENTIFIED C6 OLEFINS				
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				
3,4-DIMETHYL-1-PENTENE				
1-METHYLCYCLOPENTENE				
BENZENE				0.1
3-METHYL-1-HEXENE				
3,3-DIMETHYLPENTANE				
CYCLOHEXANE				
2-METHYLHEXANE				
2,3-DIMETHYLPENTANE				
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				0.1
2-METHYL-1-HEXENE				
TRANS-3-HEPTENE				
HEPTANE	trace		trace	0.1
CIS-3-HEPTENE				
UNIDENTIFIED C7				
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				
CIS-1,2-DIMETHYLCYCLOPENTANE				

TABLE A-5 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM TO PALLADIUM (20g/ft^3)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
2,2-DIMETHYLHEXANE				
1,1,3-TRIMETHYLCYCLOPENTANE				
2,4,4-TRIMETHYL-2-PENTENE				
2,2,3-TRIMETHYLPENTANE				
2,5-DIMETHYLHEXANE				
ETHYLCYCLOPENTANE				
2,4-DIMETHYLHEXANE				
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE				
3,3-DIMETHYLHEXANE				
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE				
2,3,4-TRIMETHYLPENTANE				
2,3,3-TRIMETHYLPENTANE				
TOLUENE				0.5
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				
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				
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				

TABLE A-5 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM TO PALLADIUM (20g/ft^3)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
2,6-DIMETHYLHEPTANE, NOTE D				
1,1,3-TRIMETHYLCYCLOHEXANE				
2,5-DIMETHYLHEPTANE, NOTE E				
3,3-DIMETHYLHEPTANE				
3,5-DIMETHYLHEPTANE, NOTE E				
ETHYLBENZENE				
2,3,4-TRIMETHYLHEXANE				
2,3-DIMETHYLHEPTANE				
m-& p-XYLENE				
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				
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				

TABLE A-5 (CONT'D). TRANSIENT CYCLE SUMMARY FOR PLATINUM TO PALLADIUM (20g/ft^3)

COMPOUND	mg/mile			
	Cold	Hot	Composite	USO6
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	8.3	3.1	5.3	2.4
ACETALDEHYDE	4.4	1.1	2.5	0.7
ACROLEIN	0.2	trace	0.1	trace
ACETONE	1.8	0.7	1.2	0.1
PROPIONALDEHYDE	1.1	0.1	0.5	0.2
CROTONALDEHYDE	0.2		0.1	trace
ISOBUTYRALDEHYDE, NOTE H	0.2		0.1	0.1
METHYL ETHYL KETONE, NOTE H	0.2		0.1	0.1
BENZALDEHYDE	trace		0.0	
ISOVALERALDEHYDE	0.1	0.1	0.1	0.2
VALERALDEHYDE	0.1	trace	trace	
O-TOLUALDEHYDE				
M/P-TOLUALDEHYDE				
HEXANALDEHYDE	trace		trace	trace
DIMETHYLBENZALDEHYDE				
SUMMED SPECIATION HYDROCARBONS	53	15	31	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 B

HYDROCARBON SPECIATION DATA FOR STEADY-STATE MODES

TABLE B-1. STEADY-STATE MODE SUMMARY FOR ENGINE-OUT EMISSIONS

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
METHANE	0.2			0.2	0.2
ETHANE	0.1	0.1	0.2	0.1	0.1
ETHYLENE	48.8	22.9	5.8	9.0	6.8
PROPANE	6.6	trace	trace	trace	0.1
PROPYLENE	16.8	8.8	2.5	2.1	1.7
ACETYLENE					
PROPADIENE	trace			trace	
BUTANE	0.3	trace			
TRANS-2-BUTENE	0.6	0.4	0.1	0.1	0.1
1-BUTENE	3.9	2.7	0.8	0.5	0.4
2-METHYLPROPENE (ISOBUTYLENE)	2.8	2.0	0.5	0.4	0.3
2,2-DIMETHYLPROPANE (NEOPENTANE)					
PROPYNE	trace		0.1	trace	0.1
1,3-BUTADIENE	6.7	2.5	0.6	0.8	0.6
2-METHYLPROPANE (ISOBUTANE)	3.4	2.2	0.7	2.5	1.4
1-BUTYNE	0.1	0.1			
METHANOL					
CIS-2-BUTENE		0.3	0.1	0.1	0.1
3-METHYL-1-BUTENE					
ETHANOL					
2-METHYLBUTANE (ISOPENTANE)	0.1	0.3	0.1	0.2	0.1
2-BUTYNE					
1-PENTENE					
2-METHYL-1-BUTENE					
PENTANE	0.1	0.1	0.2	0.2	0.2
UNIDENTIFIED C5 OLEFINS					
2-METHYL-1,3-BUTADIENE	0.3	0.2			
TRANS-2-PENTENE	0.3	0.2		0.1	
3,3-DIMETHYL-1-BUTENE					
CIS-2-PENTENE	0.2	0.1			
2-METHYL-2-BUTENE					
TERT-BUTANOL					
CYCLOPENTADIENE					
2,2-DIMETHYLBUTANE					
CYCLOPENTENE	0.4	0.3	0.1		0.1
4-METHYL-1-PENTENE	0.3	0.5	0.2	0.1	
3-METHYL-1-PENTENE					
CYCLOPENTANE	0.7	0.5	0.1		0.1
2,3-DIMETHYLBUTANE	trace	0.1	trace	0.1	0.1
MTBE					
4-METHYL-CIS-2-PENTENE					
2-METHYLPENTANE	trace	trace			trace
4-METHYL-TRANS-2-PENTENE					
3-METHYLPENTANE	1.9	1.4	0.3	0.5	0.8
2-METHYL-1-PENTENE	1.0	1.1	0.4	0.2	0.1
1-HEXENE	1.0	1.1	0.4	0.2	0.1
HEXANE					

TABLE B-1 (CONT'D). STEADY-STATE MODE SUMMARY FOR ENGINE-OUT EMISSIONS

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
UNIDENTIFIED C6 OLEFINS	0.6	0.6	0.5	0.4	
TRANS-3-HEXENE					
CIS-3-HEXENE					
DI-ISOPROPYL ETHER					
TRANS-2-HEXENE	0.1	0.1	0.1	0.1	
3-METHYL-TRANS-2-PENTENE	0.1	0.1			
2-METHYL-2-PENTENE	0.1	0.1			
3-METHYLCYCLOPENTENE					
CIS-2-HEXENE	0.1	0.1			
ETBE					
3-METHYL-CIS-2-PENTENE					
2,2-DIMETHYLPENTANE, NOTE A					
METHYLCYCLOPENTANE, NOTE A					0.1
2,4-DIMETHYLPENTANE					0.1
2,2,3-TRIMETHYLBUTANE					
3,4-DIMETHYL-1-PENTENE	0.1	0.2			
1-METHYLCYCLOPENTENE					
BENZENE	3.8	1.8	0.5	0.8	0.4
3-METHYL-1-HEXENE					
3,3-DIMETHYLPENTANE	0.1	trace			
CYCLOHEXANE					
2-METHYLHEXANE	0.2	0.1			
2,3-DIMETHYLPENTANE	trace	0.3	0.1	0.2	0.2
1,1-DIMETHYLCYCLOPENTANE					
TERT-AMYL METHYL ETHER					
CYCLOHEXENE					
3-METHYLHEXANE	0.4	0.1	0.1	0.1	
CIS-1,3-DIMETHYLCYCLOPENTANE	0.1	0.4	0.1	0.1	0.1
3-ETHYLPENTANE	0.1	0.3	0.1		
TRANS-1,2-DIMETHYLCYCLOPENTANE					
TRANS-1,3-DIMETHYLCYCLOPENTANE					
1-HEPTENE					
2,2,4-TRIMETHYLPENTANE	1.1	1.4	0.5	0.2	0.1
2-METHYL-1-HEXENE					
TRANS-3-HEPTENE					
HEPTANE	trace	0.1		0.1	
CIS-3-HEPTENE					
UNIDENTIFIED C7	0.3	0.4	0.1		0.1
2-METHYL-2-HEXENE					
3-METHYL-TRANS-3-HEXENE					
TRANS-2-HEPTENE	0.1	0.2	0.1		
3-ETHYL-CIS-2-PENTENE					
2,4,4-TRIMETHYL-1-PENTENE					
2,3-DIMETHYL-2-PENTENE					
CIS-2-HEPTENE		0.1			
METHYLCYCLOHEXANE	0.1	0.4	0.1	0.1	0.1
CIS-1,2-DIMETHYLCYCLOPENTANE					

TABLE B-1 (CONT'D). STEADY-STATE MODE SUMMARY FOR ENGINE-OUT EMISSIONS

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
2,2-DIMETHYLHEXANE					
1,1,3-TRIMETHYLCYCLOPENTANE					
2,4,4-TRIMETHYL-2-PENTENE					
2,2,3-TRIMETHYLPENTANE	0.2	0.6			0.1
2,5-DIMETHYLHEXANE					
ETHYLCYCLOPENTANE					
2,4-DIMETHYLHEXANE	0.5	0.1	0.2	trace	
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE					
3,3-DIMETHYLHEXANE					
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE					
2,3,4-TRIMETHYLPENTANE		0.1	0.1	0.1	0.1
2,3,3-TRIMETHYLPENTANE					
TOLUENE	3.2	2.1	1.0	0.1	0.7
2,3-DIMETHYLHEXANE					
1,1,2-TRIMETHYLCYCLOPENTANE					
2-METHYLHEPTANE					
3,4-DIMETHYLHEXANE, NOTE B		0.2	0.1		
4-METHYLHEPTANE	0.1				
3-METHYLHEPTANE					
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE	0.1				
CIS-1,3-DIMETHYLCYCLOHEXANE					
TRANS-1,4-DIMETHYLCYCLOHEXANE					
3-ETHYLHEXANE	0.1	0.3	0.1	0.1	
2,2,5-TRIMETHYLHEXANE	0.1	0.2	0.1		
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE					
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.3	1.1	0.4	0.2	0.1
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		
1-OCTENE					
TRANS-4-OCTENE	0.7				
OCTANE	0.1	0.2	0.1		
UNIDENTIFIED C8		0.3	0.1		
TRANS-2-OCTENE	0.1	0.2	0.1		
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C					
CIS-2-OCTENE		0.1			
ISOPROPYLCYCLOPENTANE					
2,2-DIMETHYLHEPTANE					
2,3,5-TRIMETHYLHEXANE	0.1	0.1			
CIS-1-METHYL-2-ETHYLCYCLOPENTANE		0.1	0.1		
2,4-DIMETHYLHEPTANE					
4,4-DIMETHYLHEPTANE					
CIS-1,2-DIMETHYLCYCLOHEXANE					
ETHYLCYCLOHEXANE					

TABLE B-1 (CONT'D). STEADY-STATE MODE SUMMARY FOR ENGINE-OUT EMISSIONS

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
2,6-DIMETHYLHEPTANE, NOTE D	0.1	0.3	0.1	0.4	0.5
1,1,3-TRIMETHYLCYCLOHEXANE					
2,5-DIMETHYLHEPTANE, NOTE E					0.2
3,3-DIMETHYLHEPTANE					
3,5-DIMETHYLHEPTANE, NOTE E					0.2
ETHYLBENZENE	0.2	0.3	0.1	0.1	
2,3,4-TRIMETHYLHEXANE					
2,3-DIMETHYLHEPTANE					
m-& p-XYLENE	0.7	0.8	0.3	0.1	
4-METHYLOCTANE					
3,4-DIMETHYLHEPTANE					
4-ETHYLHEPTANE					
2-METHYLOCTANE		0.3	0.1	0.1	
3-METHYLOCTANE	0.1	0.2	0.1	0.1	
STYRENE	0.2	0.3			
o-XYLENE	0.3	0.4	0.1	0.1	
1-NONENE	0.4	0.9	0.3	0.1	
TRANS-3-NONENE					
CIS-3-NONENE					
NONANE	0.1	0.5	0.1	0.1	
TRANS-2-NONENE					
ISOPROPYLBENZENE (CUMENE)		0.1	0.1		0.0
2,2-DIMETHYLOCTANE		0.2			
2,4-DIMETHYLOCTANE	0.1	0.4	0.1	0.1	
n-PROPYLBENZENE	0.1	0.4	0.1		
1-METHYL-3-ETHYLBENZENE		0.6			
1-METHYL-4-ETHYLBENZENE		0.3			
1,3,5-TRIMETHYLBENZENE		0.5			
1-METHYL-2-ETHYLBENZENE		0.3	0.3		
1,2,4-TRIMETHYLBENZENE	0.1	0.6	0.1		
TERT-BUTYLBENZENE					
1-DECENE		1.0	0.2		
DECANE, NOTE F				0.1	
ISOBUTYLBENZENE, NOTE F					
1,3,-DIMETHYL-5-ETHYLBENZENE					
METHYLPROPYLBENZENE (sec butylbenzene)		0.3			
1-METHYL-3-ISOPROPYLBENZENE	0.7	0.9	0.4		0.3
1,2,3-TRIMETHYLBENZENE				0.4	
1-METHYL-4-ISOPROPYLBENZENE		0.5	0.4		
INDAN			0.1	0.2	0.1
1-METHYL-2-ISOPROPYLBENZENE		0.3		0.1	
1,3-DIETHYLBENZENE					
1,4-DIETHYLBENZENE					
1-METHYL-3-N-PROPYLBENZENE					
1-METHYL-4-N-PROPYLBENZENE, NOTE G	0.5	1.3	0.5	0.4	0.5
1,2 DIETHYLBENZENE		0.2		0.5	
1-METHYL-2-N-PROPYLBENZENE		0.4	0.1	0.4	

TABLE B-1 (CONT'D). STEADY-STATE MODE SUMMARY FOR ENGINE-OUT EMISSIONS

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
1,4-DIMETHYL-2-ETHYLBENZENE					
1,3-DIMETHYL-4-ETHYLBENZENE	0.0	1.6	0.5	0.2	0.1
1,2-DIMETHYL-4-ETHYLBENZENE	0.1	0.2	0.1	0.1	
1,3-DIMETHYL-2-ETHYLBENZENE				0.2	0.5
UNDECANE		0.6	0.1	0.1	
1,2-DIMETHYL-3-ETHYLBENZENE		0.1			
1,2,4,5-TETRAMETHYLBENZENE	0.6	3.5	1.9	1.4	0.7
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)					
3,4 DIMETHYLCUMENE					
1,2,3,5-TETRAMETHYLBENZENE					1.0
TERT-1-BUT-2-METHYLBENZENE		0.3	0.1		
1,2,3,4-TETRAMETHYLBENZENE					
N-PENT-BENZENE		0.6			
TERT-1-BUT-3,5-DIMETHYLBENZENE					
TERT-1-BUTYL-4-ETHYLBENZENE					
NAPHTHALENE	trace	trace	0.1	0.1	
DODECANE					0.1
1,3,5-TRIETHYLBENZENE					
1,2,4-TRIETHYLBENZENE					0.1
HEXYLBENZENE					
UNIDENTIFIED C9-C12+	0.6	4.9	1.5	1.9	0.7
FORMALDEHYDE	16.4	25.6	5.6	7.2	7.5
ACETALDEHYDE	11.8	8.0	1.8	2.6	2.7
ACROLEIN	5.2	3.3	0.5	0.8	0.9
ACETONE	2.2	1.8	0.2	0.7	0.8
PROPIONALDEHYDE	0.8	1.2	0.2	0.4	0.4
CROTONALDEHYDE	1.0	0.9	0.2	0.3	0.3
ISOBUTYRALDEHYDE, NOTE H	0.4	0.7	0.2	0.3	0.2
METHYL ETHYL KETONE, NOTE H	0.4	0.7	0.2	0.3	0.2
BENZALDEHYDE	5.1	3.0	0.4	2.0	1.2
ISOVALERALDEHYDE	0.6	2.8		0.4	0.2
VALERALDEHYDE	0.2	3.7			
O-TOLUALDEHYDE	1.2	1.5		trace	0.1
M/P-TOLUALDEHYDE	3.7	11.1		0.2	0.7
HEXANALDEHYDE		trace			
DIMETHYLBENZALDEHYDE	0.5				
SUMMED SPECIATION HYDROCARBONS	163.2	148.5	34.8	42.2	35.8

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. STEADY-STATE MODE SUMMARY FOR PLATINUM ONLY (70g/ft^3)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
METHANE				0.6	0.7
ETHANE	trace	trace		0.1	0.1
ETHYLENE	5.3	2.6	0.4	0.1	6.4
PROPANE	trace	trace		trace	trace
PROPYLENE	2.1	0.8	0.1	trace	1.4
ACETYLENE					
PROPADIENE					
BUTANE	0.1	0.1	0.2	0.2	0.2
TRANS-2-BUTENE	0.1	0.1			0.1
1-BUTENE	0.7	0.3	0.1		0.1
2-METHYLPROPENE (ISOBUTYLENE)	0.5	0.3	0.1		0.1
2,2-DIMETHYLPROPANE (NEOPENTANE)					
PROPYNE	0.1	0.1	0.1	0.1	trace
1,3-BUTADIENE	0.3	0.1			0.1
2-METHYLPROPANE (ISOBUTANE)	0.3	0.2	trace		0.6
1-BUTYNE					
METHANOL					
CIS-2-BUTENE	0.1	trace			trace
3-METHYL-1-BUTENE					
ETHANOL					
2-METHYLBUTANE (ISOPENTANE)	trace	trace			trace
2-BUTYNE					
1-PENTENE					
2-METHYL-1-BUTENE					
PENTANE	0.2	0.2		trace	
UNIDENTIFIED C5 OLEFINS					
2-METHYL-1,3-BUTADIENE	0.1				0.2
TRANS-2-PENTENE	0.1				
3,3-DIMETHYL-1-BUTENE					
CIS-2-PENTENE					
2-METHYL-2-BUTENE					
TERT-BUTANOL					
CYCLOPENTADIENE					
2,2-DIMETHYLBUTANE					
CYCLOPENTENE					
4-METHYL-1-PENTENE	0.1				
3-METHYL-1-PENTENE					
CYCLOPENTANE	0.2	0.1			
2,3-DIMETHYLBUTANE					
MTBE					
4-METHYL-CIS-2-PENTENE					
2-METHYLPENTANE		trace	trace		trace
4-METHYL-TRANS-2-PENTENE					
3-METHYLPENTANE	0.5	0.2	0.1	0.1	0.3
2-METHYL-1-PENTENE	0.3	0.2	trace		
1-HEXENE	0.3	0.2	trace		
HEXANE				trace	trace

TABLE B-2 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM ONLY ($70g/ft^3$)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
UNIDENTIFIED C6 OLEFINS	0.3	0.5	0.2	0.2	
TRANS-3-HEXENE					
CIS-3-HEXENE					
DI-ISOPROPYL ETHER					
TRANS-2-HEXENE	0.1				
3-METHYL-TRANS-2-PENTENE					
2-METHYL-2-PENTENE					
3-METHYLCYCLOPENTENE					
CIS-2-HEXENE					
ETBE					
3-METHYL-CIS-2-PENTENE	0.1			0.1	
2,2-DIMETHYLPENTANE, NOTE A	0.1				
METHYLCYCLOPENTANE, NOTE A					
2,4-DIMETHYLPENTANE					
2,2,3-TRIMETHYLBUTANE					
3,4-DIMETHYL-1-PENTENE	0.1				
1-METHYLCYCLOPENTENE					
BENZENE	0.6	0.3	0.1		0.1
3-METHYL-1-HEXENE					
3,3-DIMETHYLPENTANE			trace		trace
CYCLOHEXANE					
2-METHYLHEXANE	0.1				
2,3-DIMETHYLPENTANE	0.1				
1,1-DIMETHYLCYCLOPENTANE					
TERT-AMYL METHYL ETHER					
CYCLOHEXENE					
3-METHYLHEXANE		0.1			
CIS-1,3-DIMETHYLCYCLOPENTANE	0.1	0.1			
3-ETHYLPENTANE					
TRANS-1,2-DIMETHYLCYCLOPENTANE					
TRANS-1,3-DIMETHYLCYCLOPENTANE					
1-HEPTENE					
2,2,4-TRIMETHYLPENTANE	0.4	0.1	0.1		
2-METHYL-1-HEXENE					
TRANS-3-HEPTENE					
HEPTANE	0.1				
CIS-3-HEPTENE					
UNIDENTIFIED C7	0.1				
2-METHYL-2-HEXENE					
3-METHYL-TRANS-3-HEXENE					
TRANS-2-HEPTENE	0.1				
3-ETHYL-CIS-2-PENTENE					
2,4,4-TRIMETHYL-1-PENTENE					
2,3-DIMETHYL-2-PENTENE					
CIS-2-HEPTENE					
METHYLCYCLOHEXANE	0.1	0.1			
CIS-1,2-DIMETHYLCYCLOPENTANE					

