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OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

Results from the Second Year of Operation of the Federal Methanol Fleet at Argonne National Laboratory

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OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
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Engineering Technology Division

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ABSTRACT

Argonne National Laboratory has completed two full years of operation of 19 vehicles in the Federal Methanol Fleet Project; ten of the vehicles are fueled with methanol. Over one-half million miles have been accumulated on the fleet vehicles so far, and comparisons of efficiency continue to show nearly equal performance between the methanol and gasoline vehicles. Emissions tests of some of the vehicles during the second year revealed degradations of emissions control systems for both the methanol and gasoline vehicle types, although emissions were still within legal limits. Methanol vehicles continued to require more maintenance, and the maintenance labor intensity (hours per 1000 miles) increased for all the vehicle types being monitored. Accumulation of metals in the lubricating oil of the methanol vehicles continued to be elevated compared to that of the gasoline vehicles although not at alarming levels. Drivers indicated less satisfaction with vehicles in the test during the second year, both for methanol as well as gasoline vehicles.

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1. INTRODUCTION

Argonne National Laboratory (ANL) has operated nineteen vehicles for over two years for the Department of Energy's Federal Methanol Fleet Project; ten of the vehicles are methanol-powered and nine are comparable gasoline vehicles. The Oak Ridge National Laboratory (ORNL) has project management responsibility for the entire Methanol Fleet Project including activities at ANL and, as such, collects and disseminates data and information related to the operation of the project. Previous ORNL reports[1,2*] detailed the results of the first year of operation at ANL;

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*Superscripted numbers denote references at the end of the report.

this report deals with the second year's operation. Because much of the project's background and the ANL fleet have been described in previous reports,[1-5] it will not be discussed again at any length in this report. The reader is encouraged to refer to the earlier reports for those details. The present report will deal primarily with the results and data from the past year of operation and the comparison of those data with the similar results from the first year.

Vehicles in the project at ANL include ten 1986 Chevrolet S-10 pickup trucks (5 methanol and 5 gasoline) and nine 1986 Ford Crown Victoria Sedans (5 methanol and 4 gasoline). Methanol conversions were made by Alcohol Energy Systems, Inc. and include special provisions for cold-starting in the Illinois climate where ANL is located. On the Chevrolets, a separate gasoline fuel system is automatically engaged during cold weather to start the engine and provide about 30 seconds of running before automatically switching to the methanol fuel system. The Fords incorporate a proprietary system developed by Ford which uses only the methanol fuel mixture and provides reliable starting nominally at temperatures as low as −20°F (−29°C).

The methanol fuel mixture at ANL is M85 (85% methanol and 15% regular unleaded gasoline), and the gasoline portion is tailored to the extent possible throughout the year to try to maintain favorable vapor pressure. An underground tank and associated dispensing pump are used on-site at ANL for dispensing fuel into the methanol vehicles. This is the only place in the geographic region where they can be refueled.

The Fords are used by the security department at ANL and are outfitted as police cars. They are used around the clock every day of the week, and typical driving patterns include considerable engine idling time and short trips. Their use is confined, for the most part, to the ANL site. The Chevrolet trucks are used by ANL maintenance personnel for transportation around the site to various job locations. They are used typically only during one shift per day and are also generally confined to the ANL site, which has a total of eleven miles of roads.

A small amount of data including the drivers' ratings of the vehicle's ease of starting and driveability is recorded for each trip. Fueling and maintenance data are kept by the motor pool personnel. The lubricating oil is sampled in each vehicle every 1000 miles and sent to a laboratory where it is analyzed for wear metal content, fuel dilution, base number, etc. All data from the methanol fleet project at ANL are forwarded to the ORNL project management office where the Federal Methanol Fleet database is maintained.

2. SUMMARY

The Federal Methanol Fleet operating at Argonne National Laboratory (ANL) has completed two full years of operation and is well into its third year of operation with ten methanol vehicles and nine gasoline counterpart vehicles. Nearly 200,000 miles (320,000 km) were accumulated on the nineteen vehicles during the year bringing the total to approximately one-half million miles (800,000 km). Overall fuel economy and energy efficiency for the vehicles were very similar to the first year, although there were some individual vehicle differences due to changes in patterns of use during the year.

Several of the vehicles were retested for emissions during the second year to determine how the emissions control systems may have changed with use and age. For the most part, emissions were still within legal limits (carbon monoxide being a problem on some vehicles), but in nearly all cases, including the gasoline vehicles, emissions increased over those measured before the vehicles were placed in service.

Examination of maintenance data reveals that the frequency of maintenance was stable during the second year and that the methanol vehicles still require more frequent service. Maintenance labor intensity (hours per 1000 miles) increased during the second year for all vehicle types, methanol and gasoline, although reasons for this are unclear.

Analyses of oil samples have shown that accumulation rates of iron and lead in the oil remained elevated in the methanol vehicles as compared to the gasoline vehicles. In the case of lead, the situation may have been aggravated by the release of lead from plating in the fuel tanks (for the Chevrolet S-10 vehicles). Otherwise, the rates of accumulation of metals in the oil do not appear to be alarming.

There was a general decline in the drivers' opinions of vehicles during the second year. Whereas during the first year the drivers indicated a high level of satisfaction with the vehicles of both types (methanol or gasoline), during the second year they began to rate the vehicles lower on ease of starting and driveability. However, contrary to one's intuition, the data do not reveal a clear and universal driver preference for gasoline vehicles over methanol vehicles.

3. RESULTS

3.1 FLEET UTILIZATION AND FUEL CONSUMPTION

Tables 1 and 2 summarize the fleet utilization (mileage accumulation) and fuel consumption results for the second year of operation. Shown are total miles driven, average miles per trip, average fuel economy, and efficiency for each of the nineteen cars as well as aggregate totals for the vehicles of each type - methanol or gasoline. Tables 3 and 4 summarize the same parameters for the entire two years of operation, while Tables 5 and 6 are repeated from the previous annual report[1] to facilitate comparison with the first year's data.

Nearly 200,000 miles (320,000 km) were accumulated on the nineteen fleet vehicles during the year, with the Fords accounting for about two-thirds of the total. For the two years, approximately one-half million miles (800,000 km) have been accumulated. Average trip length increased for all four car types, including a doubling of the average trip mileage for the Fords. This probably results from drivers' filling out the trip logs less frequently, as opposed to actual increases in trip lengths.

Fuel economy results were very similar to the first year's results, as were the energy efficiencies. Two of the gasoline Chevrolets, ME-561 and 567 had much lower average trip mileages and disproportionately lower total usage than the rest. One of them, ME-567, also showed much lower fuel economy, probably resulting from more stop-and-go driving. Use of the Fords was much more evenly distributed than for the Chevrolets, probably as a result of the Fords' service as police cars.

3.2 RESULTS OF EMISSIONS TESTS

All of the vehicles at ANL were tested for emissions prior to and immediately after conversion to methanol. A selected number of them were retested during the second year to see how emissions may have changed with use and age. Results from the recent testing are compared with the original results in this section.

Results from the early tests, after conversion to methanol, are presented in Table 7. These tests were conducted by the Bay Area Emissions Laboratory under the supervision of Alcohol Energy Systems, Inc., who also had performed the conversions on the vehicles. Results were calculated using a special protocol to deal with the "unburned fuel" in the exhaust. This protocol involved an assumption that the "unburned fuel" in the exhaust had the same composition as the fuel supplied to the engine. Interpretation of the output from the hydrocarbon analyzer (flame ionization detector - FID) was accomplished by (1) knowing the "methanol response factor" of the particular analyzer, (2) ignoring aldehydes in the exhaust, and (3) the fact that the reported value for

Table 1. ANL fleet utilization and fuel consumption data. Second year – January 1, 1988 to December 31, 1988

Chevrolet S-10 Pickup Trucks

Vehicle ID	Total miles	Average miles/trip	Fuel economy	
			mpg	km/Gj[a]
		Methanol vehicles		
ME-560	3,917	20	9.0	209
ME-562	4,791	19	9.6	223
ME-564	6,520	33	9.6	225
ME-566	4,552	22	8.0	187
ME-568	10,770	15	9.0	210
Total	30,550	19[b]	9.0[b]	211[b]
		Gasoline vehicles		
ME-561	3,519	6	19.2	256
ME-563	7,236	35	18.1	239
ME-565	16,328	22	16.8	223
ME-567	2,630	13	13.2	174
ME-569	6,231	23	15.7	208
Total	35,944	18[b]	17.2[b]	227[b]

[a]Based on methanol heating value of 56,560 Btu/gal and gasoline heating value of 115,400 Btu/gal: hence, M85 heating value equals 65,386 Btu/gal.

[b]Based on total quantities, not an average of individual averages.

Table 2. ANL fleet utilization and fuel consumption data. Second year – January 1, 1988 to December 31, 1988

Ford Crown Victorias

Vehicle ID	Total miles	Average miles/trip	Fuel economy	
			mpg	km/Gj[a]
		Methanol vehicles		
ME-570	16,757	29	6.6	154
ME-572	16,126	28	6.5	152
ME-574	17,099	28	6.4	150
ME-576	13,509	25	5.9	137
ME-578	11,970	29	5.5	129
Total	75,915	28[b]	6.2[b]	145[b]
		Gasoline vehicles		
ME-571	15,382	29	10.3	135
ME-573	15,016	21	10.3	136
ME-575	10,814	23	10.3	136
ME-577	16,062	27	11.3	149
Total	57,274	25[b]	10.5[b]	139[b]

[a]Based on methanol heating value of 56,560 Btu/gal and gasoline heating value of 115,400 Btu/gal: hence, M85 heating value equals 65,386 Btu/gal.

[b]Based on total quantities, not an average of individual averages.

Table 3. ANL fleet utilization and fuel consumption data. Two years – through December 31, 1988

Chevrolet S-10 Pickup Trucks

Vehicle ID	Total miles	Average miles/trip	Fuel economy	
			mpg	km/Gj[a]
Methanol vehicles				
ME-560	20,363	16	9.6	225
ME-562	10,890	20	9.1	211
ME-564	13,786	27	9.6	223
ME-566	12,330	27	8.5	198
ME-568	16,216	11	9.6	225
Total	73,585	17[b]	9.4[b]	218[b]
Gasoline vehicles				
ME-561	18,381	10	17.1	226
ME-563	17,064	30	17.2	227
ME-565	22,738	20	17.3	229
ME-567	8,545	12	15.8	209
ME-569	15,642	24	16.3	215
Total	82,370	16[b]	17.0[b]	225[b]

[a]Based on methanol heating value of 56,560 Btu/gal and gasoline heating value of 115,400 Btu/gal: hence, M85 heating value equals 65,386 Btu/gal.

