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RESULTS FROM THE SECOND YEAR OF OPERATION OF THE FEDERAL METHANOL FLEET AT OAK RIDGE NATIONAL LABORATORY

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ABSTRACT

The Oak Ridge National Laboratory has completed its second year of operation of ten vehicles for the Federal Methanol Fleet Project; five of the vehicles are fueled with methanol. Over 56,000 miles were accumulated on the vehicles in the second year bringing the total to over 152,000 miles. Energy consumption for the methanol cars was slightly higher than that of the gasoline cars again this year, most likely as a result of shorter average trip lengths for the methanol cars. Iron and lead have accumulated at greater rates in the lubricating oil of the methanol cars. Drivers' ratings of vehicles reflected some dissatisfaction with the cold-weather performance of the methanol cars, but the cars have no special provisions for cold weather starting, and the fuel vapor pressure has not been tailored to the season as at other test sites. Otherwise, drivers' opinions of the methanol cars have been favorable.

FOREWORD

This report is only one in a series of yearly reports on the results from the Federal Methanol Fleet project. Each report details the annual results from one of the three fleets participating in the project and, thus, represents only part of the entire story. Readers are directed to the other reports in the series in order to benefit from the entire context of the project rather than risking the possibility of misreading limited results from only one report.

It is well advised to review some of the philosophies and practices implemented in this project in order to further reduce the possibilities of data being taken out of context.

- This project resulted from a congressional appropriation in Fiscal Year 1985 and the associated mandate to begin to place methanol-fueled vehicles in government fleets and assess their performance. Funds for these purposes have totalled $1.8 million through Fiscal Year 1989.
- It was decided to use the best available "proven" technology for converting vehicles to methanol since it seemed to be impracticable to obtain methanol vehicles from original equipment manufacturers. It was also intended to acquire methanol converted vehicles from as many "proven" aftermarket companies as funds would permit. ("Proven" here means that the aftermarket company possessed a demonstrated record of successful conversions of gasoline vehicles to methanol.)
- It was decided to operate the methanol vehicles in all cases along-side comparable gasoline vehicles for statistical comparisons. This entailed the acquisition of the gasoline vehicles also.
- While it was desirable to achieve the lowest emissions possible with the converted methanol vehicles to be obtained, it was recognized that this would be an expensive proposition because rigorous engineering and development would be necessary in order to accomplish this goal. Because of this, the methanol vehicles are not optimized for lowest emissions. Instead, the philosophy was to acquire the vehicles, measure their emissions, and track their performance over

time. The important comparison would be how the emissions change over time, not how they would compare to the lowest attainable. Emissions measured immediately after methanol conversions would serve as the baseline for comparison.

- All of the vehicles in the project were to be used in routine fleet service within the organizations to which they were to be assigned. This limited the extent to which very specialized tests or driving cycles could be utilized. On the other hand, the vehicles would experience a "real-world" environment, and it is within that context that they have been evaluated.

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1. INTRODUCTION

Oak Ridge National Laboratory (ORNL) has operated ten vehicles for a period of over two years for the Department of Energy's Federal Methanol Fleet Project; five of the cars are methanol-powered and five are comparable gasoline vehicles. This report details the operation and results of the project for the second year. Other reports[1-10a] have detailed previous years' results from ORNL as well as from the two other fleet sites involved in the project, namely Lawrence Berkeley Laboratory, and Argonne National Laboratory. Because much of the background of this project has been described in those reports, it will not be discussed at any length in this report. The reader is encouraged to refer to the earlier reports for those details.

The ORNL fleet actually began operation in mid-1987 with the receipt of five gasoline vehicles, while five methanol vehicles arrived in late 1987 after they had been converted to methanol and had undergone emissions tests. The period of time for this report is through December 31, 1989, thus representing about two years for the methanol vehicles and about two and one-half years for the gasoline vehicles.

The ten cars at ORNL are 1987 Buick Regal coupes with turbocharged 3.8 liter V-6 engines. Five of them were converted to operate on methanol fuel by Michigan Automotive Research Corporation in Ann Arbor, Michigan, in the fall of 1987. Except for the fuel systems, the methanol and gasoline cars are similarly equipped.

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[a]Superscripted numbers denote references at the end of the report.