TABLE B-2 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM ONLY ($70g/ft^3$)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
2,2-DIMETHYLHEXANE					
1,1,3-TRIMETHYLCYCLOPENTANE					
2,4,4-TRIMETHYL-2-PENTENE					
2,2,3-TRIMETHYLPENTANE	0.2	0.1			
2,5-DIMETHYLHEXANE					
ETHYLCYCLOPENTANE					
2,4-DIMETHYLHEXANE					
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE					
3,3-DIMETHYLHEXANE					
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE					
2,3,4-TRIMETHYLPENTANE		0.1			
2,3,3-TRIMETHYLPENTANE					
TOLUENE	1.0	0.5	0.5	0.2	
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	0.1				
2,2,5-TRIMETHYLHEXANE	0.1				
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE					
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.3	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					
1-OCTENE					
TRANS-4-OCTENE					
OCTANE		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					

TABLE B-2 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM ONLY ($70g/ft^3$)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
2,6-DIMETHYLHEPTANE, NOTE D	0.1	0.1			
1,1,3-TRIMETHYLCYCLOHEXANE					
2,5-DIMETHYLHEPTANE, NOTE E		trace			
3,3-DIMETHYLHEPTANE					
3,5-DIMETHYLHEPTANE, NOTE E		trace			
ETHYLBENZENE	0.1	0.1			
2,3,4-TRIMETHYLHEXANE					
2,3-DIMETHYLHEPTANE					
m-& p-XYLENE		0.1			
4-METHYLOCTANE					
3,4-DIMETHYLHEPTANE					
4-ETHYLHEPTANE					
2-METHYLOCTANE		0.1			
3-METHYLOCTANE		0.1			
STYRENE					
o-XYLENE		0.1			
1-NONENE					
TRANS-3-NONENE					
CIS-3-NONENE					
NONANE					
TRANS-2-NONENE					
ISOPROPYLBENZENE (CUMENE)		0.1			
2,2-DIMETHYLOCTANE					
2,4-DIMETHYLOCTANE		0.1			
n-PROPYLBENZENE					
1-METHYL-3-ETHYLBENZENE					
1-METHYL-4-ETHYLBENZENE					
1,3,5-TRIMETHYLBENZENE		0.1			
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					
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		0.5			

TABLE B-2 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM ONLY ($70g/ft^3$)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
1,4-DIMETHYL-2-ETHYLBENZENE					
1,3-DIMETHYL-4-ETHYLBENZENE					
1,2-DIMETHYL-4-ETHYLBENZENE		0.1			
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	7.5	5.0	0.7	0.1	7.2
ACETALDEHYDE	1.9	1.4	trace		3.3
ACROLEIN					
ACETONE	2.4	2.4	2.4	2.5	1.9
PROPIONALDEHYDE	0.6	0.4			4.5
CROTONALDEHYDE	0.4	0.4	0.1	trace	0.3
ISOBUTYRALDEHYDE, NOTE H					trace
METHYL ETHYL KETONE, NOTE H					trace
BENZALDEHYDE	0.4	0.1	0.1	0.1	trace
ISOVALERALDEHYDE	0.1				
VALERALDEHYDE	0.3	0.2	0.2	0.3	0.1
O-TOLUALDEHYDE	0.4	0.1			
M/P-TOLUALDEHYDE	0.5				
HEXANALDEHYDE	trace	trace			
DIMETHYLBENZALDEHYDE	0.1				
SUMMED SPECIATION HYDROCARBONS	30.2	18.7	5.3	4.5	27.7

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-3. STEADY-STATE MODE SUMMARY FOR PLATINUM AND PALLADIUM (70g/ft^3)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
METHANE					0.7
ETHANE	trace	0.1	trace	0.1	0.1
ETHYLENE	6.1	3.6	0.6	0.3	6.2
PROPANE	trace	trace		trace	trace
PROPYLENE	2.2	1.0	0.1	trace	0.5
ACETYLENE					
PROPADIENE				trace	trace
BUTANE		trace	trace	trace	trace
TRANS-2-BUTENE	0.1	0.1			
1-BUTENE	0.7	0.3	0.1		trace
2-METHYLPROPENE (ISOBUTYLENE)	0.5	0.3	0.1		
2,2-DIMETHYLPROPANE (NEOPENTANE)					
PROPYNE					
1,3-BUTADIENE	0.3	0.2			
2-METHYLPROPANE (ISOBUTANE)	0.3	0.2			0.6
1-BUTYNE					
METHANOL					
CIS-2-BUTENE	0.1	trace			
3-METHYL-1-BUTENE					
ETHANOL					
2-METHYLBUTANE (ISOPENTANE)	trace				
2-BUTYNE					
1-PENTENE					
2-METHYL-1-BUTENE					
PENTANE	0.1	0.2	0.1	0.1	0.2
UNIDENTIFIED C5 OLEFINS					
2-METHYL-1,3-BUTADIENE					0.1
TRANS-2-PENTENE	0.1				
3,3-DIMETHYL-1-BUTENE					
CIS-2-PENTENE					
2-METHYL-2-BUTENE					
TERT-BUTANOL					
CYCLOPENTADIENE					
2,2-DIMETHYLBUTANE					
CYCLOPENTENE					
4-METHYL-1-PENTENE	0.1	0.1			
3-METHYL-1-PENTENE					
CYCLOPENTANE	0.2	0.2			
2,3-DIMETHYLBUTANE					
MTBE					
4-METHYL-CIS-2-PENTENE					
2-METHYLPENTANE			0.1	0.1	0.1
4-METHYL-TRANS-2-PENTENE					
3-METHYLPENTANE	0.8	0.4	0.2	0.2	0.4
2-METHYL-1-PENTENE	0.3	0.1	trace		
1-HEXENE	0.3	0.1	trace		
HEXANE	trace	trace	trace	0.1	trace

TABLE B-3 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM AND PALLADIUM (70g/ft^3)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
UNIDENTIFIED C6 OLEFINS		0.3	0.2	0.1	0.2
TRANS-3-HEXENE					
CIS-3-HEXENE					
DI-ISOPROPYL ETHER					
TRANS-2-HEXENE	0.1				
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	0.4				
METHYLCYCLOPENTANE, NOTE A					
2,4-DIMETHYLPENTANE					
2,2,3-TRIMETHYLBUTANE					
3,4-DIMETHYL-1-PENTENE					
1-METHYLCYCLOPENTENE					
BENZENE	0.6	0.3	0.1	trace	0.2
3-METHYL-1-HEXENE					
3,3-DIMETHYLPENTANE					0.1
CYCLOHEXANE					
2-METHYLHEXANE					
2,3-DIMETHYLPENTANE	0.1				0.1
1,1-DIMETHYLCYCLOPENTANE					
TERT-AMYL METHYL ETHER					
CYCLOHEXENE					
3-METHYLHEXANE					
CIS-1,3-DIMETHYLCYCLOPENTANE	0.1	0.1			
3-ETHYLPENTANE					
TRANS-1,2-DIMETHYLCYCLOPENTANE					
TRANS-1,3-DIMETHYLCYCLOPENTANE					
1-HEPTENE					
2,2,4-TRIMETHYLPENTANE	0.5	0.3	0.1	0.1	0.1
2-METHYL-1-HEXENE					
TRANS-3-HEPTENE					
HEPTANE					
CIS-3-HEPTENE					
UNIDENTIFIED C7					
2-METHYL-2-HEXENE					
3-METHYL-TRANS-3-HEXENE					
TRANS-2-HEPTENE	0.1				
3-ETHYL-CIS-2-PENTENE					
2,4,4-TRIMETHYL-1-PENTENE					
2,3-DIMETHYL-2-PENTENE					
CIS-2-HEPTENE					
METHYLCYCLOHEXANE	0.1	0.1			
CIS-1,2-DIMETHYLCYCLOPENTANE					

TABLE B-3 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM AND PALLADIUM (70g/ft^3)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
2,2-DIMETHYLHEXANE					
1,1,3-TRIMETHYLCYCLOPENTANE					
2,4,4-TRIMETHYL-2-PENTENE					
2,2,3-TRIMETHYLPENTANE	0.2	0.1			
2,5-DIMETHYLHEXANE					
ETHYLCYCLOPENTANE					
2,4-DIMETHYLHEXANE					
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE					
3,3-DIMETHYLHEXANE					
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE					
2,3,4-TRIMETHYLPENTANE		0.1			
2,3,3-TRIMETHYLPENTANE					
TOLUENE	0.8	0.6	0.5		
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	0.1				
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE					
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.3	0.1			
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	0.1	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					

TABLE B-3 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM AND PALLADIUM (70g/ft^3)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
2,6-DIMETHYLHEPTANE, NOTE D		0.1			
1,1,3-TRIMETHYLCYCLOHEXANE					
2,5-DIMETHYLHEPTANE, NOTE E					
3,3-DIMETHYLHEPTANE					
3,5-DIMETHYLHEPTANE, NOTE E					
ETHYLBENZENE	0.1	0.1			
2,3,4-TRIMETHYLHEXANE					
2,3-DIMETHYLHEPTANE					
m-& p-XYLENE	0.2	0.1			
4-METHYLOCTANE					
3,4-DIMETHYLHEPTANE					
4-ETHYLHEPTANE					
2-METHYLOCTANE		0.1			
3-METHYLOCTANE		0.1			
STYRENE					
o-XYLENE		0.1			
1-NONENE					
TRANS-3-NONENE					
CIS-3-NONENE					
NONANE					
TRANS-2-NONENE					
ISOPROPYLBENZENE (CUMENE)		0.1			
2,2-DIMETHYLOCTANE					
2,4-DIMETHYLOCTANE		0.1			
n-PROPYLBENZENE					
1-METHYL-3-ETHYLBENZENE					
1-METHYL-4-ETHYLBENZENE					
1,3,5-TRIMETHYLBENZENE		0.1			
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					
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					

TABLE B-3 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM AND PALLADIUM (70g/ft^3)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
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	7.4	5.7	1.3	0.7	7.1
ACETALDEHYDE	2.4	2.0	0.4	0.1	3.8
ACROLEIN	0.9	0.8	0.1	trace	0.7
ACETONE	0.5	0.4	0.1		1.1
PROPIONALDEHYDE	1.1	0.8	0.1		1.6
CROTONALDEHYDE	0.4	0.3	0.1	trace	0.1
ISOBUTYRALDEHYDE, NOTE H	0.1	0.1	trace	trace	trace
METHYL ETHYL KETONE, NOTE H	0.1	0.1	trace	trace	trace
BENZALDEHYDE	0.3	0.2			
ISOVALERALDEHYDE	0.1	trace			
VALERALDEHYDE	0.1	0.2	trace	trace	trace
O-TOLUALDEHYDE	0.4	0.3			
M/P-TOLUALDEHYDE	0.8	0.7			
HEXANALDEHYDE	0.1	0.2			
DIMETHYLBENZALDEHYDE		0.1			

SUMMED SPECIATION HYDROCARBONS	30.5	21.5	4.1	1.7	23.9

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. STEADY-STATE MODE SUMMARY FOR PLATINUM ONLY (20g/ft^3)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
METHANE				1.2	0.1
ETHANE	trace	trace	trace	trace	0.3
ETHYLENE	4.8	2.6	0.4	0.1	6.5
PROPANE					
PROPYLENE	1.9	0.8	0.1		1.7
ACETYLENE					
PROPADIENE					trace
BUTANE					
TRANS-2-BUTENE	0.1	0.1			0.1
1-BUTENE	0.6	0.3	trace		0.2
2-METHYLPROPENE (ISOBUTYLENE)	0.5	0.3	trace		0.1
2,2-DIMETHYLPROPANE (NEOPENTANE)					
PROPYNE	0.1	0.1	0.1	trace	0.1
1,3-BUTADIENE	0.3	0.2			0.1
2-METHYLPROPANE (ISOBUTANE)	0.4	0.2			0.9
1-BUTYNE					
METHANOL					
CIS-2-BUTENE	0.1	trace			0.1
3-METHYL-1-BUTENE					
ETHANOL					
2-METHYLBUTANE (ISOPENTANE)	trace				
2-BUTYNE					
1-PENTENE					
2-METHYL-1-BUTENE					
PENTANE	0.1	0.2	0.1		0.1
UNIDENTIFIED C5 OLEFINS					
2-METHYL-1,3-BUTADIENE	0.1	0.2			
TRANS-2-PENTENE	0.1				
3,3-DIMETHYL-1-BUTENE					
CIS-2-PENTENE					
2-METHYL-2-BUTENE					
TERT-BUTANOL					
CYCLOPENTADIENE					
2,2-DIMETHYLBUTANE					
CYCLOPENTENE					
4-METHYL-1-PENTENE					
3-METHYL-1-PENTENE					
CYCLOPENTANE	0.1	0.1			
2,3-DIMETHYLBUTANE	0.1				
MTBE					
4-METHYL-CIS-2-PENTENE					
2-METHYLPENTANE			0.1		0.1
4-METHYL-TRANS-2-PENTENE					
3-METHYLPENTANE	0.4	0.3	0.1	0.4	0.3
2-METHYL-1-PENTENE	0.3	0.2	trace		0.1
1-HEXENE	0.3	0.2	trace		0.1
HEXANE	0.5	trace	trace	0.1	

TABLE B-4 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM ONLY ($20g/ft^3$)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
UNIDENTIFIED C6 OLEFINS		0.4			
TRANS-3-HEXENE					
CIS-3-HEXENE					
DI-ISOPROPYL ETHER					
TRANS-2-HEXENE	0.1				
3-METHYL-TRANS-2-PENTENE					
2-METHYL-2-PENTENE					
3-METHYLCYCLOPENTENE	0.1				
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	0.5	0.3	trace		0.2
3-METHYL-1-HEXENE					
3,3-DIMETHYLPENTANE	0.1		0.1		0.1
CYCLOHEXANE					
2-METHYLHEXANE					
2,3-DIMETHYLPENTANE	0.1			0.1	
1,1-DIMETHYLCYCLOPENTANE					
TERT-AMYL METHYL ETHER					
CYCLOHEXENE					
3-METHYLHEXANE	0.1				
CIS-1,3-DIMETHYLCYCLOPENTANE		0.1			
3-ETHYLPENTANE					
TRANS-1,2-DIMETHYLCYCLOPENTANE					
TRANS-1,3-DIMETHYLCYCLOPENTANE					
1-HEPTENE					
2,2,4-TRIMETHYLPENTANE	0.3	0.1			
2-METHYL-1-HEXENE					
TRANS-3-HEPTENE					
HEPTANE					
CIS-3-HEPTENE					
UNIDENTIFIED C7	0.1				
2-METHYL-2-HEXENE					
3-METHYL-TRANS-3-HEXENE					
TRANS-2-HEPTENE	trace				
3-ETHYL-CIS-2-PENTENE					
2,4,4-TRIMETHYL-1-PENTENE					
2,3-DIMETHYL-2-PENTENE					
CIS-2-HEPTENE					
METHYLCYCLOHEXANE	0.1	0.1			
CIS-1,2-DIMETHYLCYCLOPENTANE					

TABLE B-4 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM ONLY ($20g/ft^3$)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
2,2-DIMETHYLHEXANE					
1,1,3-TRIMETHYLCYCLOPENTANE					
2,4,4-TRIMETHYL-2-PENTENE					
2,2,3-TRIMETHYLPENTANE	0.1	0.1			
2,5-DIMETHYLHEXANE					
ETHYLCYCLOPENTANE					
2,4-DIMETHYLHEXANE					
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE					
3,3-DIMETHYLHEXANE					
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE					
2,3,4-TRIMETHYLPENTANE					
2,3,3-TRIMETHYLPENTANE					
TOLUENE	1.1	0.8	0.6		
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	0.1				
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE					
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.3	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					
1-OCTENE					
TRANS-4-OCTENE					
OCTANE	0.1	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					

TABLE B-4 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM ONLY ($20g/ft^3$)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
2,6-DIMETHYLHEPTANE, NOTE D		0.1			
1,1,3-TRIMETHYLCYCLOHEXANE					
2,5-DIMETHYLHEPTANE, NOTE E					
3,3-DIMETHYLHEPTANE					
3,5-DIMETHYLHEPTANE, NOTE E					
ETHYLBENZENE	0.2	0.1			
2,3,4-TRIMETHYLHEXANE					
2,3-DIMETHYLHEPTANE					
m-& p-XYLENE	0.2	0.1			
4-METHYLOCTANE					
3,4-DIMETHYLHEPTANE					
4-ETHYLHEPTANE					
2-METHYLOCTANE		0.1			
3-METHYLOCTANE		0.1			
STYRENE					
o-XYLENE					
1-NONENE					
TRANS-3-NONENE					
CIS-3-NONENE					
NONANE					
TRANS-2-NONENE					
ISOPROPYLBENZENE (CUMENE)		0.1			
2,2-DIMETHYLOCTANE		0.1			
2,4-DIMETHYLOCTANE		0.1			
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					
1-METHYL-4-ISOPROPYLBENZENE					
INDAN					
1-METHYL-2-ISOPROPYLBENZENE					
1,3-DIETHYLBENZENE					
1,4-DIETHYLBENZENE		0.2			
1-METHYL-3-N-PROPYLBENZENE					
1-METHYL-4-N-PROPYLBENZENE, NOTE G					
1,2 DIETHYLBENZENE					
1-METHYL-2-N-PROPYLBENZENE					

TABLE B-4 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM ONLY ($20g/ft^3$)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
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	9.0	5.5	1.4	0.4	8.6
ACETALDEHYDE	2.7	2.1	0.3	0.1	4.0
ACROLEIN	0.7	0.5	0.1	trace	0.5
ACETONE					0.9
PROPIONALDEHYDE	0.6	0.4	0.1	trace	1.3
CROTONALDEHYDE	0.3	0.3	0.1	trace	0.1
ISOBUTYRALDEHYDE, NOTE H	trace	0.1			0.1
METHYL ETHYL KETONE, NOTE H	trace	0.1			0.1
BENZALDEHYDE	0.4	trace	0.2		
ISOVALERALDEHYDE	0.1	0.1	trace	0.1	
VALERALDEHYDE	0.1	0.1	0.4	0.1	trace
O-TOLUALDEHYDE	0.4				
M/P-TOLUALDEHYDE	0.7		0.1		
HEXANALDEHYDE	0.2	0.1	trace		
DIMETHYLBENZALDEHYDE	0.1				
SUMMED SPECIATION HYDROCARBONS	29.2	17.8	4.2	2.6	26.6

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-5. STEADY-STATE MODE SUMMARY FOR PLATINUM AND PALLADIUM (20g/ft^3)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
METHANE				1.8	
ETHANE	0.1	0.1	trace	0.1	0.1
ETHYLENE	6.2	3.9	0.8	0.4	5.9
PROPANE					trace
PROPYLENE	1.9	0.8	0.1		0.5
ACETYLENE					
PROPADIENE				trace	
BUTANE					
TRANS-2-BUTENE	0.1	0.1			
1-BUTENE	0.6	0.3	trace		trace
2-METHYLPROPENE (ISOBUTYLENE)	0.5	0.2	0.1		
2,2-DIMETHYLPROPANE (NEOPENTANE)					
PROPYNE	trace	trace	0.1	trace	
1,3-BUTADIENE	0.2	0.1			
2-METHYLPROPANE (ISOBUTANE)	0.3	0.2			0.3
1-BUTYNE					
METHANOL					
CIS-2-BUTENE	0.1	trace			
3-METHYL-1-BUTENE					
ETHANOL					
2-METHYLBUTANE (ISOPENTANE)					
2-BUTYNE					
1-PENTENE					
2-METHYL-1-BUTENE					
PENTANE	0.1	0.2			0.2
UNIDENTIFIED C5 OLEFINS					
2-METHYL-1,3-BUTADIENE		0.1	0.1		0.1
TRANS-2-PENTENE					
3,3-DIMETHYL-1-BUTENE					
CIS-2-PENTENE					
2-METHYL-2-BUTENE					
TERT-BUTANOL					
CYCLOPENTADIENE					
2,2-DIMETHYLBUTANE					
CYCLOPENTENE		0.1			
4-METHYL-1-PENTENE					
3-METHYL-1-PENTENE					
CYCLOPENTANE	0.1	0.1			
2,3-DIMETHYLBUTANE	0.2	0.1			
MTBE					
4-METHYL-CIS-2-PENTENE					
2-METHYLPENTANE					
4-METHYL-TRANS-2-PENTENE					
3-METHYLPENTANE	0.2	0.2	0.2	0.6	0.1
2-METHYL-1-PENTENE	0.3	0.1			
1-HEXENE	0.3	0.1			
HEXANE		0.3	0.1		

