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# Vehicle Fuel Weathering Effects With Operating Temperatures on the Road and Dynamometer

by

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## ABSTRACT

Several short test programs were conducted to investigate the effect of gasoline fuel weathering, as measured by Reid Vapor Pressure (RVP), as the vehicle was driven. In the first program, one vehicle was driven on a dynamometer through repetitive sequences of FTPs and LA-4s until three quarters of the fuel was used. This was followed by a road test program of four vehicles. Finally, a series of FTP temperature studies were conducted with two of these vehicles for comparison with the road temperature data and to quickly quantify the temperature effects due to placement of the cooling fan and due to the auxilary fan used for testing.

The overall conclusion for the fuel weathering tests on the dynamometer was that a typical summer blend of commercial unleaded fuel (RVP of 11.7 psi) would weather to approximately 9.0 psi as a vehicle was driven from full to the 40% level. In the road tests the 11.7 psi fuel weathered to an average of 10.7 psi at the 40% level.

For the road tests, a road route similar to the LA-4 but with less idle time was developed. The fuel RVP was periodically measured as the vehicle was operated. Fuel and vehicle operating temperatures were recorded on the road for later comparisons with dynamometer data.

The FTP temperature study of two vehicles on a dynamometer showed that lowering the fan to the floor reduced the tank fuel temperature rise on the two vehicles by 3 to 6°F. The use of an auxiliary fan at the side of the vehicle reduced the temperature rise by 8 to 12°F.

## Background

During the past two decades, commercial fuel volatility, as measured by Reid Vapor Pressure (RVP), has been increasing. Higher levels of RVP are known to cause increases in the levels of evaporative emissions. However, estimates of the in-use evaporative effects have been difficult to quantify due to interactive effects of both temperature and fuel RVP on emissions.

These short test programs were undertaken to quantify these effects and to provide input for current in-use test programs. These included several road and chassis dynamometer studies of fuel weathering and fuel temperatures and a refueling emissions test.

## Test Vehicles

Four typical late model vehicles were used for these programs. However, all of the vehicles were only used in the fuel weathering study on the road.

1984 Ford Escort, 1.6 liter, 4-cylinder
1983 Plymouth Reliant, 2.2 liter, 4-cylinder
1983 Buick Skylark, 2.8 liter, V-6
1979 Ford Granada, 302 CID, V-8

All of these vehicles were equipped with automatic transmissions. A more detailed description of each vehicle, including its evaporative emission family, is given in Appendix A.

Although the fuel weathering tests did not directly require temperature measurements, the vehicles were instrumented to provide a data base of operating temperatures to support subsequent test efforts and analysis. All four vehicles were instrumented to monitor several internal fuel tank temperatures, ambient temperature underneath the fuel tank, vehicle ambient, external carburetor bowl temperature, and oil temperature. The Escort, Reliant, and Skylark catalysts had been previously instrumented to monitor six internal catalyst temperatures.

## Test Programs and Results

The individual test programs and results are summarized in the sections below in chronological order. Detailed descriptions of the individual test programs and test results are given in the appendices. To insure the integrity of these volatile fuel samples, all samples were drawn off through the fuel line near the tank using the positive displacement of water technique. The RVP analysis was done according to ASTM procedure D323.

## Fuel Weathering During Dynamometer Tests

The evaporative emissions and the tank fuel RVP data were obtained on the 1983 Buick Skylark as it was driven from 100 percent fill down to 40 percent full.* All driving was done on the dynamometer using the LA-4 cycle. The basic test sequence used to simulate vehicle operation was a diurnal heat build from 60°F to 84°F in the SHED, an FTP, hot soak in the SHED, three consecutive LA-4s, and then a soak at 55°F in a cooled SHED to chill the fuel for the next diurnal heat build.** The sequence was repeated until 40 percent fuel remained.and the vehicle was soaked at 55°F between test sequences.

The FTP followed by a soak and three consecutive LA-4s does not mimic the typical in-use operation of trips with intervening soak periods. This type of vehicle operation would tend to heat the fuel more, thus increasing fuel weathering. The sequence was followed to minimize test time and determine the worst case emissions. The detailed test plan is given in Appendix B.

The results are tabulated in Appendix C. They show that the key test parameter, vehicle fuel tank RVP, did exhibit a marked change. It went from an initial 11.37 psi RVP at the 100% fill to 9.94 psi RVP at 52% full and ended at 8.83 psi RVP at the 31% fill level. No post-test RVP analysis was possible

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* The LA-4 fuel consumption was estimated from the FTP data and then both of these were used to estimate the vehicle fuel tank level.

** The cooling in the SHED permitted two FTP's to be conducted each day.

since there was insufficient fuel in the vehicle to obtain a valid fuel sample. In this drive down test sequence, the vehicle did not return to the pretest baseline evaporative emission levels, presumably, due in part to the combination of small vapor volume in the initial tests after the 100 percent fill and of the continued fuel weathering. However, this does not appear to adequately explain the change in hot soak emissions. Exhaust emissions and fuel economy were reasonably consistent. The spread in baseline evaporative emissions, 9.17 grams to 14.96 grams, should be viewed with caution since the canister was air purged prior to the 9.17 gram level and, therefore, may have been at an uncharacteristic level.

To confirm the baseline emission levels and permit direct comparison of the 100% fill test with standard evap tests, three additional tests were added. These were two evap tests with standard vehicle soak temperature and one at a 55°F soak temperature. These results are also tabulated in Appendix C. They show that the vehicle did return to the much higher baseline evap levels and that the two 100% fill tests (chilled and unchilled vehicle) are reasonably consistent.

Although the preceding showed a fuel weathering effect (change in RVP), the use of an FTP, hot soak and three consecutive LA-4s (without soaks) for mileage accumulation was known to have exaggerated the worst case condition by tending to excessively heat the fuel and possibly cause it to boil. Therefore, additional testing was conducted using actual road route with soak time between mileage accumulation segments.