[b]Based on total quantities, not an average of individual averages.

Table 4. ANL fleet utilization and fuel consumption data. Two years – through December 31, 1988

Ford Crown Victorias

Vehicle ID	Total miles	Average miles/trip	Fuel economy	
			mpg	km/Gj[a]
Methanol vehicles				
ME-570	31,937	15	6.5	151
ME-572	42,577	14	6.3	147
ME-574	36,963	15	6.3	147
ME-576	29,198	14	5.9	139
ME-578	32,629	15	5.8	136
Total	173,304	15[b]	6.2[b]	145[b]
Gasoline vehicles				
ME-571	34,930	13	10.2	135
ME-573	52,974	13	10.4	138
ME-575	31,901	11	10.2	135
ME-577	51,965	15	10.9	145
Total	171,770	13[b]	10.5[b]	139[b]

[a]Based on methanol heating value of 56,560 Btu/gal and gasoline heating value of 115,400 Btu/gal: hence, M85 heating value equals 65,386 Btu/gal.

[b]Based on total quantities, not an average of individual averages.

Table 5. ANL fleet utilization and fuel consumption data. First year — through December 31, 1987

Chevrolet S-10 Pickup Trucks

Vehicle ID	Total miles	Average miles/trip	Fuel economy	
			mpg	km/Gj[a]
		Methanol vehicles		
ME-560	16,446	15	9.8	229
ME-562	6,099	21	8.7	203
ME-564	7,266	22	9.5	222
ME-566	7,778	30	8.8	205
ME-568	5,446	7	11.2	261
Total	43,035	16[b]	9.6[b]	224[b]
		Gasoline vehicles		
ME-561	14,862	11	16.6	219
ME-563	9,828	27	16.6	219
ME-565	6,410	16	18.5	245
ME-567	5,915	12	17.3	229
ME-569	9,411	25	16.7	221
Total	46,426	16[b]	16.9[b]	219[b]

[a]Based on methanol heating value of 56,560 Btu/gal and gasoline heating value of 115,400 Btu/gal: hence, M85 heating value equals 65,386 Btu/gal.

[b]Based on total quantities, not an average of individual averages.

Table 6. ANL fleet utilization and fuel consumption data. First year — through December 31, 1987

Ford Crown Victorias

Vehicle ID	Total miles	Average miles/trip	Fuel economy	
			mpg	km/Gj[a]
		Methanol vehicles		
ME-570	15,180	10	6.3	147
ME-572	26,451	11	6.2	145
ME-574	19,864	11	6.2	145
ME-576	15,303	10	6.0	140
ME-578	20,591	12	6.0	140
Total	97,389	11[b]	6.2[b]	145[b]
		Gasoline vehicles		
ME-571	19,548	9	10.2	135
ME-573	37,958	12	10.5	139
ME-575	21,087	9	10.2	135
ME-577	35,903	12	10.8	143
Total	114,496	11[b]	10.5[b]	139[b]

[a]Based on methanol heating value of 56,560 Btu/gal and gasoline heating value of 115,400 Btu/gal: hence, M85 heating value equals 65,386 Btu/gal.

[b]Based on total quantities, not an average of individual averages.

Table 7. FTP emissions results — following conversion to methanol

Vehicle ID	FTP results (gm/mile)		
	HC[a]	CO	NO_x
Chevrolets			
ME-560	0.29	1.39	0.62
ME-562	0.17	0.74	0.51
ME-564	0.33	1.36	0.71
ME-566	0.28	1.44	0.44
ME-568	0.27	1.39	0.43
Range:	0.17–0.33	0.74–1.44	0.43–0.71
Fords			
ME-570	0.17	0.97	0.70
ME-572	0.20	0.76	0.62
ME-574	0.28	1.44	0.63
ME-576	0.13	1.11	0.57
ME-578	0.35	1.24	0.76
Range:	0.13–0.35	0.76–1.44	0.62–0.76
Applicable federal standards (gm/mile)	0.41	3.4	1.0

[a]See text for description of protocol used to compute HC values.

the hydrocarbons (HC) consisted of the mass of the non-oxygenated hydrocarbons plus the mass of the methanol minus the mass of the oxygen in the methanol. The gasoline-based dilution factor equation was also revised to accommodate the methanol in the fuel.

Although the use of this protocol has a significant effect on the value of HC reported, it has a negligible effect on the carbon monoxide (CO) and oxides of nitrogen (NO_x) values. The calculated HC values (Table 7) all fell within the EPA standards.

Last year, after accumulating a number of miles, six of the vehicles (four methanol and two gasoline) were retested by the Amoco Research Laboratory in Naperville, Illinois. The protocol used by Amoco to deal with the "unburned fuel" emissions was as follows:

> The unburned fuel in bags 2 and 3 (cold stabilized and hot transient phases of the Federal Test Procedure — FTP) was assumed to be all Indolene exhaust (non-oxygenated hydrocarbons). It was also assumed that the FID had a known response factor (0.79) to methanol and that in bag 1 (cold transient phase of the FTP) the methanol concentration and the non-oxygenated hydrocarbon concentration occurred in the ratio of 85/15 — the same ratio as the liquid methanol volume to liquid Indolene volume in the fuel. The HC was reported by calculating what has been called the "organic material hydrocarbon equivalent" (OMHCE). This approach essentially calculates the mass of Indolene exhaust hydrocarbons (OMHCE) that would have the same amount of carbon that exists in the actual mixture of non-oxygenated hydrocarbons and methanol in the exhaust. Aldehydes were not considered.

The results of this testing are given in Tables 8 and 9. Clearly, the carbon monoxide values obtained for the methanol S-10s indicate a problem with the fuel metering systems in these two vehicles. An examination of the test data suggests that the problems are associated with the cold transient portion of the test.

Data of Tables 7 and 8 reflect two different protocols for calculating the organic emissions, or hydrocarbons. Reported results for the

Table 8. Results of emissions retests

Vehicle description	Mileage (miles)	FTP results (gm/mile)		
		HC[a]	CO	NO_x
Chevrolets				
ME-562 (meth)	7,600	0.72	8.25	0.64
ME-568 (meth)	8,700	0.43	6.30	0.84
ME-565 (gas)	10,400	0.21	1.93	0.51
Fords				
ME-572 (meth)	32,800	0.67	2.22	0.80
ME-574 (meth)	26,900	0.64	3.13	0.71
ME-575 (gas)	23,400	0.67	0.77	1.07

[a]See text for description of protocol used to compute HC emissions from methanol-fueled vehicles.

Table 9. Ratio of in-service emissions to post-conversion emissions

Vehicle description	Mileage (miles)	Retest results/ post-conversion results		
		HC[a]	CO	NO_x
Chevrolets				
ME-562 (meth)	7,600	4.2	11.2	1.3
ME-568 (meth)	8,700	1.6	4.5	2.0
ME-565 (gas)	10,400	1.2	6.0	2.1
Fords				
ME-572 (meth)	32,800	3.4	2.9	1.3
ME-574 (meth)	26,900	2.3	2.2	1.1
ME-575 (gas)	23,400	3.4	1.9	2.5

[a]See text for protocol used in calculating HC values.

same values of emissions may be different, albeit small differences, depending on the protocol used. Therefore, recognizing the need to report emissions values on a consistent basis, ORNL has reprocessed emissions data using another protocol developed for this comparison. Referred to as the "ORNL Protocol", it uses the following assumptions:

(1) The methanol (MeOH) and non-oxygenated hydrocarbons (NOHC) concentrations in the exhaust are inferred from the hydrocarbon analyzer (FID) output by knowing the methanol response factor of the FID and by assuming that the concentrations of the MeOH and NOHC in the exhaust have the same proportions as they occur (by moles) in the fuel. For M85 fuel the ratio of $(ppm)_{NOHC}$ over $(ppm)_{MeOH}$ is assumed to be 0.383 (which is the mole ratio of gasoline over methanol in the fuel).
(2) Since the aldehyde emissions were not measured, they are ignored.
(3) The unburned fuel emissions (MeOH, NOHC, and aldehydes) are reported as the organic material hydrocarbon equivalent, OMHCE.
(4) The dilution factor is calculated using the appropriate relationship for blended fuels.
(5) It is assumed that the testing was performed in a manner such that there was no loss of methanol in the sampling system due to either condensation of the methanol itself or absorption of the methanol in liquid water.

The ORNL protocol (and other protocols used to interpret the output from the FID) has essentially no effect on the computed values for CO,

CO_2, and NO_x emissions. The effects of the various protocols on the values reported for "HC", "unburned fuel", or OMHCE are not substantial. Table 10 summarizes the results from both the original, post-conversion emissions tests of the methanol vehicles and the more recent retests, both calculated by the ORNL protocol. (Gasoline cars' results are not included because they are not affected by the protocol used for calculation.)

Table 10. Emissions test results calculated by ORNL protocol

Vehicle	Mileage (miles)	FTP results (gm/mile)			
		OMHCE[a]	CO	NO_x	MeOH[a]
Methanol Chevrolets					
ME 562	381	0.16	0.74	0.51	0.40
	7,600	0.72	8.27	0.67	1.28
ME 568	288	0.25	1.39	0.43	0.55
	8,700	0.44	6.36	0.85	0.82
Methanol Fords					
ME 572	793	0.18	0.76	0.62	0.54
	32,800	0.70	2.23	0.79	1.27
ME 574	418	0.23	1.44	0.63	0.56
	26,900	0.65	3.16	0.71	1.17

[a]See text for description of protocol for calculations.