Methanol fuel used at ORNL is nominally M85 (85% methanol and 15% regular unleaded gasoline). An existing underground storage tank, previously used for gasoline and/or diesel fuels, was reclaimed and restored to operation for the methanol fuel after having been unused for some time. Appropriate fuel lines and a dispensing pump were installed to complete the methanol fueling station.

Nine of the ten Buicks are assigned to individual research divisions within ORNL and are used to supplement routine fleet vehicles; one of the cars is assigned to the Oak Ridge Operations Office of the Department of Energy. All are used for transportation around the Oak Ridge area, between plant sites, and for occasional out-of-town trips.

A small amount of data is recorded by the drivers for each trip taken in any of the ten vehicles, and they also rate the vehicle's ease of starting and driveability. Fueling data is kept by the fuel inventory system and maintenance records are kept by the ORNL motor pool personnel. The lubricating oil of each of the ten vehicles is sampled nominally every 1000 miles and sent to a laboratory where it is analyzed for wear metal content, viscosity, base number, etc.

1.1 SUMMARY

The methanol fleet operating at ORNL has completed a satisfactory second year of operation. The ten cars accumulated a total of over 56,000 miles (90,000 km) in the second year with no major problems. Energy consumption for the five methanol cars was slightly higher than that of the five gasoline cars, but their trip lengths averaged only about two-thirds that of the gasoline cars. Except for an avoidable problem with some of the special methanol fuel pumps, the methanol cars had very few problems that resulted from the methanol fuel systems. This made the statistics of maintenance compare very well between methanol and gasoline cars. Iron and lead have accumulated at higher rates in the oil of the methanol cars but not so much greater as to cause alarm. Drivers rated the driveability of the methanol cars virtually the same as that of the gasoline cars and rated the ease of starting of the methanol cars somewhat lower. Results of the driver

survey indicate that the methanol cars are very well received, in spite of some cold-starting difficulty. Drivers impressions of ease of starting of the methanol cars clearly suffered in the colder months of the year, but these cars have no special systems for assisting cold weather starting. Only on the very coldest of days in Oak Ridge were there great problems with starting the methanol cars.

2. OAK RIDGE NATIONAL LABORATORY FLEET

Oak Ridge National Laboratory is one of three facilities operated in Oak Ridge, Tennessee by Martin Marietta Energy Systems, Inc. for the Department of Energy. Vehicles involved in this project are located at two of the sites, and the methanol refueling facility is located at the third. Much of the cars' use involves driving within and between these three sites, each of which is approximately 8 miles from the others. Weather in the East Tennessee area is generally moderate to warm, but winters can include a number of extremely cold days, a factor which influences methanol vehicle performance and driver acceptance.

2.1 METHANOL VEHICLE DESCRIPTION

Converting the Buicks to methanol operation by Michigan Automotive Research Corporation was patterned after a successful conversion that they had provided BP America (formerly Standard Oil of Ohio) a few years earlier.[11] The details of the conversion are outlined in last year's report[1] and will not be repeated here, but the major features of the methanol conversion are: changes to ECM (Engine Control Module), nickel plated fuel rail, larger stainless steel fuel tank, methanol compatible fuel pumps, cooler range spark plugs, and larger, methanol compatible fuel injectors.

No special provisions other than programming changes in the ECM were incorporated for cold-starting these vehicles, even though the winter weather in Oak Ridge is occasionally cold enough to create starting problems. (This is different from the fleet operating under this program at Argonne National Laboratory in Chicago, Illinois, where sophisticated systems were installed on the methanol vehicles to aid in cold-starting).[6-8] Funding resources were not sufficient to install such cold weather systems on the ORNL cars, and it was decided that the incidence of extremely cold weather is infrequent enough so as not to warrant an expensive development program for added systems. In addition, the Oak Ridge site has been very useful in helping define what "cold" weather is, with regard to starting methanol vehicles without special systems. The methanol vehicles at Argonne National Laboratory, with their cold-start systems, have had fewer starting problems.[6-8]

2.2 LUBRICATING OIL, OIL CHANGE AND SAMPLING INTERVALS

Lubricating oil for the methanol Buicks has been supplied by the Lubrizol Corporation and is a 10W-30 multi-grade oil with an additive package intended to reduce engine wear and corrosion that may be caused by the methanol fuel. The gasoline Buicks use a standard multi-grade lubricating oil recommended by General Motors for these turbocharged vehicles. The particular oil selected for the gasoline cars is Valvoline Turbo V (SF,CD,CC), 10W-30.

