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Technical Report

Interim Report on Durability Testing of Low Cost Catalysts for Methanol-Fueled Vehicles

By

Robert D. Wagner
Larry C. Landman

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NOTICE

U. S. Environmental Protection Agency
Office of Air and Radiation
Office of Mobile Sources
Emission Control Technology Division
Control Technology and Application Branch
2565 Plymouth Road
Ann Arbor, Michigan 48105

Background

The use of pure methanol as an automotive fuel could allow the use of less expensive exhaust catalysts. Two important benefits are expected from the use of methanol compared to unleaded gasoline. Those benefits are reduced levels of catalyst poisons, such as lead and sulfur, and reduced exhaust gas temperatures at the catalyst inlet. Therefore, both major mechanisms of catalyst deactivation, poisoning and thermal degradation, could be less of a problem with methanol.

The purpose of this program is to evaluate the durability of various low cost catalysts on a fleet of methanol-fueled venicles. This durability program is being conducted in cooperation with the California Energy Commission, Ford Motor Company, and Toyota Motor Company. Durability catalysts were tested at EPA for efficiency at zero miles on a methanol-fueled Toyota (described in Appendix 1A). The catalysts were then shipped to California where they will be run for about 10,000 miles on methanol-fueled Escorts. After mileage is accumulated, the catalysts will be returned to EPA for additional efficiency testing on the Toyota. The initial low mileage (i.e., zero-mile) data generated thus far in this program are included in Appendix 2.

The selection of catalysts for this program is based on the results of an ongoing, in-house program to evaluate catalysts at low mileage.[1]* The criteria for identifying low cost catalysts for this program were that all candidate catalysts should have provided the capability to meet the 0.41 HC and 3.4 CO levels with substantial margins of safety at low mileage in that previous program. Additionally, three-way catalysts should have provided emissions well below the 1.0 NOx level.

Test Vehicle Description

Two types of test vehicles are being used in this program. The first is a 1982 model year Toyota Cressida which is being used at the EPA to generate exhaust emission (HC, CO, NOx, and aldehyde) and catalyst efficiency data. The Cressida was modified by Toyota to operate on methanol fuel (using gasoline for cold starts). This vehicle is described in Appendix 1A.

The second type of vehicle in this program is a group of 1983 model year Ford Escorts (both sedans and station wagons)

* Numbers in brackets are references listed at the end of this report.

which Ford has modified to operate on a mixture of 90 percent methanol and 10 percent unleaded, winter-grade gasoline. The Escorts (described in Appendixes 1B and 1C) are part of a fleet of methanol-fueled vehicles in operation in Los Angeles County as part of the California Energy Commission programs. These Escorts are being used to accumulate about 10,000 miles on each of eight (8) catalysts which EPA shipped to California. These vehicles are part of a fleet which is based at the Los Angeles airport. The vehicles are driven by state employees. The fleet is operated by Thrifty Car Rental.

Descriptions of the Catalysts

Two types of catalysts have been selected thus far for this program. Both catalysts have a loading of 20 grams of noble metal per cubic foot. The first contains platinum (Pt) and palladium (Pd) in a ratio of 3:2. The second is an all palladium. They are denoted by 3Pt:2Pd(20) and Pd(20), respectively. The substrates are 400 cells per square inch with a wall thickness of 6 mils.

Both catalysts are monoliths. Each is composed of two separate biscuits in a single container. Each biscuit has an oval cross section measuring 3.15 by 4.75 inches. The front biscuit is 2.98 inches long and the rear biscuit is 4.3 inches long. This yields a total substrate volume of 92.8 cubic inches (38.0 for the shorter biscuit plus 54.8 for the longer biscuit). Biscuits of this size and shape were selected so that they would be identical in both size and shape to those used in the Escort's standard catalysts. Thus, we could easily substitute our catalysts for standard Escort catalysts. These units, at 92.8 cubic inches, are thus 23 percent larger than the corresponding 75.4 cubic inch units which were used in the low-mileage evaluation program.[1]

Four of each of those two catalysts were produced (i.e., canned). Three of the four units of each catalyst were shipped to California on January 6, 1984. The remaining unit of each type stayed at EPA for zero-mile testing (Appendix 2). Those two units were each tested as three-way catalysts (by not adding any air to the exhaust and running the engine at stoichiometry) and subsequently as oxidizing catalysts (by running the engine at stoichiometry and adding air to the exhaust, just upstream of the catalyst). After completion of the zero-mile testing, those two remaining units were also shipped (April 26, 1984) to California.

Of the four catalysts of each type which were shipped to California for mileage accumulation, two were installed as oxidation catalysts and two as three-way catalysts. For each

Escort using the catalysts as oxidizing catalysts, the downstream air tube was flush mounted with the exhaust pipe to put air (from the air pump) into the exhaust at least six inches upstream of the catalyst. For each Escort using the catalysts as three-way catalysts, the belt to the air pump was removed, and the downstream air tube was capped. A listing of those eight catalysts appears in Table 1.

Thus, durability mileage is currently being accumulated on:

- Two 3Pt:2Pd(20) catalysts being run as oxidizing catalysts;
- two 3Pt:2Pd(20) catalysts being run as three-way catalysts;
- two Pd(20) catalysts being run as oxidizing catalysts; and
- two Pd(20) catalysts being run as three-way catalysts.

As more catalysts complete the low-mileage evaluation program, additional catalysts may be selected for durability evaluation in this program.[1]

Table 1
Listing of Durability Catalysts

Designation	Serial Number	Zero-Mile Test at EPA	Mileage Accumulation As
3Pt:2Pd(20)	9K-8583 EP4-2650	No	Three-Way Catalyst
	9K-8580 EP4-2649	No	Oxidizing Catalyst
	9K-8584 EP4-2651	No	Oxidizing Catalyst
	9K-8579 EP4-2648	Yes	Three-Way Catalyst
Pd(20)	NPN, 8-17	No	Three-Way Catalyst
	NPN, 3-12	No	Oxidizing Catalyst
	NPN, 6-15	No	Oxidizing Catalyst
	NPN, 6-17	Yes	Three-Way Catalyst

Test Sequence, Instrumentation, and Fuel

The initial plan included testing of the Toyota in the no-catalyst configuration over the following sequence:

1975 Federal Test Procedure (FTP)
Highway Test Procedure (HWY)
Idle
10 mph steady state
20 mph steady state
30 mpn steady state

With the catalysts installed, the vehicle was operated over only the FTP and HWY.

The sequence was performed three times for each catalyst at each of two exhaust oxygen levels. The higher of the two exhaust oxygen levels was measured at the catalyst inlet using a Sun oxygen analyzer and was obtained at 30 miles per hour steady state. The two oxygen levels were stoichiometry (or near 0 percent) and about 6 percent. The air pump was installed (March 9, 1984) in order to provide the 6 percent oxygen level. By testing at different exhaust oxygen levels, we could, therefore, evaluate eacn catalyst as a three-way catalyst and also as an oxidation catalyst.

As the project proceeded, the idle test point was deleted. HC, CO, NOx, MPG, methane, and aldehydes were initially measured over each test in the sequence. Measurement for aldehydes was deleted during steady states in the more recent testing.

Exhaust HC emissions, as reported here, were measured with a flame ionization detector (FID) from Beckman (model 400). No corrections in tne results were made for either the FID response to methanol or the difference in tne exhaust HC composition (i.e., the hydrogen to carbon ratio) with methanol (instead of gasoline) as the fuel. NOx emissions were measured with a cnemiluminescent NO/NOx analyzer from Beckman (Model No. 951A). CO was measured with infrared analyzers from MSA and Bendix. Methane was measured with a gas chromatograpn (Bendix 8205 methane analyzer). Aldehydes were measured by high pressure liquid chromatography (HPLC) and are reported as formaldehyde. (See Appendix 2 of Reference 1 for more details on how formaldehyde is measured.) The emissions (in grams/mile) of HC, CO, and CO_2 were used to calculate fuel economy (in miles/gallon) using the following formula:

$$\text{Fuel Economy} = \frac{1124}{0.866(\text{HC}) + 0.429(\text{CO}) + 0.273(\text{CO}_2)}$$

The primary test fuel which has been used in this program is pure methanol. Five batches of methanol have been consumed, and one has been analyzed. The fuel analysis is presented in Appendix 5. The gasoline used in the cold-start system of the Toyota is Indolene Clear (unleaded) and meets the EPA specifications for that fuel (40 CFR 86.307-82).

Summary of the Test Results

Tables 2 and 3 present average zero-mile FTP and highway (HWY) emissions, respectively. (These averages appear in more detail in Appendix 4.) In light of the substantial shift in emissions which followed the replacement of the fuel injectors (March 9, 1984), these averages are based only on those tests following the change of injectors. The average FTP HC, CO, and NOx emissions are satisfactory. HC and sometimes CO are higher than the target levels of our earlier screening tests. This is the result of two things: 1) engine-out HC and CO emissions from the Toyota are very low, and 2) the catalyst volumes are appropriate for Escorts with 1.6-liter engines and have been tested on the Toyota with a much larger engine. Over every driving cycle, at both oxygen levels, and both with and without a catalyst, there is virtually no methane in the exhaust (Appendixes 2 or 4).

Emissions of aldehydes, HC, CO, and NOx for each catalyst are shown as functions of exhaust oxygen level in Figures 1 through 4, respectively. CO, NOx, and aldehydes are all affected by oxygen level. CO decreased and both NOx and aldehydes increased as the oxygen level increased.

When the aged catalysts are returned to EPA, they will be tested again using the Toyota vehicle. The purpose of this second series of tests will be to determine the efficiency loss due to mileage accumulation.

Zero-mile (i.e., baseline) catalyst efficiencies were calculated for each catalyst at each oxygen level using the average emission data from Appendix 4. The results of these calculations are presented in Tables 4 and 5 for the FTP and HWY driving cycles, respectively. Zero-mile catalyst efficiencies were also calculated for each "Bag" of the FTP and are presented in Table 6. "Catalyst efficiency," as used here, is defined as the average tailpipe emissions with no catalyst minus the average tailpipe emissions with a catalyst, that difference divided by the average tailpipe emissions with no catalyst and then multiplied by 100 percent.