3.3 COMPARISON OF MAINTENANCE AND SERVICE — METHANOL AND GASOLINE VEHICLES

Statistics illustrating the comparison of maintenance and service of the methanol and gasoline vehicles are presented in Tables 11 through 14. Included in this comparison are data on numbers of occasions of maintenance, frequency of maintenance (occasions per 1000 miles), numbers of labor hours required for maintenance, and labor intensity (labor hours per 1000 miles). Statistics for the second year as well as summaries for the entire two years are presented. In the tables, "All

Table 11. Frequency of maintenance second year and both years

	Occasions (No.) and Frequency (No./1000 miles) of maintenance			
	Second year		Both years	
	No.	Frequency	No.	Frequency
	Chevrolet Totals			
All maintenance				
Methanol	57	1.9	131	1.8
Gasoline	40	1.1	98	1.2
Fuel-related maintenance				
Methanol	10	0.3	17	0.2
Gasoline	0	0	0	0
	Ford Totals			
All maintenance				
Methanol	130	1.7	284	1.6
Gasoline	87	1.5	243	1.4
Fuel-related maintenance				
Methanol	12	0.2	34	0.2
Gasoline	1	0.02	4	0.02

Maintenance" includes all occasions for which a service work order was written, and thus includes occasions of routine maintenance such as oil changes and tire maintenance in addition to occasions of unusual maintenance, i.e., those occasions that are prompted by complaints or malfunctions. The occasions that have been designated as "Fuel Related" are those which have been identified as being intimately related to and/or caused by the nature of the fuel and fuel delivery systems. These designations are used only in an attempt to determine how much of the total difference in maintenance between methanol and gasoline car types can be traced to the methanol fuel or its systems.

Table 12. Frequency of maintenance
summary of two years

	Frequency (occassions/1000 miles)		
	Second year	First year	Two years
	Chevrolet Averages		
All maintenance			
Methanol	1.9	1.7	1.8
Gasoline	1.1	1.3	1.2
Fuel-related maintenance			
Methanol	0.3	0.2	0.2
Gasoline	0	0	0
	Ford Averages		
All maintenance			
Methanol	1.7	1.6	1.6
Gasoline	1.5	1.4	1.4
Fuel-related maintenance			
Methanol	0.2	0.2	0.2
Gasoline	0.02	0.03	0.02

Frequency of maintenance for both Chevrolets and Fords appears to be stable over the two years. For the Fords, the difference in frequency between methanol and gasoline cars is accounted for by the "Fuel Related" maintenance, suggesting that if these problems could be eliminated there would be no difference in maintenance frequency between the methanol and gasoline Fords. The same is not true for the Chevrolets, i.e., the difference in "All Maintenance" frequency is not accounted for by the difference in fuel related maintenance. Nevertheless, the frequency difference was not large.

It appears that a large part of the maintenance designated as "Fuel Related" could be eliminated fairly easily. For example, the Fords had 8 occasions of fuel filter changes, some of which were needed only to try to monitor the filter condition. Other fuel related occasions for

Table 13. Maintenance labor hours and intensity second year and both years

	Maintenance labors hours and intensity (hr/1000 miles)			
	Second year		Both years	
	Hours	Intensity	Hours	Intensity
	Chevrolet Totals			
All maintenance				
Methanol	124	4.1	210	2.9
Gasoline	31	0.9	69	0.8
Fuel-related maintenance				
Methanol	42	1.4	58	0.8
Gasoline	0	0	0	0
	Ford Totals			
All maintenance				
Methanol	289	3.8	526	3.0
Gasoline	178	3.1	407	2.4
Fuel-related maintenance				
Methanol	21	0.3	32	0.2
Gasoline	4	0.1	10	0.1

Fords included 2 occasions of replacing fuel injectors and 3 occasions for fuel pumps. In one of the fuel injector replacement occasions, the injectors were not the problem but were changed before the spark plugs were identified as the problem. In this case, the mechanics confused symptoms with those that had been experienced before with fuel injector problems. One can imagine that production methanol cars would not experience some of these kinds of situations, after there is generally more familiarity with the technology. Fuel pumps used on the methanol vehicles are prototype pumps that are probably not as reliable as those that would be mass-produced for a methanol vehicle market.

For the Chevrolets, there were 8 occasions relating to the throttle body unit or just the throttle body injector. For the Chevrolets, the

Table 14. Maintenance labor intensity summary of two years

	Labor intensity (hr/1000 miles)		
	Second year	First year	Two years
Chevrolet Averages			
All maintenance			
Methanol	4.1	2.0	2.9
Gasoline	0.9	0.8	0.8
Fuel-related maintenance			
Methanol	1.4	0.4	0.8
Gasoline	0	0	0
Ford Averages			
All maintenance			
Methanol	3.8	2.4	3.0
Gasoline	3.1	2.0	2.4
Fuel-related maintenance			
Methanol	0.3	0.1	0.2
Gasoline	0.1	0.05	0.1

gasoline throttle body injector was retained for the methanol application so as to save the high expense of injector development. Therefore, some of the internal materials, while being appropriate for gasoline, may suffer deterioration with methanol. There were also 3 occasions of fuel filter replacements, 2 vapor canister replacements, 1 fuel pump, and 2 replacements of the early fuel evaporation heater grid. Again, the heater grids may have suffered in the methanol environment. Failed parts are shared on an informal basis with the manufacturers so that they can benefit from the data and the field experience on an expedient basis.

Maintenance labor intensity increased for all four vehicle types during the second year (only slightly for the gasoline Chevrolets). Differences in labor intensity between methanol and gasoline types are large for the Chevrolets and not so great for the Fords, and the differences do not appear to result totally from the "Fuel Related" maintenance. This suggests that more time is required in general by the mechanics to assess and respond to the methanol vehicle's problems, another condition which may be expected to disappear if methanol vehicles were in widespread use.

3.4 OIL SAMPLE ANALYSES

Samples of the lubricating oil are drawn from the crankcases of the nineteen vehicles at approximately 1000 mile intervals. (Oil change interval is every 3000 miles for all of the vehicles.) The oil samples are analyzed for total base number, kinematic viscosity, and concentrations of iron, lead, copper, aluminum, chromium, sodium, and silicon. Generally, a fleet operator uses information from oil sample analyses as a diagnostic tool for implementing necessary preventive or corrective maintenance. In this project, however, the information is not generally used to intervene in the natural processes that are progressing in the engines under study. Only in rare circumstances, such as the revealed need for an air filter change, has the information been used to implement vehicle service that would not have ordinarily occurred at a given point in time.

Lubricating oil for the methanol vehicles has been supplied by the Lubrizol Corporation and is a 10W-30 multi-grade oil with a calcium based additive package developed by Lubrizol which is intended to reduce engine wear and corrosion that may be caused by the methanol fuel. The gasoline vehicles use standard 10W-30 multi-grade lubricating oil approved by the manufacturers for regular use in their vehicles and stocked routinely by ANL. Results from the oil analyses are forwarded periodically on an informal basis to the manufacturers of the vehicles and to the Lubrizol Corporation.

No significant abnormal trends have been observed in either the total base number or the kinematic viscosity of the oil of any of the cars for the period of this project. For the ANL vehicles, chromium and sodium do not accumulate in the lubricating oil in any amounts that would warrant further attention here. Silicon enters the oil usually by contamination from dirt in the environment, thus data regarding its concentration are not as enlightening as that of other contaminants *vis-à-vis* engine wear. Iron is usually the largest contributor to lubricating oil contamination in both methanol and gasoline vehicles.

Results are presented in Tables 15 and 16 for accumulation rates of metals (iron, lead, copper, and aluminum) in the lubricating oil. Results are shown for each of the two years as well as the two years combined for each vehicle type. Accumulation rates are found by (1) fitting linear regressions (least squares curve-fits) to data of wear metals concentration as a function of distance since oil change, and (2) determining the slopes (accumulation rates) of the regressions.

Table 15. Wear metals accumulation rates (in lubricating oil)[a]

Chevrolet S-10 Pickup Trucks

	ppm per 1000 miles					
	Methanol vehicles			Gasoline vehicles		
	First year	Second year	Both years	First year	Second year	Both years
Iron	42	97	72	32	19	27
Lead	64	136	100	17	23	20
Copper	4	5	5	5	7	7
Aluminum	6	6	6	2	1	2

[a]Average wear metals accumulated in lubricating oil in parts per million per 1000 miles of operation.

Table 16. Wear metals accumulation rates (in lubricating oil)[a]

Ford Crown Victorias

	ppm per 1000 miles					
	Methanol vehicles			Gasoline vehicles		
	First year	Second year	Both years	First year	Second year	Both years
Iron	67	73	70	10	17	13
Lead	10	9	10	13	10	12
Copper	3	3	3	7	6	7
Aluminum	6	5	6	2	1	2

[a]Average wear metals accumulated in lubricating oil in parts per million per 1000 miles of operation.

For the methanol Chevrolets, shown in Table 15, increases in accumulation rates occurred in the second year in both iron and lead. The increase in lead may have been caused by some degradation of the fuel tanks. These vehicles were supplied with fuel tanks that have an epoxy coating over the original terneplate (which contains lead), and the epoxy was thought to be resistant to methanol. However, evidence of deterioration of the epoxy coating appeared during the second year. This would leave the terneplate exposed to attack by the methanol and would probably release quantities of lead into the fuel, then into the engine, and ultimately into the crankcase oil. The increase in iron accumulation rate may also be related, if enough terneplate has been removed from the inside tank surfaces to reveal the metal surface. If the increased iron is not from the fuel tanks, it most likely is from cylinder walls and/or piston rings. One fuel tank was replaced during the second year with a replacement supplied by General Motors. The situation continued to be monitored even though there was not evidence that other tanks were failing.

The methanol Fords exhibited a slight increase in accumulation rate of iron, but not alarmingly greater. Rate of accumulation of lead was about the same as for the first year. For both methanol vehicle types, accumulation rates of iron and lead are still quite elevated over their gasoline counterparts.

