EPA-AA-EVRB-94-01

TECHNICAL REPORT

EXHAUST EMISSION TESTING OF TWO ETHANOL VARIABLE FUELED 1992 CHEVROLET LUMINAS TEST RESULTS - 1993

by

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U.S. Environmental Protection Agency

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1. Abstract

This report presents exhaust emission test results for two 1992 low-mileage Chevrolet Lumina ethanol variable fuel vehicles. These vehicles were tested on both Indolene and E85 fuel using the Federal Test Procedure (FTP) for exhaust emissions. In the future, the EPA will retest the Luminas at future mileage accumulations of 20,000, 50,000, and possibly 100,000. At these future mileage accumulations, the vehicles will also be tested using intermediate fuel blends for both exhaust and evaporative emissions.

When operating on 85% ethanol, the Luminas showed reductions in NMHC, CO, CO_2, and NOx with penalties in alcohol and aldehyde emissions and fuel economy (per volume of fuel) when compared to operation on Indolene. The decrease in NOx may have been because these vehicles are designed for optimum operation when ethanol is blended into the fuel or may have been because of the lower heat content of ethanol. Both vehicles saw a volumetric fuel economy penalty of 30% but saw a slight increase in energy based fuel economy when operated on 85% ethanol as compared to Indolene.

Both Luminas met, with substantial margins, Tier 1 emission standards when operating on Indolene. When operating on 85% ethanol, the CO and NOx emissions from both vehicles dropped below the pending Tier 2 standards. In addition, the ethanol fueled vehicles showed similar ratios of HC, CO, and NOx results for Indolene and 85% ethanol as two methanol fueled 1992 Luminas which were tested by General Motors on Indolene and 85% methanol.

2. Introduction

Much work has been done on methanol-powered vehicle emissions, but little is known about the emissions from vehicles fueled by ethanol/gasoline blends above 10% ethanol. The Illinois Department of Natural Resources (IDNR) currently has 12 variable-fueled vehicles in a test fleet. These vehicles are designed to operate on ethanol/gasoline blends ranging from 0% to 85% ethanol (noted as E0 and E85 in this report). Through cooperation with IDNR, EPA will evaluate two of these vehicles on various fuel blends for exhaust and evaporative emissions at three or four mileage accumulations (approximately 4,000, 20,000, 50,000, and possibly 100,000 miles). These two vehicles will also be tested for the IDNR at AutoResearch Laboratories, Inc., (ALI) for exhaust and evaporative emissions at 10,000 mile intervals. This report discusses the emission results at the first of these mileage accumulations.

Test results for two 1992 Chevrolet Lumina ethanol variable fuel vehicles are presented in this report. These vehicles were tested on both E0 and E85 fuel using the FTP for exhaust emissions. Further emission testing at intermediate blends and for evaporative emissions was omitted from this testing due to EPA facility construction. When these vehicles return for future testing, they will also be tested using intermediate fuel blends for both exhaust and evaporative emissions.

3. Vehicles

Both of the variable fuel Luminas were supplied by General Motors (GM) to the IDNR and EPA. The two vehicles will be referred to as Lumina #10 and Lumina #12 in this report. Lumina #10 had an odometer reading of 5100 miles and Lumina #12 had an odometer reading of 4400 miles at the completion of this segment of the testing. Each vehicle has a fuel sensor which allows the vehicle, combined with feedback from the oxygen sensor, to match the fuel/air ratio to the blend of the fuel. These vehicles are optimized for performance and emissions on E85. The catalysts used on these vehicles are designed to be better able to reduce alcohol and aldehyde emissions than those used on Luminas which are intended for use on gasoline only. The following table summarizes the specifications of the Luminas:

Table 3.1: Vehicle Specifications

Manufacturer	Chevrolet/General Motors
Vehicle Name	1992 Lumina
Variable Fuel Capability	0%-85% Ethanol
Lumina #10 Vehicle ID Number	2G1WL54T4N9240855
Lumina #12 Vehicle ID Number	2G1WL54TXN9241086
Engine Family	N1G3.148NVB7
Emission Family	NFO-1A
Engine Displacement	3.1 Liters
Cylinder Configuration	V-6
Fuel System	Multiport Fuel Injection
Emission Control Technology	Exhaust Gas Recirculation
	Three Way Catalyst
	Oxygen Sensor

4. Fuels

For this segment of the test program, the Luminas were only emission tested using Indolene (E0) and an 85% ethanol blend (E85). In the future, intermediate blends will be tested as well. A specifications sheet for E85 is in the Appendix. The fuel properties which were necessary for the emissions calculations are presented in the following table:

Table 4.1: Fuel Properties

Fuel Property	Indolene	85% Ethanol Blend
carbon weight fraction	0.867	0.560
specific gravity	0.7432	0.769
hydrogen to carbon ratio	1.828	2.867
oxygen to carbon ratio	--	0.410
density (lbs/gallon)	6.196	6.418

5. Test Procedure

Both of the Luminas were set-up and tested in the EPA National Vehicle and Fuel Emissions Laboratory (NVFEL) by the Vehicle Testing group. Following the vehicle preconditioning, two FTP transient tests were run for each fuel on both vehicles. In one case (Lumina #10, E85), a third transient test was run due to a 15% inconsistency between the hydrocarbon results of the first two tests. A test sequence consisted of one cold start "transient" phase (bag 1), a cold start "stabilized" phase (bag 2), and a hot start "transient" phase (bag 3). All gaseous (HC, NMHC, CO, CO_2 and NOx) emissions were collected for each test. The composite results from each test were determined from all three bags. The FTP transient tests were performed following procedures given in CFR 40 Part 86 Subpart B for light-duty vehicles (with appropriate modifications for ethanol in the calculations as shown below).

A flow chart of the test procedures is presented in Appendix A. In the interest of reproducible testing, all heat builds were included even though no evaporative emission measurements could be made at this time.

Equations for organic material hydrocarbon equivalent (OMHCE) and organic material non-methane hydrocarbon equivalent (OMNMHCE) factors for methanol-fueled vehicles are presented in CFR 40 Part 86 Subpart B. In order to modify the OMHCE equation for ethanol-fueled vehicles, terms were added for ethanol and acetaldehyde. The purpose of this equation is to add the hydrocarbon portion of the alcohol and aldehyde exhaust emissions to the total hydrocarbon exhaust emissions using the molecular weight per carbon atom of these fuels as compared to gasoline. OMHCE and OMNMHCE were calculated from the following equations:

$$OMHCE = HC + 13.876x\left(\frac{METHANOL}{32.042} + \frac{ETHANOL}{23.034} + \frac{FORMALDEHYDE}{30.026} + \frac{ACETALDEHYDE}{22.026}\right)$$

$$OMNMHCE = OMHCE + NMHC - HC$$

where all units are in grams per mile (g/mi).

A rule has been proposed in the Federal Register under the title of Fuel Economy Test Procedures: Alternative-Fueled Automobile CAFE Incentives and Fuel Economy Labeling Requirements (56FR8856, 3/1/91). The following equation for fuel economy was developed from this proposal by adding terms for ethanol and acetaldehyde:

fuel economy (mpg) =

$$\frac{CWF x SG x 3784}{(HCCWF x HC) + (0.429 x CO) + (0.273 x CO_2) + (0.375 x CH_3OH) + (0.521 x CH_2CH_3OH) + (0.400 x CH_2O) + (0.545 x C_2H_4O)}$$

where:

CWF = carbon weight fraction
SG = specific gravity
HCCWF = carbon weight fraction of HC portion of fuel
and emissions are expressed in g/mi.

6. Indolene Testing/Results

Emission testing with Indolene began with the vehicle preconditioning sequence described in the Appendix. Two Federal certification test sequences were run on each of the Luminas. Although evaporative emissions data were not collected, the diurnal loading was left in the sequence so that the tests will be reproducible when both exhaust and evaporative emissions are collected. Exhaust emissions and fuel economy (FE) results are presented in Tables 6.1 and 6.2 for Lumina #10 and in Tables 6.3 and 6.4 for Lumina #12.

The tests from the Lumina #10 resulted in average emissions of 0.133 g/mi NMHC, 1.69 g/mi CO, and 0.196 g/mi NOx while the Lumina #12 showed average emissions of 0.127 g/mi NMHC, 1.39 g/mi CO, and 0.179 g/mi NOx. Both vehicles had similar fuel economies of 18.7 and 18.6 miles per gallon (mpg) for Luminas #10 and #12 respectively. No methanol (CH_3OH) emissions were expected from either of these vehicles; however, some methanol was detected in the first bag of the first indolene test on the Lumina #10. This emission measurement may have been due to hang-up in the vehicle fuel system or emissions measurement system. No ethanol (CH_2CH_3OH) was detected from either vehicle. Finally, 4.0 mg/mi and 3.3 mg/mi formaldehyde (CH_2O) and 1.5 mg/mi and 1.2 mg/mi acetaldehyde (C_2H_4O) were measured for the Lumina #10 and #12 vehicles, respectively.

Other than for CO_2 and ethanol, the Lumina #12 vehicle had generally lower emissions than the Lumina #10 vehicle even though both vehicles had essentially the same fuel economy results. The Lumina #12 results were lower by 6% for NMHC, 18% for CO, 9% for NOx, and about 17% for aldehydes than the Lumina #10 results. This was probably due to manufacturer tolerances and measurement accuracy.