Fuel Weathering Road Test

As noted above, the principal difference between the road testing and the dynamometer tests was that there was soak time between the individual mileage accumulation segments. A route was developed to meet the emission factor criteria of three trips per day (26 total miles) with an average speed of 25 mph. This was to simulate one trip to work and a two trip segment home. The morning trip was later lengthened to 12.1 miles to more closely approach the FTP distance of 11.1 miles.

Approximately 20 different routes were laid out and checked with vehicle equipped with a fifth-wheel to record vehicle speed and actual driving patterns for each route. The final selection was 8.9 miles long with three 30-second idle periods interspersed to make the trip time 25 minutes. To

facilitate comparisons with dynamometer data, the speeds and driving patterns of this cycle were chosen to approximate the LA-4. The principal difference was that the LA-4 has considerably more idle time. For the longer morning route, three miles of start-stop driving were added to this basic cycle. Copies of these two routes are given in Appendix D.

For this test program, the four instrumented vehicles were driven over the 12.1 mile route in the morning and twice over the 8.9 mile route in the late afternoon until 60 percent of the fuel was consumed. To minimize the number of RVP samples and the volume of fuel removed from the tank as samples, only six RVP samples were taken. These consisted of replicates immediately after filling, at 70 percent full, and at 40 percent full. All vehicle soaks would be outside in a sunny parking area. The detailed test plan is given in Appendix E.

The vehicles were driven in convoy for the three trips each day. Vehicle operating temperatures were recorded as recorder availability permitted. The Escort developed driveability problems and was deleted from the test program after the 70 percent sample point. The results are summarized below.

Road Test Trip Summary

| Trip | Average Trip Time |
|---|---|
| 7:00 a.m. 12.1 miles | 34 minutes |
| 4:00 p.m. 8.9 miles | 25 minutes |
| 5:00 p.m. 8.9 miles | 25 minutes |

Fuel Analysis
RVP at (%) full

| | July 23 | July 30 | Estimate at 40% | August 2 | August 5 | August 7 |
|---|---|---|---|---|---|---|
| Escort | 11.6 (100%) | 11.2 | | | | |
| Reliant | 11.4 (100%) | 11.2 (68%) | 10.6 (40%) | | 10.4 (30%) | 10.1 (21%) |
| Skylark | 11.4 (100%) | 11.1 (63%) | 10.8 (40%) | 10.7 (33%) | | 9.8 (14%) |
| Granada | 11.6 (100%) | 11.0 (53%) | 10.7 (40%) | 10.1 (8%) | | |

Note: Fuel at dispensing nozzle was 11.7 psi.

A detailed listing of the trips and days driven for each vehicle is given in Appendix F. The fuel levels were estimated from the individual trip mileage, total mileage, and total fuel consumption. The RVP at 40% was estimated by interpolating these results. The official meteorological data for this time period is given in Appendix G. Some of the temperature data for the Reliant and Skylark were later tabulated for the analysis of vehicle fuel temperatures and are listed in Appendix H.

For comparison, the results of a previous study of the loss of fuel volatility are summarized below. For this effort the 60 gallons of fuel in a fuel cart were heated to 92°F and maintained at that temperature. The fuel vapors were vented to the atmosphere through a carbon canister.

| Days Since Filling | Average RVP |
|---|---|
| 0 | 11.85 |
| 1 | 11.27 |
| 3 | 10.51 |

Although this test did not have diurnal temperature changes, it shows that the fuel weathering is sensitive to temperature (weathering is also sensitive to fuel RVP, i.e. the more volatile fuels can weather more) since the fuel had remained at a relatively constant RVP while stored underground.

FTP Temperature Studies

Several months after the fuel weathering effects on the road testing, there was a need to quantify the heating of the fuel during the FTP and to establish the effect of fan placement and an auxiliary fan. Of particular interest was the effect on hot soak evaporative emissions. The road test temperature data for the Reliant and Skylark were tabulated for those data near the 40% fuel level.* FTP tests with evaporative emissions were then conducted on these two vehicles to quickly quantify the effect of fan placement. These results are summarized below and tabulated in Appendix I.

* For the FTP, the vehicle is drained and refueled to the 40% fuel level with chilled fuel. A diurnal heat build to 84°F precedes the FTP driving cycle.

| Plymouth Reliant | Fuel Tank Temperatures START FTP | END FTP | ΔT |
|---|---|---|---|
| Standard Fan | 86.0°F | 99.0°F | 13.0°F |
| Floor Fan | 86.0°F | 92.5°F | 6.5°F |
| Std. plus auxiliary | 87.0°F | 88.5°F | 1.5°F |
| **Buick Skylark** | | | |
| Standard Fan | 86.0°F | 100.0°F | 14.0°F |
| Floor Fan | 86.0°F | 97.0°F | 11.0°F |
| Std. plus auxiliary | 85.5°F | 91.5°F | 6.0°F |

These results show that lowering the fan to the floor reduced the tank fuel temperature rises in the Reliant by 6°F and in the Skylark by 3°F. Adding an auxiliary cooling fan reduced the tank fuel temperature rise in the Reliant by 12°F and in the Skylark by 8°F.

The comparable road test data that most closely approximated these test conditions had a temperature rise of 16°F on the Reliant and 12°F on the Skylark. Road test data we have observed generally yield a tank temperature rise on the order of 15 to 20°F during trips approximating the LA-4.

For these FTP temperature studies several tank thermocouples were used. The data presented here were for the thermocouple installed in the fuel tank at the 20% fuel level. An external thermocouple was also attached to the fuel tank with a magnet and used a thermal paste to insure thermal bonding. This magnetic thermocouple is used to monitor fuel temperatures on in-use vehicles and was used to sense the fuel temperature for the fuel heat blanket during the diurnal heat build. It was noted that when the vehicle with chilled fuel was initially hooked up to the temperature recorders, the internal thermocouple read 3 to 6°F lower than the external unit. As the fuel was heated to 60°F for the heat build, the internal unit read 1 to 2°F lower. At 84°F, the end of the diurnal heat build, the internal thermocouple was 1 to 2°F higher than the external thermocouple. Thus the temperature change for the heat build for these tests ranged from 26 to 30°F and are higher than the 24°F standard.