TABLE B-5 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM AND PALLADIUM (20g/ft^3)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
UNIDENTIFIED C6 OLEFINS		0.1			0.1
TRANS-3-HEXENE					
CIS-3-HEXENE					
DI-ISOPROPYL ETHER					
TRANS-2-HEXENE					0.1
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	0.5	0.3	0.1	0.2	0.2
3-METHYL-1-HEXENE					
3,3-DIMETHYLPENTANE					
CYCLOHEXANE					
2-METHYLHEXANE					
2,3-DIMETHYLPENTANE	0.1				
1,1-DIMETHYLCYCLOPENTANE					
TERT-AMYL METHYL ETHER					
CYCLOHEXENE					
3-METHYLHEXANE	0.1				
CIS-1,3-DIMETHYLCYCLOPENTANE	0.1	0.1			
3-ETHYLPENTANE					
TRANS-1,2-DIMETHYLCYCLOPENTANE					
TRANS-1,3-DIMETHYLCYCLOPENTANE					
1-HEPTENE					
2,2,4-TRIMETHYLPENTANE					
2-METHYL-1-HEXENE					
TRANS-3-HEPTENE					
HEPTANE	0.4	0.2	trace		
CIS-3-HEPTENE					
UNIDENTIFIED C7	0.1				
2-METHYL-2-HEXENE					
3-METHYL-TRANS-3-HEXENE					
TRANS-2-HEPTENE	0.1				
3-ETHYL-CIS-2-PENTENE					
2,4,4-TRIMETHYL-1-PENTENE					
2,3-DIMETHYL-2-PENTENE					
CIS-2-HEPTENE					
METHYLCYCLOHEXANE	0.1	0.1			
CIS-1,2-DIMETHYLCYCLOPENTANE					

TABLE B-5 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM AND PALLADIUM (20g/ft^3)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
2,2-DIMETHYLHEXANE					
1,1,3-TRIMETHYLCYCLOPENTANE					
2,4,4-TRIMETHYL-2-PENTENE					
2,2,3-TRIMETHYLPENTANE	0.1	0.1			
2,5-DIMETHYLHEXANE					
ETHYLCYCLOPENTANE					
2,4-DIMETHYLHEXANE					
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE					
3,3-DIMETHYLHEXANE					
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE					
2,3,4-TRIMETHYLPENTANE					
2,3,3-TRIMETHYLPENTANE					
TOLUENE	0.6	0.5	0.5		
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	0.1				
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE					
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.2	0.1			
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	0.1	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					

TABLE B-5 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM AND PALLADIUM (20g/ft^3)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
2,6-DIMETHYLHEPTANE, NOTE D					
1,1,3-TRIMETHYLCYCLOHEXANE					
2,5-DIMETHYLHEPTANE, NOTE E					
3,3-DIMETHYLHEPTANE					
3,5-DIMETHYLHEPTANE, NOTE E					
ETHYLBENZENE		0.1			
2,3,4-TRIMETHYLHEXANE					
2,3-DIMETHYLHEPTANE					
m-& p-XYLENE		0.1			
4-METHYLOCTANE					
3,4-DIMETHYLHEPTANE					
4-ETHYLHEPTANE					
2-METHYLOCTANE		0.1			
3-METHYLOCTANE					
STYRENE					
o-XYLENE					
1-NONENE					
TRANS-3-NONENE					
CIS-3-NONENE					
NONANE		0.1			
TRANS-2-NONENE					
ISOPROPYLBENZENE (CUMENE)					
2,2-DIMETHYLOCTANE		0.1			
2,4-DIMETHYLOCTANE					
n-PROPYLBENZENE					
1-METHYL-3-ETHYLBENZENE		0.1			
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		0.2			
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		0.1			
1,2 DIETHYLBENZENE					
1-METHYL-2-N-PROPYLBENZENE					

TABLE B-5 (CONT'D). STEADY-STATE MODE SUMMARY FOR PLATINUM AND PALLADIUM (20g/ft^3)

COMPOUND	mg/min				
	3000/75	3000/50	1800/50	1800/25	Idle
1,4-DIMETHYL-2-ETHYLBENZENE					
1,3-DIMETHYL-4-ETHYLBENZENE					
1,2-DIMETHYL-4-ETHYLBENZENE					
1,3-DIMETHYL-2-ETHYLBENZENE					
UNDECANE		0.1			
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	7.6				
ACETALDEHYDE	2.1				
ACROLEIN	0.8				
ACETONE					
PROPIONALDEHYDE	0.3				
CROTONALDEHYDE	0.4				
ISOBUTYRALDEHYDE, NOTE H	trace			trace	
METHYL ETHYL KETONE, NOTE H	trace			trace	
BENZALDEHYDE	0.3				
ISOVALERALDEHYDE	0.4	0.2	0.2	0.2	trace
VALERALDEHYDE	0.1				
O-TOLUALDEHYDE	0.5				
M/P-TOLUALDEHYDE	1.0				
HEXANALDEHYDE	0.2				
DIMETHYLBENZALDEHYDE	0.1				
SUMMED SPECIATION HYDROCARBONS	27.5	9.4	2.0	3.3	7.6

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

SUMMARY OF HYDROCARBON PERCENT REDUCTION FOR COLD UDDS, HOT UDDS, US06, AND STEADY-STATE MODES 1 THROUGH 5

TABLE C-1. COLD UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
METHANE	9.0	9.5	(6.1)	10.6	(18.2)	9.8	(8.8)	8.6	4.3
ETHANE	0.8	0.7	6.5	3.0	(286.0)	6.4	(734.2)	2.3	(198.3)
ETHYLENE	55.7	2.6	95.4	6.2	88.9	5.2	90.6	18.4	66.9
PROPANE	1.9	3.1	(61.8)		100.0	0.2	91.8	0.3	83.9
PROPYLENE	14.9	0.7	95.6	1.3	91.3	1.4	90.4	3.1	79.4
ACETYLENE									
PROPADIENE	10.1	trace	DECREASE	trace	DECREASE		100.0		100.0
BUTANE	0.1	0.1	44.4	0.1	(6.4)	trace	DECREASE	trace	DECREASE
TRANS-2-BUTENE	0.6		100.0	0.1	78.9	0.2	71.0		100.0
1-BUTENE	3.8	0.1	96.1	0.2	95.4	0.2	94.7	0.3	91.4
2-METHYLPROPENE (ISOBUTYLENE)	2.4		100.0		100.0	0.2	92.6	0.4	83.8
2,2-DIMETHYLPROPANE (NEOPENTANE)									
PROPYNE	0.2	0.8	(424.0)	0.6	(276.9)	0.3	(107.0)	0.6	(297.4)
1,3-BUTADIENE	6.2	0.2	97.2	0.3	95.7	0.2	96.9		100.0
2-METHYLPROPANE (ISOBUTANE)	0.6	0.5	30.2	0.4	37.9	0.6	12.4	0.7	(9.6)
1-BUTYNE									
METHANOL									
CIS-2-BUTENE	0.4		100.0		100.0		100.0		100.0
3-METHYL-1-BUTENE									
ETHANOL									
2-METHYLBUTANE (ISOPENTANE)	1.2		100.0		100.0		100.0		100.0
2-BUTYNE									
1-PENTENE									
2-METHYL-1-BUTENE									
PENTANE	1.6	0.3	79.1	0.3	79.8	0.4	74.6		100.0
UNIDENTIFIED C5 OLEFINS									
2-METHYL-1,3-BUTADIENE	0.3		100.0		100.0	0.4	(32.6)		100.0
TRANS-2-PENTENE	1.0		100.0		100.0	0.6	42.3	0.7	32.6
3,3-DIMETHYL-1-BUTENE	0.3		100.0		100.0		100.0		100.0
CIS-2-PENTENE									
2-METHYL-2-BUTENE	0.2		100.0		100.0		100.0		100.0
TERT-BUTANOL									
CYCLOPENTADIENE	0.5		100.0		100.0		100.0		100.0
2,2-DIMETHYLBUTANE	1.0		100.0		100.0		100.0		100.0
CYCLOPENTENE	0.3		100.0		100.0		100.0		100.0
4-METHYL-1-PENTENE									
3-METHYL-1-PENTENE									

TABLE C-1 (CONT'D). COLD UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
CYCLOPENTANE	0.7		100.0		100.0		100.0		100.0
2,3-DIMETHYLBUTANE	0.1		100.0		100.0		100.0		100.0
MTBE									
4-METHYL-CIS-2-PENTENE									
2-METHYLPENTANE				0.2	INCREASE				
4-METHYL-TRANS-2-PENTENE									
3-METHYLPENTANE	2.5	0.5	78.8	0.3	86.2		100.0		100.0
2-METHYL-1-PENTENE	1.4		100.0		100.0		100.0		100.0
1-HEXENE	1.4		100.0		100.0		100.0		100.0
HEXANE								1.1	INCREASE
UNIDENTIFIED C6 OLEFINS	0.8		100.0		100.0	0.5	38.3		100.0
TRANS-3-HEXENE									
CIS-3-HEXENE									
DI-ISOPROPYL ETHER									
TRANS-2-HEXENE	0.2		100.0		100.0		100.0		100.0
3-METHYL-TRANS-2-PENTENE									
2-METHYL-2-PENTENE									
3-METHYLCYCLOPENTENE									
CIS-2-HEXENE									
ETBE									
3-METHYL-CIS-2-PENTENE	trace	0.2	INCREASE		100.0		100.0		100.0
2,2-DIMETHYLPENTANE, NOTE A	0.2		100.0		100.0		100.0		100.0
METHYLCYCLOPENTANE, NOTE A									
2,4-DIMETHYLPENTANE									
2,2,3-TRIMETHYLBUTANE									
3,4-DIMETHYL-1-PENTENE	0.5		100.0		100.0		100.0		100.0
1-METHYLCYCLOPENTENE									
BENZENE	4.6		100.0		100.0		100.0		100.0
3-METHYL-1-HEXENE									
3,3-DIMETHYLPENTANE	0.4	trace	DECREASE		100.0		100.0		100.0
CYCLOHEXANE									
2-METHYLHEXANE	0.3		100.0		100.0		100.0		100.0
2,3-DIMETHYLPENTANE	0.5	trace	DECREASE		100.0		100.0		100.0
1,1-DIMETHYLCYCLOPENTANE									
TERT-AMYL METHYL ETHER									
CYCLOHEXENE									
3-METHYLHEXANE	0.4		100.0		100.0		100.0		100.0

TABLE C-1 (CONT'D). COLD UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
CIS-1,3-DIMETHYLCYCLOPENTANE	0.5		100.0		100.0		100.0		100.0
3-ETHYLPENTANE									
TRANS-1,2-DIMETHYLCYCLOPENTANE									
TRANS-1,3-DIMETHYLCYCLOPENTANE									
1-HEPTENE									
2,2,4-TRIMETHYLPENTANE									
2-METHYL-1-HEXENE									
TRANS-3-HEPTENE	0.2		100.0		100.0		100.0		100.0
HEPTANE	1.5		100.0		100.0		100.0	trace	DECREASE
CIS-3-HEPTENE									
UNIDENTIFIED C7	0.7		100.0		100.0		100.0		100.0
2-METHYL-2-HEXENE									
3-METHYL-TRANS-3-HEXENE									
TRANS-2-HEPTENE	0.2		100.0		100.0		100.0		100.0
3-ETHYL-CIS-2-PENTENE									
2,4,4-TRIMETHYL-1-PENTENE									
2,3-DIMETHYL-2-PENTENE									
CIS-2-HEPTENE									
METHYLCYCLOHEXANE	0.2		100.0		100.0		100.0		100.0
CIS-1,2-DIMETHYLCYCLOPENTANE									
2,2-DIMETHYLHEXANE									
1,1,3-TRIMETHYLCYCLOPENTANE									
2,4,4-TRIMETHYL-2-PENTENE									
2,2,3-TRIMETHYLPENTANE	0.5		100.0		100.0		100.0		100.0
2,5-DIMETHYLHEXANE									
ETHYLCYCLOPENTANE									
2,4-DIMETHYLHEXANE									
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE									
3,3-DIMETHYLHEXANE									
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE									
2,3,4-TRIMETHYLPENTANE	0.4		100.0		100.0		100.0		100.0
2,3,3-TRIMETHYLPENTANE									
TOLUENE	2.9		100.0		100.0		100.0		100.0
2,3-DIMETHYLHEXANE									
1,1,2-TRIMETHYLCYCLOPENTANE									
2-METHYLHEPTANE	0.2		100.0		100.0		100.0		100.0
3,4-DIMETHYLHEXANE, NOTE B									

TABLE C-1 (CONT'D). COLD UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
4-METHYLHEPTANE									
3-METHYLHEPTANE									
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE	0.2		100.0		100.0		100.0		100.0
CIS-1,3-DIMETHYLCYCLOHEXANE									
TRANS-1,4-DIMETHYLCYCLOHEXANE									
3-ETHYLHEXANE	0.2		100.0		100.0		100.0		100.0
2,2,5-TRIMETHYLHEXANE	0.4		100.0		100.0		100.0		100.0
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE									
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	1.1		100.0		100.0		100.0		100.0
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	0.5		100.0		100.0		100.0		100.0
1-OCTENE									
TRANS-4-OCTENE									
OCTANE	0.4		100.0		100.0		100.0		100.0
UNIDENTIFIED C8	0.2		100.0		100.0		100.0		100.0
TRANS-2-OCTENE	0.2		100.0		100.0		100.0		100.0
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C									
CIS-2-OCTENE									
ISOPROPYLCYCLOPENTANE									
2,2-DIMETHYLHEPTANE									
2,3,5-TRIMETHYLHEXANE	0.5		100.0		100.0		100.0		100.0
CIS-1-METHYL-2-ETHYLCYCLOPENTANE									
2,4-DIMETHYLHEPTANE									
4,4-DIMETHYLHEPTANE									
CIS-1,2-DIMETHYLCYCLOHEXANE									
ETHYLCYCLOHEXANE									
2,6-DIMETHYLHEPTANE, NOTE D	0.4		100.0		100.0		100.0		100.0
1,1,3-TRIMETHYLCYCLOHEXANE									
2,5-DIMETHYLHEPTANE, NOTE E		0.3							
3,3-DIMETHYLHEPTANE									
3,5-DIMETHYLHEPTANE, NOTE E		0.3							
ETHYLBENZENE	0.5		100.0		100.0		100.0		100.0
2,3,4-TRIMETHYLHEXANE									

TABLE C-1 (CONT'D). COLD UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
2,3-DIMETHYLHEPTANE									
m-& p-XYLENE	1.2		100.0		100.0		100.0		100.0
4-METHYLOCTANE									
3,4-DIMETHYLHEPTANE									
4-ETHYLHEPTANE									
2-METHYLOCTANE	0.3		100.0		100.0		100.0		100.0
3-METHYLOCTANE									
STYRENE									
o-XYLENE	0.6		100.0		100.0		100.0		100.0
1-NONENE	0.3		100.0		100.0		100.0		100.0
TRANS-3-NONENE									
CIS-3-NONENE									
NONANE	0.5		100.0		100.0		100.0		100.0
TRANS-2-NONENE									
ISOPROPYLBENZENE (CUMENE)	0.2		100.0		100.0		100.0		100.0
2,2-DIMETHYLOCTANE									
2,4-DIMETHYLOCTANE	0.2		100.0		100.0		100.0		100.0
n-PROPYLBENZENE	0.2		100.0		100.0		100.0		100.0
1-METHYL-3-ETHYLBENZENE									
1-METHYL-4-ETHYLBENZENE									
1,3,5-TRIMETHYLBENZENE									
1-METHYL-2-ETHYLBENZENE									
1,2,4-TRIMETHYLBENZENE	0.3		100.0		100.0		100.0		100.0
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	0.3		100.0		100.0		100.0		100.0
1-METHYL-4-ISOPROPYLBENZENE									
INDAN									
1-METHYL-2-ISOPROPYLBENZENE									
1,3-DIETHYLBENZENE									
1,4-DIETHYLBENZENE	0.3		100.0		100.0		100.0		100.0
1-METHYL-3-N-PROPYLBENZENE									

TABLE C-1 (CONT'D). COLD UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
1-METHYL-4-N-PROPYLBENZENE, NOTE G									
1,2 DIETHYLBENZENE	1.7		100.0		100.0		100.0		100.0
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	1.0		100.0		100.0		100.0		100.0
UNDECANE	0.4		100.0		100.0		100.0		100.0
1,2-DIMETHYL-3-ETHYLBENZENE									
1,2,4,5-TETRAMETHYLBENZENE									
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)									
3,4 DIMETHYLCUMENE									
1,2,3,5-TETRAMETHYLBENZENE	3.8		100.0		100.0		100.0		100.0
TERT-1-BUT-2-METHYLBENZENE	0.4		100.0		100.0		100.0		100.0
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	0.3		100.0		100.0		100.0		100.0
HEXYLBENZENE									
UNIDENTIFIED C9-C12+	3.8		100.0		100.0		100.0		100.0
FORMALDEHYDE	56.8	2.5	95.5	5.1	91.0	5.8	89.8	8.3	85.4
ACETALDEHYDE	12.9	1.1	91.5	3.1	76.2	3.3	74.8	4.4	65.8
ACROLEIN	5.5		100.0	0.1	97.4	0.1	98.1	0.2	96.6
ACETONE	4.2	0.4	90.7	1.4	67.3	1.0	75.6	1.8	57.8
PROPIONALDEHYDE	2.2	trace	DECREASE	0.7	68.7	0.8	62.9	1.1	50.6
CROTONALDEHYDE	1.8	0.1	94.3	0.2	91.6	0.2	91.4	0.2	88.3
ISOBUTYRALDEHYDE, NOTE H	0.6	0.1	91.0	0.1	81.3	0.1	79.0	0.2	70.1
METHYL ETHYL KETONE, NOTE H	0.6	0.1	91.0	0.1	81.3	0.1	79.0	0.2	70.1
BENZALDEHYDE	5.5	0.1	99.0	trace	DECREASE	trace	DECREASE	trace	DECREASE
ISOVALERALDEHYDE	1.3	0.1	95.0	trace	DECREASE	trace	DECREASE	0.1	93.0
VALERALDEHYDE	1.2	0.1	89.5	0.1	89.5	0.2	86.1	0.1	95.3
O-TOLUALDEHYDE	1.2	0.1	95.4		100.0		100.0		100.0
M/P-TOLUALDEHYDE	4.4		100.0		100.0		100.0		100.0

TABLE C-1 (CONT'D). COLD UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
HEXANALDEHYDE	0.1		100.0	trace	DECREASE	trace	DECREASE	trace	DECREASE
DIMETHYLBENZALDEHYDE	0.7		DECREASE		DECREASE		DECREASE		DECREASE
DIMETHYLTETRALINS	0.0		DECREASE		DECREASE		DECREASE		DECREASE
DIMETHYLNAPHTHALENES									
TRIMETHYLTETRALINS	trace	trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
N-HEXYLBENZENE								trace	INCREASE
METHYLTETRALINS								0.2	INCREASE
2-METHYLNAPHTHALENE									
1-METHYLNAPHTHALENE									
BIPHENYL									
N-DOCOSANE								0.7	INCREASE
N-TRICOSANE								0.8	INCREASE
N-TETRACOSANE						trace	INCREASE	1.0	INCREASE
N-PENTACOSANE						0.1	INCREASE	1.2	INCREASE
N-EICOSANE		0.2	INCREASE	0.1	INCREASE	trace	INCREASE	0.8	INCREASE
N-HENEICOSANE	trace		DECREASE		DECREASE		DECREASE		DECREASE
N-HEPTADECANE									
N-HEXADECANE									
TETRALIN									
C5 BENZENE									
AMYLBENZENE	trace		DECREASE		DECREASE		DECREASE		DECREASE
N-NONADECANE									
N-OCTADECANE	trace	trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
N-PETADECANE								trace	INCREASE
PHENANTHRENE								trace	INCREASE
PYRENE									
N-TETRADECANE									
N-TRIDECANE									
N-METHYLDECALIN								0.1	INCREASE