Table 2

Summary of Average Zero-Mile FTP Emissions at Different Oxygen Levels

Catalyst	HC (g/mi) --Oxygen- 0%	6+%	Aldy (mg/mi) ---Oxygen-- 0%	6+%	CO (g/mi) --Oxygen- 0%	6%	NOx (g/mi) --Oxygen- 0%	6%
None	.99	--	283.6	--	8.85	--	2.08	---
3Pt:2Pd(20)	.24	.27	37.3	264.6	2.80	0.34	0.51	1.35
Pd(20)	.29	.28	41.0	236.5	1.97	0.72	0.32	1.32

Table 3

Summary of Average Zero-Mile HWY Emissions at Different Oxygen Levels

Catalyst	HC (g/mi) --Oxygen- 0%	6+%	Aldy (mg/mi) ---Oxygen--- 0%	6+%	CO (g/mi) --Oxygen- 0%	6%	NOx (g/mi) --Oxygen-- 0%	6%
None	.42	--	167.2	--	6.33	---	1.88	---
3Pt:2Pd(20)	.01	.01	5.4	40.4	0.74	0.00	0.26	1.06
Pd(20)	.01	.01	7.3	31.9	0.74	0.02	0.06	1.06

Table 4

Zero-Mile Catalyst Efficiency (percent) over FTP at Different Oxygen Levels*

	HC Effic. Run As:		Aldy Effic. Run As:		CO Effic. Run As:		NOx Effic. Run As:	
	3WY	OC	3WY	OC	3WY	OC	3WY	OC
3Pt:2Pd(20)	76	73	87	7	68	96	75	35
Pd(20)	71	72	86	17	78	92	85	36

Table 5

Zero-Mile Catalyst Efficiency (percent) over HWY at Different Oxygen Levels*

	HC Effic. Run As:		Aldy Effic. Run As:		CO Effic. Run As:		NOx Effic. Run As:	
	3WY	OC	3WY	OC	3WY	OC	3WY	OC
3Pt:2Pd(20)	98	97	97	76	88	99+	86	44
Pd(20)	98	97	96	81	88	99+	97	43

Table 6

Zero-Mile Catalyst Efficiency (percent) over FTP by Bag at Different Oxygen Levels*

	HC Effic. Run As:		Aldy Effic. Run As:		CO Effic. Run As:		NOx Effic. Run As:	
	3WY	OC	3WY	OC	3WY	OC	3WY	OC
3Pt:2Pd(20)								
Bag 1	49	48	67	8	54	87	65	19
Bag 2	97	94	96	5	73	100	82	50
Bag 3	88	78	90	8	74	98	77	31
Pd(20)								
Bag 1	38	44	65	1	54	77	72	18
Bag 2	97	97	96	39	90	99	92	53
Bag 3	84	81	85	-24	78	93	87	34

* '3WY' denotes a three-way catalyst (0 percent oxygen level), and 'OC' denotes an oxidizing catalyst (6+ percent oxygen level).

FIGURE 1. Comparison of FTP Aldehyde Emissions by Oxygen Level for Each Catalyst

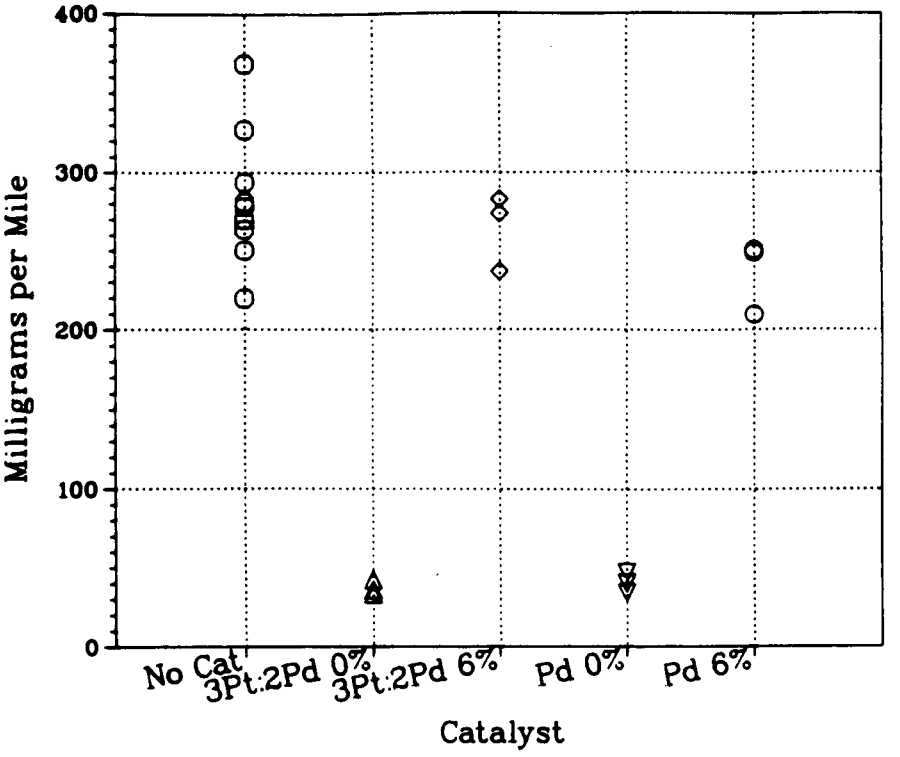


FIGURE 2. Comparison of FTP HC Emissions by Oxygen Level for Each Catalyst

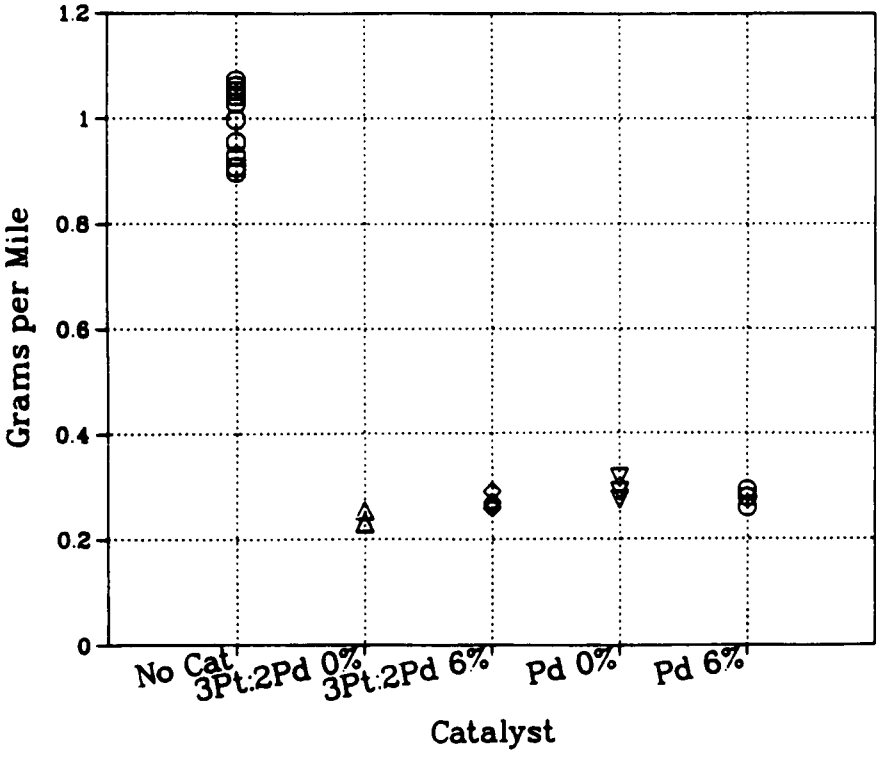


FIGURE 3. Comparison of FTP CO Emissions by Oxygen Level for Each Catalyst

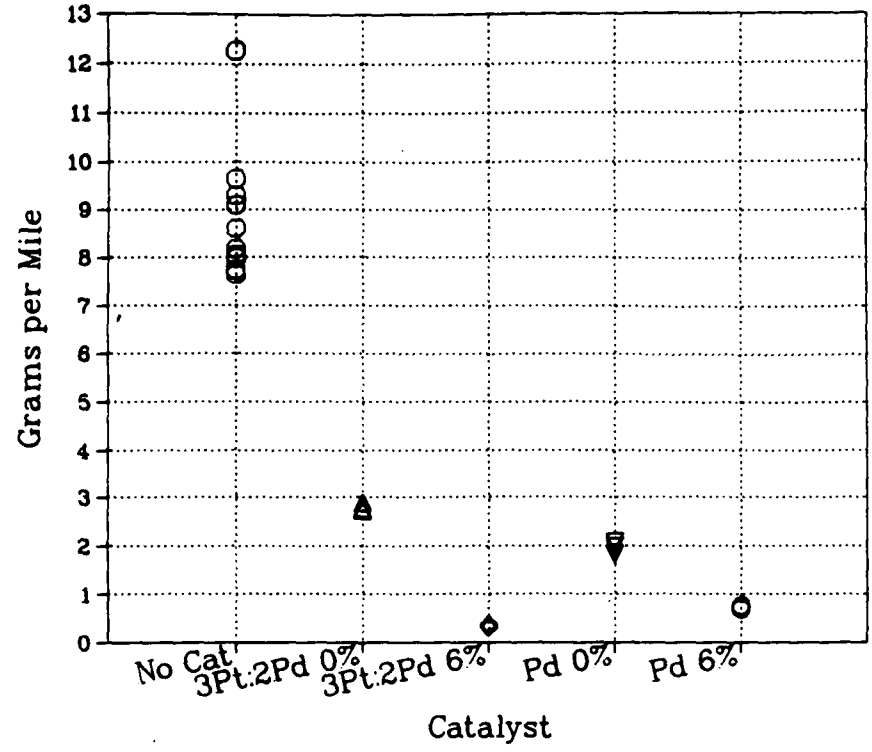
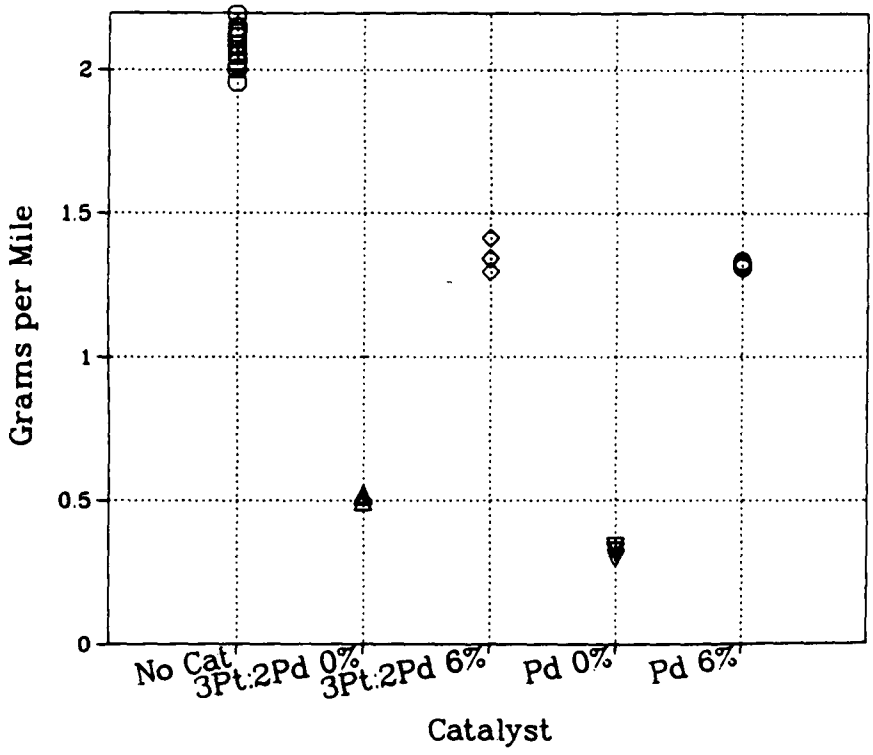