Although hot soak emissions were lower when the improved cooling reduced the heating of the fuel during the FTP, the results were highly vehicle specific. The Reliant had the

largest reduction in fuel tank temperature rise yet the hot soak emissions were reduced only slightly. However, for the Buick, the small change in the tank temperature reduced hot soak emissions by over 50% using the floor fan and by over 90% with auxiliary cooling. These large differences in emissions are probably due to the effects of canister loading and excess capacity.

## Appendixes

| | |
|---|---|
| Appendix A | Test Vehicle Description |
| Appendix B | Fuel Weathering Effects Detailed Dynamometer Test Plan. |
| Appendix C | Fuel Weathering Results for Dynamometer |
| Appendix D | Morning and Afternoon Road Routes |
| Appendix E | Fuel Weathering Effects Detailed Road Test Plan |
| Appendix F | Fuel Tank RVP Versus Driving Distance |
| Appendix G-1,-2 | July and August Meteorological Data |
| Appendix H-1,-2 | Reliant and Skylark Road Test Temperature Data |
| Appendix I-1,-2 | Reliant and Skylark FTP Temperature Study Results |

## APPENDIX A

| Make/Model | Ford Escort | Plymouth Reliant | Buick Skylark | Ford Granada |
|---|---|---|---|---|
| Model Year | 1984 | 1983 | 1983 | 1979 |
| Type | 4 dr hatchback | 4 dr sedan | 4 dr sedan | 4 dr sedan |
| Veh. ID | 2FABP1342EX12355 | 1P3BP26C9DF251538 | 1G4AB69X6DT404941 | 9W82F123952 |
| In. Odom. | 6742 miles | 21224 miles | 20985 miles | 37995 miles |
| Engine | | | | |
| Type | Spark Ignition | Spark Ignition | Spark Ignition | Spark Ignition |
| Config. | tranverse 4 | tranverse 4 | tranverse V-6 | V-8 |
| Disp. | 1.6 liters | 2.2 liters | 2.8 liters | 302 CID |
| Fuel Met. | 2V Carb | 2V Carb | 2V Carb | 2V Carb |
| Eng. Fam | EFM1.6V2GDK7 | DCR2.2V2HAC3 | DIG2.8V2NNA9 | 2V Carb |
| Evap. Fam | CM | DCRKA | 3B6-1B | |
| Emission | air pump | air pump | air pump | air pump |
| Control | EGR | EGR | EGR | EGR |
| System | 3-way cat | oxid cat<br>3-way cat | oxid cat | oxid cat |
| Trans. | automatic<br>3-speed | automatic<br>3-speed | automatic<br>3-speed | automatic<br>3-speed |
| Tires | P165/80R13 | P175/75R13 | P185/80R13 | ER 78x14 |
| Test Para. | | | | |
| inertia wt | 2375 | 2750 | 3000 | 4000 |
| HP@ 50mph | 6.4 hp | 8.0 hp | 7.3 hp | 11.1 |
| Fuel Tank Capacity | 13 gal. | 13 gal. | 15 gal. | 19 gal. |

Appendix B

Fuel Weathering Effects
Detailed Test Plan

## I. Introduction

The evaporative emissions and fuel tank RVP data are to be obtained on the 1983 Buick Skylark as it is driven from a 100% fill down to 40% fill. All driving will be done on the dynamometer using the LA-4 cycle. The vehicle will be soaked overnight in the E&D SHED at 55°F between driving cycles. The vehicle will undergo the standard diurnal heat build in an EOD SHED, three LA-4s, and then soaked at 55°F. This sequence will be repeated until 40% of the fuel remains.

## II. Vehicle Prep

Insure thermocouples are still installed in fuel tank and that they function.

Install thermocouple in engine oil.
Install top heating blanket.
Install tee in fuel line near gas tank. Route a line to side of vehicle for fuel tank RVP samples and install a shut off valve. Provide a cap for valve outlet.

Check integrity of fuel system. Pressure check gas cap.

## III. Testing

A. Pretest heat build check

1. Drain vehicle
2. 100% fill with chilled commercial unleaded.
3. Heat build from 60°F to 84°F in one hour. Use both blankets. Record settings for later use.
4. Draw off two samples from vehicle for RVP analysis and then top off tank
5. Prepare vehicle for heat build
6. When fuel temperature reaches standard test point (60°F) begin heat build for diurnal emissions. Use upper blanket to assist as necessary.
7. FTP (Do not stop test if exhaust emissions test is voided.
8. Hot soak emissions evap test
9. Three LA-4s on dyno. No exhaust emissions. Car may be driven on dyno and off dyno to E&D SHED

for soak. Do not use vehicle to set dyno horsepower.

10. Soak vehicle in E&D SHED until fuel and oil temperatures are at approximately 55°F.
11. Repeat 5 through 10 until fuel is at approximately 70% level (end of 3rd. sequence)
12. At 70% level draw off <u>two</u> samples of fuel from fuel tank for RVP analysis.
13. Repeat 5 through 10 until fuel is below 40% level (See Tony Barth, Project Engineer)
14. Repeat 12 once.

B. Preconditioning

1. Drain vehicle
2. Refuel to 40% with commercial unleaded
3. Single LA-4 prep
4. Soak in SHED until fuel and oil are at 55°F.
5. Standard diurnal (test to include normal fuel draining and 40% fill with chilled commercial unleaded gasoline), FTP with exhaust emissions and hot soak test emissions
6. Repeat 1 through 5 once.
7. Drain and 40% fill with chilled commercial unleaded gasoline.
8. Single LA-4 prep.
9. Soak at 55°F until 100% fill test.