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 C-2. HOT UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
METHANE	8.7	5.1	41.5	7.4	15.4	1.3	84.7	7.6	12.7
ETHANE	0.4	0.5	(19.7)	0.7	(82.5)	0.4	6.4	0.3	34.9
ETHYLENE	42.6	0.2	99.6	0.5	98.8	0.3	99.3	1.6	96.3
PROPANE	0.2	0.1	44.0	0.2	4.4		100.0	trace	DECREASE
PROPYLENE	11.4		100.0	0.1	98.9		100.0		100.0
ACETYLENE									
PROPADIENE	7.7	trace	DECREASE	trace	DECREASE		100.0		100.0
BUTANE	trace	0.1	INCREASE	trace		trace		trace	
TRANS-2-BUTENE	0.4		100.0		100.0		100.0		100.0
1-BUTENE	2.9		100.0		100.0		100.0		100.0
2-METHYLPROPENE (ISOBUTYLENE)	1.8		100.0		100.0		100.0		100.0
2,2-DIMETHYLPROPANE (NEOPENTANE)									
PROPYNE	0.4	0.7	(62.1)	0.1	66.1	0.2	45.2	0.1	71.6
1,3-BUTADIENE	5.0		100.0		100.0		100.0		100.0
2-METHYLPROPANE (ISOBUTANE)	0.6		100.0		100.0		100.0		100.0
1-BUTYNE									
METHANOL									
CIS-2-BUTENE	0.3		100.0		100.0		100.0		100.0
3-METHYL-1-BUTENE									
ETHANOL									
2-METHYLBUTANE (ISOPENTANE)	1.0		100.0		100.0		100.0		100.0
2-BUTYNE									
1-PENTENE									
2-METHYL-1-BUTENE									
PENTANE	1.3	trace	DECREASE	0.1	95.8	0.3	73.3		100.0
UNIDENTIFIED C5 OLEFINS									
2-METHYL-1,3-BUTADIENE	0.4		100.0		100.0		100.0		100.0
TRANS-2-PENTENE	0.7		100.0		100.0	0.3	62.9		100.0
3,3-DIMETHYL-1-BUTENE	0.3		100.0		100.0		100.0		100.0
CIS-2-PENTENE									
2-METHYL-2-BUTENE	0.3		100.0		100.0		100.0		100.0
TERT-BUTANOL									
CYCLOPENTADIENE	0.3		100.0		100.0		100.0		100.0
2,2-DIMETHYLBUTANE	0.6		100.0		100.0		100.0		100.0
CYCLOPENTENE	0.2		100.0		100.0		100.0		100.0
4-METHYL-1-PENTENE									
3-METHYL-1-PENTENE									

TABLE C-2 (CONT'D). HOT UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
CYCLOPENTANE	0.6		100.0		100.0		100.0		100.0
2,3-DIMETHYLBUTANE	0.5	0.2	63.7		100.0		100.0		100.0
MTBE									
4-METHYL-CIS-2-PENTENE									
2-METHYLPENTANE		trace	INCREASE	0.2	INCREASE				
4-METHYL-TRANS-2-PENTENE									
3-METHYLPENTANE	1.9	0.7	62.8	0.8	56.8		100.0		100.0
2-METHYL-1-PENTENE	0.9		100.0		100.0		100.0		100.0
1-HEXENE	0.9		100.0		100.0		100.0		100.0
HEXANE						0.2		0.2	
UNIDENTIFIED C6 OLEFINS	0.5	0.2	64.8		100.0	0.9	(84.4)		100.0
TRANS-3-HEXENE									
CIS-3-HEXENE									
DI-ISOPROPYL ETHER									
TRANS-2-HEXENE	0.2		100.0		100.0		100.0		100.0
3-METHYL-TRANS-2-PENTENE									
2-METHYL-2-PENTENE									
3-METHYLCYCLOPENTENE									
CIS-2-HEXENE									
ETBE									
3-METHYL-CIS-2-PENTENE	trace	0.2	INCREASE		100.0		100.0		100.0
2,2-DIMETHYLPENTANE, NOTE A	0.2		100.0		100.0		100.0		100.0
METHYLCYCLOPENTANE, NOTE A									
2,4-DIMETHYLPENTANE									
2,2,3-TRIMETHYLBUTANE									
3,4-DIMETHYL-1-PENTENE	0.3		100.0		100.0		100.0		100.0
1-METHYLCYCLOPENTENE									
BENZENE	4.0		100.0		100.0		100.0		100.0
3-METHYL-1-HEXENE									
3,3-DIMETHYLPENTANE	0.3		100.0		100.0		100.0		100.0
CYCLOHEXANE									
2-METHYLHEXANE	0.3		100.0		100.0		100.0		100.0
2,3-DIMETHYLPENTANE	0.4		100.0		100.0		100.0		100.0
1,1-DIMETHYLCYCLOPENTANE									
TERT-AMYL METHYL ETHER									
CYCLOHEXENE									
3-METHYLHEXANE	0.4		100.0		100.0		100.0		100.0

TABLE C-2 (CONT'D). HOT UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
CIS-1,3-DIMETHYLCYCLOPENTANE	0.4		100.0		100.0		100.0		100.0
3-ETHYLPENTANE									
TRANS-1,2-DIMETHYLCYCLOPENTANE									
TRANS-1,3-DIMETHYLCYCLOPENTANE									
1-HEPTENE									
2,2,4-TRIMETHYLPENTANE									
2-METHYL-1-HEXENE									
TRANS-3-HEPTENE	0.2		100.0		100.0		100.0		100.0
HEPTANE	1.3		100.0		100.0		100.0		100.0
CIS-3-HEPTENE									
UNIDENTIFIED C7	0.5		100.0		100.0		100.0		100.0
2-METHYL-2-HEXENE									
3-METHYL-TRANS-3-HEXENE									
TRANS-2-HEPTENE	0.2		100.0		100.0		100.0		100.0
3-ETHYL-CIS-2-PENTENE									
2,4,4-TRIMETHYL-1-PENTENE									
2,3-DIMETHYL-2-PENTENE									
CIS-2-HEPTENE									
METHYLCYCLOHEXANE	0.2		100.0		100.0		100.0		100.0
CIS-1,2-DIMETHYLCYCLOPENTANE									
2,2-DIMETHYLHEXANE									
1,1,3-TRIMETHYLCYCLOPENTANE									
2,4,4-TRIMETHYL-2-PENTENE									
2,2,3-TRIMETHYLPENTANE	0.4		100.0		100.0		100.0		100.0
2,5-DIMETHYLHEXANE									
ETHYLCYCLOPENTANE									
2,4-DIMETHYLHEXANE									
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE									
3,3-DIMETHYLHEXANE									
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE									
2,3,4-TRIMETHYLPENTANE	0.2		100.0		100.0		100.0		100.0
2,3,3-TRIMETHYLPENTANE									
TOLUENE	3.2		100.0		100.0		100.0		100.0
2,3-DIMETHYLHEXANE									
1,1,2-TRIMETHYLCYCLOPENTANE									
2-METHYLHEPTANE									
3,4-DIMETHYLHEXANE, NOTE B									

TABLE C-2 (CONT'D). HOT UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
4-METHYLHEPTANE									
3-METHYLHEPTANE									
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE									
CIS-1,3-DIMETHYLCYCLOHEXANE									
TRANS-1,4-DIMETHYLCYCLOHEXANE									
3-ETHYLHEXANE									
2,2,5-TRIMETHYLHEXANE	0.2		100.0		100.0		100.0		100.0
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE									
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.7		100.0		100.0		100.0		100.0
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									
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	0.3		100.0		100.0		100.0		100.0
1,1,3-TRIMETHYLCYCLOHEXANE									
2,5-DIMETHYLHEPTANE, NOTE E									
3,3-DIMETHYLHEPTANE									
3,5-DIMETHYLHEPTANE, NOTE E									
ETHYLBENZENE	0.3		100.0		100.0		100.0		100.0
2,3,4-TRIMETHYLHEXANE									

TABLE C-2 (CONT'D). HOT UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
2,3-DIMETHYLHEPTANE									
m-& p-XYLENE	0.7		100.0		100.0		100.0		100.0
4-METHYLOCTANE									
3,4-DIMETHYLHEPTANE									
4-ETHYLHEPTANE									
2-METHYLOCTANE									
3-METHYLOCTANE									
STYRENE									
o-XYLENE	0.4		100.0		100.0		100.0		100.0
1-NONENE	0.2		100.0		100.0		100.0		100.0
TRANS-3-NONENE									
CIS-3-NONENE									
NONANE	0.4		100.0		100.0		100.0		100.0
TRANS-2-NONENE									
ISOPROPYLBENZENE (CUMENE)	0.2		100.0		100.0		100.0		100.0
2,2-DIMETHYLOCTANE									
2,4-DIMETHYLOCTANE	0.2		100.0		100.0		100.0		100.0
n-PROPYLBENZENE									
1-METHYL-3-ETHYLBENZENE									
1-METHYL-4-ETHYLBENZENE									
1,3,5-TRIMETHYLBENZENE									
1-METHYL-2-ETHYLBENZENE									
1,2,4-TRIMETHYLBENZENE	0.3		100.0		100.0		100.0		100.0
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	0.3		100.0		100.0		100.0		100.0
1-METHYL-4-ISOPROPYLBENZENE									
INDAN									
1-METHYL-2-ISOPROPYLBENZENE									
1,3-DIETHYLBENZENE									
1,4-DIETHYLBENZENE	0.2		100.0		100.0		100.0		100.0
1-METHYL-3-N-PROPYLBENZENE									

TABLE C-2 (CONT'D). HOT UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
1-METHYL-4-N-PROPYLBENZENE, NOTE G									
1,2 DIETHYLBENZENE	1.8		100.0		100.0		100.0		100.0
1-METHYL-2-N-PROPYLBENZENE									
1,4-DIMETHYL-2-ETHYLBENZENE									
1,3-DIMETHYL-4-ETHYLBENZENE									
1,2-DIMETHYL-4-ETHYLBENZENE	0.6		100.0		100.0		100.0		100.0
1,3-DIMETHYL-2-ETHYLBENZENE	0.3		100.0		100.0		100.0		100.0
UNDECANE	0.2		100.0		100.0		100.0		100.0
1,2-DIMETHYL-3-ETHYLBENZENE									
1,2,4,5-TETRAMETHYLBENZENE									
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)									
3,4 DIMETHYLCUMENE									
1,2,3,5-TETRAMETHYLBENZENE	3.4		100.0		100.0		100.0		100.0
TERT-1-BUT-2-METHYLBENZENE	0.2		100.0		100.0		100.0		100.0
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	0.4		100.0		100.0		100.0		100.0
HEXYLBENZENE									
UNIDENTIFIED C9-C12+	1.2		100.0		100.0		100.0		100.0
FORMALDEHYDE	40.3	0.3	99.2	0.1	99.6	0.6	98.4	3.1	92.3
ACETALDEHYDE	18.7	0.1	99.7		100.0	0.3	98.5	1.1	94.3
ACROLEIN	0.7		100.0		100.0		100.0	0.0	96.3
ACETONE	5.9	1.3	77.6		100.0	0.3	94.8	0.7	87.2
PROPIONALDEHYDE	3.5	trace	DECREASE		100.0	0.1	95.7	0.1	97.6
CROTONALDEHYDE	2.6	trace	DECREASE		100.0	0.1	97.9		100.0
ISOBUTYRALDEHYDE, NOTE H	0.7		100.0		100.0	trace	DECREASE		100.0
METHYL ETHYL KETONE, NOTE H	0.7		100.0		100.0	trace	DECREASE		100.0
BENZALDEHYDE	6.6	trace	DECREASE		100.0		100.0		100.0
ISOVALERALDEHYDE	0.7	trace	DECREASE		100.0		100.0	0.1	92.8
VALERALDEHYDE	0.7	0.2	75.0		100.0	trace	DECREASE	trace	DECREASE
O-TOLUALDEHYDE	0.6		100.0		100.0		100.0		100.0
M/P-TOLUALDEHYDE	2.7		100.0		100.0		100.0		100.0

TABLE C-2 (CONT'D). HOT UDDS CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
HEXANALDEHYDE	0.3		100.0		100.0		100.0		100.0
DIMETHYLBENZALDEHYDE									
DIMETHYLTETRALINS									
DIMETHYLNAPHTHALENES									
TRIMETHYLTETRALINS	trace	trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
N-HEXYLBENZENE									
METHYLTETRALINS								0.3	INCREASE
2-METHYLNAPHTHALENE									
1-METHYLNAPHTHALENE									
BIPHENYL									
N-DOCOSANE									
N-TRICOSANE						trace	INCREASE		
N-TETRACOSANE						0.1	INCREASE		
N-PENTACOSANE						0.1	INCREASE		
N-EICOSANE		0.2	INCREASE	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE
N-HENEICOSANE	trace		DECREASE		DECREASE		DECREASE		DECREASE
N-HEPTADECANE									
N-HEXADECANE									
TETRALIN									
C5 BENZENE									
AMYLBENZENE									
N-NONADECANE									
N-OCTADECANE	trace	trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
N-PETADECANE									
PHENANTHRENE								trace	INCREASE
PYRENE									
N-TETRADECANE									
N-TRIDECANE									
1-METHYLDECALIN									

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 C-3. US06 CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
METHANE		0.6	INCREASE	0.1	INCREASE	0.3	INCREASE	0.1	INCREASE
ETHANE				0.1	INCREASE	trace	INCREASE		
ETHYLENE	10.6	0.4	96.6	1.1	89.9	0.5	95.1	1.2	88.2
PROPANE		trace	INCREASE						
PROPYLENE	3.3	0.1	96.2	0.2	94.1	0.2	95.1	0.2	95.2
ACETYLENE									
PROPADIENE				trace	INCREASE	trace	INCREASE		
BUTANE		trace	INCREASE					trace	INCREASE
TRANS-2-BUTENE	0.1		100.0		100.0		100.0		100.0
1-BUTENE	0.9		100.0	0.1	93.2	0.1	94.1	0.1	94.0
2-METHYLPROPENE (ISOBUTYLENE)	0.7		100.0	0.1	91.2		100.0	0.1	91.5
2,2-DIMETHYLPROPANE (NEOPENTANE)									
PROPYNE	0.2	0.3	(77.7)	0.1	46.4	0.2	(4.0)	0.1	31.1
1,3-BUTADIENE	1.1		100.0		100.0		100.0		100.0
2-METHYLPROPANE (ISOBUTANE)	1.8	trace	DECREASE	0.1	97.0		100.0		100.0
1-BUTYNE									
METHANOL									
CIS-2-BUTENE	0.1		100.0		100.0		100.0		100.0
3-METHYL-1-BUTENE									
ETHANOL									
2-METHYLBUTANE (ISOPENTANE)	0.2		100.0		100.0		100.0		100.0
2-BUTYNE									
1-PENTENE									
2-METHYL-1-BUTENE									
PENTANE	0.1		100.0		100.0		100.0		100.0
UNIDENTIFIED C5 OLEFINS									
2-METHYL-1,3-BUTADIENE	trace		100.0		100.0		100.0		100.0
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		100.0		100.0		100.0		100.0
3-METHYL-1-PENTENE									

TABLE C-3 (CONT'D). US06 CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
CYCLOPENTANE									
2,3-DIMETHYLBUTANE									
MTBE									
4-METHYL-CIS-2-PENTENE									
2-METHYLPENTANE		trace	INCREASE	0.1	INCREASE	0.1	INCREASE		
4-METHYL-TRANS-2-PENTENE									
3-METHYLPENTANE	1.0	0.5	50.3	0.3	68.1	0.9	11.8	0.4	60.0
2-METHYL-1-PENTENE	0.4	trace	DECREASE		100.0		100.0		100.0
1-HEXENE	0.4	trace	DECREASE		100.0		100.0		100.0
HEXANE	trace		100.0		100.0		100.0		100.0
UNIDENTIFIED C6 OLEFINS	0.5	0.1	81.8	0.3	45.3		100.0		100.0
TRANS-3-HEXENE									
CIS-3-HEXENE									
DI-ISOPROPYL ETHER									
TRANS-2-HEXENE	0.1		100.0		100.0	0.1	(37.9)		100.0
3-METHYL-TRANS-2-PENTENE									
2-METHYL-2-PENTENE									
3-METHYLCYCLOPENTENE									
CIS-2-HEXENE									
ETBE									
3-METHYL-CIS-2-PENTENE		0.1	INCREASE	0.1	INCREASE				
2,2-DIMETHYLPENTANE, NOTE A	0.1		100.0		100.0		100.0		100.0
METHYLCYCLOPENTANE, NOTE A									
2,4-DIMETHYLPENTANE									
2,2,3-TRIMETHYLBUTANE									
3,4-DIMETHYL-1-PENTENE									
1-METHYLCYCLOPENTENE									
BENZENE	1.1	0.2	85.3	0.1	87.5	0.1	90.6	0.1	91.9
3-METHYL-1-HEXENE									
3,3-DIMETHYLPENTANE	0.2	trace	DECREASE		100.0	0.1	11.3		100.0
CYCLOHEXANE									
2-METHYLHEXANE									
2,3-DIMETHYLPENTANE	0.2	trace	DECREASE		100.0		100.0		100.0
1,1-DIMETHYLCYCLOPENTANE									
TERT-AMYL METHYL ETHER									
CYCLOHEXENE									
3-METHYLHEXANE	0.1		100.0		100.0		100.0		100.0

TABLE C-3 (CONT'D). US06 CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
CIS-1,3-DIMETHYLCYCLOPENTANE	0.1		100.0		100.0		100.0		100.0
3-ETHYLPENTANE									
TRANS-1,2-DIMETHYLCYCLOPENTANE									
TRANS-1,3-DIMETHYLCYCLOPENTANE									
1-HEPTENE									
2,2,4-TRIMETHYLPENTANE	0.4	trace	DECREASE		100.0	trace	DECREASE	0.1	63.6
2-METHYL-1-HEXENE									
TRANS-3-HEPTENE									
HEPTANE								0.1	
CIS-3-HEPTENE									
UNIDENTIFIED C7	0.1		100.0		100.0		100.0		100.0
2-METHYL-2-HEXENE									
3-METHYL-TRANS-3-HEXENE									
TRANS-2-HEPTENE	0.1		100.0		100.0		100.0		100.0
3-ETHYL-CIS-2-PENTENE									
2,4,4-TRIMETHYL-1-PENTENE									
2,3-DIMETHYL-2-PENTENE									
CIS-2-HEPTENE									
METHYLCYCLOHEXANE	0.1		100.0		100.0		100.0		100.0
CIS-1,2-DIMETHYLCYCLOPENTANE									
2,2-DIMETHYLHEXANE									
1,1,3-TRIMETHYLCYCLOPENTANE									
2,4,4-TRIMETHYL-2-PENTENE									
2,2,3-TRIMETHYLPENTANE	0.2		100.0		100.0		100.0		100.0
2,5-DIMETHYLHEXANE									
ETHYLCYCLOPENTANE									
2,4-DIMETHYLHEXANE									
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE									
3,3-DIMETHYLHEXANE									
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE									
2,3,4-TRIMETHYLPENTANE	0.2		100.0		100.0		100.0		100.0
2,3,3-TRIMETHYLPENTANE									
TOLUENE	1.4	0.8	42.4	0.5	64.8	0.9	35.6	0.5	63.7
2,3-DIMETHYLHEXANE									
1,1,2-TRIMETHYLCYCLOPENTANE									
2-METHYLHEPTANE									
3,4-DIMETHYLHEXANE, NOTE B									

TABLE C-3 (CONT'D). US06 CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
4-METHYLHEPTANE									
3-METHYLHEPTANE									
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE									
CIS-1,3-DIMETHYLCYCLOHEXANE									
TRANS-1,4-DIMETHYLCYCLOHEXANE									
3-ETHYLHEXANE									
2,2,5-TRIMETHYLHEXANE	0.1		100.0		100.0		100.0		100.0
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE									
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.3		100.0		100.0		100.0		100.0
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									
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	0.1		100.0		100.0		100.0		100.0
1,1,3-TRIMETHYLCYCLOHEXANE									
2,5-DIMETHYLHEPTANE, NOTE E									
3,3-DIMETHYLHEPTANE									
3,5-DIMETHYLHEPTANE, NOTE E									
ETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
2,3,4-TRIMETHYLHEXANE									