Table 6.1: Lumina #10--Indolene Test #1

	HC (g/mi)	NMHC (g/mi)	CO (g/mi)	CO_2 (g/mi)	NOx (g/mi)	FE (mpg)
Bag 1	0.637	0.598	4.25	466	0.446	18.8
Bag 2	0.029	0.009	0.97	507	0.107	17.6
Bag 3	0.057	0.035	1.08	412	0.151	21.6
Composite	**0.163**	**0.138**	**1.68**	**472**	**0.189**	**18.8**

	OMHCE (g/mi)	OMNMHCE (g/mi)	CH_3OH (g/mi)	CH_2CH_3OH (g/mi)	CH_2O (g/mi)	C_2H_4O (g/mi)
Bag 1	0.652	0.613	0.010	0.000	0.015	0.006
Bag 2	0.030	0.011	0.000	0.000	0.002	0.001
Bag 3	0.057	0.036	0.000	0.000	0.001	0.000
Composite	**0.167**	**0.142**	**0.0021**	**0.000**	**0.0041**	**0.0017**

Table 6.2: Lumina #10--Indolene Test #2

	HC (g/mi)	NMHC (g/mi)	CO (g/mi)	CO_2 (g/mi)	NOx (g/mi)	FE (mpg)
Bag 1	0.587	0.549	3.27	466	0.516	18.9
Bag 2	0.043	0.014	1.41	507	0.090	17.5
Bag 3	0.048	0.027	1.02	409	0.179	21.7
Composite	**0.159**	**0.128**	**1.69**	**472**	**0.202**	**18.8**

	OMHCE (g/mi)	OMNMHCE (g/mi)	CH_3OH (g/mi)	CH_2CH_3OH (g/mi)	CH_2O (g/mi)	C_2H_4O (g/mi)
Bag 1	0.597	0.559	0.000	0.000	0.014	0.005
Bag 2	0.044	0.015	0.000	0.000	0.002	0.001
Bag 3	0.048	0.027	0.000	0.000	0.000	0.000
Composite	**0.160**	**0.131**	**0.000**	**0.000**	**0.0039**	**0.0013**

Table 6.3: Lumina #12--Indolene Test #1

	HC (g/mi)	NMHC (g/mi)	CO (g/mi)	CO_2 (g/mi)	NOx (g/mi)	FE (mpg)
Bag 1	0.478	0.447	2.36	467	0.526	18.9
Bag 2	0.040	0.016	0.89	514	0.064	17.3
Bag 3	0.060	0.035	0.93	412	0.107	21.6
Composite	**0.136**	**0.111**	**1.20**	**476**	**0.172**	**18.7**

	OMHCE (g/mi)	OMNMHCE (g/mi)	CH_3OH (g/mi)	CH_2CH_3OH (g/mi)	CH_2O (g/mi)	C_2H_4O (g/mi)
Bag 1	0.487	0.455	0.000	0.000	0.012	0.005
Bag 2	0.041	0.017	0.000	0.000	0.002	0.000
Bag 3	0.060	0.036	0.000	0.000	0.000	0.000
Composite	**0.139**	**0.113**	**0.000**	**0.000**	**0.0035**	**0.0013**

Table 6.4: Lumina #12--Indolene Test #2

	HC (g/mi)	NMHC (g/mi)	CO (g/mi)	CO_2 (g/mi)	NOx (g/mi)	FE (mpg)
Bag 1	0.572	0.537	3.46	465	0.492	18.9
Bag 2	0.067	0.041	1.15	511	0.116	17.4
Bag 3	0.048	0.025	0.91	410	0.083	21.7
Composite	**0.166**	**0.139**	**1.56**	**474**	**0.185**	**18.7**

	OMHCE (g/mi)	OMNMHCE (g/mi)	CH_3OH (g/mi)	CH_2CH_3OH (g/mi)	CH_2O (g/mi)	C_2H_4O (g/mi)
Bag 1	0.579	0.544	0.000	0.000	0.009	0.005
Bag 2	0.069	0.042	0.000	0.000	0.002	0.000
Bag 3	0.048	0.026	0.000	0.000	0.000	0.000
Composite	**0.169**	**0.142**	**0.000**	**0.000**	**0.0032**	**0.0012**

7. 85% Ethanol Testing Results

Once the Indolene tests were complete, both vehicles were preconditioned on E85 in order to clear the vehicle fuel system and the emission measurement system of E0 fuel. The emission testing was completed in the same manner described in Section 6 for the Indolene tests. Exhaust emissions and fuel economy results are presented in Tables 7.1 to 7.3 for the Lumina #10 and in Tables 7.4 and 7.5 for the Lumina #12.

Test results for E85 fuel from the Lumina #10 vehicle show emission levels of 0.110 g/mi OMNMHCE, 1.04 g/mi CO, and 0.128 g/mi NOx, while tests from the Lumina #12 vehicle show levels of 0.112 g/mi OMNMHCE, 0.61 g/mi CO, and 0.151 g/mi NOx. Both vehicles had essentially the same fuel economy (13.6 mpg for Lumina #10 and 13.5 for Lumina #12). Alcohol and aldehyde results were 4.93 mg/mi CH_3OH, 80.9 mg/mi CH_2CH_3OH, 8.29 mg/mi CH_2O, and 26.1 mg/mi C_2H_4O for Lumina #10 and 5.53 mg/mi CH_3OH, 79.5 mg/mi CH_2CH_3OH, 9.43 mg/mi CH_2O, and 28.7 mg/mi C_2H_4O for Lumina #12.

The Lumina #12 had significantly lower CO and CH_2O and higher NOx, CH_3OH and C_2H_4O than the Lumina #10. Emission result differences for Lumina #12 compared to Lumina #10 were -41% CO, 18% NOx, 12% CH_3OH, -14% CH_2O, and 10% C_2H_4O. However, both vehicles had similar results for OMNMHCE, CO_2, ethanol, and fuel economy. Differences between the vehicle results may have been due to manufacturing tolerances and test variability.

When operated on E85, both vehicles showed decreases in CO, CO_2, and NOx with penalties in alcohol and aldehyde emissions as well as volumetric fuel economy as compared to Indolene. Emission reductions due to the E85 fuel for Lumina #10 were 17% NMHC, 38% CO, 8% CO_2, and 35% NOx. Emission reductions for Lumina #12 were 12% NMHC, 56% CO, 8% CO_2, and 16% NOx. (Note that NMHC was used for E0 and OMNMHCE was used for E85 in the NMHC reduction calculations). Increases of 110% formaldehyde and 1600% acetaldehyde for Lumina #10 and 180% formaldehyde and 2300% acetaldehyde for Lumina #12 were observed.

Both vehicles saw a volumetric fuel economy penalty of 30% when operated on E85 as compared to Indolene. In order to approximate the fuel economy on an energy equivalent basis, energy contents of 114,218 Btu/gal for Indolene, 106,500 Btu/gal for natural gasoline (used in E85) and 75,670 Btu/gal for ethanol were used (values supplied by GM). An energy content of 81,661 Btu/gal was calculated for E85 assuming 80.4% ethanol, 0.6% water, and 19% natural gasoline. Energy based fuel economy results are presented in Table 7.1. Both vehicles saw an energy based fuel economy increase of 2% when operated on E85.

Table 7.1: Energy Based Fuel Economy

Vehicle, Fuel	Fuel Economy miles/gallon	Energy Content Btu/gallon	Fuel Economy miles/Btu
Lumina #10, E0	18.8	114,218	1.65×10^{-4}
Lumina #12, E0	18.7	114,218	1.64×10^{-4}
Lumina #10, E85	13.7	81,661	1.68×10^{-4}
Lumina #12, E85	13.6	81,661	1.67×10^{-4}

With the addition of 85% ethanol, the decreases in HC, CO, and CO_2 were expected due to the added oxygen in the fuel. In addition, the alcohol and aldehyde increases are characteristic to adding alcohol to the combustion process. The decrease in NOx may be due to the Luminas being optimized for operation on ethanol blends while the previously tested vehicles mentioned in this paragraph were optimized using Indolene or may have been due to the lower heat content of ethanol.

Table 7.2: Lumina #10--E85 Test #1

	HC (g/mi)	NMHC (g/mi)	CO (g/mi)	CO_2 (g/mi)	NOx (g/mi)	FE (mpg)
Bag 1	0.227	0.169	2.63	438	0.352	13.5
Bag 2	0.034	0.003	0.34	462	0.070	12.9
Bag 3	0.065	0.017	0.91	377	0.088	15.8
Composite	**0.082**	**0.041**	**0.97**	**433**	**0.133**	**13.7**

	OMHCE (g/mi)	OMNMHCE (g/mi)	CH_3OH (g/mi)	CH_2CH_3OH (g/mi)	CH_2O (g/mi)	C_2H_4O (g/mi)
Bag 1	0.585	0.528	0.022	0.421	0.027	0.131
Bag 2	0.037	0.006	0.000	0.000	0.007	0.001
Bag 3	0.069	0.021	0.000	0.000	0.007	0.001
Composite	**0.159**	**0.118**	**0.0046**	**0.0872**	**0.0109**	**0.0276**

Table 7.3: Lumina #10--E85 Test #2

	HC (g/mi)	NMHC (g/mi)	CO (g/mi)	CO_2 (g/mi)	NOx (g/mi)	FE (mpg)
Bag 1	0.227	0.164	2.32	438	0.338	13.2
Bag 2	0.032	0.000	0.36	466	0.054	12.8
Bag 3	0.065	0.015	2.08	379	0.078	15.3
Composite	**0.081**	**0.037**	**1.24**	**436**	**0.120**	**13.6**

	OMHCE (g/mi)	OMNMHCE (g/mi)	CH_3OH (g/mi)	CH_2CH_3OH (g/mi)	CH_2O (g/mi)	C_2H_4O (g/mi)
Bag 1	0.540	0.478	0.024	0.359	0.025	0.120
Bag 2	0.034	0.000	0.000	0.000	0.004	0.001
Bag 3	0.065	0.016	0.000	0.000	0.001	0.001
Composite	**0.147**	**0.103**	**0.0050**	**0.0744**	**0.0072**	**0.0253**

Table 7.4: Lumina #10--E85 Test #3

	HC (g/mi)	NMHC (g/mi)	CO (g/mi)	CO_2 (g/mi)	NOx (g/mi)	FE (mpg)
Bag 1	0.221	0.163	2.18	433	0.355	13.6
Bag 2	0.042	0.003	0.50	460	0.060	13.0
Bag 3	0.065	0.017	0.70	378	0.095	15.7
Composite	**0.085**	**0.040**	**0.90**	**432**	**0.130**	**13.8**