FIGURE 4. Comparison of FTP NOx Emissions by Oxygen Level for Each Catalyst



References

1. "Low Mileage Catalyst Evaluation with a Methanol-Fueled Rabbit Second Interim Report," R. Wagner and L. Landman, EPA Report No. EPA/AA/CTAB/TA/84-3, May 1984.

APPENDIX 1

Test Vehicle Description

Appendix 1A

Emission Test Vehicle Description

1982 Toyota Cressida (methanol-fueled)
Vehicle Identification Number: MX62-083780

Engine:

Type	4 Stroke Otto cycle, In-Line 6
Bore x Stroke	83.0 x 85.0 mm
Displacement	2759 cc (168 CID)
Compression Ratio	10.0:1
Fuel Metering	Two separate fuel injection systems. (The main fuel injection system uses pure methanol; a separate cold-start fuel injection system uses pure gasoline.)

Drive Train:

Transmission Type	4-speed automatic with overdrive
Axle Ratio	3.73

Chassis:

Type	4-Door Sedan
Tires	Dunlop 185/70SR14 steel belted radials
Curb Weight	2,855 pounds
Test Weight (ETW)	3,000 pounds
Actual Dynamometer Horsepower	10.3

Appendix 1B

Mileage Accumulation Vehicle Description

1983 Ford Escorts (methanol-fueled)

Engine:

Type	4-stroke Otto cycle, In-Line 4
Bore x Stroke	80.0 x 79.5 mm
Displacement	1.6 liters (98 CID)
Compression Ratio	11.8:1
Fuel Metering	2-barrel carburetor

Drive Train:

Transmission Type	3-speed automatic transaxle

Chassis:

Type	4-door station wagon or 4-door sedan
Vehicle Identification Numbers*	1FABP1373DW237349 1FABP137XDW237350 1FABP1376DW237359 1FABP137XDW237378 1FABP1379DW237386 1FABP1379DW237405

* The identification numbers, of the two vehicles which were equipped in April 1984 with the catalysts, are not yet available.

Appendix 1C

Modifications Made to the 1983 Model Year Gasoline-Fueled Escorts to Convert Them to Methanol-Fueled

Fuel System

Fuel Tank:

- Same design as gasoline-fueled Escort, but it is made of stainless steel for corrosion protection.

Fuel Tank Sending Unit:

- Same design as standard unit, but it is nickel plated to prevent corrosion and has a nickel plated brass float.

Fuel Tank Straps:

- Same design as standard model, but the straps are coated with nylon to prevent dissimilar metal corrosion with the stainless steel methanol fuel tank.

Fuel Lines:

- Same routing as standard Escort, but the lines are fabricated from stainless steel to prevent corrosion.

Fuel Pump:

- Same design as standard unit, but all metallic parts have been made corrosion resistant through nickel plating, and all plastic and rubber parts are made from a material which will withstand methanol.

Carburetor:

- The carburetor is base 740 model modified and recalibrated to meet the higher fuel-flow requirements of the methanol engine. All parts have been nickel plated or manufactured from a material which is compatible with fuel methanol. For example, idle adjusting needles and throttle shafts are made of stainless steel. The float unit is an acetal hollow design and replaces the standard unit.

Carburetor Spacer:

- A rectangular spacer plate is installed between the carburetor base and intake manifold. This plate uses a round electrical heating unit which replaces the square heating unit used on the gasoline-fueled engine.

Appendix 1C (cont'd)

Modifications Made to the 1983 Model Year Gasoline-Fueled Escorts to Convert Them to Methanol-Fueled

Engine

Basic Engine:

- The engine that powers the methanol vehicle is the same basic design as the Escort's gasoline-fueled 1.6L high-output (HO) engine.

- The compression ratio has been increased from 8.8:1 to 11.8:1. This was accomplished by installing the piston from a European 1.3L Ford engine in the 1.6L block. Each piston has been fitted with a special top compression ring which is barrel faced and hard chromed steel. Piston rings two and three are standard.

- A 1984 head gasket that will withstand higher compression pressures is used to replace the standard gasoline head gasket. This head gasket uses a stainless steel fire ring and special backing material.

- The base 1.6L camshaft (pink color code) is used in place of the HO camshaft (yellow color code).

Engine Oil:

- A unique engine oil containing a special additive must be used with methanol-fueled engines. The recommended oil is marked for methanol engines only.

Ignition

Distributor:

- The distributor is a modified, solid-state unit. Its operation is the same as the standard unit; the advance curves have been modified. The major difference is less mechanical advance.

Spark Plugs:

- The spark plugs used in the methanol-fueled engine are two heat ranges colder than the spark plugs in the gasoline powered 1.6L engine. This is necessary to prevent engine damage due to preignition.

APPENDIX 2

Initial, Low Mileage Data from the Catalyst Durability Evaluation Program

Appendix 2A

Emissions (by Bag) during the FTP Driving Cycle

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)
TOYOTA CATALYST:												
842014	0.0	STOCK	1-19-84	872.0:								
				Bag 1:	42.67	10.0	.501	2.788	407.742	.165	.493	.007
				Bag 2:	5.08	11.3	.010	.814	363.040	-.003	.008	.002
				Bag 3:	0.00	12.5	.004	.286	328.335	.021	.002	.001
				Weighted:	11.51	11.2786	0.1105	1.0790	362.78	0.0388	0.1076	0.00290
842020	0.0	STOCK	1-20-84	959.3:								
				Bag 1:	43.95	10.3	.458	2.496	393.294	.156	.452	.005
				Bag 2:	6.46	11.2	.006	.646	366.137	.000	.004	.001
				Bag 3:	1.42	12.7	.002	.272	324.241	.037	.001	.001
				Weighted:	12.86	11.3806	0.0984	0.9272	360.25	0.0426	0.0967	0.00172
842026	0.0	STOCK	1-24-84	1044.0:								
				Bag 1:	50.89	10.0	.556	3.151	406.415	.173	.550	.006
				Bag 2:	5.45	11.9	.013	.628	345.880	.003	.011	.001
				Bag 3:	1.89	12.9	.003	.287	317.885	.029	.002	.001
				Weighted:	13.87	11.6617	0.1219	1.0558	350.74	0.0452	0.1202	0.00170
STRAIGHT PIPE, NO CATALYST:												
842032	0.0	NONE	1-31-84	1130.7:								
				Bag 1:	364.14	10.2	2.099	19.107	368.763	2.741	2.088	.010
				Bag 2:	266.94	11.6	1.122	25.581	310.085	1.248	1.117	.005
				Bag 3:	156.26	12.6	.864	18.702	293.568	2.000	.860	.004
				Weighted:	256.16	11.5303	1.2519	22.3398	317.59	1.7638	1.2462	0.00567
842037	0.0	NONE	2-01-84	1220.3:								
				Bag 1:	385.22	9.8	3.220	22.947	372.883	2.701	3.208	.012
				Bag 2:	263.49	11.6	1.316	28.108	306.440	1.218	1.310	.005
				Bag 3:	157.37	12.8	.865	20.395	285.921	1.954	.861	.004
				Weighted:	259.28	11.4941	1.5837	24.9270	314.47	1.7253	1.5775	0.00618
842042	0.0	NONE	2-02-84	1305.8:								
				Bag 1:	375.00	10.2	2.408	21.254	364.471	2.738	2.398	.010
				Bag 2:	298.47	11.6	1.421	28.792	305.868	1.257	1.414	.007
				Bag 3:	177.63	12.8	.951	21.360	284.713	1.806	.946	.005
				Weighted:	281.30	11.5534	1.4964	25.2086	312.19	1.7124	1.4896	0.00680
STRAIGHT PIPE, NO CATALYST (AFTER RETURN FROM TOYOTA):												
842283	0.0	NONE	2-22-84	1632.6:								
				Bag 1:	238.70	10.4	2.174	19.285	358.399	2.835	2.173	.001
				Bag 2:	237.07	12.1	1.134	24.644	299.080	1.150	1.131	.002
				Bag 3:	146.19	13.2	.821	17.482	282.521	1.892	.820	.001
				Weighted:	212.62	11.9362	1.2629	21.5905	306.78	1.6994	1.2612	0.00174
842288	0.0	NONE	2-23-84	1717.0:								
				Bag 1:	315.71	10.3	2.116	21.386	359.115	2.685	2.113	.003
				Bag 2:	239.49	12.1	1.272	26.780	294.270	1.106	1.268	.003
				Bag 3:	151.42	13.2	.881	19.635	277.875	1.783	.879	.002
				Weighted:	230.92	11.9511	1.3383	23.7052	303.11	1.6174	1.3355	0.00282
3Pt:2Pd(20) CATALYST:												
842293	0.0	(#1)	2-24-84	1799.2:								
				Bag 1:	91.66	10.4	.715	4.507	385.169	.624	.705	.010
				Bag 2:	8.25	12.3	.022	1.794	333.151	.099	.018	.003
				Bag 3:	6.25	13.3	.017	1.581	306.816	.319	.015	.001
				Weighted:	24.78	12.0699	0.1621	2.2912	336.65	0.2661	0.1581	0.00403
842295	0.0	(#1)	2-25-84	1860.9:								
				Bag 1:	88.72	10.0	.694	4.973	399.732	.661	.688	.006
				Bag 2:	12.67	11.7	.012	1.825	350.030	.103	.009	.003
				Bag 3:	8.56	12.6	.015	2.096	323.555	.306	.011	.003
				Weighted:	27.23	11.5169	0.1531	2.5464	353.03	0.2733	0.1497	0.00340

Appendix 2A (Cont.)