Figures 1 and 2 show the iron and lead concentration data for the methanol Chevrolets for the second year, while Fig. 3 shows the iron

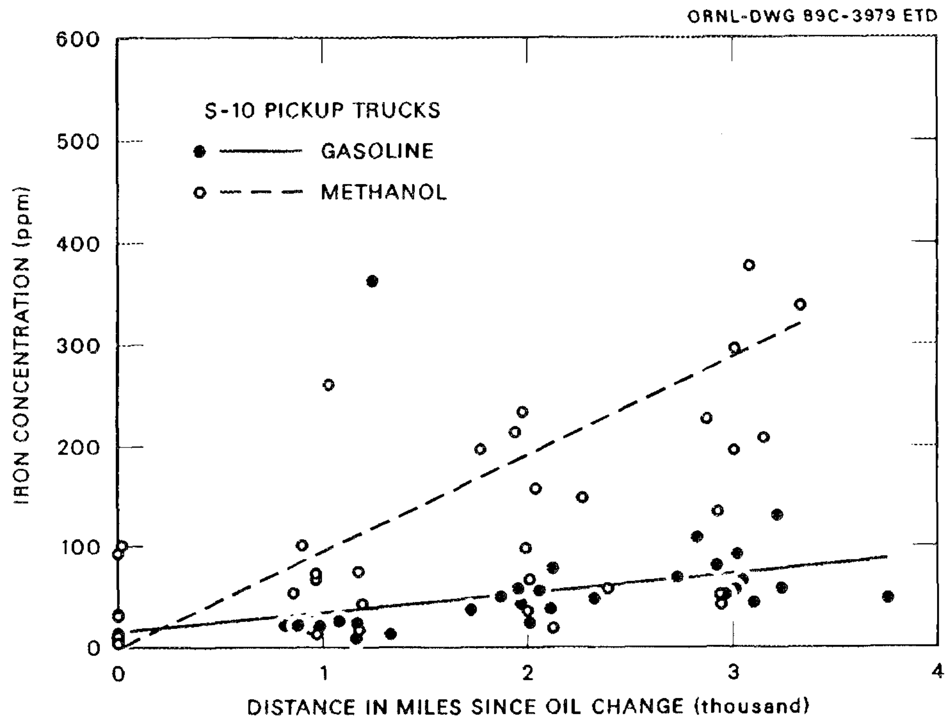

Fig. 1. Concentration of iron in lubricating oil — Chevrolets.

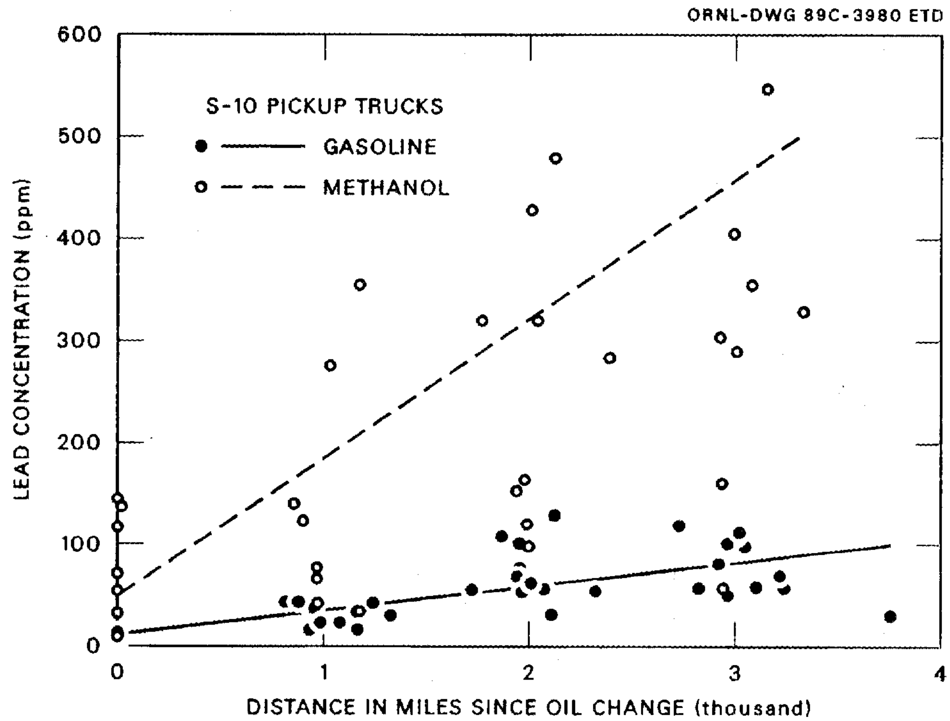

Fig. 2. Concentration of lead in lubricating oil — Chevrolets.

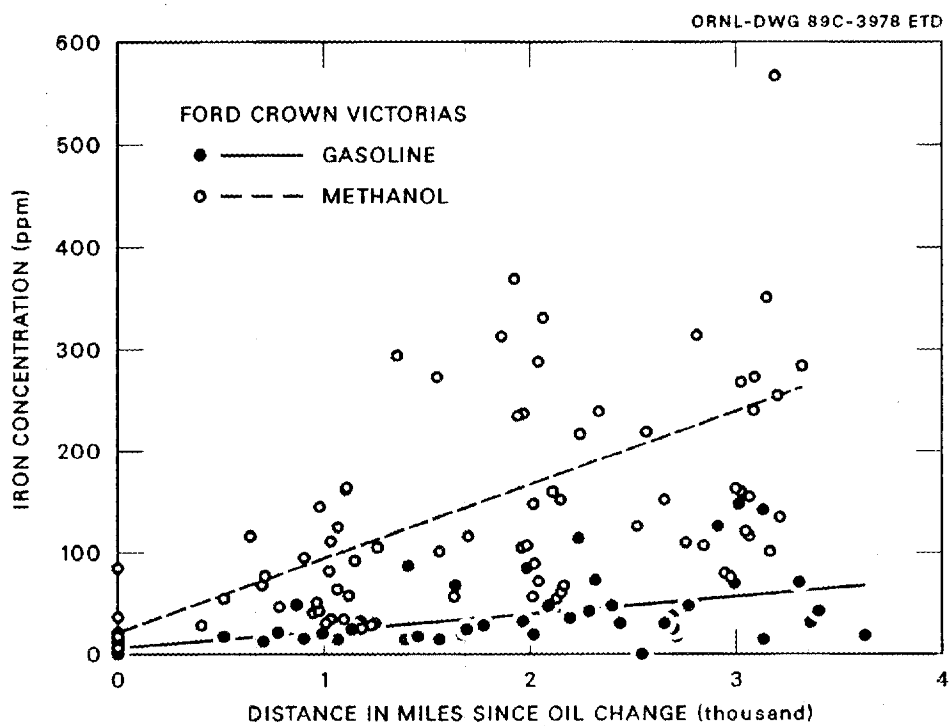

Fig. 3. Concentration of iron in lubricating oil — Fords.

concentration data for the methanol Fords. The linear regressions are shown as computed by the method of least squares. The slopes of these regressions are the accumulation rates.

3.5 DRIVERS' PERCEPTIONS OF VEHICLE PERFORMANCE

3.5.1 Drivers' Ratings of Vehicle Performance - Daily Trip Logs

Drivers at ANL evaluate the vehicles' ease of starting and driveability at the end of each trip by making a check mark under either "Good", "Average", or "Poor" on the trip log for both "Ease of Starting" and "Driveability". This simple process yields a profile of the drivers' general impressions of the cars' performance and how their impressions may change over time.

The second year included records of 3582 trips in the Chevrolets (1580 methanol and 2002 gasoline) and 5074 trips in the Fords (2760 methanol and 2314 gasoline). For the two years, this brings the totals to 9302 recorded trips in the Chevrolets and 25,062 for the Fords.

Results of drivers' ratings during the second year are shown in Tables 17 and 18 both in numbers of responses as well as in percentages. For comparison, the first year's results are shown in the same format in Tables 19 and 20, and summaries of the two years are shown in Tables 21 and 22.

For the Chevrolets, ratings of the methanol trucks improved slightly during the second year, while those of the gasoline trucks declined. Ratings of Good for both types of trucks still dominated the results for both Ease of Starting and Driveability.

Most noticeable was the decline in the frequency of the Good rating for the gasoline trucks accompanied by large increases in the percentage of Average ratings. Part of this difference can be attributed to a single driver of one of the gasoline trucks, who rated the Ease of Starting and Driveability as Average about 90% of the time and who also accounted for the vast majority of that truck's use. (Most drivers use the Good rating to represent general satisfaction, but some believe that Average should mean that they are satisfied.) This situation with one truck appears to represent a bias which needs to be balanced by reassignment of vehicles so that this driver uses a methanol truck for an equal period of time.

For the Fords, the second year's ratings featured a large shift to Average from the largely Good ratings of the first year so that the Average rating dominated for both Ease of Starting and Driveability and for both methanol and gasoline Fords. This represents a sizeable decline in the overall Ford ratings, the reason for which is not clear. The set of drivers for the Fords, being confined to the security

Table 17. Responses from ANL daily trip logs for Ease of Starting and Driveability
Second year – January 1, 1988 to December 31, 1988

Chevrolet S-10 Pickup Trucks

	Responses			
	Good	Average	Poor	No response
Ease of Starting				
	Numbers of Responses			
Methanol	1,366	158	45	11
Gasoline	1,697	294	4	7
	Percent of Total			
Methanol	86	10	3	1
Gasoline	85	15	0	0
Driveability				
	Numbers of Responses			
Methanol	1,331	213	27	9
Gasoline	1,625	362	4	11
	Percent of Total			
Methanol	84	13	2	1
Gasoline	81	18	0	1

Table 18. Responses from ANL daily trip logs for Ease of Starting and Driveability
Second year – January 1, 1988 to December 31, 1988

Ford Crown Victorias

	Responses			
	Good	Average	Poor	No response
Ease of Starting				
	Numbers of Responses			
Methanol	691	2,017	40	12
Gasoline	822	1,480	5	7
	Percent of Total			
Methanol	25	73	2	0
Gasoline	36	64	0	0
Driveability				
	Numbers of Responses			
Methanol	597	2,089	56	18
Gasoline	782	1,505	20	7
	Percent of Total			
Methanol	21	76	2	1
Gasoline	34	65	1	0

Table 19. Responses from ANL daily trip logs for Ease of Starting and Driveability
First year - through December 31, 1987

Chevrolet S-10 Pickup Trucks

	Responses			
	Good	Average	Poor	No response
Ease of Starting				
	Numbers of Responses			
Methanol	2,360	301	36	19
Gasoline	2,803	135	25	41
	Percent of Total			
Methanol	87	11	1	1
Gasoline	93	4	1	2
Driveability				
	Numbers of Responses			
Methanol	2,060	517	99	40
Gasoline	2,788	135	25	56
	Percent of Total			
Methanol	76	19	4	1
Gasoline	92	6	0	2

Table 20. Responses from ANL daily trip logs for Ease of Starting and Driveability
First year - through December 31, 1987