TABLE C-3 (CONT'D). US06 CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
2,3-DIMETHYLHEPTANE									
m-& p-XYLENE	0.2		100.0		100.0		100.0		100.0
4-METHYLOCTANE									
3,4-DIMETHYLHEPTANE									
4-ETHYLHEPTANE									
2-METHYLOCTANE	0.1		100.0		100.0		100.0		100.0
3-METHYLOCTANE	0.1		100.0		100.0		100.0		100.0
STYRENE									
o-XYLENE	0.1		100.0		100.0		100.0		100.0
1-NONENE									
TRANS-3-NONENE									
CIS-3-NONENE									
NONANE									
TRANS-2-NONENE									
ISOPROPYLBENZENE (CUMENE)									
2,2-DIMETHYLOCTANE									
2,4-DIMETHYLOCTANE	0.1		100.0		100.0		100.0		100.0
n-PROPYLBENZENE									
1-METHYL-3-ETHYLBENZENE									
1-METHYL-4-ETHYLBENZENE									
1,3,5-TRIMETHYLBENZENE									
1-METHYL-2-ETHYLBENZENE									
1,2,4-TRIMETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
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	0.3		100.0		100.0		100.0		100.0
1-METHYL-4-ISOPROPYLBENZENE									
INDAN	0.2		100.0		100.0		100.0		100.0
1-METHYL-2-ISOPROPYLBENZENE	0.1		100.0		100.0		100.0		100.0
1,3-DIETHYLBENZENE									
1,4-DIETHYLBENZENE									
1-METHYL-3-N-PROPYLBENZENE									

TABLE C-3 (CONT'D). US06 CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
1-METHYL-4-N-PROPYLBENZENE, NOTE G									
1,2 DIETHYLBENZENE	0.5		100.0		100.0		100.0		100.0
1-METHYL-2-N-PROPYLBENZENE	0.3		100.0		100.0		100.0		100.0
1,4-DIMETHYL-2-ETHYLBENZENE									
1,3-DIMETHYL-4-ETHYLBENZENE									
1,2-DIMETHYL-4-ETHYLBENZENE	0.2		100.0		100.0		100.0		100.0
1,3-DIMETHYL-2-ETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
UNDECANE									
1,2-DIMETHYL-3-ETHYLBENZENE									
1,2,4,5-TETRAMETHYLBENZENE									
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)									
3,4 DIMETHYLCUMENE									
1,2,3,5-TETRAMETHYLBENZENE	0.8		100.0		100.0		100.0		100.0
TERT-1-BUT-2-METHYLBENZENE	0.1		100.0		100.0		100.0		100.0
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	0.1		100.0		100.0		100.0		100.0
1,2,4-TRIETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
HEXYLBENZENE									
UNIDENTIFIED C9-C12+	0.2		100.0		100.0		100.0		100.0
FORMALDEHYDE	10.1	0.7	93.5	1.4	86.5	1.1	88.7	2.4	75.9
ACETALDEHYDE	3.6	0.2	95.0	0.5	86.1	0.5	87.0	0.7	79.6
ACROLEIN	1.4		100.0	0.1	94.2	0.1	95.3	trace	DECREASE
ACETONE	1.4	1.6	(19.6)	0.2	88.6	trace	DECREASE	0.1	89.6
PROPIONALDEHYDE	0.6	trace	DECREASE	0.1	80.9	0.1	75.1	0.2	65.5
CROTONALDEHYDE	0.5	trace	DECREASE		100.0	0.1	87.5	trace	DECREASE
ISOBUTYRALDEHYDE, NOTE H	0.1		100.0	trace	DECREASE		100.0	0.1	53.3
METHYL ETHYL KETONE, NOTE H	0.1		100.0	trace	DECREASE		100.0	0.1	53.3
BENZALDEHYDE	1.3	trace	DECREASE		100.0		100.0		100.0
ISOVALERALDEHYDE	0.2		100.0		100.0		100.0	0.2	7.7
VALERALDEHYDE	trace	0.1	INCREASE	trace			100.0		100.0
O-TOLUALDEHYDE	0.3		100.0		100.0		100.0		100.0
M/P-TOLUALDEHYDE	0.8		100.0		100.0		100.0		100.0

TABLE C-3 (CONT'D). US06 CYCLE SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/mi	Pt Only (75 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/mi	% Reduction	Pt Only (20 g/ft3) mg/mi	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/mi	% Reduction
HEXANALDEHYDE								trace	INCREASE
DIMETHYLBENZALDEHYDE	0.2		100.0		100.0		100.0		100.0
Dimethyltetralins						trace	INCREASE		
Dimethylnaphthalenes						trace	INCREASE		
Trimethyltetralins	trace	trace	DECREASE	trace	DECREASE	trace	INCREASE	trace	INCREASE
N-HEXYLBENZENE		trace	INCREASE					trace	INCREASE
METHYLTETRALINS						0.1	INCREASE	0.3	INCREASE
2-METHYLNAPHTHALENE									
1-METHYLNAPHTHALENE									
BIPHENYL		trace	INCREASE						
N-DOCOSANE		trace	INCREASE	trace	INCREASE	trace	INCREASE		
N-TRICOSANE		trace	INCREASE	trace	INCREASE	0.1	INCREASE		
N-TETRACOSANE		trace	INCREASE	0.1	INCREASE	0.2	INCREASE		
N-PENTACOSANE		0.1	INCREASE	0.2	INCREASE	0.4	INCREASE		
N-EICOSANE		0.1	INCREASE	0.1	INCREASE	trace	INCREASE	trace	INCREASE
N-HENEICOSANE		trace	INCREASE	trace	INCREASE		INCREASE	trace	INCREASE
N-HEPTADECANE									
N-HEXADECANE		0.1	INCREASE	0.1	INCREASE	0.2	INCREASE	trace	INCREASE
TETRALIN	trace		DECREASE		DECREASE	trace	INCREASE		DECREASE
C5 BENZENE		0.1				0.2	INCREASE	2.1	INCREASE
AMYLBENZENE	trace		DECREASE		DECREASE	trace	INCREASE		DECREASE
N-NONADECANE	trace	trace	INCREASE		DECREASE	trace	INCREASE	trace	INCREASE
N-OCTADECANE		0.1	INCREASE			0.1	INCREASE	trace	INCREASE
N-PETADECANE		0.1	INCREASE			0.1	INCREASE	trace	INCREASE
PHENANTHRENE									
PYRENE		trace	INCREASE						
N-TETRADECANE		0.4	INCREASE			0.3	INCREASE		
N-TRIDECANE		0.1	INCREASE			0.1	INCREASE	trace	INCREASE
1-METHYLDECALIN						trace	INCREASE		

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 C-4. MODE 1 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
METHANE	0.2		100.0		100.0		100.0		100.0
ETHANE	0.1	trace	DECREASE	trace	DECREASE	trace	DECREASE	0.1	(13.1)
ETHYLENE	48.8	5.3	89.2	6.1	87.5	4.8	90.2	6.2	87.3
PROPANE	6.6	trace	DECREASE	trace	DECREASE		100.0		100.0
PROPYLENE	16.8	2.1	87.8	2.2	86.9	1.9	88.7	1.9	88.4
ACETYLENE									
PROPADIENE	trace		100.0		100.0		100.0		100.0
BUTANE	0.3	0.1	53.8		100.0		100.0		100.0
TRANS-2-BUTENE	0.6	0.1	78.0	0.1	77.4	0.1	81.0	0.1	79.4
1-BUTENE	3.9	0.7	82.5	0.7	81.1	0.6	83.8	0.6	83.6
2-METHYLPROPENE (ISOBUTYLENE)	2.8	0.5	81.3	0.5	81.0	0.5	82.9	0.5	82.9
2,2-DIMETHYLPROPANE (NEOPENTANE)									
PROPYNE	trace	0.1	INCREASE		100.0	0.1	INCREASE	trace	
1,3-BUTADIENE	6.7	0.3	95.0	0.3	95.8	0.3	94.8	0.2	96.7
2-METHYLPROPANE (ISOBUTANE)	3.4	0.3	89.9	0.3	89.7	0.4	89.6	0.3	90.3
1-BUTYNE	0.1		100.0		100.0		100.0		100.0
METHANOL									
CIS-2-BUTENE		0.1	INCREASE	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE
3-METHYL-1-BUTENE									
ETHANOL									
2-METHYLBUTANE (ISOPENTANE)	0.1	trace	DECREASE	trace	DECREASE	trace	DECREASE		100.0
2-BUTYNE									
1-PENTENE									
2-METHYL-1-BUTENE									
PENTANE	0.1	0.2	(86.9)	0.1	38.8	0.1	23.2	0.1	(8.7)
UNIDENTIFIED C5 OLEFINS									
2-METHYL-1,3-BUTADIENE	0.3	0.1	80.4		100.0	0.1	74.9		100.0
TRANS-2-PENTENE	0.3	0.1	75.9	0.1	81.5	0.1	78.6		100.0
3,3-DIMETHYL-1-BUTENE									
CIS-2-PENTENE	0.2		100.0		100.0		100.0		100.0
2-METHYL-2-BUTENE									
TERT-BUTANOL									
CYCLOPENTADIENE									
2,2-DIMETHYLBUTANE									
CYCLOPENTENE	0.4		100.0		100.0		100.0		100.0
4-METHYL-1-PENTENE	0.3	0.1	57.5	0.1	53.7		100.0		100.0
3-METHYL-1-PENTENE									

TABLE C-4 (CONT'D). MODE 1 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
CYCLOPENTANE	0.7	0.2	69.6	0.2	67.2	0.1	79.2	0.1	82.2
2,3-DIMETHYLBUTANE	trace		100.0		100.0	0.1	INCREASE	0.2	INCREASE
MTBE									
4-METHYL-CIS-2-PENTENE									
2-METHYLPENTANE	trace		100.0		100.0		100.0		100.0
4-METHYL-TRANS-2-PENTENE									
3-METHYLPENTANE	1.9	0.5	71.3	0.8	56.9	0.4	81.0	0.2	91.8
2-METHYL-1-PENTENE	1.0	0.3	66.3	0.3	68.9	0.3	71.3	0.3	72.7
1-HEXENE	1.0	0.3	66.3	0.3	68.9	0.3	71.3	0.3	72.7
HEXANE				trace	INCREASE	0.5	INCREASE		
UNIDENTIFIED C6 OLEFINS	0.6	0.3	36.8		100.0		100.0		100.0
TRANS-3-HEXENE									
CIS-3-HEXENE									
DI-ISOPROPYL ETHER									
TRANS-2-HEXENE	0.1	0.1	(7.1)	0.1	(2.5)	0.1	(76.6)		100.0
3-METHYL-TRANS-2-PENTENE	0.1		100.0		100.0		100.0		100.0
2-METHYL-2-PENTENE	0.1		100.0		100.0		100.0		100.0
3-METHYLCYCLOPENTENE						0.1	INCREASE		
CIS-2-HEXENE	0.1		100.0		100.0		100.0		100.0
ETBE									
3-METHYL-CIS-2-PENTENE		0.1	INCREASE						
2,2-DIMETHYLPENTANE, NOTE A		0.1	INCREASE	0.4	INCREASE				
METHYLCYCLOPENTANE, NOTE A									
2,4-DIMETHYLPENTANE									
2,2,3-TRIMETHYLBUTANE									
3,4-DIMETHYL-1-PENTENE	0.1	0.1	(69.3)		100.0		100.0		100.0
1-METHYLCYCLOPENTENE									
BENZENE	3.8	0.6	84.5	0.6	85.3	0.5	87.5	0.5	85.9
3-METHYL-1-HEXENE									
3,3-DIMETHYLPENTANE	0.1		100.0		100.0	0.1	31.3		100.0
CYCLOHEXANE									
2-METHYLHEXANE	0.2	0.1	60.6		100.0		100.0		100.0
2,3-DIMETHYLPENTANE	trace	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE
1,1-DIMETHYLCYCLOPENTANE									
TERT-AMYL METHYL ETHER									
CYCLOHEXENE									
3-METHYLHEXANE	0.4		100.0		100.0	0.1	84.5	0.1	81.7

TABLE C-4 (CONT'D). MODE 1 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
CIS-1,3-DIMETHYLCYCLOPENTANE	0.1	0.1	42.9	0.1	42.5		100.0	0.1	44.6
3-ETHYLPENTANE	0.1		100.0		100.0		100.0		100.0
TRANS-1,2-DIMETHYLCYCLOPENTANE									
TRANS-1,3-DIMETHYLCYCLOPENTANE									
1-HEPTENE									
2,2,4-TRIMETHYLPENTANE	1.1	0.4	64.1	0.5	53.9	0.3	68.5		100.0
2-METHYL-1-HEXENE									
TRANS-3-HEPTENE									
HEPTANE	trace	0.1	INCREASE		100.0		100.0	0.4	INCREASE
CIS-3-HEPTENE									
UNIDENTIFIED C7	0.3	0.1	79.5		100.0	0.1	81.3	0.1	77.0
2-METHYL-2-HEXENE									
3-METHYL-TRANS-3-HEXENE									
TRANS-2-HEPTENE	0.1	0.1	59.3	0.1	54.4	trace	DECREASE	0.1	45.7
3-ETHYL-CIS-2-PENTENE									
2,4,4-TRIMETHYL-1-PENTENE									
2,3-DIMETHYL-2-PENTENE									
CIS-2-HEPTENE									
METHYLCYCLOHEXANE	0.1	0.1	24.2	0.1	11.7	0.1	13.2	0.1	4.3
CIS-1,2-DIMETHYLCYCLOPENTANE									
2,2-DIMETHYLHEXANE									
1,1,3-TRIMETHYLCYCLOPENTANE									
2,4,4-TRIMETHYL-2-PENTENE									
2,2,3-TRIMETHYLPENTANE	0.2	0.2	32.7	0.2	31.3	0.1	74.6	0.1	48.5
2,5-DIMETHYLHEXANE									
ETHYLCYCLOPENTANE									
2,4-DIMETHYLHEXANE	0.5		100.0		100.0		100.0		100.0
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE									
3,3-DIMETHYLHEXANE									
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE									
2,3,4-TRIMETHYLPENTANE									
2,3,3-TRIMETHYLPENTANE									
TOLUENE	3.2	1.0	67.4	0.8	73.5	1.1	66.2	0.6	80.6
2,3-DIMETHYLHEXANE									
1,1,2-TRIMETHYLCYCLOPENTANE									
2-METHYLHEPTANE									
3,4-DIMETHYLHEXANE, NOTE B									

TABLE C-4 (CONT'D). MODE 1 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
4-METHYLHEPTANE	0.1		100.0		100.0		100.0		100.0
3-METHYLHEPTANE									
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE	0.1		100.0		100.0		100.0		100.0
CIS-1,3-DIMETHYLCYCLOHEXANE									
TRANS-1,4-DIMETHYLCYCLOHEXANE									
3-ETHYLHEXANE	0.1	0.1	40.6		100.0		100.0		100.0
2,2,5-TRIMETHYLHEXANE	0.1	0.1	(4.0)	0.1	22.6	0.1	(40.7)	0.1	5.0
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE									
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.3	0.3	(30.0)	0.3	(1.9)	0.3	(7.9)	0.2	9.8
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	0.7		100.0		100.0		100.0		100.0
OCTANE	0.1		100.0	0.1	53.5	0.1	57.9	0.1	58.9
UNIDENTIFIED C8									
TRANS-2-OCTENE	0.1		100.0		100.0		100.0		100.0
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C									
CIS-2-OCTENE									
ISOPROPYLCYCLOPENTANE									
2,2-DIMETHYLHEPTANE									
2,3,5-TRIMETHYLHEXANE	0.1		100.0		100.0		100.0		100.0
CIS-1-METHYL-2-ETHYLCYCLOPENTANE									
2,4-DIMETHYLHEPTANE									
4,4-DIMETHYLHEPTANE									
CIS-1,2-DIMETHYLCYCLOHEXANE									
ETHYLCYCLOHEXANE									
2,6-DIMETHYLHEPTANE, NOTE D	0.1	0.1	8.5		100.0		100.0		100.0
1,1,3-TRIMETHYLCYCLOHEXANE									
2,5-DIMETHYLHEPTANE, NOTE E									
3,3-DIMETHYLHEPTANE									
3,5-DIMETHYLHEPTANE, NOTE E									
ETHYLBENZENE	0.2	0.1	61.5	0.1	4.6	0.2	(1.1)		100.0
2,3,4-TRIMETHYLHEXANE									

TABLE C-4 (CONT'D). MODE 1 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
2,3-DIMETHYLHEPTANE									
m-& p-XYLENE	0.7		100.0	0.2	76.3	0.2	74.9		100.0
4-METHYLOCTANE									
3,4-DIMETHYLHEPTANE									
4-ETHYLHEPTANE									
2-METHYLOCTANE									
3-METHYLOCTANE	0.1		100.0		100.0		100.0		100.0
STYRENE	0.2		100.0		100.0		100.0		100.0
o-XYLENE	0.3		100.0		100.0		100.0		100.0
1-NONENE	0.4		100.0		100.0		100.0		100.0
TRANS-3-NONENE									
CIS-3-NONENE									
NONANE	0.1		100.0		100.0		100.0		100.0
TRANS-2-NONENE									
ISOPROPYLBENZENE (CUMENE)									
2,2-DIMETHYLOCTANE									
2,4-DIMETHYLOCTANE	0.1		100.0		100.0		100.0		100.0
n-PROPYLBENZENE	0.1		100.0		100.0		100.0		100.0
1-METHYL-3-ETHYLBENZENE									
1-METHYL-4-ETHYLBENZENE									
1,3,5-TRIMETHYLBENZENE									
1-METHYL-2-ETHYLBENZENE									
1,2,4-TRIMETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
TERT-BUTYLBENZENE									
1-DECENE									
DECANE, NOTE F									
ISOBUTYLBENZENE, NOTE F									
1,3,-DIMETHYL-5-ETHYLBENZENE									
METHYLPROPYLBENZENE (sec butylbenzene)									
1-METHYL-3-ISOPROPYLBENZENE	0.7		100.0		100.0		100.0		100.0
1,2,3-TRIMETHYLBENZENE									
1-METHYL-4-ISOPROPYLBENZENE									
INDAN									
1-METHYL-2-ISOPROPYLBENZENE									
1,3-DIETHYLBENZENE									
1,4-DIETHYLBENZENE									
1-METHYL-3-N-PROPYLBENZENE									

TABLE C-4 (CONT'D). MODE 1 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
1-METHYL-4-N-PROPYLBENZENE, NOTE G	0.5		100.0		100.0		100.0		100.0
1,2 DIETHYLBENZENE									
1-METHYL-2-N-PROPYLBENZENE									
1,4-DIMETHYL-2-ETHYLBENZENE									
1,3-DIMETHYL-4-ETHYLBENZENE	trace		DECREASE		DECREASE		DECREASE		DECREASE
1,2-DIMETHYL-4-ETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
1,3-DIMETHYL-2-ETHYLBENZENE									
UNDECANE									
1,2-DIMETHYL-3-ETHYLBENZENE									
1,2,4,5-TETRAMETHYLBENZENE	0.6		100.0		100.0		100.0		100.0
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	trace		DECREASE		DECREASE		DECREASE		DECREASE
DODECANE									
1,3,5-TRIETHYLBENZENE									
1,2,4-TRIETHYLBENZENE									
HEXYLBENZENE									
UNIDENTIFIED C9-C12+	0.6		100.0		100.0		100.0		100.0
FORMALDEHYDE	16.4	7.5	54.5	7.4	54.5	9.0	45.2	7.6	53.3
ACETALDEHYDE	11.8	1.9	83.8	2.4	79.6	2.7	76.7	2.1	82.5
ACROLEIN	5.2		100.0	0.9	82.9	0.7	87.4	0.8	84.5
ACETONE	2.2	2.4	(9.0)	0.5	77.9		100.0		100.0
PROPIONALDEHYDE	0.8	0.6	22.1	1.1	(41.7)	0.6	23.4	0.3	58.5
CROTONALDEHYDE	1.0	0.4	57.8	0.4	56.6	0.3	70.3	0.4	60.9
ISOBUTYRALDEHYDE, NOTE H	0.4		100.0	0.1	84.4	trace	DECREASE	trace	DECREASE
METHYL ETHYL KETONE, NOTE H	0.4		100.0	0.1	84.4	trace	DECREASE	trace	DECREASE
BENZALDEHYDE	5.1	0.4	91.8	0.3	94.0	0.4	92.8	0.3	93.5
ISOVALERALDEHYDE	0.6	0.1	83.3	0.1	86.7	0.1	76.7	0.4	39.8
VALERALDEHYDE	0.2	0.3	(62.4)	0.1	37.6	0.1	62.5	0.1	24.7
O-TOLUALDEHYDE	1.2	0.4	64.0	0.4	65.6	0.4	67.2	0.5	62.2
M/P-TOLUALDEHYDE	3.7	0.5	85.3	0.8	77.6	0.7	79.8	1.0	71.5

