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# Effects of Reid Vapor Pressure on Hydrocarbon Evaporative Emissions

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Abstract

A test program was conducted to investigate the effect of gasoline volatility, as measured by Reid Vapor Pressure (RVP), on evaporative hydrocarbon (HC) emissions. The program consisted of a series of short test sequences designed to quantify these effects. The principal test variables were the vehicle evaporative standard, test fuel, test driving cycles, and prep cycles.

Testing of eight typical passenger vehicles was conducted at EPA's Motor Vehicle Emission Laboratory from October 1983 through January 1984. Three were manufactured to a 6.0 gm standard (1978-80 model year) while the other five met a 2.0 gm standard (1981 model or later). Two of the latter were fuel injected to increase the technology mix. The vehicles were tested using Indolene (RVP of 9.0 psi), commercial unleaded (RVP of 11.7 psi), and a blend of these two fuels (RVP of 10.4 psi). The basic test procedure was the Federal Test Procedure (FTP) which uses the LA-4 driving cycle. Evaporative emissions were measured using the SHED enclosure prescribed by this procedure. A modification of this procedure using 10 minute segments of the LA-4 cycle was utilized to investigate the effects of different driving cycles. Vehicles were prepped for the test by the LA-4 (per the FTP), the above LA-4 segments, or a 10 minute road route.

The overall conclusion from these tests is that the increase in fuel RVP significantly increased evaporative emissions and that most of this effect occurred in the diurnal evaporative emissions. For all vehicles, diurnal emissions with commercial fuel averaged three times the level with Indolene. Hot soak emissions with commercial fuel were 30% above the Indolene levels for the 2.0 gm vehicles and were three times the Indolene levels for the 6.0 gm vehicles.

The use of a 10 minute road prep or 10 minute segments of the LA-4 instead of the standard prep (the 23 minute LA-4) tended to cause an additional increase in diurnal evaporative emissions. However, although individual vehicles did show marked increases or decreases, no consistent pattern was evident.

Exhaust emissions (HC, CO and $NO_x$) and fuel economy were not significantly changed by these changes in the fuel.

## 1.0 Background

Ambient air quality models are used to estimate and predict the levels of atmospheric emissions. The mobile source components of these models utilize mobile source emission models (i.e., MOBILE2, MOBILE3)* to predict the emissions of the total population of vehicles. The input data for these mobile models come from in-use vehicle testing programs.

Over the past several years, the volatility of commercial fuels, as measured by Reid Vapor Pressure (RVP), has been increasing. Higher values of RVP are known to cause increases in the levels of evaporative emissions. Also, the in-use test programs** have indicated that evaporative emissions with commercial fuels are significantly higher than with Indolene.*** Since the calculations and projections of ambient air quality have been based on the results obtained using Indolene as the test fuel, it was postulated that the amount of evaporative emissions was being underestimated.

This test program was undertaken in order to immediately acquire some additional data for MOBILE3, to quantify the effects of RVP on evaporative emissions, and to gain some testing experience with the problems likely to be encountered in the current in-use test program. These problems include road versus dynamometer preconditioning, need for preconditioning between different test fuels, length and time of travel (purging) before the diurnal and hot soak evaporative tests, and the repeatability of the tests.

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* MOBILE2 is the model presently used to estimate the fleet emissions. MOBILE3 is an updated version that is now being developed.

** "A Study of Emissions From Passenger Cars in Six Cities" (FY77). EPA-460/3-78-011, January 1979.

*** Indolene is a reference gasoline used by EPA as the test fuel for emission and fuel economy tests because its consistency is better controlled than commercial fuel. Evaporative emissions are measured during these tests.

## 2.0 Test Plan

The vehicles were tested for evaporative and exhaust emissions using the basic cold-start FTP with SHED test for evaporative emissions. The standard evaporative test sequence is outlined in Appendix A-1 and is summarized below:

refuel vehicle
LA-4 dynamometer prep
overnight soak
refuel with chilled fuel
diurnal evap test
FTP
hot soak evap test

Note: For each test sequence in which there was a change in the type of fuel used, the vehicle was preconditioned with a 125 mile road route before the replicate testing.

The vehicles were tested with Indolene, commercial unleaded, and a blend of these two so as to cover a range of RVP. Two back-to-back sequences were performed at each step in the process. The test program was subsequently modified to add the following testing: (1) replace the standard LA-4 prep with the 10 minute road test of an EPA in-use vehicle test program, (2) test with the blended fuel only those vehicles that show a large increase in evaporative emissions with commercial fuel, (3) test the five 2.0 gm vehicles with commercial fuel using two 10 minute cycles to be derived from the LA-4 cycle, and (4) test one vehicle for test fuel carry over effects. The test sequences followed are detailed in Appendix A and are summarized below:

| | |
|---|---|
| RVP Effects on Vehicle | Standard evaporative emission test on all eight vehicles with both Indolene and commercial unleaded. |
| RVP Effects on a Vehicle using 10 minute Road Prep | Standard evaporative emission test on five vehicles with commercial unleaded using a 10 minute road prep instead of the LA-4 dynamometer prep. |
| RVP Effects of Indolene/ Commercial Blend | Standard evaporative emission test on three vehicles with the blended fuel. |
| RVP Effects on Vehicle using Modified Driving cycles. | Evaporative emission test on five vehicles with commercial unleaded using the two 10 minute driving cycles instead of the LA-4 driving cycle. |

| | |
|---|---|
| Carry over RVP Evaporative Emission Effects | Standard evaporative emission test on one vehicle using Indolene, then commercial unleaded, then Indolene. |

## 3.0 Test Vehicles

Five typical 2.0 gm standard (1981 model or later) vehicles were selected. Two of these were fuel injected.

1981 Ford Escort, 1.6 liter, 4-cylinder
1983 Plymouth Reliant, 2.2 liter, 4-cylinder
1982 Chevrolet Citation, 2.5 liter, 4-cylinder fuel injected
1983 Ford LTD Crown Victoria, 5.0 liter, V-8 fuel injected
1983 Oldsmobile Custom Cruiser, 5.0 liter, V-8

Three typical 6.0 gm standard (1978-80 model year) vehicles were selected.

1979 Ford Pinto, 2.3 liter, 4-cylinder
1980 Chevrolet Citation 2.8 liter, V-6
1979 Oldsmobile Cutlass, 3.8 liter, V-6

All of these vehicles were equipped with automatic transmissions. A more detailed description of each vehicle, including its evaporative emission family, is given in Tables B-1 and B-2 of Appendix B. Each vehicle was set to manufacturer's specifications prior to the start of testing. The vehicles were obtained from several sources including in-use, rental, and EPA test vehicles

## 4.0 Test Results Overview - Evaporative Emissions, Exhaust Emissions and Fuel Economy

The test results for each vehicle are given in the two test result listings in Appendix C. A test matrix which summarizes the test sequences done on each vehicle is also given in Appendix C.

Exhaust emissions (HC, CO, and $NO_x$) and fuel economy were not significantly altered by the changes in fuel for the tests using the FTP driving cycle. Exhaust emissions and fuel economy for the modified cycles were consistent with the FTP results.

Evaporative emissions for each test are also given in the same listings. These results are summarized in Tables I through IV and discussed below for each test sequence.

## 4.1 Test Results - RVP Effects on Vehicle

The evaporative test results are summarized in Table I and compared in Tables II and Figure 1. The testing showed that the higher volatility (higher RVP) of the commercial fuel (RVP 11.7 psi for commercial vs. 9.0 for Indolene) caused a significant increase in evaporative emissions. In most cases the changes occurred largely in the diurnal portion of the test. Diurnal emissions with commercial fuel were typically three times the level with Indolene. Hot soak emissions with commercial fuel were 30% above the Indolene levels for the 2.0 gm vehicles and were three times the Indolene levels for the 6.0 gm vehicles.

However, individual vehicles showed marked departures from these overall trends. The Escort evaporative emissions were not affected by the fuel change. The diurnal emissions of the 1983 Oldsmobile were seven times higher due to the increase in fuel RVP. The hot soak emissions of the 1980 Citation with commercial fuel were almost four times the level with Indolene.

All three 6.0 gm standard vehicles and three of the five 2.0 gm standard vehicles met their evaporative standard when tested with Indolene and a fourth vehicle was only 25 percent above the standard. Also, although evaporative emissions increased when these vehicles were tested with commercial fuel, four of these (three 2.0 gm and one 6.0 gm vehicle) were still below the 2.0 gm standard.

The individual test results are further compared in Figure 1. Except for the two Oldsmobiles, the test results are repeatable.