	OMHCE (g/mi)	OMNMHCE (g/mi)	CH_3OH (g/mi)	CH_2CH_3OH (g/mi)	CH_2O (g/mi)	C_2H_4O (g/mi)
Bag 1	0.555	0.497	0.025	0.392	0.024	0.121
Bag 2	0.044	0.005	0.000	0.000	0.003	0.001
Bag 3	0.066	0.018	0.000	0.000	0.001	0.001
Composite	**0.156**	**0.110**	**0.0052**	**0.0812**	**0.0067**	**0.0255**

Table 7.5: Lumina #12--E85 Test #1

	HC (g/mi)	NMHC (g/mi)	CO (g/mi)	CO_2 (g/mi)	NOx (g/mi)	FE (mpg)
Bag 1	0.224	0.176	1.84	439	0.413	13.5
Bag 2	0.021	0.002	0.04	466	0.065	12.8
Bag 3	0.049	0.010	0.30	380	0.121	15.7
Composite	**0.071**	**0.040**	**0.49**	**437**	**0.153**	**13.6**

	OMHCE (g/mi)	OMNMHCE (g/mi)	CH_3OH (g/mi)	CH_2CH_3OH (g/mi)	CH_2O (g/mi)	C_2H_4O (g/mi)
Bag 1	0.565	0.517	0.030	0.379	0.031	0.136
Bag 2	0.024	0.006	0.000	0.000	0.007	0.001
Bag 3	0.051	0.012	0.000	0.000	0.003	0.000
Composite	**0.144**	**0.113**	**0.0062**	**0.0787**	**0.0106**	**0.0287**

Table 7.6: Lumina #12--E85 Test #2

	HC (g/mi)	NMHC (g/mi)	CO (g/mi)	CO_2 (g/mi)	NOx (g/mi)	FE (mpg)
Bag 1	0.222	0.170	1.73	443	0.389	13.4
Bag 2	0.032	0.000	0.30	463	0.071	12.8
Bag 3	0.070	0.014	0.80	382	0.116	15.6
Composite	**0.081**	**0.038**	**0.73**	**437**	**0.149**	**13.6**

	OMHCE (g/mi)	OMNMHCE (g/mi)	CH_3OH (g/mi)	CH_2CH_3OH (g/mi)	CH_2O (g/mi)	C_2H_4O (g/mi)
Bag 1	0.565	0.514	0.024	0.388	0.029	0.136
Bag 2	0.034	0.000	0.000	0.000	0.004	0.000
Bag 3	0.071	0.015	0.000	0.000	0.001	0.001
Composite	**0.154**	**0.110**	**0.0049**	**0.0803**	**0.0082**	**0.0287**

8. Comparison of Results With Federal Standards

Even when operating on Indolene, the Luminas meet Tier 1 standards. In addition, these vehicles have NOx levels near those specified in the Clean Air Act as the pending Tier 2 standards. When operated on 85% ethanol, OMNMHCE, CO and NOx are reduced, but the Lumina OMNMHCE levels do not meet the pending Tier 2 standards. Combined E0 and E85 results as well as Tier 1, pending Tier 2, LEV, and ULEV standards are presented in the following table:

Table 8.1: Ethanol Results and Federal Standards

Level	NMHC (g/mi)	CO (g/mi)	NOx (g/mi)
Combined Indolene Results*	0.168	1.94	0.21
Combined E85 Results*	0.144**	1.04	0.15
Tier 1 Standards (1994+)	0.25	3.4	0.4
Pending Tier 2 Standards (2004+)	0.125	1.7	0.2
Clean Fuel Fleet LEV (1998)	0.073	3.4	0.2
Clean Fuel Fleet ULEV (1998)	0.039	1.7	0.2

* 1992 Lumina (Indolene) deterioration factors applied: (HC = 1.300, CO = 1.262, and NOx = 1.100 for 50,000 miles)

** OMNMHCE

9. Comparison of Results With Methanol-Fueled Luminas

General Motors supplied exhaust emission data for two 1992 Chevrolet Lumina variable fuel vehicles which were aged to 5500 and 4000 miles and were tested on methanol as a part of the California Light-Duty Methanol Fuel Flexible Vehicle Demonstration Program[1,2]. These data are presented in Table 9.1. These vehicles showed reductions of 31% HC, 39% CO, and 10% NOx using M85 over Indolene. The E85-Luminas tested at EPA saw reductions of 50% HC, 46% CO, and 26% NOx using E85 over Indolene. No formaldehyde data were supplied for the M85-Luminas when operated on Indolene.

This data seems to indicate that ethanol and methanol are both effective at reducing HC, CO, NOx emissions with some penalty in formaldehyde emissions. However, even though all four vehicles were the same basic models, the E85 pair and the M85 pair have different emissions performance when operated on Indolene. Therefore, it may be inappropriate to draw conclusions from this data on the comparative effects of ethanol and methanol on exhaust emissions.

Table 9.1: E85 and M85 Emission Results

Level	HC (g/mi)	CO (g/mi)	NOx (g/mi)	CH_2O (g/mi)
Ethanol Lumina E0 Results	0.16	1.53	0.19	--
Ethanol Lumina E85 Results	0.08	0.83	0.14	0.009
Methanol Lumina M0 Results	0.13	2.21	0.21	--
Methanol Lumina M85 Results	0.09	1.34	0.19	0.012

[1] Memo from Samuel A. Leonard, Director of Automotive Emission Control (GM) to K. D. Drachand, Chief of Mobile Source Division (CARB), February 28, 1992.

[2] Memo from Samuel A. Leonard, Director of Automotive Emission Control (GM) to K. D. Drachand, Chief of Mobile Source Division (CARB), November 12, 1992.

10. Analysis and Conclusions

Tailpipe emission data were collected from two 1992 Chevrolet Lumina ethanol variable fueled vehicles operating on both Indolene and an 85% ethanol blend. The vehicles are referred to as Lumina #10 and Lumina #12 where Lumina #10 was at 5100 miles and Lumina #12 was at 4400 miles at the completion of this segment of testing. Further segments of testing at 30,000, 50,000, and possibly 100,000 miles will include evaporative emission testing as well as a more extensive look at the effects of the amount of ethanol in the fuel.

When operating on Indolene, Lumina #12 seemed to operate "cleaner" than Lumina #10. Lumina #12 showed 6% lower NMHC, 18% lower CO, 9% lower NOx, and nearly 20% lower aldehydes. When operating on 85% ethanol, Lumina #12 had 41% lower CO and 14% lower formaldehyde than Lumina #10; however, NOx, methanol, and acetaldehyde were higher by 18%, 12%, and 10% respectively. These differences were probably due to manufacturer tolerances as well as test variability. Indolene and E85 results are presented in Table 10.1.

Table 10.1: Lumina Exhaust Emission Tests

Vehicle & Fuel	HC (g/mi)	NMHC (g/mi)	CO (g/mi)	CO_2 (g/mi)	NOx (g/mi)	FE (mpg)
#10 E0	0.165	0.133	1.69	472	0.196	18.8
#12 E0	0.151	0.125	1.38	475	0.179	18.7
#10 E85	0.083	0.039	1.04	434	0.128	13.7
#12 E85	0.076	0.039	0.61	437	0.151	13.6

Vehicle & Fuel	OMHCE (g/mi)	OMNMHCE (g/mi)	CH_3OH (g/mi)	CH_2CH_3OH (g/mi)	CH_2O (g/mi)	C_2H_4O (g/mi)
#10 E0	0.164	0.137	0.0011	0.000	0.0040	0.0015
#12 E0	0.154	0.128	0.000	0.000	0.0033	0.0012
#10 E85	0.154	0.110	0.0049	0.0809	0.0083	0.0261
#12 E85	0.149	0.112	0.0055	0.0795	0.0094	0.0287

The use of E85 showed reductions in CO, CO_2, and NOx with penalties in alcohol and aldehyde emissions and fuel economy. Lumina #12 showed much larger reductions in CO and NOx and larger increases in formaldehyde and acetaldehyde than Lumina #10; however, the emission trends were the same for both vehicles. The decrease in NOx may have been because these vehicles were designed

for optimum operation on ethanol blends or may gave been due to the lower heat content of ethanol. These effects of E85 on the Luminas are presented in Table 10.2.

Table 10.2: Effects of E85 on Emissions Compared to E0

Vehicle	NMHC*	CO	CO_2	NOx	CH_2O	C_2H_4O
Lumina #10	-17%	-38%	-8%	-35%	110%	1600%
Lumina #12	-10%	-56%	-8%	-16%	180%	2300%

* Calculated: 100 X ($NMHC_{E0}$ - $OMNMHCE_{E85}$) / $NMHC_{E0}$

Both Luminas are capable of meeting Tier 1 emission standards when operating on Indolene. When operating on 85% ethanol, CO and NOx are reduced below the pending Tier 2 standards. In addition, the ethanol fueled vehicles showed similar ratios of HC, CO, and NOx results for Indolene and 85% ethanol as two methanol fueled 1992 Luminas which were tested by General Motors on Indolene and 85% methanol.

