APTD-1568a

ALDEHYDE AND REACTIVE ORGANIC EMISSIONS FROM MOTOR VEHICLES

Part I

Advanced Automotive Control Systems Vehicles

Final Report

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Water Programs
Office of Mobile Source Air Pollution Control
Emission Control Technology Division
Ann Arbor, Michigan 48105

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ALDEHYDE AND REACTIVE ORGANIC EMISSIONS FROM MOTOR VEHICLES

Part I - Advanced Automotive Control Systems Vehicles

Final Report

Prepared by

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Interagency Agreement Number EPA-IAG-0188(D)

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Prepared for

ENVIRONMENTAL PROTECTION AGENCY
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March 1973

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Publication No. APTD-1568a

FOREWORD

This report presents a summary of work performed by the Fuels Combustion Research Group, Bartlesville Energy Research Center, Bureau of Mines, for the Environmental Protection Agency (EPA), Office of Air & Water Programs, Office of Mobile Source Air Pollution Control, Emission Control Technology Division, Emission Characterization and Control Development Branch under Interagency Agreement number EPA-IAG-0188(D).

The program at Bartlesville was directed by R. W. Hurn, Research Supervisor; Dr. R. D. Fleming, Assistant Research Supervisor was responsible for the experimental work. Others who contributed to the experimental work were: R. D. Lawrence, Mechanical Engineer; T. R. French, Research Chemist; and R. D. Tate, J. L. Bennett, Jr., and D. R. Thompson as Mechanical Engineering Technicians. C. J. Raible, Research Physicist; Sammy Montee, Physical Sciences Aide; and L. E. Nichols, Jr., Mechanical Engineering Technican, assisted in the chromatographic analysis of hydrocarbons. J. M. Clingenpeel, Chemical Engineer; Carol Wilson, Research Chemist; and R. F. Stevens, Mechanical Engineering Technician, assisted in aldehyde measurements. Dr. Joseph H. Somers was the Project Officer for EPA.

Vehicles used in the experimental program were furnished by General Motors Corporation, Esso Research and Engineering Company, Chrysler Corporation, Ford Motor Company, and Ethyl Corporation.

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PART I -- ALDEHYDE AND REACTIVE ORGANIC EMISSIONS FROM ADVANCED AUTOMOTIVE CONTROL SYSTEMS VEHICLES

I. SUBJECT

This report covers results from experimental work in measurement of aldehyde and reactive organic emissions as well as carbon monoxide and oxides of nitrogen emissions from automobiles equipped with various types of advanced prototype emission control systems including both catalytic and thermal reactor type systems.

II. OBJECTIVE

The objective of the study was to characterize aldehyde and reactive organic emissions from vehicles with prototype advanced emission control systems to provide data necessary to help determine if there is a need for aldehyde and/or reactive organic motor vehicle regulations, and to determine on a preliminary basis, the effect of ambient temperature on the emission characteristics of advanced emission control systems.

III. SUMMARY AND CONCLUSIONS

Definitive engineering information was obtained on the emission characteristics of six vehicles equipped with advanced emission control systems. The emission control systems included:

1. A base-metal oxidation catalyst system with exhaust gas recirculation (EGR).

2. An Esso RAM thermal reactor system with EGR.

3. Two systems with platinum oxidation catalyst and EGR.

4. An Ethyl lean reactor system with EGR.

5. An Esso dual catalyst system with a Monel reduction catalyst and a platinum oxidation catalyst.

Experimental data were taken using the 1975 Federal test procedure on all six vehicles in a fuel study with tests conducted at 75° F ambient temperature and using fuels varying in aromatic content from 10 to 40 pct. In addition, data were taken on three of the vehicles in a temperature study with tests being conducted at 25°, 45°, and 95° F ambient temperature. The three systems used in the temperature study were:

1. The base-metal oxidation catalyst system with EGR.
2. A platinum oxidation catalyst system with EGR.
3. The Ethyl lean reactor system.

The following were observed and conclusions were drawn as follows:

A. <u>Applicable to the Fuel Study</u>

In the following list of observations and/or conclusions fuel composition is expressed in terms of fuel aromaticity. It should be noted, however, that increases in fuel aromaticity also result in increases in fuel density which can affect carburetor metering which in turn can affect air-fuel ratio. Since mass emissions can be influenced by air-fuel ratio, some of the following observed trends may be due to changes in air-fuel ratio rather than changes in fuel aromaticity, per se.

1. Carbon monoxide (CO) emissions from the base-metal oxidation catalyst system increased about 50 pct when fuel aromatics decreased from 35 to 10 pct. Carbon monoxide emission from the Esso dual catalyst system increased about 30 pct and CO emission from the Ethyl lean reactor decreased about 18 pct when fuel aromatics decreased from 40 to 10 pct. Carbon monoxide emission from the other three vehicles was unaffected by fuel composition.

2. Hydrocarbon (HC) emissions from the base-metal oxidation catalyst system increased about 50 pct when fuel aromaticity decreased from 35 to 10 pct. Hydrocarbon emission from one of the platinum oxidation catalyst systems increased about 20 pct and HC emission from the Esso dual catalyst system increased

about 30 pct when fuel aromaticity decreased from 40 to 10 pct. The other three vehicles showed no consistent trend in HC emissions with fuel composition.

3. Nitrogen oxides (NO_x) emission decreased from 13 to 20 pct for the two platinum oxidation catalyst systems and the Ethyl lean reactor system; NO_x increased about 22 pct for the Esso dual catalyst when fuel aromaticity decreased from 40 to 10 pct. The other two vehicles showed no consistent trend in NO_x emission with changes in fuel composition.

4. Aldehyde emissions [as measured by 3-methyl-2-benzothiazolone hydrazone hydrochloride (MBTH)] ranged from 8 to 46 mg/mile for the six vehicles. The aldehydes were from 3 to 10 pct of the total organic emissions. Aldehyde emission from the base-metal oxidation catalyst system increased about 43 pct when fuel aromaticity decreased from 35 to 10 pct. Aldehyde emission from the two platinum catalyst systems increased about 25 pct when fuel aromaticity decreased from 40 to 10 pct. The other three vehicles showed no consistent trend in aldehyde emissions with changes in fuel composition.

5. C_3-C_5 olefins in the exhaust from the base-metal oxidation catalyst system increased from 28 to 56 mg/mile as fuel aromaticity decreased from 35 to 10 pct. C_3-C_5 olefin emissions for one of the platinum oxidation systems increased from 42 to 72 mg/mile and from 58 to 100 mg/mile for the other platinum oxidation catalyst system when fuel aromaticity decreased from 40 to 10 pct. The other three vehicles showed no fuel effect on exhaust olefins.

6. All six vehicles showed a decreasing trend in C_{7+} aromatics in the exhaust with decreasing fuel aromaticity. For the vehicles tested, C_{7+} aromatics in the exhaust decreased from 55 to 80 pct when fuel aromaticity decreased from 40 to 10 pct.

7. Aldehydes when measured by the 2,4-dinitrophenylhydrazone (DNPH) method, were on the average about 44 pct higher than the aldehydes measured by the MBTH methods.

B. Applicable to the Temperature Study

The following observations and/or conclusions are based on results obtained when using the high aromatic fuels.

1. Carbon monoxide emission from the base-metal oxidation catalyst system increased from 7.1 to 13.5 g/mile when ambient temperature was decreased from 75° to 25° F; CO increased from 7.1 to 12.0 g/mile when ambient temperature increased from 75° to 95° F. For the platinum oxidation catalyst system, CO increased from 5.2 g/mile at 95° F ambient to 66.4 g/mile at 25° F ambient temperature. Carbon monoxide from the Ethyl lean reactor system increased from 4.5 g/mile at 95° F to 25.1 g/mile at 25° F.

2. Hydrocarbon emission for all three vehicles used in the temperature study was lowest for 75° F ambient temperature and increased as the temperature was either increased or decreased. The increase in hydrocarbon emission when the ambient temperature was decreased from 75° to 25° F was: From 0.33 to 0.82 g/mile for the base-metal oxidation catalyst system; from 0.72 to 4.2 g/mile for the platinum oxidation system; and from 0.43 to 1.85 g/mile for the Ethyl lean reactor system. When ambient temperature was increased from 75° to 95° F the increases in HC emission for the three vehicles were: 0.33 to 0.63 g/mile; 0.72 to 0.82 g/mile; and 0.43 to 0.47 g/mile, respectively.

3. Nitrogen oxides emission from the base-metal oxidation catalyst system and the platinum oxidation catalyst system was relatively insensitive to changes in ambient temperature. For the Ethyl lean reactor system, NO_x emission increased from 3.2 to 6.1 g/mile when ambient temperature decreased from 75° to 25° F and NO_x emission increased from 3.2 to 3.4 g/mile when ambient temperature increased from 75° to 95° F.

4. Aldehyde emission increased with decreasing ambient temperature over the range of temperatures tested for all three vehicles. As ambient temperature was decreased from 95° to 25° F aldehyde emission increased from: 22 to 41 mg/mile

for the base metal oxidation system; 19 to 36 mg/mile for the platinum oxidation system; and 12 to 63 mg/mile for the Ethyl lean reactor system.

IV. DESCRIPTION OF VEHICLES AND FUELS

A. Vehicles

The following is a description of the six vehicles used in the test program.

Car No. 403 - A 1972 Oldsmobile Delta 88 with a 455-cubic inch displacement (CID) engine and a 4-barrel carburetor. This car was furnished by General Motors Corporation. The emission control system included an air injection reactor (A.I.R.), a single bed catalytic converter with a base-metal catalyst, exhaust gas recirculation, a modified carburetor, and modified spark timing schedule. The vehicle had about 3,800 miles at the start of test and the catalyst mileage was about 650 miles.

Car No. 810 - A 1971 Ford LTD with a 351-CID engine and 2-barrel carburetor. This car was furnished by Esso Research and Engineering Company and was equipped with a thermal reactor system known as the RAM (Rapid Action Manifold) (1)[1/]. This system controls CO and HC by homogeneous oxidation effected by injection of secondary air into the net-rich exhaust, prior to its entry into the well-mixed reactors. Nitrogen oxides emission is controlled by a combination of fuel-rich carburetion, EGR, and spark retard. The vehicle and thermal reactors had about 5,100 miles at the start of testing.

Car No. 333 - A 1971 Plymouth Fury III with a 360-CID engine and 2-barrel carburetor. This car was furnished by Chrysler Corporation and was equipped with an air injection system and dual catalytic converters containing two elements each of platinum monolithic catalyst. This system also contained a modified carburetor, EGR, a water temperature switch to eliminate

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1/ Underlined numbers in parentheses refer to the list of references at the end of this report.

EGR and vacuum spark advance when coolant temperature was under 140° F, and a transmission governor pressure switch to cut out vacuum spark advance when vehicle speed was under 34 mph. The vehicle mileage was 57,200 miles, the left catalyst had 52,000 miles and the right catalyst had approximately 1,500 miles at the start of testing.

Car No. 724 - A 1972 Ford Torino with a 351-CID engine and 2-barrel carburetor. This vehicle was furnished by Ford Motor Company and was equipped with an air injection system, dual platinum oxidation catalysts, modified carburetor, and modified spark timing schedule. The vehicle had about 6,400 miles and the catalyst mileage was about 4,000 miles.

Car No. 775 - A 1971 Plymouth Fury III with a 360-CID engine. This vehicle was furnished by Ethyl Corporation and was equipped with the lean reactor system. The system incorporated an experimental high velocity carburetor, modified intake manifold with improved carburetor quick-heat system, automatic starting sequence device, thermal reactors, and EGR. This system was essentially the same as that described in the Aerospace report (2) with the exception of the quick-heat system and the automatic start sequence device. The car and reactor mileage was 13,600 miles.

Car No. 58 - A 1970 Chevrolet Impala with a 350-CID engine and 4-barrel carburetor. This vehicle was furnished by Esso Research and Engineering Company and was equipped with a dual catalyst system consisting of two GEM Monel NO_x reduction catalysts and two platinum oxidation catalysts. The system used a modified carburetor to provide constant air-fuel ratio control but did not incorporate EGR. The car mileage was 17,900 miles and the catalyst mileage was about 1,400 miles.

B. Fuels

The experimental program called for three different fuels: (1) a high aromatic fuel, (2) a midrange aromatic fuel, and (3) a high alkylate fuel. At the start of the program a high aromatic fuel was blended to 35 pct aromatic and was designated typical clear I (fuel No. 7202). This fuel was used in the first two vehicles tested (cars 403 and 810). Following testing of the first two cars, it was decided that the typical clear (or high aromatic) fuel should be closer to the composition that was projected for 1975 by the Bonner and Moore study (3). A second typical clear fuel designated typical clear II (fuel No. 7221) was obtained by adding toluene to fuel 7202 to increase the aromatic content to 40 pct and n-butane to maintain the Reid vapor pressure (RVP) at about 9 psi. Fuel 7221 was used as the high aromatic fuel in the last four vehicles tested (cars 333, 724, 775, and 58). Fuel inspection data for all the fuels used in the program are given in table 1.

V. DESCRIPTION OF THE EXPERIMENTAL PROGRAM

The experimental program consisted of two parts: (1) a fuel study to determine the influence of fuel composition on mass emissions and exhaust hydrocarbon composition, and (2) a temperature study to determine the effect of ambient temperature on emission characteristics of the low emission systems.

In the fuel study all six test vehicles were used and were operated on the high aromatic, midrange aromatic, and high alkylate fuels. All tests were conducted at 75° F ambient temperature and three replicate tests were made for each vehicle and fuel combination.

For the temperature study, three of the six vehicles were selected and emission tests were made at 25°, 45°, and 95° F ambient temperature. (The 75° F fuel study data was also used in the temperature study.) The three vehicles selected for the temperature study were: Car 403 equipped with a base-metal catalyst and EGR, car 724 equipped with two platinum catalysts and EGR, and car 775 equipped with the Ethyl lean reactor system and EGR.

In the temperature study, car 403 was operated on the high aromatic, midrange aromatic, and high alkylate fuels. Cars 724 and 775 were operated on the high aromatic and high alkylate fuels. Three replicate tests were made with each vehicle, fuel, and temperature combination.

TABLE 1. - Fuel inspection data

	Typical clear I (7202)	Typical clear II (7221)	Indolene clear (7203)	High alkylate (7212)
RVP........................	8.8	9.1	9.0	9.1
Specific gravity.............	.745	.755	.720	.704
API gravity..................	58.4	55.7	65.0	69.5
Octane number, research method......................	91	93	91	94
Distillation, °F				
IBP.........................	93	96	92	96
10 pct evaporated...........	133	136	128	136
50 pct evaporated...........	221	224	204	213
90 pct evaporated...........	325	322	302	296
End point...................	396	390	372	386
Composition, vol pct (FIA)				
Aromatics..................	33	39	21	8
Olefins....................	9	8	10	8
Paraffins..................	58	53	69	84
Composition, vol pct (GLC)				
Aromatics..................	35	40	22	10
Olefins....................	9	7	11	9
Paraffins..................	56	53	67	81

The emissions measured for both the fuel and temperature studies were: Mass emissions of CO, total hydrocarbons, NO_x, and aldehydes. In addition, the exhaust samples were chromatographically analyzed for the various hydrocarbons.

VI. EXPERIMENTAL PROCEDURES

A. Test Procedures

All vehicle tests were run on a chassis dynamometer with the vehicles operated on the 1975 Federal test cycle and exhaust samples collected using a constant volume sampling (CVS) system. The vehicles were preconditioned prior to all tests by operating the vehicle at 50 miles per hour cruise for 10 minutes at the test temperature and on the fuel to be used. This preconditioning was then followed by at least a 12-hour soak at the test temperature before the start of the test. The fueling procedure for the vehicles was different for the first two vehicles tested (cars 403 and 810) than that used later on in the program. Cars 403 and 810 were fueled from the vehicle tank and all vehicle tests on each fuel were conducted before using the next fuel. This method was abandoned (after testing the first two cars) because of the mileage accumulation between tests using different fuels and therefore making it difficult to differentiate between fuel effects and drift in vehicle and/or emission control equipment. For example, car 403 was used in both the fuel and temperature studies which involved a total of 12 tests on each fuel. Including both the preconditioning and test runs this could amount to over 200 miles of driving on one fuel before changing to the next fuel. For car 403, three replicate emission tests were conducted using fuel 7202 at the end of testing on this car to obtain a measure of system deterioration. Results of these tests will be discussed in the experimental results section of this report. The last four vehicles tested were fueled from separate cans and the fuels were run in random order as far as possible. The evaporative emission control canisters on the last four vehicles, when present, were disconnected.

B. Exhaust Sampling and Analysis

Exhaust samples were collected in accordance with the 1975 Federal test procedure. All bag samples were analyzed for CO, carbon dioxide (CO_2), NO_x, and HC. The analytical methods were: nondispersive infrared (NDIR) for CO and CO_2; chemiluminescence for NO_x; and flame ionization detection (FID) for total HC. Hydrocarbon distributions were determined using a chromatographic system described by Seizinger and Dimitriades (4). In order to reduce the uncertainty of the chromatographic peak identification for the C_3-C_5 hydrocarbons, a second chromatographic analysis was performed for each exhaust sample after a portion of the sample was passed through a palladium sulfate-sulfuric acid scrubber (5) to remove unsaturated hydrocarbons.

During each vehicle test, a constant flow of diluted (CVS) exhaust gas was passed through a heated line to an aldehyde collection train.

Aldehydes were determined for each segment of the 1975 Federal test procedure by the MBTH method (6). Aldehydes were also determined (using a parallel sampling train) by the DNPH method for two out of the three replicate tests.

One sample for the DNPH method (7) was collected for each test and data were expressed in terms of the 1972 Federal test procedure.

VII. EXPERIMENTAL RESULTS

A. Fuel Study

All six vehicles were used to study the effect of fuel composition on emissions. Mass emission data for the six cars are summarized in table 2 and plotted in figures 1 and 2. Data for individual bags and individual replicate tests are given in Appendix A. The following discussion will refer to fuel composition in terms of fuel aromaticity, however, it should be noted that an increase in fuel aromaticity also corresponds to an increase in fuel density.

TABLE 2. - Summary data on influence of fuel composition on mass emissions from prototype low emission vehicles 1/

Fuel	Emissions, grams/mile			
	Carbon monoxide	Hydro-carbon	Nitrogen oxides 2/	Aldehydes (MBTH)
1972 OLDSMOBILE DELTA 88 (CAR 403) WITH A 455-CID ENGINE AND EQUIPPED WITH A BASE-METAL OXIDATION CATALYST AND EGR				
Typical clear I, 35 percent aromatic (7202)...	7.06	0.33	1.30	0.030
Indolene clear, 22 percent aromatic (7203)...	8.77	.43	1.25	.040
High alkylate, 10 percent aromatic (7212)...	10.6	.50	1.27	.043
1971 FORD LTD (CAR 810) WITH A 351-CID ENGINE AND EQUIPPED WITH ESSO RAM REACTORS AND EGR				
Typical clear I, 35 percent aromatic (7202)...	9.35	0.17	0.95	0.0094
Indolene clear, 22 percent aromatic (7203)...	6.89	.11	.69	.0075
High alkylate, 10 percent aromatic (7212)...	9.03	.13	.71	.0082
1971 PLYMOUTH FURY III (CAR 333) WITH A 360-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR				
Typical clear II, 40 percent aromatic (7221)...	6.36	0.40	2.46	0.037
Indolene clear, 22 percent aromatic (7203)...	6.79	.39	2.24	.038
High alkylate, 10 percent aromatic (7212)...	6.56	.50	2.15	.046

See footnotes at end of table.

TABLE 2. - Summary data on influence of fuel composition on mass emissions from prototype low emission vehicles 1/—Continued

Fuel	Emissions, grams/mile			
	Carbon monoxide	Hydrocarbon	Nitrogen oxides 2/	Aldehydes (MBTH)
1972 FORD TORINO (CAR 724) WITH A 351-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR				
Typical clear II, 40 percent aromatic (7221)...	6.32	0.72	2.35	0.019
Indolene clear, 22 percent aromatic (7203)...	6.06	.79	2.01	.021
High alkylate, 10 percent aromatic (7212)...	6.74	.86	1.87	.024
1971 PLYMOUTH FURY III (CAR 775) WITH A 360-CID ENGINE AND EQUIPPED WITH THE ETHYL LEAN REACTORS AND EGR				
Typical clear II, 40 percent aromatic (7221)...	5.01	0.43	3.15	0.016
Indolene clear, 22 percent aromatic (7203)...	4.28	.44	2.70	.016
High alkylate, 10 percent aromatic (7212)...	4.08	.36	2.64	.018
1970 CHEVROLET IMPALA (CAR 58) WITH A 350-CID ENGINE AND EQUIPPED WITH GEM MONEL NO_x REDUCTION CATALYSTS AND PLATINUM OXIDATION CATALYSTS				
Typical clear II, 40 percent aromatic (7221)...	2.12	0.30	0.45	0.011
Indolene clear, 22 percent aromatic (7203)...	2.59	.34	.49	.010
High alkylate, 10 percent aromatic (7212)...	2.75	.40	.55	.011

1/All tests were conducted at 75° F ambient temperature. Data are weighted in accordance with the 1975 Federal test procedure and each value represents the average of three replicate tests.

2/NO_x data are corrected for humidity to 75 grains H_2O per lb of dry air.

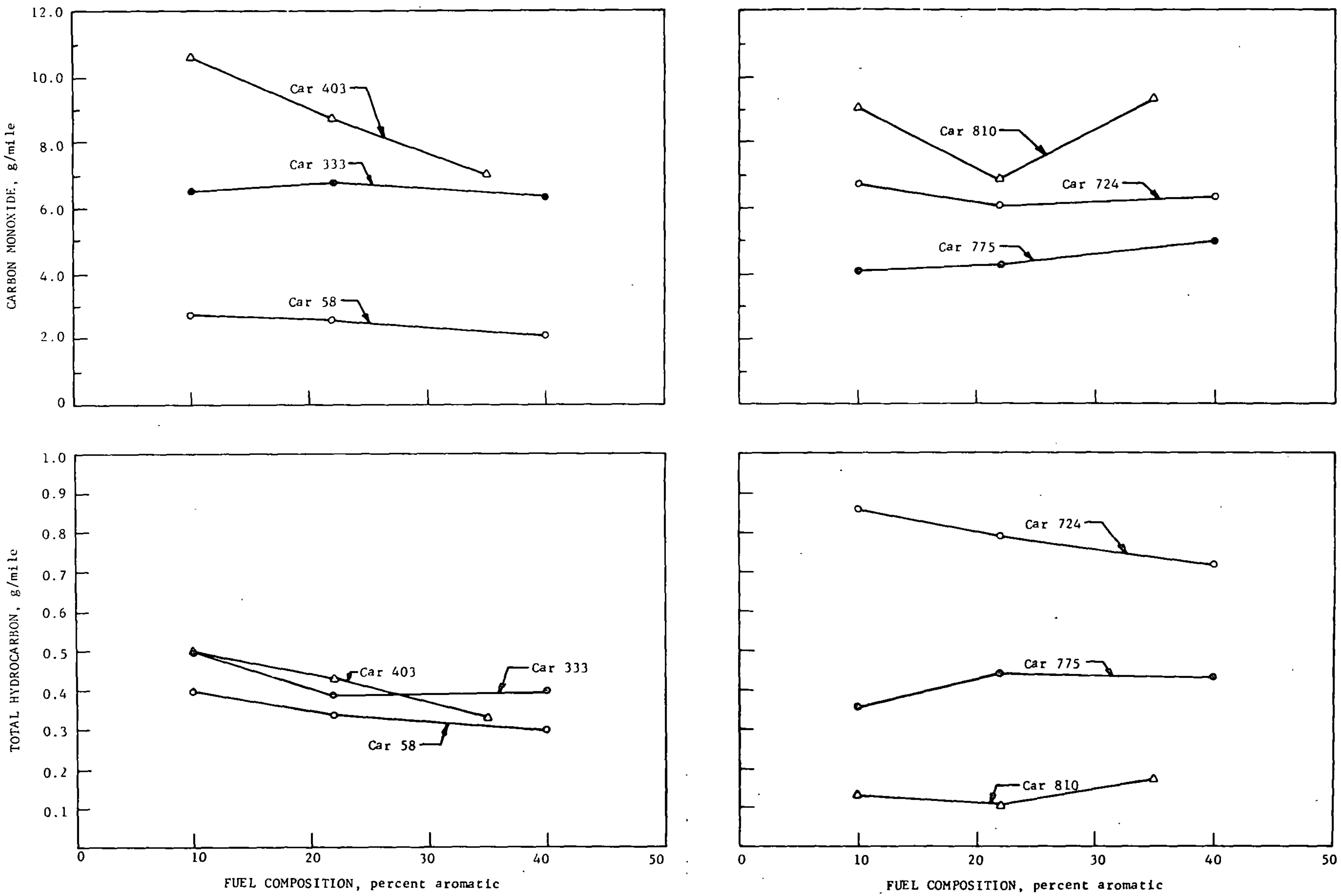

FIGURE 1. - The Influence of Fuel Composition on Carbon Monoxide and Total Hydrocarbon Emissions from Prototype Low Emission Systems

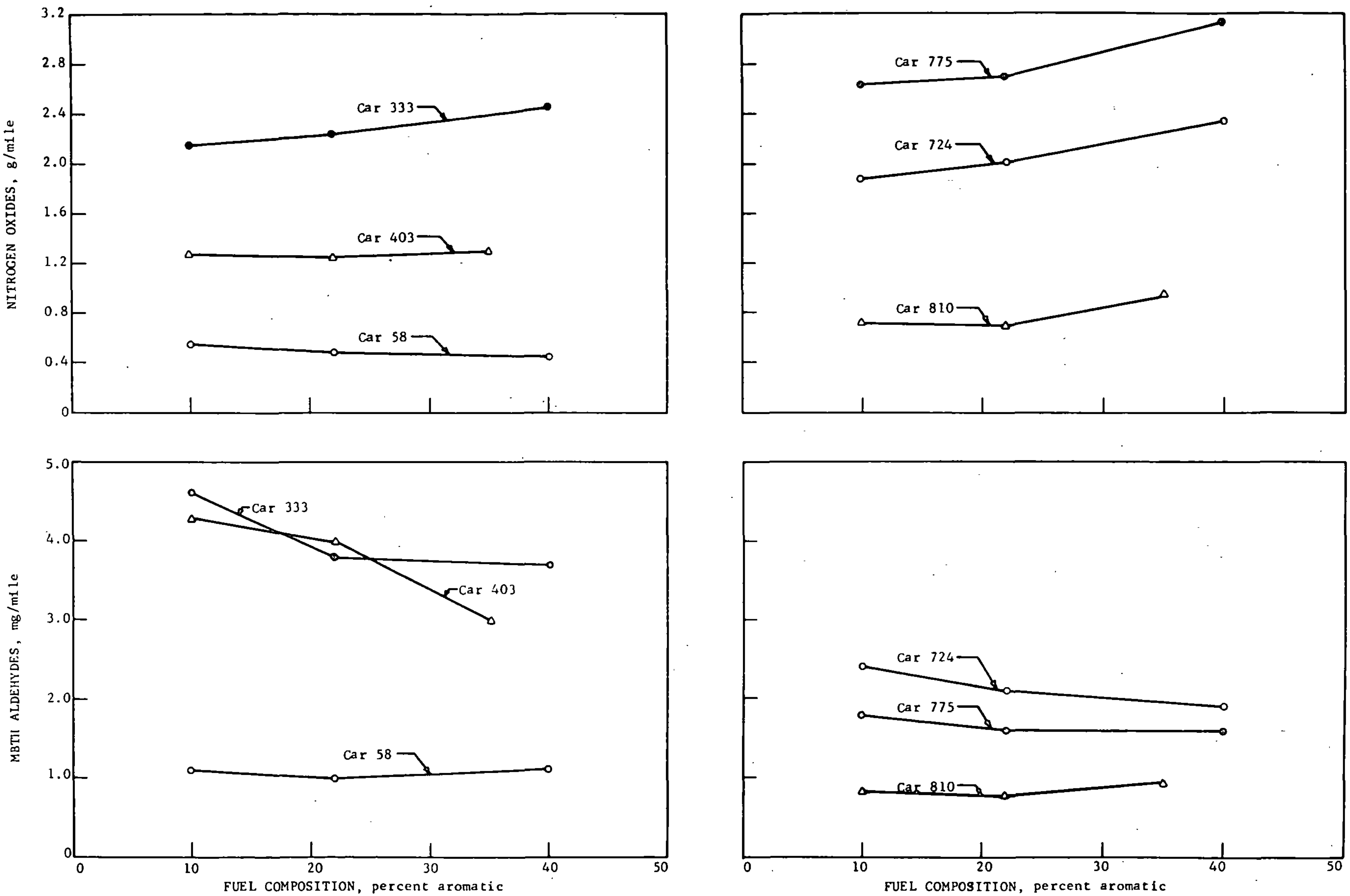

FIGURE 2. - The Influence of Fuel Composition on Nitrogen Oxides and Aldehyde Emissions from Prototype Low Emission Systems

Since changes in fuel density can affect carburetor metering, some of the change in emissions with fuel composition could possibly be due to variation in air-fuel ratio because of changing fuel density. This is particularly true in the case of CO and HC emissions which are strongly influenced by air-fuel ratio.