Oil change interval for all ten cars in the fleet is set at 3000 miles, and the oil is sampled at 1000 mile intervals for laboratory analyses of wear metals, base number, viscosity, etc.

3. RESULTS

3.1 FLEET UTILIZATION AND FUEL CONSUMPTION

Table 1 summarizes the fleet utilization (mileage accumulation) and fuel consumption of the ORNL fleet for the second year of operation. Shown are data for total miles driven, average miles per trip, and average fuel economy for each of the ten cars as well as aggregate totals for the five cars of each type – methanol or gasoline. Tables 2 and 3 show the same data for the composite of two years, and the first year, respectively.

Table 1. Fleet Utilization and Fuel Consumption Data

Second Year: January 1–December 31, 1989

Total vehicle ID	Average miles	Fuel economy		
		miles/trip	mpg	km/GJ[a]
	Methanol vehicles			
9390	4,375	10	8.8	205
9392	2,724	9	9.6	224
9394	5,565	7	9.6	224
9396	4,237	8	9.5	222
9398	8,232	11	9.9	231
TOTAL	25,133	9[b]	9.5[b]	222
	Gasoline vehicles			
9391	2,995	6	15.2	201
9393	6,254	22	18.7	247
9395	6,769	15	18.3	242
9397	9,078	20	17.7	234
9399	6,413	17	16.8	222
TOTAL	31,509	15[b]	17.5[b]	232[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. Fleet Utilization and Fuel Consumption Data

Two Years: Through December 31, 1989

Total vehicle ID	Average miles	Fuel economy		
		miles/trip	mpg	km/GJ[a]
	Methanol vehicles			
9390	14,090	11	9.5	222
9392	6,702	8	9.3	217
9394	10,239	8	9.3	217
9396	10,784	10	10.0	233
9398	14,999	14	10.0	233
TOTAL	56,814	10[b]	9.7[b]	225[b]
	Gasoline vehicles			
9391	12,250	10	17.2	227
9393	17,848	19	18.7	247
9395	24,977	19	19.4	256
9397	22,497	20	18.9	250
9399	18,417	20	18.1	239
TOTAL	95,989	17[b]	18.6[b]	246[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. Fleet Utilization and Fuel Consumption Data

First Year: Through December 31, 1988

Total vehicle ID	Average miles	Fuel economy		
		miles/trip	mpg	km/GJ[a]
	Methanol vehicles			
9390	9,715	12	9.9	231
9392	3,978	7	9.1	212
9394	4,674	8	9.0	210
9396	6,547	12	10.3	240
9398	6,767	18	10.1	236
TOTAL	31,681	11[b]	9.8[b]	224[b]
	Gasoline vehicles			
9391	9,255	13	17.9	237
9393	11,594	17	18.7	247
9395	18,208	21	19.8	261
9397	13,419	19	19.8	261
9399	12,004	22	18.9	249
TOTAL	64,480	18[b]	19.1[b]	253[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.

Over 56,000 miles (90,000 km) were accumulated on the ten cars during the period of this report with about 31,000 of the miles being accounted for by the gasoline cars, which were used for more out-of-town trips than the methanol cars due to the general unavailability of M85 fuel. Average trip lengths for the methanol cars were shorter probably because the gasoline cars account for the majority of use on out-of-town trips.

Energy efficiency (km/GJ) was slightly lower for the methanol group than for the gasoline group, but this likely resulted, at least in part, from the shorter trips experienced by the methanol cars. This year's difference in energy efficiency between the two types of cars was not as great as last year due to a decline in the gasoline vehicles' efficiency. It is likely that the gasoline cars were used for fewer out-of-town trips than the previous year, as the total miles driven are less than half of that of the previous year, and this is reflected in the data by shorter average trip lengths.