NOTE 1: Once the vehicle is fueled for this 100% fill test, do not drain or refuel vehicle for subsequent diurnal tests.

NOTE 2: Gas cap is put on vehicle for diurnal test immediately following 100% fill. Do not remove gas cap for subsequent diurnal heat builds.

APPENDIX C
Fuel Weathering
1983 Buick Skylark
11.8 psi RVP Commercial Unleaded

| | | FTP Emissions gms/mi | | | | Evaporative Emissions gms/test | | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Test No. | HC | CO | $NO_x$ | MPG | Diurnal | Hot Soak | Total | Comments |
| 05-15-85 | 85-3637 | .24 | 1.91 | .32 | 21.8 | 3.03 | 6.14 | 9.17 | baseline, canister air purged prior to prep |
| 05-16-85 | 85-3636 | .29 | 3.37 | .35 | 21.5 | 4.15 | 10.80 | 14.96 | baseline |
| 05-21-85 | Fuel Supply | | | | | | | | 11.45 psi RVP at dispenser |
| 05-21-85 | Vehicle 100% Full | | | | | | | | 11.37 psi RVP |
| 05-21-85 | 85-3744 | .27 | 1.99 | .33 | 21.4 | .73 | 2.67 | 3.40 | 100% fill, chilled vehicle |
| 05-22-85 | 85-3745 | .21 | 1.86 | .30 | 21.4 | 1.40 | 2.70 | 4.10 | 89% full |
| 05-22-85 | 85-3757 | .33 | 3.08 | .33 | 21.1 | .63 | 3.14 | 3.77 | 79% full |
| 05-23-85 | 85-3758 | .27 | 1.80 | .35 | 21.5 | 1.65 | 2.50 | 4.15 | 68% full |
| 05-23-85 | Vehicle 57% Full | | | | | | | | 9.94 psi RVP |
| 05-23-85 | 85-3759 | .31 | 2.89 | .37 | 21.1 | .64 | 2.43 | 3.07 | 52% full |
| 05-24-85 | 85-3760 | .27 | 2.34 | .35 | 21.1 | 1.62 | 1.60 | 3.22 | 41% full |
| 05-24-85 | Vehicle 31% Full | | | | | | | | 8.83 psi RVP |
| 05-30-85 | 85-3761 | .27 | 2.09 | .37 | 21.2 | .50 | 1.48 | 1.99 | 26% full |
| 05-31-85 | 85-3850 | .30 | 2.86 | .31 | 21.8 | .71 | 1.00 | 1.71 | 15% full |
| | Insufficient fuel for post-test RVP sample | | | | | | | | |
| 06-05-85 | 85-3852 | .26 | 3.01 | .46 | 21.4 | 2.46 | 9.85 | 12.31 | baseline |
| 06-06-85 | 85-3853 | .19 | 1.78 | .36 | 21.7 | .86 | 2.03 | 2.89 | baseline w 100% fill |
| 06-14-85 | 85-4080 | .28 | 2.53 | .40 | 21.4 | 1.53 | 7.68 | 9.22 | baseline w 55°F soak |

APPENDIX D

# Morning Route
## US 23/Highway Safety/Fire Station Route

Initial odometer_____miles, reset and start stopwatch

EPA to Plymouth Road (left turn)

to US 23 (South)
to Geddes (West)
to Earhart (North)
to Glacier Way West
to Marksbarry (North)

stop and idle for 30 seconds prior to next turn

to Windemere (West)
to Charter Place (Southwest)
to Bardstown Trail (North)
to Windemere (West)
to Barrister (North)
to Larchmont (West)
to Green (South)
to Vintage Valley Loop (Circle)

Stop and idle for 30 seconds prior to next turn)

to Green (North)
to Hubbard (West)
to Dean (North)

Stop and idle for 30 seconds prior to next turn)

to Baxter (West)
to Huron Parkway (North)
to Nixon (South)
to Plymouth Road (West)

to EPA

EPA to Plymouth Road (left turn)

to Green (South)
to Baxter (West)
to Dean (South)
to Hubbard (West)
to Beal (North)
to Fire Station (Left to Plymouth Road)
Plymouth Road (East) to EPA

to EPA

Final Odometer_____miles. Total Time_____

APPENDIX D

Afternoon Route
US 23/Highway Safety/Route

Initial odometer_____miles, reset and start stopwatch

EPA to Plymouth Road (left turn)

to US 23 (South)
to Geddes (West)
to Earhart (North)
to Glacier Way West
to Marksbarry (North)

stop and idle for 30 seconds prior to next turn

to Windemere (West)
to Charter Place (Southwest)
to Bardstown Trail (North)
to Windemere (West)
to Barrister (North)
to Larchmont (West)
to Green (South)
to Vintage Valley Loop (Circle)

Stop and idle for 30 seconds prior to next turn

to Green (North)
to Hubbard (West)
to Dean (North)

Stop and idle for 30 seconds prior to next turn

to Baxter (West)
to Huron Parkway (North)
to Nixon (South)
to Plymouth Road (West)

to EPA

Final Odometer_____miles. Total Time_____

APPENDIX E

# Fuel Weathering Effects
# Detailed Test Plan

## I. Introduction

The evaporative emissions and fuel tank RVP data are to be obtained on four vehicles as they are driven from a 100% fill down to 40% fill. The sequence will consist of an 11-mile road route, soak outside, eight mile road route, soak outside, eight mile road route, overnight soak outside. This sequence will also be repeated until 40% of the fuel remains. The average speed on the road route will be approximately 25 miles per hour.

## II. Vehicle Prep

Insure thermocouples are still installed in fuel tank and that they function.