Ford Crown Victorias

	Responses			
	Good	Average	Poor	No response
Ease of Starting				
	Numbers of Responses			
Methanol	6,536	2,366	227	60
Gasoline	9,428	1,277	32	62
	Percent of Total			
Methanol	71	26	2	1
Gasoline	87	12	0	1
Driveability				
	Numbers of Responses			
Methanol	5,155	3,127	825	82
Gasoline	8,997	1,686	40	76
	Percent of Total			
Methanol	56	34	9	1
Gasoline	83	16	0	1

Table 21. Responses from ANL daily trip logs for Ease of Starting and Driveability
Two years – through December 31, 1988

Chevrolet S-10 Pickup Trucks

	Responses			
	Good	Average	Poor	No response
Ease of Starting				
	Numbers of Responses			
Methanol	3,726	459	81	30
Gasoline	4,500	429	29	48
	Percent of Total			
Methanol	87	10	2	1
Gasoline	90	8	1	1
Driveability				
	Numbers of Responses			
Methanol	3,391	730	126	49
Gasoline	4,413	497	29	67
	Percent of Total			
Methanol	79	17	3	1
Gasoline	88	10	1	1

Table 22. Responses from ANL daily trip logs for Ease of Starting and Driveability
Two years – through December 31, 1988

Ford Crown Victorias

	Responses			
	Good	Average	Poor	No response
Ease of Starting				
	Numbers of Responses			
Methanol	7,227	4,383	267	72
Gasoline	10,250	2,757	37	69
	Percent of Total			
Methanol	60	37	2	1
Gasoline	78	21	0	1
Driveability				
	Numbers of Responses			
Methanol	5,752	5,216	881	100
Gasoline	9,779	3,191	60	83
	Percent of Total			
Methanol	48	44	7	1
Gasoline	75	24	0	1

department, was basically unchanged from the first to the second years. So, the decline in ratings is probably a real indicator of decline in the satisfaction level of the drivers. Drivers still favored gasoline Fords over the methanol Fords by a slight margin, judging from the frequencies of the Good ratings.

3.5.2 Variation of Ratings with Ambient Temperature

Drivers at ANL provide an estimate of ambient temperature for each trip logged in any of the vehicles. Three ranges of temperatures are indicated on the trip log, and drivers check the one that fits their estimate. Ranges are: Greater than 40°F, 6 to 40°F, and 5°F or less. In this way, it can be determined whether the drivers' ratings of Ease of Starting and Driveability are related to the ambient temperature.

The frequency (percentage of total responses) of ratings of Good and Poor are shown graphically in Figs. 4 through 7 as functions of temperature range. The percentages represent the fraction of the numbers

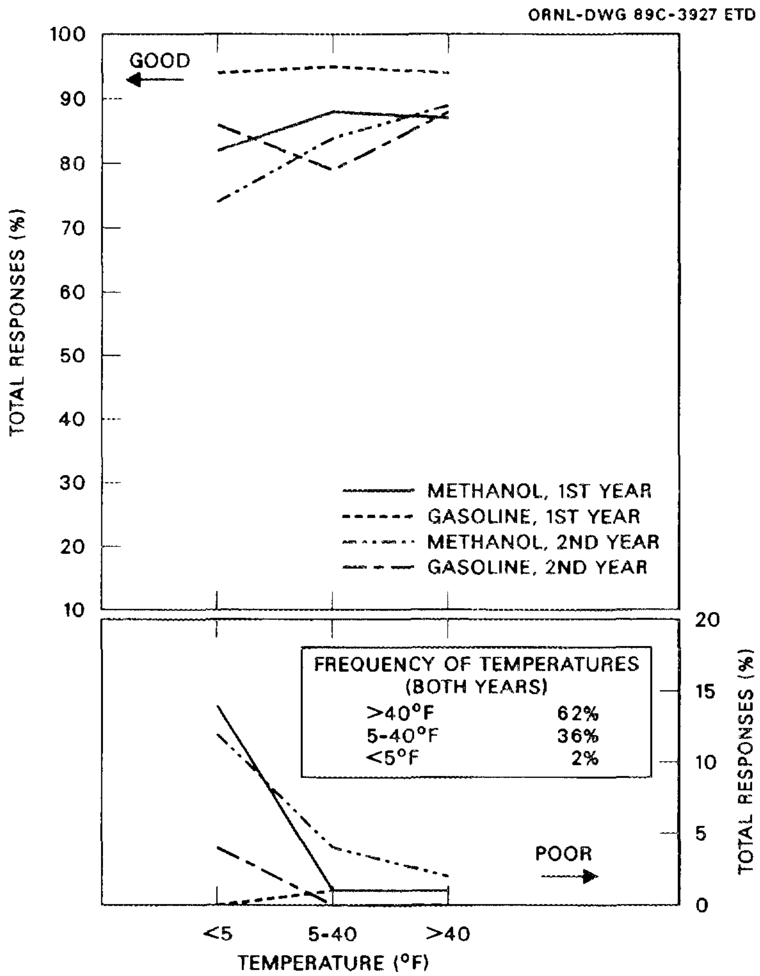

Fig. 4. Ease of starting as a function of temperature — Chevrolets.

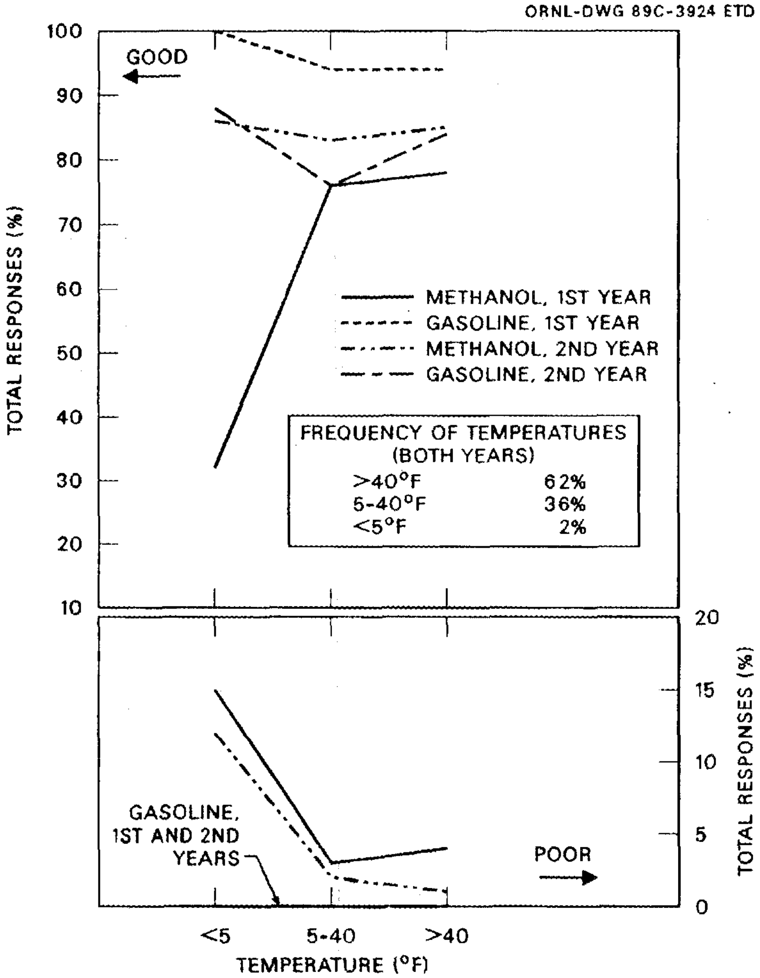

Fig. 5. Driveability as a function of temperature — Chevrolets.

of responses that were Good or Poor. Results for the second year as well as the first are shown as separate plots so as to reveal how the ratings have changed.

Frequency (percentages) of Good ratings for Ease of Starting (Fig. 4) decreased during the second year for the Chevrolets, while Poor ratings increased slightly in frequency. For the Fords, Good ratings of Ease of Starting (Fig. 6) were significantly less frequent during the second year for all temperature ranges for both methanol and gasoline cars. Gasoline cars continued to maintain a slight advantage over methanol in frequency of Good ratings. Ratings of Poor Ease of Starting did not change greatly from the first year.

The frequency of the Good rating for the methanol Chevrolets' Driveability (Fig. 5) surpassed that of the gasoline vehicles, mostly as

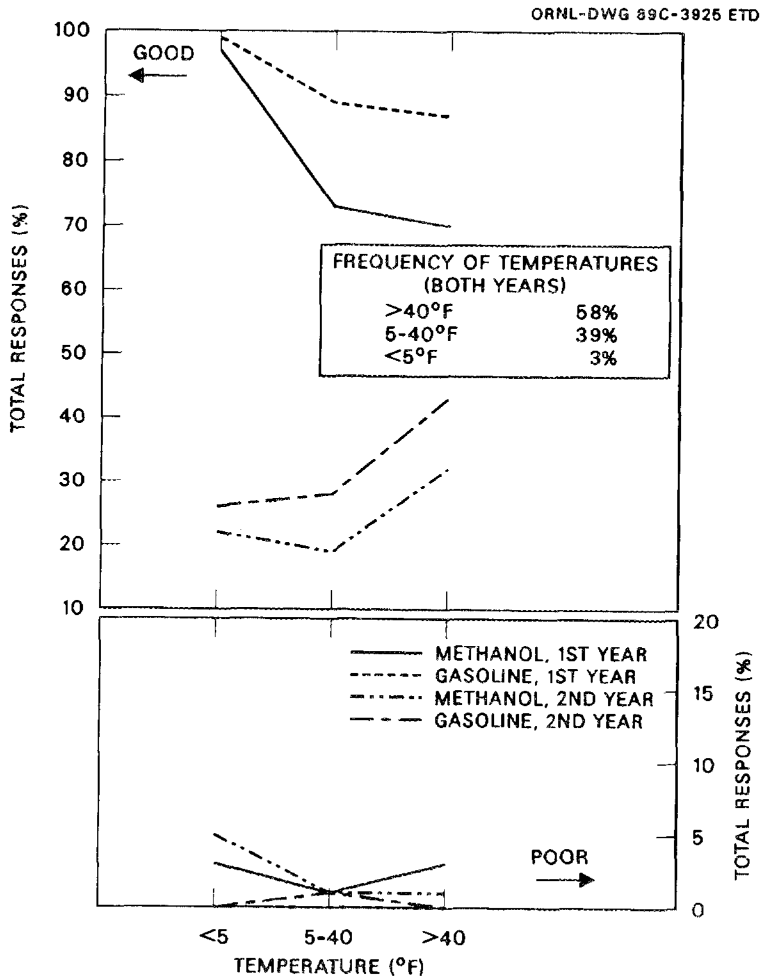

Fig. 6. Ease of starting as a function of temperature — Fords.

a result of a large decline in the frequency of the Good rating during the second year for the gasoline Chevrolets. Poor ratings for the methanol vehicles at the lowest temperature were much higher than those of the gasoline vehicles. Incidence of the Good rating of Fords' Driveability (Fig. 7) suffered a great decline in the second year, both for methanol and gasoline cars while the Poor rating was not greatly different during the second year and was still very nearly zero for all cars.