Emissions (by Bag) during the FTP Driving Cycle

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)
842297	0.0	(#1)	2-26-84	1923.7:								
				Bag 1:	88.24	10.4	.621	4.366	388.521	.558	.616	.005
				Bag 2:	8.58	11.8	.017	2.176	344.657	.095	.013	.004
				Bag 3:	6.99	12.2	.015	2.522	334.461	.341	.012	.002
				Weighted:	24.50	11.5742	0.1411	2.7212	350.90	0.2575	0.1375	0.00359
		Pd(20) CATALYST:										
842299	0.0	(#2)	2-27-84	1985.5:								
				Bag 1:	88.99	9.7	.645	3.462	415.203	.305	N/A	N/A
				Bag 2:	11.20	11.5	.011	1.304	355.695	.006	N/A	N/A
				Bag 3:	6.82	12.9	.014	1.586	316.683	.070	N/A	N/A
				Weighted:	26.23	11.4268	0.1424	1.8250	357.29	0.0852	N/A	N/A
842301	0.0	(#2)	2-28-84	2052.2:								
				Bag 1:	99.28	10.4	.788	4.134	386.956	.268	.781	.006
				Bag 2:	6.46	12.1	.008	1.571	338.062	.003	.004	.003
				Bag 3:	6.26	13.3	.010	.734	309.521	.109	.007	.002
				Weighted:	25.61	11.9869	0.1694	1.8717	340.35	0.0869	0.1659	0.00354
842303	0.0	(#2)	2-29-84	2113.1:								
				Bag 1:	91.53	10.4	.745	4.210	387.318	.315	.737	.008
				Bag 2:	7.06	11.7	.020	2.924	346.670	.012	.015	.005
				Bag 3:	6.97	12.9	.015	2.539	316.306	.101	.011	.003
				Weighted:	24.43	11.6842	0.1680	3.0838	346.72	0.0991	0.1632	0.00484
842305	0.0	(#2)	3-01-84	2173.9:								
				Bag 1:	105.17	10.4	.734	4.386	385.075	.342	.728	.005
				Bag 2:	10.11	12.1	.017	5.482	331.734	.009	.012	.004
				Bag 3:	8.70	13.2	.013	2.353	307.428	.107	.010	.003
				Weighted:	29.32	11.9883	0.1637	4.4004	336.08	0.1044	0.1594	0.00429
842307	0.0	(#2)	3-02-84	2252.8:								
				Bag 1:	75.09	10.2	.728	5.462	393.226	.282	.720	.007
				Bag 2:	6.82	12.1	.008	1.706	336.805	.012	.005	.002
				Bag 3:	2.21	13.1	.015	2.655	311.222	.103	.011	.004
				Weighted:	19.61	11.9061	0.1583	2.7390	341.42	0.0925	0.1546	0.00370
		STRAIGHT PIPE, NO CATALYST:										
842309	0.0	NONE	3-04-84	2330.9:								
				Bag 1:	343.23	10.3	2.403	23.294	356.766	2.375	2.395	.007
				Bag 2:	342.26	11.8	2.223	31.238	292.406	1.090	2.212	.010
				Bag 3:	211.77	13.0	1.225	22.163	278.547	1.620	1.222	.002
				Weighted:	306.79	11.7326	1.9871	27.1212	301.86	1.4996	1.9796	0.00754
842331	0.0	NONE	3-05-84	2414.5:								
				Bag 1:	290.00	10.3	2.577	23.839	353.813	2.440	N/A	N/A
				Bag 2:	358.49	11.7	2.545	33.015	290.700	1.138	N/A	N/A
				Bag 3:	197.41	13.0	1.252	22.428	278.348	1.761	N/A	N/A
				Weighted:	300.22	11.7195	2.1965	28.2208	300.30	1.5772	N/A	N/A

Based on the change in emissions following the replacement of the injectors, the data generated prior to March 10, 1984, may not be representative of the vehicle's performance from then on.

		STRAIGHT PIPE, NO CATALYST (NEW INJECTORS, AIR PUMP INSTALLED):										
842336	0.0	NONE	3-14-84	2629.1:								
				Bag 1:	504.26	10.5	1.944	11.548	368.820	3.155	1.939	.005
				Bag 2:	392.94	12.4	.735	8.803	315.355	1.615	.732	.002
				Bag 3:	220.73	13.3	.626	7.804	295.764	2.411	.624	.002
				Weighted:	369.11	12.1692	0.9550	9.0980	321.06	2.1493	0.9522	0.00277

Appendix 2A (Cont.)

Emissions (by Bag) during the FTP Driving Cycle

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)
842691	0.0	NONE	3-15-84	2711.4:								
				Bag 1:	504.40	10.6	1.910	11.624	365.798	2.998	N/A	N/A
				Bag 2:	314.98	12.5	.680	8.984	312.776	1.597	N/A	N/A
				Bag 3:	217.07	13.5	.584	8.155	290.416	2.335	N/A	N/A
				Weighted:	327.33	12.2720	0.9083	9.3026	317.61	2.0895	N/A	N/A
842696	0.0	NONE	3-16-84	2793.7:								
				Bag 1:	N/A	10.6	1.891	11.574	363.670	2.898	1.889	.001
				Bag 2:	224.41	12.6	.668	9.557	310.765	1.535	.668	.000
				Bag 3:	173.54	13.5	.584	8.385	289.205	2.221	.582	.001
				Weighted:	N/A	12.3265	0.8979	9.6525	315.79	2.0049	0.8973	0.00056
		Pd(20)	CATALYST:									
842701	0.0	(#2)	3-17-84	2873.8:								
				Bag 1:	153.21	10.3	1.283	5.006	389.521	.848	1.280	.003
				Bag 2:	13.55	12.5	.026	1.021	327.921	.114	.022	.004
				Bag 3:	32.30	13.4	.139	1.880	303.214	.329	.138	.001
				Weighted:	47.42	12.1713	0.3158	2.0766	333.85	0.3237	0.3130	0.00279
842703	0.0	(#2)	3-18-84	2934.9:								
				Bag 1:	98.33	10.4	1.241	5.248	385.410	.865	1.239	.001
				Bag 2:	11.50	12.5	.026	.668	328.179	.158	.026	.000
				Bag 3:	30.60	12.2	.070	1.456	334.157	.288	.069	.000
				Weighted:	34.71	11.9065	0.2895	1.8313	341.65	0.3399	0.2892	0.00034
843000	0.0	(#2)	3-19-84	2996.1:								
				Bag 1:	129.48	10.4	1.132	4.796	383.118	.835	1.126	.005
				Bag 2:	12.22	12.3	.020	.980	333.832	.098	.020	.000
				Bag 3:	28.29	12.9	.110	1.786	316.426	.282	.109	.000
				Weighted:	40.80	12.0036	0.2742	1.9883	339.23	0.3001	0.2731	0.00106
843002	6.4	(#2)	3-20-84	3061.9:								
				Bag 1:	338.00	10.5	1.190	2.498	383.926	2.513	1.187	.003
				Bag 2:	154.29	12.1	.026	.080	339.582	.720	.024	.001
				Bag 3:	217.83	13.2	.124	.482	311.727	1.528	.123	.001
				Weighted:	209.62	12.0030	0.2932	0.6892	341.09	1.3115	0.2917	0.00152
843004	6.4	(#2)	3-21-84	3123.3:								
				Bag 1:	379.64	10.4	1.008	2.351	387.612	2.504	1.007	.001
				Bag 2:	198.42	12.1	.028	.145	340.856	.735	.028	.000
				Bag 3:	247.23	13.0	.134	.542	315.025	1.582	.133	.000
				Weighted:	249.14	11.9361	0.2593	0.7083	343.42	1.3317	0.2591	0.00024
843006	6.4	(#2)	3-22-84	3184.4:								
				Bag 1:	371.04	10.3	1.108	2.535	391.675	2.513	1.106	.002
				Bag 2:	175.24	12.0	.025	.142	343.825	.717	.025	.000
				Bag 3:	303.91	12.9	.135	.584	317.946	1.575	.134	.000
				Weighted:	250.73	11.7945	0.2786	0.7568	346.63	1.3220	0.2783	0.00035
		STRAIGHT	PIPE, NO	CATALYST:								
843008	0.0	NONE	3-23-84	3250.2:								
				Bag 1:	370.23	10.5	1.961	13.427	365.609	2.934	1.947	.013
				Bag 2:	275.06	12.4	.909	13.090	308.720	1.439	.909	.000
				Bag 3:	186.09	13.4	.710	9.872	288.505	2.203	.710	.000
				Weighted:	280.93	12.1920	1.0719	12.2762	314.92	1.9574	1.0692	0.00271
		STRAIGHT	PIPE, NO	CATALYST	(NEW	INJECTORS):						
843013	0.0	NONE	4-10-84	3557.7:								
				Bag 1:	288.10	10.5	2.024	9.899	371.528	3.158	2.007	.017
				Bag 2:	325.44	12.6	.836	7.290	312.918	1.554	.828	.007
				Bag 3:	237.87	13.4	.729	6.635	294.681	2.399	.723	.006
				Weighted:	293.74	12.2770	1.0521	7.6501	320.04	2.1168	1.0433	0.00879

Appendix 2A (Cont.)