TABLE C-4 (CONT'D). MODE 1 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
HEXANALDEHYDE		trace	INCREASE	0.1	INCREASE	0.2	INCREASE	0.2	INCREASE
DIMETHYLBENZALDEHYDE	0.5	0.1	80.8		100.0	0.1	84.6	0.1	73.0
DIMETHYLTETRALINS		trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
DIMETHYLNAPHTHALENES	trace	trace	INCREASE	trace	INCREASE	0.1	INCREASE	0.1	INCREASE
TRIMETHYLTETRALINS	trace	trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
N-HEXYLBENZENE		trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
METHYLTETRALINS		0.2	INCREASE	0.3	INCREASE	0.4	INCREASE	1.3	INCREASE
2-METHYLNAPHTHALENE		trace	INCREASE	trace	INCREASE	trace	INCREASE	0.1	INCREASE
1-METHYLNAPHTHALENE	trace	trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
BIPHENYL	trace	trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
N-DOCOSANE		trace	INCREASE	trace	INCREASE	0.1	INCREASE	trace	INCREASE
N-TRICOSANE		0.1	INCREASE	0.1	INCREASE	0.3	INCREASE	trace	INCREASE
N-TETRACOSANE		0.1	INCREASE	0.3	INCREASE	0.6	INCREASE	0.1	INCREASE
N-PENTACOSANE		0.2	INCREASE	0.5	INCREASE	0.9	INCREASE	0.1	INCREASE
N-EICOSANE	trace	0.2	INCREASE	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE
N-HENEICOSANE		trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
N-HEPTADECANE	trace	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE
N-HEXADECANE		0.5	INCREASE	0.6	INCREASE	0.7	INCREASE	0.3	INCREASE
TETRALIN	trace	trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
C5 BENZENE		0.5	INCREASE	0.5	INCREASE	0.6	INCREASE	8.6	INCREASE
AMYLBENZENE	trace	trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
N-NONADECANE	trace	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE
N-OCTADECANE	trace	0.2	INCREASE	0.2	INCREASE	0.2	INCREASE	0.2	INCREASE
N-PETADECANE		0.4	INCREASE	0.4	INCREASE	0.4	INCREASE	0.3	INCREASE
PHENANTHRENE		trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
PYRENE		trace	INCREASE	trace	INCREASE				
N-TETRADECANE		1.0	INCREASE	1.2	INCREASE	1.2	INCREASE	0.7	INCREASE
N-TRIDECANE		0.5	INCREASE	0.5	INCREASE	0.6	INCREASE	0.5	INCREASE
1-METHYLDECALIN		0.3	INCREASE	0.2	INCREASE	0.3	INCREASE	0.3	INCREASE

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 C-5. MODE 2 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
METHANE									
ETHANE	0.1	trace	DECREASE	0.1	30.8	trace	DECREASE	0.1	(1.7)
ETHYLENE	22.9	2.6	88.5	3.6	84.1	2.6	88.6	3.9	83.2
PROPANE	trace	trace		trace			DECREASE		DECREASE
PROPYLENE	8.8	0.8	90.6	1.0	88.6	0.8	90.4	0.8	90.6
ACETYLENE									
PROPADIENE									
BUTANE	trace	0.1	INCREASE	trace			100.0		100.0
TRANS-2-BUTENE	0.4	0.1	86.7	0.1	83.2	0.1	86.2	0.1	85.1
1-BUTENE	2.7	0.3	89.3	0.3	87.7	0.3	88.9	0.3	90.0
2-METHYLPROPENE (ISOBUTYLENE)	2.0	0.3	86.8	0.3	85.7	0.3	87.3	0.2	87.8
2,2-DIMETHYLPROPANE (NEOPENTANE)									
PROPYNE		0.1	INCREASE			0.1	INCREASE	trace	INCREASE
1,3-BUTADIENE	2.5	0.1	94.1	0.2	91.1	0.2	93.0	0.1	95.1
2-METHYLPROPANE (ISOBUTANE)	2.2	0.2	92.3	0.2	91.7	0.2	92.7	0.2	93.0
1-BUTYNE	0.1		100.0		100.0		100.0		100.0
METHANOL									
CIS-2-BUTENE	0.3	trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
3-METHYL-1-BUTENE									
ETHANOL									
2-METHYLBUTANE (ISOPENTANE)	0.3	trace	DECREASE		100.0		100.0		100.0
2-BUTYNE									
1-PENTENE									
2-METHYL-1-BUTENE									
PENTANE	0.1	0.2	(87.0)	0.2	(62.7)	0.2	(93.0)	0.2	(79.2)
UNIDENTIFIED C5 OLEFINS									
2-METHYL-1,3-BUTADIENE	0.2		100.0		100.0	0.2	(7.4)	0.1	50.6
TRANS-2-PENTENE	0.2		100.0		100.0		100.0		100.0
3,3-DIMETHYL-1-BUTENE									
CIS-2-PENTENE	0.1		100.0		100.0		100.0		100.0
2-METHYL-2-BUTENE									
TERT-BUTANOL									
CYCLOPENTADIENE									
2,2-DIMETHYLBUTANE									
CYCLOPENTENE	0.3		100.0		100.0		100.0	0.1	82.1
4-METHYL-1-PENTENE	0.5		100.0	0.1	80.3		100.0		100.0
3-METHYL-1-PENTENE									

TABLE C-5 (CONT'D). MODE 2 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
CYCLOPENTANE	0.5	0.11	76.9	0.15	69.2	0.11	77.2	0.06	87.9
2,3-DIMETHYLBUTANE	0.1		100.0		100.0		100.0	0.14	(128.9)
MTBE									
4-METHYL-CIS-2-PENTENE									
2-METHYLPENTANE	trace	trace			100.0		100.0		100.0
4-METHYL-TRANS-2-PENTENE									
3-METHYLPENTANE	1.4	0.2	88.7	0.4	69.0	0.3	80.7	0.2	86.1
2-METHYL-1-PENTENE	1.1	0.2	84.1	0.1	87.5	0.2	83.4	0.1	91.9
1-HEXENE	1.1	0.2	84.1	0.1	87.5	0.2	83.4	0.1	91.9
HEXANE				trace	INCREASE	trace	INCREASE	0.3	INCREASE
UNIDENTIFIED C6 OLEFINS	0.6	0.5	18.4	0.3	54.2	0.4	28.9	0.1	89.7
TRANS-3-HEXENE									
CIS-3-HEXENE									
DI-ISOPROPYL ETHER									
TRANS-2-HEXENE	0.1		100.0		100.0		100.0		100.0
3-METHYL-TRANS-2-PENTENE	0.1		100.0		100.0		100.0		100.0
2-METHYL-2-PENTENE	0.1		100.0		100.0		100.0		100.0
3-METHYLCYCLOPENTENE									
CIS-2-HEXENE	0.1		100.0		100.0		100.0		100.0
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	0.2		100.0		100.0		100.0		100.0
1-METHYLCYCLOPENTENE									
BENZENE	1.8	0.3	84.6	0.3	80.7	0.3	84.7	0.3	80.9
3-METHYL-1-HEXENE									
3,3-DIMETHYLPENTANE	trace		100.0		100.0		100.0		100.0
CYCLOHEXANE									
2-METHYLHEXANE	0.1		100.0		100.0		100.0		100.0
2,3-DIMETHYLPENTANE	0.3		100.0		100.0		100.0		100.0
1,1-DIMETHYLCYCLOPENTANE									
TERT-AMYL METHYL ETHER									
CYCLOHEXENE									
3-METHYLHEXANE	0.1	0.1	34.3		100.0		100.0		100.0

TABLE C-5 (CONT'D). MODE 2 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
CIS-1,3-DIMETHYLCYCLOPENTANE	0.4	0.1	72.8	0.1	80.2	0.1	79.4	0.1	79.7
3-ETHYLPENTANE	0.3		100.0		100.0		100.0		100.0
TRANS-1,2-DIMETHYLCYCLOPENTANE									
TRANS-1,3-DIMETHYLCYCLOPENTANE									
1-HEPTENE									
2,2,4-TRIMETHYLPENTANE	1.4	0.1	90.5	0.3	77.6	0.1	89.4		100.0
2-METHYL-1-HEXENE									
TRANS-3-HEPTENE									
HEPTANE	0.1		100.0		100.0		100.0	0.2	(12.0)
CIS-3-HEPTENE									
UNIDENTIFIED C7	0.4		100.0		100.0		100.0		100.0
2-METHYL-2-HEXENE									
3-METHYL-TRANS-3-HEXENE									
TRANS-2-HEPTENE	0.2		100.0		100.0		100.0		100.0
3-ETHYL-CIS-2-PENTENE									
2,4,4-TRIMETHYL-1-PENTENE									
2,3-DIMETHYL-2-PENTENE									
CIS-2-HEPTENE	0.1		100.0		100.0		100.0		100.0
METHYLCYCLOHEXANE	0.4	0.1	65.8	0.1	75.0	0.1	74.5	0.1	83.2
CIS-1,2-DIMETHYLCYCLOPENTANE									
2,2-DIMETHYLHEXANE									
1,1,3-TRIMETHYLCYCLOPENTANE									
2,4,4-TRIMETHYL-2-PENTENE									
2,2,3-TRIMETHYLPENTANE	0.6	0.1	80.9	0.1	80.5	0.1	76.5	0.1	86.4
2,5-DIMETHYLHEXANE									
ETHYLCYCLOPENTANE									
2,4-DIMETHYLHEXANE	0.1		100.0		100.0		100.0		100.0
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE									
3,3-DIMETHYLHEXANE									
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE									
2,3,4-TRIMETHYLPENTANE	0.1	0.1	16.7	0.1	(54.4)		100.0		100.0
2,3,3-TRIMETHYLPENTANE									
TOLUENE	2.1	0.5	74.7	0.6	73.4	0.8	64.5	0.5	75.2
2,3-DIMETHYLHEXANE									
1,1,2-TRIMETHYLCYCLOPENTANE									
2-METHYLHEPTANE									
3,4-DIMETHYLHEXANE, NOTE B	0.2		100.0		100.0		100.0		100.0

TABLE C-5 (CONT'D). MODE 2 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
4-METHYLHEPTANE									
3-METHYLHEPTANE									
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE									
CIS-1,3-DIMETHYLCYCLOHEXANE									
TRANS-1,4-DIMETHYLCYCLOHEXANE									
3-ETHYLHEXANE	0.3		100.0		100.0		100.0		100.0
2,2,5-TRIMETHYLHEXANE	0.2		100.0		100.0		100.0		100.0
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE									
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	1.1	0.2	85.7	0.1	87.2	0.2	85.1	0.1	89.1
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		100.0		100.0		100.0		100.0
1-OCTENE									
TRANS-4-OCTENE									
OCTANE	0.2	0.1	65.1	0.1	62.8	0.1	61.4	0.1	28.9
UNIDENTIFIED C8	0.3		100.0		100.0		100.0		100.0
TRANS-2-OCTENE	0.2		100.0		100.0		100.0		100.0
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C									
CIS-2-OCTENE	0.1		100.0		100.0		100.0		100.0
ISOPROPYLCYCLOPENTANE									
2,2-DIMETHYLHEPTANE									
2,3,5-TRIMETHYLHEXANE	0.1		100.0		100.0		100.0		100.0
CIS-1-METHYL-2-ETHYLCYCLOPENTANE	0.1		100.0		100.0		100.0		100.0
2,4-DIMETHYLHEPTANE									
4,4-DIMETHYLHEPTANE									
CIS-1,2-DIMETHYLCYCLOHEXANE									
ETHYLCYCLOHEXANE									
2,6-DIMETHYLHEPTANE, NOTE D	0.3	0.1	56.2	0.1	56.4	0.1	77.8		100.0
1,1,3-TRIMETHYLCYCLOHEXANE									
2,5-DIMETHYLHEPTANE, NOTE E		trace	INCREASE						
3,3-DIMETHYLHEPTANE									
3,5-DIMETHYLHEPTANE, NOTE E		trace	INCREASE						
ETHYLBENZENE	0.3	0.1	84.8	0.1	81.8	0.1	81.0	0.1	83.9
2,3,4-TRIMETHYLHEXANE									

TABLE C-5 (CONT'D). MODE 2 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
2,3-DIMETHYLHEPTANE									
m-& p-XYLENE	0.8	0.1	86.3	0.1	85.0	0.1	91.0	0.1	91.1
4-METHYLOCTANE									
3,4-DIMETHYLHEPTANE									
4-ETHYLHEPTANE									
2-METHYLOCTANE	0.3	0.1	56.4	0.1	52.0	0.1	61.7	0.1	53.7
3-METHYLOCTANE	0.2	0.1	63.6	0.1	59.1	0.1	70.5		100.0
STYRENE	0.3		100.0		100.0		100.0		100.0
o-XYLENE	0.4	0.1	83.0	0.1	82.2		100.0		100.0
1-NONENE	0.9		100.0		100.0		100.0		100.0
TRANS-3-NONENE									
CIS-3-NONENE									
NONANE	0.5		100.0		100.0		100.0	0.1	84.6
TRANS-2-NONENE									
ISOPROPYLBENZENE (CUMENE)	0.1	0.1	(33.0)	0.1	(20.2)	0.1	(9.1)		100.0
2,2-DIMETHYLOCTANE	0.2		100.0		100.0	0.1	43.7	0.1	69.4
2,4-DIMETHYLOCTANE	0.4	0.1	69.9	0.1	74.4	0.1	73.6		100.0
n-PROPYLBENZENE	0.4		100.0		100.0		100.0		100.0
1-METHYL-3-ETHYLBENZENE	0.6		100.0		100.0		100.0	0.1	87.0
1-METHYL-4-ETHYLBENZENE	0.3		100.0		100.0		100.0		100.0
1,3,5-TRIMETHYLBENZENE	0.5	0.1	88.2	0.1	88.8		100.0		100.0
1-METHYL-2-ETHYLBENZENE	0.3		100.0		100.0		100.0		100.0
1,2,4-TRIMETHYLBENZENE	0.6		100.0		100.0		100.0		100.0
TERT-BUTYLBENZENE									
1-DECENE	1.0		100.0		100.0		100.0		100.0
DECANE, NOTE F									
ISOBUTYLBENZENE, NOTE F									
1,3,-DIMETHYL-5-ETHYLBENZENE									
METHYLPROPYLBENZENE (sec butylbenzene)	0.3		100.0		100.0		100.0		100.0
1-METHYL-3-ISOPROPYLBENZENE	0.9		100.0		100.0		100.0	0.2	73.4
1,2,3-TRIMETHYLBENZENE									
1-METHYL-4-ISOPROPYLBENZENE	0.5		100.0		100.0		100.0		100.0
INDAN									
1-METHYL-2-ISOPROPYLBENZENE	0.3		100.0		100.0		100.0		100.0
1,3-DIETHYLBENZENE									
1,4-DIETHYLBENZENE						0.2			
1-METHYL-3-N-PROPYLBENZENE									

TABLE C-5 (CONT'D). MODE 2 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
1-METHYL-4-N-PROPYLBENZENE, NOTE G	1.3		100.0		100.0		100.0	0.1	93.0
1,2 DIETHYLBENZENE	0.2		100.0		100.0		100.0		100.0
1-METHYL-2-N-PROPYLBENZENE	0.4	0.5	(34.7)		100.0		100.0		100.0
1,4-DIMETHYL-2-ETHYLBENZENE									
1,3-DIMETHYL-4-ETHYLBENZENE	1.6		100.0		100.0		100.0		100.0
1,2-DIMETHYL-4-ETHYLBENZENE	0.2	0.1	47.0		100.0		100.0		100.0
1,3-DIMETHYL-2-ETHYLBENZENE									
UNDECANE	0.6		100.0		100.0		100.0	0.1	85.7
1,2-DIMETHYL-3-ETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
1,2,4,5-TETRAMETHYLBENZENE	3.5		100.0		100.0		100.0		100.0
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)									
3,4 DIMETHYLCUMENE									
1,2,3,5-TETRAMETHYLBENZENE									
TERT-1-BUT-2-METHYLBENZENE	0.3		100.0		100.0		100.0		100.0
1,2,3,4-TETRAMETHYLBENZENE									
N-PENT-BENZENE	0.6		100.0		100.0		100.0		100.0
TERT-1-BUT-3,5-DIMETHYLBENZENE									
TERT-1-BUTYL-4-ETHYLBENZENE									
NAPHTHALENE	0.0		100.0		100.0		100.0		100.0
DODECANE									
1,3,5-TRIETHYLBENZENE									
1,2,4-TRIETHYLBENZENE									
HEXYLBENZENE									
UNIDENTIFIED C9-C12+	4.9		100.0		100.0		100.0		100.0
FORMALDEHYDE	25.6	5.0	80.6	5.7	77.9	5.5	78.5		100.0
ACETALDEHYDE	8.0	1.4	82.4	2.0	74.9	2.1	73.9		100.0
ACROLEIN	3.3		100.0	0.8	77.0	0.5	84.4		100.0
ACETONE	1.8	2.4	(28.7)	0.4	77.3		100.0		100.0
PROPIONALDEHYDE	1.2	0.4	69.0	0.8	33.6	0.4	64.4		100.0
CROTONALDEHYDE	0.9	0.4	56.1	0.3	60.8	0.3	67.9		100.0
ISOBUTYRALDEHYDE, NOTE H	0.7		100.0	0.1	91.7	0.1	92.0		100.0
METHYL ETHYL KETONE, NOTE H	0.7		100.0	0.1	91.7	0.1	92.0		100.0
BENZALDEHYDE	3.0	0.1	95.5	0.2	93.5	trace	DECREASE		100.0
ISOVALERALDEHYDE	2.8		100.0	trace	DECREASE	0.1	97.9	0.2	94.4
VALERALDEHYDE	3.7	0.2	95.1	0.2	95.6	0.1	96.7		100.0
O-TOLUALDEHYDE	1.5	0.1	93.2	0.3	82.2		100.0		100.0
M/P-TOLUALDEHYDE	11.1		100.0	0.7	93.4		100.0		100.0

TABLE C-5 (CONT'D). MODE 2 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
HEXANALDEHYDE	trace	trace		0.2	INCREASE	0.1	INCREASE		100.0
DIMETHYLBENZALDEHYDE				0.1	INCREASE				
Dimethyltetralins	0.1	trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
Dimethylnaphthalenes	0.5	0.1	81.5	0.1	83.0	0.1	80.0	0.1	87.9
Trimethyltetralins	trace	trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
n-Hexylbenzene	trace	trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
Methyltetralins	1.8	0.5	73.4	0.5	69.5	0.6	64.3	0.4	79.4
2-Methylnaphthalene	0.4	0.1	80.2	0.1	78.4	0.1	85.9	trace	DECREASE
1-Methylnaphthalene	0.2	trace	DECREASE	trace	DECREASE	trace	DECREASE		
Biphenyl	0.1	trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
n-Docosane	trace	trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
n-Tricosane	0.0	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE	trace	INCREASE
n-Tetracosane	0.0	0.1	INCREASE	0.2	INCREASE	0.3	INCREASE	0.1	INCREASE
n-Pentacosane	0.0	0.2	INCREASE	0.3	INCREASE	0.5	INCREASE	0.1	INCREASE
n-Eicosane	0.3	0.2	40.3	0.2	49.9	0.1	59.2	0.1	60.1
n-Heneicosane	0.1	trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
n-Heptadecane	1.2	0.4	65.7	0.3	73.4	0.3	71.1	0.4	68.1
n-Hexadecane	1.7	1.0	41.5	1.0	40.6	1.0	41.4	0.7	60.0
Tetralin	0.3	0.0	DECREASE	0.1	73.0	0.1	81.3	trace	DECREASE
C5 Benzene	0.3	0.4	INCREASE	0.6	INCREASE	0.7	INCREASE	0.4	INCREASE
Amylbenzene	0.1	trace	DECREASE	0.1	58.1	trace	DECREASE	T	DECREASE
n-Nonadecane	0.3	0.1	61.3	0.2	49.0	0.1	60.0	0.1	74.9
n-Octadecane	0.6	0.3	52.3	0.2	58.5	0.2	60.3	0.2	70.6
n-Petadecane	2.1	1.1	47.8	1.1	50.1	1.0	53.0	0.9	57.6
Phenanthrene	0.1	trace	DECREASE	trace	DECREASE	trace	DECREASE		
Pyrene	trace	trace	DECREASE	trace	DECREASE				
n-Tetradecane	3.4	1.9	45.3	2.0	40.8	1.8	48.9	1.3	63.0
n-Tridecane	2.7	1.3	51.9	1.3	49.3	1.2	55.1	1.1	59.1
1-Methyldecalin	1.7	0.6	62.5	0.7	59.5	0.6	66.4	0.6	63.2