Three of the six vehicles tested showed a trend of changing CO emission with fuel aromaticity (table 2 and figure 1). The average CO emission for car 403 (base-metal oxidation catalyst and EGR) increased from 7.1 g/mile for a 35 pct aromatic fuel to 10.6 g/mile for a 10 pct aromatic fuel. This is the order in which the fuels were run in this vehicle, so some of the increase in CO could be attributed to system deterioration. To obtain some measure of system deterioration, three replicate tests were conducted at the end of testing of car 403 on fuel 7202. The results of the initial and final tests on fuel 7202 are compared below:

Exhaust component	Emissions, g/mile	
	Initial tests	Final tests
Carbon monoxide	7.06	8.63
Hydrocarbon	.33	.40
Nitrogen oxides	1.30	1.48

The results indicate that CO and HC emissions had increased about 20 pct and NO_x emission increased about 14 pct. Since the vehicle had been driven only about 875 miles between the initial and final tests, one would not expect significant deterioration of catalyst performance. Since CO, HC, and NO_x emissions increased with mileage, it appears that deterioration in catalyst performance was not the cause of the increased emissions. There was no check made to determine whether any other part of the system had changed such as air-fuel ratio, EGR rate, etc. At any rate, these results suggest that the observed changes in emissions with fuel composition are probably not due to fuel effects alone. For car 775 (Ethyl lean reactor), the average CO emission decreased from 5.0 g/mile for a 40 pct aromatic fuel to 4.1 g/mile for the 10 pct aromatic fuel. The average CO emission for car 58 (Esso dual catalyst system) was 2.1 g/mile for the 40 pct aromatic fuel and increased to 2.8 g/mile for the 10 pct aromatic fuel.

Three of the six vehicles tested showed an increase in HC emission with decreasing fuel aromaticity; the other three vehicles showed no significant effect of fuel aromaticity on HC emission (table 2 and figure 1). Average HC emissions from car 403 (base-metal oxidation catalysts system) increased from 0.33 to 0.50 g/mile; HC from car 724 (platinum oxidation catalyst system) increased from 0.72 to 0.86 g/mile and HC from car 58 (Esso dual catalyst system) increased from 0.30 to 0.40 g/mile when aromatics in the fuel decreased from 40 (35 for car 403) to 10 pct.

Three of the six vehicles tested (cars 333, 724, and 775) showed a trend of decreasing NO_x emissions with decreasing aromatics in the fuel. The decrease in NO_x emission from these three vehicles was from 13 to 20 pct when the fuel aromaticity decreased from 40 to 10 pct (table 2 and figure 2). Car 58 (dual catalyst system) showed a 22 pct increase in NO_x emission when the aromaticity in the fuel decreased from 40 to 10 pct. The other two vehicles showed no consistent trend in NO_x emission with fuel composition.

Aldehyde emissions (by MBTH method) from the six vehicles ranged from 0.008 to 0.046 g/mile (table 2). Aldehydes ranged from 2.6 to 9.7 pct of the total organic emissions. This compares to 5 to 10 pct for conventional vehicles (8). Results indicate (table 2 and figure 2) that aldehyde emission from the base-metal oxidation catalyst system (car 403) increased about 43 pct (from 0.030 to 0.043 g/mile) as fuel aromaticity was decreased from 35 to 10 pct. Aldehyde emission from the two platinum oxidation catalyst systems (cars 333 and 724) increased about 25 pct when fuel aromaticity decreased from 40 to 10 pct. For the other three vehicles, aldehyde emission did not change in a consistent trend with changes in fuel composition.

Data on the influence of fuel composition on exhaust hydrocarbon distribution are summarized in table 3. The data for all tests are shown in Appendix B.

TABLE 3. - Summary data on the influence of fuel composition on hydrocarbon distribution in exhaust from prototype low emission vehicles[1]

Fuel	Total HC emissions, g/mile	HC distribution, wt pct of total HC								
		Paraffins			Olefins			Aromatics		Acetylenes
		Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
1972 OLDSMOBILE DELTA 88 (CAR 403) WITH A 455-CID ENGINE AND EQUIPPED WITH A BASE-METAL OXIDATION CATALYST AND EGR										
Typical clear I, 35 percent aromatic (7202)..	0.33	6.6	16.2	23.9	20.9	8.6	0.9	7.7	13.6	1.6
Indolene clear, 22 percent aromatic (7203)..	.43	11.0	16.3	24.3	20.0	8.5	1.7	6.0	8.6	3.6
High alkylate, 10 percent aromatic (7212)..	.50	16.0	12.9	29.4	18.0	11.2	2.3	2.9	4.0	3.3
1971 FORD LTD (CAR 810) WITH A 351-CID ENGINE AND EQUIPPED WITH ESSO RAM REACTORS AND EGR										
Typical clear I, 35 percent aromatic (7202)..	0.17	11.3	7.6	22.9	7.4	7.9	3.1	4.5	27.5	7.8
Indolene clear, 22 percent aromatic (7203)..	.11	12.2	8.9	24.6	9.9	10.7	3.2	4.3	18.0	8.2
High alkylate, 10 percent aromatic (7212)..	.13	22.1	6.3	24.4	10.2	12.0	2.0	1.8	8.5	12.7

See footnotes at end of table.

TABLE 3. - Summary data on the influence of fuel composition on hydrocarbon distribution in exhaust from prototype low emission vehicle 1/—Continued

Fuel	Total HC emissions, g/mile	HC distribution, wt pct of total HC								
		Paraffins			Olefins			Aromatics		Acetylenes
		Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
1971 PLYMOUTH FURY III (CAR 333) WITH A 360-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR										
Typical clear II, 40 percent aromatic (7221)..	0.40	21.4	9.5	14.9	8.9	10.5	1.9	5.8	25.1	2.0
Indolene clear, 22 percent aromatic (7203)..	.39	26.0	11.4	19.0	10.4	12.3	1.6	3.9	12.6	2.8
High alkylate, 10 percent aromatic (7212)..	.50	23.3	10.2	30.1	8.6	14.5	2.9	1.5	6.2	2.7
1972 FORD TORINO (CAR 724) WITH A 351-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR										
Typical clear II, 40 percent aromatic (7221)..	0.72	16.7	16.9	17.8	6.0	8.1	1.9	4.2	25.7	2.7
Indolene clear, 22 percent aromatic (7203)..	.79	17.3	21.0	25.1	6.2	9.4	2.1	3.2	12.3	3.4
High alkylate, 10 percent aromatic (7212)..	.86	22.3	16.4	28.9	6.7	11.6	2.1	1.3	5.4	5.3

See footnotes at end of table.

TABLE 3. - Summary data on the influence of fuel composition on hydrocarbon distribution in exhaust from prototype low emission vehicle 1/—Continued

Fuel	Total HC emissions, g/mile	HC distribution, 25 pct of total HC								
		Paraffins			Olefins			Aromatics		Acetylenes
		Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
1971 PLYMOUTH FURY III (CAR 775) WITH A 360-CID ENGINE AND EQUIPPED WITH THE ETHYL LEAN REACTORS AND EGR										
Typical clear II, 40 percent aromatic (7221)..	0.43	5.3	17.1	16.0	10.0	11.3	2.1	5.0	23.2	10.0
Indolene clear, 22 percent aromatic (7203)..	.44	4.4	23.2	22.9	10.1	14.5	2.7	3.5	9.9	8.8
High alkylate, 10 percent aromatic (7212)..	.36	6.7	19.9	24.0	12.2	16.7	2.4	1.7	5.5	10.9
1970 CHEVROLET IMPALA (CAR 58) WITH A 350-CID ENGINE AND EQUIPPED WITH GEM MONEL NO_x REDUCTION CATALYSTS AND PLATINUM OXIDATION CATALYSTS										
Typical clear II, 40 percent aromatic (7221)..	0.30	38.3	11.6	12.9	4.6	7.2	1.0	3.7	20.3	0.4
Indolene clear, 22 percent aromatic (7203)..	.34	44.2	12.0	15.6	5.3	7.9	.9	2.5	9.7	1.9
High alkylate, 10 percent aromatic (7212)	.40	51.3	11.7	16.7	4.6	7.8	.9	1.1	4.9	1.0

1/ All tests were conducted at 75° F ambient temperature. Data are weighted in accordance with the 1975 Federal test procedure and each value represents the average of three replicate tests.

The change in aromatics in the fuel had very little effect on exhaust hydrocarbon distribution except for methane and C_{7+} aromatics. Ethylene and C_3-C_5 olefin emissions showed an increase with respect to decreasing aromatics in the fuel for some of the cars (figure 3). C_3-C_5 olefins in the exhaust from the base-metal oxidation catalyst system (car 403) increased from 0.028 to 0.056 g/mile when fuel aromaticity decreased from 40 to 10 pct. For cars 333 and 724 (the two platinum oxidation systems), aldehyde emissions increased from 0.042 to 0.072 g/mile and 0.058 to 0.100 g/mile, respectively, as fuel aromaticity decreased from 40 to 10 pct. Results from car 58 (dual catalyst system) and cars 810 and 775 (thermal reactor systems) showed no effect of fuel aromatics on olefin emissions.

All the catalyst cars showed an increase in methane emission with decreasing fuel aromaticity (figure 4). Methane from car 403 (base-metal oxidation catalyst system) increased about 267 pct (0.022 to 0.080 g/mile) as fuel aromaticity decreased from 35 to 10 pct. Methane from cars 333 and 724 (platinum oxidation catalyst systems) increased about 36 pct (0.086 to 0.12 g/mile) and about 59 pct (0.12 to 0.19 g/mile), respectively, as fuel aromaticity decreased from 40 to 10 pct. Methane from car 58 (dual catalyst system) increased about 78 pct (0.11 to 0.20 g/mile) as fuel aromaticity was decreased from 40 to 10 pct. Methane emission for the two thermal reactor systems was independent of fuel aromatics.

All six cars showed a decrease in C_{7+} aromatic emission with decreasing aromatics in the fuel (figure 4) with decreases in C_{7+} aromatics ranging from 55 to 80 pct when fuel aromaticity decreased from 40 to 10 pct. Car 775 (Ethyl lean reactor system) showed the largest decrease,(in terms of pct decrease) with C_{7+} aromatics in the exhaust decreasing from 0.10 g/mile for a 40 pct aromatic fuel to 0.02 g/mile for a 10 pct aromatic fuel. The smallest decrease was with car 403 (base metal oxidation catalyst system) where C_{7+} aromatics in the exhaust decreased from 0.045 to 0.02 g/mile when fuel aromaticity decreased from 35 to 10 pct.

Total olefin content in terms of weight percent of total HC ranged from 13 pct for car 58 to 31 pct for

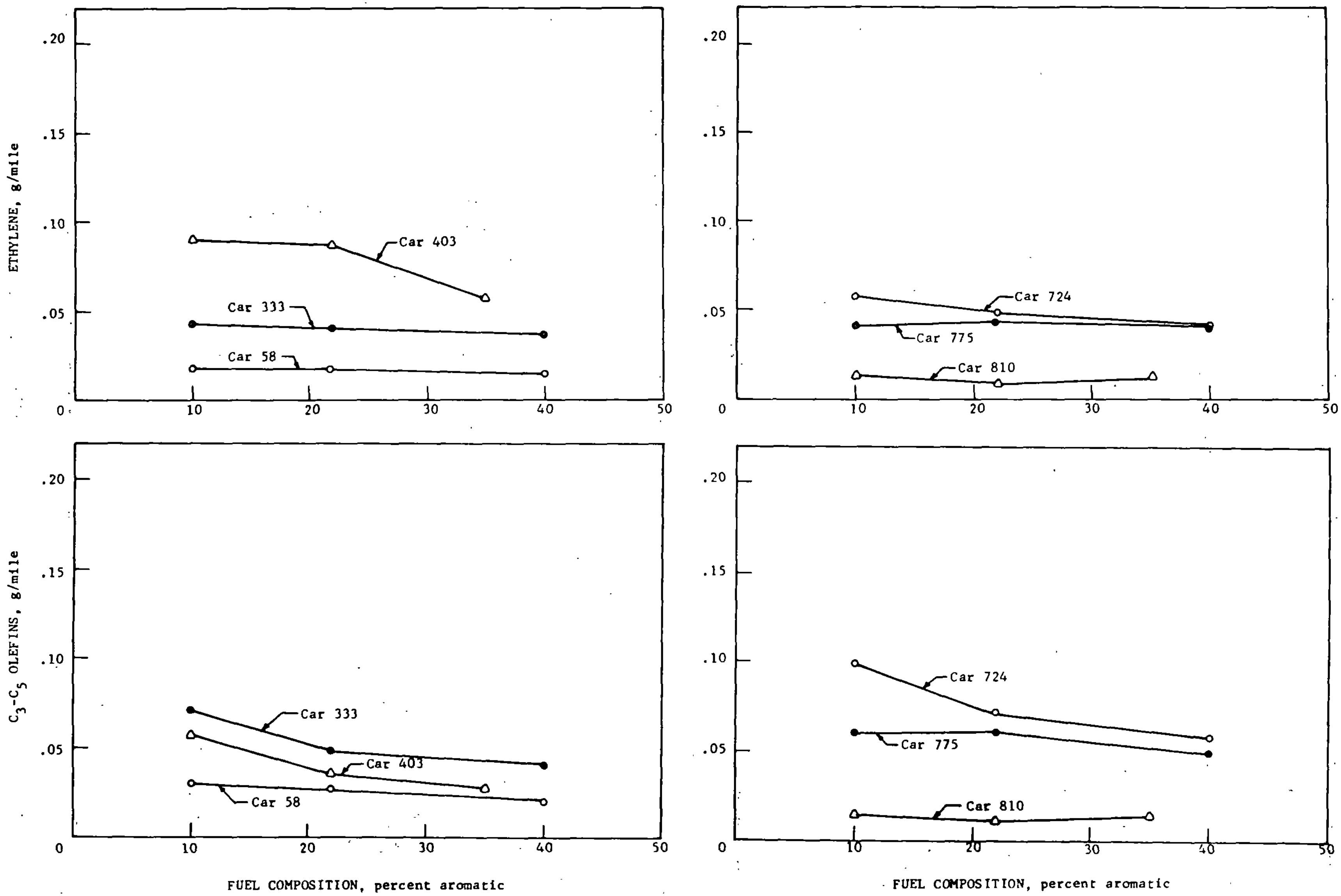

FIGURE 3. - The Influence of Fuel Composition on Ethylene and C_3-C_5 Olefin Emissions from Prototype Low-Emission Systems

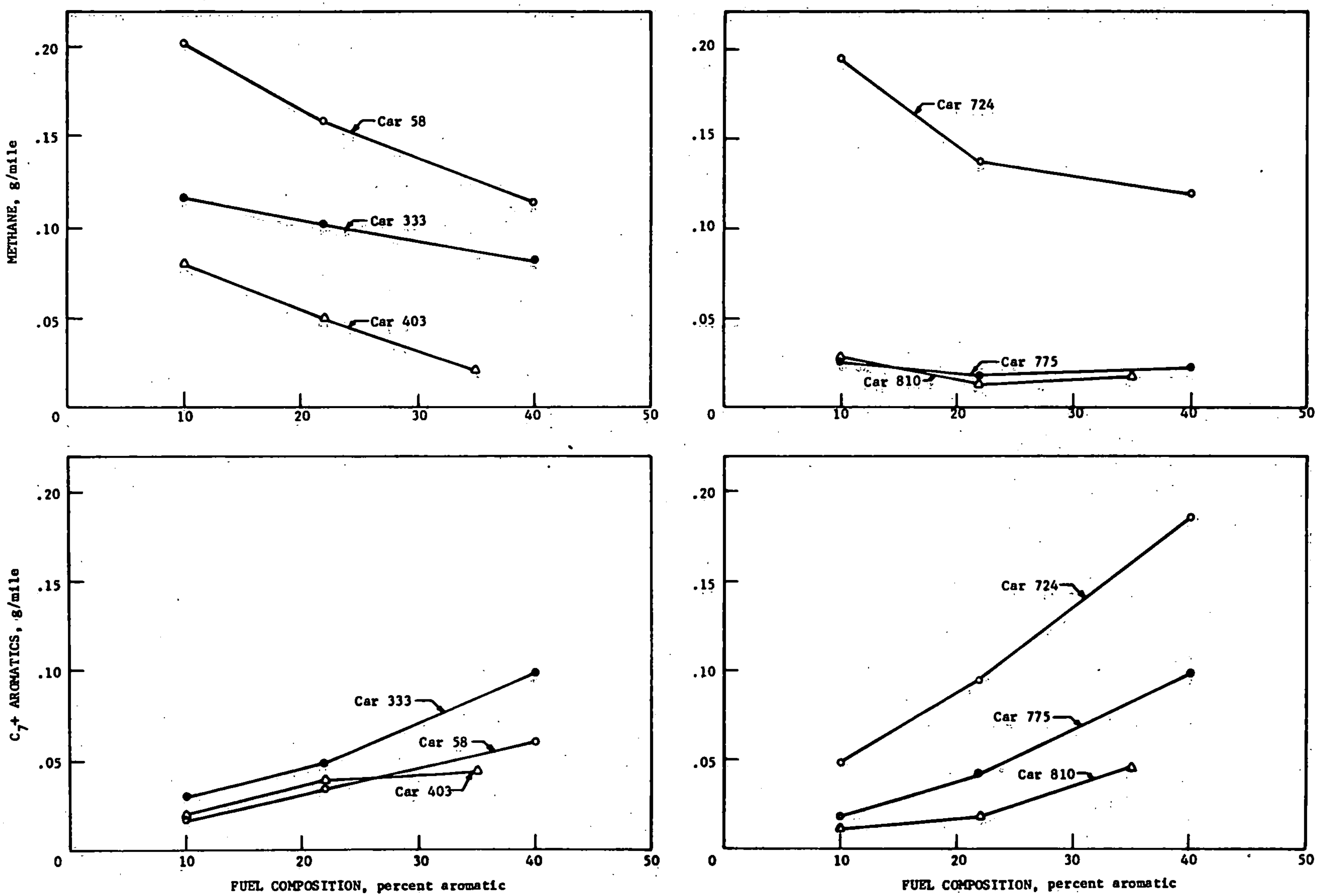

FIGURE 4. - The Influence of Fuel Composition on Methane and C_{7+} Aromatic Emissions from Prototype Low-Emission Systems

car 403 (table 3) which corresponds to a range of 10 to 37 mole pct. This compares with results from Wigg (9) which shows olefins for conventional vehicles ranging from 25 to 35 mole pct with fuel aromatics from 10 to 40 pct.

B. Temperature Study

Three of the six cars were selected for use in the temperature study: (1) car 403, a base-metal catalyst with EGR, (2) car 724, a platinum catalyst with EGR, and (3) car 775, the Ethyl lean reactor system. Emission tests were conducted at 25°, 45°, and 95° F ambient temperature, and the 75° F data from the fuel study was also used.

Results on mass emissions from the temperature study are summarized in table 4 and the results are shown in figures 5 and 6 for the high-aromatic and high-alkylate fuels, respectively. Data for individual bag samples and individual replicate tests are in Appendix C. Emissions (figures 5 and 6) of CO, HC, and NO_x were lowest at 75° F ambient temperature. The emissions increased when the ambient temperature was either higher or lower than 75° F. The increase in CO and HC was much greater when the ambient temperature was decreased from 75° F than when it was increased to 95° F. Results for car 724 (figure 5) showed the largest increase in CO and HC emission (from 6.3 to 66.4 g/mile for CO and 0.72 to 4.2 g/mile for HC) when the ambient temperature was lowered from 75° to 25° F. This extremely large increase in CO and HC emissions with lower temperature for car 724 is primarily due to an increase in emissions during the cold start portion of the cycle (see Appendix C, table C-2). All indications were that the mixture was rich during the earlier part of the warmup due to the choke action. That is, the choke stayed on a longer period of time at the lower temperature. The emissions from this car at the lower temperature could probably be reduced significantly with modifications in the choke system.

Car 775 showed a substantial increase in NO_x emission (figures 5 and 6) at the lower temperature. For example, NO_x emission increased from 3.2 to 6.1 g/mile

TABLE 4. - Summary data on the influence of ambient temperature on mass emissions from prototype low emission systems 1/

Fuel	Ambient temperature, °F	Emissions, grams/mile			
		Carbon monoxide	Hydro-carbon	Nitrogen oxides 2/	Aldehydes (MBTH)
1972 OLDSMOBILE DELTA 88 (CAR 403) WITH A 455-CID ENGINE AND EQUIPPED WITH A BASE-METAL OXIDATION CATALYST AND EGR					
Typical clear I, 35 percent aromatic (7202)	25	13.5	0.82	1.63	0.041
	45	11.2	.45	1.72	.041
	75	7.06	.33	1.30	.030
	95	12.0	.63	1.61	.022
Indolene clear, 22 percent aromatic (7203)	25	15.8	0.62	1.40	0.039
	45	12.9	.44	1.50	.037
	75	8.77	.43	1.25	.040
	95	15.1	.52	1.37	.025
High alkylate, 10 percent aromatic (7212)	25	17.6	0.89	1.43	0.037
	45	11.2	.59	1.32	.038
	75	10.6	.50	1.27	.043
	95	16.5	.58	1.26	.021
1972 FORD TORINO (CAR 724) WITH A 351-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR					
Typical clear II, 40 percent aromatic (7221)	25	66.4	4.23	2.62	0.036
	45	38.2	2.36	3.12	.030
	75	6.32	.72	2.35	.019
	95	5.25	.82	2.45	.019
High alkylate, 10 percent aromatic (7212)	25	67.3	4.97	2.07	0.052
	45	44.4	3.31	2.42	.045
	75	6.74	.86	1.87	.024
	95	8.32	1.06	1.91	.026

See footnotes at end of table.

TABLE 4. - Summary of data on the influence of ambient temperature on mass emissions from prototype low emission systems 1/—Continued

Fuel	Ambient temperature, °F	Emissions, grams/mile			
		Carbon monoxide	Hydro-carbon	Nitrogen oxides 2/	Aldehydes (MBTH)
1971 PLYMOUTH FURY III (CAR 775) WITH A 360-CID ENGINE AND EQUIPPED WITH THE ETHYL LEAN REACTORS AND EGR					
Typical clear II, 40 percent aromatic (7221)	25	25.1	1.85	6.10	0.063
	45	10.8	.74	5.38	.042
	75	5.01	.43	3.15	.016
	95	4.49	.47	3.38	.012
High alkylate, 10 percent aromatic (7212)	25	26.0	2.15	4.75	0.054
	45	9.60	.77	4.41	.050
	75	4.08	.36	2.64	.018
	95	5.21	.63	2.72	.019

1/ Data are weighted in accordance with the 1975 Federal test procedure and each value represents the average of three replicate tests.

2/ For 75° and 95° F ambient temperature tests, NO_x data are corrected for humidity to 75 grains H_2O per lb of dry air; for 25° and 45° F ambient temperature tests, NO_x data are uncorrected for humidity.