Appendices

A. Test Sequence

B. Indolene Exhaust Emission Test Results

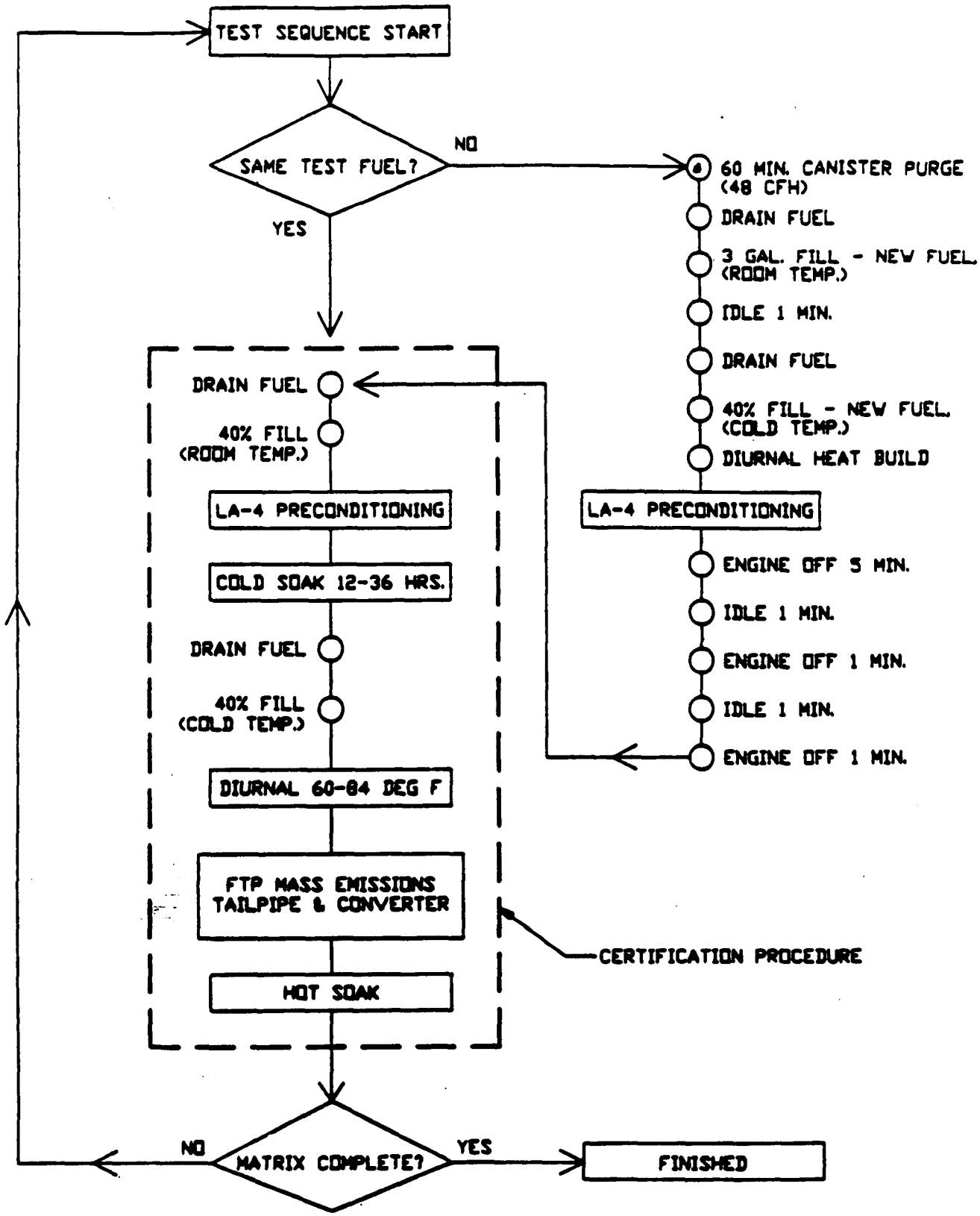
C. 85% Ethanol Exhaust Emission Test Results

D. OMHCE and OMNMHCE Results

E. Fuel Economy Results

F. Fuel Specifications for E85

A. Test Sequence



Dyno: D209 Test No: 93-1182

VEHICLE CHASSIS DYNAMOMETER TEST ANALYSIS
Emission, Mass, and Fuel Economy Determination
MFR: 040 Veh ID: ETHNL-10 Ver: 00

Processed: 07/28/93 08:47

Dyno/CVS	VMIX	Roll Revs	Miles	F.E. HC CWF	SPGRAV F	Density effic	Gas Dil Fact	CxHyOz	DF Numer	DF Denom	FFV Dil Fac	Correct
Bag 1	5002	8363	3.587	0.867	0.7432	6.202049256	19.437	1	13.5275529	0.6894692	19.620	0.9485510
Bag 2	8594	8991	3.856	Exhaust CWF			28.277	1.828		0.4738957	28.545	0.9646350
Bag 3	5011	8365	3.588	0.867			22.132	0		0.6054563	22.343	0.9548169

Corrected Concentrations			FID HC ppmC	HC ppmC	NMHC ppmC	CH3OH ppmC	CH2CH3OH ppmC	CH2O ppmC	C2H4O ppmC	CO ppm	CO2 pct	NOx ppm
Bag 1			28.127	27.986	26.2600	0.1925	0.0000	0.2962	0.1620	92.425	0.645	6.654
Bag 2			0.801	0.801	0.2566	0.0000	0.0000	0.0223	0.0115	13.107	0.439	1.001
Bag 3			2.481	2.481	1.5416	0.0000	0.0000	0.0103	0.0105	23.506	0.570	2.253

Mass Emissions	OMHCE grams	OMNMHCE grams	FID HC grams	HC grams	NMHC grams	CH3OH grams	CH2CH3OH grams	CH2O grams	C2H4O grams	CO grams	CO2 grams	NOx grams
Bag 1	2.339	2.198	2.297	2.286	2.145	0.036	0.000	0.052	0.021	15.242	1672.065	1.599
Bag 2	0.117	0.041	0.112	0.112	0.036	0.000	0.000	0.007	0.003	3.714	1954.230	0.413
Bag 3	0.205	0.128	0.203	0.203	0.126	0.000	0.000	0.002	0.001	3.883	1478.763	0.542

Mass Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
Bag 1	0.652	0.613	0.641	0.637	0.598	0.010	0.000	0.015	0.006	4.249	466.166	0.446
Bag 2	0.030	0.011	0.029	0.029	0.009	0.000	0.000	0.002	0.001	0.963	506.777	0.107
Bag 3	0.057	0.036	0.057	0.057	0.035	0.000	0.000	0.001	0.000	1.082	412.175	0.151

Composite Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
UNWEIGHTED UNR	0.24123	0.21456	0.23687	0.23583	0.20916	0.00329	0.00000	0.0055295	0.0022610	2.07053	462.80	0.23159
WEIGHTED UNR	0.16655	0.14226	0.16337	0.16271	0.13842	0.00210	0.00000	0.0040776	0.0016625	1.67687	472.37	0.18944
UNWEIGHTED ROU	0.241	0.215	0.237	0.236	0.209	0.003	0.000	0.00553	0.00226	2.071	463.	0.232
WEIGHTED ROU	0.167	0.142	0.163	0.163	0.138	0.002	0.000	0.00408	0.00166	1.677	472.	0.189

Fuel Economy	Numerator	Denominator		Weighted MPG	Bag 1 MPG	Bag 2 MPG	Bag 3 MPG	Efficiency	
MY88 Gas FE	33338896.66	1782140.203		18.707	18.72	17.48	21.47	162.69	<---- MY88 FE Equation
Cert Meth FE	2438.881404	129.7200407	<-- FRM	18.801				163.51	<---- 1992 <---- The donom includes all C emissions
Ethanol FE 1	2421.336	129.7200407		18.666				162.33	<---- Old Cert Proposed Methanol FE adapted to Ethanol
Methanol FE 1	2421.336	129.7200407		18.666				162.33	<---- Old Cert Proposed Methanol FE
Meth&Eth FE	2421.336	129.7200407		18.666				162.33	<---- Old Cert Prpsd Meth FE adapted to Eth and/or Meth

B.1. Lumina #10--Indolene Test #1

Dyno: D209 Test No: 93-1183

VEHICLE CHASSIS DYNAMOMETER TEST ANALYSIS
Emission, Mass, and Fuel Economy Determination
MFR: 040 Veh ID: ETHNL-10 Ver: 00

Processed: 07/28/93 08:5

Dyno/CVS	VMIX	Roll Revs	Miles	F.E. HC CWF	SPGRAV F	Density effic	Gas Dil Fact	CxHyOz	DF Numer	DF Denom	FFV Dil Fac	Correct
Bag 1	4971	8380	3.594	0.867	0.7432	6.202049256	19.295	1	13.5275529	0.6945231	19.477	0.9481732
Bag 2	8528	9030	3.873	Exhaust CWF			27.819	1.828		0.4816811	28.084	0.9640539
Bag 3	4961	8375	3.592	0.867			21.987	0		0.6094562	22.196	0.9545183

Corrected Concentrations			FID HC ppmC	HC ppmC	NMHC ppmC	CH3OH ppmC	CH2CH3OH ppmC	CH2O ppmC	C2H4O ppmC	CO ppm	CO2 pct	NOx ppm
Bag 1			26.000	26.000	24.3004	0.0000	0.0000	0.2895	0.1447	71.653	0.650	7.809
Bag 2			1.187	1.187	0.3947	0.0000	0.0000	0.0226	0.0098	19.420	0.444	0.855
Bag 3			2.139	2.139	1.1778	0.0000	0.0000	0.0065	-0.0039	22.435	0.572	2.705

Mass Emissions	OMHCE grams	OMNMHCE grams	FID HC grams	HC grams	NMHC grams	CH3OH grams	CH2CH3OH grams	CH2O grams	C2H4O grams	CO grams	CO2 grams	NOx grams
Bag 1	2.146	2.008	2.111	2.111	1.973	0.000	0.000	0.051	0.019	11.744	1673.824	1.855
Bag 2	0.170	0.059	0.165	0.165	0.055	0.000	0.000	0.007	0.002	5.460	1962.699	0.348
Bag 3	0.173	0.096	0.173	0.173	0.095	0.000	0.000	0.001	-0.001	3.670	1470.140	0.641

Mass Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
Bag 1	0.597	0.559	0.587	0.587	0.549	0.000	0.000	0.014	0.005	3.267	465.709	0.516
Bag 2	0.044	0.015	0.043	0.043	0.014	0.000	0.000	0.002	0.001	1.410	506.775	0.090
Bag 3	0.048	0.027	0.048	0.048	0.027	0.000	0.000	0.000	0.000	1.022	409.283	0.179