Install thermocouple in engine oil.
Install a thermocouple beneath fuel tank.
Install an ambient thermocouple shielded from the sun.
Install tee in fuel line near gas tank. Route a line to side of vehicle for fuel tank RVP samples and install a shutoff valve. Provide a cap for valve outlet.

Check integrity of fuel system. Pressure check gas cap.

## III. Testing - 100% Fill without evap or emissions test

1. No preconditioning required
2. Drain vehicle
3. 100% fill with unchilled commercial unleaded
4. Draw off two samples of fuel for RVP analysis from refueling facility through nozzle.
5. Draw off two samples from vehicle for RVP analysis and then top off tank
6. About 7:00 am, drive vehicle over 11 mile morning road route and record temperature
7. Soak outside until approximately 4:00pm
8. Drive vehicle over eight mile afternoon road route and record temperatures
9. Soak outside until approximately 5:00pm
10. Drive vehicle over eight mile road route and record temperatures
11. Soak outside until next mornings road driving
12. Repeat 6 through 11 until fuel is at approximately

the 70% level. (end of 4th sequence)

13. At 70% level draw off two samples of fuel from fuel tank prior to the initial driving cycle of the day
14. Repeat 6 through 11 until fuel is a approximately the 40% level. (See Tony Barth, Project Engineer)
15. Repeat 13 once.

Note 1: Once the vehicle is fueled for this 100% fill test, do not drain or refuel vehicle for subsequent tests.

Note 2: Gas cap is put on vehicle immediately following 100% fill. Do not remove gas cap.

Note 3: Testing will take about two weeks.

APPENDIX F
Reid Vapor Pressure (RVP) of Fuel in Vehicle Tank
vs
Driving Distance

| Date | Trip No. | Ford Escort | | Plymouth Reliant | | Buick Skylark | | Ford Granada | |
|---|---|---|---|---|---|---|---|---|---|
| | | % Fuel | RVP | % Fuel | RVP | % Fuel | RVP | % Fuel | RVP |
| 7-23 | | 100% | 11.6 | 100% | 11.4 | 100% | 11.4 | 100% | 11.6 |
| 7-24 | 1 | x | | 96 | | 96 | | 94 | |
| | 2 | x | | 93 | | 92 | | 90 | |
| | 3 | x | | 91 | | 89 | | 86 | |
| 7-25 | 1 | x | | 87 | | 85 | | 81 | |
| | 2 | x | | 84 | | 82 | | 77 | |
| | 3 | x | | 81 | | 78 | | 73 | |
| 7-26 | 1 | x | | 77 | | 74 | | 67 | |
| | 2 | x | | 74 | | 71 | | 63 | |
| | 3 | x | | 72 | | 68 | | 59 | |
| 7-30 | 1 | x | | 68 | | 63 | | 53 | |
| | | | 11.2 | | 11.2 | | 11.1 | | 11.0 |
| | 2 | | | 61 | | 56 | | 46 | |
| | 3 | | | 58 | | 53 | | 42 | |
| 7-31 | 1 | | | 54 | | 49 | | 36 | |
| | 2 | | | 51 | | | | 32 | |
| | 3 | | | 48 | | | | 28 | |
| 8-1 | 1 | | | 45 | | 44 | | 22 | |
| | 2 | | | 42 | | 41 | | 18 | |
| | 3 | | | 39 | | 38 | | 14 | |
| 8-2 | 1 | | | 35 | | 33 | | 8 | |
| | | | | | | | 10.7 | | 10.1 |
| | 2 | | | 32 | | 26 | | | ---- |
| | 3 | | | 30 | | 23 | | | |
| 8-5 | | | | | 10.4 | | | | |
| 8-6 | 1 | | | 21 | | 18 | | | |
| 8-7 | 1 | | | | | 14 | | | |
| | | | | | 10.1 | | 9.8 | | |
| 8-29 | | | | | 9.4 | | | | |

Note: % full is at end of trip
Trip #1 Morning 7:00 am 12.1 miles
Trip #2 Afternoon 4:00 pm 8.9 miles
Trip #3 Afternoon 5:00 pm 8.9 miles

Escort mileage accumulation suspended after 7-30 due to driveability problems. No fuel quantity data available.

APPENDIX G-1
DEGREE DAY RECORD FOR PERIOD
1 JULY 1985 TO 31 JULY 1985
MIDNIGHT TO MIDNIGHT OBSERVATIONS (EST)
UNIVERSITY OF MICHIGAN, ANN ARBOR