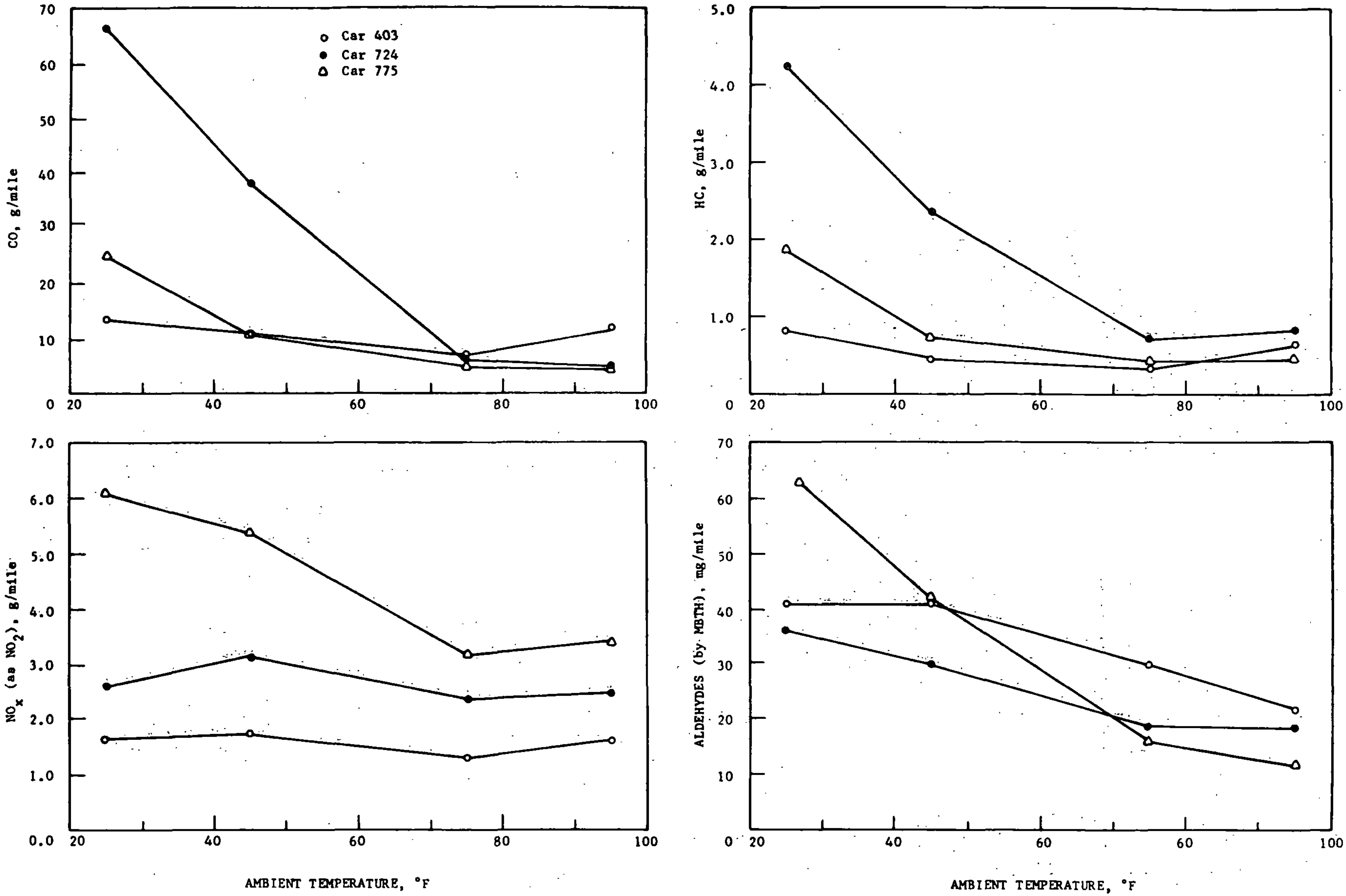

FIGURE 5. - The Influence of Ambient Temperature on Mass Emissions from Prototype Low-Emission Systems (Vehicles Operated on High Aromatic Fuels; Car 403 on Fuel 7202 and Cars 724 and 775 on Fuel 7221)

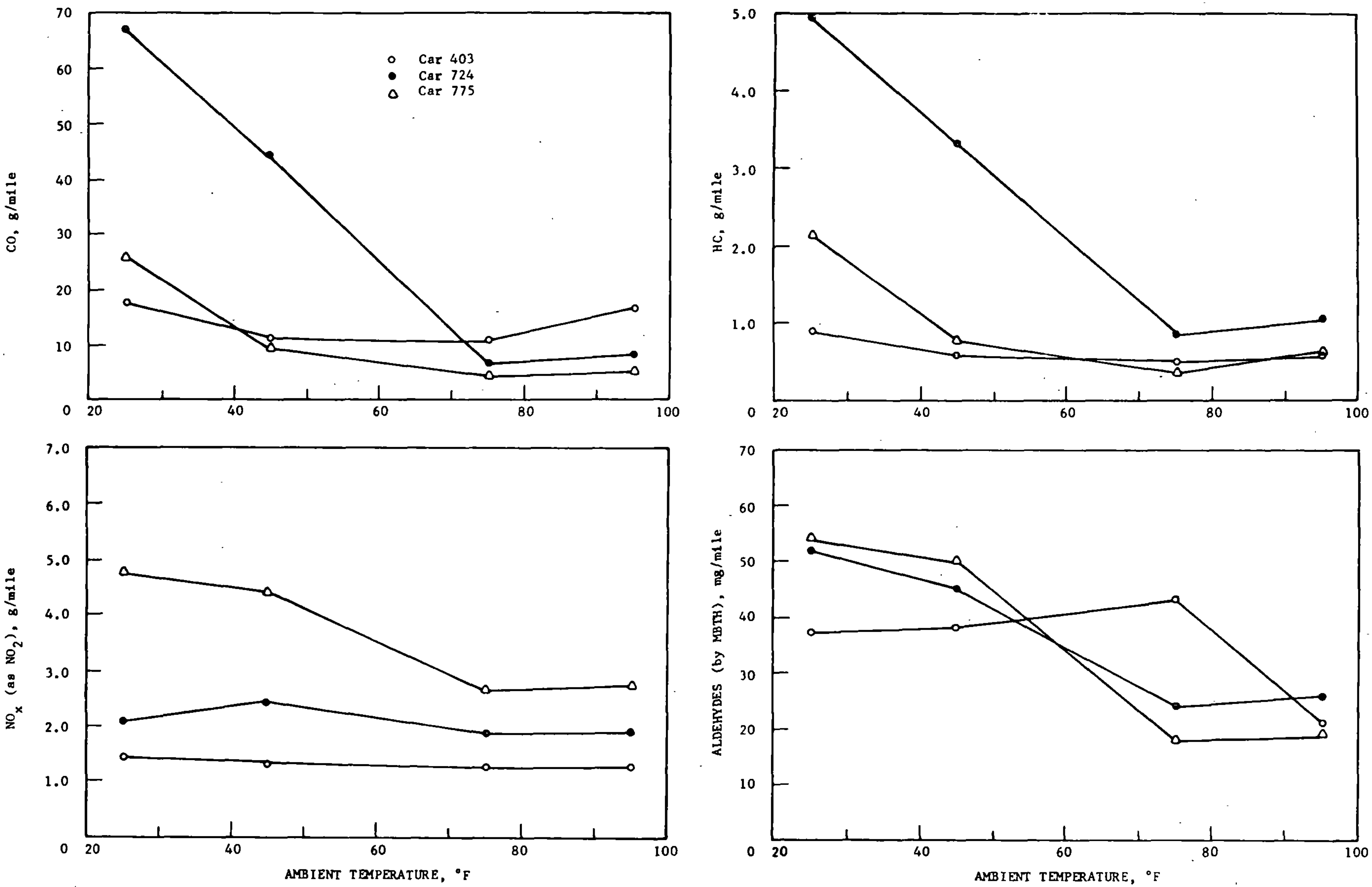

FIGURE 6. - The Influence of Ambient Temperature on Mass Emissions from Prototype Low-Emission Systems [Vehicles Operated on High Alkylate Fuel (7212)]

when ambient temperature decreased from 75° to 25° F. This is because the system was designed to have EGR cut off at the lower temperature. Apparently, the 25° and 45° F ambient temperatures were borderline cases (i.e., when the EGR cut off was about to take place) because some tests showed high NO_x and others low NO_x (see individual replicate tests, Appendix C, table C-6).

Aldehyde emissions (figures 5 and 6) for the three cars increased from 7.5 to 42.5 pct as ambient temperature was decreased from 95° to 25° F. One exception was car 403 (for the high alkylate fuel) which showed a slight decrease (about 14 pct) in aldehydes when ambient temperature changed from 75° to 25° F.

Results on HC distribution for the temperature study are summarized in table 5 and the complete set of data for all tests are in Appendix D. No particular trends with respect to ambient temperature were noted for the HC distribution except for car 724 (platinum oxidation catalyst) and car 775 (lean reactor) in which the weight fraction of C_2-C_5 paraffins appears to decrease with decreasing ambient temperature. However, if these data were expressed as mass emissions it would show the C_2-C_5 paraffins at a minimum somewhere in the range of 45° to 75° F ambient temperature.

C. Comparison of MBTH and DNPH Methods for Aldehyde Measurement

Aldehyde measurements using the DNPH method were made on two out of the three replicate tests for each vehicle, fuel, and temperature combination. Because of the large sample required and the time required for sample analysis, the samples for the DNPH method were collected and data were calculated in accordance with the 1972 Federal test procedure. Results for the MBTH method were also calculated on the basis of the 1972 Federal test procedure (by combining results of bags 1 and 2 of the 1975 procedure) for comparison. Comparison data from the MBTH and DNPH methods are given in Appendix E. The results from the two methods are shown as a function of aromatics in the fuel in figure 7. The results show that the aldehydes measured by the DNPH method averaged about 44 pct higher than those measured by the MBTH

TABLE 5. - Summary of data on the influence of ambient temperature on hydrocarbon distribution in exhaust from prototype low emission systems 1/

Fuel	Ambient temperature, °F	Total HC emissions, g/mile	Hydrocarbon distribution, weight percent								
			Paraffins			Olefins			Aromatics		Acetylenes
			Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
1972 OLDSMOBILE DELTA 88 (CAR 403) WITH A 455-CID ENGINE AND EQUIPPED WITH A BASE-METAL OXIDATION CATALYST AND EGR											
Typical clear I,	25	0.82	6.8	12.4	26.7	11.3	6.2	3.0	5.2	24.9	3.5
35 percent	45	.45	9.4	14.5	21.2	20.5	8.4	1.1	7.2	15.0	2.7
aromatic (7202)	75	.33	6.6	16.2	23.9	20.9	8.6	.9	7.7	13.6	1.6
	95	.63	5.6	13.2	31.5	10.2	4.5	2.4	4.7	27.1	.8
Indolene clear,	25	0.62	12.6	13.2	22.2	18.4	10.0	1.2	6.2	10.6	5.6
22 percent	45	.44	11.2	13.7	23.7	21.5	9.6	2.0	6.3	8.2	3.8
aromatic (7203)	75	.43	11.0	16.3	24.3	20.0	8.5	1.7	6.0	8.6	3.6
	95	.52	13.9	18.6	27.4	13.4	7.8	2.6	5.2	9.9	1.2
High alkylate,	25	0.89	15.5	11.7	33.1	13.2	10.0	2.2	2.0	3.4	8.9
10 percent	45	.59	14.0	12.8	31.3	17.1	11.2	2.7	2.3	3.7	4.9
aromatic (7212)	75	.50	16.0	12.9	29.4	18.0	11.2	2.3	2.9	4.0	3.3
	95	.58	15.6	15.4	36.3	12.8	8.7	3.1	2.1	5.0	1.0
1972 FORD TORINO (CAR 724) WITH A 351-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR											
Typical clear II,	25	4.23	16.1	6.2	14.5	7.0	6.7	2.0	4.3	32.5	10.7
40 percent	45	2.36	20.3	6.2	11.9	8.1	6.2	1.4	4.4	28.1	13.4
aromatic (7221)	75	.72	16.7	16.9	17.8	6.0	8.1	1.9	4.2	25.7	2.7
	95	.82	14.4	20.4	18.1	5.5	9.7	1.9	4.4	23.3	2.3
High alkylate,	25	4.97	21.8	7.2	27.1	8.2	11.1	2.1	1.8	7.1	13.6
10 percent	45	3.31	24.9	6.7	22.2	9.0	10.4	1.7	1.7	5.7	17.7
aromatic (7212)	75	.86	22.3	16.4	28.9	6.7	11.6	2.1	1.3	5.4	5.3
	95	1.06	20.3	21.7	30.0	6.2	10.3	2.0	1.5	5.4	2.6

See footnotes at end of table.

TABLE 5. - Summary of data on the influence of ambient temperature on hydrocarbon distribution in exhaust from prototype low emission systems 1/—Continued

Fuel	Ambient temperature, °F	Total HC emissions, g/mile	Hydrocarbon distribution, weight percent								
			Paraffins			Olefins			Aromatics		Acetylenes
			Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
1971 PLYMOUTH FURY III (CAR 775) WITH A 360-CID ENGINE AND EQUIPPED WITH THE ETHYL LEAN REACTORS AND EGR											
Typical clear II, 40 percent aromatic (7221)	25	1.85	8.5	8.4	16.2	9.5	9.6	2.0	4.7	30.4	10.7
	45	.74	7.5	8.6	13.0	12.6	11.0	1.4	5.8	30.0	10.1
	75	.43	5.3	17.1	16.0	10.0	11.3	2.1	5.0	23.2	10.0
	95	.47	3.5	25.5	20.1	6.7	11.1	2.8	3.7	19.8	6.8
High alkylate, 10 percent aromatic (7212)	25	2.15	13.1	8.0	33.5	9.3	12.7	2.7	1.6	7.1	12.0
	45	.77	9.2	8.7	27.6	14.0	19.5	2.3	2.0	6.3	10.4
	75	.36	6.7	19.9	24.0	12.2	16.7	2.4	1.7	5.5	10.9
	95	.63	5.6	24.0	33.8	7.7	11.3	3.1	1.3	5.7	7.5

1/ Data are weighted in accordance with the 1975 Federal test procedure and each value represents the average of three replicate tests.

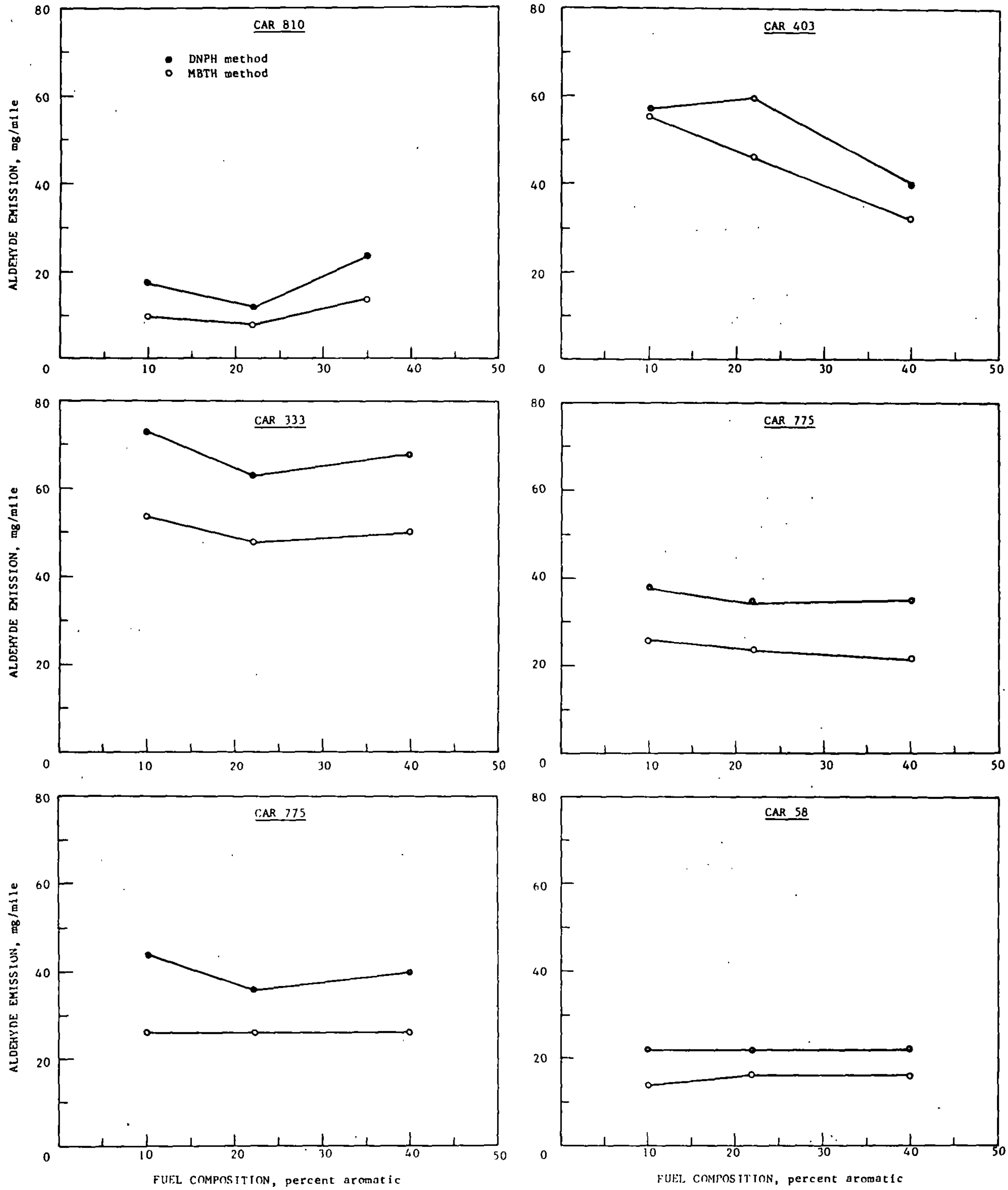

FIGURE 7. - Comparison of DNPH and MBTH Methods for Measurement of Aldehyde Emissions Using Fuels of Varied Aromatic Content (Data are expressed in Terms of the 1972 Federal Test Procedure)

method. Since the MBTH method is known to be less sensitive to aromatic aldehydes than the DNPH method, the difference could in part be due to aromatic aldehydes in the exhaust. This, however, is not clearly known because the actual aldehyde distribution for the exhaust is unknown.

VIII. COMPARISON OF RESULTS FROM THIS PROGRAM WITH THE RESULTS OF OTHER INVESTIGATIONS

The results of this study showed a trend of increasing C_{7+} aromatics in the exhaust with increasing aromatics in the fuel. This result, in general, is in agreement with that reported by Wigg (9). If aromatics are expressed as a mole fraction of total HC, the Esso RAM reactor vehicle shows a somewhat stronger fuel effect than the catalyst equipped vehicles. This was also reported in reference 9.

Results of this study showed a very slight decrease in C_3-C_5 olefins in the exhaust with increasing fuel aromatics. Wigg (9) reported that there was no fuel effect on exhaust olefins. It should be noted that for the two Esso cars used in this program (RAM reactor and dual catalyst systems) there was no effect of fuel aromatics on exhaust olefins which is in agreement with that reported by Wigg (9).

Results of a temperature study done by General Motors Engineering staff (10) involving four prototype low-emission systems showed that CO emissions (expressed in terms of the 1972 Federal test procedure) were from 4 to 21 g/mile at 75° F ambient temperature and CO emissions increased by factors of 1.1 to 9.3 as the ambient temperature was lowered to 25° F. The three cars (cars 403, 724, and 775) used in the Bureau of Mines study emitted from 7.4 to 10.1 g/mile of CO at 75° F ambient temperature when expressed in terms of the 1972 Federal test procedure. Carbon monoxide emissions increased by factors of 2.8, 14.8, and 7.2 for cars 403, 724, and 775, respectively, when ambient temperature was lowered to 25° F. Hydrocarbon emission from the four cars in the GM study (10) ranged from 0.30 to 0.47 g/mile at 75° F ambient temperature and increased by factors of 1.02 to 4.86 as the ambient temperature was lowered to 25° F. Results from the Bureau of Mines study showed that HC emissions were 0.43, 0.81, and 0.63 g/mile in terms of the 1972 Federal test procedure for cars 403, 724, and 775, respectively, at

75° F ambient temperature. The HC values increased by factors of 3.7, 11.2, and 6.4 for cars 403, 724, and 775, respectively, as ambient temperature was decreased to 25° F. The effect of ambient temperature on CO and HC emissions for cars 403 and 775 compares reasonably well with the results of the GM study (10), but the CO and HC emissions from cars 724 were affected much stronger by ambient temperature than that of the prototype cars tested in the GM study (10).

Engelhard Industries (11) reported that with a vehicle operating at 30 mph cruise the hydrocarbons are removed by the PTX platinum catalyst by the following percentages:

Hydrocarbon	Fresh catalyst (After 500 miles)	Aged catalyst (After 50,000 miles)
Acetylenes	100.0	100.0
Olefins	99.1	93.7
Aromatics	99.1	93.4
Paraffins:		
Methane	11.3	9.6
Other paraffins	93.9	36.8

Since only tailpipe emissions were determined in the Bureau of Mines study, it was impossible to determine the conversion efficiencies of the various emission control systems. Therefore, a comparison of data between the Engelhard study and the Bureau of Mines study was not possible.

The amount of methane relative to total HC in the exhaust from several prototype emission control systems (operating on a cold-start cycle) have been reported and are listed below and compared to results of the Bureau of Mines study.

Type of system	Reference	Methane in the exhaust, mole %
Thermal reactor (DuPont)	(12)	25.8
GM (2 catalytic cars)	(12)	46.9
Wayne State University (catalytic system)	(12)	47.5
Universal Oil Products (2 base-metal catalyst systems)	(12)	37.8
Esso RAM thermal reactor	(13)	22.4
Esso dual catalyst	(13)	74.5
Car 403 (base-metal catalyst)	This report	17.0
Car 810 (Esso RAM thermal reactor)	This report	30.9
Car 333 (platinum catalyst)	This report	51.0
Car 724 (platinum catalyst)	This report	44.1
Car 775 (Ethyl lean reactor)	This report	15.8
Car 58 (Esso dual catalyst)	This report	70.3

The results of the Bureau of Mines' study were computed using data obtained with the high aromatic fuels. The methane results from cars used in this study are in the range of those determined by other researchers with the exception of cars 403 (base-metal catalyst system) and 775 (Ethyl lean reactor system). Methane in the exhaust from these two systems was lower than that reported for other systems. The low methane in exhaust from the lean reactor would be predicted because of lean air-fuel ratio, since it is known that lean combustion produces less methane than rich combustion.

The only data that is directly comparable to data in this report are those reported by Esso Research and Engineering Co. (13) because the same systems were used in both studies. According to Esso, hydrocarbons in the exhaust from the RAM thermal reactor was 22.4 mole pct methane which compares to 30.9 mole pct methane for the Bureau of Mines' study. The Esso study showed that the exhaust hydrocarbons from the dual catalyst system was 74.5 mole pct methane which compares to 70.3 mole pct methane from the Bureau of Mines' study.

Universal Oil Products Company reported (14) that exhaust hydrocarbon from an oxidation catalytic converter was 29.5 weight pct methane when the converter was mounted on a Ford 6-cylinder engine and the exhaust HC was 60.0 weight pct methane when the converter was mounted on a Ford V-8 engine. Both engines were operated at 30 miles per hour cruise. The methane in the exhaust from the six cars tested in the Bureau of Mines' study on the 1975 Federal test procedure ranged from 6.6 to 38.3 weight pct. Since the cold-start test (1975 Federal test procedure) yields HC in the first few seconds which has significant quantities of unburned fuel, one would expect that the relative amount of methane would be lower for a cold-start test when compared with a 30 miles per hour cruise test.

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APPENDIX A -- DATA ON THE INFLUENCE OF FUEL COMPOSITION ON MASS EMISSIONS FROM PROTOTYPE LOW EMISSION SYSTEMS

TABLE A-1. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the fuel study 1/

Fuel	Bag number	Emissions, grams/test			
		Carbon monoxide	Hydrocarbon	Nitrogen oxides 2/	Aldehydes (MBTH)
1972 OLDSMOBILE DELTA 88 (CAR 403) WITH A 455-CID ENGINE AND EQUIPPED WITH A BASE-METAL OXIDATION CATALYST AND EGR					
Typical clear I, 35 percent aromatic (7202)	1	72.4	2.29	4.52	0.19
		89.0	3.08	3.53	.18
		48.9	2.32	4.89	.14
	Avg..	70.1	2.56	4.31	.17
	2	4.86	0.57	5.22	0.086
		5.52	.69	4.73	.11
		4.67	.67	5.41	.071
	Avg..	5.02	.64	5.12	.089
	3	30.8	1.19	4.90	0.10
		39.2	1.29	4.06	.13
		23.6	1.12	5.61	.09
	Avg..	31.2	1.20	4.86	.11
Indolene clear, 22 percent aromatic (7203)	1	79.5	2.63	4.91	0.24
		103	4.13	4.42	.24
		92.4	4.17	4.35	.22
	Avg..	91.7	3.64	4.56	.23
	2	6.36	0.72	5.35	0.12
		5.12	.70	4.85	.13
		5.93	.71	5.06	.095
	Avg..	5.80	.71	5.09	.12
	3	34.9	1.83	3.31	0.16
		43.3	1.52	4.90	.14
		30.1	1.59	4.10	.13
	Avg..	36.1	1.65	4.10	.14
High alkylate, 10 percent aromatic (7212)	1	93.6	4.14	4.29	0.28
		103	3.93	4.94	.30
		91.3	4.67	3.76	.28
	Avg..	96.0	4.25	4.33	.29
	2	4.98	0.74	4.90	0.13
		3.50	.76	5.10	.10
		3.55	.99	4.74	.14
	Avg..	4.01	.83	4.91	.12
	3	63.8	1.62	5.33	0.13
		66.3	1.96	5.13	.13
		49.6	2.13	4.16	.15
	Avg..	59.9	1.90	4.87	.14

See footnotes at end of table.

TABLE A-1. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the fuel study 1/--Continued

Fuel	Bag number	Emissions, grams/test			
		Carbon monoxide	Hydrocarbon	Nitrogen oxides 2/	Aldehydes (MBTH)
1971 FORD LTD (CAR 810) WITH A 351-CID ENGINE AND EQUIPPED WITH ESSO RAM REACTORS AND EGR					
Typical clear I, 35 percent aromatic (7202)	1	117	1.69	5.00	0.085
		102	2.99	4.76	.086
		104	2.15	5.48	.070
	Avg..	108	2.28	5.08	.080
	2	15.0	0.09	2.56	0.020
		8.56	.03	2.69	.0087
		7.26	.06	2.88	.0069
	Avg..	10.3	.06	2.71	.012
	3	20.0	0.30	4.12	0.033
		23.5	.39	4.10	.048
		26.8	.65	3.49	.049
	Avg..	23.4	.45	3.90	.043
Indolene clear, 22 percent aromatic (7203)	1	51.3	0.71	4.38	0.056
		62.2	1.48	3.92	.048
		55.7	1.09	3.26	.032
	Avg..	56.4	1.09	3.85	.045
	2	11.1	0.08	1.87	0.027
		18.0	.09	2.06	.019
		16.4	.04	1.92	.005
	Avg..	15.2	.07	1.95	.017
	3	20.6	0.34	2.97	0.048
		23.3	.53	2.46	.039
		20.7	.46	2.53	.026
	Avg..	21.5	.44	2.65	.038
High alkylate, 10 percent aromatic (7212)	1	122	2.57	4.23	0.083
		94.9	1.05	4.03	.049
		104	1.97	3.86	.062
	Avg..	107	1.86	4.04	.065
	2	11.1	0.01	1.99	0.0078
		7.54	.02	2.22	.015
		10.4	.03	2.14	.016
	Avg..	9.68	.02	2.12	.013
	3	24.9	0.48	2.71	0.042
		20.7	.28	2.58	.031
		18.6	.37	2.61	.036
	Avg..	21.4	.38	2.63	.036

See footnotes at end of table.

TABLE A-1. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the fuel study 1/--Continued

Fuel	Bag number	Emissions, grams/test: Carbon monoxide	Hydrocarbon	Nitrogen oxides 2/	Aldehydes (MBTH)
1971 PLYMOUTH FURY III (CAR 333) WITH A 360-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR					
Typical clear II, 40 percent aromatic (7221)	1	52.8	3.79	11.9	0.31
		51.6	3.12	12.4	.25
		43.3	2.67	11.0	.23
	Avg..	49.2	3.19	11.8	.26
	2	15.9	1.12	7.28	0.11
		12.1	.92	6.27	.082
		12.2	.86	5.83	.10
	Avg..	13.4	.97	6.46	.10
	3	25.4	1.22	12.0	0.12
		21.8	1.15	13.1	.12
		21.8	1.10	11.4	.12
	Avg..	23.0	1.16	12.2	.12
Indolene clear, 22 percent aromatic (7203)	1	49.2	2.34	11.4	0.25
		52.1	2.04	11.1	.25
		41.5	2.46	11.4	.24
	Avg..	47.6	2.28	11.3	.25
	2	14.1	0.97	5.64	0.10
		13.0	.90	6.03	.11
		11.8	.89	5.96	.10
	Avg..	13.0	.92	5.88	.10
	3	31.2	1.56	9.12	0.14
		29.6	1.50	12.0	.13
		31.3	2.18	10.9	.14
	Avg..	30.7	1.75	10.7	.14
High alkylate, 10 percent aromatic (7212)	1	56.4	4.84	9.18	0.32
		78.3	3.78	9.52	.28
		49.6	3.37	11.9	.30
	Avg..	61.4	4.00	10.2	.30
	2	13.3	1.27	5.24	0.13
		11.0	1.16	5.36	.11
		10.2	1.12	5.84	.13
	Avg..	11.5	1.18	5.48	.12
	3	23.2	1.70	10.2	0.17
		17.8	1.40	11.7	.14
		18.4	1.35	11.1	.15
	Avg..	19.8	1.48	11.0	.15

See footnotes at end of table.