Table I
Summary of Results from the FTP Evaporative Emission Tests

| Vehicle | Evaporative Standard | Test fuel/Condition | (HC) gms Diurnal | Hot Soak | Total |
|---|---|---|---|---|---|
| 1981 Escort | 2 gm | Indolene | .27 | 1.37 | 1.64 |
| | | Commercial | .26 | 1.27 | 1.53 |
| 1983 Reliant | 2 gm | Indolene | 1.13 | 1.34 | 2.46 |
| | | Commercial | 2.76 | 1.62 | 4.38 |
| | | Comm/10 min road prep | 4.69 | 1.81 | 6.50 |
| 1982 Citation | 2 gm | Indolene (1 test) | .13 | .34 | .47 |
| | | Commercial | .28 | .36 | .64 |
| | | Comm/10 min road prep | .85 | .91 | 1.76 |
| 1983 Crown Vic. | 2 gm | Indolene | .41 | .46 | .87 |
| | | Commercial | .72 | .58 | 1.30 |
| | | Comm/10 min road prep | 1.25 | .65 | 1.90 |
| 1983 Oldsmobile | 2 gm | Indolene | .72 | 2.74 | 3.46 |
| | | Commercial | 4.99 | 4.34 | 9.33 |
| | | Comm/10 min road prep | 7.57 | 4.11 | 11.68 |
| | | Ind/Comm Blend | 1.71 | 3.22 | 4.93 |
| 1979 Pinto | 6 gm | Indolene/Baseline | .23 | .68 | .91 |
| | | Commercial | .37 | .92 | 1.28 |
| 1980 Citation | 6 gm | Indolene/Baseline (3 tests) | 1.35 | 4.44 | 5.79 |
| | | Commercial | 4.41 | 16.76 | 21.16 |
| | | Comm/10 min road prep | 4.72 | 22.46 | 27.18 |
| | | Ind/Comm Blend | 1.80 | 8.46 | 10.26 |
| 1979 Cutlass | 6 gm | Indolene/Baseline | 1.89 | 1.78 | 3.67 |
| | | Commercial (3 tests) | 7.16 | 1.66 | 8.83 |
| | | Ind/Comm Blend | 2.06 | 1.71 | 3.77 |
| Mean Evap for above five 2.0 gm vehicles | | Indolene/Baseline | .53 | 1.25 | 1.78 |
| | | Commercial | 1.80 | 1.63 | 3.44 |
| Mean Evap for above three 6.0 gm vehicles | | Indolene/Baseline | 1.16 | 2.30 | 3.46 |
| | | Commercial | 3.98 | 6.45 | 10.42 |
| Mean Evap for above 8 vehicles | | Indolene/Baseline | .77 | 1.64 | 2.41 |
| | | Commercial | 2.62 | 3.44 | 6.06 |
| Mean Evap for above excluding the two vehicles showing the greatest increase (1983 Olds & 1980 Citation) | | Indolene/Baseline | .68 | 1.00 | 1.67 |
| | | Commercial | 1.93 | 1.07 | 2.99 |

Note: Test results are the average for the duplicate (and in a few cases triplicate) tests conducted on each vehicle. The 1982 Citation was tested only once for baseline.

Table II
Comparison of Evaporative Emissions for FTP

| Vehicle | Ratio of Commercial/Indolene Diurnal Emissions | Ratio of Commercial/Indolene Hot Soak Emissions | Ratio of Commercial/Indolene Total Emissions |
|---|---|---|---|
| 1981 Escort | .96 | .92 | .93 |
| 1983 Reliant | 2.45 | 1.21 | 1.78 |
| 1982 Citation | 2.12 | 1.06 | 1.35 |
| 1983 Crown Vic. | 1.76 | 1.17 | 1.49 |
| 1983 Oldsmobile | 6.93 | 1.59 | 2.70 |
| 1979 Pinto | 1.59 | 1.35 | 1.40 |
| 1980 Citation | 3.27 | 3.78 | 3.66 |
| 1979 Cutlass | 3.74 | .94 | 2.41 |
| Mean for above five 2.0 gm vehicles | 3.39 | 1.31 | 1.93 |
| Mean for above three 6.0 gm vehicles | 3.43 | 2.80 | 3.01 |
| Mean for above 8 vehicles | 3.40 | 2.10 | 2.51 |
| Mean for above excluding the two vehicles showing the greatest increase (1983 Olds and 1980 Citation) | 2.84 | 1.07 | 1.79 |

Note: Ratios for above means were calculated using corresponding means from Table I

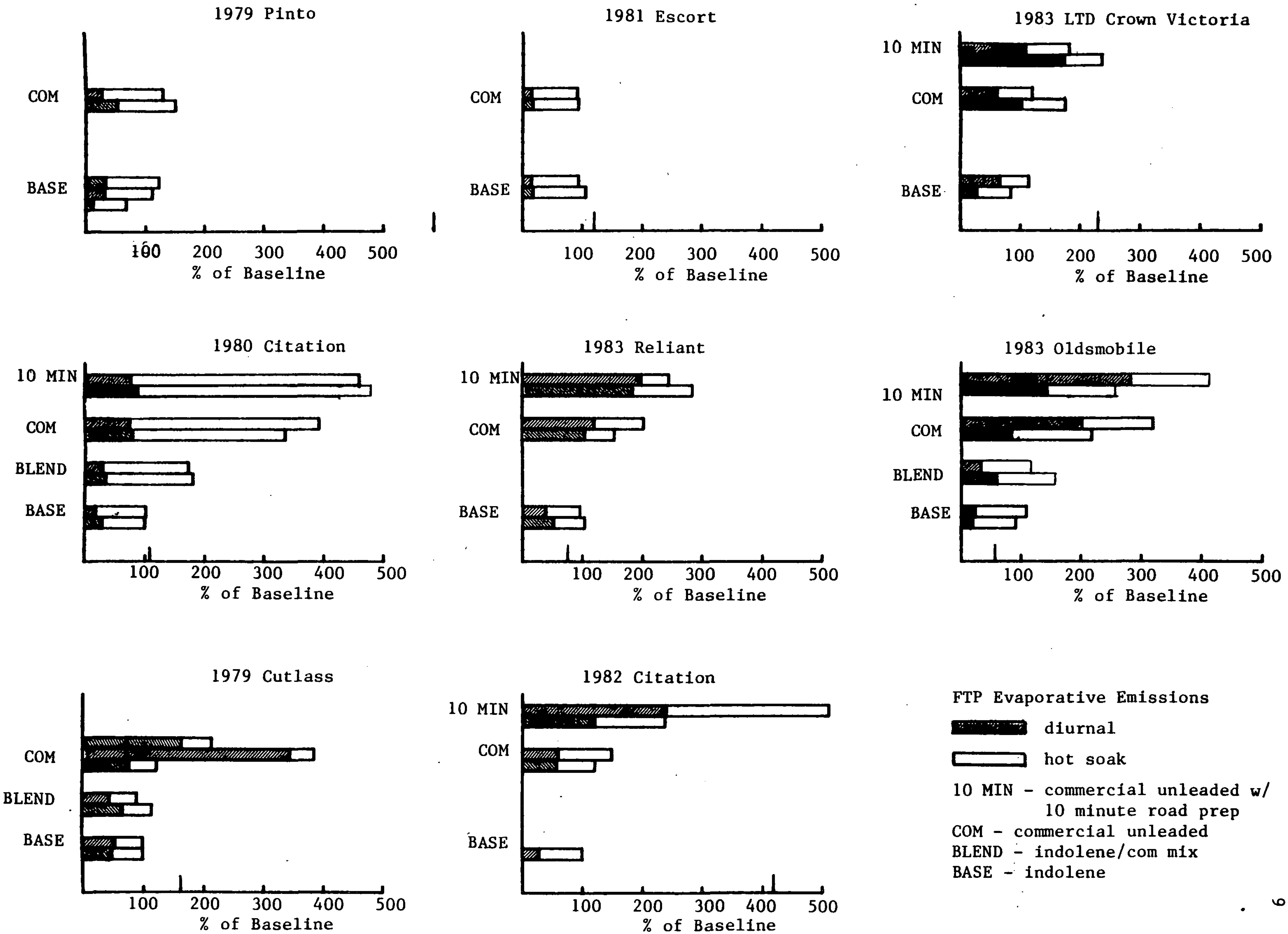


Figure 1 FTP Evaporative Emission Results

## 4.2 Test Results - RVP Effects on a Vehicle Using Commercial Fuel Using 10 Minute Road Prep

Five of the vehicles were retested with commercial fuel but using a 10 minute road prep in lieu of the normal LA-4 dynamometer prep. The evaporative results are also summarized in Table I and compared in Table III. These tests showed a 30 percent increase in evaporative emissions due solely to the change in vehicle prep. Most of this change was due to the increase in diurnal evaporative emissions.