Emissions (by Bag) during the FTP Driving Cycle

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)
843018	0.0	NONE	4-11-84	3538.4:								
				Bag 1:	284.24	10.3	1.917	10.114	376.023	3.238	1.902	.015
				Bag 2:	259.58	12.4	.789	7.285	317.881	1.571	.781	.007
				Bag 3:	205.73	13.2	.701	7.929	296.096	2.595	.693	.007
				Weighted:	249.95	12.1160	0.9979	8.0454	323.95	2.1949	0.9889	0.00897
843156	0.0	NONE	4-12-84	3618.3:								
				Bag 1:	330.60	10.6	1.811	9.919	366.167	3.161	1.793	.018
				Bag 2:	254.53	12.7	.724	7.447	310.520	1.592	.716	.007
				Bag 3:	230.00	13.6	.650	6.648	290.514	2.379	.644	.006
				Weighted:	263.49	12.3972	0.9282	7.7391	316.54	2.1305	0.9191	0.00909
		3Pt:2Pd(20) CATALYST:										
843161	0.0	(#1)	4-13-84	3701.3:								
				Bag 1:	143.29	10.4	1.069	5.313	384.707	1.058	1.053	.016
				Bag 2:	12.42	12.6	.021	2.366	323.135	.276	.011	.010
				Bag 3:	23.91	13.3	.083	2.064	305.347	.568	.077	.006
				Weighted:	42.51	12.2409	0.2540	2.8905	330.95	0.5169	0.2438	0.01025
843163	0.0	(#1)	4-17-84	3762.7:								
				Bag 1:	118.57	10.5	.967	4.602	383.573	1.108	.949	.017
				Bag 2:	11.76	12.4	.016	2.455	327.046	.271	.007	.008
				Bag 3:	19.43	13.4	.078	1.986	302.797	.550	.071	.007
				Weighted:	35.95	12.2142	0.2296	2.7702	332.07	0.5206	0.2200	0.00958
843165	0.0	(#1)	4-18-84	3823.6:								
				Bag 1:	107.13	10.6	.969	4.771	379.501	1.031	.953	.016
				Bag 2:	10.87	12.6	.016	2.249	324.332	.264	.009	.006
				Bag 3:	20.52	13.5	.083	2.104	301.708	.534	.077	.006
				Weighted:	33.42	12.2893	0.2312	2.7308	329.53	0.4965	0.2231	0.00810
843167	6.2	(#1)	4-19-84	3890.6:								
				Bag 1:	302.30	10.3	.968	1.415	392.532	2.566	.952	.016
				Bag 2:	298.97	12.5	.039	-.008	330.506	.747	.032	.006
				Bag 3:	204.56	13.3	.144	.157	309.217	1.563	.138	.005
				Weighted:	273.96	12.1330	0.2590	0.3300	337.52	1.3428	0.2509	0.00811
843169	6.2	(#1)	4-20-84	3951.1:								
				Bag 1:	287.83	10.3	1.008	1.294	393.638	2.317	0.992	0.016
				Bag 2:	235.99	12.3	0.045	0.0	333.591	0.723	0.039	0.006
				Bag 3:	199.63	13.1	0.134	0.136	312.734	1.617	0.128	0.005
				Weighted:	236.75	12.0625	0.2683	0.3045	340.26	1.2971	0.2602	0.00804
843171	6.2	(#1)	4-24-84	4012.5:								
				Bag 1:	428.82	10.3	1.054	1.574	392.192	2.559	1.037	.017
				Bag 2:	284.17	12.1	.053	.000	338.914	.817	.045	.008
				Bag 3:	171.53	13.1	.160	.171	313.675	1.675	.154	.006
				Weighted:	283.01	11.9512	0.2897	0.3729	342.99	1.4140	0.2805	0.00920

Testing completed. Both catalysts were shipped to Calif for mileage accumulation (April 26, 1984).

		STRAIGHT PIPE, NO CATALYST:										
843173	0.0	NONE	4-25-84	4078.8:								
				Bag 1:	305.96	10.7	1.979	9.914	363.837	3.022	1.964	.015
				Bag 2:	277.80	12.6	.835	7.635	310.962	1.510	.828	.006
				Bag 3:	191.44	13.6	.730	7.202	289.406	2.346	.725	.005
				Weighted:	219.45	12.4064	1.0423	7.9863	315.95	2.0519	1.0345	0.00780

Appendix 2A (Cont.)

Emissions (by Bag) during the FTP Driving Cycle

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)
843178	0.0	NONE	4-26-84	4160.0:								
				Bag 1:	363.90	10.6	2.053	10.109	365.832	3.060	2.038	.014
				Bag 2:	263.20	12.7	.790	7.807	309.087	1.490	.783	.006
				Bag 3:	211.94	13.5	.716	7.426	290.078	2.270	.710	.006
				Weighted:	269.83	12.3968	1.0292	8.1757	315.54	2.0261	1.0214	0.00775
843183	0.0	NONE	4-27-84	4245.4:								
				Bag 1:	355.25	10.6	2.110	10.402	364.791	3.100	2.094	.016
				Bag 2:	288.49	12.7	.810	8.436	309.532	1.473	.803	.006
				Bag 3:	200.46	13.6	.746	7.580	287.629	2.367	.740	.006
				Weighted:	278.15	12.4051	1.0612	8.6071	314.93	2.0546	1.0530	0.00817

Appendix 2B

Emissions during the HWY Driving Cycle

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)
TOYOTA CATALYST:												
842015	0.0	STOCK	1-19-84	892.5	1.44	15.0852	0.0044	1.2184	271.27	0.0043	0.0034	0.00098
842021	0.0	STOCK	1-20-84	992.8	1.97	15.0284	0.0037	1.2398	272.24	0.0031	0.0031	0.00061
842027	0.0	STOCK	1-24-84	1077.9	2.61	15.1913	0.0039	1.2759	269.18	0.0032	0.0016	0.00227
STRAIGHT PIPE, NO CATALYST:												
842033	0.0	NONE	1-31-84	1164.6	170.71	15.1574	0.4770	16.6208	244.50	1.5857	0.4741	0.00288
842038	0.0	NONE	2-01-84	1254.0	153.35	15.1448	0.4821	17.3859	243.44	1.4956	0.4783	0.00383
842282	0.0	NONE	2-02-84	1339.8	N/A	15.2675	0.5008	17.8730	240.33	1.4491	0.4976	0.00324
STRAIGHT PIPE, NO CATALYST (AFTER RETURN FROM TOYOTA):												
842284	0.0	NONE	2-22-84	1650.0	222.21	15.2960	0.4699	16.3412	241.54	1.4347	0.4687	0.00119
842289	0.0	NONE	2-23-84	1750.5	183.28	15.3904	0.4990	17.1448	239.44	1.4196	0.4975	0.00154
3Pt:2Pd(20):												
842294	0.0	(#1)	2-24-84	1833.5	4.92	15.6318	0.0062	0.8689	261.76	0.0757	0.0059	0.00025
842296	0.0	(#1)	2-25-84	1895.1	4.86	15.1883	0.0062	1.3052	268.61	0.0585	N/A	N/A
842298	0.0	(#1)	2-26-84	1956.7	5.25	15.4812	0.0050	1.2346	263.93	0.0508	0.0042	0.00075
Pd(20):												
842300	0.0	(#2)	2-27-84	2023.8	5.28	14.2389	0.0084	1.9874	285.97	0.0103	0.0084	0.00002
842302	0.0	(#2)	2-28-84	2085.5	3.80	15.5006	0.0126	4.8205	258.30	0.0280	0.0097	0.00294
842304	0.0	(#2)	2-29-84	2146.6	4.00	15.5833	0.0135	5.8254	255.12	0.0410	0.0104	0.00311
842306	0.0	(#2)	3-01-84	2207.8	4.27	15.5045	0.0124	4.7811	258.41	0.0465	0.0104	0.00188
842308	0.0	(#2)	3-02-84	2302.3	4.36	15.3437	0.0113	5.2828	260.02	0.0395	0.0090	0.00228
STRAIGHT PIPE, NO CATALYST:												
842310	0.0	NONE	3-04-84	2364.4	218.21	15.3732	0.5847	18.4316	237.21	1.3226	0.5827	0.00197
842332	0.0	NONE	3-05-84	2448.1	217.85	15.1763	0.6472	19.8818	237.50	1.3163	N/A	N/A

Based on the change in emissions following the replacement of the injectors, the data generated prior to March 10, 1984, may not be representative of the vehicle's performance from then on.