Composite Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
UNWEIGHTED UNR	0.22508	0.19559	0.22146	0.22146	0.19197	0.00000	0.00000	0.0053206	0.0018369	1.88744	461.76	0.25723
WEIGHTED UNR	0.15957	0.13090	0.15691	0.15691	0.12824	0.00000	0.00000	0.0039301	0.0013257	1.68782	471.54	0.20245
UNWEIGHTED ROU	0.225	0.196	0.221	0.221	0.192	0.000	0.000	0.00532	0.00184	1.887	462.	0.257
WEIGHTED ROU	0.160	0.131	0.157	0.157	0.128	0.000	0.000	0.00393	0.00133	1.688	472.	0.202

Fuel Economy	Numerator	Denominator		Weighted MPG	Bag 1 MPG	Bag 2 MPG	Bag 3 MPG	Efficiency	
MY88 Gas FE	33338896.66	1782119.969		18.707	18.80	17.46	21.63	162.69	<---- MY88 FE Equation
Cert Meth FE	2438.881404	129.7185679	<-- FRM	18.801				163.51	<---- 1992 <---- The donom includes all C emissions
Ethanol FE 1	2421.336	129.7185679		18.666				162.33	<---- Old Cert Proposed Methanol FE adapted to Ethanol
Methanol FE 1	2421.336	129.7185679		18.666				162.33	<---- Old Cert Proposed Methanol FE
Meth&Eth FE	2421.336	129.7185679		18.666				162.33	<---- Old Cert Prpsd Meth FE adapted to Eth and/or Meth

Dyno: D209 Test No: 93-1193

VEHICLE CHASSIS DYNAMOMETER TEST ANALYSIS
Emission, Mass, and Fuel Economy Determination
MFR: 040 Veh ID: ETHNL-12 Ver: 00

Processed: 07/28/93 09:04

Dyno/CVS	VMIX	Roll Revs	Miles	F.E. HC CWF	SPGRAV F	Density effic	Gas Dil Fact	CxHyOz	DF Numer	DF Denom	FFV Dil Fac	Correct
Bag 1	5011	8368	3.589	0.867	0.7432	6.202049256	19.543	1	13.5275529	0.6856944	19.728	0.9488316
Bag 2	8596	8982	3.852	Exhaust CWF			27.924	1.828		0.4798773	28.190	0.9641886
Bag 3	5006	8377	3.593	0.867			22.106	0		0.6061847	22.316	0.9547626

Corrected Concentrations			FID HC ppmC	HC ppmC	NMHC ppmC	CH3OH ppmC	CH2CH3OH ppmC	CH2O ppmC	C2H4O ppmC	CO ppm	CO2 pct	NOx ppm
Bag 1			20.978	20.978	19.5975	0.0000	0.0000	0.2433	0.1265	51.280	0.646	7.854
Bag 2			1.095	1.095	0.4470	0.0000	0.0000	0.0209	0.0073	12.038	0.445	0.601
Bag 3			2.633	2.633	1.5434	0.0000	0.0000	0.0090	0.0091	20.300	0.571	1.602

Mass Emissions	OMHCE grams	OMNMHCE grams	FID HC grams	HC grams	NMHC grams	CH3OH grams	CH2CH3OH grams	CH2O grams	C2H4O grams	CO grams	CO2 grams	NOx grams
Bag 1	1.747	1.634	1.717	1.717	1.604	0.000	0.000	0.043	0.016	8.472	1677.752	1.888
Bag 2	0.158	0.067	0.154	0.154	0.063	0.000	0.000	0.006	0.002	3.412	1981.678	0.248
Bag 3	0.217	0.128	0.215	0.215	0.126	0.000	0.000	0.002	0.001	3.351	1479.963	0.385

Mass Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
Bag 1	0.487	0.455	0.478	0.478	0.447	0.000	0.000	0.012	0.005	2.361	467.472	0.526
Bag 2	0.041	0.017	0.040	0.040	0.016	0.000	0.000	0.002	0.000	0.886	514.410	0.064
Bag 3	0.060	0.036	0.060	0.060	0.035	0.000	0.000	0.000	0.000	0.933	411.919	0.107

Composite Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
UNWEIGHTED UNR	0.19224	0.16569	0.18901	0.18901	0.16246	0.00000	0.00000	0.0046292	0.0017436	1.38064	465.77	0.22838
WEIGHTED UNR	0.13872	0.11315	0.13632	0.13632	0.11076	0.00000	0.00000	0.0034688	0.0012583	1.20441	476.48	0.17181
UNWEIGHTED ROU	0.192	0.166	0.189	0.189	0.162	0.000	0.000	0.00463	0.00174	1.381	466.	0.228
WEIGHTED ROU	0.139	0.113	0.136	0.136	0.111	0.000	0.000	0.00347	0.00126	1.204	476.	0.172

Fuel Economy	Numerator	Denominator		Weighted MPG	Bag 1 MPG	Bag 2 MPG	Bag 3 MPG	Efficiency	
MY88 Gas FE	33338896.66	1794016.491		18.583	18.80	17.23	21.49	161.61	<---- MY88 FE Equation
Cert Meth FE	2438.881404	130.5845027	<-- FRM	18.677				162.43	<---- 1992 <--- The donom includes all C emissions
Ethanol FE 1	2421.336	130.5845027		18.542				161.26	<---- Old Cert Proposed Methanol FE adapted to Ethanol
Methanol FE 1	2421.336	130.5845027		18.542				161.26	<---- Old Cert Proposed Methanol FE
Meth&Eth FE	2421.336	130.5845027		18.542				161.26	<---- Old Cert Prpsd Meth FE adapted to Eth and/or Meth

Dyno: D209 Test No: 93-1194

VEHICLE CHASSIS DYNAMOMETER TEST ANALYSIS
Emission, Mass, and Fuel Economy Determination
MFR: 040 Veh ID: ETHNL-12 Ver: 00

page 3/3
Processed: 07/28/93 09:07

Dyno/CVS	VMIX	Roll Revs	Miles	F.E. HC CWF	SPGRAV F	Density effic	Gas Dil Fact	CxHyOz	DF Numer	DF Denom	FFV Dil Fac	Correct
Bag 1	4963	8403	3.604	0.867	0.7432	6.202049256	19.286	1	13.5275529	0.6948408	19.469	0.9481487
Bag 2	8510	9030	3.873	Exhaust CWF			27.667	1.828		0.4843385	27.930	0.9638557
Bag 3	4954	8362	3.586	0.867			22.035	0		0.6081141	22.245	0.9546184

Corrected Concentrations			FID HC ppmC	HC ppmC	NMHC ppmC	CH3OH ppmC	CH2CH3OH ppmC	CH2O ppmC	C2H4O ppmC	CO ppm	CO2 pct	NOx ppm
Bag 1			25.416	25.416	23.8696	0.0000	0.0000	0.1903	0.1393	76.088	0.652	7.509
Bag 2			1.879	1.879	1.1374	0.0000	0.0000	0.0282	0.0079	15.825	0.449	1.105
Bag 3			2.113	2.113	1.1301	0.0000	0.0000	0.0091	-0.0041	19.909	0.573	1.256

Mass Emissions	OMHCE grams	OMNMHCE grams	FID HC grams	HC grams	NMHC grams	CH3OH grams	CH2CH3OH grams	CH2O grams	C2H4O grams	CO grams	CO2 grams	NOx grams
Bag 1	2.087	1.961	2.060	2.060	1.935	0.000	0.000	0.033	0.018	12.450	1675.584	1.774
Bag 2	0.266	0.163	0.261	0.261	0.158	0.000	0.000	0.008	0.002	4.440	1979.690	0.448
Bag 3	0.171	0.092	0.171	0.171	0.091	0.000	0.000	0.002	-0.001	3.252	1469.888	0.296

Mass Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
Bag 1	0.579	0.544	0.572	0.572	0.537	0.000	0.000	0.009	0.005	3.455	464.923	0.492
Bag 2	0.069	0.042	0.067	0.067	0.041	0.000	0.000	0.002	0.000	1.146	511.162	0.116
Bag 3	0.048	0.026	0.048	0.048	0.025	0.000	0.000	0.000	0.000	0.907	409.848	0.083

Composite Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
UNWEIGHTED UNR	0.22815	0.20032	0.22524	0.22524	0.19741	0.00000	0.00000	0.0039303	0.0017293	1.82063	463.26	0.22763
WEIGHTED UNR	0.16874	0.14165	0.16650	0.16650	0.13941	0.00000	0.00000	0.0031791	0.0012228	1.55915	473.81	0.18465
UNWEIGHTED ROU	0.228	0.200	0.225	0.225	0.197	0.000	0.000	0.00393	0.00173	1.821	463.	0.228
WEIGHTED ROU	0.169	0.142	0.166	0.166	0.139	0.000	0.000	0.00318	0.00122	1.559	474.	0.185

Fuel Economy	Numerator	Denominator		Weighted MPG	Bag 1 MPG	Bag 2 MPG	Bag 3 MPG	Efficiency	
MY88 Gas FE	33338896.66	1788963.072		18.636	18.83	17.32	21.61	162.07	<---- MY88 FE Equation
Cert Meth FE	2438.881404	130.2166699	<-- FRM	18.729				162.88	<---- 1992 <--- The donom includes all C emissions
Ethanol FE 1	2421.336	130.2166699		18.595				161.71	<---- Old Cert Proposed Methanol FE adapted to Ethanol
Methanol FE 1	2421.336	130.2166699		18.595				161.71	<---- Old Cert Proposed Methanol FE
Meth&Eth FE	2421.336	130.2166699		18.595				161.71	<---- Old Cert Prpsd Meth FE adapted to Eth and/or Meth