A general conclusion from the four figures is that both Ease of Starting and Driveability suffer in the drivers' opinions for all four car types as the weather becomes colder, with the exception of the Fords for the first year. As mentioned in last year's report,[1] the unexpected trends in the first year's data probably resulted from maintenance problems in the warmer months of the year.

Otherwise, it is not clear that gasoline has a clear and universal advantage over methanol in the drivers' ratings.

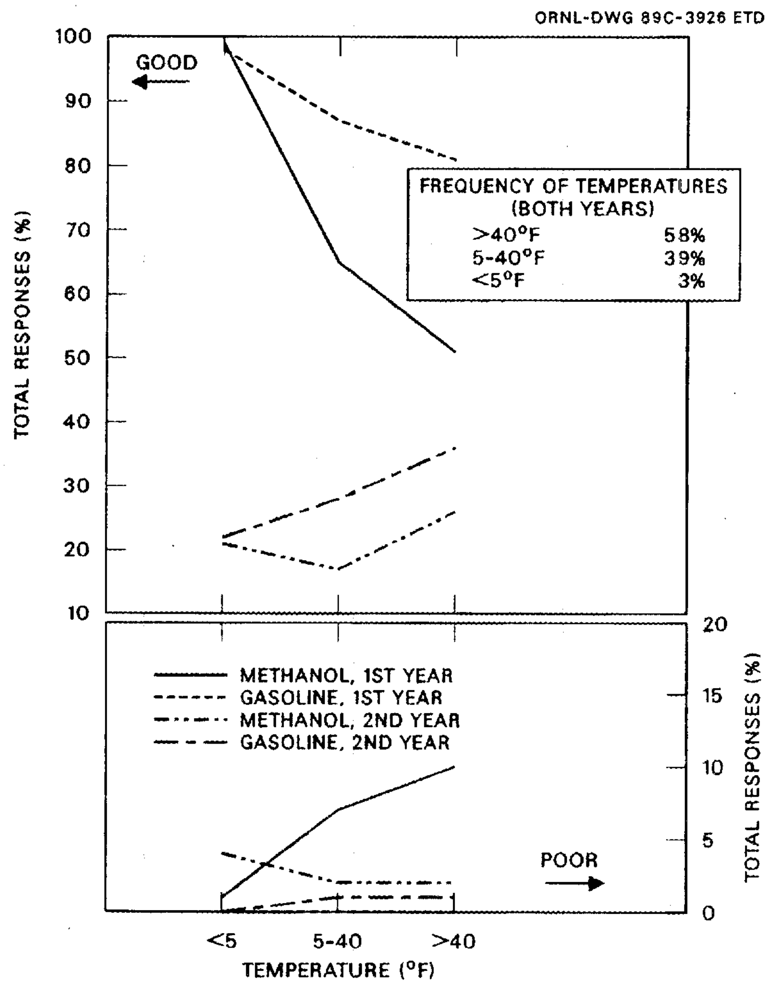

Fig. 7. Driveability as a function of temperature — Fords.

3.6 RESULTS OF DRIVER SURVEY

Late in the second year drivers were anonymously surveyed in order to elicit from them more in-depth evaluations of the vehicles and their experiences and perceptions. Approximately 200 survey forms were mailed to ANL drivers; 97 were returned by mail to ORNL. The survey results are summarized in Appendix A; included are all of the written remarks and comments that the drivers provided on their forms. Results from the survey indicate a generally favorable impression by ANL drivers of the methanol vehicle technology, but evidence of driveability problems exists in the responses.

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REFERENCES

1. R. N. McGill and S. L. Hillis, *Results from the First Year of Operation of the Federal Methanol Fleet at Argonne National Laboratory*, Oak Ridge National Laboratory Report ORNL/TM-10816, October, 1988.

2. R. N. McGill and S. L. Hillis, *The Department of Energy's Federal Methanol Fleet – A Progress Report*, SAE paper 881629, Society of Automotive Engineers, Warrendale, Pennsylvania, October, 1988.

3. *Project Plan for Fleet Operations of Federal Methanol-Fueled Vehicles*, DOE/CE-0126, Department of Energy, Washington DC, April, 1985.

4. R. N. McGill, S. L. Hillis, and J. L. Wantland, *Results from the First Year of Operation of the Federal Methanol Fleet at Lawrence Berkeley Laboratory*, ORNL/TM-10485, Oak Ridge National Laboratory, Oak Ridge, Tennessee, August, 1987.

5. R. N. McGill and S. L. Hillis, *Results from the Second Year of Operation of the Federal Methanol Fleet at Lawrence Berkeley Laboratory*, ORNL/TM-10815, Oak Ridge National Laboratory, Oak Ridge, Tennessee, August, 1988.

Appendix A. RESULTS OF ANL DRIVER SURVEY

Results from the survey of ANL drivers are presented below, divided as to vehicle make so that all results for Chevrolets are tabulated together and all for Fords together. In the first section for each vehicle make, each survey question (except the first question about which car type was driven) is listed along with the possible answers. All possible answers were multiple choice, and the percentage of those responding to each is shown next to the answer. In the second section, all written comments and remarks from the respondents are listed under the question for which the comment was offered.

Many of the comments and complaints were a result of perceived driveability problems with the vehicles, many of which were not exclusive to the methanol vehicles. Other comments reflect rather serious misperceptions about fuel economy of methanol vehicles, perhaps indicating that drivers expect fuel economy (mpg) in methanol vehicles similar to that which they experience in gasoline vehicles. This appears to represent a challenge for public relations personnel in any future marketing of methanol vehicles; it suggests that education is needed regarding the relationship between fuel economy and energy density of the fuel. (Note that the methanol vehicles at ANL have regular size fuel tanks and, thus, have about half the range of their gasoline counterparts. This also seems to have disturbed some of the drivers.)

ARGONNE NATIONAL LABORATORY
FEDERAL METHANOL FLEET
FALL 1988
DRIVER SURVEY

SECTION I

1. **How long have you been driving any of these vehicles? Remember, the gasoline S-10's and Crown Vic's were placed in service September of 1986 and their methanol counterparts were received 3 months later in December of 1986.**

	Frequency of response (%)	
	Chevrolet S-10's	Ford Crown Victorias
Less than 6 months	9	2
6 months to 1 year	25	5
1 year to 18 months	32	9
From the start	34	84

2. **How do the S-10's and Crown Vic's (methanol or gasoline) at the Laboratory perform relative to other cars of their types that you have previously driven?**

	Chevrolet S-10's	Ford Crown Victorias
Better	2	7
Equal	60	50
Worse	21	30
No comparable experience	17	13

SECTION II
OBSERVATIONS BASED UPON
PERSONAL FLEET EXPERIENCE

3. **Did you have difficulty in STARTING the engines? (Please indicate 1 answer for EACH group.)**

3. (continued)

METHANOL

	Chevrolet S-10's	Ford Crown Victorias
Yes	35	75
No	65	23
Do not remember	0	2

GASOLINE

	Chevrolet S-10's	Ford Crown Victorias
Yes	0	2
No	94	96
Do not remember	6	2

4. Given your experience, how would you compare the EASE OF STARTING of the vehicles?

	Chevrolet S-10's	Ford Crown Victorias
Methanol much better	0	0
Methanol slightly better	2	0
About the same	54	19
Gasoline slightly better	22	25
Gasoline much better	22	56

5. How would you compare the performance of the vehicle during the WARM-UP period?

	Chevrolet S-10's	Ford Crown Victorias
Methanol much better	0	0
Methanol slightly better	2	
About the same	52	30
Gasoline slightly better	30	33
Gasoline much better	16	37

6. **How would you compare the performance of the vehicles when FULLY WARMED-UP?**

	Chevrolet S-10's	Ford Crown Victorias
Methanol much better	2	0
Methanol slightly better	10	23
About the same	66	44
Gasoline slightly better	16	12
Gasoline much better	6	21

7. **Comparing the methanol vehicles to their gasoline counterparts, which type of vehicle do you feel was better in OVERALL performance?**

	Chevrolet S-10's	Ford Crown Victorias
Methanol was best	6	14
About the same	44	9
Gasoline was best	33	72
Cannot say	17	5

8. **How would you compare the DRIVEABILITY of the vehicles?**

	Chevrolet S-10's	Ford Crown Victorias
Methanol much better	0	2
Methanol slightly better	6	5
About the same	66	56
Gasoline slightly better	22	21
Gasoline much better	6	16

9. **Do you feel SAFE driving the Fleet vehicles?**

METHANOL

	Chevrolet S-10's	Ford Crown Victorias
Yes	68	70
No	8	9
Did not consider it	24	21

9. (continued)

GASOLINE

	Chevrolet S-10's	Ford Crown Victorias
Yes	76	82
No	0	2
Did not consider it	24	16

10. Given your experience, how would you rate the DRIVING RANGE of the methanol vehicles as compared to the gasoline vehicles?

	Chevrolet S-10's	Ford Crown Victorias
Much better	0	2
Slightly better	7	2
About the same	55	33
Slightly worse	13	37
Much worse	25	26

11. If methanol fuel were available at nearly every fueling station, would you be willing to use a methanol vehicle for longer business trips?

	Chevrolet S-10's	Ford Crown Victorias
Yes	52	33
No	48	67

12. If the costs of running a vehicle on gasoline or methanol were roughly equal, which fuel would you prefer?

	Chevrolet S-10's	Ford Crown Victorias
Prefer methanol by far	4	5
Prefer methanol slightly	8	7
Would make no difference	37	7
Prefer gasoline slightly	24	16
Prefer gasoline by far	27	65

13. Given your experience, would you consider buying a methanol powered vehicle?

	Chevrolet S-10's	Ford Crown Victorias
Would definitely buy one	2	5
Might consider buying one	44	12
Probably would not buy one	29	25
Would definitely not buy one	25	58

14. Do you feel that the use of methanol fuel in vehicles is a possible solution to our nation's dependence on imported oil?