STRAIGHT PIPE, NO CATALYST (NEW INJECTORS, AIR PUMP INSTALLED):												
842337	0.0	NONE	3-14-84	2662.9	214.21	15.6993	0.3871	6.3752	251.03	1.9304	0.3856	0.00153
842692	0.0	NONE	3-15-84	2744.0	182.31	15.8065	0.3812	7.1679	247.65	1.8580	N/A	N/A
842697	0.0	NONE	3-16-84	2826.9	162.73	16.0496	0.3780	7.2062	243.87	1.7970	0.3775	0.00054
Pd(20):												
842702	0.0	(#2)	3-17-84	2907.3	11.44	15.8821	0.0134	0.7602	258.13	0.0602	0.0123	0.00106
842704	0.0	(#2)	3-18-84	2968.3	5.72	15.8800	0.0088	0.7919	257.69	0.0619	0.0087	0.00013
843001	0.0	(#2)	3-19-84	3029.7	4.79	15.8314	0.0089	0.6552	258.81	0.0582	0.0084	0.00048
843003	6.4	(#2)	3-20-84	3095.5	27.74	15.9542	0.0152	0.0080	258.49	1.0547	0.0143	0.00090
843005	6.4	(#2)	3-21-84	3156.8	30.09	15.8312	0.0118	0.0217	259.86	1.0782	0.0113	0.00041
843007	6.4	(#2)	3-22-84	3221.5	37.80	15.7102	0.0130	0.0245	262.38	1.0594	0.0129	0.00006
STRAIGHT PIPE, NO CATALYST:												
843009	0.0	NONE	3-23-84	3283.6	188.97	15.9044	0.4247	7.9711	244.99	1.7416	N/A	N/A
STRAIGHT PIPE, NO CATALYST (NEW INJECTORS):												
843014	0.0	NONE	4-10-84	3495.0	196.87	15.5619	0.4494	5.8188	254.48	1.9205	0.4447	0.00471
843019	0.0	NONE	4-11-84	3558.0	112.38	15.5388	0.4340	6.0961	253.96	1.9513	0.4294	0.00464
843157	0.0	NONE	4-12-84	3651.9	111.24	15.7147	0.4071	5.5353	251.70	1.9298	0.4024	0.00469
3Pt:2Pd(20):												
843162	0.0	(#1)	4-13-84	3734.9	6.61	15.8854	0.0106	0.7278	258.41	0.2503	0.0070	0.00361
843164	0.0	(#1)	4-17-84	3795.9	5.47	15.9463	0.0092	0.7391	256.67	0.2774	0.0059	0.00325
843166	0.0	(#1)	4-18-84	3856.7	4.16	16.0087	0.0069	0.7444	256.18	0.2550	0.0035	0.00336
843168	6.2	(#1)	4-19-84	3923.8	37.10	15.8331	0.0122	0.0047	260.14	1.0095	0.0079	0.00432
843170	6.2	(#1)	4-20-84	3984.5	42.95	15.7722	0.0126	0.0000	261.01	1.0517	0.0080	0.00456
843172	6.2	(#1)	4-24-84	4045.7	41.22	15.7121	0.0129	0.0000	261.60	1.1078	0.0082	0.00469
STRAIGHT PIPE, NO CATALYST:												
843174	0.0	NONE	4-25-84	4112.0	210.56	16.0719	0.4384	5.5883	245.75	1.8966	0.4338	0.00465
843179	0.0	NONE	4-26-84	4193.8	132.86	16.0516	0.4458	5.7804	246.43	1.8798	0.4412	0.00463
843184	0.0	NONE	4-27-84	42[illegible]3.6	159.91	16.1802	0.4285	5.7876	243.67	1.8785	0.4245	0.00402

Testing completed. Both catalysts were shipped to Calif for mileage accumulation (April 26, 1984).

Appendix 2C

Emissions during Idle

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Aldehyde (mg/min)	Mins / Gallon	HC (g/min)	CO (g/min)	CO2 (g/min)	NOx (g/min)	Non-Methane HC (g/min)	METHANE (g/min)
		TOYOTA CATALYST:										
842016	0.0	STOCK	1-19-84	895.2	0.566	94.0	0.0015	0.0135	43.9187	0.0008	0.0008	0.0007
842022	0.0	STOCK	1-20-84	1008.4	0.149	91.0	0.0003	0.0457	44.9817	0.0000	0.0002	0.0001
842028	0.0	STOCK	1-24-84	1094.0	0.00	102.0	0.0007	0.0054	40.3118	0.0000	0.0006	0.0001

Based on the change in emissions following the replacement of the injectors, the data generated prior to March 10, 1984, may not be representative of the vehicle's performance from then on.

Appendix 2D

Emissions during Steady State Driving at 10 MPH

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Aldehyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Methane HC (g/mi)	METHANE (g/mi)
TOYOTA CATALYST:												
842017	0.0	STOCK	1-19-84	898.4	2.54	7.8	0.006	0.897	524.012	0.005	0.0030	0.003
842023	0.0	STOCK	1-20-84	1008.5	1.85	7.9	0.010	2.239	518.317	0.000	0.0092	0.001
842029	0.0	STOCK	1-24-84	1094.0	2.26	13.0	0.005	0.111	317.197	0.005	0.0042	0.001
STRAIGHT PIPE, NO CATALYST:												
842034	0.0	NONE	1-31-84	1181.0	584.58	8.7	3.585	52.889	379.000	0.668	3.5658	0.019
842039	0.0	NONE	2-01-84	1270.6	557.85	8.9	6.569	53.996	358.515	0.634	6.5480	0.020
STRAIGHT PIPE, NO CATALYST (AFTER RETURN FROM TOYOTA):												
842285	0.0	NONE	2-22-84	1670.2	343.61	8.9	4.786	52.632	366.075	0.557	4.7792	0.007
842290	0.0	NONE	2-23-84	1767.0	321.40	8.9	8.565	54.298	347.667	0.650	8.5553	0.010
3Pt:2Pd(20):												
Pd(20):												
STRAIGHT PIPE, NO CATALYST:												
842311	0.0	NONE	3-04-84	2383.4	N/A	8.9	9.728	48.269	357.579	0.698	9.7181	0.010
842333	0.0	NONE	3-05-84	2468.8	N/A	8.3	10.325	53.035	379.688	0.837	N/A	N/A

Based on the change in emissions following the replacement of the injectors, the data generated prior to March 10, 1984, may not be representative of the vehicle's performance from then on.

STRAIGHT PIPE, NO CATALYST (NEW INJECTORS, AIR PUMP INSTALLED):												
842338	0.0	NONE	3-14-84	2680.0	N/A	9.6	0.590	11.036	408.019	0.432	0.5859	0.004
842693	0.0	NONE	3-15-84	2764.5	N/A	9.3	0.591	11.642	420.458	0.573	N/A	N/A
842698	0.0	NONE	3-16-84	2844.0	N/A	13.9	0.560	7.465	282.155	0.258	0.5603	0.000
Pd(20):												
STRAIGHT PIPE, NO CATALYST:												
843010	0.0	NONE	3-23-84	3300.1	N/A	9.6	1.140	21.971	389.323	0.431	N/A	N/A
STRAIGHT PIPE, NO CATALYST (NEW INJECTORS):												
843015	0.0	NONE	4-10-84	3507.0	N/A	9.7	0.639	10.188	406.570	0.485	0.6229	0.016
843153	0.0	NONE	4-11-84	3588.0	N/A	9.9	0.656	11.869	396.946	0.429	0.6366	0.019
843158	0.0	NONE	4-12-84	3670.9	N/A	9.5	0.625	9.856	417.580	0.577	0.6097	0.016
3Pt:2Pd(20):												
STRAIGHT PIPE, NO CATALYST:												
843175	0.0	NONE	4-25-84	4129.0	N/A	14.9	0.616	5.731	265.829	0.244	0.6084	0.008
843180	0.0	NONE	4-26-84	4213.0	N/A	9.7	0.685	11.819	403.688	0.470	0.6673	0.018
843185	0.0	NONE	4-27-84	4246.9	N/A	15.6	1.254	1.940	256.768	0.236	1.2527	0.001

Testing completed. Both catalysts were shipped to Calif for mileage accumulation (April 26, 1984).

Appendix 2E

Emissions during Steady State Driving at 20 MPH

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)
		TOYOTA CATALYST:										
842018	0.0	STOCK	1-19-84	935.0	1.42	15.5	0.012	0.394	265.116	0.002	0.0076	0.005
842024	0.0	STOCK	1-20-84	1016.6	7.17	15.3	0.009	0.397	268.274	0.000	0.0061	0.003
842030	0.0	STOCK	1-24-84	1106.2	3.88	16.0	0.012	0.517	255.909	0.000	0.0086	0.004
		STRAIGHT PIPE, NO CATALYST:										
842035	0.0	NONE	1-31-84	1194.0	185.26	16.6	0.761	23.438	208.052	0.554	0.7543	0.007
842040	0.0	NONE	2-01-84	1278.0	161.18	17.4	0.771	22.159	199.560	0.586	0.7642	0.006
		STRAIGHT PIPE, NO CATALYST (AFTER RETURN FROM TOYOTA):										
842286	0.0	NONE	2-22-84	1686.6	149.57	17.6	0.767	21.896	196.660	0.514	0.7641	0.003
842291	0.0	NONE	2-23-84	1770.0	153.54	17.1	1.248	26.105	195.193	0.501	1.2443	0.003
		3Pt:2Pd(20):										
		Pd(20):										
		STRAIGHT PIPE, NO CATALYST:										
842312	0.0	NONE	3-04-84	2387.0	N/A	16.6	3.660	27.249	194.183	0.697	3.6558	0.004
842334	0.0	NONE	3-05-84	2472.0	N/A	16.2	4.515	28.673	195.064	0.764	N/A	N/A

Based on the change in emissions following the replacement of the injectors, the data generated prior to March 10, 1984, may not be representative of the vehicle's performance from then on.

		STRAIGHT PIPE, NO CATALYST (NEW INJECTORS, AIR PUMP INSTALLED):										
842689	0.0	NONE	3-14-84	2683.5	N/A	18.4	0.394	5.217	214.361	0.656	0.3917	0.002
842694	0.0	NONE	3-15-84	2768.0	N/A	18.0	0.390	6.021	217.961	0.706	N/A	N/A
842699	0.0	NONE	3-16-84	2847.0	N/A	18.5	0.395	5.763	212.249	0.621	0.3946	0.000
		Pd(20):										
		STRAIGHT PIPE, NO CATALYST:										
843011	0.0	NONE	3-23-84	3303.2	N/A	18.7	0.456	8.348	205.866	0.496	N/A	N/A
		STRAIGHT PIPE, NO CATALYST (NEW INJECTORS):										
843016	0.0	NONE	4-10-84	3510.0	N/A	18.2	0.462	4.246	217.811	0.692	0.4575	0.005
843154	0.0	NONE	4-11-84	3592.0	N/A	18.5	0.419	4.660	213.953	0.666	0.4129	0.006
843159	0.0	NONE	4-12-84	3674.5	N/A	18.3	0.424	4.632	216.258	0.703	0.4184	0.006
		3Pt:2Pd(20):										
		STRAIGHT PIPE, NO CATALYST:										
843176	0.0	NONE	4-25-84	4132.0	N/A	18.5	0.445	4.766	213.071	0.655	0.4407	0.004
843181	0.0	NONE	4-26-84	4216.0	N/A	18.8	0.447	4.804	210.406	0.648	0.4421	0.005
843186	0.0	NONE	4-27-84	4299.5	N/A	19.8	0.704	1.231	203.645	0.392	0.7043	0.000

Testing completed. Both catalysts were shipped to Calif for mileage accumulation (April 26, 1984).