Dyno: D209 Test No: 93-1179

VEHICLE CHASSIS DYNAMOMETER TEST ANALYSIS
Emission, Mass, and Fuel Economy Determination
MFR: 040 Veh ID: ETHNL-10 Ver: 00

Processed: 07/28/93 08:26

Dyno/CVS	VMIX	Roll Revs	Miles	F.E. HC CWF	SPGRAV F	Density effic	Gas Dil Fact	CxHyOz	DF Numer	DF Denom	FFV Dil Fac	Correct
Bag 1	*4972*	*8363*	3.587	0.527	0.76544	6.38764341	20.661	*1*	12.3187906	0.6493182	18.972	0.9472904
Bag 2	*8531*	*9011*	3.865	Exhaust CWF			30.673	*2.867*		0.4368808	28.197	0.9645354
Bag 3	*4954*	*8376*	3.592	*0.56*			23.844	*0.41*		0.5620027	21.919	0.9543784

Corrected Concentrations			FID HC ppmC	HC ppmC	NMHC ppmC	CH3OH ppmC	CH2CH3OH ppmC	CH2O ppmC	C2H4O ppmC	CO ppm	CO2 pct	NOx ppm
Bag 1			18.274	10.010	7.4851	0.4272	11.2059	0.5427	3.6419	57.621	0.610	5.223
Bag 2			0.937	0.937	0.0709	0.0000	0.0000	0.0861	0.0093	4.716	0.404	0.654
Bag 3			2.904	2.904	0.7679	0.0000	0.0000	0.1453	0.0213	19.993	0.527	1.307

Mass Emissions	OMHCE grams	OMNMHCE grams	FID HC grams	HC grams	NMHC grams	CH3OH grams	CH2CH3OH grams	CH2O grams	C2H4O grams	CO grams	CO2 grams	NOx grams
Bag 1	2.097	1.892	1.484	0.813	0.608	0.080	1.511	0.095	0.470	9.446	1570.771	1.261
Bag 2	0.144	0.023	0.130	0.130	0.010	0.000	0.000	0.026	0.002	1.326	1784.089	0.271
Bag 3	0.248	0.076	0.235	0.235	0.062	0.000	0.000	0.025	0.003	3.265	1353.639	0.315

Mass Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
Bag 1	0.585	0.528	0.414	0.227	0.169	0.022	0.421	0.027	0.131	2.633	437.925	0.352
Bag 2	0.037	0.006	0.034	0.034	0.003	0.000	0.000	0.007	0.001	0.343	461.629	0.070
Bag 3	0.069	0.021	0.065	0.065	0.017	0.000	0.000	0.007	0.001	0.909	376.804	0.088

Composite Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
UNWEIGHTED UNR	0.22542	0.18028	0.16744	0.10668	0.06155	0.00725	0.13679	0.0132934	0.0429462	1.27105	426.34	0.16726
WEIGHTED UNR	0.15930	0.11808	0.12108	0.08236	0.04114	0.00462	0.08717	0.0109329	0.0275779	0.97259	433.43	0.13322
UNWEIGHTED ROU	0.225	0.180	0.167	0.107	0.062	0.007	0.137	0.01329	0.04295	1.271	426.	0.167
WEIGHTED ROU	0.159	0.118	0.121	0.082	0.041	0.005	0.087	0.01093	0.02758	0.973	433.	0.133

Fuel Economy	Numerator	Denominator		Weighted MPG	Bag 1 MPG	Bag 2 MPG	Bag 3 MPG	Efficiency	
MY88 Gas FE	21527979.2	1631013.782		13.199	12.60	12.10	14.78	172.2	<---- MY88 FE Equation
Cert Meth FE	1526.384762	118.7362238	<-- FRM	12.855				167.71	<---- 1992 <---- The donom includes all C emissions
Ethanol FE 1	1780.4088	118.7362238		14.995				195.62	<---- Old Cert Proposed Methanol FE adapted to Ethanol
Methanol FE 1	2421.336	118.7362238		20.393				266.04	<---- Old Cert Proposed Methanol FE
Meth&Eth FE	1780.4088	118.7362238		14.995				195.62	<---- Old Cert Prpsd Meth FE adapted to Eth and/or Meth

C.1. Lumina #10--85% Ethanol Test #1

Dyno: D209 Test No: 93-1180

VEHICLE CHASSIS DYNAMOMETER TEST ANALYSIS
Emission, Mass, and Fuel Economy Determination
MFR: 040 Veh ID: ETHNL-10 Ver: 00

Processed: 07/28/93 08:32

Dyno/CVS	VMIX	Roll Revs	Miles	F.E. HC CWF	SPGRAV F	Density effic	Gas Dil Fact	CxHyOz	DF Numer	DF Denom	FFV Dil Fac	Correct
Bag 1	*5033*	*8366*	3.588	0.527	0.76544	6.38764341	20.789	*1*	12.3187906	0.6452261	19.092	0.9476226
Bag 2	*8633*	*8996*	3.858	Exhaust CWF			30.602	*2.867*		0.4378901	28.132	0.9644535
Bag 3	*5021*	*8373*	3.591	*0.56*			23.824	*0.41*		0.5624722	21.901	0.9543403

Corrected Concentrations			FID HC ppmC	HC ppmC	NMHC ppmC	CH3OH ppmC	CH2CH3OH ppmC	CH2O ppmC	C2H4O ppmC	CO ppm	CO2 pct	NOx ppm
Bag 1			16.917	9.889	7.1638	0.4551	9.4393	0.4977	3.3009	50.062	0.602	4.967
Bag 2			0.865	0.865	-0.0519	0.0000	0.0000	0.0445	0.0094	4.817	0.402	0.502
Bag 3			2.832	2.832	0.6672	0.0000	0.0000	0.0211	0.0154	45.139	0.523	1.155

Mass Emissions	OMHCE grams	OMNMHCE grams	FID HC grams	HC grams	NMHC grams	CH3OH grams	CH2CH3OH grams	CH2O grams	C2H4O grams	CO grams	CO2 grams	NOx grams
Bag 1	1.938	1.714	1.390	0.813	0.589	0.086	1.288	0.089	0.431	8.307	1570.638	1.213
Bag 2	0.130	0.000	0.122	0.122	-0.007	0.000	0.000	0.014	0.002	1.371	1798.094	0.210
Bag 3	0.235	0.058	0.232	0.232	0.055	0.000	0.000	0.004	0.002	7.472	1359.833	0.281

Mass Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
Bag 1	0.540	0.478	0.387	0.227	0.164	0.024	0.359	0.025	0.120	2.315	437.731	0.338
Bag 2	0.034	0.000	0.032	0.032	-0.002	0.000	0.000	0.004	0.001	0.355	466.028	0.054
Bag 3	0.065	0.016	0.065	0.065	0.015	0.000	0.000	0.001	0.001	2.081	378.664	0.078

Composite Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
UNWEIGHTED UNR	0.20866	0.16058	0.15805	0.10572	0.05764	0.00783	0.11670	0.0095937	0.0393999	1.55383	428.40	0.15437
WEIGHTED UNR	0.14732	0.10345	0.11443	0.08107	0.03720	0.00499	0.07438	0.0072239	0.0253105	1.23552	436.16	0.11975
UNWEIGHTED ROU	0.209	0.161	0.158	0.106	0.058	0.008	0.117	0.00959	0.03940	1.554	428.	0.154
WEIGHTED ROU	0.147	0.103	0.114	0.081	0.037	0.005	0.074	0.00722	0.02531	1.236	436.	0.120

Fuel Economy	Numerator	Denominator		Weighted MPG	Bag 1 MPG	Bag 2 MPG	Bag 3 MPG	Efficiency	
MY88 Gas FE	21527979.2	1643675.376		13.097	12.63	11.98	14.63	170.87	<---- MY88 FE Equation
Cert Meth FE	1526.384762	119.6580298	<-- FRM	12.756				166.42	<---- 1992 <---- The donom includes all C emissions
Ethanol FE 1	1780.4088	119.6580298		14.879				194.11	<---- Old Cert Proposed Methanol FE adapted to Ethanol
Methanol FE 1	2421.336	119.6580298		20.235				263.99	<---- Old Cert Proposed Methanol FE
Meth&Eth FE	1780.4088	119.6580298		14.879				194.11	<---- Old Cert Prpsd Meth FE adapted to Eth and/or Meth

Dyno: D209 Test No: 93-1181

VEHICLE CHASSIS DYNAMOMETER TEST ANALYSIS
Emission, Mass, and Fuel Economy Determination
MFR: 040 Veh ID: ETHNL-10 Ver: 00

Processed: 07/28/93 08:39

Dyno/CVS	VMIX	Roll Revs	Miles	F.E. HC CWF	SPGRAV F	Density effic	Gas Dil Fact	CxHyOz	DF Numer	DF Denom	FFV Dil Fac	Correct
Bag 1	4990	8368	3.589	0.527	0.7694	6.420689851	20.926	1	12.3187906	0.6410392	19.217	0.9479625
Bag 2	8567	8996	3.858	Exhaust CWF			30.930	2.867		0.4332459	28.434	0.9648305
Bag 3	4991	8371	3.590	0.56			23.945	0.41		0.5596289	22.012	0.9545711

Corrected Concentrations			FID HC ppmC	HC ppmC	NMHC ppmC	CH3OH ppmC	CH2CH3OH ppmC	CH2O ppmC	C2H4O ppmC	CO ppm	CO2 pct	NOx ppm
Bag 1			17.446	9.720	7.1609	0.4755	10.3998	0.4914	3.3437	47.452	0.601	5.259
Bag 2			1.165	1.165	0.0936	0.0000	0.0000	0.0357	0.0090	6.798	0.400	0.553
Bag 3			2.846	2.846	0.7512	0.0000	0.0000	0.0202	0.0229	15.190	0.525	1.409