3.2 COMPARISON OF MAINTENANCE AND SERVICE

Maintenance data for both the second year and the cumulative total of two years are given in Tables 4 and 5. Table 4 shows the number of occasions and frequency of maintenance (occasions per 1000 miles), while Table 5 shows the number of labor hours and intensity (labor hours per 1000 miles). The labor intensity and frequency for the first and second year are summarized in Table 6. "All Maintenance" includes all occasions for maintenance for which a service work order was written. This would include occasions of routine maintenance such as oil changes and tire maintenance as well as occasions of unusual maintenance, that is, those occasions that are prompted by complaints or malfunctions. The occasions designated as "Fuel Related" are those which have been identified as being intimately related to the nature of the fuel and/or fuel delivery systems. For methanol cars in general, all of the fuel related occasions resulted from situations that have been caused by the fuel or the systems incorporated in the methanol conversion. Similar situations for the gasoline cars have also been designated as fuel

Table 4. Occasions and Frequency of maintenance

	Number of occasions		Frequency (#/1000 mi)	
	2nd year	Two years	2nd year	Two years
	Five-car totals			
<u>All maintenance</u>				
Methanol	33	105	1.3	1.8
Gasoline	39	142	1.2	1.4
<u>Fuel-related maintenance</u>				
Methanol	6	13	0.2	0.2
Gasoline	0	1	0	0.01

Table 5. Maintenance Labor Hours and Intensity

	Hours		Intensity (hrs/1000 mi)	
	2nd year	Two years	2nd year	Two years
	Five-car totals			
<u>All maintenance</u>				
Methanol	45	100	1.8	1.7
Gasoline	51	132	1.6	1.4
<u>Fuel-related Maintenance</u>				
Methanol	12	26	0.5	0.5
Gasoline	0	1	0	0.01

Table 6. Summary of Maintenance Frequency and Intensity

	Frequency (#/1000 mi)		Intensity (hr/1000 mi)	
	2nd year	1st year	2nd year	1st year
	Five-car totals			
All Maintenance				
Methanol	1.3	2.2	1.8	1.7
Gasoline	1.2	1.6	1,6	1.3
Fuel-Related Maintenance				
Methanol	0.2	0.2	0.5	0.4
Gasoline	0	0.02	0	0.02

related. These delineations are used only in an attempt to show how much of the maintenance required by the methanol cars can be traced to the methanol fuel or its systems.

Much of the methanol cars' fuel-related maintenance has been related to the prototype methanol fuel pumps. The pumps were designed and fabricated for methanol compatibility, but there was apparently a problem with an overcrimped connecting wire in some of the pumps' internals during assembly. This has resulted in eventual failure of some of the pumps (due to loss of power connection) and has required pump replacement. For the second year, pump replacement or trouble-shooting the pump problem accounted for 4 of the 6 occasions of fuel-related maintenance in Table 4. The only other fuel-related problem is replacement of fuel level sending units. Since a true methanol compatible unit is not available, standard gasoline sending units are used, which can corrode and eventually fail. Two sending units have been replaced in the same car since the beginning of the project.

The overall frequency of maintenance for the methanol cars in the second year is reduced to 1.2 occasions per 1000 miles and the labor intensity to 1.3 hours per 1000 miles if one discounts data in the tables by the amounts associated with the pump replacements. On the basis of these discounted figures, it can be concluded that there was not any great difference between methanol and gasoline cars in the maintenance required during the second year — except for those few avoidable incidents as described above.

3.3 OIL SAMPLE ANALYSES

Samples of the lubricating oil are drawn from the crankcase of each of the ten cars at approximately 1000 mile intervals. These 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.

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. Also, aluminum, chromium, and sodium do not accumulate in any amounts that would warrant further attention here. Silicon enters the oil usually by contamination from dirt in the environment, and data regarding its concentration are not as enlightening as that of other contaminants with respect to engine wear. Iron is usually the largest contributor to lubricating oil contamination in both the methanol vehicles and the gasoline vehicles.