Table III
Comparison of Evaporative Emissions for FTP
Using LA-4 and 10 Minute Road Prep Cycles

| Vehicle | Ratio of Comm. 10 min road/LA-4 Diurnal Emissions | Ratio of Comm. 10 min road/LA-4 Hot Soak Emissions | Ratio of Comm. 10 min road/LA-4 Total Emissions |
|---|---|---|---|
| 1983 Reliant | 1.70 | 1.12 | 1.48 |
| 1982 Citation | 3.04 | 2.53 | 2.75 |
| 1983 Crown Vic. | 1.74 | 1.12 | 1.46 |
| 1983 Oldsmobile | 1.52 | .94 | 1.25 |
| 1980 Citation | 1.07 | 1.25 | 1.22 |
| Mean for above five vehicles | 1.45 | 1.27 | 1.33 |
| Mean for above four 2.0 gm vehicles (excludes 80 Citation, a 6.0 gm vehicle) | 1.99 | 1.15 | 1.59 |

## 4.3 Test Results - RVP Effects of Indolene/Commercial Blend

The preceding testing showed that, while all of the vehicles maintained reasonable evaporative emission control on Indolene, the results on commercial fuel were mixed. That is, some maintained control, some did not, and some had high variability. Thus, only the vehicles which showed both large and repeatable increases with commercial fuel were tested with the blend of commercial and Indolene. The fuel was a 50/50 blend of Indolene and commercial unleaded and had a RVP midway between these of 10.4 psi.

The evaporative results are summarized in Table I and compared in Table IV. Although the results fell between those tests with Indolene and commercial, the results were much closer to the Indolene levels. This indicates that, although the evaporative emisions increase with increases in RVP, the increases may be nonlinear (see Table IV).

Table IV
Comparison of Evaporative Emissions
for FTP With Three Fuels

| Vehicle/Fuel | Ratio of test fuel/Indolene Diurnal Emissions | Ratio of test fuel/Indolene Hot Soak Emissions | Ratio of test fuel/Indolene Total Emissions |
|---|---|---|---|
| 1983 Oldsmobile | | | |
| Indolene | 1.00 | 1.00 | 1.00 |
| Blend | 2.38 | 1.18 | 1.42 |
| Commercial | 6.93 | 1.59 | 2.70 |
| 1980 Citation | | | |
| Indolene | 1.00 | 1.00 | 1.00 |
| Blend | 1.33 | 1.91 | 1.77 |
| Commercial | 3.27 | 3.78 | 3.66 |
| 1979 Cutlass | | | |
| Indolene | 1.00 | 1.00 | 1.00 |
| Blend | 1.09 | .96 | 1.03 |
| Commercial | 3.74 | .94 | 2.41 |

## 4.4 Test Results - RVP Effects on Vehicle With Modified Driving Cycles

The in-use vehicle testing program incorporates a ten minute road prep instead of the LA-4 prep. This was done to reduce test costs, to simplify procedures, and to prep with a cycle of shorter time. Because the testing with a 10 minute road prep indicated that there was a difference and since available data indicates that the median trip time is slightly over 10 minutes* rather than the 23 minutes of the LA-4, it was decided to investigate the problem further using a dynamometer driving cycle slightly greater than ten minutes.

Therefore, two test cycles were derived from the LA-4 driving schedule. They were selected to emphasize the lower and higher speed segments of the LA-4. The Low Speed Cycle is from 625 to 1251 seconds of the LA-4, takes 10.4 minutes to drive, and is 3.02 miles long. The Moderate Speed cycle is from 0 to 630 seconds of the LA-4, takes 10.5 minutes to drive, and is 4.04 miles long. These cycles are described in greater detail and compared to the LA-4 and HFET in Table B-3.

The five late model vehicles were retested with commercial fuel using these new cycles. The procedures followed the standard FTP procedure except that the new test cycle was used for both the prep and test cycles (e.g., low speed prep with low speed test or moderate speed prep with moderate speed test). For each test cycle the vehicle was preconditioned with a 125 mile road route and then tested twice using the test cycle.

* "A Survey of Average Driving Patterns in Six Urban Areas of the United States. Summary Report "TM-(L)-4119/007/00, Systems Development Corporation, January 29, 1971

The exhaust emissions were consistent with the previous FTP results. These test results are tabulated in Appendix C and the evaporative results are summarized in Table V. To facilitate comparisons between the two cycles (low and mod speed) and the previous testing with commercial fuel (FTP w/LA-4 prep and FTP w/10 min road prep), the evaporative emission results in Tables I and V are retabulated in Table VI for these five vehicles.

Table V
Summary of Results from the Short Cycle
Evaporative Emission Tests

| Vehicle | Evaporative Standard | Test Condition | (HC) gms Diurnal | Hot Soak | Total |
|---|---|---|---|---|---|
| 1981 Escort | 2 gm | low spd-A | .69 | .95 | 1.64 |
| | | mod spd-B | .29 | 1.12 | 1.41 |
| 1983 Reliant | 2 gm | low spd-A | 4.17 | 1.03 | 5.20 |
| | | mod spd-B (3 tests) | 2.20 | 1.10 | 3.30 |
| 1982 Citation | 2 gm | low spd-A | .93 | .97 | 1.89 |
| | | mod spd-B | .90 | .69 | 1.59 |
| 1983 Crown Vic. | 2 gm | low spd-A | 2.15 | .55 | 2.70 |
| | | mod spd-B (1 test) | 3.01 | .55 | 3.56 |
| 1983 Oldsmobile | 2 gm | low spd-A | 1.56 | 2.63 | 4.18 |
| | | mod spd-B (3 tests) | 2.01 | 2.93 | 4.94 |
| Mean for above | | low spd-A | 1.90 | 1.23 | 3.12 |
| five vehicles | | mod spd-B | 1.68 | 1.28 | 2.96 |

Low Spd-A - low speed, cycle A - portion of LA-4 driving cycle from 625 to 1251 seconds (10.4 minutes), 3.02 miles.

Mod Spd-B - moderate speed, cycle B - portion of LA-4 driving cycle from 0 to 630 seconds (10.5 minutes), 4.04 miles.

Note: Test results are the average for the duplicate (and in a few cases, triplicate) tests conducted on each vehicle. The 1983 LTD Crown Victoria was tested only once for the moderate speed cycle due to vehicle mechanical problems.

Table VI
Summary of Commercial Unleaded Fuel Tests
From Tables I and V

| Vehicle | Test Condition | HC (gms) Diurnal | Hot Soak | Total |
|---|---|---|---|---|
| 1981 Escort | FTP w/LA-4 prep | .26 | 1.27 | 1.53 |
| | FTP w/10 min road prep | - | - | - |
| | low spd-A for test & prep | .69 | .95 | 1.64 |
| | mod spd-B for test & prep | .29 | 1.12 | 1.41 |
| 1983 Reliant | FTP w/LA-4 prep | 2.76 | 1.62 | 4.38 |
| | FTP w/10 min road prep | 4.69 | 1.81 | 6.50 |
| | low spd-A for test & prep | 4.17 | 1.03 | 5.20 |
| | mod spd-B for test & prep | 2.20 | 1.10 | 3.30 |
| 1982 Citation | FTP w/LA-4 prep | .28 | .36 | .64 |
| | FTP w/10 min road prep | .85 | .91 | 1.76 |
| | low spd-A for test & prep | .93 | .97 | 1.89 |
| | mod spd-B for test & prep | .90 | .69 | 1.59 |
| 1983 Crown Vic | FTP w/LA-4 prep | .72 | .58 | 1.30 |
| | FTP w/10 min road prep | 1.25 | .65 | 1.90 |
| | low spd-A for test & prep | 2.15 | .55 | 2.70 |
| | mod spd-B for test & prep | 3.01 | .55 | 3.56 |
| 1983 Oldsmobile | FTP w/LA-4 prep | 4.99 | 4.34 | 9.33 |
| | FTP w/10 min road prep | 7.57 | 4.11 | 11.68 |
| | low spd-A for test & prep | 1.56 | 2.63 | 4.18 |
| | mod spd-B for test & prep | 2.01 | 2.93 | 4.94 |
| Means for above five vehicles | FTP w/LA-4 prep | 1.80 | 1.63 | 3.44 |
| | FTP w/10 min road prep | 3.59 | 1.87 | 5.46 |
| | low spd-A for test & prep | 1.90 | 1.23 | 3.12 |
| | mod spd-B for test & prep | 1.68 | 1.28 | 2.96 |

It appears there is no appreciable difference in the diurnal or hot soak emissions for this fleet of five vehicles between these two tests or those using LA-4 preps on the dynamometer. However, as noted in Section 4.2, the tests with a road prep did not follow this trend.