	Chevrolet S-10's	Ford Crown Victorias
Yes	47	36
No	10	23
Do not know	43	41

15. In your experience, how frequently do people mistake methanol (wood alcohol) for ethanol (grain alcohol)?

	Chevrolet S-10's	Ford Crown Victorias
Most are confused	30	11
Slightly more are confused	6	16
50-50	23	14
Slightly more are not confused	2	0
Most are not confused	11	9
Do not know	28	50

16. From what you've heard, which of the vehicles require more service or repair, methanol or gasoline?

	Chevrolet S-10's	Ford Crown Victorias
Methanol by far	22	38
Methanol slightly more	43	43
Both about the same	22	17
Gasoline slightly more	0	0
Gasoline by far	0	0
Do not know	13	2

17. Do you have any trouble with fuel (methanol) dispensing pumps at your refueling station? If so, what type of problems do you encounter?

	Chevrolet S-10's	Ford Crown Victorias
Yes	0	21
No	100	79

18. To the best of your knowledge, does your refueling station have any problems in storing and dispensing the methanol fuel?

	Chevrolet S-10's	Ford Crown Victorias
Yes	0	2
No	100	98

19. Which type of driving do you experience the most when you drive your personal vehicle.

	Chevrolet S-10's	Ford Crown Victorias
Highway	36	63
In town	58	27
Both driven equally	6	10

20. Please indicate which professional grouping BEST represents your employment category during your Federal Methanol Fleet experience.

	Chevrolet S-10's	Ford Crown Victorias
Administration	0	0
Security	0	93
Research Staff	21	0
Maintenance, Secretarial and Support Staff	63	2
Fleet and Shop Staff	16	5

21. Age

	Chevrolet S-10's	Ford Crown Victorias
18-35	9	46
36-50	51	47
51-UP	40	7

22. Sex

	Chevrolet S-10's	Ford Crown Victorias
Female	11	23
Male	89	77

ARGONNE NATIONAL LABORATORY
Fall 1988 - Driver Survey Comments

QUESTION: DID YOU HAVE DIFFICULTY IN STARTING THE METHANOL ENGINES?

- "Only in winter conditions" Answer to Q=[Yes] (Crown-Vic)
- "In cold only" Answer to Q=[Yes] (Crown-Vic)
- "In winter" Answer to Q=[Yes] (Crown-Vic)
- "The methanol vehicles were hard starting at temperatures below 10 F, however when a gas start-up system was installed the truck did much better starting" Answer to Q=[Yes - no to gasoline] (S-10)

QUESTION: GIVEN YOUR EXPERIENCE, HOW WOULD YOU COMPARE THE EASE OF STARTING OF THE VEHICLES?

- "In winter" Answer to Q=[gasoline slightly better] (Crown-Vic)

QUESTION: HOW WOULD YOU COMPARE THE PERFORMANCE OF THE VEHICLES DURING THE WARM-UP PERIOD?

- "During cold weather (0 and below) methanol truck was sluggish. The garage made a number of adjustments which helped." Answer to Q=[gasoline slightly better] (S-10)
- "Seems like the engine races longer than my gasoline auto & if you drive before completely warmed up it seems to have a more difficult time at automatic shifting." Answer to Q=[about the same] (S-10)

QUESTION: IF METHANOL FUEL WERE AVAILABLE AT NEARLY EVERY FUELING STATION, WOULD YOU BE WILLING TO USE A METHANOL VEHICLE FOR LONGER BUSINESS TRIPS?

- "I was not impressed by the mileage" Answer to Q=[No] (Crown-Vic)
- "You get pretty good gas mileage" Answer to Q=[Yes] (Crown-Vic)
- "If they would make the engine design solely for methanol and not use a partial conversion of gas/methanol." Answer to Q=[Yes] (Crown-Vic)
- "There's a lot of technical maintenance to be done." Answer to Q=[No] (Crown-Vic)
- "Only during warm seasons." Answer to Q=[Yes] (both types driven)
- "Sucks" Answer to Q=[No] (Crown-Vic)
- "Didn't like the cars acting up, couldn't depend on it" Answer to Q=[No] (Crown-Vic)
- "The methanol cars drink fuel like I drink water - a lot" Answer to Q=[No] (Crown-Vic)
- "As long as it wasn't winter time." Answer to Q=[Yes] (Crown-Vic)
- "If it were less expensive, I would like it for a long trip - no good in traffic - clogs in fuel injectors" Answer to Q=[No] (Crown-Vic)
- "Mileage seems to be worse" Answer to Q=[No] (Crown-Vic)
- "They do not run as good as gas" Answer to Q=[No] (Crown-Vic)
- "The driving range for methanol cars is less than gasoline. You would use much more fuel with methanol and if prices are equal it would cost much more with the methanol" Answer to Q=[No] (Crown-Vic)

- "Don't start good when its cold outside and they seem to use more fuel. They also run roughly in cold or if A.C. is on" Answer to Q=[No] (Crown-Vic)
- "Only in warmer climates - the methanol is unreliable in cold climates." Answer to Q=[Yes] (Crown-Vic)
- "Don't know enough about it to go far from home." Answer to Q=[Yes] (Crown-Vic)
- "Methanol I believe burns little more than regular gas." Answer to Q=[No] (Crown-Vic)
- "Methanol has to be refueled more often than gas." Answer to Q=[No] (Crown-Vic)
- "I would not want a methanol vehicle in cold weather, they don't run or start well." Answer to Q=[No] (Crown-Vic)
- "If 'not' in sub-zero weather - fix that problem and you have a 'better' mouse trap." Answer to Q=[Yes] (Crown-Vic)
- "No way" Answer to Q=[No] (Crown-Vic)
- "For cost effective reasons" Answer to Q=[No] (S-10)
- "Poor mileage of methanol fuel" Answer to Q=[No] (S-10)
- "The methanol vehicles ran fine most of the time in the milder weather" Answer to Q=[Yes] (S-10)
- "Refueling twice as often as gasoline is tolerable but inconvenient" Answer to Q=[Yes] (S-10)
- "Vehicles don't seem to drive or accelerate very good" Answer to Q=[Yes] (Crown-Vic)
- "Poor running" Answer to Q=[No] (both types driven)
- "The performance of the Chevy S-10 was about the same when using either fuel" Answer to Q=[Yes] (S-10)
- "Assuming road breakdowns, I don't know if rapid service would be available." Answer to Q=[No] (S-10)
- "Too much refueling" Answer to Q=[No] (S-10)
- "It has no odor and appears to burn cleaner. The exhaust is more tolerable." Answer to Q=[Yes] (S-10)
- "I feel they have not been perfected. Very unreliable." Answer to Q=[No] (S-10)
- "In winter, you don't know if the vehicle will start." Answer to Q=[No] (S-10)
- "Not enough range." Answer to Q=[No] (S-10)
- "Fuel mileage is about half." Answer to Q=[No] (S-10)
- "For my personal vehicles I prefer a fuel-tank range of about 500 miles (ie., I buy the optional, longer tank)." Answer to Q=[Yes] (S-10)
- "Gas mileage is not good enough unless the price was much cheaper / gas." Answer to Q=[No] (s-10 & Crown-Vic)
- "Methanol vehicles did not seem dependable." Answer to Q=[No] (S-10)
- "I have found methanol to burn faster than gasoline." Answer to Q=[No] (S-10)
- "The methanol vehicles did not run well at all." Answer to Q=[No] (Crown-Vic)
- "Don't know enough about methanol." Answer to Q=[No] (S-10)
- "I'd be more willing in a warmer climate than Illinois." Answer to Q=[Yes] (S-10)
- "I have had few problems." Answer to Q=[Yes] (S-10)
- "Cost too much." Answer to Q=[No] (S-10)

- "As long as vehicles get me to my destination." Answer to Q=[Yes] (S-10). "If the methanol was completely accessible." Answer to Q=[Yes] (S-10)
- "Less pollution" Answer to Q=[Yes] (Crown-Vic)

<u>QUESTION:</u> IF THE COSTS OF RUNNING A VEHICLE ON GASOLINE OR METHANOL WERE ROUGHLY EQUAL, WHICH FUEL WOULD YOU PREFER?

- "At this time there is more maintenance under the hood in cold weather in a methanol vehicle." Answer to Q=[prefer gasoline by far] (S-10). "To much dependence on oil" Answer to Q=[prefer methanol by far] (S-10)
- "Smoother running engine." Answer to Q=[prefer gasoline by far] (Crown-Vic) . "Trouble with methanol cold weather, & the methanol seemed to require more maintenance (eg. fuel injectors)." Answer to Q=[prefer gasoline by far] (Crown-Vic)
- "Well for one thing the engine seems to be up in performance & as I have said before, you get good gas mileage." Answer to Q=[prefer methanol by far] (Crown-Vic)
- "If I had to to use our present vehicles, gas-because of the many problems we have encountered with these methanol cars)." Answer to Q=[prefer gasoline slightly] (Crown-Vic)
- "Less repair" Answer to Q=[prefer gasoline by far] (Crown-Vic)
- "Parts easier to obtain" Answer to Q=[prefer gasoline by far] (Crown-Vic). "Gas seems to run better in cold weather)." Answer to Q=[prefer gasoline slightly] (both types driven)
- "Less dependent on oil." Answer to Q=[prefer methanol slightly] (Crown-Vic) . "For the added pep in the performance." Answer to Q=[prefer methanol slightly] (Crown-Vic)
- "You have to refuel methanol more often)." Answer to Q=[prefer gasoline slightly] (Crown-Vic)
- "The methanol have a way of running rough more often than gasoline" answer to Q=[prefer gasoline by far] (Crown-Vic)
- "No warm-up time, less jerky driving." Answer to Q=[prefer gasoline by far] (Crown-Vic)
- "Mileage" Answer to Q=[prefer gasoline slightly] (Crown-Vic)
- "You would have to make more stops with methanol, 5-6 miles per gallon is not very good." Answer to Q=[prefer gasoline by far] (Crown-Vic)
- "The gasoline fueled vehicles are more dependable in colder climates." Answer to Q=[prefer gasoline by far] (Crown-Vic)
- "Because thats the kind of gas I burn (gasoline - 92 octane)" Answer to Q=[prefer gasoline by far] (Crown-Vic)
- "Been using it all time, and wouldn't want to switch" Answer to Q=[prefer gasoline by far] (Crown-Vic)
- "Gasoline use lasts longer in tank than methanol" Answer to Q=[prefer gasoline by far] (Crown-Vic)
- "Poor startability and driveability in winter, also they use more methanol fuel than gasoline." Answer to Q=[prefer gasoline by far] (Crown-Vic)
- "They perform equally well." Answer to Q=[would make no difference] (Crown-Vic)
- "Better performance - if you can get it started in cold weather" answer to Q=[prefer methanol slightly] (Crown-Vic)