Results are presented in Table 7 for accumulation rates of wear metals (iron, lead, and copper) in the lubricating oil. 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. Results in Table 7 use an entire year of data for the regression. Similar regressions were also performed on data from each calendar quarter to investigate any seasonal trends that might exist. These results are shown in Figures 1, 2, and 3 for iron, lead, and copper, respectively. Note that there is a general tendency in both

Table 7. Wear Metals Accumulation Rates (in lubricating oil)

Average wear metals accumulated in lubricating oil (ppm/1000 mi)

Wear Metal	2nd year	1st year
Methanol vehicles		
Iron	27	22
Lead	7	23
Copper	7	7
Gasoline vehicles		
Iron	5	3
Lead	4	3
Copper	2	1

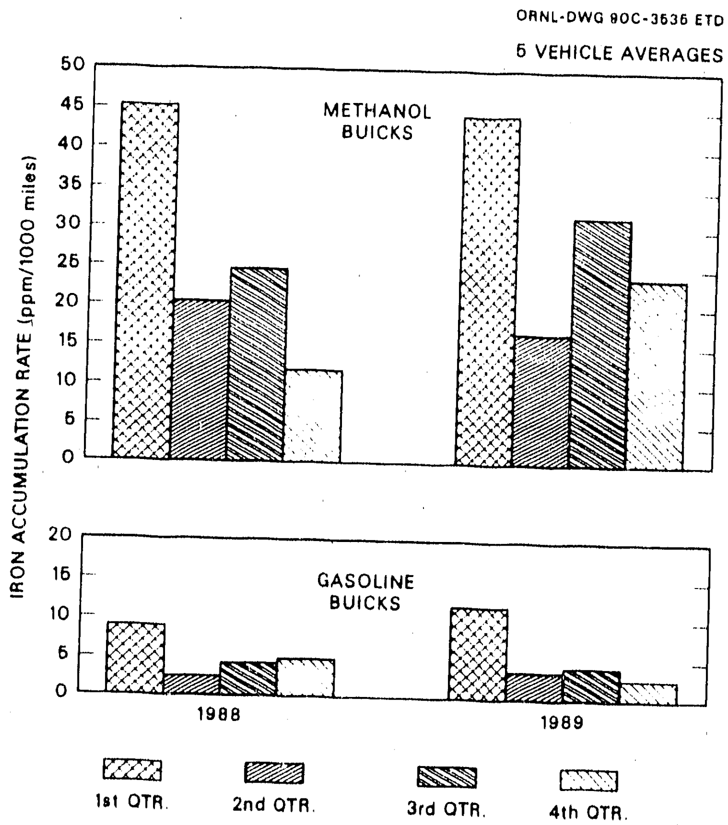

Fig. 1. Iron accumulation rate as a function of quarter.

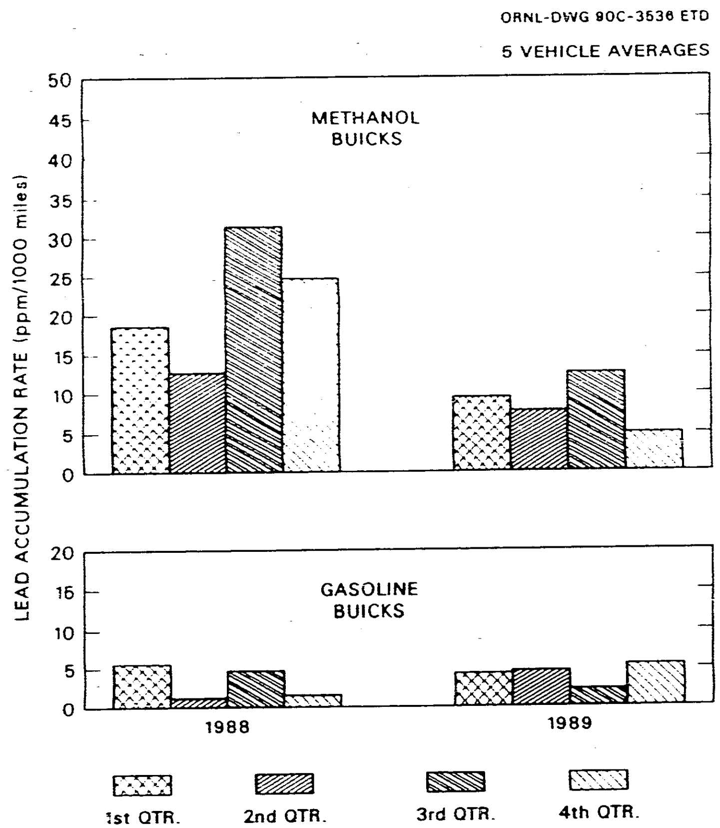

Fig. 2. Lead accumulation rate as a function of quarter.