TABLE A-1. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the fuel study 1/--Continued

Fuel	Bag number	Emissions, grams/test: Carbon monoxide	Hydrocarbon	Nitrogen oxides 2/	Aldehydes (MBTH)
1972 FORD TORINO (CAR 724) WITH A 351-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR					
Typical clear II, 40 percent aromatic (7221)	1	70.8	5.41	10.6	0.11
		68.8	4.50	9.88	.11
		58.1	3.99	11.1	.09
	Avg..	65.9	4.63	10.5	.10
	2	12.0	1.52	6.55	0.054
		11.1	1.70	7.39	.070
		6.32	1.19	7.90	.050
	Avg..	9.81	1.47	7.28	.058
	3	17.8	3.49	10.0	0.071
		13.0	2.90	10.1	.085
		17.9	3.66	10.6	.066
	Avg..	16.2	3.35	10.2	.074
Indolene clear, 22 percent aromatic (7203)	1	72.8	4.55	10.1	0.12
		53.7	4.03	9.99	.12
		44.0	3.76	10.2	.12
	Avg..	56.8	4.11	10.1	.12
	2	9.57	1.50	5.64	0.057
		11.8	1.64	5.96	.061
		11.2	1.49	5.81	.060
	Avg..	10.9	1.54	5.80	.059
	3	16.5	4.71	8.37	0.070
		17.9	4.73	8.91	.072
		18.7	4.13	8.42	.074
	Avg..	17.7	4.52	8.57	.072
High alkylate, 10 percent aromatic (7212)	1	65.4	5.37	8.61	0.11
		68.5	4.53	10.1	.13
		73.3	5.44	8.53	.12
	Avg..	69.1	5.11	9.07	.12
	2	9.40	1.80	5.30	0.067
		13.4	2.07	5.57	.081
		12.2	1.99	5.55	.100
	Avg..	11.7	1.95	5.47	.083
	3	15.4	4.30	8.23	0.084
		19.4	4.93	8.07	.092
		13.8	2.71	8.20	.084
	Avg..	16.2	3.98	8.17	.087

See footnotes at end of table.

TABLE A-1. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the fuel study 1/--Continued

Fuel	Bag number	Emissions, grams/test			
		Carbon monoxide	Hydrocarbon	Nitrogen oxides 2/	Aldehydes (MBTH)
1971 PLYMOUTH FURY III (CAR 775) WITH A 360-CID ENGINE AND EQUIPPED WITH THE ETHYL LEAN REACTORS AND EGR					
Typical clear II, 40 percent aromatic (7221)	1	46.8	4.11	14.0	0.19
		43.2	3.89	13.1	.18
		53.0	5.64	11.7	.19
	Avg..	47.7	4.55	13.0	.19
	2	8.15	0.17	11.0	0.011
		7.73	.15	10.1	.0091
		6.58	.15	9.74	.020
	Avg..	7.49	.16	10.3	.013
	3	21.0	1.89	14.8	0.049
		14.8	2.16	13.0	.057
		14.4	1.74	13.2	.041
	Avg..	16.7	1.93	13.7	.049
Indolene clear, 22 percent aromatic (7203)	1	32.1	2.79	11.5	0.20
		34.6	3.78	10.6	.17
		37.5	3.84	12.2	.17
	Avg..	34.7	3.47	11.5	.18
	2	7.76	0.11	9.33	0.0090
		7.02	.14	8.14	.010
		6.90	.11	9.17	.010
	Avg..	7.23	.12	8.88	.010
	3	18.0	2.66	12.5	0.062
		18.7	3.29	9.30	.068
		15.4	2.69	11.9	.059
	Avg..	17.4	2.88	11.2	.063
High alkylate, 10 percent aromatic (7212)	1	37.6	3.31	10.5	0.19
		32.5	2.84	10.4	.17
		34.1	2.98	10.3	.19
	Avg..	34.7	3.04	10.4	.18
	2	7.36	0.13	8.18	0.021
		6.57	.10	7.74	.011
		6.57	.11	8.23	.030
	Avg..	6.83	.11	8.05	.021
	3	18.6	2.04	10.8	0.063
		13.8	3.00	13.0	.057
		14.0	1.78	14.5	.059
	Avg..	15.5	2.27	12.8	.060

See footnotes at end of table.

TABLE A-1. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the fuel study 1/--Continued

Fuel	Bag number	Emissions, grams/test			
		Carbon monoxide	Hydrocarbon	Nitrogen oxides 2/	Aldehydes (MBTH)
1970 CHEVROLET IMPALA (CAR 58) WITH A 350-CID ENGINE AND EQUIPPED WITH GEM MONEL NO_x REDUCTION CATALYSTS AND PLATINUM OXIDATION CATALYSTS					
Typical clear II, 40 percent aromatic (7221)	1	22.3	1.90	2.35	0.081
		28.7	3.11	2.49	.094
		29.6	2.21	2.98	.095
	Avg..	26.9	2.41	2.61	.090
	2	2.14	0.69	1.12	0.032
		1.85	.57	1.41	.031
		2.50	.80	1.62	.031
	Avg..	2.16	.69	1.38	.031
	3	3.77	0.89	1.24	0.025
		3.24	.84	1.61	.022
		4.34	1.00	1.79	.016
	Avg..	3.78	.91	1.55	.021
Indolene clear, 22 percent aromatic (7203)	1	32.6	2.34	2.80	0.11
		43.9	3.29	2.91	.079
		38.5	2.40	3.03	.10
	Avg..	38.3	2.68	2.91	.096
	2	0.92	0.83	1.15	0.024
		1.68	.77	1.42	.028
		2.04	.94	1.59	.025
	Avg..	1.55	.85	1.39	.026
	3	1.63	1.03	1.49	0.021
		2.97	1.02	1.84	.013
		2.89	.94	1.92	.011
	Avg..	2.50	1.00	1.75	.015
High alkylate, 10 percent aromatic (7212)	1	35.8	2.42	2.99	0.088
		38.2	2.71	2.94	.075
		38.9	2.83	3.05	.127
	Avg..	37.6	2.65	2.99	.097
	2	2.34	1.08	2.12	0.040
		2.27	1.17	1.55	.011
		2.31	1.17	1.92	.039
	Avg..	2.31	1.14	1.86	.030
	3	5.32	1.29	1.82	0.028
		3.01	1.20	1.56	.012
		2.85	1.19	1.76	.023
	Avg..	3.73	1.23	1.71	.021

1/ All tests were conducted at 75° F ambient temperature.

2/ NO_x data are corrected for humidity to 75 grains H_2O per lb of dry air.

TABLE A-2. - Mass emissions for individual replicate tests for the fuel study 1/

[Data weighted in accordance with the 1975 Federal test procedure]

Fuel	Emissions, grams/mile			
	Carbon monoxide	Hydrocarbon	Nitrogen oxides 2/	Aldehydes (MBTH)
1972 OLDSMOBILE DELTA 88 (CAR 403) WITH A 455-CID ENGINE AND EQUIPPED WITH A BASE-METAL OXIDATION CATALYST AND EGR				
Typical clear I, 35 percent aromatic (7202)	7.14	0.30	1.33	0.031
	8.82	.37	1.14	.036
	5.22	.31	1.43	.024
Avg...	7.06	.33	1.30	.030
Indolene clear, 22 percent aromatic (7203)	8.06	0.39	1.25	0.043
	9.89	.45	1.27	.042
	8.37	.45	1.23	.035
Avg...	8.77	.43	1.25	.040
High alkylate, 10 percent aromatic (7212)	10.9	0.46	1.30	0.043
	11.4	.48	1.35	.040
	9.48	.56	1.16	.046
Avg...	10.6	.50	1.27	.043
1971 FORD LTD (CAR 810) WITH A 351-CID ENGINE AND EQUIPPED WITH ESSO RAM REACTORS AND EGR				
Typical clear I, 35 percent aromatic (7202)	10.3	0.13	0.94	0.010
	8.79	.21	.94	.0097
	8.97	.18	.96	.0087
Avg...	9.35	.17	.95	.0094
Indolene clear, 22 percent aromatic (7203)	5.99	0.08	0.73	0.010
	7.74	.14	.69	.0082
	6.95	.10	.64	.0045
Avg...	6.89	.11	.69	.0075
High alkylate, 10 percent aromatic (7212)	10.3	0.18	0.71	0.0090
	8.02	.08	.72	.0071
	8.77	.14	.71	.0084
Avg...	9.03	.13	.71	.0082

See footnotes at end of table.

TABLE A-2. - Mass emissions for individual replicate tests for the fuel study 1/--Continued

[Data weighted in accordance with the 1975 Federal test procedure]

Fuel	Emissions, grams/mile			
	Carbon monoxide	Hydrocarbon	Nitrogen oxides 2/	Aldehydes (MBTH)
1971 PLYMOUTH FURY III (CAR 333) WITH A 360-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR				
Typical clear II, 40 percent aromatic (7221)	7.08	0.46	2.56	0.041
	6.23	.39	2.54	.034
	5.76	.35	2.27	.036
Avg....	6.36	.40	2.46	.037
Indolene clear 22 percent aromatic (7203)	7.07	.38	2.10	0.038
	6.97	.35	2.35	.039
	6.33	.43	2.28	.038
Avg....	6.79	.39	2.24	.038
High alkylate, 10 percent aromatic (7212)	6.77	0.58	2.00	0.049
	7.31	.48	2.15	.042
	5.61	.45	2.30	.046
Avg....	6.56	.50	2.15	.046
1972 FORD TORINO (CAR 724) WITH A 351-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR				
Typical clear II, 40 percent aromatic (7221)	7.01	0.78	2.24	0.019
	6.41	.70	2.32	.022
	5.54	.67	2.50	.017
Avg....	6.32	.72	2.35	.019
Indolene clear, 22 percent aromatic (7203)	6.71	0.82	1.97	0.020
	6.01	.81	2.05	.021
	5.45	.73	2.00	.021
Avg....	6.06	.79	2.01	.021
High alkylate, 10 percent aromatic (7212)	6.17	0.88	1.83	0.022
	7.19	.91	1.93	.025
	6.87	.78	1.85	.026
Avg....	6.74	.86	1.87	.024

See footnotes at end of table.

TABLE A-2. - Mass emissions for individual replicate tests for the fuel study 1/--Continued

[Data weighted in accordance with the 1975 Federal test procedure]

Fuel	Emissions, grams/mile			
	Carbon monoxide	Hydrocarbon	Nitrogen oxides 2/	Aldehydes (MBTH)
1971 PLYMOUTH FURY III (CAR 775) WITH A 360-CID ENGINE AND EQUIPPED WITH THE ETHYL LEAN REACTORS AND EGR				
Typical clear II, 40 percent aromatic (7221)	5.37	0.40	3.40	0.016
	4.64	.41	3.09	.016
	5.01	.48	2.97	.017
Avg...	5.01	.43	3.15	.016
Indolene clear, 22 percent aromatic (7203)	4.25	0.38	2.86	0.018
	4.34	.49	2.40	.016
	4.24	.44	2.83	.015
Avg...	4.28	.44	2.70	.016
High alkylate, 10 percent aromatic (7212)	4.55	0.36	2.51	0.018
	3.79	.40	2.62	.016
	3.90	.32	2.79	.019
Avg...	4.08	.36	2.64	.018
1970 CHEVROLET IMPALA (CAR 58) WITH A 350-CID ENGINE AND EQUIPPED WITH GEM MONEL NO_x REDUCTION CATALYSTS AND PLATINUM OXIDATION CATALYSTS				
Typical clear II, 40 percent aromatic (7221)	1.85	0.27	0.38	0.011
	2.14	.32	.45	.011
	2.36	.31	.52	.011
Avg...	2.12	.30	.45	.011
Indolene clear, 22 percent aromatic (7203)	2.11	0.32	0.43	0.011
	2.97	.37	.50	.0092
	2.70	.34	.53	.010
Avg...	2.59	.34	.49	.010
High alkylate, 10 percent aromatic (7212)	2.77	0.38	0.59	0.012
	2.72	.40	.49	.0067
	2.76	.41	.57	.014
Avg...	2.75	.40	.55	.011

1/ All tests were conducted at 75° F ambient temperature.

2/ NO_x data are corrected for humidity to 75 grains H_2O per lb of dry air.

APPENDIX B -- DATA ON THE INFLUENCE OF FUEL COMPOSITION ON HYDROCARBON DISTRIBUTION IN EXHAUST FROM PROTOTYPE LOW EMISSION SYSTEMS

TABLE B-1. - Exhaust hydrocarbon distribution for individual bags of the 1975 Federal test procedure and individual replicate tests for the fuel study 1/

Fuel	Bag number	Total HC, grams/test	Hydrocarbon distribution, weight percent								
			Paraffins			Olefins			Aromatics		
			Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	Acetylenes
1972 OLDSMOBILE DELTA 88 (CAR 403) WITH A 455-CID ENGINE AND EQUIPPED WITH A BASE-METAL OXIDATION CATALYST AND EGR											
Typical clear I,	1	2.29	8.5	12.4	21.8	16.8	10.8	1.4	6.6	18.9	2.8
35 percent		3.08	10.5	9.1	24.6	14.0	9.3	2.1	6.0	19.3	5.1
aromatic		2.32	8.3	11.9	21.6	17.5	10.6	1.6	6.6	19.1	2.8
(7202)	Avg...	2.56	9.1	11.1	22.7	16.1	10.2	1.7	6.4	19.1	3.6
	2	0.57	0	20.4	24.7	31.0	6.1	0.2	11.4	6.2	0
		.69	1.0	15.2	31.5	26.3	8.4	.5	10.0	7.1	0
		.67	0	16.1	22.2	32.9	10.0	.2	10.6	8.0	0
	Avg...	.64	.3	17.2	26.1	30.1	8.2	.3	10.7	7.1	0
	3	1.19	7.4	25.5	23.3	19.3	5.8	0.4	6.7	11.6	0
		1.29	10.6	23.7	24.2	18.5	6.1	.2	6.7	10.0	0
		1.12	7.5	21.5	24.7	20.7	6.8	.3	7.7	10.8	0
	Avg...	1.20	8.5	23.6	24.1	19.5	6.2	.3	7.0	10.8	0
Indolene	1	2.63	12.0	12.8	23.3	17.9	11.7	2.5	5.6	10.8	3.4
clear,		4.13	11.7	9.2	28.2	13.3	9.1	3.3	4.6	13.4	7.2
22 percent		4.17	15.2	9.4	23.7	15.2	7.8	1.2	5.0	11.8	10.7
aromatic	Avg...	3.64	13.0	10.5	25.1	15.4	9.5	2.3	5.1	12.0	7.1
(7203)	2	0.72	3.6	20.4	23.5	30.4	6.7	0.9	7.7	6.8	0
		.70	5.6	17.9	20.3	33.7	8.9	.8	8.7	4.1	0
		.71	9.9	15.6	19.7	34.0	8.4	.8	9.1	2.5	0
	Avg...	.71	6.4	18.0	21.2	32.6	8.0	.8	8.5	4.5	0
	3	1.83	11.0	25.3	25.3	17.9	7.0	1.3	5.7	6.5	0
		1.52	11.1	24.9	24.8	18.5	7.7	1.1	5.8	6.1	0
		1.59	11.7	25.8	24.7	18.7	7.3	1.3	5.6	4.9	0
	Avg...	1.65	11.3	25.4	24.9	18.4	7.3	1.2	5.7	5.8	0
High alkylate,	1	4.15	13.6	8.1	32.2	13.5	11.1	3.4	2.7	7.4	8.0
10 percent		3.93	14.8	11.9	29.6	16.5	13.8	2.8	2.1	4.2	4.3
aromatic		4.67	17.0	11.3	28.5	14.7	12.4	3.3	2.2	3.6	7.0
(7212)	Avg...	4.25	15.1	10.4	30.1	14.9	12.5	3.2	2.3	5.1	6.4
	2	0.74	13.3	13.1	27.2	28.8	8.5	1.2	4.7	3.2	0
		.76	15.4	14.8	21.8	29.4	8.3	1.1	6.8	2.4	0
		.99	21.5	15.1	23.3	25.3	9.3	1.3	2.8	1.4	0
	Avg...	.83	16.7	14.3	24.1	27.9	8.7	1.2	4.8	2.3	0
	3	1.62	16.7	14.5	32.5	18.5	8.7	1.6	3.3	4.2	0
		1.96	18.7	11.3	31.8	15.5	15.9	1.6	2.3	2.8	.1
		2.13	14.6	23.2	33.5	14.3	7.6	1.8	2.1	2.9	0
	Avg...	1.90	16.7	16.3	32.7	16.1	10.7	1.6	2.6	3.3	0
1971 FORD LTD (CAR 810) WITH A 351-CID ENGINE AND EQUIPPED WITH ESSO RAM REACTORS AND EGR											
Typical clear I,	1	1.69	18.2	7.0	19.3	8.0	8.5	2.5	4.7	22.8	9.0
35 percent		2.99	8.3	8.1	24.9	5.1	8.2	4.2	4.3	30.3	6.6
aromatic		2.15	10.5	8.4	29.9	5.4	6.8	4.1	3.8	25.5	5.6
(7202)	Avg...	2.28	12.3	7.8	24.7	6.2	7.8	3.6	4.3	26.2	7.1
	2/2	.09	-	-	-	-	-	-	-	-	-
		.03	-	-	-	-	-	-	-	-	-
		.06	-	-	-	-	-	-	-	-	-
	Avg...	.06	-	-	-	-	-	-	-	-	-
	3	.30	6.2	7.3	17.6	12.8	7.6	1.1	6.0	32.5	8.9
		.39	4.2	7.2	20.4	10.4	8.2	1.0	5.9	34.2	8.5
		.65	10.4	6.0	14.2	12.6	7.8	1.0	4.6	30.5	12.9
	Avg...	.45	6.9	6.8	17.4	11.9	7.9	1.0	5.5	32.5	10.1
Indolene	1	.71	18.9	8.6	16.2	11.7	12.8	2.0	4.1	17.5	8.2
clear,		1.48	9.3	9.6	37.6	5.2	7.9	5.8	3.9	15.5	5.2
22 percent		1.09	15.8	8.4	29.0	7.3	8.9	3.8	4.0	14.5	8.3
aromatic	Avg...	1.09	14.7	8.9	27.5	8.1	9.9	3.9	4.0	15.8	7.2
(7203)	2/2	.08	-	-	-	-	-	-	-	-	-
		.09	-	-	-	-	-	-	-	-	-
		.04	-	-	-	-	-	-	-	-	-
	Avg...	.07	-	-	-	-	-	-	-	-	-
	3	.34	8.2	8.2	17.1	14.3	12.4	.8	5.3	24.5	9.2
		.53	7.4	10.1	17.0	13.6	14.4	3.1	4.6	18.7	11.1
		.46	8.8	9.2	22.1	11.7	10.5	1.7	4.5	21.9	9.6
	Avg...	.44	8.1	9.2	18.7	13.2	12.4	1.9	4.8	21.7	10.0
High alkylate,	1	2.57	19.6	6.7	26.4	8.5	13.3	2.6	1.8	8.5	12.6
10 percent		1.05	31.3	5.4	21.7	9.4	10.4	1.7	1.8	8.0	10.3
aromatic		1.97	27.7	5.3	21.6	7.8	10.3	1.9	1.3	6.6	17.5
(7212)	Avg...	1.86	26.2	5.8	23.2	8.6	11.3	2.1	1.6	7.7	13.5
High alkylate,	2/2	0.01	-	-	-	-	-	-	-	-	-
10 percent		.02	-	-	-	-	-	-	-	-	-
aromatic		.03	-	-	-	-	-	-	-	-	-
(7212)	Avg...	.02	-	-	-	-	-	-	-	-	-
	3	.48	2.0	8.5	33.0	14.9	15.7	2.1	2.0	12.9	8.9
		.28	9.9	7.4	27.1	17.0	15.3	1.4	2.2	10.9	8.8
		.37	13.6	7.9	25.3	15.3	12.8	1.4	1.8	11.0	10.9
	Avg...	.38	8.5	7.9	28.5	15.8	14.6	1.6	2.0	11.6	9.5

See footnotes at end of table.

TABLE B-1. - Exhaust hydrocarbon distribution for individual bags of the 1975 Federal test procedure and individual replicate tests for the fuel study 1/--Continued

Fuel	Bag number	Total HC, grams/test	Hydrocarbon distribution, weight percent								
			Paraffins			Olefins			Aromatics		
			Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	Acetylenes
1971 PLYMOUTH FURY III (CAR 333) WITH A 360-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR											
Typical clear II, 40 percent aromatic (7221)	1	3.79	10.4	9.2	21.0	8.0	11.4	3.9	5.4	27.6	3.1
		3.12	13.7	9.5	17.3	8.7	10.6	2.4	5.7	28.5	3.6
		2.67	13.1	10.4	18.9	8.8	11.9	2.7	5.6	25.6	3.0
	Avg..	3.19	12.4	9.7	19.1	8.5	11.3	3.0	5.0	27.2	3.2
	2	1.12	28.4	7.9	10.7	9.2	10.7	0.8	6.8	24.9	0.6
		.92	35.8	9.7	10.6	8.7	9.2	.8	5.6	19.2	.4
		.86	35.7	8.3	11.1	8.8	9.4	.6	5.8	19.8	.5
	Avg..	.97	33.3	8.6	10.8	8.9	9.8	.7	6.1	21.3	.5
	3	1.22	21.6	9.5	12.4	10.4	9.7	1.00	6.3	27.2	1.9
		1.15	21.9	11.4	12.8	9.4	9.5	1.1	5.8	26.4	1.7
		1.10	24.3	10.1	12.4	9.5	10.3	1.1	6.2	24.6	1.5
	Avg..	1.16	22.6	10.3	12.5	9.8	9.8	1.1	6.1	26.1	1.7
Indolene clear, 22 percent aromatic (7203)	1	2.34	18.4	10.4	22.4	10.9	14.9	2.2	4.6	12.9	3.3
		2.04	21.4	10.3	19.3	11.8	14.9	1.8	4.3	12.2	4.0
		2.46	15.6	11.2	22.7	10.1	13.5	2.2	3.9	17.4	3.4
	Avg..	2.28	18.5	10.6	21.4	10.9	14.4	2.1	4.3	14.2	3.6
	2	0.97	33.4	10.3	15.5	9.5	14.0	1.0	4.0	11.8	0.5
		.90	37.7	12.4	15.8	9.0	9.8	1.0	3.4	10.4	.5
		.89	39.6	11.8	15.4	8.8	9.2	1.4	2.7	10.6	.5
	Avg..	.92	36.9	11.5	15.6	9.1	11.0	1.1	3.4	10.9	.5
	3	1.56	24.6	10.7	18.1	11.6	12.2	1.5	4.2	13.3	3.8
		1.50	25.3	11.8	17.5	12.3	12.2	1.3	3.9	11.7	4.0
		2.18	20.5	13.5	23.1	10.1	9.7	2.1	3.8	12.8	4.4
	Avg..	1.75	23.4	12.0	19.6	11.3	11.4	1.6	4.0	12.6	4.1
High alkylate, 10 percent aromatic (7212)	1	4.84	12.1	11.9	40.1	7.3	13.7	3.6	1.2	6.5	3.6
		3.78	17.7	6.7	33.4	8.5	14.9	3.9	1.8	6.4	6.7
		3.37	14.0	9.2	35.7	8.3	15.5	3.5	1.8	8.5	3.5
	Avg..	4.00	14.6	9.3	36.4	8.0	14.7	3.7	1.6	7.1	4.6
	2	1.27	32.4	9.7	21.5	9.2	18.2	2.2	1.3	4.8	0.7
		1.16	41.0	10.8	20.3	8.7	12.3	1.7	.9	3.7	.6
		1.12	35.6	10.7	23.2	8.6	13.4	2.1	1.1	4.7	.6
	Avg..	1.18	36.3	10.4	21.7	8.9	14.6	2.0	1.1	4.4	.6
	3	1.70	21.5	12.1	30.0	9.3	13.9	2.8	1.5	7.3	1.6
		1.40	22.0	10.5	30.9	8.8	14.2	3.4	1.7	7.0	1.5
		1.35	24.7	12.5	26.1	10.4	14.8	1.7	1.7	6.2	1.9
	Avg..	1.48	22.8	11.7	29.0	9.5	14.3	2.6	1.6	6.8	1.7
1972 FORD TORINO (CAR 724) WITH A 351-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR											
Typical clear II, 40 percent aromatic (7221)	1	5.41	13.4	9.3	19.1	6.8	8.1	2.5	5.0	32.5	3.3
		4.50	14.5	9.5	17.7	7.0	8.5	2.0	5.0	32.6	3.2
		3.99	14.9	9.8	17.7	7.6	8.7	1.9	4.8	30.4	4.2
	Avg..	4.63	14.3	9.6	18.0	7.1	8.5	2.1	4.9	31.9	3.6
	2	1.52	22.1	14.3	15.9	6.4	7.7	1.3	5.3	25.4	1.6
		1.70	28.8	14.8	13.9	6.0	6.8	1.1	4.3	22.4	1.9
		1.19	29.9	14.9	13.9	6.1	6.8	0.8	4.4	21.4	1.8
	Avg..	1.47	26.9	14.7	14.5	6.2	7.1	1.1	4.7	23.0	1.8
	3	3.49	10.9	25.9	20.4	5.2	8.9	2.1	3.4	21.2	2.0
		2.90	12.3	28.3	18.7	4.5	8.0	2.0	3.2	21.4	1.6
		3.66	10.9	24.8	20.5	4.5	8.8	2.5	3.0	21.1	3.9
	Avg..	3.35	11.4	26.3	19.9	4.7	8.6	2.2	3.2	21.2	2.5
Indolene clear, 22 percent aromatic (7203)	1	4.55	18.9	11.8	22.5	8.6	10.9	2.3	3.4	14.9	6.7
		4.03	18.0	12.1	23.5	8.5	11.7	2.1	3.9	15.4	4.8
		3.76	17.4	12.4	25.2	7.5	10.4	2.4	3.5	14.1	7.1
	Avg..	4.11	18.1	12.1	23.7	8.2	11.0	2.3	3.6	14.8	6.2
	2	1.50	28.9	18.1	19.3	6.8	7.8	1.2	3.4	12.3	2.2
		1.64	27.9	14.3	20.7	7.1	11.3	1.1	4.2	11.4	2.0
		1.49	27.7	16.0	20.6	6.4	9.5	1.2	3.7	13.2	1.7
	Avg..	1.54	28.1	16.1	20.2	6.8	9.5	1.2	3.8	12.3	2.0
	3	4.71	9.4	29.5	29.8	4.2	8.2	3.0	2.3	11.5	2.1
		4.73	10.1	29.7	29.5	4.3	8.2	2.6	2.7	10.3	2.6
		4.13	11.4	31.0	27.6	5.4	8.2	2.0	2.7	9.3	2.4
	Avg..	4.52	10.3	30.0	29.0	4.6	8.2	2.5	2.6	10.4	2.4
High alkylate, 10 percent aromatic (7212)	1	5.37	21.5	9.8	24.3	7.3	13.7	2.0	1.4	5.5	14.5
		4.53	19.4	10.8	28.9	8.1	15.3	2.6	1.6	6.1	7.2
		5.44	21.1	9.4	26.3	8.3	13.2	2.0	1.7	6.6	11.4
	Avg..	5.11	20.6	10.0	26.5	7.9	14.1	2.2	1.6	6.1	11.0
	2	1.80	31.0	14.9	25.9	7.0	11.8	1.7	1.0	4.8	1.9
		2.07	30.1	13.3	26.3	7.2	13.1	1.8	1.4	5.0	1.8
		1.99	36.4	14.5	24.1	6.6	9.9	1.4	1.1	4.2	1.8
	Avg..	1.95	32.5	14.2	25.5	6.9	11.6	1.6	1.2	4.7	1.8
	3	4.30	12.9	26.1	34.6	5.1	8.8	2.9	1.1	5.8	2.7
		4.93	12.5	27.5	35.8	5.0	8.6	2.4	1.2	4.7	2.3
		2.71	20.6	18.3	32.2	6.5	11.3	2.2	1.2	5.6	2.1
	Avg..	3.98	15.3	23.9	34.2	5.5	9.6	2.5	1.2	5.4	2.4

See footnotes at end of table.