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 C-6. MODE 3 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
METHANE									
ETHANE	0.2		100.0	trace	DECREASE	trace	DECREASE	trace	DECREASE
ETHYLENE	5.8	0.4	93.9	0.6	90.1	0.4	93.8	0.8	86.8
PROPANE	trace		100.0		100.0		100.0		100.0
PROPYLENE	2.5	0.1	95.2	0.1	94.6	0.1	96.1	0.1	94.9
ACETYLENE									
PROPADIENE									
BUTANE		0.2	INCREASE	trace	INCREASE				
TRANS-2-BUTENE	0.1		100.0		100.0		100.0		100.0
1-BUTENE	0.8	0.1	93.7	0.1	93.4	trace	DECREASE	trace	DECREASE
2-METHYLPROPENE (ISOBUTYLENE)	0.5	0.1	84.0	0.1	90.7	trace	DECREASE	0.1	90.6
2,2-DIMETHYLPROPANE (NEOPENTANE)									
PROPYNE	0.1	0.1	(36.0)		100.0	0.1	(92.3)	0.1	12.4
1,3-BUTADIENE	0.6		100.0		100.0		100.0		100.0
2-METHYLPROPANE (ISOBUTANE)	0.7	trace	DECREASE		100.0		100.0		100.0
1-BUTYNE									
METHANOL									
CIS-2-BUTENE	0.1		100.0		100.0		100.0		100.0
3-METHYL-1-BUTENE									
ETHANOL									
2-METHYLBUTANE (ISOPENTANE)	0.1		100.0		100.0		100.0		100.0
2-BUTYNE									
1-PENTENE									
2-METHYL-1-BUTENE									
PENTANE	0.2		100.0	0.1	43.5	0.1	28.7		100.0
UNIDENTIFIED C5 OLEFINS									
2-METHYL-1,3-BUTADIENE								0.1	INCREASE
TRANS-2-PENTENE									
3,3-DIMETHYL-1-BUTENE									
CIS-2-PENTENE									
2-METHYL-2-BUTENE									
TERT-BUTANOL									
CYCLOPENTADIENE									
2,2-DIMETHYLBUTANE									
CYCLOPENTENE	0.1		100.0		100.0		100.0		100.0
4-METHYL-1-PENTENE	0.2		100.0		100.0		100.0		100.0
3-METHYL-1-PENTENE									

TABLE C-6 (CONT'D). MODE 3 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
CYCLOPENTANE	0.1		100.0		100.0		100.0		100.0
2,3-DIMETHYLBUTANE	trace		DECREASE		DECREASE		DECREASE		DECREASE
MTBE									
4-METHYL-CIS-2-PENTENE									
2-METHYLPENTANE		trace	INCREASE	0.1	INCREASE	0.1	INCREASE		
4-METHYL-TRANS-2-PENTENE									
3-METHYLPENTANE	0.3	0.1	42.1	0.2	11.5	0.1	51.7	0.2	38.2
2-METHYL-1-PENTENE	0.4	trace	DECREASE	trace	DECREASE	trace	DECREASE		100.0
1-HEXENE	0.4	trace	DECREASE	trace	DECREASE	trace	DECREASE		100.0
HEXANE				trace	INCREASE	trace	INCREASE	0.1	INCREASE
UNIDENTIFIED C6 OLEFINS	0.5	0.2	64.7	0.2	64.4		100.0		100.0
TRANS-3-HEXENE									
CIS-3-HEXENE									
DI-ISOPROPYL ETHER									
TRANS-2-HEXENE	0.1		100.0		100.0		100.0		100.0
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	0.5	0.1	79.4	0.1	78.1	trace	DECREASE	0.1	83.7
3-METHYL-1-HEXENE									
3,3-DIMETHYLPENTANE		trace	INCREASE			0.1	INCREASE		
CYCLOHEXANE									
2-METHYLHEXANE									
2,3-DIMETHYLPENTANE	0.1		100.0		100.0		100.0		100.0
1,1-DIMETHYLCYCLOPENTANE									
TERT-AMYL METHYL ETHER									
CYCLOHEXENE									
3-METHYLHEXANE	0.1		100.0		100.0		100.0		100.0

TABLE C-6 (CONT'D). MODE 3 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
CIS-1,3-DIMETHYLCYCLOPENTANE	0.1		100.0		100.0		100.0		100.0
3-ETHYLPENTANE	0.1		100.0		100.0		100.0		100.0
TRANS-1,2-DIMETHYLCYCLOPENTANE									
TRANS-1,3-DIMETHYLCYCLOPENTANE									
1-HEPTENE									
2,2,4-TRIMETHYLPENTANE	0.5	0.1	89.9	0.1	73.4		100.0		100.0
2-METHYL-1-HEXENE									
TRANS-3-HEPTENE									
HEPTANE								trace	INCREASE
CIS-3-HEPTENE									
UNIDENTIFIED C7	0.1		100.0		100.0		100.0		100.0
2-METHYL-2-HEXENE									
3-METHYL-TRANS-3-HEXENE									
TRANS-2-HEPTENE	0.1		100.0		100.0		100.0		100.0
3-ETHYL-CIS-2-PENTENE									
2,4,4-TRIMETHYL-1-PENTENE									
2,3-DIMETHYL-2-PENTENE									
CIS-2-HEPTENE									
METHYLCYCLOHEXANE	0.1		100.0		100.0		100.0		100.0
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	0.2		100.0		100.0		100.0		100.0
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE									
3,3-DIMETHYLHEXANE									
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE									
2,3,4-TRIMETHYLPENTANE	0.1		100.0		100.0		100.0		100.0
2,3,3-TRIMETHYLPENTANE									
TOLUENE	1.0	0.5	47.6	0.5	54.9	0.6	39.6	0.5	54.3
2,3-DIMETHYLHEXANE									
1,1,2-TRIMETHYLCYCLOPENTANE									
2-METHYLHEPTANE									
3,4-DIMETHYLHEXANE, NOTE B	0.1		100.0		100.0		100.0		100.0

TABLE C-6 (CONT'D). MODE 3 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
4-METHYLHEPTANE									
3-METHYLHEPTANE									
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE									
CIS-1,3-DIMETHYLCYCLOHEXANE									
TRANS-1,4-DIMETHYLCYCLOHEXANE									
3-ETHYLHEXANE	0.1		100.0		100.0		100.0		100.0
2,2,5-TRIMETHYLHEXANE	0.1		100.0		100.0		100.0		100.0
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE									
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.4		100.0		100.0		100.0		100.0
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		100.0		100.0		100.0		100.0
1-OCTENE									
TRANS-4-OCTENE									
OCTANE	0.1		100.0		100.0		100.0		100.0
UNIDENTIFIED C8	0.1		100.0		100.0		100.0		100.0
TRANS-2-OCTENE	0.1		100.0		100.0		100.0		100.0
TRANS-1,3-DIMETHYLCYCLOHEXANE, NOTE C									
CIS-2-OCTENE									
ISOPROPYLCYCLOPENTANE									
2,2-DIMETHYLHEPTANE									
2,3,5-TRIMETHYLHEXANE									
CIS-1-METHYL-2-ETHYLCYCLOPENTANE	0.1		100.0		100.0		100.0		100.0
2,4-DIMETHYLHEPTANE									
4,4-DIMETHYLHEPTANE									
CIS-1,2-DIMETHYLCYCLOHEXANE									
ETHYLCYCLOHEXANE									
2,6-DIMETHYLHEPTANE, NOTE D	0.1		100.0		100.0		100.0		100.0
1,1,3-TRIMETHYLCYCLOHEXANE									
2,5-DIMETHYLHEPTANE, NOTE E									
3,3-DIMETHYLHEPTANE									
3,5-DIMETHYLHEPTANE, NOTE E									
ETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
2,3,4-TRIMETHYLHEXANE									

TABLE C-6 (CONT'D). MODE 3 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
2,3-DIMETHYLHEPTANE									
m-& p-XYLENE	0.3		100.0		100.0		100.0		100.0
4-METHYLOCTANE									
3,4-DIMETHYLHEPTANE									
4-ETHYLHEPTANE									
2-METHYLOCTANE	0.1		100.0		100.0		100.0		100.0
3-METHYLOCTANE	0.1		100.0		100.0		100.0		100.0
STYRENE									
o-XYLENE	0.1		100.0		100.0		100.0		100.0
1-NONENE	0.3		100.0		100.0		100.0		100.0
TRANS-3-NONENE									
CIS-3-NONENE									
NONANE	0.1		100.0		100.0		100.0		100.0
TRANS-2-NONENE									
ISOPROPYLBENZENE (CUMENE)	0.1		100.0		100.0		100.0		100.0
2,2-DIMETHYLOCTANE									
2,4-DIMETHYLOCTANE	0.1		100.0		100.0		100.0		100.0
n-PROPYLBENZENE	0.1		100.0		100.0		100.0		100.0
1-METHYL-3-ETHYLBENZENE									
1-METHYL-4-ETHYLBENZENE									
1,3,5-TRIMETHYLBENZENE									
1-METHYL-2-ETHYLBENZENE	0.3		100.0		100.0		100.0		100.0
1,2,4-TRIMETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
TERT-BUTYLBENZENE									
1-DECENE	0.2		100.0		100.0		100.0		100.0
DECANE, NOTE F									
ISOBUTYLBENZENE, NOTE F									
1,3,-DIMETHYL-5-ETHYLBENZENE									
METHYLPROPYLBENZENE (sec butylbenzene)									
1-METHYL-3-ISOPROPYLBENZENE	0.4		100.0		100.0		100.0		100.0
1,2,3-TRIMETHYLBENZENE									
1-METHYL-4-ISOPROPYLBENZENE	0.4		100.0		100.0		100.0		100.0
INDAN	0.1		100.0		100.0		100.0		100.0
1-METHYL-2-ISOPROPYLBENZENE									
1,3-DIETHYLBENZENE									
1,4-DIETHYLBENZENE									
1-METHYL-3-N-PROPYLBENZENE									

TABLE C-6 (CONT'D). MODE 3 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
1-METHYL-4-N-PROPYLBENZENE, NOTE G	0.5		100.0		100.0		100.0		100.0
1,2 DIETHYLBENZENE									
1-METHYL-2-N-PROPYLBENZENE	0.1		100.0		100.0		100.0		100.0
1,4-DIMETHYL-2-ETHYLBENZENE									
1,3-DIMETHYL-4-ETHYLBENZENE	0.5		100.0		100.0		100.0		100.0
1,2-DIMETHYL-4-ETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
1,3-DIMETHYL-2-ETHYLBENZENE									
UNDECANE	0.1		100.0		100.0		100.0		100.0
1,2-DIMETHYL-3-ETHYLBENZENE									
1,2,4,5-TETRAMETHYLBENZENE	1.9		100.0		100.0		100.0		100.0
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)									
3,4 DIMETHYLCUMENE									
1,2,3,5-TETRAMETHYLBENZENE									
TERT-1-BUT-2-METHYLBENZENE	0.1		100.0		100.0		100.0		100.0
1,2,3,4-TETRAMETHYLBENZENE									
N-PENT-BENZENE									
TERT-1-BUT-3,5-DIMETHYLBENZENE									
TERT-1-BUTYL-4-ETHYLBENZENE									
NAPHTHALENE	0.1		100.0		100.0		100.0		100.0
DODECANE									
1,3,5-TRIETHYLBENZENE									
1,2,4-TRIETHYLBENZENE									
HEXYLBENZENE									
UNIDENTIFIED C9-C12+	1.5		100.0		100.0		100.0		100.0
FORMALDEHYDE	5.6	0.7	87.5	1.3	77.4	1.4	74.6		100.0
ACETALDEHYDE	1.8	trace	DECREASE	0.4	78.8	0.3	80.9		100.0
ACROLEIN	0.5		100.0	0.1	87.2	0.1	87.2		100.0
ACETONE	0.2	2.4	(1130.1)	0.1	55.6		100.0		100.0
PROPIONALDEHYDE	0.2		100.0	0.1	44.0	0.1	54.0		100.0
CROTONALDEHYDE	0.2	0.1	67.0	0.1	54.1	0.1	67.0		100.0
ISOBUTYRALDEHYDE, NOTE H	0.2		100.0	trace	DECREASE		100.0		100.0
METHYL ETHYL KETONE, NOTE H	0.2		100.0	trace	DECREASE		100.0		100.0
BENZALDEHYDE	0.4	0.1	77.6		100.0	0.2	41.0		100.0
ISOVALERALDEHYDE						trace	INCREASE	0.2	INCREASE
VALERALDEHYDE		0.2	INCREASE	trace	INCREASE	0.4	INCREASE		
O-TOLUALDEHYDE									
M/P-TOLUALDEHYDE						0.1	INCREASE		

TABLE C-6 (CONT'D). MODE 3 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
HEXANALDEHYDE						trace	INCREASE		
DIMETHYLBENZALDEHYDE									
Dimethyltetralins				trace	INCREASE	trace	INCREASE	trace	INCREASE
Dimethylnaphthalenes		trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
Trimethyltetralins	trace	trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
n-Hexylbenzene		trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
Methyltetralins		0.1	INCREASE	0.1	INCREASE	0.4	INCREASE	0.4	INCREASE
2-Methylnaphthalene		trace	INCREASE			trace	INCREASE		
1-Methylnaphthalene		trace	INCREASE						
Biphenyl		trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
n-Docosane	0.1	trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
n-Tricosane	trace	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE	trace	INCREASE
n-Tetracosane		0.1	INCREASE	0.2	INCREASE	0.2	INCREASE	trace	INCREASE
n-Pentacosane		0.2	INCREASE	0.4	INCREASE	0.3	INCREASE	0.1	INCREASE
n-Eicosane	trace	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE
n-Heneicosane		trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
n-Heptadecane	trace	0.2	INCREASE	0.2	INCREASE	0.2	INCREASE	0.2	INCREASE
n-Hexadecane		0.7		0.7	INCREASE	0.7	INCREASE	0.4	INCREASE
Tetralin	trace	trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
C5 Benzene		0.4	INCREASE	0.4	INCREASE	0.6	INCREASE	1.5	INCREASE
Amylbenzene	trace	trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
n-Nonadecane	trace	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE
n-Octadecane	trace	0.2	INCREASE	0.2	INCREASE	0.2	INCREASE	0.1	INCREASE
n-Petadecane	trace	0.4	INCREASE	0.4	INCREASE	0.4	INCREASE	0.3	INCREASE
Phenanthrene		trace	INCREASE	trace	INCREASE	trace	INCREASE		
Pyrene		trace	INCREASE						
n-Tetradecane		1.5	INCREASE	1.0	INCREASE	0.9	INCREASE	0.5	INCREASE
n-Tridecane	trace	0.5	INCREASE	0.4	INCREASE	0.3	INCREASE	0.3	INCREASE
1-Methyldecalin	trace	0.2	INCREASE	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE

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 C-7. MODE 4 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
METHANE	0.2	0.6	(200.4)		100.0	1.2	(500.8)	1.8	(800.9)
ETHANE	0.1	0.1	19.7	0.1	(0.1)	trace	DECREASE	0.1	12.8
ETHYLENE	9.0	0.1	99.0	0.3	97.1	0.1	98.8	0.4	95.1
PROPANE	trace	trace		trace			100.0		100.0
PROPYLENE	2.1	trace	DECREASE	trace	DECREASE		100.0		100.0
ACETYLENE									
PROPADIENE	trace		100.0	trace			100.0	trace	
BUTANE		0.2	INCREASE	trace	INCREASE				
TRANS-2-BUTENE	0.1		100.0		100.0		100.0		100.0
1-BUTENE	0.5		100.0		100.0		100.0		100.0
2-METHYLPROPENE (ISOBUTYLENE)	0.4		100.0		100.0		100.0		100.0
2,2-DIMETHYLPROPANE (NEOPENTANE)									
PROPYNE	trace	0.1	INCREASE		100.0	trace		trace	
1,3-BUTADIENE	0.8		100.0		100.0		100.0		100.0
2-METHYLPROPANE (ISOBUTANE)	2.5		100.0		100.0		100.0		100.0
1-BUTYNE									
METHANOL									
CIS-2-BUTENE	0.1		100.0		100.0		100.0		100.0
3-METHYL-1-BUTENE									
ETHANOL									
2-METHYLBUTANE (ISOPENTANE)	0.2		100.0		100.0		100.0		100.0
2-BUTYNE									
1-PENTENE									
2-METHYL-1-BUTENE									
PENTANE	0.2	trace	DECREASE	0.1	62.7		100.0		100.0
UNIDENTIFIED C5 OLEFINS									
2-METHYL-1,3-BUTADIENE									
TRANS-2-PENTENE	0.1		100.0		100.0		100.0		100.0
3,3-DIMETHYL-1-BUTENE									
CIS-2-PENTENE									
2-METHYL-2-BUTENE									
TERT-BUTANOL									
CYCLOPENTADIENE									
2,2-DIMETHYLBUTANE									
CYCLOPENTENE									
4-METHYL-1-PENTENE	0.1		100.0		100.0		100.0		100.0
3-METHYL-1-PENTENE									

TABLE C-7 (CONT'D). MODE 4 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
CYCLOPENTANE									
2,3-DIMETHYLBUTANE	0.1		100.0		100.0		100.0		100.0
MTBE									
4-METHYL-CIS-2-PENTENE									
2-METHYLPENTANE				0.1					
4-METHYL-TRANS-2-PENTENE									
3-METHYLPENTANE	0.5	0.1	78.4	0.2	59.9	0.4	6.6	0.6	(18.4)
2-METHYL-1-PENTENE	0.2		100.0		100.0		100.0		100.0
1-HEXENE	0.2		100.0		100.0		100.0		100.0
HEXANE		trace	INCREASE	0.1	INCREASE	0.1	INC		
UNIDENTIFIED C6 OLEFINS	0.4	0.2	57.4	0.1	64.6		100.0		100.0
TRANS-3-HEXENE									
CIS-3-HEXENE									
DI-ISOPROPYL ETHER									
TRANS-2-HEXENE	0.1		100.0		100.0		100.0		100.0
3-METHYL-TRANS-2-PENTENE									
2-METHYL-2-PENTENE									
3-METHYLCYCLOPENTENE									
CIS-2-HEXENE									
ETBE									
3-METHYL-CIS-2-PENTENE		0.1	INCREASE						
2,2-DIMETHYLPENTANE, NOTE A									
METHYLCYCLOPENTANE, NOTE A									
2,4-DIMETHYLPENTANE									
2,2,3-TRIMETHYLBUTANE									
3,4-DIMETHYL-1-PENTENE									
1-METHYLCYCLOPENTENE									
BENZENE	0.8		100.0	trace	DECREASE		100.0	0.2	73.0
3-METHYL-1-HEXENE									
3,3-DIMETHYLPENTANE									
CYCLOHEXANE									
2-METHYLHEXANE									
2,3-DIMETHYLPENTANE	0.2		100.0		100.0	0.1	58.9		100.0
1,1-DIMETHYLCYCLOPENTANE									
TERT-AMYL METHYL ETHER									
CYCLOHEXENE									
3-METHYLHEXANE	0.1		100.0		100.0		100.0		100.0

TABLE C-7 (CONT'D). MODE 4 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
CIS-1,3-DIMETHYLCYCLOPENTANE	0.1		100.0		100.0		100.0		100.0
3-ETHYLPENTANE									
TRANS-1,2-DIMETHYLCYCLOPENTANE									
TRANS-1,3-DIMETHYLCYCLOPENTANE									
1-HEPTENE									
2,2,4-TRIMETHYLPENTANE	0.2		100.0	0.1	46.2		100.0		100.0
2-METHYL-1-HEXENE									
TRANS-3-HEPTENE									
HEPTANE	0.1		100.0		100.0		100.0		100.0
CIS-3-HEPTENE									
UNIDENTIFIED C7									
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	0.1		100.0		100.0		100.0		100.0
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	trace		100.0		100.0		100.0		100.0
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE									
3,3-DIMETHYLHEXANE									
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE									
2,3,4-TRIMETHYLPENTANE	0.1		100.0		100.0		100.0		100.0
2,3,3-TRIMETHYLPENTANE									
TOLUENE	0.1	0.2	(15.7)		100.0		100.0		100.0
2,3-DIMETHYLHEXANE									
1,1,2-TRIMETHYLCYCLOPENTANE									
2-METHYLHEPTANE									
3,4-DIMETHYLHEXANE, NOTE B									