- "Gasoline don't burn as fast as methanol." Answer to Q=[prefer gasoline by far] (Crown-Vic)
- "Better mileage" Answer to Q=[prefer gasoline by far] (Crown-Vic)
- "I have more trust in gasoline" Answer to Q=[prefer gasoline slightly] (S-10)
- "Better miles per gallon" Answer to Q=[prefer gasoline by far] (S-10)
- "During cold weather we had a lot of trouble starting the methanol vehicles" Answer to Q=[prefer gasoline slightly] (S-10)
- "Better performance" Answer to Q=[prefer methanol slightly] (S-10)
- "Gasoline vehicles run better and use less fuel" Answer to Q=[prefer gasoline by far] (Crown-Vic)
- "Better performance" Answer to Q=[prefer gasoline by far] (both types driven)
- "It appears to have slightly more pep than methanol." Answer to Q=[prefer gasoline slightly] (S-10)
- "For this type of climate gasoline seems better" Answer to Q=[prefer gasoline by far] (S-10)
- "Less problems, better mileage with gas." Answer to Q=[prefer gasoline by far] (S-10)
- "I would use the fuel that created less air polution." Answer to Q=[would make no difference] (S-10)
- "Gasoline easier to start. If trouble exists on highway who could fix it" Answer to Q=[prefer gasoline slightly] (S-10 & Crown-Vic)
- "Cleaner burning" Answer to Q=[prefer methanol slightly] (S-10)
- "Bad fuel consumption" Answer to Q=[prefer gasoline by far] (S-10)
- "Fuel-tank range" Answer to Q=[prefer gasoline slightly] (S-10)
- "Only if cold weather starting problems could be solved" Answer to Q=[prefer methanol slightly] (S-10 & Crown-Vic)
- "Its obvious that using alternate fuels will cut down our dependence on foreign oil" Answer to Q=[prefer methanol by far] (S-10)
- "Gas vehicles ran much better" Answer to Q=[prefer gasoline by far] (S-10)
- "Doesn't smell as bad" Answer to Q=[prefer gasoline by far] (S-10)
- "I found driving range for gasoline vehicles better" Answer to Q=[prefer gasoline slightly] (S-10)
- "Seem to have more heat content for fast warm-ups" Answer to Q=[prefer gasoline slightly] (S-10)
- "Don't have to plug in engine blockheater" Answer to Q=[prefer gasoline slightly] (S-10)
- "Assuming both fuels are equally available, gasoline vehicles will have more range" Answer to Q=[prefer gasoline slightly] (S-10)
- "If they were equal I feel it really would not make a difference which one I used." Answer to Q=[would make no difference] (S-10)
- "Until tests results were published including factual information on which type of fuel was proven more efficient, more economical, and more environmentally safe." Answer to Q=[would make no difference] (S-10).
- "Keep the farmers in control of their farms" Answer to Q=[prefer methanol by far] (Crown-Vic & thought "Slightly more are confused" about the difference between methanol and ethanol)
- "Winter starting & carb. icing problems would be somewhat alleviated." Answer to Q=[prefer methanol slightly] (Crown-Vic)

QUESTION: GIVEN YOUR EXPERIENCE, WOULD YOU CONSIDER BUYING A METHANOL POWERED VEHICLE?

- "Only unless the convenience of gasoline and methanol were about equal." Answer to Q=[probably would not buy one] (S-10's)
- "Higher expense for no better performance" Answer to Q=[would definitely not buy one] (Crown-Vic)
- "I guess I like the way the engine performs on methanol gas" Answer to Q=[would definitely buy one] (Crown-Vic)
- "Again, if a better design comes along, why not?" Answer to Q=[probably would not buy one] (Crown-Vic)
- "Thought gasoline powered vehicles ran better & servicing probably will be cheaper" Answer to Q=[probably would not buy one] (both types driven)
- "If the bugs wouldn't occur like they did in the beginning I would and if they didn't drink fuel so much" Answer to Q=[might consider buying one] (Crown-Vic)
- "At times methanol vehicle runs & idles roughly." Answer to Q=[would definitely not buy one] (Crown-Vic)
- "I wouldn't want them in cold weather" Answer to Q=[probably would not buy one] (Crown-Vic)
- "Not as convenient to obtain as gasoline - unless much cheaper" answer to Q=[probably would not buy one] (Crown-Vic)
- "I do not like the performance on methanol" Answer to Q=[would definitely not buy one] (Crown-Vic)
- "Starting is not dependable" Answer to Q=[would definitely not buy one] (Crown-Vic)
- "I'm used to gasoline powered and be kind of skeptical of something new" Answer to Q=[probably would not buy one] (Crown-Vic)
- "They stink, use too much fuel, drive sluggish on take off" Answer to Q=[would definitely not buy one] (Crown-Vic)
- "They still have engine problems that needs to be resolved" Answer to Q=[would definitely not buy one] (Crown-Vic)
- "Not unless they become very common - fuel is available -etc." Answer to Q=[would definitely not buy one] (Crown-Vic)
- "They do not drive too hot" Answer to Q=[would definitely not buy one] (Crown-Vic)
- "They have not been sufficiently proven" Answer to Q=[would definitely not buy one] (S-10)
- "It might be hard to service" Answer to Q=[would definitely not buy one] (S-10)
- "If gasoline was more expensive or in short supply." Answer to Q=[might consider buying one] (S-10)
- "Would stick with gas with other factors remaining equal." Answer to Q=[might consider buying one] (S-10)
- "Cost and maintenance prohibitive" Answer to Q=[would definitely not buy one] (Crown-Vic)
- "Depends on cost and fuel availability." Answer to Q=[might consider buying one] (S-10)
- "Like gasoline cars better" Answer to Q=[would definitely not buy one] (both types driven)

- "If it had a larger fuel tank and good maintenance was available." answer to Q=[might consider buying one] (S-10)
- "If more data was available on the cost of operation and the long term life was better." Answer to Q=[might consider buying one] (S-10)
- "Because of methanol's lower btu, further engine developments are needed, to develop comparably powered engines. I would consider buying one after further development by the oem's." Answer to Q=[probably would not buy one] (S-10)
- "Hard starting, less performance" Answer to Q=[would definitely not buy one] (S-10)
- "Poor range, special oil, fuel availability, etc" Answer to Q=[would definitely not buy one] (S-10)
- "Fuel-tank range is better with gasoline." Answer to Q=[probably would not buy one] (S-10)
- "If the performance / cost was comparable to gasoline engines then I would consider it." Answer to Q=[might consider buying one] (S-10 & Crown-Vic)
- "More testing of fuel system materials is needed." Answer to Q=[might consider buying one] (S-10)
- "Rough idle, no pick up, low gas mileage." Answer to Q=[would definitely not buy one] (S-10)
- "If the cost was less than gasoline." Answer to Q=[might consider buying one] (S-10)
- "Concern centers mostly on the lack of experience of mechanics that I deal with." Answer to Q=[probably would not buy one] (S-10)
- "Unreliable" Answer to Q=[would definitely not buy one] (S-10)
- "They are a long way from perfect" Answer to Q=[would definitely not buy one] (S-10)
- "Seem cleaner - I expect improvements in the program in the future." Answer to Q=[might consider buying one] (S-10)
- "The price of the vehicle should be lower than gasoline vehicles to off-set the possible risks of being a 'pioneer'." Answer to Q=[might consider buying one] (S-10)
- "I would let someone else work out problems." Answer to Q=[probably would not buy one] (S-10)
- "It has been my experience to discover the overall performance of the methanol vehicles to be equal to that of gasoline vehicles." Answer to Q=[would definitely buy one] (S-10)
- "If the engines were strictly methanol." Answer to Q=[would definitely buy one] (S-10)
- "I might if the vehicle could be serviced readily by myself." Answer to Q=[might consider buying one] (S-10)

QUESTION: DO YOU FEEL THAT THE USE OF METHANOL FUEL IN VEHICLES IS A POSSIBLE SOLUTION TO OUR NATION'S DEPENDENCE ON IMPORTED OIL?

- "Is it economical to produce, how about installation, country wide acceptance, etc.?" Answer to Q=[Yes] (S-10)

<u>QUESTION:</u> DO YOU HAVE ANY TROUBLE WITH FUEL (METHANOL) DISPENSING PUMPS AT YOUR REFUELING STATION? IF SO, WHAT TYPE OF PROBLEMS DO YOU ENCOUNTER?

- "Some trouble in the winter - I don't know if it was mechanical or due to the fuel itself?"Answer to Q=[Yes] (Crown-Vic)
- "They keep breaking down"Answer to Q=[Yes] (Crown-Vic)
- "The hose on the pump during cold weather becomes unmanageable to handle." Answer to Q=[Yes] (Crown-Vic)
- "In cold weather, thick hose is difficult to handle." Answer to Q=[Yes] (Crown-Vic)
- "Confusion existed because we were using methanol & gasoline vehicles, sometimes gasoline was placed in methanol vehicles & vice versa. This caused shut down time on squad operations until the mistakes were remedied." Answer to Q=[Yes] (Crown-Vic)
- "Except for the hose which is too stiff and heavy." Answer to Q=[No] (Crown-Vic)
- "Primarily, personnel filling tanks with wrong fuel." Answer to Q=[Yes] (Crown-Vic)
- "Worse gas mileage" Answer to Q=[Yes] (Crown-Vic)
- "Have not pumped methanol, but don't know why it would be any different than gasoline." Answer to Q=[No] (S-10)
- "The hose was about 4" in diameter & made fueling difficult." Answer to Q=[No] (S-10)

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