TABLE B-1. - Exhaust hydrocarbon distribution for individual bags of the 1975 Federal test procedure and individual replicate tests for the fuel study 1/--Continued

Fuel	Bag number	Total HC, grams/test	Hydrocarbon distribution, weight percent								
			Paraffins			Olefins			Aromatics		Acetylenes
			Methane	C_2-C_5	C_{6+}	Ethylene	C_3-C_5	C_{6+}	Benzene	C_{7+}	
1971 PLYMOUTH FURY III (CAR 775) WITH A 360-CID ENGINE AND EQUIPPED WITH THE ETHYL LEAN REACTORS AND EGR											
Typical clear II,	1	4.11	6.7	11.1	12.1	13.0	12.2	1.5	6.2	25.4	11.8
40 percent		3.89	6.3	14.3	13.6	11.9	13.1	2.1	5.7	22.0	11.0
aromatic		5.64	6.1	12.6	19.6	8.6	10.4	3.0	4.7	25.0	10.0
(7221)	Avg..	4.55	6.4	12.7	15.1	11.2	11.9	2.2	5.5	24.1	10.9
	3/ 2	0.17	0.0	4.9	4.4	18.6	7.3	0.2	8.7	29.2	26.7
		.15	.0	8.1	10.5	13.8	10.5	.9	6.4	28.8	21.0
		.15	25.6	3.0	5.9	12.9	5.5	.2	4.4	18.4	24.1
	Avg..	.16	8.6	5.3	6.9	15.1	7.8	.4	6.5	25.5	23.9
	3	1.89	4.4	24.1	15.7	9.4	11.2	1.8	4.6	20.4	8.4
		2.16	1.9	29.4	20.2	6.1	10.6	2.5	3.4	20.8	5.1
		1.74	3.0	25.9	19.4	6.6	10.7	2.4	3.7	21.9	6.4
	Avg..	1.93	3.1	26.5	18.5	7.4	10.8	2.2	3.9	21.0	6.6
Indolene	1	2.79	7.4	13.8	14.8	16.7	18.9	1.7	4.2	9.5	13.0
clear,		3.78	6.4	16.1	20.4	12.9	16.7	2.6	4.0	9.8	11.1
22 percent		3.84	6.5	14.9	21.1	12.6	17.1	2.8	3.9	10.2	10.9
aromatic	Avg..	3.47	6.8	14.9	18.7	14.1	17.6	2.4	4.0	9.8	11.7
(7203)	3/ 2	0.11	0.0	15.1	10.8	20.1	4.6	0.3	3.7	16.1	29.3
		.14	6.4	4.8	12.0	18.4	4.9	.2	2.4	18.0	32.9
		.11	0	5.1	13.4	18.7	6.6	.2	4.3	20.9	30.8
	Avg..	.12	2.1	8.3	12.1	19.1	5.4	.2	3.5	18.3	31.0
	3	2.66	3.0	34.7	24.4	6.3	13.1	2.6	2.8	7.6	5.5
		3.29	2.2	33.1	27.4	5.7	12.6	3.2	2.9	8.9	4.0
		2.69	2.1	27.0	30.7	5.5	12.2	3.7	2.9	11.8	4.1
	Avg..	2.88	2.4	31.6	27.5	5.8	12.7	3.2	2.9	9.4	4.5
High alkylate,	1	3.31	9.0	10.1	15.7	16.8	24.0	3.0	2.5	5.2	13.7
10 percent		2.84	9.7	10.2	17.2	16.5	23.0	1.7	2.2	4.9	14.6
aromatic		2.98	8.8	12.0	17.5	16.0	23.5	1.6	2.1	5.7	12.8
(7212)	Avg..	3.04	9.2	10.7	16.8	16.4	23.5	2.1	2.3	5.3	13.7
	3/ 2	0.13	0	4.7	12.6	20.6	15.3	0.4	2.2	17.0	27.2
		.10	29.4	4.3	6.3	15.2	3.6	.1	1.1	7.6	32.4
		.11	8.1	4.8	12.6	18.8	6.1	.8	1.7	17.3	29.8
	Avg..	.11	12.5	4.6	10.5	18.2	8.3	.4	1.7	14.0	29.8
	3	2.04	5.6	28.8	26.0	10.6	12.2	2.0	1.4	4.7	8.7
		3.00	2.4	34.7	36.9	4.5	8.8	3.7	1.1	4.3	3.6
		1.78	4.4	27.2	33.4	8.0	10.2	2.5	1.2	5.8	7.3
	Avg..	2.27	4.1	30.3	32.1	7.7	10.4	2.7	1.2	4.9	6.6
1970 CHEVROLET IMPALA (CAR 58) WITH A 350-CID ENGINE AND EQUIPPED WITH GEM MONEL NO_x REDUCTION CATALYSTS AND PLATINUM OXIDATION CATALYSTS											
Typical clear II,	1	1.90	28.9	10.9	13.6	7.0	7.2	1.2	4.9	25.3	1.0
40 percent		3.11	20.0	11.5	19.4	6.7	8.1	2.2	4.6	26.8	.7
aromatic		2.21	31.7	9.8	13.0	7.5	7.4	1.0	5.2	23.7	.7
(7221)	Avg..	2.41	26.8	10.7	15.3	7.1	[illegible]	1.5	4.9	25.3	.8
	2	0.69	51.9	11.0	8.8	2.0	7.0	0.3	2.3	16.7	0
		.57	43.5	11.7	10.8	1.9	17.0	.4	2.8	11.9	0
		.80	59.1	10.8	7.4	2.5	7.1	.3	2.3	10.5	0
	Avg..	.69	51.5	11.2	9.0	2.1	10.4	.3	2.5	13.0	0
	3	0.89	44.7	15.2	12.1	3.0	3.4	0.6	3.2	17.8	0
		.84	43.3	13.2	12.6	3.2	3.3	.7	3.4	20.3	0
		1.00	42.6	12.8	13.8	2.9	2.9	.7	3.4	20.9	0
	Avg..	.91	43.5	13.7	12.9	3.0	3.2	.7	3.3	19.7	0
Indolene	1	2.34 4/	-	-	-	-	-	-	-	-	-
clear,		3.29	26.0	12.4	20.3	7.7	10.6	1.4	3.4	13.1	5.1
22 percent		2.40	31.8	10.2	19.1	9.2	11.1	1.3	3.7	10.9	2.7
aromatic	Avg..	2.68	28.9	11.3	19.7	8.5	10.8	1.4	3.5	12.0	3.9
(7203)											
	2	0.83 4/	-	-	-	-	-	-	-	-	-
		.77	63.0	11.7	7.9	2.3	8.1	.5	1.4	5.1	0
		.94	61.3	10.7	10.6	2.3	5.5	.5	1.4	7.7	0
	Avg..	.85	62.1	11.2	9.3	2.3	6.8	.5	1.4	6.4	0
	3	1.03 4/	-	-	-	-	-	-	-	-	-
		1.02	49.3	16.2	17.3	2.9	3.4	.7	2.0	8.2	0
		.94	51.9	13.4	15.0	3.1	3.7	.7	2.1	10.1	0
	Avg..	1.00	50.6	14.8	16.1	3.0	3.6	.7	2.1	9.1	0
High alkylate,	1	2.42	35.7	9.7	21.4	8.0	11.3	1.2	2.1	8.7	1.9
10 percent		2.71	37.7	10.6	20.6	7.9	11.2	1.3	1.8	6.0	2.9
aromatic		2.83	36.2	10.0	22.4	8.2	12.1	1.3	1.6	5.4	2.8
(7212)	Avg..	2.65	36.5	10.1	21.5	8.0	11.5	1.3	1.9	6.7	2.5
	2	1.08	59.5	11.0	12.0	2.5	9.4	0.5	0.7	4.4	0
		1.17	65.0	11.9	11.4	1.9	2.8	.5	.6	5.9	0
		1.17	66.5	11.5	10.4	2.1	5.6	.5	.6	2.8	0
	Avg..	1.14	63.6	11.5	11.3	2.2	5.9	.5	.6	4.4	0
	3	1.29	53.0	14.4	18.5	3.9	5.4	0.9	1.0	2.9	0
		1.20	55.5	15.9	17.1	2.8	3.7	.9	.7	3.4	0
		1.19	56.7	14.1	18.1	2.6	4.0	.9	.7	2.9	0
	Avg..	1.23	55.0	14.8	17.9	3.1	4.4	.9	.8	3.1	-

1/ All tests were conducted at 75° F ambient temperature.

2/ The GLC results for car 810 from bag 2 were not reliable because of the very low concentration of exhaust hydrocarbons and the relatively large contribution of hydrocarbons in the CVS diluent air.

3/ The methane values for car 775 from bag 2 were not reliable because of the very low concentration of exhaust hydrocarbons and the relatively large contribution of hydrocarbons in the CVS diluent air.

4/ The sample for GLC analysis was lost on the first replicate test.

TABLE B-2. - Exhaust hydrocarbon distribution for individual replicate tests for the fuel study 1/

[Data weighted in accordance with the 1975 Federal test procedure]

Fuel	Total HC, grams/mile	Hydrocarbon distribution, weight percent								
		Paraffins			Olefins			Aromatics		
		Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	Acetylenes
1972 OLDSMOBILE DELTA 88 (CAR 403) WITH A 455-CID ENGINE AND EQUIPPED WITH A BASE-METAL OXIDATION CATALYST AND EGR										
Typical clear I,	0.30	6.0	18.4	23.0	21.2	8.1	0.8	7.9	13.4	1.2
35 percent	.37	8.1	14.5	26.3	18.3	8.2	1.2	7.2	13.7	2.5
aromatic	.31	5.7	15.8	22.5	22.9	9.4	.8	8.1	13.6	1.2
(7202) Avg...	.33	6.6	16.2	23.9	20.9	8.6	.9	7.7	13.6	1.6
Indolene clear,	0.39	9.4	18.7	24.0	21.3	8.9	1.7	6.2	8.4	1.4
22 percent	.45	10.3	15.1	25.7	18.9	8.7	2.2	5.7	9.5	3.9
aromatic	.45	13.2	15.1	23.1	20.1	7.8	1.1	6.0	8.0	5.6
(7203) Avg...	.43	11.0	16.3	24.3	20.0	8.5	1.7	6.0	8.6	3.6
High alkylate,	0.46	14.4	10.9	31.2	18.1	9.9	2.4	3.3	5.6	4.2
10 percent	.48	16.1	12.3	28.5	18.8	13.3	2.0	3.2	3.4	2.4
aromatic	.56	17.4	15.6	28.7	17.1	10.3	2.4	2.3	2.9	3.3
(7212) Avg...	.50	16.0	12.9	29.4	18.0	11.2	2.3	2.9	4.0	3.3
1971 FORD LTD (CAR 810) WITH A 351-CID ENGINE AND EQUIPPED WITH ESSO RAM REACTORS AND EGR										
Typical clear I,	0.13	15.8	7.0	19.0	8.9	8.4	2.2	4.9	24.8	9.0
35 percent	.21	7.7	8.0	24.2	5.9	8.2	3.8	4.6	30.8	6.8
aromatic	.18	10.5	7.7	25.4	7.5	7.2	3.2	4.0	26.9	7.6
(7202) Avg...	.17	11.3	7.6	22.9	7.4	7.9	3.1	4.5	27.5	7.8
Indolene clear,	.08	14.8	8.4	16.6	12.8	12.5	1.6	4.6	20.1	8.6
22 percent	.14	8.6	9.8	30.9	7.9	10.0	5.0	4.2	16.5	7.1
aromatic	.10	13.3	8.6	26.4	8.9	9.5	3.0	4.2	17.3	8.8
(7203) Avg...	.11	12.2	8.9	24.6	9.9	10.7	3.2	4.3	18.0	8.2
High alkylate,	.18	16.2	7.0	27.7	9.7	13.8	2.5	1.9	9.3	11.9
10 percent	.08	25.7	5.8	23.1	11.5	11.6	1.6	2.0	8.7	10.0
aromatic	.14	24.9	5.9	22.3	9.2	10.8	1.8	1.4	7.5	16.2
(7212) Avg...	.13	22.1	6.3	24.4	10.2	12.0	2.0	1.8	8.5	12.7

See footnote at end of table.

TABLE B-2. - Exhaust hydrocarbon distribution for individual replicate tests for the fuel study 1/--Continued

[Data weighted in accordance with the 1975 Federal test procedure]

Fuel	Total HC, grams/mile	Hydrocarbon distribution, weight percent								
		Paraffins			Olefins			Aromatics		
		Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	Acetylenes
1971 PLYMOUTH FURY III (CAR 333) WITH A 360-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR										
Typical clear II,	0.46	18.5	8.9	15.9	8.9	10.9	2.3	6.0	26.6	2.0
40 percent	.39	22.5	10.0	14.2	8.8	9.9	1.6	5.7	25.1	2.2
aromatic	.35	23.1	9.6	14.8	9.0	10.7	1.7	5.8	23.5	1.8
(7221) Avg...	.40	21.4	9.5	14.9	8.9	10.5	1.9	5.8	25.1	2.0
Indolene clear,	0.38	25.9	10.5	18.7	10.6	13.8	1.6	4.3	12.6	2.5
22 percent	.35	28.3	11.5	17.5	11.0	12.3	1.3	3.9	11.4	2.8
aromatic	.43	24.2	12.2	20.9	9.7	10.9	1.9	3.5	13.7	3.0
(7203) Avg...	.39	26.0	11.4	19.0	10.4	12.3	1.6	3.9	12.6	2.8
High alkylate,	0.58	20.2	11.3	32.4	8.3	15.0	3.0	1.3	6.2	2.3
10 percent	.48	26.1	8.9	28.6	8.6	13.9	3.1	1.5	5.7	3.6
aromatic	.45	23.7	10.5	29.3	8.9	14.6	2.6	1.6	6.7	2.1
(7212) Avg...	.50	23.3	10.2	30.1	8.6	14.5	2.9	1.5	6.2	2.7
1972 FORD TORINO (CAR 724) WITH A 351-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR										
Typical clear II,	0.78	14.8	16.3	18.7	6.2	8.3	2.0	4.5	26.8	2.4
40 percent	.70	18.4	17.1	16.8	5.9	7.8	1.7	4.2	25.8	2.3
aromatic	.67	16.8	17.3	18.0	5.9	8.3	1.9	4.0	24.3	3.5
(7221) Avg...	.72	16.7	16.9	17.8	6.0	8.1	1.9	4.2	25.7	2.7
Indolene clear,	0.82	17.1	21.1	24.9	6.2	9.0	2.3	2.9	12.8	3.6
22 percent	.81	17.2	20.5	25.4	6.2	10.0	2.1	3.4	12.1	3.1
aromatic	.73	17.6	21.4	25.0	6.3	9.2	1.9	3.2	11.8	3.6
(7203) Avg...	.79	17.3	21.0	25.1	6.2	9.4	2.1	3.2	12.3	3.4
High alkylate,	0.88	21.0	17.3	28.6	6.4	11.3	2.2	1.2	5.4	6.6
10 Percent	.91	19.8	18.4	31.0	6.6	11.9	2.3	1.3	5.2	3.5
aromatic	.78	26.2	13.4	27.1	7.2	11.6	1.9	1.4	5.5	5.7
(7212) Avg...	.86	22.3	16.4	28.9	6.7	11.6	2.1	1.3	5.4	5.3

See footnote at end of table.

TABLE B-2. - Exhaust hydrocarbon distribution for individual replicate tests for the fuel study 1/--Continued

[Data weighted in accordance with the 1975 Federal test procedure]

Fuel	Total HC, grams/mile	Hydrocarbon distribution, weight percent								
		Paraffins			Olefins			Aromatics		Acetylenes
		Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
1971 PLYMOUTH FURY III (CAR 775) WITH A 360-CID ENGINE AND EQUIPPED WITH THE ETHYL LEAN REACTORS AND EGR										
Typical clear II,	0.40	5.5	15.4	12.9	12.1	11.6	1.5	5.8	23.8	11.4
40 percent	.41	4.2	20.1	16.1	9.6	12.0	2.2	4.8	21.9	9.1
aromatic	.48	6.1	15.9	18.9	8.2	10.3	2.7	4.4	23.9	9.6
(7221) Avg...	.43	5.3	17.1	16.0	10.0	11.3	2.1	5.0	23.2	10.0
Indolene clear,	0.38	4.7	25.1	19.8	11.3	15.2	2.1	3.5	8.7	9.6
22 percent	.49	4.2	24.4	23.7	9.4	14.1	2.8	3.4	9.7	8.3
aromatic	.44	4.3	20.2	25.3	9.5	14.4	3.1	3.5	11.3	8.4
(7203) Avg...	.44	4.4	23.2	22.9	10.1	14.5	2.7	3.5	9.9	8.8
High alkylate,	0.36	7.1	17.8	20.0	14.3	18.5	2.5	2.0	5.5	12.3
10 percent	.40	6.2	23.8	27.9	9.7	14.4	2.8	1.5	4.7	9.0
aromatic	.32	6.9	18.1	24.0	12.7	17.1	1.9	1.7	6.3	11.3
(7212) Avg...	.36	6.7	19.9	24.0	12.2	16.7	2.4	1.7	5.5	10.9
1970 CHEVROLET IMPALA (CAR 58) WITH A 350-CID ENGINE AND EQUIPPED WITH GEM MONEL NO_x REDUCTION CATALYSTS AND PLATINUM OXIDATION CATALYSTS										
Typical clear II,	0.27	40.8	12.0	11.6	4.2	6.2	0.7	3.6	20.5	0.4
40 percent	.32	30.3	11.9	16.0	4.9	9.2	1.5	3.9	21.9	.4
aromatic	.31	43.8	10.9	11.3	4.6	6.2	.7	3.7	18.5	.3
(7221) Avg...	.30	38.3	11.6	12.9	4.6	7.2	1.0	3.7	20.3	.4
Indolene clear,	0.32 2/	-	-	-	-	-	-	-	-	-
22 percent	.37	41.2	13.0	16.3	5.2	8.4	1.0	2.5	9.8	2.6
aromatic	.34	47.2	11.0	15.0	5.3	7.4	0.9	2.5	9.6	1.1
(7203) Avg...	.34	44.2	12.0	15.6	5.3	7.9	.9	2.5	9.7	1.9
High alkylate,	0.38	49.1	11.4	17.1	4.8	9.1	0.9	1.3	5.6	0.7
10 percent	.40	52.4	12.3	16.2	4.4	6.2	.9	1.1	5.4	1.1
aromatic	.41	52.3	11.5	16.9	4.6	7.9	.9	1.0	3.8	1.1
(7212) Avg...	.40	51.3	11.7	16.7	4.6	7.8	.9	1.1	4.9	1.0

1/All tests were conducted at 75° F ambient temperature.
2/ The sample for GLC analysis was lost on the first replicate test.

APPENDIX C -- DATA ON THE INFLUENCE OF AMBIENT TEMPERATURE ON MASS EMISSIONS FROM PROTOTYPE LOW EMISSION SYSTEMS

TABLE C-1. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1972 Oldsmobile Delta 88 (Car 403) with a 455-CID engine and equipped with a base metal oxidation catalyst and EGR]

Fuel	Bag number	Emissions, grams/test			
		Carbon monoxide	Hydrocarbon	Nitrogen oxides	Aldehydes (MBTH)
25° F AMBIENT TEMPERATURE					
Typical clear I, 35 percent aromatic (7202)	1	218	10.4	5.32	0.17
		219	13.4	5.56	.22
		184	9.36	5.89	.26
	Avg..	207	11.0	5.59	.22
	2	2.99	0.73	6.05	0.096
		3.58	.84	6.42	.13
		4.43	1.03	6.51	.19
	Avg..	3.67	.87	6.33	.14
	3	19.2	0.92	6.14	0.11
		13.0	.94	6.66	.14
		11.4	.99	5.63	.17
	Avg..	14.5	.95	6.14	.14
Indolene clear, 22 percent aromatic (7203)	1	224	6.09	5.00	0.19
		274	8.62	4.93	.19
		217	5.48	5.19	.23
	Avg..	238	6.73	5.04	.20
	2	4.31	0.91	4.60	0.12
		4.58	.95	5.67	.14
		4.50	1.27	5.04	.13
	Avg..	4.46	1.04	5.10	.13
	3	21.2	1.41	5.43	0.15
		19.0	1.15	5.57	.13
		19.5	1.06	6.01	.14
	Avg..	19.9	1.21	5.67	.14
High alkylate, 10 percent aromatic (7212)	1	233	8.75	4.77	0.23
		275	14.0	4.48	.25
		265	11.0	4.65	.25
	Avg..	258	11.2	4.63	.24
	2	3.29	1.11	6.23	0.14
		2.27	.84	5.81	.10
		2.45	.87	4.88	.065
	Avg..	2.67	.94	5.64	.10
	3	23.0	1.46	5.13	0.15
		25.3	1.34	4.82	.11
		48.0	1.77	6.21	.13
	Avg..	32.1	1.52	5.39	.13

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TABLE C-1. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1972 Oldsmobile Delta 88 (Car 403) with a 455-CID engine and equipped with a base metal oxidation catalyst and EGR]--Con.

Fuel	Bag number	Emissions, grams/test			
		Carbon monoxide	Hydrocarbon	Nitrogen oxides	Aldehydes (MBTH)
45° F AMBIENT TEMPERATURE					
Typical clear I, 35 percent aromatic (7202)	1/ 1	182	5.56	5.39	0.15
		139	3.83	5.54	.21
		139	4.19	6.03	.22
		176	4.88	5.62	.27
	Avg..	159	4.62	5.64	.21
	1/ 2	4.11	0.72	6.45	0.088
		4.43	.93	7.17	.14
		4.15	.81	7.41	.14
		3.99	.75	6.37	.16
	Avg..	4.17	.80	6.85	.13
	1/ 3	26.2	0.95	5.77	0.11
		12.9	1.00	6.32	.14
		19.2	1.04	6.71	.15
		21.6	1.16	6.82	.20
	Avg..	20.0	1.04	6.40	.15
Indolene clear, 22 percent aromatic (7203)	1	142	3.57	5.69	0.18
		179	4.52	5.23	.20
		201	4.35	5.06	.16
	Avg..	174	4.15	5.33	.18
	2	4.55	0.83	5.60	0.13
		4.90	.84	5.94	.13
		4.75	.86	5.73	.10
	Avg..	4.73	.84	5.76	.12
	3	27.8	1.19	5.22	0.15
		35.1	1.10	5.88	.16
		27.8	1.22	5.76	.11
	Avg..	30.2	1.17	5.62	.14
High alkylate, 10 percent aromatic (7212)	1	186	5.67	4.82	0.21
		148	7.19	4.63	.31
		143	5.31	5.08	.21
	Avg..	159	6.06	4.84	.24
	2	4.34	1.17	5.16	0.11
		3.04	1.11	5.22	.10
		2.45	.77	4.82	.083
	Avg..	3.28	1.02	5.07	.10
	3	24.3	1.49	4.59	0.13
		15.1	1.47	5.07	.15
		25.8	1.53	4.95	.12
	Avg..	21.8	1.50	4.87	.13

1/A fourth replicate test was made at 45° F ambient temperature using fuel 7202 because the sample for GLC analysis was lost on the first replicate test.

TABLE C-1. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1972 Oldsmobile Delta 88 (Car 403) with a 455-CID engine and equipped with a base metal oxidation catalyst and EGR]--Con.

Fuel	Bag number	Emissions, grams/test			
		Carbon monoxide	Hydrocarbon	Nitrogen oxides 2/	Aldehydes (MBTH)
75° F AMBIENT TEMPERATURE					
Typical clear I, 35 percent aromatic (7202)	1	72.4	2.29	4.52	0.19
		89.0	3.08	3.53	.18
		48.9	2.32	4.89	.14
	Avg..	70.1	2.56	4.31	.17
	2	4.86	0.57	5.22	0.086
		5.52	.69	4.73	.11
		4.67	.67	5.41	.071
	Avg..	5.02	.64	5.12	.089
	3	30.8	1.19	4.90	0.10
		39.2	1.29	4.06	.13
		23.6	1.12	5.61	.09
	Avg..	31.2	1.20	4.86	.11
Indolene clear, 22 percent aromatic (7203)	1	79.5	2.63	4.91	0.24
		103	4.13	4.42	.24
		92.4	4.17	4.35	.22
	Avg..	91.7	3.64	4.56	.23
	2	6.36	0.72	5.35	0.12
		5.12	.70	4.85	.13
		5.93	.71	5.06	.095
	Avg..	5.80	.71	5.09	.12
	3	34.9	1.83	3.31	0.16
		43.3	1.52	4.90	.14
		30.1	1.59	4.10	.13
	Avg..	36.1	1.65	4.10	.14
High alkylate, 10 percent aromatic (7212)	1	93.6	4.14	4.29	0.28
		103	3.93	4.94	.30
		91.3	4.67	3.76	.28
	Avg..	96.0	4.25	4.33	.29
	2	4.98	0.74	4.90	0.13
		3.50	.76	5.10	.10
		3.55	.99	4.74	.14
	Avg..	4.01	.83	4.91	.12
	3	63.8	1.62	5.33	0.13
		66.3	1.96	5.13	.13
		49.6	2.13	4.16	.15
	Avg..	59.9	1.90	4.87	.14

2/ NO_x data are corrected for humidity to 75 grains H_2O per lb of dry air.

TABLE C-1. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1972 Oldsmobile Delta 88 (Car 403) with a 455-CID engine and equipped with a base metal oxidation catalyst and EGR]--Con.