Individual vehicles did show marked differences for these new test cycles (e.g., Reliant low speed diurnal emissions were twice the moderate speed diurnal emissions) but no consistent pattern was evident (e.g., Crown Victoria showed opposite effect of Reliant on diurnal emissions). Hot soak emissions were relatively unaffected by the two cycles.

## 4.5 Test Results - Carry Over Evaporative Emission Test Results

Vehicles received extended road preconditioning between tests with different fuels so as to eliminate any influence one fuel might have on the results using another fuel. However, since it was desired to keep this type of preconditioning as short as possible, the in-use test programs would test vehicles with both Indolene and commercial fuel without a vehicle preconditioning. Thus, it was desirable to quantify any carry over effect. Therefore, one vehicle was used for a three test FTP sequence to check on this potential problem.

Accordingly, the Reliant was tested using Indolene, then commercial, and then Indolene to investigate this problem. There were no appreciable differences in the exhaust emissions. The evaporative results are tabulated in Table VII. From these results it appears that there are no carry over effects. The differences observed are within normal test-to-test variability.

Table VII
Carry Over Evaporative Emission Test Results

| Vehicle | Evaporative Standard | Test Fuel | HC (gms) Diurnal | HC (gms) Hot Soak | HC (gms) Total |
|---|---|---|---|---|---|
| 1983 Reliant | 2 gm | Indolene | 1.47 | 1.25 | 2.72 |
| | | Commercial | 2.87 | 1.33 | 4.20 |
| | | Indolene | 1.08 | 1.23 | 2.31 |

## 4.6 Test Results - Continuous Measurement of HC Levels During Diurnal and Hot Soak Tests

A Flame Ionization Detector (FID) is used to measure the HC levels in the SHED at the beginning and end of both the diurnal and hot soak segments of the evaporative test. These values are used to calculate the HC evaporative mass emissions. For these tests the FID was used to continuously monitor the HC levels throughout both the diurnal and hot soak portions of the evaporative test to determine if and when canister "breakthrough"* occurred. On most tests, HC emissions increased at a relatively constant rate throughout the one hour test periods of both the diurnal and hot soak. This pattern was seen in tests at all emission levels.

## 4.7 Test Results - Comparison of Thermocouple Measurement Techniques

To test for diurnal evaporative emisions, the vehicle is fueled with chilled fuel to 40 percent of tank capacity. The vehicle then undergoes a heat build in the SHED to raise the fuel temperature from 60°F to 84°F in one hour at a constant rate of increase.

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* Breakthrough refers to a condition where the rate of increase in HC levels in the SHED increases markedly due to the overloading of the evaporative control system of the vehicle.

The fuel temperature of a certification vehicle is measured with a thermocouple permanently mounted in the fuel tank at a proper height. To install the thermocouple, the tank must be removed and purged. To avoid this removal and purging of the fuel tank of test vehicles, the thermocouple is installed through the fuel cap or attached to the exterior of the tank.

For this testing, fuel temperature was monitored by means of a thermocouple installed through the fuel cap. However, our large in-use test programs use external thermocouples to preclude the need for extra fuel caps and the risk of venting the fuel vapors through an incompletely sealed thermocouple wire through the cap.

To gain experience with the use of external tank versus internal tank (through the cap) fuel temperature measurements, both temperatures were monitored during the latter stages of this test program. For these tests, the fuel tank surface was cleaned to bare metal at the midpoint of the 40% fuel fill. A thermal conducting paste was applied to the surface and the thermocouple was then taped to the tank.

Typically, the externally mounted thermocouple initially read 2°F higher than the internal one. However, the two were usually equal after 50 minutes of the heat build and within a degree after one hour (at this time the internal temperature was usually slightly higher than the external temperature). In those few instances where there was an improper thermal bonding of the thermocouple to the tank, the problem was immediately evident since the initial temperature of the external thermocouple exceeded the initial temperature limit of the fuel.

### 4.8 Test Results - Measurement of the RVP of the Fuels

Throughout the test program the RVP of the test fuels was checked. Fuel samples from the underground tank were obtained by lowering a sample bottle into the tank. Fuel samples from the hose of the fuel cart were obtained by first pumping out a half gallon of fuel to put fresh fuel in the hose and then putting the nozzle into the sample bottle. Fuel samples from the fuel cart and vehicles were obtained by the positive displacement of water method in the sample bottle. This bottle was chilled in an ice bath to reduce loss of the lighter hydrocarbons of the fuel while obtaining the sample. The fuel samples were tested for RVP by using ASTM procedure D323.

In order to monitor the RVP of the fuel throughout the fuel handling process, fuel samples were taken from the underground tanks, the refueling cart*, and the vehicle fuel tanks. The underground tanks were sampled only once or twice since prior experience had shown the results were repeatable over a several month period. The refueling cart was sampled after each refilling of the cart. Also, samples were taken from the vehicle fuel tanks to determine RVP changes during vehicle refueling.

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* Test fuel was pumped from the underground tank to a refueling cart. The cart chilled the fuel for the diurnal heat build.

The RVP test results are tabulated in Table VIII and plotted in Figure 2. The refueling cart samples are listed in the order sampled. It was immediately evident that there was an appreciable drop in the RVP of the commercial fuel sample taken from the hose. However, samples from the cart showed only a small decrease. To determine if this was unique to the hose sample and if the vehicle fuel in the vehicle experienced a similar loss, vehicle fuel tank samples were also taken. The Crown Victoria and Cutlass showed a loss in RVP of about .7 psi (from the cart), the remaining vehicles experienced changes ranging from 0 to .3 psi. The change in RVP was considerably less with the blended fuel, being 0 psi on two vehicles and .5 psi on the other tested.

Table VIII
RVP of Fuel at Noted Locations (psi)

| Fuel | Underground tank | Refueling Cart | Vehicle Fuel Tank | |
|---|---|---|---|---|
| Commercial | 11.70 | 10.70 (from hose) | Escort | 11.5 |
| Unleaded | 11.60 | 10.10 (from hose) | Reliant | 11.35 |
| | | 11.35 | 82 Citation | 11.50 |
| | | 11.50 | Crown Vic. | 10.80 |
| | | 11.00 (from hose) | " | 11.10 |
| | | 11.55 | Custom Cruiser | 11.20 |
| | | 11.60 (from hose) | Pinto | 11.50 |
| | | 11.70 (from hose) | 80 Citation | 11.15 |
| | | 11.60 | Cutlass | 10.70 |
| | | 11.40 | " | 10.75 |
| | | 11.10 | | |
| | | 11.60 | | |
| | | 11.70 | | |
| | | 11.50 | | |
| Blend | | 10.60 | Cruiser | 9.70 |
| | | 10.35 | 80 Citation | 10.45 |
| | | 10.25 | Cutlass | 10.25 |
| | | 10.35 | | |
| | | 10.30 | | |
| Indolene | 9.0 | | Cruiser | 8.90 |
| | | | 80 Citation | 8.85 |
| | | | Cutlass | 8.80 |

Note: There is not a one-to-one correlation between all of the above values, e.g., the refueling cart was refilled and checked for RVP numerous times and each fill was sufficient for four to six vehicle tests. Thus, although the cart values given are in chronological order, they do not necessarily represent the RVP of the fuel in the vehicle fuel tank on the same line.