TABLE C-7 (CONT'D). MODE 4 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
4-METHYLHEPTANE									
3-METHYLHEPTANE									
1-CIS,2-TRANS,3-TRIMETHYLCYCLOPENTANE									
CIS-1,3-DIMETHYLCYCLOHEXANE									
TRANS-1,4-DIMETHYLCYCLOHEXANE									
3-ETHYLHEXANE	0.1		100.0		100.0		100.0		100.0
2,2,5-TRIMETHYLHEXANE									
TRANS-1-METHYL-3-ETHYLCYCLOPENTANE									
CIS-1-METHYL-3-ETHYLCYCLOPENTANE	0.2		100.0		100.0		100.0		100.0
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									
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	0.4		100.0		100.0		100.0		100.0
1,1,3-TRIMETHYLCYCLOHEXANE									
2,5-DIMETHYLHEPTANE, NOTE E									
3,3-DIMETHYLHEPTANE									
3,5-DIMETHYLHEPTANE, NOTE E									
ETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
2,3,4-TRIMETHYLHEXANE									

TABLE C-7 (CONT'D). MODE 4 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
2,3-DIMETHYLHEPTANE									
m-& p-XYLENE	0.1		100.0		100.0		100.0		100.0
4-METHYLOCTANE									
3,4-DIMETHYLHEPTANE									
4-ETHYLHEPTANE									
2-METHYLOCTANE	0.1		100.0		100.0		100.0		100.0
3-METHYLOCTANE	0.1		100.0		100.0		100.0		100.0
STYRENE									
o-XYLENE	0.1		100.0		100.0		100.0		100.0
1-NONENE	0.1		100.0		100.0		100.0		100.0
TRANS-3-NONENE									
CIS-3-NONENE									
NONANE	0.1		100.0		100.0		100.0		100.0
TRANS-2-NONENE									
ISOPROPYLBENZENE (CUMENE)									
2,2-DIMETHYLOCTANE									
2,4-DIMETHYLOCTANE	0.1		100.0		100.0		100.0		100.0
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	0.1		100.0		100.0		100.0		100.0
ISOBUTYLBENZENE, NOTE F									
1,3,-DIMETHYL-5-ETHYLBENZENE									
METHYLPROPYLBENZENE (sec butylbenzene)									
1-METHYL-3-ISOPROPYLBENZENE									
1,2,3-TRIMETHYLBENZENE	0.4		100.0		100.0		100.0		100.0
1-METHYL-4-ISOPROPYLBENZENE									
INDAN	0.2		100.0		100.0		100.0		100.0
1-METHYL-2-ISOPROPYLBENZENE	0.1		100.0		100.0		100.0		100.0
1,3-DIETHYLBENZENE									
1,4-DIETHYLBENZENE									
1-METHYL-3-N-PROPYLBENZENE									

TABLE C-7 (CONT'D). MODE 4 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
1-METHYL-4-N-PROPYLBENZENE, NOTE G	0.4		100.0		100.0		100.0		100.0
1,2 DIETHYLBENZENE	0.5		100.0		100.0		100.0		100.0
1-METHYL-2-N-PROPYLBENZENE	0.4		100.0		100.0		100.0		100.0
1,4-DIMETHYL-2-ETHYLBENZENE									
1,3-DIMETHYL-4-ETHYLBENZENE	0.2		100.0		100.0		100.0		100.0
1,2-DIMETHYL-4-ETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
1,3-DIMETHYL-2-ETHYLBENZENE	0.2		100.0		100.0		100.0		100.0
UNDECANE	0.1		100.0		100.0		100.0		100.0
1,2-DIMETHYL-3-ETHYLBENZENE									
1,2,4,5-TETRAMETHYLBENZENE	1.4		100.0		100.0		100.0		100.0
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	0.1		100.0		100.0		100.0		100.0
DODECANE									
1,3,5-TRIETHYLBENZENE									
1,2,4-TRIETHYLBENZENE									
HEXYLBENZENE									
UNIDENTIFIED C9-C12+	1.9		100.0		100.0		100.0		100.0
FORMALDEHYDE	7.2	0.1	98.2	0.7	91.0	0.4	94.9		100.0
ACETALDEHYDE	2.6		100.0	0.1	98.0	0.1	94.6		100.0
ACROLEIN	0.8		100.0	trace	DECREASE	trace	DECREASE		100.0
ACETONE	0.7	2.5	(247.0)		100.0		100.0		100.0
PROPIONALDEHYDE	0.4		100.0		100.0	trace	DECREASE		100.0
CROTONALDEHYDE	0.3	trace	DECREASE	trace	DECREASE	trace	DECREASE		100.0
ISOBUTYRALDEHYDE, NOTE H	0.3		100.0	trace	DECREASE		100.0	trace	DECREASE
METHYL ETHYL KETONE, NOTE H	0.3		100.0	trace	DECREASE		100.0	trace	DECREASE
BENZALDEHYDE	2.0	0.1	96.4		100.0		100.0		100.0
ISOVALERALDEHYDE	0.4		100.0		100.0	0.1	85.0	0.2	60.0
VALERALDEHYDE		0.3	INCREASE	trace	INCREASE	0.1	INCREASE		
O-TOLUALDEHYDE	trace		100.0		100.0		100.0		100.0
M/P-TOLUALDEHYDE	0.2		100.0		100.0		100.0		100.0

TABLE C-7 (CONT'D). MODE 4 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
HEXANALDEHYDE									
DIMETHYLBENZALDEHYDE									
Dimethyltetralins	trace		DECREASE	trace	DECREASE	trace	DECREASE		DECREASE
Dimethylnaphthalenes		trace	INCREASE	trace	INCREASE	trace	INCREASE	0.1	INCREASE
Trimethyltetralins	trace	trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
n-Hexylbenzene				trace	INCREASE	trace	INCREASE	0.3	INCREASE
Methyltetralins		trace	INCREASE	0.2	INCREASE	0.2	INCREASE	1.2	INCREASE
2-Methylnaphthalene								trace	INCREASE
1-Methylnaphthalene		trace	INCREASE					trace	INCREASE
Biphenyl		trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
n-Docosane		trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
n-Tricosane		0.1	INCREASE	0.1	INCREASE	trace	INCREASE	trace	INCREASE
n-Tetracosane		0.1	INCREASE	0.2	INCREASE	0.1	INCREASE	0.1	INCREASE
n-Pentacosane		0.2	INCREASE	0.4	INCREASE	0.2	INCREASE	0.1	INCREASE
n-Eicosane	trace	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE
n-Heneicosane		trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
n-Heptadecane	trace	0.1	INCREASE	0.1	INCREASE	trace	INCREASE	0.1	INCREASE
n-Hexadecane		0.4	INCREASE	0.5	INCREASE	0.4	INCREASE	0.4	INCREASE
Tetralin	trace		DECREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
C5 Benzene		0.2	INCREASE	0.5	INCREASE	0.4	INCREASE	9.0	INCREASE
Amylbenzene	trace		DECREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
n-Nonadecane	trace	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE
n-Octadecane	trace	0.1	INCREASE	0.2	INCREASE	0.1	INCREASE	0.2	INCREASE
n-Petadecane	trace	0.2	INCREASE	0.3	INCREASE	0.2	INCREASE	0.2	INCREASE
Phenanthrene									
Pyrene		trace	INCREASE						
n-Tetradecane		1.1	INCREASE	0.8	INCREASE	0.7	INCREASE	0.5	INCREASE
n-Tridecane	0.1	0.3	INCREASE	0.2	INCREASE	0.2	INCREASE	0.2	INCREASE
1-Methyldecalin	0.1		DECREASE	0.1	30.8	trace	DECREASE		DECREASE

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 C-8. MODE 5 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
METHANE	0.2	0.7	(250.5)	0.7	(250.8)	0.1	49.8		100.0
ETHANE	0.1	0.1	41.5	0.1	(27.1)	0.3	(150.2)	0.1	(8.3)
ETHYLENE	6.8	6.4	6.1	6.2	9.1	6.5	3.9	5.9	12.3
PROPANE	0.1	trace	DECREASE	trace	DECREASE		100.0	trace	DECREASE
PROPYLENE	1.7	1.4	16.4	0.5	69.5	1.7	3.8	0.5	72.6
ACETYLENE									
PROPADIENE				trace	INCREASE	trace	INCREASE		
BUTANE		0.2	INCREASE	trace	INCREASE				
TRANS-2-BUTENE	0.1	0.1	4.2		100.0	0.1	(20.3)		100.0
1-BUTENE	0.4	0.1	70.5	trace	DECREASE	0.2	53.8	trace	DECREASE
2-METHYLPROPENE (ISOBUTYLENE)	0.3	0.1	80.9		100.0	0.1	81.4		100.0
2,2-DIMETHYLPROPANE (NEOPENTANE)									
PROPYNE	0.1	trace	DECREASE		100.0	0.1	(38.0)		100.0
1,3-BUTADIENE	0.6	0.1	83.3		100.0	0.1	79.7		100.0
2-METHYLPROPANE (ISOBUTANE)	1.4	0.6	59.3	0.6	60.2	0.9	33.3	0.3	78.8
1-BUTYNE									
METHANOL									
CIS-2-BUTENE	0.1	trace	DECREASE		100.0	0.1	(36.0)		100.0
3-METHYL-1-BUTENE									
ETHANOL									
2-METHYLBUTANE (ISOPENTANE)	0.1	trace	DECREASE		100.0		100.0		100.0
2-BUTYNE									
1-PENTENE									
2-METHYL-1-BUTENE									
PENTANE	0.2		100.0	0.2	(0.2)	0.1	45.6	0.2	16.9
UNIDENTIFIED C5 OLEFINS									
2-METHYL-1,3-BUTADIENE		0.2	INCREASE	0.1	INCREASE			0.1	INCREASE
TRANS-2-PENTENE									
3,3-DIMETHYL-1-BUTENE									
CIS-2-PENTENE									
2-METHYL-2-BUTENE									
TERT-BUTANOL									
CYCLOPENTADIENE									
2,2-DIMETHYLBUTANE									
CYCLOPENTENE	0.1		100.0		100.0		100.0		100.0
4-METHYL-1-PENTENE									
3-METHYL-1-PENTENE									

TABLE C-8 (CONT'D). MODE 5 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
CYCLOPENTANE	0.1		100.0		100.0		100.0		100.0
2,3-DIMETHYLBUTANE	0.1		100.0		100.0		100.0		100.0
MTBE									
4-METHYL-CIS-2-PENTENE									
2-METHYLPENTANE	trace	trace		0.1	INCREASE	0.1	INCREASE		100.0
4-METHYL-TRANS-2-PENTENE									
3-METHYLPENTANE	0.8	0.3	59.1	0.4	54.7	0.3	68.6	0.1	82.4
2-METHYL-1-PENTENE	0.1		100.0		100.0	0.1	22.5		100.0
1-HEXENE	0.1		100.0		100.0	0.1	22.5		100.0
HEXANE		trace	INCREASE	trace	INCREASE				
UNIDENTIFIED C6 OLEFINS				0.2	INCREASE			0.1	INCREASE
TRANS-3-HEXENE									
CIS-3-HEXENE									
DI-ISOPROPYL ETHER									
TRANS-2-HEXENE								0.1	INCREASE
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	0.1		100.0		100.0		100.0		100.0
2,4-DIMETHYLPENTANE	0.1		100.0		100.0		100.0		100.0
2,2,3-TRIMETHYLBUTANE									
3,4-DIMETHYL-1-PENTENE									
1-METHYLCYCLOPENTENE									
BENZENE	0.4	0.1	66.5	0.2	47.7	0.2	55.5	0.2	47.9
3-METHYL-1-HEXENE									
3,3-DIMETHYLPENTANE		trace	INCREASE	0.1	INCREASE	0.1	INCREASE		
CYCLOHEXANE									
2-METHYLHEXANE									
2,3-DIMETHYLPENTANE	0.2		100.0	0.1	63.9		100.0		100.0
1,1-DIMETHYLCYCLOPENTANE									
TERT-AMYL METHYL ETHER									
CYCLOHEXENE									
3-METHYLHEXANE									

TABLE C-8 (CONT'D). MODE 5 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
CIS-1,3-DIMETHYLCYCLOPENTANE	0.1		100.0		100.0		100.0		100.0
3-ETHYLPENTANE									
TRANS-1,2-DIMETHYLCYCLOPENTANE									
TRANS-1,3-DIMETHYLCYCLOPENTANE									
1-HEPTENE									
2,2,4-TRIMETHYLPENTANE	0.1		100.0	0.1	24.0		100.0		100.0
2-METHYL-1-HEXENE									
TRANS-3-HEPTENE									
HEPTANE									
CIS-3-HEPTENE									
UNIDENTIFIED C7	0.1		100.0		100.0		100.0		100.0
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	0.1		100.0		100.0		100.0		100.0
CIS-1,2-DIMETHYLCYCLOPENTANE									
2,2-DIMETHYLHEXANE									
1,1,3-TRIMETHYLCYCLOPENTANE									
2,4,4-TRIMETHYL-2-PENTENE									
2,2,3-TRIMETHYLPENTANE	0.1		100.0		100.0		100.0		100.0
2,5-DIMETHYLHEXANE									
ETHYLCYCLOPENTANE									
2,4-DIMETHYLHEXANE									
1-TRANS-2-CIS-4-TRIMETHYLCYCLOPENTANE									
3,3-DIMETHYLHEXANE									
1-TRANS-2-CIS-3-TRIMETHYLCYCLOPENTANE									
2,3,4-TRIMETHYLPENTANE	0.1		100.0		100.0		100.0		100.0
2,3,3-TRIMETHYLPENTANE									
TOLUENE	0.7		100.0		100.0		100.0		100.0
2,3-DIMETHYLHEXANE									
1,1,2-TRIMETHYLCYCLOPENTANE									
2-METHYLHEPTANE									
3,4-DIMETHYLHEXANE, NOTE B									

TABLE C-8 (CONT'D). MODE 5 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
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	0.1		100.0		100.0		100.0		100.0
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									
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		100.0		100.0		100.0		100.0
1,1,3-TRIMETHYLCYCLOHEXANE									
2,5-DIMETHYLHEPTANE, NOTE E	0.2		100.0		100.0		100.0		100.0
3,3-DIMETHYLHEPTANE									
3,5-DIMETHYLHEPTANE, NOTE E	0.2		100.0		100.0		100.0		100.0
ETHYLBENZENE									
2,3,4-TRIMETHYLHEXANE									

TABLE C-8 (CONT'D). MODE 5 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
2,3-DIMETHYLHEPTANE									
m-& p-XYLENE									
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)	trace		DECREASE		DECREASE		DECREASE		DECREASE
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	0.3		100.0		100.0		100.0		100.0
1,2,3-TRIMETHYLBENZENE									
1-METHYL-4-ISOPROPYLBENZENE									
INDAN	0.1		100.0		100.0		100.0		100.0
1-METHYL-2-ISOPROPYLBENZENE									
1,3-DIETHYLBENZENE									
1,4-DIETHYLBENZENE									
1-METHYL-3-N-PROPYLBENZENE									

TABLE C-8 (CONT'D). MODE 5 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
1-METHYL-4-N-PROPYLBENZENE, NOTE G	0.5		100.0		100.0		100.0		100.0
1,2 DIETHYLBENZENE									
1-METHYL-2-N-PROPYLBENZENE									
1,4-DIMETHYL-2-ETHYLBENZENE									
1,3-DIMETHYL-4-ETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
1,2-DIMETHYL-4-ETHYLBENZENE									
1,3-DIMETHYL-2-ETHYLBENZENE	0.5		100.0		100.0		100.0		100.0
UNDECANE									
1,2-DIMETHYL-3-ETHYLBENZENE									
1,2,4,5-TETRAMETHYLBENZENE	0.7		100.0		100.0		100.0		100.0
2-METHYLBUTYLBENZENE (sec AMYLBENZENE)									
3,4 DIMETHYLCUMENE									
1,2,3,5-TETRAMETHYLBENZENE	1.0		100.0		100.0		100.0		100.0
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	0.1		100.0		100.0		100.0		100.0
1,3,5-TRIETHYLBENZENE									
1,2,4-TRIETHYLBENZENE	0.1		100.0		100.0		100.0		100.0
HEXYLBENZENE									
UNIDENTIFIED C9-C12+	0.7		100.0		100.0		100.0		100.0
FORMALDEHYDE	7.5	7.2	4.0	7.1	5.2	8.6	(14.7)		100.0
ACETALDEHYDE	2.7	3.3	(25.3)	3.8	(41.9)	4.0	(50.4)		100.0
ACROLEIN	0.9		100.0	0.7	29.5	0.5	49.2		100.0
ACETONE	0.8	1.9	(138.6)	1.1	(44.9)	0.9	(10.3)		100.0
PROPIONALDEHYDE	0.4	4.5	(968.0)	1.6	(265.5)	1.3	(211.3)		100.0
CROTONALDEHYDE	0.3	0.3	18.2	0.1	66.8	0.1	60.4		100.0
ISOBUTYRALDEHYDE, NOTE H	0.2	trace	DECREASE	trace	DECREASE	0.1	71.9		100.0
METHYL ETHYL KETONE, NOTE H	0.2	trace	DECREASE	trace	DECREASE	0.1	73.0		100.0
BENZALDEHYDE	1.2	trace	DECREASE		100.0		100.0		100.0
ISOVALERALDEHYDE	0.2		100.0		100.0		100.0	trace	DECREASE
VALERALDEHYDE		0.1	INCREASE	trace	INCREASE	trace	INCREASE		
O-TOLUALDEHYDE	0.1		100.0		100.0		100.0		100.0
M/P-TOLUALDEHYDE	0.7		100.0		100.0		100.0		100.0

TABLE C-8 (CONT'D). MODE 5 SUMMARY OF PERCENT REDUCTION

COMPOUND	Engine Out mg/min	Pt Only (75 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (75 g/ft3) mg/min	% Reduction	Pt Only (20 g/ft3) mg/min	% Reduction	3:1 Pt/Pd (20 g/ft3) mg/min	% Reduction
HEXANALDEHYDE									
DIMETHYLBENZALDEHYDE									
Dimethyltetralins									
Dimethylnaphthalenes									
Trimethyltetralins	trace	trace	DECREASE	trace	DECREASE	trace	DECREASE	trace	DECREASE
n-Hexylbenzene									
Methyltetralins						trace	INCREASE		
2-Methylnaphthalene									
1-Methylnaphthalene									
Biphenyl									
n-Docosane		trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
n-Tricosane		trace	INCREASE	trace	INCREASE	trace	INCREASE	trace	INCREASE
n-Tetracosane		trace	INCREASE	0.1	INCREASE	0.1	INCREASE		INCREASE
n-Pentacosane		0.1	INCREASE	0.2	INCREASE	0.1	INCREASE		INCREASE
n-Eicosane		0.1	INCREASE	0.1	INCREASE	0.1	INCREASE	0.1	INCREASE
n-Heneicosane		trace	INCREASE	trace	INCREASE	trace	INCREASE	0.1	INCREASE
n-Heptadecane									
n-Hexadecane		trace	INCREASE	0.1	INCREASE	0.1	INCREASE		
Tetralin								0.1	INCREASE
C5 Benzene				trace	INCREASE	0.1	INCREASE		
Amylbenzene	trace		DECREASE		DECREASE		DECREASE	0.1	INCREASE
n-Nonadecane	trace	trace	DECREASE	trace	DECREASE	trace	DECREASE	0.4	INCREASE
n-Octadecane		0.1	INCREASE	0.1	INCREASE	0.1	INCREASE		
n-Petadecane						trace	INCREASE		
Phenanthrene								0.1	INCREASE
Pyrene								0.1	INCREASE
n-Tetradecane		0.2	INCREASE	0.2	INCREASE	0.2	INCREASE		
n-Tridecane				trace	INCREASE				
1-Methyldecalin	trace		DECREASE		DECREASE	trace	DECREASE	0.3	INCREASE

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.