Fuel	Bag number	Emissions, grams/test			
		Carbon monoxide	Hydrocarbon	Nitrogen oxides[2/]	Aldehydes (MBTH)
95° F AMBIENT TEMPERATURE					
Typical clear I, 35 percent aromatic (7202)	1	91.4	6.85	5.96	0.18
		78.0	6.71	5.67	.13
		85.6	6.68	5.27	.14
	Avg..	85.0	6.75	5.63	.15
	2	6.24	0.72	6.54	0.070
		6.79	.56	6.44	.050
		8.73	.84	6.65	.051
	Avg..	7.25	.71	6.54	.057
	3	90.2	2.37	5.75	0.10
		70.9	1.66	5.52	.053
		83.2	1.98	5.05	.060
	Avg..	81.4	2.00	5.44	.071
Indolene clear, 22 percent aromatic (7203)	1	140	3.56	4.81	0.19
		120	2.89	4.88	.15
		98.0	5.23	4.87	.19
	Avg..	119	3.89	4.85	.18
	2	7.51	0.73	5.50	0.075
		8.05	.68	5.42	.080
		6.37	.68	5.81	.073
	Avg..	7.31	.70	5.58	.076
	3	111	2.61	4.28	0.060
		100	2.97	4.52	.052
		76.8	2.49	4.79	.068
	Avg..	95.9	2.69	4.53	0.060
High alkylate, 10 percent aromatic (7212)	1	109	4.45	4.75	0.20
		129	4.65	4.34	.22
		138	5.29	4.52	.19
	Avg..	125	4.80	4.54	.20
	2	5.05	0.63	5.18	0.053
		5.57	.72	5.32	.052
		5.20	.70	5.06	.021
	Avg..	5.27	.68	5.19	.042
	3	92.2	2.26	4.43	0.059
		104	2.58	4.12	.054
		145	3.52	3.62	.027
	Avg..	114	2.79	4.06	.047

2/ NO_x data are corrected for humidity to 75 grains H_2O per lb of dry air.

TABLE C-2. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1972 Ford Torino (Car 724) with a 351-CID engine and equipped with platinum oxidation catalyst and EGR]

Fuel	Bag number	Emissions, grams/test			
		Carbon monoxide	Hydrocarbon	Nitrogen oxides	Aldehydes (MBTH)
25° F AMBIENT TEMPERATURE					
Typical clear II, 40 percent aromatic (7221)	1	1,070	63.9	6.78	0.32
		1,140	65.4	6.70	.32
		1,100	67.6	7.00	.36
	Avg..	1,103	65.7	6.83	.33
	2	12.4	2.08	8.70	0.075
		19.6	2.36	8.34	.087
		14.5	2.29	9.80	.091
	Avg..	15.5	2.24	8.95	.084
	3	13.3	2.14	13.7	0.071
		15.9	2.32	12.7	.078
		13.1	2.28	14.5	.079
	Avg..	14.1	2.25	13.6	.076
High alkylate, 10 percent aromatic (7212)	1	1,100	83.5	5.46	0.53
		1,100	71.6	5.68	.48
		1,150	77.8	5.61	.58
	Avg..	1,120	77.6	5.58	.53
	2	13.4	2.36	7.08	0.12
		16.4	2.52	6.82	.10
		19.0	2.45	6.73	.11
	Avg..	16.3	2.44	6.88	.11
	3	13.0	2.42	11.1	0.095
		16.8	2.50	10.6	.093
		15.4	2.52	11.1	.096
	Avg..	15.1	2.48	10.9	.095
45° F AMBIENT TEMPERATURE					
Typical clear II, 40 percent aromatic (7221)	1	553	34.4	11.2	0.24
		681	36.9	10.6	.26
		613	32.8	12.0	.21
	Avg..	616	34.7	11.2	.24
	2	16.9	1.84	11.1	0.078
		10.7	1.53	10.2	.078
		17.7	1.71	9.9	.074
	Avg..	15.1	1.69	10.4	.077
	3	14.8	1.97	14.2	0.076
		10.6	1.94	14.2	.075
		11.6	1.90	14.4	.074
	Avg..	12.3	1.94	14.3	.075
High alkylate, 10 percent aromatic (7212)	1	760	49.7	7.53	0.44
		710	51.0	9.06	.43
		721	49.7	7.76	.43
	Avg..	730	50.1	8.12	.43
	2	11.0	1.93	8.24	0.098
		11.3	1.92	8.15	.092
		14.3	1.99	7.79	.10
	Avg..	12.2	1.95	8.06	.097
	3	9.7	2.18	11.5	0.10
		13.8	2.33	11.9	.10
		13.1	2.36	11.2	.099
	Avg..	12.2	2.29	11.6	.10

TABLE C-2. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1972 Ford Torino (Car 724) with a 351-CID engine and equipped with platinum oxidation catalyst and EGR]--Continued

Fuel	Bag number	Emissions, grams/test			
		Carbon monoxide	Hydrocarbon	Nitrogen oxides 1/	Aldehydes (MBTH)
75° F AMBIENT TEMPERATURE					
Typical clear II, 40 percent aromatic (7221)	1	70.8	5.41	10.6	0.11
		68.8	4.50	9.88	.11
		58.1	3.99	11.1	.09
	Avg..	65.9	4.63	10.5	.10
	2	12.0	1.52	6.55	0.054
		11.1	1.70	7.39	.070
		6.32	1.19	7.90	.050
	Avg..	9.81	1.47	7.28	.058
	3	17.8	3.49	10.0	0.071
		13.0	2.90	10.1	.085
		17.9	3.66	10.6	.066
	Avg..	16.2	3.35	10.2	.074
High alkylate, 10 percent aromatic (7212)	1	65.4	5.37	8.61	0.11
		68.5	4.53	10.1	.13
		73.3	5.44	8.53	.12
	Avg..	69.1	5.11	9.07	.12
	2	9.40	1.80	5.30	0.067
		13.4	2.07	5.57	.081
		12.2	1.99	5.55	.100
	Avg..	11.7	1.95	5.47	.083
	3	15.4	4.30	8.23	0.084
		19.4	4.93	8.07	.092
		13.8	2.71	8.20	.084
	Avg..	16.2	3.98	8.17	.087
95° F AMBIENT TEMPERATURE					
Typical clear II, 40 percent aromatic (7221)	1	31.5	3.58	10.3	0.093
		26.2	2.83	10.6	.077
		25.9	2.96	11.2	.081
	Avg..	27.9	3.12	10.7	.084
	2	14.5	2.01	7.92	0.074
		14.7	1.90	8.26	.065
		13.0	1.85	7.66	.059
	Avg..	14.1	1.92	7.95	.066
	3	26.7	5.17	9.44	0.075
		20.6	5.19	10.6	.082
		22.8	4.84	10.5	.071
	Avg..	23.4	5.07	10.2	.076
High alkylate, 10 percent aromatic (7212)	1	42.3	4.34	8.72	0.11
		34.4	3.91	10.5	.13
		31.0	3.63	9.35	.11
	Avg..	35.9	3.96	9.52	.12
	2	44.5	2.76	5.13	0.086
		30.9	2.69	5.92	.084
		17.2	2.39	5.84	.080
	Avg..	30.9	2.61	5.63	.083
	3	34.1	6.72	7.63	0.11
		29.0	6.55	8.27	.11
		20.8	5.94	8.18	.10
	Avg..	30.0	6.40	8.03	.11

1/ NO_x data are corrected for humidity to 75 grains H_2O per lb of dry air.

TABLE C-3. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1971 Plymouth Fury III (Car 775) with a 360-CID engine and equipped with the Ethyl lean reactors and EGR]

Fuel	Bag number	Emissions, grams/test			
		Carbon monoxide	Hydrocarbon	Nitrogen oxides	Aldehydes (MBTH)
25° F AMBIENT TEMPERATURE					
Typical clear II, 40 percent aromatic (7221)	1	326	31.0	21.8	0.81
		454	33.7	36.1	.57
		370	22.2	36.6	.55
	Avg..	384	29.0	31.5	.64
	2	11.7	0.92	20.3	0.18
		11.3	.89	22.4	.15
		13.1	1.13	22.5	.19
	Avg..	12.0	.98	21.8	.17
	3	17.0	0.66	18.7	0.046
		25.0	.87	18.1	.042
		19.1	.70	18.0	.050
	Avg..	20.4	.74	18.3	.046
High alkylate, 10 percent aromatic (7212)	1	293	17.4	35.8	0.45
		506	48.2	18.0	.54
		403	36.9	18.1	.57
	Avg..	400	34.2	24.0	.52
	2	11.9	0.91	17.3	0.16
		10.7	.75	16.7	.11
		12.7	1.09	16.4	.18
	Avg..	11.8	.92	16.8	.15
	3	17.0	0.70	15.2	0.051
		24.6	1.06	14.6	.044
		16.7	.90	15.1	.073
	Avg..	19.4	.89	15.0	.056
45° F AMBIENT TEMPERATURE					
Typical clear II, 40 percent aromatic (7221)	1	155	11.3	22.7	0.48
		132	10.2	41.1	.51
		156	11.5	44.2	.57
	Avg..	148	11.0	36.0	.52
	2	6.70	0.16	14.2	0.032
		6.71	.14	14.4	.091
		7.75	.23	14.3	.066
	Avg..	7.05	.18	14.3	.063
	3	21.5	1.06	15.2	0.053
		16.0	1.47	24.2	.065
		19.1	.92	16.0	.037
	Avg..	18.9	1.15	18.5	.052
High alkylate, 10 percent aromatic (7212)	1	113	11.2	16.8	0.51
		112	10.4	39.1	.71
		138	10.1	38.6	.53
	Avg..	121	10.6	31.5	.58
	2	6.25	0.17	11.4	0.040
		8.70	.29	12.3	.106
		8.75	.34	12.6	.106
	Avg..	7.90	.27	12.1	.084
	3	22.8	2.01	12.9	0.048
		24.2	1.89	12.5	.079
		17.3	1.00	13.6	.067
	Avg..	21.4	1.63	13.0	.065

TABLE C-3. - Mass emissions for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1971 Plymouth Fury III (Car 775) with a 360-CID engine and equipped with the Ethyl lean reactors and EGR]--Continued

Fuel	Bag number	Emissions, grams/test: Carbon monoxide	Hydrocarbon	Nitrogen oxides[1/]	Aldehydes (MBTH)
75° F AMBIENT TEMPERATURE					
Typical clear II, 40 percent aromatic (7221)	1	46.8	4.11	14.0	0.19
		43.2	3.89	13.1	.18
		53.0	5.64	11.7	.19
	Avg..	47.7	4.55	13.0	.19
	2	8.15	0.17	11.0	0.011
		7.73	.15	10.1	.0091
		6.58	.15	9.74	.020
	Avg..	7.49	.16	10.3	.013
	3	21.0	1.89	14.8	0.049
		14.8	2.16	13.0	.057
		14.4	1.74	13.2	.041
	Avg..	16.7	1.93	13.7	.049
High alkylate, 10 percent aromatic (7212)	1	37.6	3.31	10.5	0.19
		32.5	2.84	10.4	.17
		34.1	2.98	10.3	.19
	Avg..	34.7	3.04	10.4	.18
	2	7.36	0.13	8.18	0.021
		6.57	.10	7.74	.011
		6.57	.11	8.23	.030
	Avg..	6.83	.11	8.05	.021
	3	18.6	2.04	10.8	0.063
		13.8	3.00	13.0	.057
		14.0	1.78	14.5	.059
	Avg..	15.5	2.27	12.8	.060
95° F AMBIENT TEMPERATURE					
Typical clear II, 40 percent aromatic (7221)	1	37.2	3.83	12.3	0.12
		26.7	3.54	12.9	.10
		29.9	2.48	12.7	.11
	Avg..	31.3	3.28	12.6	.11
	2	8.27	0.19	9.57	0.016
		9.35	.19	9.71	.011
		7.90	.14	10.1	.005
	Avg..	8.51	.17	9.79	.011
	3	18.7	4.00	15.6	0.061
		21.8	2.73	18.6	.048
		21.4	3.49	19.0	.049
	Avg..	20.6	3.41	17.7	.053
High alkylate, 10 percent aromatic (7212)	1	37.0	5.17	12.3	0.174
		30.3	2.70	13.7	.115
		38.4	3.98	9.29	.155
	Avg..	35.2	3.95	11.8	.148
	2	9.30	0.10	8.61	0.080
		7.91	.09	9.85	.0060
		7.80	.17	8.16	.0070
	Avg..	8.30	.12	8.87	.031
	3	22.3	4.92	16.1	0.103
		31.0	6.00	8.60	.093
		28.7	4.40	9.45	.088
	Avg..	27.3	5.11	11.4	.095

1/ NO_x data are corrected for humidity to 75 grains H_2O per lb of dry air.

TABLE C-4. - Mass emissions for individual replicate tests weighted in accordance with the 1975 Federal test procedure for the temperature study [1972 Oldsmobile Delta 88 (Car 403) with a 455-CID engine and equipped with a base metal oxidation catalyst and EGR]

Fuel	Emissions, grams/mile			
	Carbon monoxide	Hydrocarbon	Nitrogen oxides	Aldehydes (MBTH)
25° F AMBIENT TEMPERATURE				
Typical clear I,	14.4	0.76	1.58	0.031
35 percent	14.0	.95	1.68	.040
aromatic (7202)	12.0	.75	1.63	.053
Avg...	13.5	.82	1.63	.041
Indolene clear,	15.0	0.58	1.31	0.038
22 percent	17.8	.71	1.46	.039
aromatic (7203)	14.5	.56	1.43	.041
Avg...	15.8	.62	1.40	.039
High alkylate	15.5	0.76	1.49	0.043
10 percent	18.0	1.02	1.40	.036
aromatic (7212)	19.2	.88	1.39	.033
Avg...	17.6	.89	1.43	.037
45° F AMBIENT TEMPERATURE				
Typical clear I,	13.0	0.49	1.61	0.028
35 percent	9.57	.42	1.75	.042
aromatic (7202)	9.97	.43	1.84	.043
1/	12.2	.47	1.69	.052
Avg...	11.2	.45	1.72	.041
Indolene clear,	10.9	0.41	1.47	0.040
22 percent	13.6	.45	1.54	.041
aromatic (7203)	14.3	.46	1.49	.031
Avg...	12.9	.44	1.50	.037
High alkylate,	13.1	0.59	1.31	0.037
10 percent	10.0	.67	1.35	.043
aromatic (7212)	10.5	.52	1.31	.033
Avg...	11.2	.59	1.32	.038

1/ A fourth replicate test was made at 45° F ambient temperature using fuel 7202 because the sample for GLC analysis was lost on the first replicate test.

TABLE C-4. - Mass emissions for individual replicate tests weighted in accordance with the 1975 Federal test procedure for the temperature study [1972 Oldsmobile Delta 88 (Car 403) with a 455-CID engine and equipped with a base metal oxidation catalyst and EGR]--Continued

Fuel	Emissions, grams/mile			
	Carbon monoxide	Hydrocarbon	Nitrogen oxides[2/]	Aldehydes (MBTH)
75° F AMBIENT TEMPERATURE				
Typical clear I, 35 percent aromatic (7202)	7.14	0.30	1.33	0.031
	8.82	.37	1.14	.036
	5.22	.31	1.43	.024
Avg...	7.06	.33	1.30	.030
Indolene clear, 22 percent aromatic (7203)	8.06	0.39	1.25	0.043
	9.89	.45	1.27	.042
	8.37	.45	1.23	.035
Avg...	8.77	.43	1.25	.040
High alkylate, 10 percent aromatic (7212)	10.9	0.46	1.30	0.043
	11.4	.48	1.35	.040
	9.48	.56	1.16	.046
Avg...	10.6	.50	1.27	.043
95° F AMBIENT TEMPERATURE				
Typical clear I, 35 percent aromatic (7202)	12.9	0.67	1.65	0.027
	10.8	.58	1.60	.018
	12.4	.65	1.57	.020
Avg...	12.0	.63	1.61	.022
Indolene clear, 22 percent aromatic (7203)	17.5	0.50	1.33	0.025
	15.6	.48	1.35	.023
	12.3	.58	1.42	.026
Avg...	15.1	.52	1.37	.025
High alkylate, 10 percent aromatic (7212)	13.9	0.51	1.30	0.023
	16.0	.56	1.27	.024
	19.6	.66	1.21	.016
Avg...	16.5	.58	1.26	.021

2/ NO_x data are corrected for humidity to 75 grains H_2O per lb of dry air.

TABLE C-5. - Mass emissions for individual replicate tests weighted in accordance with the 1975 Federal test procedure for the temperature study [1972 Ford Torino (Car 724) with a 351-CID engine and equipped with platinum oxidation catalyst and EGR]

Fuel	Emissions, grams/mile			
	Carbon monoxide	Hydrocarbon	Nitrogen oxides 1/	Aldehydes (MBTH)
25° F AMBIENT TEMPERATURE				
Typical clear II,	63.9	4.10	2.59	0.034
40 percent	69.2	4.24	2.46	.036
aromatic (7221)	66.0	4.36	2.81	.039
Avg...	66.4	4.23	2.62	.036
High alkylate,	65.7	5.29	2.10	0.054
10 percent	66.8	4.63	2.04	.048
aromatic (7212)	69.4	4.98	2.07	.055
Avg...	67.3	4.97	2.07	.052
45° F AMBIENT TEMPERATURE				
Typical clear II,	35.1	2.37	3.20	0.030
40 percent	41.2	2.47	3.05	.031
aromatic (7221)	38.4	2.25	3.10	.028
Avg...	38.2	2.36	3.12	.030
High alkylate,	45.8	3.27	2.40	0.046
10 percent	43.3	3.36	2.51	.044
aromatic (7212)	44.2	3.29	2.34	.046
Avg...	44.4	3.31	2.42	.045
75° F AMBIENT TEMPERATURE				
Typical clear II,	7.01	0.78	2.24	0.019
40 percent	6.41	.70	2.32	.022
aromatic (7221)	5.54	.67	2.50	.017
Avg...	6.32	.72	2.35	.019
High alkylate,	6.17	0.88	1.83	0.022
10 percent	7.19	.91	1.93	.025
aromatic (7212)	6.87	.78	1.85	.026
Avg...	6.74	.86	1.87	.024
95° F AMBIENT TEMPERATURE				
Typical clear II,	5.77	0.87	2.37	0.021
40 percent	5.03	.81	2.52	.019
aromatic (7221)	4.96	.78	2.46	.018
Avg...	5.25	.82	2.45	.019
High alkylate,	11.0	1.13	1.76	0.026
10 percent	8.31	1.08	2.02	.027
aromatic (7212)	5.65	.98	1.94	.024
Avg...	8.32	1.06	1.91	.026

1/For 75° and 95° F tests, NO_x data are corrected for humidity to 75 grains H_2O per lb of dry air; for 25° and 45° F tests, NO_x data are not corrected for humidity.

TABLE C-6.--Mass emissions for individual replicate tests weighted in accordance with the 1975 Federal test procedure for the temperature study [1971 Plymouth Fury III (Car 775) with a 360-CID engine and equipped with the Ethyl lean reactors and EGR]

Fuel	Emissions, grams/mile			
	Carbon monoxide	Hydrocarbon	Nitrogen oxides 1/	Aldehydes (MBTH)
25° F AMBIENT TEMPERATURE				
Typical clear II,	21.6	1.95	5.38	0.073
40 percent	29.4	2.12	6.44	.056
aromatic (7221)	24.4	1.47	6.48	.061
Avg...	25.1	1.85	6.10	.063
High alkylate,	19.7	1.17	5.52	0.051
10 percent	32.3	2.95	4.37	.049
aromatic (7212)	26.0	2.33	4.37	.063
Avg...	26.0	2.15	4.75	.054
45° F AMBIENT TEMPERATURE				
Typical clear II,	11.4	0.75	4.35	0.036
40 percent	9.67	.71	6.12	.047
aromatic (7221)	11.4	.76	5.66	.044
Avg...	10.8	.74	5.38	.042
High alkylate,	9.03	0.82	3.46	0.038
10 percent	9.39	.78	4.84	.061
aromatic (7212)	10.37	.70	4.92	.050
Avg...	9.60	.77	4.41	.050
75° F AMBIENT TEMPERATURE				
Typical clear II,	5.37	0.40	3.40	0.016
40 percent	4.64	.41	3.09	.016
aromatic (7221)	5.01	.48	2.97	.017
Avg...	5.01	.43	3.15	.016
High alkylate,	4.55	0.36	2.51	0.018
10 percent	3.79	.40	2.62	.016
aromatic (7212)	3.90	.32	2.79	.019
Avg...	4.08	.36	2.64	.018
95° F AMBIENT TEMPERATURE				
Typical clear II,	4.66	0.55	3.17	0.013
40 percent	4.43	.44	3.45	.011
aromatic (7221)	4.39	.43	3.51	.011
Avg...	4.49	.47	3.38	.012
High alkylate,	5.06	0.68	3.08	0.028
10 percent	5.15	.62	2.75	.014
aromatic (7212)	5.42	.59	2.34	.016
Avg...	5.21	.63	2.72	.019

1/ For 75° and 95° F tests, NO_x data are corrected for humidity to 75 grains H_2O per lb of dry air; for 25° and 45° F tests, NO_x data are not corrected for humidity.

APPENDIX D -- DATA ON THE INFLUENCE OF AMBIENT TEMPERATURE ON HYDROCARBON DISTRIBUTION IN EXHAUST FROM PROTOTYPE LOW EMISSION SYSTEMS

TABLE D-1. - Exhaust hydrocarbon distribution for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1972 Oldsmobile Delta 88 (Car 403) with a 455-CID engine and equipped with a base-metal oxidation catalyst and EGR]

Fuel	Bag number	Total HC, grams/test	Hydrocarbon distribution, weight percent: Paraffins: Methane	Paraffins: C_2-C_5	Paraffins: C_6+	Olefins: Ethylene	Olefins: C_3-C_5	Olefins: C_6+	Aromatics: Benzene	Aromatics: C_7+	Acetylenes
			25° F AMBIENT TEMPERATURE								
Typical clear I, 35 percent aromatic (7202)	1	10.4	8.5	10.9	26.0	6.4	6.2	2.7	4.1	30.1	5.1
		13.4	6.0	11.5	30.4	4.7	5.4	3.3	3.6	30.8	4.3
		9.36	7.5	11.5	28.5	6.8	5.6	5.7	3.8	26.1	4.5
	Avg...	11.0	7.3	11.3	28.3	6.0	5.8	3.9	3.8	29.0	4.6
	2	.73	0	15.0	21.2	31.8	7.9	.2	10.8	13.1	0
		.84	8.9	14.8	19.8	30.5	7.6	.2	10.3	7.9	0
		1.03	3.8	17.6	20.8	29.2	6.7	.2	10.1	11.6	0
	Avg...	.87	4.2	15.8	20.6	30.5	7.4	.2	10.4	10.9	0
	3	.92	6.7	14.6	21.8	26.6	8.8	.2	8.9	12.4	0
		.94	5.4	16.9	24.9	24.1	8.4	.2	9.6	10.5	0
		.99	7.6	17.3	20.6	28.9	8.6	.2	8.4	8.4	0
	Avg...	.95	6.6	16.3	22.4	26.5	8.6	.2	9.0	10.4	0
Indolene clear, 22 percent aromatic (7203)	1	6.09	-	-	-	-	-	-	-	-	-
		8.62	17.2	10.4	20.9	10.9	8.6	1.3	4.6	14.0	12.1
		5.48	13.4	13.4	24.2	11.1	11.2	1.2	5.6	15.3	4.6
	Avg...	6.73	15.3	11.9	22.6	11.0	9.9	1.2	5.1	14.6	8.4
	2	.91	-	-	-	-	-	-	-	-	-
		.95	5.9	11.9	22.5	32.4	14.0	1.3	8.6	3.4	0
		1.27	7.3	15.6	20.6	31.7	11.8	1.1	8.4	3.5	0
	Avg...	1.04	6.6	13.8	21.7	32.0	12.9	1.2	8.5	3.4	0
	3	1.41	-	-	-	-	-	-	-	-	-
		1.15	9.5	22.4	24.0	26.9	3.6	1.0	7.2	5.3	.1
		1.06	9.5	15.3	22.7	30.1	9.3	1.1	7.2	4.8	0
	Avg...	1.21	9.5	18.9	23.5	28.5	6.4	1.0	7.2	5.0	0
High alkylate, 10 percent aromatic (7212)	1	8.75	14.8	10.8	37.3	10.0	10.6	2.7	1.9	5.0	6.9
		14.0	17.3	9.3	32.3	8.2	9.4	2.3	1.6	5.6	14.0
		11.0	14.8	10.4	36.2	8.4	10.3	2.3	1.8	5.8	10.0
	Avg...	11.2	15.6	10.2	35.2	8.9	10.1	2.4	1.8	5.5	10.3
	2	1.11	14.0	16.1	26.3	27.2	9.8	1.5	3.3	1.8	0
		.84	12.5	16.5	24.8	26.6	12.7	1.7	3.1	2.1	0
		.87	15.4	14.8	26.7	25.7	10.1	1.7	3.3	2.3	0
	Avg...	.94	14.0	15.8	25.9	26.5	10.9	1.6	3.2	2.1	0
	3	1.46	16.0	14.9	26.6	26.3	9.5	1.8	2.2	2.7	0
		1.34	14.2	16.2	31.0	22.2	9.1	1.7	2.5	3.1	0
		1.77	16.8	15.7	30.6	20.2	9.5	1.8	2.6	2.7	.1
	Avg...	1.52	15.7	15.6	29.4	22.9	9.4	1.8	2.4	2.8	0
			45° F AMBIENT TEMPERATURE								
Typical clear I, 35 percent aromatic (7202)	1/ 1	5.56	-	-	-	-	-	-	-	-	-
		3.83	10.4	12.0	22.6	13.1	9.5	1.9	6.1	21.1	3.3
		4.19	14.3	11.8	19.5	15.0	8.0	1.7	5.2	19.0	5.5
		4.88	14.1	11.6	19.7	13.4	8.2	1.5	5.4	20.4	5.7
	Avg...	4.62	12.9	11.8	20.6	13.8	8.6	1.7	5.6	20.2	4.8
	1/ 2	.72	-	-	-	-	-	-	-	-	-
		.93	2.4	17.9	21.4	32.8	8.5	.2	10.7	6.1	0
		.81	2.3	19.5	21.6	30.1	7.4	.2	9.6	9.3	0
		.75	4.1	17.9	19.8	33.2	9.3	.4	10.0	5.3	0
	Avg...	.80	2.9	18.4	20.9	32.0	8.4	.3	10.2	6.9	0
	1/ 3	.95	-	-	-	-	-	-	-	-	-
		1.00	6.1	17.1	22.8	25.6	8.4	.2	8.6	11.2	0
		1.04	7.6	17.2	22.3	24.4	8.6	.4	7.8	11.7	0
		1.16	8.8	18.3	23.2	24.5	7.7	.6	7.6	9.1	.2
	Avg...	1.04	7.5	17.5	22.8	24.8	8.2	.4	8.0	10.7	.1
Indolene clear, 22 percent aromatic (7203)	1	3.57	14.5	11.7	23.0	15.7	11.2	2.7	5.5	10.5	5.2
		4.52	14.9	10.1	25.4	12.5	9.1	2.9	4.6	12.1	8.4
		4.35	17.4	10.9	22.0	15.4	9.7	2.5	4.8	10.2	7.1
	Avg...	4.15	15.6	10.9	23.5	14.5	10.0	2.7	5.0	10.9	6.9
	2	.83	3.0	16.8	23.6	33.1	9.5	1.0	9.1	3.9	0
		.84	2.6	17.1	24.5	31.4	9.7	.9	8.7	5.1	0
		.86	2.9	17.3	23.3	33.8	9.1	1.4	8.8	3.4	0
	Avg...	.84	2.8	17.1	23.8	32.8	9.4	1.1	8.9	4.1	0
	3	1.19	10.4	17.0	22.5	27.1	9.1	1.1	6.8	6.0	0
		1.10	9.6	16.5	25.4	25.3	8.9	1.2	6.6	6.5	0
		1.22	9.8	16.5	24.7	25.6	9.1	1.2	6.8	6.1	.2
	Avg...	1.17	9.9	16.7	24.2	26.0	9.0	1.2	6.7	6.2	.1
High alkylate, 10 percent aromatic (7212)	1	5.67	16.5	10.5	30.2	12.5	12.3	3.3	2.1	4.2	8.4
		7.19	11.2	10.3	41.3	9.0	10.7	4.4	1.7	5.5	5.9
		5.31	17.0	10.3	28.4	12.7	11.8	2.7	1.9	3.9	11.3
	Avg...	6.06	14.9	10.4	33.3	11.4	11.6	3.5	1.9	4.5	8.5
	2	1.17	10.5	18.3	26.4	25.4	12.1	1.6	2.9	2.8	0
		1.11	12.0	15.6	27.3	26.8	11.5	1.4	3.0	2.4	0
		.77	13.1	15.2	25.4	29.8	9.9	1.8	3.3	1.5	0
	Avg...	1.02	11.9	16.4	26.4	27.3	11.1	1.6	3.1	2.2	0
	3	1.49	13.3	17.1	30.7	22.4	10.0	1.6	2.7	2.2	0
		1.47	14.2	15.7	30.7	22.5	10.3	1.6	2.8	2.2	0
		1.53	15.2	16.8	30.0	21.8	9.3	1.5	2.5	2.9	0
	Avg...	1.50	14.2	16.5	30.5	22.2	9.9	1.6	2.7	2.4	0

1/ A fourth replicate test was made at 45° F ambient temperature using fuel 7202 because the sample for GLC analysis was lost on the first replicate test.