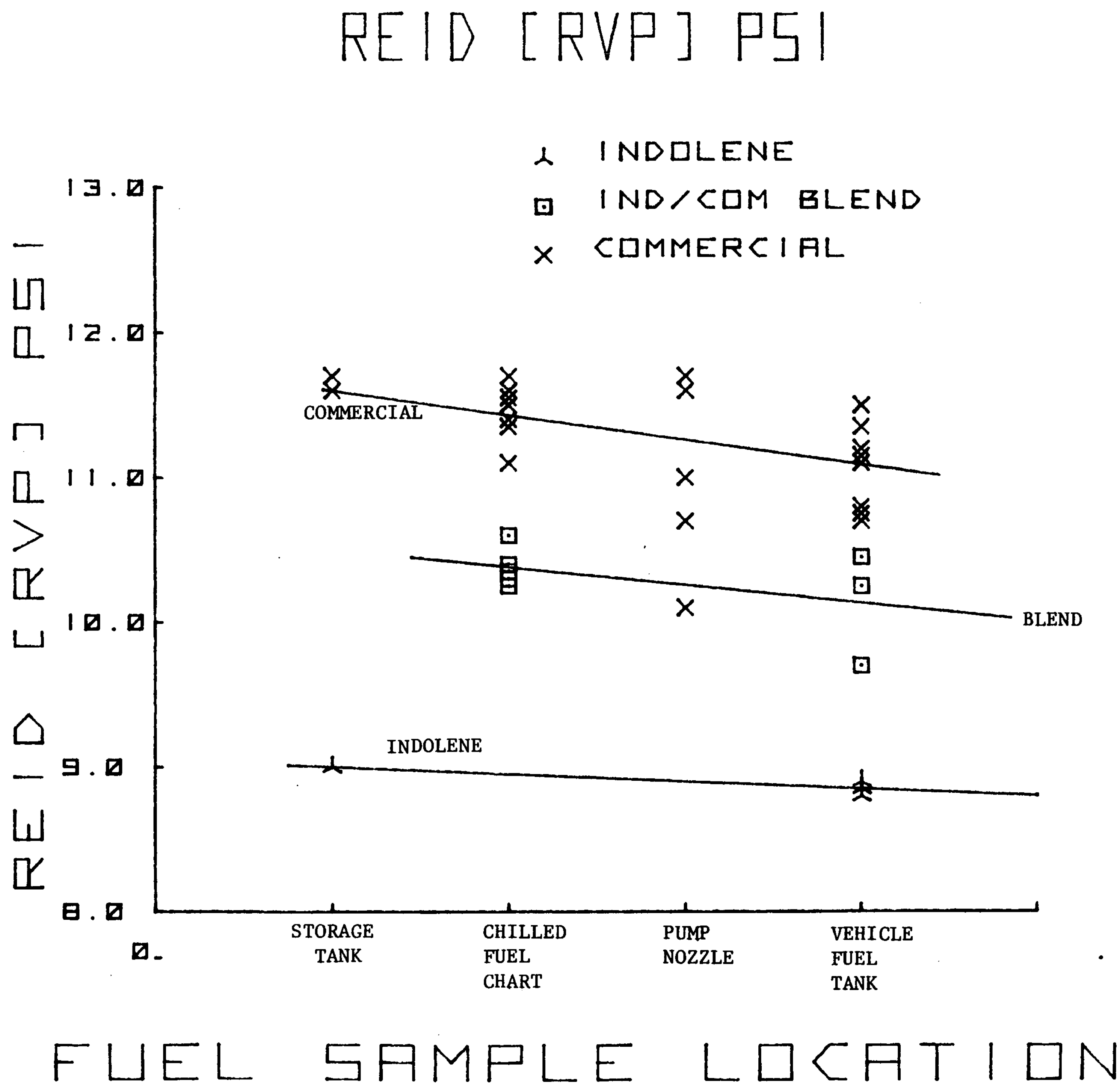


Figure 2 RVP of Test Fuels

These changes noted in the RVP of the commercial fuel in vehicle tanks did not correlate with the changes in emissions. The Crown Victoria and Cutlass showed the largest RVP changes due to refueling but the Crown maintained good evaporative control while the Cutlass did not. The 80 Citation showed very little RVP change, yet was the poorest vehicle in maintaining total emission control.

## 5.0 Summary of Findings

The increase in fuel RVP significantly increased evaporative emissions. For the group of vehicles, diurnal emissions with commercial fuel were three times the level with Indolene. Hot soak emissions with commercial fuel were 30% above the Indolene levels for the 2.0 gm vehicles and were three times the Indolene levels for the 6.0 gm vehicles.

The use of a 10 minute road prep in lieu of the LA-4 dynamometer prep further increased the evaporative emissions of the commercial fuel. Most of this change occurred in the diurnal emissions and was therefore probably due to incomplete purging of the canister during the prep.

The 50/50 blend of Indolene and commercial unleaded had a RVP of 10.4 which was midway between these fuels. However, although the evaporative emission results fell between those with Indolene and commercial, the results were much closer to the Indolene levels. This indicated that although the evaporative emissions increase with increases in RVP, the increases may be non-linear.

Differences in diurnal evaporative emissions were noted for both of the two 10 minute modified driving cycles derived from the 23 minute LA-4. However, no consistent overall pattern was evident. Hot soak emissions were relatively unaffected by these two cycles.

There was no noticeable carry over effect between the two fuels for the one vehicle tested.

The changes in fuel types/RVP did not cause a significant change in exhaust emissions or fuel economy.

The continuous monitoring of HC levels during the SHED test showed very few cases of HC "breakthrough." This pattern was seen in tests at all emission levels.

External thermocouples appeared to reasonably track thermocouples installed through the fuel cap.

During refueling, some vehicles experienced a relatively large change in fuel tank RVP, whereas others experience very little. Unlike the changes in fuel RVP due to change in fuel, the changes in RVP during refueling did not correlate with the changes in evaporative emissions.

# Appendix Contents

## Appendix A
## Test Sequence Descriptions


| | |
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| RVP Effects of Indolene/Commercial Blend | page A-3 |
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## Appendix B


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## Appendix C


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## Test Sequence
## RVP Effects on Vehicle

1. Check vehicle.

2. Drain vehicle and refuel with Indolene.

3. Road preconditioning - #1 Adrian Road Route (a 125 mile road route).

The standard evaporative emission test consists of Steps 4 through 10 below:

4. Drain and 40% refuel with Indolene.

5. Dynamometer prep using LA-4 driving cycle.

6. Standard soak (a minimum of 12 hours to a maximum of 36 hours).

7. Drain and 40% refuel with chilled Indolene.

8. Diurnal evaporative emissions test (one hour soak in SHED enclosure, fuel is heated from 60°F to 84°F).

9. Test using FTP (uses LA-4 driving cycle with repeat of first half of cycle).

10. Hot soak evaporative emissions test (one hour soak in SHED enclosure).

11. Repeat numbers 4 through 10 above.

12. Repeat numbers 2 through 11 above using commercial unleaded.

Notes: All tests use Indolene unleaded for first two tests and commercial unleaded for next two.

Test vehicles for this test sequence are given below. Detailed descriptions of these vehicles are given in Tables V and VI.

1981 Ford Escort
1983 Plymouth Reliant
1982 Chevrolet Citation
1983 Ford Crown Victoria
1983 Oldsmobile Custom Cruiser
1979 Ford Pinto
1980 Chevrolet Citation
1979 Oldsmobile Cutlass

Test Sequence
RVP Effects on a Vehicle Using a 10 Minute Road Prep

1. Start sequence after standard tests with commercial unleaded.

2. Drain vehicle and 40% refuel with commercial unleaded.

3. Road prep - 10 minute road route.
(no dynamometer prep)

4. Standard soak.

5. Drain and 40% refuel with chilled commercial unleaded.

6. Diurnal evaporative emissions test.

7. Test using FTP.

8. Hot soak evaporative emissions test.

9. Repeat numbers 2 through 8 above.

Test vehicles for this test sequence are given below. Detailed descriptions of these vehicles are given in Tables V and VI.

1983 Plymouth Reliant
1982 Chevrolet Citation
1983 Ford Crown Victoria
1983 Oldsmobile Custom Cruiser
1980 Chevrolet Citation

Test Sequence
RVP Effects of Indolene/Commercial Blend

1. Check vehicle.

2. Drain vehicle and refuel with blended test fuel.

3. Road preconditioning - #1 Adrian Road Route (a 125 mile road route).

4. Drain and 40% refuel with blended fuel.

5. Dynamometer prep with LA-4.

6. Standard soak.

7. Drain and 40% refuel with chilled blended fuel.

8. Diurnal evaporative emissions test.

9. Test using FTP.

10. Hot soak evaporative emissions test.

11. Repeat numbers 4 through 10 above.

Test vehicles for this test sequence are given below. Detailed descriptions of these vehicles are given in Tables V and VI.

1983 Oldsmobile Custom Cruiser
1980 Chevrolet Citation
1979 Oldsmobile Cutlass

## Test Sequence
## RVP Effects on Vehicle Using Modified Driving Cycles

1. Drain vehicle and refuel with commercial unleaded.
2. Road preconditioning - #1 Adrian Road Route (a 125 mile road route).
3. Drain and 40% refuel with commercial unleaded.
4. Dynamometer prep with Low Speed Cycle (test cycle A).
5. Standard soak.
6. Drain and 40% refuel with chilled commercial unleaded.
7. Diurnal evaporative emissions test.
8. Test using Low Speed Cycle.
9. Hot soak evaporative emissions test.
10. Repeat numbers 3 through 9 above.
11. Repeat numbers 1 through 10 above using Moderate Speed Cycle (test cycle B).

Notes: All tests use commercial unleaded gasoline.

Low Speed Cycle - LA-4 driving cycle from 625 to 1251 seconds, 3.02 miles.

Moderate Speed Cycle - LA-4 driving cycle from 0 to 630 seconds, 4.04 miles.