Appendix 2F

Emissions during Steady State Driving at 30 MPH

Test Number	O2 %	CAT#	Test Date	ODOM (km)	Alde-hyde (mg/mi)	Miles / Gallon	HC (g/mi)	CO (g/mi)	CO2 (g/mi)	NOx (g/mi)	Non-Meth-ane HC (g/mi)	METHANE (g/mi)
TOYOTA CATALYST:												
842019	0.0	STOCK	1-19-84	950.0	0.00	23.1	0.005	0.309	177.729	0.003	0.0041	0.001
842025	0.0	STOCK	1-20-84	1023.6	1.88	18.1	0.004	0.272	226.462	0.000	0.0028	0.002
842031	0.0	STOCK	1-24-84	1115.0	1.26	18.6	0.004	0.361	220.231	0.000	0.0018	0.002
STRAIGHT PIPE, NO CATALYST:												
842036	0.0	NONE	1-31-84	1200.0	116.90	18.8	0.522	19.512	186.108	0.799	0.5164	0.006
842041	0.0	NONE	2-01-84	1288.0	119.17	18.0	0.508	19.807	195.673	0.941	0.5036	0.005
STRAIGHT PIPE, NO CATALYST (AFTER RETURN FROM TOYOTA):												
842287	0.0	NONE	2-22-84	1696.4	101.47	18.8	0.522	16.757	191.521	0.933	0.5198	0.002
842292	0.0	NONE	2-23-84	1778.7	103.28	18.4	0.612	19.037	192.127	0.912	0.6088	0.003
3Pt:2Pd(20):												
Pd(20):												
STRAIGHT PIPE, NO CATALYST:												
842313	0.0	NONE	3-04-84	2393.0	N/A	18.5	0.741	22.073	185.537	0.773	0.7383	0.003
842335	0.0	NONE	3-05-84	2478.2	N/A	7.5	3.405	63.514	441.030	1.896	N/A	N/A

Based on the change in emissions following the replacement of the injectors, the data generated prior to March 10, 1984, may not be representative of the vehicle's performance from then on.

STRAIGHT PIPE, NO CATALYST (NEW INJECTORS, AIR PUMP INSTALLED):												
842690	0.0	NONE	3-14-84	2691.3	N/A	18.8	0.388	5.434	209.538	1.269	0.3868	0.001
842695	0.0	NONE	3-15-84	2773.8	N/A	19.8	0.359	6.120	197.433	1.086	0.0000	0.000
842700	0.0	NONE	3-16-84	2853.0	N/A	20.1	0.355	6.296	193.586	0.987	0.3541	0.001
Pd(20):												
STRAIGHT PIPE, NO CATALYST:												
843012	0.0	NONE	3-23-84	3310.0	N/A	19.7	0.400	6.378	197.907	1.155	N/A	N/A
STRAIGHT PIPE, NO CATALYST (NEW INJECTORS):												
843017	0.0	NONE	4-10-84	3517.0	N/A	19.6	0.459	4.824	200.872	1.250	0.4545	0.004
843155	0.0	NONE	4-11-84	3598.0	N/A	19.7	0.423	5.129	199.336	1.225	0.4180	0.005
843160	0.0	NONE	4-12-84	3680.5	N/A	19.9	0.401	4.932	198.231	1.167	0.3974	0.004
3Pt:2Pd(20):												
STRAIGHT PIPE, NO CATALYST:												
843177	0.0	NONE	4-25-84	4140.0	N/A	20.0	0.531	1.218	202.226	0.977	0.5302	0.000
843182	0.0	NONE	4-26-84	4225.0	N/A	19.5	0.454	5.670	200.501	1.268	0.4499	0.004
843187	0.0	NONE	4-27-84	4310.0	N/A	19.7	0.438	5.664	198.326	1.180	0.4338	0.005

Testing completed. Both catalysts were shipped to Calif for mileage accumulation (April 26, 1984).

APPENDIX 3

Unscheduled Maintenance on the Toyota Cressida

Appendix 3

Unscheduled Maintenance on the Toyota Cressida

Date	Problem	Repair
Feb. 1, 1984	Excessive cranking to start in prior testing--no gasoline injection.	New thermal switch to cold start injector installed.
Feb. 1, 1984	Noise in engine compartment.	Vacuum switch disabled, later replaced on April 15, 1984.
Feb. 17, 1984	Fuel gauge not reading full.	Replaced sender unit, corrosion noted.
	Low coolant level.	Coolant added, new tube in overflow reservoir.
Mar. 9, 1984	None	Air pump installed.
	Increase in HC and CO.	New fuel injectors installed.
Mar. 26, 1984	None	Installed a new thermal switch with revised calibrations.
Apr. 5, 1984	Lack of acceleration and metallic particles in fuel.	Installed new fuel injectors, flushed fuel tank of foreign materials, and cleaned fuel strainer in tank.
May 7, 1984	Prior injector plugging.	New stainless steel fuel tank and new fuel filter at engine.
May 23, 1984	Prior injector plugging.	Installed new fuel inlet pipe to the fuel tank (nickel plated), fuel pump (nickel plated), fuel injectors, and fuel log to main injectors (nickel plated).
June 13, 1984	Screw found missing in pulsating damper valve.	Valve replaced.

Appendix 3 (cont'd)

Unscheduled Maintenance on the Toyota Cressida

Date	Problem	Repair
June 28, 1984	High HC	New injectors, new gasoline-type pulsating damper valve.
June 29, 1984	Prior problem	Pulsating damper valve replaced with methanol-compatible unit.

APPENDIX 4

Statistics with the Data Stratified by Oxygen Level, Test Cycle, and Individual Catalyst

(Data generated prior to March 10, 1984, are omitted from these analyses since they cannot be duplicated due to the shift in emissions which followed the replacement of the fuel injectors.)

Emission Statistics for FTP Driving Cycle
For Catalyst: 3Pt:2Pd(20)

Tested As a 3-Way Catalyst (0% Exhaust Oxygen)

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	33.420	42.510	37.293	4.6915
Fuel Econ (mpg)	3	12.214	12.289	12.248‡	---
HC	3	.22960	.25400	.23827	.01365
CO	3	2.7308	2.8905	2.7972	.08320
NOx	3	.49650	.52060	.51133	.01298
Non-Methane HC	3	.22000	.24380	.22897	.01294
Methane	3	.00810	.01025	.00931	.00110

Tested As an Oxidizing Catalyst (6.2% Exhaust Oxygen)

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	236.75	283.01	264.57	24.517
Fuel Econ (mpg)	3	11.951	12.133	12.048‡	---
HC	3	.25900	.28970	.27233	.01574
CO	3	.30450	.37290	.33580	.03457
NOx	3	1.2971	1.4140	1.3513	.05891
Non-Methane HC	3	.25090	.28050	.26387	.01514
Methane	3	.00804	.00920	.00845	.00065

‡ The mean Fuel Economy is a harmonic average.

Emission Statistics for HWY Driving Cycle
For Catalyst: 3Pt:2Pd(20)

Tested As a 3-Way Catalyst (0% Exhaust Oxygen)

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	4.1600	6.6100	5.4133	1.2260
Fuel Econ (mpg)	3	15.885	16.009	15.947‡	---
HC	3	.00690	.01060	.00890	.00187
CO	3	.72780	.74440	.73710	.00848
NOx	3	.25030	.27740	.26090	.01448
Non-Methane HC	3	.00350	.00700	.00547	.00179
Methane	3	.00325	.00361	.00341	.00018

Tested As an Oxidizing Catalyst (6.2% Exhaust Oxygen)

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	37.100	42.950	40.423	3.0053
Fuel Econ (mpg)	3	15.712	15.833	15.772‡	---
HC	3	.01220	.01290	.01257	.00035
CO	3	0.	.00470	.00157	.00271
NOx	3	1.0095	1.1078	1.0563	.04931
Non-Methane HC	3	.00790	.00820	.00803	.00015
Methane	3	.00432	.00469	.00452	.00019

‡ The mean Fuel Economy is a harmonic average.

Emission Statistics for FTP Driving Cycle
For Catalyst: Pd(20)

Tested As a 3-Way Catalyst (0% Exhaust Oxygen)

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	34.710	47.420	40.977	6.3568
Fuel Econ (mpg)	3	11.906	12.171	12.026‡	---
HC	3	.27420	.31580	.29317	.02104
CO	3	1.8313	2.0766	1.9654	.12424
NOx	3	.30010	.33990	.32123	.02001
Non-Methane HC	3	.27310	.31300	.29177	.02007
Methane	3	.00034	.00279	.00140	.00126

Tested As an Oxidizing Catalyst (6.4% Exhaust Oxygen)

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	209.62	250.73	236.50	23.289
Fuel Econ (mpg)	3	11.794	12.003	11.911‡	---
HC	3	.25930	.29320	.27703	.01700
CO	3	.68920	.75680	.71810	.03485
NOx	3	1.3115	1.3317	1.3217	.01010
Non-Methane HC	3	.25910	.29170	.27637	.01639
Methane	3	.00024	.00152	.00070	.00071

‡ The mean Fuel Economy is a harmonic average.