TABLE D-1. - Exhaust hydrocarbon distribution for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1972 Oldsmobile Delta 88 (Car 403) with a 455-CID engine and equipped with a base-metal oxidation catalyst and EGR]--Continued

Fuel	Bag number	Total HC, grams/test	Hydrocarbon distribution, weight percent								
			Paraffins			Olefins			Aromatics		Acetylenes
			Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
75° F AMBIENT TEMPERATURE											
Typical clear I, 35 percent aromatic (7202)	1	2.29	8.5	12.4	21.8	16.8	10.8	1.4	6.6	18.9	2.8
		3.08	10.5	9.1	24.6	14.0	9.3	2.1	6.0	19.3	5.1
		2.32	8.3	11.9	21.6	17.5	10.6	1.6	6.6	19.1	2.8
	Avg...	2.56	9.1	11.1	22.7	16.1	10.2	1.7	6.4	19.1	3.6
	2	.57	0	20.4	24.7	31.0	6.1	.2	11.4	6.2	0
		.69	1.0	15.2	31.5	26.3	8.4	.5	10.0	7.1	0
		.67	0	16.1	22.2	32.9	10.0	.2	10.6	8.0	0
	Avg...	.64	.3	17.2	26.1	30.1	8.2	.3	10.7	7.1	0
	3	1.19	7.4	25.5	23.3	19.3	5.8	.4	6.7	11.6	0
		1.29	10.6	23.7	24.2	18.5	6.1	.2	6.7	10.0	0
		1.12	7.5	21.5	24.7	20.7	6.8	.3	7.7	10.8	0
	Avg...	1.20	8.5	23.6	24.1	19.5	6.2	.3	7.0	10.8	0
Indolene clear, 22 percent aromatic (7203)	1	2.63	12.0	12.8	23.3	17.9	11.7	2.5	5.6	10.8	3.4
		4.13	11.7	9.2	28.2	13.3	9.1	3.3	4.6	13.4	7.2
		4.17	15.2	9.4	23.7	15.2	7.8	1.2	5.0	11.8	10.7
	Avg...	3.64	13.0	10.5	25.1	15.4	9.5	2.3	5.1	12.0	7.1
	2	.72	3.6	20.4	23.5	30.4	6.7	.9	7.7	6.8	0
		.70	5.6	17.9	20.3	33.7	8.9	.8	8.7	4.1	0
		.71	9.9	15.6	19.7	34.0	8.4	.8	9.1	2.5	0
	Avg...	.71	6.4	18.0	21.2	32.6	8.0	.8	8.5	4.5	0
	3	1.83	11.0	25.3	25.3	17.9	7.0	1.3	5.7	6.5	0
		1.52	11.1	24.9	24.8	18.5	7.7	1.1	5.8	6.1	0
		1.59	11.7	25.8	24.7	18.7	7.3	1.3	5.6	4.9	0
	Avg...	1.65	11.3	25.4	24.9	18.4	7.3	1.2	5.7	5.8	0
High alkylate, 10 percent aromatic (7212)	1	4.14	13.6	8.1	32.2	13.5	11.1	3.4	2.7	7.4	8.0
		3.93	14.8	11.9	29.6	16.5	13.8	2.8	2.1	4.2	4.3
		4.67	17.0	11.3	28.5	14.7	12.4	3.3	2.2	3.6	7.0
	Avg...	4.25	15.1	10.4	30.1	14.9	12.5	3.2	2.3	5.1	6.4
	2	0.74	13.3	13.1	27.2	28.8	8.5	1.2	4.7	3.2	0
		.76	15.4	14.8	21.8	29.4	8.3	1.1	6.8	2.4	0
		.99	21.5	15.1	23.3	25.3	9.3	1.3	2.8	1.4	0
	Avg...	.83	16.7	14.3	24.1	27.9	8.7	1.2	4.8	2.3	0
	3	1.62	16.7	14.5	32.5	18.5	8.7	1.6	3.3	4.2	0
		1.96	18.7	11.3	31.8	15.5	15.9	1.6	2.3	2.8	.1
		2.13	14.6	23.2	33.5	14.3	7.6	1.8	2.1	2.9	0
	Avg...	1.90	16.7	16.3	32.7	16.1	10.7	1.6	2.6	3.3	0
95° F AMBIENT TEMPERATURE											
Typical clear I, 35 percent aromatic (7202)	1	6.85	-	-	-	-	-	-	-	-	-
		6.71	2.7	5.5	36.2	5.2	4.3	3.4	3.8	37.6	1.3
		6.68	3.1	6.6	36.3	5.3	4.3	3.5	3.6	36.1	1.2
	Avg...	6.75	2.9	6.1	36.2	5.2	4.3	3.5	3.7	36.8	1.3
	2	.72	-	-	-	-	-	-	-	-	-
		.56	0	23.6	22.4	29.9	6.4	.3	9.7	7.7	0
		.84	11.9	19.6	20.7	23.7	2.2	.4	7.9	13.6	0
	Avg...	.71	5.9	21.6	21.6	26.8	4.3	.4	8.8	10.6	0
	3	2.37	-	-	-	-	-	-	-	-	-
		1.66	10.5	28.4	24.4	14.3	5.5	.3	6.3	10.3	0
		1.98	13.9	27.2	24.1	12.6	5.1	.6	5.8	10.7	0
	Avg...	2.00	12.2	27.8	24.2	13.5	5.3	.5	6.0	10.5	0
Indolene clear, 22 percent aromatic (7203)	1	3.56	11.6	11.0	27.0	15.0	11.0	3.3	5.3	13.1	2.7
		2.89	11.8	11.9	25.8	14.7	12.1	3.4	5.7	12.0	2.6
		5.23	6.7	10.6	36.2	8.2	7.7	4.2	3.9	19.6	2.9
	Avg...	3.89	10.0	11.2	29.7	12.6	10.3	3.6	5.0	14.9	2.7
	2	.73	18.1	19.3	18.1	23.8	7.9	.6	6.4	5.8	0
		.68	19.9	18.7	19.2	24.7	6.3	.9	6.8	3.5	0
		.68	20.5	16.1	18.3	24.7	7.6	.9	7.4	4.4	0
	Avg...	.70	19.5	18.0	18.5	24.4	7.3	.8	6.9	4.6	0
	3	2.61	16.9	27.2	25.8	11.0	6.0	2.3	4.8	6.0	0
		2.97	15.6	24.8	31.6	8.1	5.5	2.7	4.5	7.2	0
		2.49	14.8	29.2	26.3	11.1	6.3	1.5	4.8	6.0	0
	Avg...	2.69	15.8	27.1	27.9	10.0	5.9	2.2	4.7	6.4	0
High alkylate, 10 percent aromatic (7212)	1	4.45	9.0	9.0	44.7	9.8	11.3	4.8	1.9	7.2	2.3
		4.65	10.2	9.5	43.0	11.2	10.7	4.3	1.8	7.2	2.1
		5.29	-	-	-	-	-	-	-	-	-
	Avg...	4.80	9.6	9.3	43.8	10.5	11.0	4.6	1.8	7.2	2.2
	2	0.63	28.1	14.6	22.1	23.1	6.0	1.0	2.8	2.3	0
		.72	22.6	19.4	22.5	21.0	6.4	1.7	2.7	3.7	0
		.70	-	-	-	-	-	-	-	-	-
	Avg...	.68	25.4	17.0	22.3	22.0	6.2	1.4	2.7	3.0	0
	3	2.26	19.1	23.6	31.8	11.5	7.1	2.0	2.2	2.7	0
		2.58	20.0	23.2	32.1	11.1	6.4	2.0	2.2	3.0	0
		3.52	-	-	-	-	-	-	-	-	-
	Avg...	2.79	19.6	23.4	31.9	11.3	6.8	2.0	2.2	2.8	0

TABLE D-2. - Exhaust hydrocarbon distribution for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1972 Ford Torino (Car 724) with a 351-CID engine and equipped with platinum oxidation catalysts and EGR]

Fuel	Bag number	Total HC, grams/test	Hydrocarbon distribution, weight percent								
			Paraffins			Olefins			Aromatics		Acetylenes
			Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
25° F AMBIENT TEMPERATURE											
Typical clear II, 40 percent aromatic (7221)	1	63.9	16.2	5.6	13.5	7.3	6.6	2.0	4.1	31.4	13.3
		65.4	15.0	5.4	13.9	7.0	6.3	2.1	4.2	35.1	11.0
		67.6	15.1	5.8	15.5	6.8	6.8	2.2	4.3	32.1	11.4
	Avg...	65.7	15.4	5.6	14.3	7.0	6.6	2.1	4.2	32.9	11.9
	2	2.08	23.2	10.1	18.0	5.4	8.4	2.2	4.9	26.4	1.4
		2.36	25.6	10.8	12.6	6.5	7.9	1.1	5.3	28.7	1.5
		2.29	22.9	10.5	16.9	5.7	8.3	2.0	5.2	27.1	1.4
	Avg...	2.24	23.9	10.5	15.8	5.9	8.2	1.8	5.1	27.4	1.4
	3	2.14	17.7	12.0	18.6	6.8	7.9	1.7	4.5	28.4	2.4
		2.32	17.2	10.9	15.5	6.4	7.1	1.0	4.3	35.8	1.8
		2.28	15.5	11.3	19.0	6.0	7.5	1.7	4.3	32.8	1.9
	Avg...	2.25	16.8	11.4	17.7	6.4	7.5	1.5	4.4	32.3	2.0
High alkylate, 10 percent aromatic (7212)	1	83.5	20.8	5.9	27.0	8.3	11.3	2.3	1.8	6.7	15.9
		71.6	21.8	5.8	25.7	8.9	11.8	2.0	1.8	6.8	15.4
		77.8	19.3	8.0	30.0	7.8	9.9	2.3	2.0	7.2	13.5
	Avg...	77.6	20.6	6.6	27.5	8.4	11.0	2.2	1.9	6.9	14.9
	2	2.36	37.5	11.8	21.6	7.2	10.6	1.6	1.4	6.4	1.9
		2.52	34.9	10.6	21.5	7.1	11.0	1.7	1.4	10.1	1.7
		2.45	37.3	11.1	20.8	7.5	11.6	1.1	1.3	7.0	2.3
	Avg...	2.44	36.5	11.1	21.3	7.3	11.1	1.5	1.4	7.8	2.0
	3	2.42	22.7	13.1	30.2	7.4	10.9	2.0	1.6	9.7	2.4
		2.50	26.6	13.7	24.9	8.1	12.2	1.4	1.6	8.9	2.6
		2.52	26.9	13.5	25.1	8.1	12.3	1.4	1.6	8.3	2.8
	Avg...	2.48	25.4	13.4	26.7	7.9	11.8	1.6	1.6	9.0	2.6

TABLE D-2. - Exhaust hydrocarbon distribution for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1972 Ford Torino (Car 724) with a 351-CID engine and equipped with platinum oxidation catalysts and EGR]--Continued

Fuel	Bag number	Total HC, grams/test	Hydrocarbon distribution, weight percent								
			Paraffins			Olefins			Aromatics		Acetylenes
			Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
45° F AMBIENT TEMPERATURE											
Typical clear II, 40 percent aromatic (7221)	1	34.4	21.3	4.9	10.3	8.8	5.6	1.1	4.2	27.5	16.3
		36.9	19.2	5.6	12.2	8.1	6.0	1.6	4.0	27.5	15.8
		32.8	19.6	4.8	11.5	7.9	5.6	1.4	4.1	30.4	14.7
	Avg...	34.7	20.0	5.1	11.3	8.3	5.7	1.4	4.1	28.5	15.6
	2	1.84	28.1	11.3	11.6	7.6	7.4	.6	6.3	25.2	1.9
		1.53	23.7	12.1	15.3	6.6	10.1	1.4	5.7	23.3	1.8
		1.71	23.9	10.8	16.3	6.5	9.1	1.5	5.7	24.5	1.7
	Avg...	1.69	25.2	11.4	14.4	6.9	8.9	1.2	5.9	24.3	1.8
	3	1.97	19.1	14.7	14.8	7.7	8.2	1.0	5.3	27.0	2.2
		1.94	13.3	13.2	20.3	6.1	7.6	1.9	4.3	31.3	2.0
		1.90	17.4	13.0	16.1	7.4	7.9	1.4	5.1	29.4	2.3
	Avg...	1.94	16.6	13.6	17.1	7.1	7.9	1.4	4.9	29.2	2.2
High alkylate, 10 percent aromatic (7212)	1	49.7	24.4	5.3	22.2	9.0	10.2	1.8	1.8	5.8	19.5
		51.0	24.0	5.4	20.9	9.4	10.1	1.7	1.7	5.2	21.6
		49.7	23.9	5.8	22.7	9.3	10.3	1.6	1.8	5.7	18.9
	Avg...	50.1	24.1	5.5	21.9	9.2	10.2	1.7	1.8	5.6	20.0
	2	1.93	37.2	13.6	20.4	7.5	11.1	1.9	1.2	5.3	1.8
		1.92	32.7	13.1	24.6	6.8	11.3	2.3	1.8	5.7	1.7
		1.99	33.6	13.1	21.8	7.5	12.9	1.6	1.9	5.6	2.0
	Avg...	1.95	34.5	13.3	22.3	7.3	11.8	1.9	1.6	5.5	1.8
	3	2.18	24.5	15.2	27.3	7.9	11.6	2.2	1.7	7.1	2.5
		2.33	25.0	15.4	25.8	8.8	11.5	1.4	1.6	7.5	3.0
		2.36	23.7	15.0	27.7	8.0	11.1	2.0	1.7	8.2	2.6
	Avg...	2.29	24.4	15.2	26.9	8.2	11.4	1.9	1.7	7.6	2.7

TABLE D-2. - Exhaust hydrocarbon distribution for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1972 Ford Torino (Car 724) with a 351-CID engine and equipped with platinum oxidation catalysts and EGR]--Continued

Fuel	Bag number	Total HC, grams/test	Hydrocarbon distribution, weight percent								
			Paraffins			Olefins			Aromatics		Acetylenes
			Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
75° F AMBIENT TEMPERATURE											
Typical clear II, 40 percent aromatic (7221)	1	5.41	13.4	9.3	19.1	6.8	8.1	2.5	5.0	32.5	3.3
		4.50	14.5	9.5	17.7	7.0	8.5	2.0	5.0	32.6	3.2
		3.99	14.9	9.8	17.7	7.6	8.7	1.9	4.8	30.4	4.2
	Avg..	4.63	14.3	9.6	18.0	7.1	8.5	2.1	4.9	31.9	3.6
	2	1.52	22.1	14.3	15.9	6.4	7.7	1.3	5.3	25.4	1.6
		1.70	28.8	14.8	13.9	6.0	6.8	1.1	4.3	22.4	1.9
		1.19	29.9	14.9	13.9	6.1	6.8	.8	4.4	21.4	1.8
	Avg..	1.47	26.9	14.7	14.5	6.2	7.1	1.1	4.7	23.0	1.8
	3	3.49	10.9	25.9	20.4	5.2	8.9	2.1	3.4	21.2	2.0
		2.90	12.3	28.3	18.7	4.5	8.0	2.0	3.2	21.4	1.6
		3.66	10.9	24.8	20.5	4.5	8.8	2.5	3.0	21.1	3.9
	Avg..	3.35	11.4	26.3	19.9	4.7	8.6	2.2	3.2	21.2	2.5
High alkylate, 10 percent aromatic (7212)	1	5.37	21.5	9.8	24.3	7.3	13.7	2.0	1.4	5.5	14.5
		4.53	19.4	10.8	28.9	8.1	15.3	2.6	1.6	6.1	7.2
		5.44	21.1	9.4	26.3	8.3	13.2	2.0	1.7	6.6	11.4
	Avg..	5.11	20.6	10.0	26.5	7.9	14.1	2.2	1.6	6.1	11.0
	2	1.80	31.0	14.9	25.9	7.0	11.8	1.7	1.0	4.8	1.9
		2.07	30.1	13.3	26.3	7.2	13.1	1.8	1.4	5.0	1.8
		1.99	36.4	14.5	24.1	6.6	9.9	1.4	1.1	4.2	1.8
	Avg..	1.95	32.5	14.2	25.5	6.9	11.6	1.6	1.2	4.7	1.8
	3	4.30	12.9	26.1	34.6	5.1	8.8	2.9	1.1	5.8	2.7
		4.93	12.5	27.5	35.8	5.0	8.6	2.4	1.2	4.7	2.3
		2.71	20.6	18.3	32.2	6.5	11.3	2.2	1.2	5.6	2.1
	Avg..	3.98	15.3	23.9	34.2	5.5	9.6	2.5	1.2	5.4	2.4

TABLE D-2. - Exhaust hydrocarbon distribution for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1972 Ford Torino (Car 724) with a 351-CID engine and equipped with platinum oxidation catalysts and EGR]--Continued

Fuel	Bag number	Total HC, grams/test	Hydrocarbon distribution, weight percent								Acetylenes
			Paraffins			Olefins			Aromatics		
			Methane	C_2-C_5	C_{6+}	Ethylene	C_3-C_5	C_{6+}	Benzene	C_{7+}	
95° F AMBIENT TEMPERATURE											
Typical clear II, 40 percent aromatic (7221)	1	3.58	13.2	12.3	18.2	6.8	10.0	2.2	5.1	28.8	3.4
		2.83	15.0	10.8	15.2	7.3	10.0	1.8	5.4	31.0	3.5
		2.96	15.8	12.5	15.9	7.4	9.5	1.6	5.3	28.6	3.4
	Avg...	3.12	14.7	11.9	16.4	7.2	9.8	1.9	5.3	29.4	3.4
	2	2.01	21.0	17.7	14.8	6.6	9.4	1.3	5.5	22.2	1.5
		1.90	22.5	16.2	11.9	6.9	8.9	.7	5.6	25.3	2.0
		1.85	23.8	17.3	11.7	6.6	10.3	.9	5.3	22.4	1.7
	Avg...	1.92	22.4	17.1	12.8	6.7	9.5	1.0	5.5	23.3	1.7
	3	5.17	8.8	25.0	23.0	3.9	9.8	2.7	3.2	21.4	2.2
		5.19	8.7	25.6	22.8	4.0	9.3	2.6	3.3	21.6	2.1
		4.84	10.0	29.0	21.0	4.2	9.7	2.2	3.2	18.3	2.4
	Avg...	5.07	9.2	26.5	22.3	4.0	9.6	2.5	3.3	20.4	2.2
High alkylate, 10 percent aromatic (7212)	1	4.34	20.0	13.0	29.1	7.5	14.1	2.3	1.8	6.7	5.5
		3.91	21.9	13.0	28.4	7.5	13.7	2.2	1.7	6.1	5.5
		3.63	19.4	12.6	29.2	7.3	13.4	2.5	1.8	7.6	6.2
	Avg...	3.96	20.4	12.9	28.9	7.4	13.7	2.4	1.8	6.8	5.7
	2	2.76	30.6	16.6	21.3	8.0	12.7	1.7	2.2	4.9	2.0
		2.69	32.5	17.9	21.0	7.6	11.4	1.2	1.7	4.9	1.8
		2.39	30.7	19.6	20.1	8.0	11.7	1.1	1.7	5.1	2.0
	Avg...	2.61	31.3	18.0	20.8	7.9	11.9	1.3	1.9	5.0	1.9
	3	6.72	12.4	27.4	38.3	4.3	7.3	2.4	1.1	5.2	1.6
		6.55	12.3	29.0	37.8	4.0	7.2	2.4	1.1	5.0	1.2
		5.94	12.7	28.8	35.4	4.8	8.1	2.3	1.1	5.0	1.8
	Avg...	6.40	12.5	28.4	37.1	4.4	7.5	2.4	1.1	5.1	1.5

TABLE D-3. - Exhaust hydrocarbon distribution for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1971 Plymouth Fury III (Car 775) with a 360-CID engine and equipped with the Ethyl lean reactors and EGR]

Fuel	Bag number	Total HC, grams/test	Hydrocarbon distribution, weight percent								
			Paraffins			Olefins			Aromatics		Acetylenes
			Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
25° F AMBIENT TEMPERATURE											
Typical clear II, 40 percent aromatic (7221)	1	31.0	6.9	9.5	19.4	7.4	9.6	2.9	4.3	33.1	6.9
		33.7	10.9	9.7	15.2	8.0	8.9	1.7	3.6	29.1	12.9
		22.2	9.6	7.4	16.0	9.0	9.4	1.9	5.0	30.1	11.6
	Avg...	29.0	9.1	8.8	16.9	8.1	9.3	2.2	4.3	30.8	10.5
	2	0.92	8.6	3.2	5.8	25.2	11.6	0.1	8.1	21.6	15.8
		.89	1.7	3.8	6.7	24.9	12.8	.1	8.6	26.9	14.5
		1.13	.2	5.7	13.0	21.5	16.3	1.8	7.8	22.6	11.1
	Avg...	.98	3.5	4.2	8.5	23.8	13.6	.7	8.2	23.7	13.8
	3	0.66	4.5	4.1	11.9	14.9	9.0	0.6	6.8	36.1	12.1
		.87	3.9	3.0	9.0	12.8	7.0	.2	6.0	47.5	10.6
		.70	2.6	4.4	13.8	14.6	10.3	1.9	6.9	34.0	11.5
	Avg...	.74	3.6	3.8	11.5	14.1	8.8	.9	6.6	39.2	11.5
High alkylate, 10 percent aromatic (7212)	1	17.4	15.9	7.2	28.4	10.1	16.0	2.3	1.9	7.2	11.0
		48.2	12.1	9.3	40.0	6.0	8.7	3.3	1.3	7.0	12.3
		36.9	13.2	8.7	38.0	6.8	10.3	3.0	1.4	6.5	12.1
	Avg...	34.2	13.7	8.4	35.5	7.6	11.7	2.9	1.5	6.9	11.8
	2	0.91	7.6	3.1	12.7	27.9	24.6	1.3	2.4	7.4	13.0
		.75	4.5	4.6	11.5	26.2	24.8	.4	2.8	11.4	13.8
		1.09	5.8	4.4	10.9	28.8	27.1	.5	2.7	7.3	12.5
	Avg...	.92	6.0	4.0	11.7	27.7	25.5	.7	2.6	8.7	13.1
	3	0.70	10.3	4.9	16.1	21.4	20.0	0.6	3.0	7.8	15.9
		1.06	11.7	8.0	22.5	16.2	15.3	1.2	2.1	9.3	13.7
		.90	8.4	7.1	22.5	19.3	14.8	1.9	2.4	9.9	13.7
	Avg...	.89	10.1	6.7	20.4	19.0	16.7	1.2	2.5	9.0	14.4

TABLE D-3. - Exhaust hydrocarbon distribution for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1971 Plymouth Fury III (Car 775) with a 360-CID engine and equipped with the Ethyl lean reactors and EGR]--Continued

Fuel	Bag number	Total HC, grams/test	Hydrocarbon distribution, weight percent								
			Paraffins			Olefins			Aromatics		Acetylenes
			Methane	C_2-C_5	C_{6+}	Ethylene	C_3-C_5	C_{6+}	Benzene	C_{7+}	
45° F AMBIENT TEMPERATURE											
Typical clear II, 40 percent aromatic (7221)	1	11.3	8.7	7.8	12.2	12.1	10.4	1.2	5.8	31.4	10.4
		10.2	6.9	8.9	12.1	13.3	11.9	1.3	6.0	31.1	8.5
		11.5	7.1	7.7	14.4	12.5	12.1	1.6	6.0	29.5	9.1
	Avg...	11.0	7.6	8.1	12.9	12.6	11.5	1.4	5.9	30.7	9.3
	2	0.16	12.8	6.0	7.2	15.2	6.9	0.3	5.8	19.8	26.0
		.14	14.4	2.6	3.0	19.4	4.3	.0	5.1	20.7	30.5
		.23	8.0	5.0	8.9	17.1	8.8	.2	5.6	25.0	21.4
	Avg...	.18	11.7	4.5	6.4	17.2	6.7	.2	5.5	21.8	26.0
	3	1.06	7.4	10.3	10.7	13.6	9.6	1.1	5.6	28.0	13.7
		1.47	5.0	16.8	20.2	7.8	9.0	2.3	4.0	25.1	9.8
		.92	7.0	9.3	13.3	12.9	8.4	1.4	5.9	29.3	12.5
	Avg...	1.15	6.5	12.1	14.7	11.4	9.0	1.6	5.2	27.5	12.0
High alkylate, 10 percent aromatic (7212)	1	11.2	7.6	8.1	33.9	10.6	18.6	3.4	1.7	7.0	9.1
		10.4	9.8	7.8	23.8	16.4	23.4	1.5	2.0	5.5	9.8
		10.1	9.5	7.8	25.7	14.6	22.3	2.1	2.1	6.0	9.9
	Avg...	10.6	9.0	7.9	27.8	13.9	21.4	2.3	1.9	6.2	9.6
	2	0.17	11.2	15.6	15.9	13.7	11.7	0.4	1.3	7.3	22.9
		.29	14.8	6.5	8.8	25.2	11.2	.2	2.3	10.5	20.5
		.34	13.7	4.2	18.9	21.0	15.2	.4	4.0	5.9	16.7
	Avg...	.27	13.2	8.8	14.5	20.0	12.7	.4	2.5	7.9	20.0
	3	2.01	8.0	15.5	36.2	9.6	10.3	2.5	1.5	5.5	10.9
		1.89	9.5	13.8	31.1	11.8	12.4	2.0	1.6	6.9	10.9
		1.00	10.2	8.6	21.5	18.2	15.4	1.6	2.5	8.0	14.0
	Avg...	1.63	9.2	12.6	29.6	13.2	12.7	2.1	1.9	6.8	11.9

TABLE D-3. - Exhaust hydrocarbon distribution for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1971 Plymouth Fury III (Car 775) with a 360-CID engine and equipped with the Ethyl lean reactors and EGR]--Continued

Fuel	Bag number	Total HC, grams/test	Hydrocarbon distribution, weight percent								
			Paraffins			Olefins			Aromatics		Acetylenes
			Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
75° F AMBIENT TEMPERATURE											
Typical clear II, 40 percent aromatic (7221)	1	4.11	6.7	11.1	12.1	13.0	12.2	1.5	6.2	25.4	11.8
		3.89	6.3	14.3	13.6	11.9	13.1	2.1	5.7	22.0	11.0
		5.64	6.1	12.6	19.6	8.6	10.4	3.0	4.7	25.0	10.0
	Avg..	4.55	6.4	12.7	15.1	11.2	11.9	2.2	5.5	24.1	10.9
	1/2	0.17	0.0	4.9	4.4	18.6	7.3	0.2	8.7	29.2	26.7
		.15	.0	8.1	10.5	13.8	10.5	.9	6.4	28.8	21.0
		.15	25.6	3.0	5.9	12.9	5.5	.2	4.4	18.4	24.1
	Avg..	.16	8.6	5.3	6.9	15.1	7.8	.4	6.5	25.5	23.9
	3	1.89	4.4	24.1	15.7	9.4	11.2	1.8	4.6	20.4	8.4
		2.16	1.9	29.4	20.2	6.1	10.6	2.5	3.4	20.8	5.1
		1.74	3.0	25.9	19.4	6.6	10.7	2.4	3.7	21.9	6.4
	Avg..	1.93	3.1	26.5	18.5	7.4	10.8	2.2	3.9	21.0	6.6
High alkylate, 10 percent aromatic (7212)	1	3.31	9.0	10.1	15.7	16.8	24.0	3.0	2.5	5.2	13.7
		2.84	9.7	10.2	17.2	16.5	23.0	1.7	2.2	4.9	14.6
		2.98	8.8	12.0	17.5	16.0	23.5	1.6	2.1	5.7	12.8
	Avg..	3.04	9.2	10.7	16.8	16.4	23.5	2.1	2.3	5.3	13.7
	1/2	0.13	0.0	4.7	12.6	20.6	15.3	0.4	2.2	17.0	27.2
		.10	29.4	4.3	6.3	15.2	3.6	.1	1.1	7.6	32.4
		.11	8.1	4.8	12.6	18.8	6.1	.8	1.7	17.3	29.8
	Avg..	.11	12.5	4.6	10.5	18.2	8.3	.4	1.7	14.0	29.8
	3	2.04	5.6	28.8	26.0	10.6	12.2	2.0	1.4	4.7	8.7
		3.00	2.4	34.7	36.9	4.5	8.8	3.7	1.1	4.3	3.6
		1.78	4.4	27.2	33.4	8.0	10.2	2.5	1.2	5.8	7.3
	Avg..	2.27	4.1	30.3	32.1	7.7	10.4	2.7	1.2	4.9	6.6

1/The GLC results from bag 2 were not reliable because of the very low concentration of exhaust hydrocarbons and the relatively large contribution of hydrocarbons in the CVS diluent air.