Test vehicles for this test sequence are given below. Detailed descriptions of these vehicles are given in Tables V and VI.

1981 Ford Escort
1983 Plymouth Reliant
1982 Chevrolet Citation
1983 Ford Crown Victoria
1983 Oldsmobile Custom Cruiser

Carry Over Test Sequence
RVP Evaporative Emission Effects

1. Vehicle delivered.

2. Drain vehicle and 40% refuel with Indolene.

3. Ten minute dynamometer prep, moderate speed - cycle B.

4. Standard soak.

5. Drain and 40% refuel with chilled Indolene.

6. Diurnal evaporative emissions test.

7. Test using FTP.

8. Hot soak evaporative emissions test.

9. Repeat numbers 2 through 8 above using commercial unleaded.

10. Repeat numbers 2 through 8 above using Indolene.

Moderate speed, cycle B - LA-4 from 0 to 630 seconds, 10.5 minutes, 4.04 miles.

The test vehicle for this test sequence is the 1983 Plymouth Reliant described in Table V.

Table B-1
Test Vehicle Description
2.0 Gram Evaporative Standard Vehicles

| Make/Model | Ford Escort | Plymouth Reliant | Chevrolet | Ford LTD Crown Vic. | Olds Custom Cruiser |
|---|---|---|---|---|---|
| Model Year | 1981 | 1983 | 1982 | 1983 | 1983 |
| Type | 2 dr hatchback | 4 dr sedan | 4dr hatchback | 4dr sedan | station wagon |
| Veh. ID | 1FABP0524BW158832 | 1P3BP26C9DF251538 | 1G1AX68R6CT102873 | 2FABP432DB148513 | 1G3AP35Y5DX34364 |
| In. Odom. | 29900 miles | 2500 miles | 35200 miles | 10700 miles | 22400 miles |
| Engine | | | | | |
| Type | Spark Ignition | Spark Ignition | Spark Ignition | Spark Ignition | Spark Ignition |
| Config. | transverse 4 | transverse 4 | transverse 4 | V-8 | V-8 |
| Disp. | 1.6 liters | 2.2 liters | 2.5 liters | 5.0 liters | 5.0 liters |
| Fuel Met. | 2V Carb | 2V Carb | Fuel Injection | Fuel Injection | 4V Carb |
| Eng. Fam | 1.6AP | DCR2.2V2HAC3 | C2G2.5V5TPG5 | DFM5.0V5HLF8 | D3G5.0V4ARA9 |
| Evap. Fam | CM | DCRKA | 2B0-2A | 3FQ | 3B4-3A |
| Emission Control System | EGR<br>3-way cat.<br><br><br>air pump | EGR<br>3-way cat<br>closed loop<br>oxid. cat.<br>air pump | EGR<br>3-way cat<br>closed loop | EGR<br>3-way cat.<br>closed loop<br>oxid. cat.<br>air pump | EGR<br>3-way cat.<br>closed loop<br>oxid. cat.<br>air pump |
| Trans. | automatic<br>3-speed | automatic<br>3-speed | automatic<br>3-speed lock-up | automatic<br>4-speed lock-up | automatic<br>4-speed lock-up |
| Tires | P155/80R13 | P175/75R13 | P185/80R13 | P215/75R14 | P225/75R15 |
| Test Para. | | | | | |
| inertia wt | 2375 lbs. | 2750 lbs. | 3000 lbs. | 4250 lbs. | 4750 lbs. |
| HP @ 50 mph | 6.4hp | 8.0hp | 7.3hp | 12.8hp | 12.7hp |

Table B-2
Test Vehicle Description
6.0 Gram Evaporative Standard Vehicles

| Make/Model | Ford Pinto | Chev Citation | Olds. Cutlass Supreme |
|---|---|---|---|
| Model Year | 1979 | 1980 | 1979 |
| Type | 2 dr hatchback | 4 dr hatchback | 2 dr hardtop |
| Vehicle ID | 9T11Y186165 | 1Y687AW139507 | 3R47A9M523280 |
| Initital Od. | 26750 miles | 37030 miles | 37700 miles |
| Engine: | | | |
| Type | Spark Ignition | Spark Ignition | Spark Ignition |
| Config. | In-line 4 | Transverse V-6 | V-6 |
| Disp. | 2.3 liters | 2.8 liters | 231 CID |
| Fuel Metering | 2V Carb. | 1V Carb. | 2V Carb. |
| Engine Fam. | 2.3A1X92EGR/CAT | 01C2EY2.8L | 3.8L940B2 |
| Evap. Fam. | B | 0B6-1 | 9B3-4 |
| Emission Cont. System | EGR<br>Oxid. Cat.<br>Pulse Air | EGR<br>Oxid. Cat.<br>Pulse Air | EGR<br>Oxid. Cat.<br>Pulse Air |
| Transmission | Automatic<br>3 speed | Automatic<br>3 speed | Automatic<br>3 speed |
| Tires | BR78X13 | P185/80R13 | P195/75R13 |
| Test Parameters: | | | |
| Inertia Wt. | 2750 lbs | 3000 lbs | 3500 lbs |
| HP @ 50 MPH | 9.7hp | 7.3hp | 9.5hp |

Table B-3
Comparison of Two 10 Minute Cycles
With Standard Cycles

| Cycle | Length Miles | Average Speed (MPH) | Top Speed (MPH) | # of Modes | % Time Idle | Cycle Time Seconds |
|---|---|---|---|---|---|---|
| Low Speed (Cycle A) | 3.02 | 17.4 | 34.3 | 9(1) | 16.9% | 626 |
| Moderate Speed (Cycle B) | 4.04 | 23.1 | 56.7 | 7(2) | 20.6% | 630 |
| Bag(1) LA-4 | 3.59 | 25.6 | 56.7 | 5 | 18.8% | 505 |
| Bag(2) LA-4 | 3.91 | 16.2 | 34.3 | 13 | 19.1% | 867 |
| LA-4 | 7.45 | 19.7 | 56.7 | 18 | 19.0% | 1372 |
| HFET | 10.24 | 48.2 | 59.9 | 1 | .5% | 765 |

(1) Modes 8 thru 16 of LA-4 (LA-4 cycle from 625 to 1251 seconds).

(2) Modes 1 thru 7 of LA-4 (LA-4 cycle from 0 to 630 seconds).

(3) Idle time equals time @1.0 mph or less.

Test Matrix for RVP Project

| Car | FTP Test Status | | | | Modified Driving Cycle | | |
|---|---|---|---|---|---|---|---|
| | Baseline (Indolene) | Commercial 11.5 RVP | Commercial 10 min. prep | Blend 10 RVP | Low speed cycle(1) | Moderate speed cycle(2) | Carry Over |
| 2.0 gm Std | | | | | | | |
| 81 Escort | X | X | | | X | X | |
| 83 Reliant | X | X | X | | X | X | X |
| 82 Citation | X | X | X | | X | X | |
| 83 Crown Victoria | X | X | X | | X | X | |
| 83 Olds | X | X | X | X | X | X | |
| 6.0 gm Std. | | | | | | | |
| 79 Pinto | X | X | | | | | |
| 80 Citation | X | X | X | X | | | |
| 79 Cutlass | X | X | | X | | | |

(1) Low speed cycle-LA-4 from 625 to 1251 seconds, 10.4 minutes, 3.02 miles.

(2) Moderate speed cycle-LA-4 from 0 to 630 seconds, 10.5 minutes 4.04 miles.