| DATE | MAXIMUM(F) | MINIMUM(F) | MEAN(F) | DEGREE DAYS HEATING (65F BASE) | DEGREE DAYS COOLING (65F BASE) | DEGREE DAYS COOLING (75F BASE) |
|---|---|---|---|---|---|---|
| JULY 1 | 76. | 57. | 66.5 | 0.0 | 1.5 | 0.0 |
| 2 | 81. | 62. | 71.5 | 0.0 | 6.5 | 0.0 |
| 3 | 82. | 58. | 70.0 | 0.0 | 5.0 | 0.0 |
| 4 | 84. | 58. | 71.0 | 0.0 | 6.0 | 0.0 |
| 5 | 79. | 61. | 70.0 | 0.0 | 5.0 | 0.0 |
| 6 | 76. | 60. | 68.0 | 0.0 | 3.0 | 0.0 |
| 7 | 79. | 53. | 66.0 | 0.0 | 1.0 | 0.0 |
| 8 | 92. | 71. | 81.5 | 0.0 | 16.5 | 6.5 |
| 9 | 84. | 64. | 74.0 | 0.0 | 9.0 | 0.0 |
| 10 | 77. | 61. | 69.0 | 0.0 | 4.0 | 0.0 |
| 11 | 77. | 58. | 67.5 | 0.0 | 2.5 | 0.0 |
| 12 | 84. | 62. | 73.0 | 0.0 | 8.0 | 0.0 |
| 13 | 85. | 64. | 74.5 | 0.0 | 9.5 | 0.0 |
| 14 | 84. | 68. | 76.0 | 0.0 | 11.0 | 1.0 |
| 15 | 82. | 61. | 71.5 | 0.0 | 6.5 | 0.0 |
| 16 | 75. | 58. | 66.5 | 0.0 | 1.5 | 0.0 |
| 17 | 76. | 54. | 65.0 | 0.0 | 0.0 | 0.0 |
| 18 | 80. | 56. | 68.0 | 0.0 | 3.0 | 0.0 |
| 19 | 84. | 63. | 73.5 | 0.0 | 8.5 | 0.0 |
| 20 | 82. | 67. | 74.5 | 0.0 | 9.5 | 0.0 |
| 21 | 79. | 68. | 73.5 | 0.0 | 8.5 | 0.0 |
| 22 | 74. | 56. | 65.0 | 0.0 | 0.0 | 0.0 |
| 23 | 73. | 50. | 61.5 | 3.5 | 0.0 | 0.0 |
| 24 | 83. | 51. | 67.0 | 0.0 | 2.0 | 0.0 |
| 25 | 89. | 71. | 80.0 | 0.0 | 15.0 | 5.0 |
| 26 | 78. | 62. | 70.0 | 0.0 | 5.0 | 0.0 |
| 27 | 81. | 57. | 69.0 | 0.0 | 4.0 | 0.0 |
| 28 | 84. | 61. | 72.5 | 0.0 | 7.5 | 0.0 |
| 29 | 86. | 65. | 75.5 | 0.0 | 10.5 | 0.5 |
| 30 | 74. | 60. | 67.0 | 0.0 | 2.0 | 0.0 |
| 31 | 64. | 59. | 61.5 | 3.5 | 0.0 | 0.0 |

SUMMARY

AVERAGE MAXIMUM= 80.1 F
AVERAGE MINIMUM= 60.5 F
AVERAGE MEAN= 70.3 F

TOTAL DEGREE DAYS
HEATING (65F BASE)= 7.0
COOLING (65F BASE)= 172.0
COOLING (75F BASE)= 13.0

APPENDIX G-2

DEGREE DAY RECORD FOR PERIOD
1 AUG. 1985 TO 31 AUG. 1985
MIDNIGHT TO MIDNIGHT OBSERVATIONS (EST)
UNIVERSITY OF MICHIGAN, ANN ARBOR

| DATE | MAXIMUM(F) | MINIMUM(F) | MEAN(F) | DEGREE DAYS HEATING (65F BASE) | DEGREE DAYS COOLING (65F BASE) | DEGREE DAYS COOLING (75F BASE) |
|---|---|---|---|---|---|---|
| AUG. 1 | 77. | 56. | 66.5 | 0.0 | 1.5 | 0.0 |
| 2 | 77. | 51. | 64.0 | 1.0 | 0.0 | 0.0 |
| 3 | 80. | 54. | 67.0 | 0.0 | 2.0 | 0.0 |
| 4 | 84. | 58. | 71.0 | 0.0 | 6.0 | 0.0 |
| 5 | 73. | 65. | 69.0 | 0.0 | 4.0 | 0.0 |
| 6 | 79. | 63. | 71.0 | 0.0 | 6.0 | 0.0 |
| 7 | 85. | 64. | 74.5 | 0.0 | 9.5 | 0.0 |
| 8 | 86. | 59. | 72.5 | 0.0 | 7.5 | 0.0 |
| 9 | 85. | 62. | 73.5 | 0.0 | 8.5 | 0.0 |
| 10 | 84. | 63. | 73.5 | 0.0 | 8.5 | 0.0 |
| 11 | 79. | 56. | 67.5 | 0.0 | 2.5 | 0.0 |
| 12 | 79. | 53. | 66.0 | 0.0 | 1.0 | 0.0 |
| 13 | 89. | 64. | 76.5 | 0.0 | 11.5 | 1.5 |
| 14 | 82. | 66. | 74.0 | 0.0 | 9.0 | 0.0 |
| 15 | 70. | 61. | 65.5 | 0.0 | 0.5 | 0.0 |
| 16 | 77. | 55. | 66.0 | 0.0 | 1.0 | 0.0 |
| 17 | 79. | 56. | 67.5 | 0.0 | 2.5 | 0.0 |
| 18 | 81. | 61. | 71.0 | 0.0 | 6.0 | 0.0 |
| 19 | 69. | 54. | 61.5 | 3.5 | 0.0 | 0.0 |
| 20 | 66. | 53. | 59.5 | 5.5 | 0.0 | 0.0 |
| 21 | 70. | 56. | 63.0 | 2.0 | 0.0 | 0.0 |
| 22 | 73. | 51. | 62.0 | 3.0 | 0.0 | 0.0 |
| 23 | 75. | 57. | 66.0 | 0.0 | 1.0 | 0.0 |
| 24 | 67. | 63. | 65.0 | 0.0 | 0.0 | 0.0 |
| 25 | 75. | 59. | 67.0 | 0.0 | 2.0 | 0.0 |
| 26 | 73. | 60. | 66.5 | 0.0 | 1.5 | 0.0 |
| 27 | 77. | 59. | 68.0 | 0.0 | 3.0 | 0.0 |
| 28 | 81. | 63. | 72.0 | 0.0 | 7.0 | 0.0 |
| 29 | 79. | 64. | 71.5 | 0.0 | 6.5 | 0.0 |
| 30 | 72. | 58. | 65.0 | 0.0 | 0.0 | 0.0 |
| 31 | 71. | 54. | 62.5 | 2.5 | 0.0 | 0.0 |