Emission Statistics for HWY Driving Cycle
For Catalyst: Pd(20)

Tested As a 3-Way Catalyst (0% Exhaust Oxygen)

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	4.7900	11.440	7.3167	3.6011
Fuel Econ (mpg)	3	15.831	15.882	15.864‡	---
HC	3	.00880	.01340	.01037	.00263
CO	3	.65520	.79190	.73577	.07155
NOx	3	.05820	.06190	.06010	.00185
Non-Methane HC	3	.00840	.01230	.00980	.00217
Methane	3	.00013	.00106	.00056	.00047

Tested As an Oxidizing Catalyst (6.4% Exhaust Oxygen)

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	27.740	37.800	31.877	5.2626
Fuel Econ (mpg)	3	15.710	15.954	15.831‡	---
HC	3	.01180	.01520	.01333	.00172
CO	3	.00800	.02450	.01807	.00883
NOx	3	1.0547	1.0782	1.0641	.01244
Non-Methane HC	3	.01130	.01430	.01283	.00150
Methane	3	.00006	.00090	.00046	.00042

‡ The mean Fuel Economy is a harmonic average.

Emission Statistics for 'No Catatyst' (i.e., Baseline) at a 0% Exhaust Oxygen Level:

FTP Driving Cycle

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	9	219.45	369.11	283.55	43.597
Fuel Econ (mpg)	10	12.116	12.406	12.295‡	---
HC	10	.89790	1.0719	.99440	.06665
CO	10	7.6501	12.276	8.8533	1.3836
NOx	10	1.9574	2.1949	2.0776	.07223
Non-Methane HC	9	.89730	1.0692	.99766	.06182
Methane	9	.00056	.00909	.00629	.00330

HWY Driving Cycle

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	10	111.24	214.21	167.20	38.096
Fuel Econ (mpg)	10	15.539	16.180	15.855‡	---
HC	10	.37800	.44940	.41742	.02710
CO	10	5.5353	7.9711	6.3327	.83393
NOx	10	1.7416	1.9513	1.8783	.06542
Non-Methane HC	8	.37750	.44470	.41739	.02564
Methane	8	.00054	.00471	.00368	.00167

‡ The mean Fuel Economy is a harmonic average.

Emission Statistics for Steady State Driving Cycles For No Catatyst & for a 0% Exhaust Oxygen Level:

10 MPH Steady State Driving Cycle

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0	N/A	N/A	N/A	N/A
Fuel Econ (mpg)	10	9.3000	15.600	10.947‡	---
HC	10	.56000	1.2540	.73560	.24720
CO	10	1.9400	21.971	10.352	5.1888
NOx	10	.23600	.57700	.41350	.12727
Non-Methane HC	8	.56030	1.2527	.69297	.22841
Methane	8	0.	.01900	.01025	.00791

20 MPH Steady State Driving Cycle

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0	N/A	N/A	N/A	N/A
Fuel Econ (mpg)	10	18.000	19.800	18.559‡	---
HC	10	.39000	.70400	.45360	.09189
CO	10	1.2310	8.3480	4.9688	1.7635
NOx	10	.39200	.70600	.62350	.10118
Non-Methane HC	8	.39170	.70430	.45777	.10228
Methane	8	0.	.00600	.00350	.00251

30 MPH Steady State Driving Cycle

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	0	N/A	N/A	N/A	N/A
Fuel Econ (mpg)	10	18.800	20.100	19.674‡	---
HC	10	.35500	.53100	.42080	.05276
CO	10	1.2180	6.3780	5.1665	1.4903
NOx	10	.97700	1.2690	1.1564	.10807
Non-Methane HC	9	0.	.53020	.38052	.15114
Methane	9	0.	.00500	.00267	.00212

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‡ The mean Fuel Economy is a harmonic average.

Emission Statistics for 3Pt:2Pd(20) Catalyst Tested As a 3-Way Catalyst (0% Exhaust Oxygen)

Bag 1 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	107.13	143.29	123.00	18.482
HC	3	.967	1.069	1.0017	.05832
CO	3	4.602	5.313	4.8953	.37145
NOx	3	1.031	1.108	1.0657	.03907
Non-Methane HC	3	.949	1.053	.98500	.05892
Methane	3	.016	.017	.01633	.00058

Bag 2 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	10.87	12.42	11.683	.77784
HC	3	.016	.021	.01767	.00289
CO	3	2.249	2.455	2.3567	.10332
NOx	3	.264	.276	.27033	.00603
Non-Methane HC	3	.007	.011	.00900	.00200
Methane	3	.006	.010	.00800	.00200

Bag 3 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	19.43	23.91	21.287	2.3363
HC	3	.078	.083	.08133	.00289
CO	3	1.986	2.104	2.0513	.06001
NOx	3	.534	.568	.55067	.01701
Non-Methane HC	3	.071	.077	.07500	.00346
Methane	3	.006	.007	.00633	.00058

Emission Statistics for 3Pt:2Pd(20) Catalyst
Tested As an Oxidizing Catalyst (6.2% Exhaust Oxygen)

Bag 1 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	287.83	428.82	339.65	77.562
HC	3	.968	1.054	1.0100	.04304
CO	3	1.294	1.574	1.4277	.14043
NOx	3	2.317	2.566	2.4807	.14178
Non-Methane HC	3	.952	1.037	.99367	.04252
Methane	3	.016	.017	.01633	.00058

Bag 2 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	235.99	298.97	273.04	32.931
HC	3	.039	.053	.04567	.00702
CO	3	-.008	.000	-.00267	.00462
NOx	3	.723	.817	.76233	.04884
Non-Methane HC	3	.032	.045	.03867	.00651
Methane	3	.006	.008	.00667	.00115

Bag 3 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	171.53	204.56	191.91	17.818
HC	3	.134	.160	.14600	.01312
CO	3	.136	.171	.15467	.01762
NOx	3	1.563	1.675	1.6183	.05601
Non-Methane HC	3	.128	.154	.14000	.01312
Methane	3	.005	.006	.00533	.00058

Emission Statistics for Pd(20) Catalyst
Tested As a 3-Way Catalyst (0% Exhaust Oxygen)

Bag 1 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	98.33	153.21	127.01	27.523
HC	3	1.132	1.283	1.2187	.07794
CO	3	4.796	5.248	5.0167	.22619
NOx	3	.835	.865	.84933	.01504
Non-Methane HC	3	1.126	1.280	1.2150	.07976
Methane	3	.001	.005	.00300	.00200

Bag 2 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	11.50	13.55	12.423	1.0400
HC	3	.020	.026	.02400	.00346
CO	3	.668	1.021	.88967	.19306
NOx	3	.098	.158	.12333	.03107
Non-Methane HC	3	.020	.026	.02267	.00306
Methane	3	.000	.004	.00133	.00231

Bag 3 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	28.29	32.30	30.397	2.0127
HC	3	.070	.139	.10633	.03465
CO	3	1.456	1.880	1.7073	.22268
NOx	3	.282	.329	.29967	.02558
Non-Methane HC	3	.069	.138	.10533	.03465
Methane	3	.000	.001	.00033	.00058

Emission Statistics for Pd(20) Catalyst
Tested As an Oxidizing Catalyst (6.4% Exhaust Oxygen)

Bag 1 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	338.00	379.64	362.89	21.983
HC	3	1.008	1.190	1.1020	.09115
CO	3	2.351	2.535	2.4613	.09733
NOx	3	2.504	2.513	2.5100	.00520
Non-Methane HC	3	1.007	1.187	1.1000	.09015
Methane	3	.001	.003	.00200	.00100

Bag 2 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	154.29	198.42	175.98	22.074
HC	3	.025	.028	.02633	.00153
CO	3	.080	.145	.12233	.03669
NOx	3	.717	.735	.72400	.00964
Non-Methane HC	3	.024	.028	.02567	.00208
Methane	3	.000	.001	.00033	.00058

Bag 3 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	3	217.83	303.91	256.32	43.755
HC	3	.124	.135	.13100	.00608
CO	3	.482	.584	.53600	.05126
NOx	3	1.528	1.582	1.5617	.02937
Non-Methane HC	3	.123	.134	.13000	.00608
Methane	3	.000	.001	.00033	.00058

Emission Statistics for No Catalyst (i.e., Baseline)

Bag 1 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	9	284.24	504.40	367.44	83.667
HC	10	1.811	2.110	1.9600	.08639
CO	10	9.899	13.427	10.853	1.1638
NOx	10	2.898	3.238	3.0724	.10954
Non-Methane HC	9	1.793	2.094	1.9526	.08851
Methane	9	.001	.018	.01267	.00577

Bag 2 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	10	224.41	392.94	287.64	47.140
HC	10	.668	.909	.77760	.07567
CO	10	7.285	13.090	8.6334	1.7517
NOx	10	1.439	1.615	1.5376	.05849
Non-Methane HC	9	.668	.909	.78311	.07128
Methane	9	.000	.007	.00456	.00300

Bag 3 of the FTP Driving Cycle:

VARIABLE	N	MINIMUM	MAXIMUM	MEAN	STD DEV
Aldehyde	10	173.54	237.87	207.49	20.103
HC	10	.584	.746	.67760	.06154
CO	10	6.635	9.872	7.7636	.94252
NOx	10	2.203	2.595	2.3526	.11160
Non-Methane HC	9	.582	.740	.68344	.05405
Methane	9	.000	.007	.00433	.00260

APPENDIX 5

Fuel Analysis

Appendix 5

Analysis of One Batch of Test Fuel

The following analysis was performed by Southwest Research Institute in November 1982 and were reported to EPA in May 1983:

Test	Results
Heat of Combustion (ASTM D-240)	
Gross	10,292 Btu/lb
Net	9,143 Btu/lb
Water Content by Karl Fischer Titration (ASTM D-1744) wt. percent	0.055 %
API Gravity (ASTM D-287)	46.9° @ 60°F
Density (ASTM D-287)	0.7928 @ 15°C
Flash Point (ASTM D-93)	71.9°F
Acid Number (ASTM D-664) equiv. mg KOH/g sample	0.00
Lead by A.A. (ASTM D-3237)	3 ppm
Sulfur by Dohrmann Microcoulometer	N.D. (<0.001 %)
Phosphorous by A.A.	1.7 ppm
Higher Alcohols by G.C.	N.D. (<0.1% ea.)

N.D. = none detected.