## FTP - Baseline, Commercial, 10 Minute Road Prep and Blenc

VEHICLE.ID 1FABP0524BW15883 1981 FORD ESCORT
TEST.PROCEDURE CVS.75-LATR

| TEST.NUMBER | TEST.DATE | TEST.DISP | ODOMETER | HC | CO | NOX | MI/GAL | DIURNAL | HOT.SOAK | TOTAL.EVAP |
|---|---|---|---|---|---|---|---|---|---|---|
| 840645 | 03-83-11 | BASE.CONFIG | 30044.0 | 2.47538 | 94.6267 | .6144 | 21.5478 | .30 | 1.45 | 1.74 |
| 840646 | 05-83-11 | BASE.CONFIG | 30073.6 | 2.30295 | 93.0661 | .5605 | 21.8664 | .24 | 1.29 | 1.53 |
| 840397 | 07-83-11 | COMM.UNLEAD | 30227.0 | 2.39867 | 94.3369 | .5757 | 21.7431 | .28 | 1.26 | 1.54 |
| 840396 | 08-83-11 | COMM.UNLEAD | 30247.0 | 2.32125 | 87.4842 | .5470 | 22.6325 | .24 | 1.27 | 1.51 |

VEHICLE.ID 1G1AX68R6CT10287 1982 CHEVROLET CITATION
TEST.PROCEDURE CVS.75-LATR

| TEST.NUMBER | TEST.DATE | TEST.DISP | ODOMETER | HC | CO | NOX | MI/GAL | DIURNAL | HOT.SOAK | TOTAL.EVAP |
|---|---|---|---|---|---|---|---|---|---|---|
| 840723 | 07-83-11 | BASE.CONFIG | 35350.0 | .18280 | 2.9754 | .3287 | 28.0403 | .13 | .34 | .47 |
| 840781 | 10-83-11 | COMM.UNLEAD | 35520.0 | .17844 | 4.6254 | .4518 | 28.0778 | .27 | .30 | .57 |
| 840799 | 15-83-11 | COMM.UNLEAD | 35539.0 | .18279 | 3.9200 | .3748 | 28.1760 | .28 | .42 | .70 |
| 841064 | 23-83-11 | COMM.10.MIN | 35556.0 | .21315 | 5.0528 | .4204 | 30.7268 | .57 | .55 | 1.12 |
| 841128 | 29-83-11 | COMM.10.MIN | 35574.0 | .18791 | 3.9304 | .3772 | 27.7326 | 1.13 | 1.27 | 2.40 |

VEHICLE.ID 1G3AP35Y5DX34364 1983 OLDSMOBILE CUSTOM CRUISER
TEST.PROCEDURE CVS.75-LATR

| TEST.NUMBER | TEST.DATE | TEST.DISP | ODOMETER | HC | CO | NOX | MI/GAL | DIURNAL | HOT.SOAK | TOTAL.EVAP |
|---|---|---|---|---|---|---|---|---|---|---|
| 840862 | 17-83-11 | BASE.CONFIG | 22532.0 | .37687 | 2.9628 | .7816 | 15.9830 | .65 | 2.49 | 3.15 |
| 840863 | 18-83-11 | BASE.CONFIG | 22551.0 | .34629 | 3.3397 | .8008 | 15.7698 | .79 | 2.98 | 3.76 |
| 840864 | 22-83-11 | COMM.UNLEAD | 22703.0 | .41936 | 3.3322 | .7721 | 16.0491 | 2.98 | 4.60 | 7.58 |
| 840865 | 23-83-11 | COMM.UNLEAD | 22721.0 | .00000 | .0000 | .0000 | .0000 | 7.00 | 4.08 | 11.08 |
| 841148 | 01-83-12 | COMM.10.MIN | 22744.0 | .38637 | 2.8488 | .7015 | 16.2211 | 5.11 | 3.89 | 9.00 |
| 841158 | 02-83-12 | COMM.10.MIN | 22760.0 | .39988 | 3.8110 | .7427 | 16.4146 | 10.02 | 4.33 | 14.35 |
| 841187 | 06-83-12 | IND/COM.MIX | 22909.0 | .40835 | 3.3299 | .6952 | 16.4064 | 2.07 | 3.51 | 5.58 |
| 841188 | 07-83-12 | IND/COM.MIX | 22928.0 | .38462 | 2.8515 | .7164 | 16.3709 | 1.35 | 2.93 | 4.28 |

VEHICLE.ID 1P3BP26C9DF25153 1983 PLYMOUTH RELIANT
TEST.PROCEDURE CVS.75-LATR

| TEST.NUMBER | TEST.DATE | TEST.DISP | ODOMETER | HC | CO | NOX | MI/GAL | DIURNAL | HOT.SOAK | TOTAL.EVAP |
|---|---|---|---|---|---|---|---|---|---|---|
| 840383 | 20-83-10 | BASE.CONFIG | 2632.0 | .14653 | 1.5161 | .6649 | 25.0614 | 1.28 | 1.27 | 2.55 |
| 840384 | 21-83-10 | BASE.CONFIG | 2651.0 | .15812 | 1.6924 | .6670 | 25.1823 | .97 | 1.40 | 2.37 |
| 840385 | 26-83-10 | COMM.UNLEAD | 2814.0 | .26237 | 3.1953 | .7065 | 25.5669 | 2.58 | 1.20 | 3.79 |
| 840387 | 31-83-10 | COMM.UNLEAD | 2841.0 | .29027 | 3.8293 | .7484 | 24.7065 | 2.94 | 2.03 | 4.97 |
| 840386 | 05-83-11 | COMM.10.MIN | 2858.0 | .25377 | 3.5948 | .7733 | 24.8096 | 4.52 | 2.47 | 6.99 |
| 840390 | 07-83-11 | COMM.10.MIN | 2876.0 | .30415 | 3.1396 | .4695 | 29.9701 | 4.86 | 1.14 | 6.00 |
| 841743 | 06-83-01 | BASE.CONFIG | 3043.0 | .18471 | 1.8202 | .7858 | 22.5970 | 1.47 | 1.25 | 2.72 |
| 841744 | 09-84-01 | COMM.UNLEAD | 3446.0 | .19730 | 2.2543 | .7895 | 24.5545 | 2.87 | 1.33 | 4.20 |
| 841745 | 10-84-01 | BASE.CONFIG | 3462.1 | .17931 | 1.6136 | .8202 | 24.4235 | 1.08 | 1.30 | 2.38 |

VEHICLE.ID 1X687AW139507 1980 CHEVROLET CITATION
TEST.PROCEDURE CVS.75-LATR

| TEST.NUMBER | TEST.DATE | TEST.DISP | ODOMETER | HC | CO | NOX | MI/GAL | DIURNAL | HOT.SOAK | TOTAL.EVAP |
|---|---|---|---|---|---|---|---|---|---|---|
| 840176 | 07-83-10 | BASE.CONFIG | 37184.0 | .40111 | 3.3814 | 1.1940 | 19.5512 | 1.37 | 4.05 | 5.42 |
| 840177 | 12-83-10 | BASE.CONFIG | 37203.0 | .43229 | 3.6346 | 1.0957 | 19.8359 | 1.63 | 4.10 | 5.73 |
| 840178 | 14-83-10 | BASE.CONFIG | 37222.0 | .39295 | 2.6738 | 1.2182 | 19.8639 | 1.07 | 4.77 | 5.84 |
| 840080 | 02-83-11 | COMM.UNLEAD | 37386.0 | .42608 | 3.1988 | 1.0796 | 19.6903 | 4.56 | 14.98 | 19.53 |
| 840179 | 03-83-11 | COMM.UNLEAD | 37408.0 | .43251 | 3.7431 | 1.0767 | 19.5225 | 4.26 | 18.53 | 22.79 |
| 840180 | 05-83-11 | COMM.10.MIN | 37425.0 | .51067 | 4.5455 | 1.0598 | 19.8939 | 5.04 | 22.66 | 27.70 |
| 840379 | 07-83-11 | COMM.10.MIN | 37442.0 | .42059 | 3.9697 | .9762 | 19.8137 | 4.39 | 22.26 | 26.65 |
| 840776 | 10-83-11 | IND/COM.MIX | 37590.0 | .00000 | .0000 | .0000 | .0000 | 1.98 | 8.47 | 10.45 |
| 840855 | 16-83-11 | IND/COM.MIX | 37611.0 | .42061 | 4.4145 | 1.1327 | 19.9613 | 1.61 | 8.45 | 10.06 |

VEHICLE.ID 2FABP43F2DB14851 1983 LTD CROWN VICTORIA
TEST.PROCEDURE CVS.75-LATR

| TEST.NUMBER | TEST.DATE | TEST.DISP | ODOMETER | HC | CO | NOX | MI/GAL | DIURNAL | HOT.SOAK | TOTAL.EVAP |
|---|---|---|---|---|---|---|---|---|---|---|
| 840643 | 03-83-11 | BASE.CONFIG | 10865.0 | .31219 | 5.3174 | .6419 | 15.6033 | .24 | .50 | .74 |
| 840644 | 04-83-11 | BASE.CONFIG | 10883.0 | .31205 | 5.9754 | .6430 | 15.8533 | .58 | .42 | 1.00 |
| 840720 | 07-83-11 | COMM.UNLEAD | 11032.0 | .35950 | 5.9702 | .6502 | 16.1378 | .90 | .58 | 1.48 |
| 840742 | 08-83-11 | COMM.UNLEAD | 11054.0 | .30680 | 6.6205 | .7231 | 16.2308 | .54 | .57 | 1.11 |
| 840775 | 10-83-11 | COMM.10.MIN | 11070.0 | .33814 | 6.4590 | .6204 | 16.4461 | 1.53 | .64 | 2.17 |
| 840800 | 15-83-11 | COMM.10.MIN | 11087.0 | .36595 | 9.1289 | .7285 | 16.2268 | .97 | .66 | 1.63 |