SUMMARY

AVERAGE MAXIMUM= 77.2 F
AVERAGE MINIMUM= 58.6 F
AVERAGE MEAN= 67.9 F

TOTAL DEGREE DAYS
HEATING (65F BASE) = 17.5
COOLING (65F BASE) = 108.5
COOLING (75F BASE) = 1.5

Appendix I-1
1983 Plymouth Reliant
2.2 Liter 4 cylinder

Commercial Unleaded

| Test No. and Fan Position | DIURNAL Start | DIURNAL End | DIURNAL WT | FTP Start | FTP 23 Min | FTP End | FTP WT | HOT SOAK Start | HOT SOAK End |
|---|---|---|---|---|---|---|---|---|---|
| No. 86-1522 Std. Position | 59.0 | 86.0 | 27.0 | 85.0 | 94.0 | 98.0 | 13.0 | 99.0 | 94.0 |
| No. 86-1715 Std. Position | 61.0 | 88.0 | 27.0 | 86.0 | 94.0 | 99.0 | 13.0 | 99.0 | 94.0 |
| No. 86-1714 Fan on Floor | 57.5 | 86.5 | 29.0 | 86.0 | 89.5 | 92.5 | 6.5 | 93.0 | 91.5 |
| No. 86-1815 Aux. Fan | 58.0 | 87.0 | 29.0 | 87.0 | 88.0 | 88.5 | 1.5 | 89.0 | 87.0 |
| No. 86-1816 Std. Position | 58.0 | 88.0 | 30.0 | 86.5 | 95.0 | 100.0 | 13.5 | 100.5 | 95.0 |

FTP Emissions

| Date | Test No. | gm/mi HC | gm/mi CO | gm/mi NOx | MPG | Evaporative Grams Diurnal | Evaporative Grams Hot Soak | Evaporative Grams Total |
|---|---|---|---|---|---|---|---|---|
| 1-30-86 | 86-1522 | .53 | 6.73 | .77 | 26.9 | 6.83 | 1.11 | 7.94 |
| Fan Standard Position | | | | | | | | |
| 2-07-86 | 86-1715 | .56 | 6.92 | .76 | 27.0 | 6.34 | 1.18 | 7.52 |
| Fan at Floor | | | | | | | | |
| 2-13-86 | 86-1714 | .53 | 5.93 | .80 | 26.8 | 6.18 | .91 | 7.09 |
| Fan Standard position, metal drain fittings | | | | | | | | |
| 2-14-86 | 86-1815 | .62 | 6.10 | .79 | 27.2 | 10.26 | .88 | 11.14 |
| Auxiliary Fan | | | | | | | | |
| 2-19-86 | 86-1816 | .57 | 7.07 | .75 | 27.5 | 8.95 | 1.68 | 10.63 |
| Fan Standard Position | | | | | | | | |

Fuel Temperatures on Road During Summer

| Trip | Ambient | Start | End | Fuel Level at End |
|---|---|---|---|---|
| 7:00 am 12.1 miles | 60°F | 61°F | 77°F | 45% |
| 4:00 pm 8.9 miles | 79°F | 82°F | 98°F | 42% |
| 5:00 pm 8.9 miles | 80°F | 91°F | 101°F | 39% |

Notes: Front wheel drive vehicle with fuel tank in front of rear axle.

8.9 mile road route driving pattern is similar to LA-4 but with reduced idle time. 12.1 mile road route has 3 miles of low speed start/stop driving added to 8.9 mile road route. FTP at 23 minutes is at the end of bag 2 and start of the 10 minute soak. Typically driving times were 25 minutes for the 8.9 mile route and 34 minutes for the 12.1 mile route.

APPENDIX I-2
1983 Buick Skylark
2.8 Liter V-6

Commercial Unleaded
Internal Fuel Tank Temperatures During FTP

| Test No. and Fan Position | DIURNAL Start | DIURNAL End | DIURNAL WT | FTP Start | FTP 23 Min | FTP End | FTP WT | HOT SOAK Start | HOT SOAK End |
|---|---|---|---|---|---|---|---|---|---|
| 86-1520 Std. Position | 58.0 | 84.0 | 26.0 | -- | -- | -- | -- | 101.0 | 96.5 |
| 86-1531 FTP Emissions | 59.0 | 86.5 | 27.5 | 86.0 | 95.0 | 101.0 | 14.0 | 102.0 | 97.5 |
| 86-1579 Fan to Floor | 59.0 | 86.0 | 27.0 | 86.0 | 93.0 | 97.0 | 11.0 | 98.0 | 93.0 |
| 86-1612 Std. Position | -- | 85.0 | -- | 84.0 | 93.0 | 100.5 | 16.5 | 102.5 | 97.5 |
| 86-1817 Aux. Fan | 60.0 | 87.0 | 27.0 | 88.5 | 89.0 | 91.5 | 6.5 | 91.0 | 89.0 |
| 86.1818 Std. Position | -- | -- | -- | 87.5 | 96.0 | 101.5 | 14.0 | 101.5 | 97.0 |

| Date | Test No. | gm/mi HC | gm/mi CO | gm/mi NOx | MPG | Evaporative Grams Diurnal | Evaporative Grams Hot Soak | Evaporative Grams Total |
|---|---|---|---|---|---|---|---|---|
| 1-23-86 | 86-1520 | .21 | 3.30 | .59 | 21.1 | 4.93 | 10.85 | 15.78 |
| Fan Standard Position | | | | | | | | |
| 1-24-86 | 86-1531 | .20 | 2.95 | .62 | 21.3 | 5.02 | 10.43 | 15.46 |
| Fan Standard Position | | | | | | | | |
| 1-28-86 | 86-1579 | .22 | 3.74 | .60 | 21.6 | 5.03 | 4.80 | 9.83 |
| Fan at Floor | | | | | | | | |
| 1-29-86 | 86-1612 | .20 | 3.50 | .53 | 22.1 | 5.91 | 12.72 | 18.63 |
| Fan Standard Position, metal drain fittings | | | | | | | | |
| 2-14-86 | 86-1817 | .16 | 1.86 | .53 | 21.6 | 6.69 | .96 | 7.65 |
| Auxiliary Cooling Fans | | | | | | | | |
| 2-19-86 | 86-1818 | .24 | 5.98 | .61 | 21.3 | 5.69 | 14.22 | 19.91 |
| Fan Standard Position | | | | | | | | |

Fuel Temperatures on Road During Summer

| Trip | Ambient | Start | End | Fuel Level at End |
|---|---|---|---|---|
| 7:00 am 12.1 miles | 63°F | 61°F | 82°F | 44% |
| 4:00 pm 8.9 miles | 78°F | 80°F | 92°F | 41% |
| 5:00 pm 8.9 miles | 75°F | 87°F | 99°F | 38% |

Notes: All notes for Reliant also apply to Skylark.