Mass Emissions	OMHCE grams	OMNMHCE grams	FID HC grams	HC grams	NMHC grams	CH3OH grams	CH2CH3OH grams	CH2O grams	C2H4O grams	CO grams	CO2 grams	NOx grams
Bag 1	1.991	1.782	1.422	0.792	0.584	0.089	1.407	0.087	0.433	7.807	1553.201	1.273
Bag 2	0.169	0.019	0.163	0.163	0.013	0.000	0.000	0.011	0.002	1.920	1773.817	0.230
Bag 3	0.235	0.065	0.232	0.232	0.061	0.000	0.000	0.004	0.003	2.500	1358.447	0.341

Mass Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
Bag 1	0.555	0.497	0.396	0.221	0.163	0.025	0.392	0.024	0.121	2.175	432.768	0.355
Bag 2	0.044	0.005	0.042	0.042	0.003	0.000	0.000	0.003	0.001	0.498	459.736	0.060
Bag 3	0.066	0.018	0.065	0.065	0.017	0.000	0.000	0.001	0.001	0.696	378.368	0.095

Composite Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
UNWEIGHTED UNR	0.21706	0.16911	0.16459	0.10755	0.05960	0.00811	0.12748	0.0091583	0.0396451	1.10772	424.50	0.16708
WEIGHTED UNR	0.15571	0.11047	0.12173	0.08537	0.04014	0.00517	0.08124	0.0067307	0.0254738	0.89984	431.79	0.13046
UNWEIGHTED ROU	0.217	0.169	0.165	0.108	0.060	0.008	0.127	0.00916	0.03965	1.108	425.	0.167
WEIGHTED ROU	0.156	0.110	0.122	0.085	0.040	0.005	0.081	0.00673	0.02547	0.900	432.	0.130

Fuel Economy	Numerator	Denominator		Weighted MPG	Bag 1 MPG	Bag 2 MPG	Bag 3 MPG	Efficiency	
MY88 Gas FE	22292903.36	1661554.776		13.417	12.84	12.20	14.81	174.14	<---- MY88 FE Equation
Cert Meth FE	1534.281506	118.4275314	<-- FRM	12.955				168.15	<---- 1992 <---- The donom includes all C emissions
Ethanol FE 1	1780.4088	118.4275314		15.034				195.12	<---- Old Cert Proposed Methanol FE adapted to Ethanol
Methanol FE 1	2421.336	118.4275314		20.446				265.36	<---- Old Cert Proposed Methanol FE
Meth&Eth FE	1780.4088	118.4275314		15.034				195.12	<---- Old Cert Prpsd Meth FE adapted to Eth and/or Meth

Dyno: D209 Test No: 93-1191

VEHICLE CHASSIS DYNAMOMETER TEST ANALYSIS
Emission, Mass, and Fuel Economy Determination
MFR: 040 Veh ID: ETHNL-12 Ver: 00

Processed: 07/28/93 08:55

Dyno/CVS	VMIX	Roll Revs	Miles	F.E. HC CWF	SPGRAV F	Density effic	Gas Dil Fact	CxHyOz	DF Numer	DF Denom	FFV Dil Fac	Correct
Bag 1	*4973*	*8392*	3.599	0.527	0.76544	6.38764341	20.652	*1*	12.3187906	0.6495990	18.964	0.9472676
Bag 2	*8537*	*8998*	3.859	Exhaust CWF			30.565	*2.867*		0.4384154	28.098	0.9644108
Bag 3	*4959*	*8372*	3.591	*0.56*			23.730	*0.41*		0.5646978	21.815	0.9541596

Corrected Concentrations			FID HC ppmC	HC ppmC	NMHC ppmC	CH3OH ppmC	CH2CH3OH ppmC	CH2O ppmC	C2H4O ppmC	CO ppm	CO2 pct	NOx ppm
Bag 1			17.517	9.920	7.7955	0.5697	10.1216	0.6244	3.8003	40.487	0.613	6.172
Bag 2			0.578	0.578	0.0627	0.0000	0.0000	0.0871	0.0102	0.596	0.407	0.606
Bag 3			2.183	2.183	0.4465	0.0000	0.0000	0.0577	0.0098	6.677	0.531	1.809

Mass Emissions	OMHCE grams	OMNMHCE grams	FID HC grams	HC grams	NMHC grams	CH3OH grams	CH2CH3OH grams	CH2O grams	C2H4O grams	CO grams	CO2 grams	NOx grams
Bag 1	2.033	1.861	1.423	0.806	0.633	0.107	1.365	0.110	0.490	6.638	1578.652	1.486
Bag 2	0.094	0.022	0.081	0.081	0.009	0.000	0.000	0.026	0.002	0.168	1798.107	0.250
Bag 3	0.182	0.042	0.177	0.177	0.036	0.000	0.000	0.010	0.001	1.092	1365.533	0.434

Mass Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
Bag 1	0.565	0.517	0.395	0.224	0.176	0.030	0.379	0.031	0.136	1.844	438.601	0.413
Bag 2	0.024	0.006	0.021	0.021	0.002	0.000	0.000	0.007	0.001	0.043	465.928	0.065
Bag 3	0.051	0.012	0.049	0.049	0.010	0.000	0.000	0.003	0.000	0.304	380.296	0.121

Composite Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
UNWEIGHTED UNR	0.20904	0.17421	0.15204	0.09620	0.06136	0.00967	0.12352	0.0132337	0.0446699	0.71477	429.20	0.19648
WEIGHTED UNR	0.14380	0.11346	0.10635	0.07078	0.04044	0.00616	0.07868	0.0106330	0.0286523	0.48874	436.73	0.15251
UNWEIGHTED ROU	0.209	0.174	0.152	0.096	0.061	0.010	0.124	0.01323	0.04467	0.715	429.	0.196
WEIGHTED ROU	0.144	0.113	0.106	0.071	0.040	0.006	0.079	0.01063	0.02865	0.489	437.	0.153

Fuel Economy	Numerator	Denominator		Weighted MPG	Bag 1 MPG	Bag 2 MPG	Bag 3 MPG	Efficiency	
MY88 Gas FE	21527979.2	1643031.169		13.103	12.62	12.00	14.68	170.94	<---- MY88 FE Equation
Cert Meth FE	1526.384762	119.6114626	<-- FRM	12.761				166.48	<---- 1992 <--- The donom includes all C emissions
Ethanol FE 1	1780.4088	119.6114626		14.885				194.19	<---- Old Cert Proposed Methanol FE adapted to Ethanol
Methanol FE 1	2421.336	119.6114626		20.243				264.1	<---- Old Cert Proposed Methanol FE
Meth&Eth FE	1780.4088	119.6114626		14.885				194.19	<---- Old Cert Prpsd Meth FE adapted to Eth and/or Meth

Dyno: D209 Test No: 93-1192

VEHICLE CHASSIS DYNAMOMETER TEST ANALYSIS
Emission, Mass, and Fuel Economy Determination
MFR: 040 Veh ID: ETHNL-12 Ver: 00

Processed: 07/28/93 09:00

Dyno/CVS	VMIX	Roll Revs	Miles	F.E. HC CWF	SPGRAV F	Density effic	Gas Dil Fact	CxHyOz	DF Numer	DF Denom	FFV Dil Fac	Correct
Bag 1	5022	8374	3.592	0.527	0.76544	6.38764341	20.563	1	12.3187906	0.6524045	18.882	0.9470399
Bag 2	8624	9020	3.869	Exhaust CWF			30.536	2.867		0.4388393	28.071	0.9643764
Bag 3	5022	8371	3.590	0.56			23.682	0.41		0.5658309	21.771	0.9540677

Corrected Concentrations			FID HC ppmC	HC ppmC	NMHC ppmC	CH3OH ppmC	CH2CH3OH ppmC	CH2O ppmC	C2H4O ppmC	CO ppm	CO2 pct	NOx ppm
Bag 1			17.300	9.715	7.4655	0.4480	10.2290	0.5846	3.7595	37.506	0.612	5.719
Bag 2			0.868	0.868	-0.0733	0.0000	0.0000	0.0469	0.0083	4.041	0.401	0.654
Bag 3			3.054	3.054	0.6161	0.0000	0.0000	0.0245	0.0204	17.275	0.527	1.707

Mass Emissions	OMHCE grams	OMNMHCE grams	FID HC grams	HC grams	NMHC grams	CH3OH grams	CH2CH3OH grams	CH2O grams	C2H4O grams	CO grams	CO2 grams	NOx grams
Bag 1	2.029	1.844	1.419	0.797	0.612	0.085	1.393	0.104	0.490	6.210	1591.067	1.398
Bag 2	0.130	-0.003	0.122	0.122	-0.010	0.000	0.000	0.014	0.002	1.149	1792.831	0.275
Bag 3	0.254	0.054	0.250	0.250	0.051	0.000	0.000	0.004	0.003	2.860	1371.555	0.417

Mass Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
Bag 1	0.565	0.514	0.395	0.222	0.170	0.024	0.388	0.029	0.136	1.729	443.001	0.389
Bag 2	0.034	-0.001	0.032	0.032	-0.003	0.000	0.000	0.004	0.000	0.297	463.428	0.071
Bag 3	0.071	0.015	0.070	0.070	0.014	0.000	0.000	0.001	0.001	0.797	382.019	0.116

Composite Emissions	OMHCE g/mi	OMNMHCE g/mi	FID HC g/mi	HC g/mi	NMHC g/mi	CH3OH g/mi	CH2CH3OH g/mi	CH2O g/mi	C2H4O g/mi	CO g/mi	CO2 g/mi	NOx g/mi
UNWEIGHTED UNR	0.21836	0.17158	0.16211	0.10582	0.05904	0.00768	0.12604	0.0110808	0.0447090	0.92478	430.34	0.18911
WEIGHTED UNR	0.15379	0.11011	0.11730	0.08145	0.03777	0.00489	0.08028	0.0082322	0.0286680	0.73055	436.86	0.14928
UNWEIGHTED ROU	0.218	0.172	0.162	0.106	0.059	0.008	0.126	0.01108	0.04471	0.925	430.	0.189
WEIGHTED ROU	0.154	0.110	0.117	0.081	0.038	0.005	0.080	0.00823	0.02867	0.731	437.	0.149