VEHICLE.ID 3R47A9M523280 1979 OLDSMOBILE CUTLASS
TEST.PROCEDURE CVS.75-LATR

| TEST.NUMBER | TEST.DATE | TEST.DISP | ODOMETER | HC | CO | NOX | MI/GAL | DIURNAL | HOT.SOAK | TOTAL.EVAP |
|---|---|---|---|---|---|---|---|---|---|---|
| 822397 | 30-83-09 | BASE.CONFIG | 37854.0 | 1.18670 | 12.8680 | 2.3905 | 18.6679 | 1.80 | 1.85 | 3.66 |
| 840181 | 04-83-10 | BASE.CONFIG | 37873.0 | 1.40030 | 16.7870 | 2.3258 | 18.9960 | 1.98 | 1.70 | 3.68 |
| 840182 | 06-83-10 | COMM.UNLEAD | 38018.0 | .99930 | 14.9630 | 2.6362 | 19.2474 | 2.81 | 1.68 | 4.49 |
| 840183 | 27-83-10 | COMM.UNLEAD | 38057.0 | 1.28210 | 17.6410 | 2.3159 | 18.9199 | 12.65 | 1.48 | 14.13 |
| 840184 | 03-83-11 | COMM.UNLEAD | 38080.0 | .95480 | 12.7730 | 2.4779 | 19.4421 | 6.03 | 1.83 | 7.86 |
| 840185 | 16-83-11 | IND/COM.MIX | 38225.0 | 1.42140 | 18.2410 | 2.4445 | 19.2741 | 2.46 | 1.76 | 4.22 |
| 840868 | 17-83-11 | IND/COM.MIX | 38247.0 | 1.27710 | 16.4620 | 2.6706 | 19.1128 | 1.65 | 1.66 | 3.31 |

VEHICLE.ID 9T11Y186165 1979 FORD PINTO
TEST.PROCEDURE CVS.75-LATR

| TEST.NUMBER | TEST.DATE | TEST.DISP | ODOMETER | HC | CO | NOX | MI/GAL | DIURNAL | HOT.SOAK | TOTAL.EVAP |
|---|---|---|---|---|---|---|---|---|---|---|
| 822399 | 30-83-09 | BASE.CONFIG | 26903.0 | 1.55980 | 14.4800 | 1.2922 | 21.9652 | .11 | .50 | .62 |
| 840186 | 04-83-10 | BASE.CONFIG | 26922.0 | 1.60820 | 18.4720 | 1.1889 | 22.3841 | .28 | .73 | 1.01 |
| 840187 | 05-83-10 | BASE.CONFIG | 26941.0 | 1.43740 | 12.7650 | 1.4157 | 22.8158 | .30 | .81 | 1.11 |
| 840188 | 31-83-10 | COMM.UNLEAD | 27068.0 | 1.51690 | 14.8650 | 1.2898 | 22.4375 | .48 | .90 | 1.37 |
| 840377 | 01-83-11 | COMM.UNLEAD | 27109.0 | 1.43980 | 12.3040 | 1.2521 | 22.7448 | .25 | .93 | 1.18 |

## Modified Driving Cycles

VEHICLE.ID 1FABP0524BW15883 1981 FORD ESCORT
TEST.PROCEDURE BAG.BY.BAG

| TEST.NUMBER | TEST.DATE | ECTD.TEST.DISP | ODOMETER | HC | CO | NOX | MI/GAL | DIURNAL | HOT.SOAK | TOTAL.EVAP |
|---|---|---|---|---|---|---|---|---|---|---|
| 840395 | 12-83-12 | LOW.SPD-A | 30410.0 | 2.221 | 51.595 | .903 | 22.8 | .51 | .97 | 1.48 |
| 840394 | 15-83-12 | LOW.SPD-A | 30430.0 | .000 | .000 | .000 | .0 | .86 | .93 | 1.79 |
| 840398 | 20-83-12 | MED.SPD-B | 30561.0 | 1.491 | 46.278 | 1.176 | 23.5 | .34 | 1.11 | 1.45 |
| 840393 | 22-83-12 | MED.SPD-B | 30573.0 | .000 | .000 | .000 | | .23 | 1.13 | 1.36 |

VEHICLE.ID 1G1AX68R6CT10287 1982 CHEVROLET CITATION
TEST.PROCEDURE BAG.BY.BAG

| TEST.NUMBER | TEST.DATE | ECTD.TEST.DISP | ODOMETER | HC | CO | NOX | MI/GAL | DIURNAL | HOT.SOAK | TOTAL.EVAP |
|---|---|---|---|---|---|---|---|---|---|---|
| 841345 | 13-83-12 | LOW.SPD-A | 35723.0 | .669 | 7.523 | .637 | 24.4 | 1.03 | .91 | 1.94 |
| 841346 | 14-83-12 | LOW.SPD-A | 35740.0 | .000 | .000 | .000 | .0 | .82 | 1.02 | 1.84 |
| 841347 | 21-83-12 | MED.SPD-B | 35872.0 | .522 | 9.372 | .814 | 24.5 | .62 | .71 | 1.33 |
| 841348 | 04-84-01 | MED.SPD-B | 35889.0 | .488 | 12.020 | .771 | 24.7 | 1.18 | .67 | 1.85 |

VEHICLE.ID 1G3AP35Y5DX34364 1983 OLDSMOBILE CUSTOM CRUISER
TEST.PROCEDURE BAG.BY.BAG

| TEST.NUMBER | TEST.DATE | ECTD.TEST.DISP | ODOMETER | HC | CO | NOX | MI/GAL | DIURNAL | HOT.SOAK | TOTAL.EVAP |
|---|---|---|---|---|---|---|---|---|---|---|
| 841195 | 09-83-12 | LOW.SPD-A | 23073.0 | .916 | 13.767 | .938 | 13.7 | 1.24 | 2.60 | 3.84 |
| 841196 | 12-83-12 | LOW.SPD-A | 23079.0 | .869 | 15.914 | .934 | 13.7 | 1.88 | 2.64 | 4.51 |
| 841197 | 16-83-12 | MED.SPD-B | 23221.0 | .675 | 12.316 | 1.083 | 15.1 | 2.42 | 3.04 | 5.46 |
| 841198 | 19-83-12 | MED.SPD-B | 23229.0 | .633 | 10.126 | 1.207 | 14.8 | 1.07 | 2.81 | 3.89 |
| 841622 | 10-84-01 | MED.SPD-B | 23258.0 | .653 | 9.507 | 1.157 | 14.6 | 2.54 | 2.94 | 5.48 |

VEHICLE.ID 1P3BP26C9DF25153 1983 PLYMOUTH RELIANT
TEST.PROCEDURE BAG.BY.BAG

| TEST.NUMBER | TEST.DATE | ECTD.TEST.DISP | ODOMETER | HC | CO | NOX | MI/GAL | DIURNAL | HOT.SOAK | TOTAL.EVAP |
|---|---|---|---|---|---|---|---|---|---|---|
| 841199 | 15-83-12 | LOW.SPD-A | 3235.0 | .975 | 19.489 | .517 | 21.5 | 3.92 | .97 | 4.89 |
| 841200 | 19-83-12 | LOW.SPD-A | 3241.0 | .535 | 11.667 | .584 | 21.8 | 4.41 | 1.09 | 5.51 |
| 840389 | 21-83-12 | MED.SPD-B | 3384.0 | .498 | 11.501 | .979 | 21.9 | 2.52 | 1.17 | 3.69 |
| 840388 | 22-83-12 | MED.SPD-B | 3392.0 | .483 | 11.259 | .971 | 22.4 | 2.19 | 1.09 | 3.28 |
| 841624 | 04-84-01 | MED.SPD-B | 3417.0 | .382 | 7.299 | .970 | 22.1 | 1.88 | 1.04 | 2.92 |

VEHICLE.ID 2FABP43F2DB14851 1983 LTD CROWN VICTORIA
TEST.PROCEDURE BAG.BY.BAG

| TEST.NUMBER | TEST.DATE | ECTD.TEST.DISP | ODOMETER | HC | CO | NOX | MI/GAL | DIURNAL | HOT.SOAK | TOTAL.EVAP |
|---|---|---|---|---|---|---|---|---|---|---|
| 841344 | 12-83-12 | LOW.SPD-A | 11231.0 | .855 | 16.326 | .738 | 12.1 | 2.74 | .57 | 3.30 |
| 841349 | 14-83-12 | LOW.SPD-A | 11237.0 | .570 | 11.088 | .649 | 12.3 | 1.56 | .53 | 2.10 |
| 841351 | 19-83-12 | MED.SPD-B | 11373.0 | .758 | 18.965 | .626 | 13.6 | 3.01 | .55 | 3.56 |