APPENDIX H-1
1983 Plymouth Reliant
2.2 Liter Inline 4-cylinder

| Date | Trip # | % Full | Ambient °F | Fuel Temp °F Initial | Fuel Temp °F Final | Carb Bowl Temp °F Initial | Carb Bowl Temp °F Final | Carb Bowl Temp °F Post Test Peak |
|---|---|---|---|---|---|---|---|---|
| 07-24 | 1 | 96% | -- | -- | | -- | -- | -- |
| 07-24 | 2 | 93% | 89 | 85 | | 92 | 107 | -- |
| 07-24 | 3 | 91% | 89 | 95 | | 153 | 111 | 174 |
| 07-25 | 1 | 87% | 74 | 75 | | 74 | 107 | 156 |
| 07-25 | 2 | 84% | 91 | 90 | | 91 | 105 | 162 |
| 07-25 | 3 | 81% | 91 | 97 | | 162 | 110 | 157 |
| 07-26 | 1 | 77% | 66 | 71 | | 72 | 94 | 149 |
| 07-26 | 2 | 74% | 81 | 81 | | 87 | 108 | 157 |
| 07-26 | 3 | 72% | 81 | 90 | | 157 | 100 | 156 |
| 07-30 | 1 | 68% | -- | -- | -- | -- | -- | -- |
| 07-30 | 2 | 61% | 77 | 77 | 89 | 80 | 96 | 148° |
| 07-30 | 3 | 58% | 75 | 86 | 93 | 148 | 97 | 148° |
| 07-31 | 1 | 54% | 66 | 66 | 84 | 66 | 84 | 154° |
| 07-31 | 2 | 51% | 65 | 67 | 77 | 72 | 85 | 143° |
| 07-31 | 3 | 48% | 66 | 74 | 80 | 143 | 84 | 141° |
| 08-01 | 1 | 45% | 60 | 61 | 77 | 62 | 83 | 128° |
| 08-01 | 2 | 42% | 79 | 82 | 98 | 85 | 100 | 151° |
| 08-01 | 3 | 39% | 80 | 91 | 101 | 150 | 100 | 156° |
| 08-02 | 1 | 35% | 59 | 59 | 78 | 60 | 82 | 145° |
| 08-02 | 2 | 32% | 81 | 79 | 99 | 83 | 100 | 155° |
| 08-02 | 3 | 30% | 80 | 92 | 101 | 143 | 99 | 157° |
| 08-06 0 | 1 | 21% | 65 | 67 | 84 | 68 | 87 | 148° |

NOTE:

% full is at end of trip. Ambient measured at vehicle.

TRIP # 1 Morning 7:00 am 12.1 miles
2 Afternoon 4:00 pm 8.9 miles
3 Afternoon 5:00 pm 8.9 miles

APPENDIX H-2
On-Road Fuel Temperatures
EPA Weathering Study

1983 Buick Skylark
2.8 Liter V-6

| Date | Trip # | % Full | Ambient °F | Fuel Temp °F | | Carb Bowl Temp °F | | Post Test |
|---|---|---|---|---|---|---|---|---|
| | | | | Initial | Final | Initial | Final | Peak |
| 7-24 | 1 | 96% | -- | -- | | | | |
| 7-24 | 2 | 92% | 90 | 85 | | | | |
| 7-24 | 3 | 89% | 89 | 95 | | | | |
| 7-25 | 1 | 85% | 79 | 76 | | | | |
| 7-25 | 2 | 82% | 93 | 90 | | | | |
| 7-25 | 3 | 78% | 95 | 100 | | | | |
| 7-26 | 1 | 74% | 68 | 68 | | | | |
| 7-26 | 2 | 71% | 75 | 72 | | | | |
| 7-26 | 3 | 68% | 73 | 77 | | | | |
| 07-30 | 1 | 63% | 60 | 65 | 75 | 70 | 112 | 154 |
| 07-30 | 2 | 56% | 70 | 70 | 80 | 80 | 109 | 155 |
| 07-30 | 3 | 53% | 70 | 80 | 86 | 150 | 114 | 160 |
| 07-31 | 1 | 49% | -- | -- | -- | --- | --- | --- |
| 08-01 | 1 | 44% | 63 | 61 | 82 | 70 | 112 | 162 |
| 08-01 | 2 | 41% | 78 | 80 | 92 | 92 | 120 | 163 |
| 08-01 | 3 | 38% | 75 | 87 | 99 | 162 | 125 | 173 |
| 08-02 | 1 | 33% | 67 | 60 | 80 | 65 | 120 | 162 |
| 08-02 | 2 | 26% | 80 | 81 | 100 | 96 | 123 | 172 |
| 08-02 | 3 | 23% | 80 | 91 | 106 | 172 | 130 | 176 |
| 08-06 | 1 | 18% | 70 | 70 | | | | |
| 08-07 | 1 | 14% | 70 | 70 | | | | |

NOTE:
% full is at end of trip. Ambient measured at vehicle.
TRIP # 1 Morning 7:00 am 12.1 miles
2 Afternoon 4:00 pm 8.9 miles
3 Afternoon 5:00 pm 8.9 miles