Fuel Economy	Numerator	Denominator		Weighted MPG	Bag 1 MPG	Bag 2 MPG	Bag 3 MPG	Efficiency	
MY88 Gas FE	21527979.2	1644523.118		13.091	12.50	12.05	14.58	170.78	<---- MY88 FE Equation
Cert Meth FE	1526.384762	119.719746	<-- FRM	12.750				166.33	<---- 1992 <--- The donom includes all C emissions
Ethanol FE 1	1780.4088	119.719746		14.871				194.01	<---- Old Cert Proposed Methanol FE adapted to Ethanol
Methanol FE 1	2421.336	119.719746		20.225				263.86	<---- Old Cert Proposed Methanol FE
Meth&Eth FE	1780.4088	119.719746		14.871				194.01	<---- Old Cert Prpsd Meth FE adapted to Eth and/or Meth

Results from Lumina Ethanol Variable Fueled Vehicle Program

	HC	NMHC	METHANOL	ETHANOL
E 0-10-1	0.163	0.138	0.002	0.000
E 0-10-2	0.157	0.128	0.000	0.000
E 0-12-1	0.136	0.111	0.000	0.000
E 0-12-1	0.166	0.139	0.000	0.000
E 85-10-1	0.082	0.041	0.005	0.087
E 85-10-2	0.081	0.037	0.005	0.074
E 85-10-3	0.085	0.040	0.005	0.081
E 85-12-1	0.071	0.040	0.006	0.079
E 85-12-2	0.081	0.038	0.005	0.080

	FORMALDEHYDE	ACETALDEHYDE	OMHCE	OMNMHCE
E 0-10-1	0.0041	0.0017	0.167	0.142
E 0-10-2	0.0039	0.0013	0.160	0.131
E 0-12-1	0.0035	0.0013	0.138	0.113
E 0-12-1	0.0032	0.0012	0.168	0.141
E 85-10-1	0.0109	0.0276	0.159	0.118
E 85-10-2	0.0072	0.0253	0.147	0.103
E 85-10-3	0.0067	0.0255	0.155	0.110
E 85-12-1	0.0106	0.0287	0.144	0.113
E 85-12-2	0.0082	0.0287	0.153	0.110

OMHCE = HC + 13.876*(METH/32.042 + ETH/23.034 + FORM/30.026 + ACET/22.026)

OMNMHCE = OMHCE + NMHC - HC

Fuel Economy Worksheet for Alternative Fueled Vehicles

Vehicle	Bag	HC	CO	CO2	(G/MI) CH3OH	CH2CH3OH	CH2O	C2H4O	CWF	SG	(MPG) FE
E0-10-1	1	0.637	4.249	466.166	0.01	0	0.015	0.006	0.867	0.7432	18.81
	2	0.029	0.963	506.777	0	0	0.002	0.001	0.867	0.7432	17.57
	3	0.057	1.082	412.175	0	0	0.001	0	0.867	0.7432	21.57
	Composite	0.165	1.677	472.37	0.0021	0	0.004078	0.001663	0.867	0.7432	18.78
E0-10-2	1	0.587	3.267	465.709	0	0	0.014	0.005	0.867	0.7432	18.89
	2	0.043	1.41	506.775	0	0	0.002	0.001	0.867	0.7432	17.54
	3	0.048	1.022	409.283	0	0	0	0	0.867	0.7432	21.73
	Composite	0.15921	1.688	471.54	0	0	0.00393	0.001326	0.867	0.7432	18.81
E0-12-1	1	0.478	2.361	467.472	0	0	0.012	0.005	0.867	0.7432	18.89
	2	0.04	0.886	514.41	0	0	0.002	0	0.867	0.7432	17.31
	3	0.06	0.933	411.919	0	0	0	0	0.867	0.7432	21.60
	Composite	0.13885	1.204	476.48	0	0	0.003469	0.001258	0.867	0.7432	18.65
E0-12-2	1	0.572	3.455	464.923	0	0	0.009	0.005	0.867	0.7432	18.91
	2	0.067	1.146	511.162	0	0	0.002	0	0.867	0.7432	17.40
	3	0.048	0.907	409.848	0	0	0	0	0.867	0.7432	21.71
	Composite	0.16931	1.559	473.81	0	0	0.003179	0.001223	0.867	0.7432	18.73
E85-10-1	1	0.227	2.633	437.925	0.022	0.421	0.027	0.131	0.56	0.7694	13.45
	2	0.034	0.343	461.629	0	0	0.007	0.001	0.56	0.7694	12.92
	3	0.065	0.909	376.804	0	0	0.007	0.001	0.56	0.7694	15.78
	Composite	0.10337	0.973	433.43	0.00462	0.08717	0.010933	0.027578	0.56	0.7694	13.71
E85-10-2	1	0.227	8.307	437.731	0.024	0.359	0.025	0.12	0.56	0.7694	13.20
	2	0.032	1.371	466.028	0	0	0.004	0.001	0.56	0.7694	12.75
	3	0.065	7.472	378.664	0	0	0.001	0.001	0.56	0.7694	15.29
	Composite	0.09933	1.236	436.16	0.00499	0.07438	0.007224	0.025311	0.56	0.7694	13.62
E85-10-3	1	0.221	2.175	432.768	0.025	0.392	0.024	0.121	0.56	0.7694	13.64
	2	0.042	0.498	459.736	0	0	0.003	0.001	0.56	0.7694	12.96
	3	0.065	0.696	378.368	0	0	0.001	0.001	0.56	0.7694	15.73
	Composite	0.10533	0.9	431.79	0.00517	0.08124	0.006731	0.025474	0.56	0.7694	13.77
E85-12-1	1	0.224	1.844	438.601	0.03	0.379	0.031	0.136	0.56	0.7694	13.47
	2	0.021	0.043	465.928	0	0	0.007	0.001	0.56	0.7694	12.81
	3	0.049	0.304	380.296	0	0	0.003	0	0.56	0.7694	15.68
	Composite	0.08964	0.489	436.73	0.00616	0.07868	0.106331	0.028652	0.56	0.7694	13.63
E85-12-2	1	0.222	1.729	443.001	0.024	0.388	0.029	0.136	0.56	0.7694	13.35
	2	0.032	0.297	463.428	0	0	0.004	0	0.56	0.7694	12.87
	3	0.07	0.797	382.019	0	0	0.001	0.001	0.56	0.7694	15.57
	Composite	0.10098	0.731	436.86	0.00489	0.08028	0.008232	0.028668	0.56	0.7694	13.62

FUEL ECONOMY = (CWF*SG*3784)/((HCCWF*HC)+(0.429*CO)+(0.273*CO2)+(0.375*CH3OH)+(0.521*CH2CH3OH)+(0.400*CH2O)+(0.545*C2H4O))

HCCWF = 0.866 for Indolene, 0.841 for gasoline portion of E85

F. Fuel Specifications

ILLINOIS DEPT. OF ENERGY AND NATURAL RESOURCES
E85 FFV EMISSIONS TESTING
INDOLENE ANALYSES

	ALI Drum 1	ALI Drum 2	AMOCO Certificate of Analysis	Fuel Blending & Analysis SAE 902094 A/O report
Vapor Pressure, psi	8.73	8.76	8.81	0.8
Distillation, °F				
IBP	87	84	95	20
5	108	108	-	
10	124	126	124	11
20	147	149	-	
30	171	172	-	
40	196	197	-	
50	217	218	209	21
60	232	233	-	
70	248	248	-	
80	272	271	-	
90	315	313	320	11
95	337	334	-	
EP	384	380	390	20
Recovery, %	98.8	97.0	-	
Residue, %	1.3	1.3	-	
Loss, %	1.9	1.7	-	
Specific Gravity, 60°/60°F	0.7428	0.743	0.7432	—
Water, W% (Fischer)	0.012		-	
PIANO		In Progress	FIA — silica gel separation using Fluorescent Indicator	
n-Paraffins	10.98		-	
Iso-Paraffins	44.32		-	
Aromatics	32.71		31.0	
Naphthenes	2.08		-	
Olefins	6.46		7.0	
Diolefins	0.14		-	
Unknowns	3.34		-	
Gum, mg/100 ml				
Unwashed	1.6	1.4	-	
Washed	0.8	1.0	2.4	
Octanes				A/O report
Research	97.5	97.5	98.8	±0.74
Motor	87.2	87.3	88.7	±0.93
(R+M)/2	92.4	92.4	91.8	

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ILLINOIS DEPT. OF ENERGY AND NATURAL RESOURCES
E85 FFV EMISSIONS TESTING
E85 FUEL ANALYSES

	ADM Sample sent to GM	ALI Drum 1	ALI Drum 2	Proposed GM E85 Certification Fuel Specifications
Vapor Pressure, psi	8.67	8.76	8.83	7.2-8.7
Ethanol, V%	81.0	81.0	83.5	79 min.
Hydrocarbon, V%	19.0	19.0	16.5	19-21
Acidity as acetic acid, W%	-			0.0050 max.
Conductivity, micro S/m	150			300 max.
Gum, mg/100 ml				
Unwashed	-	1.4	1.8	100 max.
Washed	-	0.8	0.8	5 max.
Specific Gravity, 60°/60°F	-	0.7695	0.7693	-
Water, W% (Fischer)	-			-
PIANO on denaturant	-			-
Distillation, °F				
IBP	-	99	100	-
5	-	122	123	-
10	-	138	139	-
20	-	158	159	-
30	-	167	167	-
40	-	169	170	-
50	-	170	170	-
60	-	171	171	-
70	-	171	171	-
80	-	171	171	-
90	-	171	171	-
95	-	171	171	-
EP	-	192	187	-
Recovery, %	-	98.1	98.4	-
Residue, %	-	0.2	0.2	-
Loss, %	-	1.7	1.4	-

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