TABLE D-3. - Exhaust hydrocarbon distribution for individual bags of the 1975 Federal test procedure and individual replicate tests for the temperature study [1971 Plymouth Fury III (Car 775) with a 360-CID engine and equipped with the Ethyl lean reactors and EGR]--Continued

Fuel	Bag number	Total HC, grams/test	Hydrocarbon distribution, weight percent								
			Paraffins			Olefins			Aromatics		Acetylenes
			Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
95° F AMBIENT TEMPERATURE											
Typical clear II, 40 percent aromatic (7221)	1	3.83	5.1	16.1	20.5	9.6	11.5	3.0	5.0	20.0	9.2
		3.54	3.9	26.1	22.6	6.5	11.5	3.4	3.8	14.8	7.4
		2.48	5.5	23.5	13.6	12.1	9.2	1.7	5.3	19.2	9.9
	Avg..	3.28	4.9	21.9	18.9	9.4	10.7	2.7	4.7	18.0	8.8
	2	0.19	0	5.9	9.5	17.3	9.7	0.3	7.1	28.4	21.8
		.19	9.0	4.2	6.8	16.4	8.2	.3	6.5	29.8	18.8
		.14	0	4.1	12.6	12.6	6.0	.3	4.8	37.3	22.3
	Avg..	.17	3.0	4.8	9.6	15.4	8.0	.3	6.1	31.8	21.0
	3	4.00	2.2	30.6	23.2	3.6	10.5	3.5	2.7	19.9	3.8
		2.73	2.9	27.4	21.6	5.1	10.6	2.9	3.2	22.3	4.0
		3.49	2.8	32.0	21.0	4.1	9.9	2.7	2.8	19.8	4.9
	Avg..	3.41	2.6	30.0	21.9	4.3	10.3	3.1	2.9	20.7	4.2
High alkylate, 10 percent aromatic (7212)	1	5.17	6.6	15.6	34.8	9.3	14.0	3.4	1.7	5.9	8.7
		2.70	9.2	16.7	24.7	12.9	14.6	2.1	2.0	4.7	13.1
		3.98	8.0	16.3	27.9	11.0	16.0	2.8	1.8	5.9	10.3
	Avg..	3.95	7.9	16.2	29.1	11.1	14.9	2.8	1.8	5.5	10.7
	2	0.10	0	12.1	25.6	13.2	18.0	0.4	2.9	6.0	21.8
		.09	0	6.9	17.9	19.5	7.9	1.5	1.5	14.4	30.4
		.17	5.1	8.9	15.1	17.1	13.7	.5	1.7	15.7	22.2
	Avg..	.12	1.7	9.3	19.5	16.6	13.2	.8	2.1	12.0	24.8
	3	4.92	4.1	28.2	38.4	5.1	8.6	3.3	1.0	5.9	5.4
		6.00	4.2	27.5	39.8	5.0	8.5	3.8	1.0	5.6	4.6
		4.40	5.4	32.1	30.9	6.7	10.5	2.7	1.1	4.7	5.9
	Avg..	5.11	4.6	29.3	36.3	5.6	9.2	3.3	1.0	5.4	5.3

TABLE D-4. - Exhaust hydrocarbon distribution for individual replicate tests weighted in accordance with the 1975 Federal test procedure for the temperature study [1972 Oldsmobile Delta 88 (Car 403) with a 455-CID engine and equipped with a base metal oxidation catalyst and EGR]

Fuel	Total HC, grams/mile	Hydrocarbon distribution, weight percent								
		Paraffins			Olefins			Aromatics		Acetylenes
		Methane	C_2-C_5	C_{6+}	Ethylene	C_3-C_5	C_{6+}	Benzene	C_{7+}	
25° F AMBIENT TEMPERATURE										
Typical clear I,	0.76	7.3	11.8	25.0	11.5	6.6	2.2	5.4	26.2	4.0
35 percent	.95	6.3	12.3	28.7	9.2	5.9	2.7	4.9	26.6	3.4
aromatic	.75	6.8	13.2	26.3	13.1	6.1	4.1	5.4	21.8	3.2
(7202) Avg..	.82	6.8	12.4	26.7	11.3	6.2	3.0	5.2	24.9	3.5
Indolene clear,	.58	-	-	-	-	-	-	-	-	-
22 percent	.71	14.2	12.1	21.6	16.8	8.9	1.3	5.6	11.0	8.5
aromatic	.56	11.0	14.3	22.9	20.0	11.1	1.2	6.7	10.2	2.6
(7203) Avg..	.62	12.6	13.2	22.2	18.4	10.0	1.2	6.2	10.6	5.6
High alkylate,	.76	14.8	12.4	33.5	15.5	10.3	2.4	2.2	.4	8.5
10 percent	1.02	16.4	10.8	31.4	11.6	9.7	2.2	1.8	5.0	11.1
aromatic	.88	15.2	11.8	34.1	12.5	10.1	2.1	2.1	4.9	7.2
(7212) Avg..	.89	15.5	11.7	33.1	13.2	10.0	2.2	2.0	3.4	8.9
45° F AMBIENT TEMPERATURE										
Typical clear I,	1/0.49	-	-	-	-	-	-	-	-	-
35 percent	.42	7.3	14.6	22.3	21.3	9.0	1.1	7.9	14.8	1.7
aromatic	.43	10.0	14.7	20.6	20.6	7.9	1.1	6.8	15.2	3.1
(7202)	.47	11.0	14.2	20.4	19.7	8.4	1.1	6.8	15.0	3.4
Avg..	.45	9.4	14.5	21.2	20.5	8.4	1.1	7.2	15.0	2.7
Indolene clear,	.41	10.4	14.3	23.0	23.0	10.3	1.9	6.8	7.7	2.6
22 percent	.45	10.9	13.0	25.2	19.5	9.2	2.1	6.0	9.3	4.8
aromatic	.46	12.2	13.7	22.9	22.1	9.4	2.0	6.2	7.6	3.9
(7203) Avg..	.44	11.2	13.7	23.7	21.5	9.6	2.0	6.3	8.2	3.8
High alkylate,	.59	14.3	13.8	29.3	17.8	11.8	2.5	2.4	3.5	4.6
10 percent	.67	11.8	12.3	36.4	15.2	10.8	3.3	2.2	4.4	3.6
aromatic	.52	15.8	12.7	28.1	18.2	10.9	2.2	2.3	3.2	6.6
(7212) Avg..	.59	14.0	12.8	31.3	17.1	11.2	2.7	2.3	3.7	4.9

1/ A fourth replicate test was made at 45° F ambient temperature using fuel 7202 because the sample GLC analysis was lost on the first replicate test.

TABLE D-4. - Exhaust hydrocarbon distribution for individual replicate tests weighted in accordance with the 1975 Federal test procedure for the temperature study [1972 Oldsmobile Delta 88 (Car 403) with a 455-CID engine and equipped with a base metal oxidation catalyst and EGR]--Continued

Fuel	Total HC, grams/mile	Hydrocarbon distribution, weight percent								
		Paraffins			Olefins			Aromatics		Acetylenes
		Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
75° F AMBIENT TEMPERATURE										
Typical clear I,	0.30	6.0	18.4	23.0	21.2	8.1	0.8	7.9	13.4	1.2
35 percent	.37	8.1	14.5	26.3	18.3	8.2	1.2	7.2	13.7	2.5
aromatic	.31	5.7	15.8	22.5	22.9	9.4	.8	8.1	13.6	1.2
(7202) Avg..	.33	6.6	16.2	23.9	20.9	8.6	.9	7.7	13.6	1.6
Indolene clear,	.39	9.4	18.7	24.0	21.3	8.9	1.7	6.2	8.4	1.4
22 percent	.45	10.3	15.1	25.7	18.9	8.7	2.2	5.7	9.5	3.9
aromatic	.45	13.2	15.1	23.1	20.1	7.8	1.1	6.0	8.0	5.6
(7203) Avg..	.43	11.0	16.3	24.3	20.0	8.5	1.7	6.0	8.6	3.6
High alkylate,	.46	14.4	10.9	31.2	18.1	9.9	2.4	3.3	5.6	4.2
10 percent	.48	16.1	12.3	28.5	18.8	13.3	2.0	3.2	3.4	2.4
aromatic	.56	17.4	15.6	28.7	17.1	10.3	2.4	2.3	2.9	3.3
(7212) Avg..	.50	16.0	12.9	29.4	18.0	11.2	2.3	2.9	4.0	3.3
95° F AMBIENT TEMPERATURE										
Typical clear I,	0.67	-	-	-	-	-	-	-	-	-
35 percent	.58	4.0	12.8	32.1	10.3	4.9	2.4	4.6	28.0	.9
aromatic	.65	7.1	13.6	30.9	10.2	4.1	2.3	4.9	26.2	.7
(7202) Avg..	.63	5.6	13.2	31.5	10.2	4.5	2.4	4.7	27.1	.8
Indolene clear,	.50	15.0	19.0	25.0	15.2	8.3	2.3	5.3	8.8	1.1
22 percent	.48	15.1	19.2	27.3	13.5	7.9	2.6	5.4	8.1	.9
aromatic	.58	11.5	17.5	30.3	11.8	7.1	2.8	4.8	12.7	1.5
(7203) Avg..	.52	13.9	18.6	27.4	13.4	7.8	2.6	5.2	9.9	1.2
High alkylate,	.51	15.5	14.8	36.8	12.6	9.0	3.2	2.1	4.9	1.1
10 percent	.56	15.7	16.0	35.8	12.9	8.4	3.0	2.1	5.1	1.0
aromatic	.66	-	-	-	-	-	-	-	-	-
(7212) Avg..	.58	15.6	15.4	36.3	12.8	8.7	3.1	2.1	5.0	1.0

TABLE D-5. - Exhaust hydrocarbon distribution for individual replicate tests weighted in accordance with the 1975 Federal test procedure for the temperature study [1972 Ford Torino (Car 724) with a 351-CID engine and equipped with platinum oxidation catalysts and EGR]

Fuel	Total HC, grams/mile	Hydrocarbon distribution, weight percent								
		Paraffins			Olefins			Aromatics		Acetylenes
		Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
25° F AMBIENT TEMPERATURE										
Typical clear II, 40 percent aromatic	4.10	16.8	6.1	14.0	7.1	6.8	2.0	4.2	31.0	12.0
	4.24	15.9	6.0	13.9	7.0	6.4	1.9	4.3	34.7	9.9
	4.36	15.7	6.4	15.7	6.7	6.9	2.1	4.4	31.8	10.3
(7221) Avg...	4.23	16.1	6.2	14.5	7.0	6.7	2.0	4.3	32.5	10.7
High alkylate, 10 percent aromatic	5.29	21.8	6.5	26.8	8.2	11.3	2.2	1.8	6.8	14.6
	4.63	22.9	6.5	25.3	8.7	11.8	1.9	1.8	7.2	13.9
	4.98	20.8	8.4	29.3	7.8	10.1	2.2	1.9	7.2	12.3
(7212) Avg...	4.97	21.8	7.2	27.1	8.2	11.1	2.1	1.8	7.1	13.6
45° F AMBIENT TEMPERATURE										
Typical clear II, 40 percent aromatic	2.37	21.9	6.2	10.7	8.6	5.9	1.1	4.5	27.2	13.9
	2.47	19.2	6.6	12.9	7.9	6.4	1.6	4.2	27.4	13.8
	2.25	19.9	6.0	12.3	7.7	6.1	1.4	4.4	29.7	12.5
(7221) Avg...	2.36	20.3	6.2	11.9	8.1	6.2	1.4	4.4	28.1	13.4
High alkylate, 10 percent aromatic	3.27	25.4	6.5	22.4	8.8	10.4	1.8	1.7	5.8	17.2
	3.36	24.7	6.6	21.4	9.2	10.2	1.7	1.7	5.4	19.1
	3.29	24.7	6.9	22.8	9.1	10.5	1.6	1.8	5.9	16.7
(7212) Avg...	3.31	24.9	6.7	22.2	9.0	10.4	1.7	1.7	5.7	17.7

TABLE D-5. - Exhaust hydrocarbon distribution for individual replicate tests weighted in accordance with the 1975 Federal test procedure for the temperature study [1972 Ford Torino (Car 724) with a 351-CID engine and equipped with platinum oxidation catalysts and EGR]--Con.

Fuel	Total HC, grams/mile	Hydrocarbon distribution, weight percent								
		Paraffins			Olefins			Aromatics		Acetylenes
		Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
75° F AMBIENT TEMPERATURE										
Typical clear II,	0.78	14.8	16.3	18.7	6.2	8.3	2.0	4.5	26.8	2.4
40 percent	.70	18.4	17.1	16.8	5.9	7.8	1.7	4.2	25.8	2.3
aromatic	.67	16.8	17.3	18.0	5.9	8.3	1.9	4.0	24.3	3.5
(7221) Avg...	.72	16.7	16.9	17.8	6.0	8.1	1.9	4.2	25.7	2.7
High alkylate,	0.88	21.0	17.3	28.6	6.4	11.3	2.2	1.2	5.4	6.6
10 percent	.91	19.8	18.4	31.0	6.6	11.9	2.3	1.3	5.2	3.5
aromatic	.78	26.2	13.4	27.1	7.2	11.6	1.9	1.4	5.5	5.7
(7212) Avg...	.86	22.3	16.4	28.9	6.7	11.6	2.1	1.3	5.4	5.3
95° F AMBIENT TEMPERATURE										
Typical clear II,	0.87	13.6	19.7	19.3	5.4	9.7	2.2	4.4	23.4	2.3
40 percent	.81	14.1	19.8	17.9	5.6	9.3	1.9	4.4	24.7	2.3
aromatic	.78	15.5	21.8	17.0	5.6	9.9	1.6	4.3	21.9	2.4
(7221) Avg...	.82	14.4	20.4	18.1	5.5	9.7	1.9	4.4	23.3	2.3
High alkylate,	1.13	20.0	20.7	30.7	6.2	10.6	2.2	1.6	5.4	2.6
10 percent	1.08	21.0	22.0	30.3	5.9	9.9	2.0	1.4	5.2	2.3
aromatic	.98	20.0	22.3	29.1	6.4	10.4	1.9	1.5	5.6	2.8
(7212) Avg...	1.06	20.3	21.7	30.0	6.2	10.3	2.0	1.5	5.4	2.6

TABLE D-6. - Exhaust hydrocarbon distribution for individual replicate tests weighted in accordance with the 1975 Federal test procedure for the temperature study [1971 Plymouth Fury III (Car 775) with a 360-CID engine and equipped with the Ethyl lean reactors and EGR]

Fuel	Total HC, grams/mile	Hydrocarbon distribution, weight percent								
		Paraffins			Olefins			Aromatics		Acetylenes
		Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
25° F AMBIENT TEMPERATURE										
Typical clear II,	1.95	7.0	8.9	18.4	8.8	9.7	2.6	4.6	32.4	7.6
40 percent	2.12	10.2	9.2	14.5	9.1	9.1	1.5	4.0	29.5	12.9
aromatic	1.47	8.4	7.2	15.6	10.5	10.1	1.9	5.3	29.4	11.6
(7221) Avg...	1.85	8.5	8.4	16.2	9.5	9.6	2.0	4.7	30.4	10.7
High alkylate,	1.17	14.8	6.6	26.3	12.4	17.1	2.1	2.0	7.3	11.4
10 percent	2.95	11.9	9.1	38.5	7.0	9.4	3.1	1.4	7.2	12.4
aromatic	2.33	12.6	8.4	35.8	8.6	11.5	2.8	1.5	6.7	12.1
(7212) Avg...	2.15	13.1	8.0	33.5	9.3	12.7	2.7	1.6	7.1	12.0
45° F AMBIENT TEMPERATURE										
Typical clear II,	0.75	8.7	8.0	11.9	12.3	10.2	1.2	5.8	30.7	11.2
40 percent	.71	6.8	9.9	13.1	12.6	11.3	1.4	5.7	29.9	9.3
aromatic	.76	7.1	7.8	14.1	12.7	11.6	1.5	6.0	29.3	9.9
(7221) Avg...	.74	7.5	8.6	13.0	12.6	11.0	1.4	5.8	30.0	10.1
High alkylate,	0.82	7.7	9.7	33.8	10.5	16.9	3.2	1.7	6.7	9.8
10 percent	.78	10.0	8.8	24.4	16.0	20.7	1.6	2.0	6.0	10.5
aromatic	.70	9.8	7.6	24.8	15.4	21.1	2.0	2.3	6.2	10.8
(7212) Avg...	.77	9.2	8.7	27.6	14.0	19.5	2.3	2.0	6.3	10.4

TABLE D-6. - Exhaust hydrocarbon distribution for individual replicate tests weighted in accordance with the 1975 Federal test procedure for the temperature study [1971 Plymouth Fury III (Car 775) with a 360-CID engine and equipped with the Ethyl lean reactors and EGR]--Con.

Fuel	Total HC, grams/mile	Hydrocarbon distribution, weight percent								
		Paraffins			Olefins			Aromatics		Acetylenes
		Methane	C_2-C_5	C_6+	Ethylene	C_3-C_5	C_6+	Benzene	C_7+	
75° F AMBIENT TEMPERATURE										
Typical clear II,	0.40	5.5	15.4	12.9	12.1	11.6	1.5	5.8	23.8	11.4
40 percent	.41	4.2	20.1	16.1	9.6	12.0	2.2	4.8	21.9	9.1
aromatic	.48	6.1	15.9	18.9	8.2	10.3	2.7	4.4	23.9	9.6
(7221) Avg...	.43	5.3	17.1	16.0	10.0	11.3	2.1	5.0	23.2	10.0
High alkylate,	0.36	7.1	17.8	20.0	14.3	18.5	2.5	2.0	5.5	12.3
10 percent	.40	6.2	23.8	27.9	9.7	14.4	2.8	1.5	4.7	9.0
aromatic	.32	6.9	18.1	24.0	12.7	17.1	1.9	1.7	6.3	11.3
(7212) Avg...	.36	6.7	19.9	24.0	12.2	16.7	2.4	1.7	5.5	10.9
95° F AMBIENT TEMPERATURE										
Typical clear II,	0.55	3.3	23.7	21.5	6.6	10.8	3.2	3.8	20.3	6.8
40 percent	.44	3.8	25.4	21.2	6.4	10.9	3.0	3.7	19.2	6.4
aromatic	.43	3.5	27.3	17.7	7.0	11.6	2.3	3.6	19.9	7.1
(7221) Avg...	.47	3.5	25.5	20.1	6.7	11.1	2.8	3.7	19.8	6.8
High alkylate,	0.68	5.1	22.4	36.6	7.1	11.1	3.3	1.3	5.9	7.2
10 percent	.62	5.3	24.5	35.6	7.3	10.0	3.3	1.3	5.5	7.2
aromatic	.59	6.4	25.1	29.1	8.8	12.8	2.6	1.4	5.6	8.2
(7212) Avg...	.63	5.6	24.0	33.8	7.7	11.3	3.1	1.3	5.7	7.5

APPENDIX E -- DATA ON THE COMPARISON OF MBTH AND DNPH METHODS FOR ALDEHYDE MEASUREMENTS (DATA ARE EXPRESSED AS GRAMS/MILE ON THE BASIS OF THE 1972 FEDERAL TEST PROCEDURE)

Fuel	Ambient temperature							
	25° F		45° F		75° F		95° F	
	MBTH	DNPH	MBTH	DNPH	MBTH	DNPH	MBTH	DNPH
1972 OLDSMOBILE DELTA 88 (CAR 403) WITH A 455-CID ENGINE AND EQUIPPED WITH A BASE-METAL OXIDATION CATALYST AND EGR								
Typical clear I,	0.047	0.052	0.031	0.058	0.037	0.039	0.034	0.037
35 percent	.060	.063	.048	.052	.028	.040	.026	.040
aromatic (7202)	-	-	.057	.059	-	-	-	-
Avg...	.054	.058	.045	.056	.032	.040	.030	.038
Indolene clear,	0.041	0.053	0.043	0.052	0.049	0.063	0.035	0.043
22 percent	.044	.059	.044	.062	.042	.058	.031	.047
aromatic (7203)	.048	.062	-	-	-	-	-	-
Avg...	.044	.058	.044	.057	.046	.060	.033	.045
High alkylate,	0.049	0.052	0.044	0.052	0.054	0.057	0.034	0.054
10 percent	.047	.057	.055	.057	.056	.057	.028	.045
aromatic (7212)	.042	.054	-	-	-	-	-	-
Avg...	.046	.054	.050	.054	.055	.057	.031	.050
1971 FORD LTD (CAR 810) WITH A 351-CID ENGINE AND EQUIPPED WITH ESSO RAM REACTORS AND EGR 1/								
Typical clear I,					0.014	0.024		
35 percent					.013	.024		
aromatic (7202)								
Avg...					.014	.024		
Indolene clear,					0.011	0.013		
22 percent					.005	.012		
aromatic (7203)								
Avg...					.008	.012		
High alkylate,					0.012	0.018		
10 percent					.008	.019		
aromatic (7212)								
Avg...					.010	.018		
1971 PLYMOUTH FURY III (CAR 333) WITH A 360-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR 1/								
Typical clear II,					0.056	0.078		
40 percent					.044	.058		
aromatic (7221)								
Avg...					.050	.068		
Indolene clear,					0.047	0.060		
22 percent					.048	.066		
aromatic (7203)								
Avg...					.048	.063		
High alkylate,					0.060	0.078		
10 percent					.052	.064		
aromatic (7212)					.058	.078		
Avg...					.057	.073		
1972 FORD TORINO (CAR 724) WITH A 351-CID ENGINE AND EQUIPPED WITH PLATINUM OXIDATION CATALYSTS AND EGR								
Typical clear II,	0.052	0.071	-	-	0.021	0.039	0.022	0.031
40 percent	.055	.074	0.045	0.056	.024	.032	.019	.034
aromatic (7221)								
Avg...	.054	.072	.045	.056	.022	.035	.020	.032
Indolene clear,					0.023	0.034		
22 percent					.025	.036		
aromatic (7203)								
Avg...					.024	.035		
High alkylate,	0.087	0.112	0.072	0.081	0.024	0.036	0.026	0.035
10 percent	.078	.099	.069	.094	.028	.041	.029	.037
aromatic (7212)								
Avg...	.082	.106	.070	.088	.026	.038	.028	.036
1971 PLYMOUTH FURY III (CAR 775) WITH A 360-CID ENGINE AND EQUIPPED WITH THE ETHYL LEAN REACTORS AND EGR								
Typical clear II,	0.131	0.183	0.068	0.092	0.026	0.040	0.017	0.019
40 percent	.099	.130	.081	.113	.026	.040	.014	.029
aromatic (7221)								
Avg...	.115	.156	.074	.102	.026	.040	.016	.024
Indolene clear,					0.028	0.035		
22 percent					.024	.038		
aromatic (7203)								
Avg...					.026	.036		
High alkylate,	0.081	0.114	0.074	0.089	0.028	0.046	0.034	0.038
10 percent	.086	.109	.109	.143	.025	.042	.016	.036
aromatic (7212)								
Avg...	.084	.112	.092	.116	.026	.044	.025	.037
1970 CHEVROLET IMPALA (CAR 58) WITH A 350-CID ENGINE AND EQUIPPED WITH GEM MONEL NO_x REDUCTION CATALYSTS AND PLATINUM OXIDATION CATALYSTS 1/								
Typical clear II,					0.017	0.022		
40 percent					.015	.021		
aromatic (7221)								
Avg...					.016	.022		
Indolene clear,					0.014	0.023		
22 percent					.018	.021		
aromatic (7203)								
Avg...					.016	.022		
High alkylate,					0.012	0.017		
10 percent					.017	.026		
aromatic (7212)								
Avg...					.014	.022		

1/ Car Nos. 810, 333, and 58 were used in the fuel study only and data were taken at 75° F ambient temperature only.