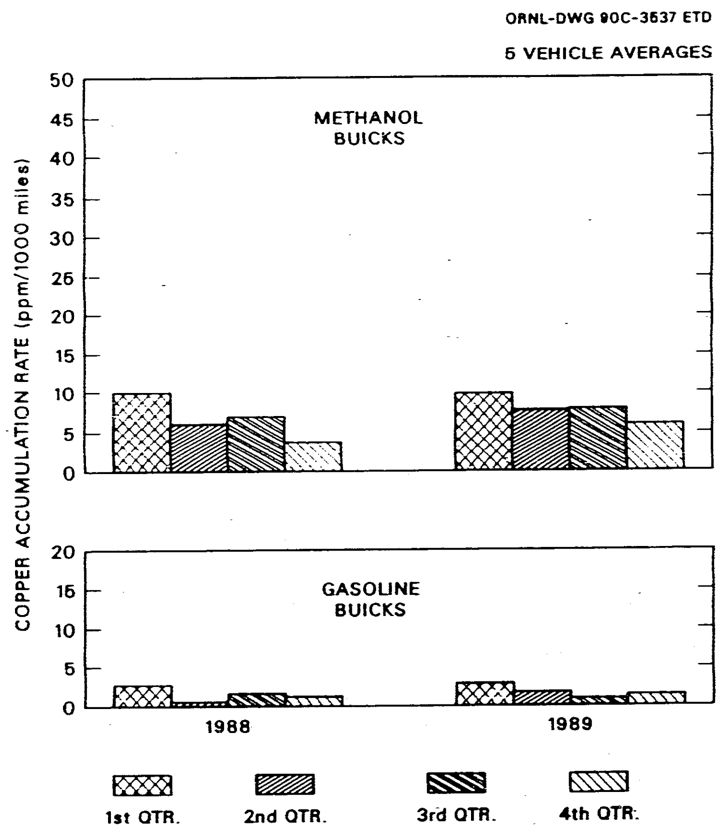

Fig. 3. Copper accumulation rate as a function of quarter.

types of vehicles for the metal accumulation rate to be higher in the first (winter) quarter, this being especially true for iron. There also seems to be a tendency, at least for the methanol cars, for iron and lead accumulation rates to be higher in the third (summer) quarter as well. Cold weather is believed to play a role in accelerated engine wear, especially under short trip conditions, however hot weather can also accelerate engine wear when coupled with high load service.[12,13] This may partially account for the high iron and lead accumulation rates evident in Figures 1 and 2 for the methanol cars in the third quarter. The accumulation of wear metals in the gasoline cars has been quite nominal, although the iron accumulation rate was highest in the first quarter for both years.

Note that the linear regressions performed for each individual quarter used as few as 5 and as many as 16 data points. The reader should also note that the possibility certainly exists that oil samples can be drawn (and analyzed) during a quarter subsequent to the quarter in which the metal accumulation actually occurred. Also, driving style can contribute to or nullify the effects of weather on engine wear. Hence, the quarterly metals accumulation data only represent trends and serve only to suggest that engine wear is affected by ambient temperature.

Both iron and lead are considerably elevated in the oil of methanol cars as compared to gasoline cars but not any more so than in other methanol fleet vehicles at other sites. In fact, the accumulation rates of these metals in the methanol cars is only moderately greater than the rate of the same metals in some of the gasoline cars at another site.[6-8] Although direct comparisons cannot be made between different engine types subjected to different types of service, this does tend to indicate that the higher metal accumulation rates in the Oak Ridge methanol cars is not cause for alarm.

3.4 DRIVERS' RATINGS OF VEHICLE PERFORMANCE

Drivers are asked to evaluate the car's 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 impression may change over time.

During the second year, 4794 trip log entries were recorded; 2738 for methanol cars and 2056 for gasoline cars, bringing the two year total to 11,191 trips. Approximately 400 persons at ORNL have driven at least one of the cars in the fleet project.

Results of drivers' ratings are shown in Tables 8, 9, and 10 in terms of numbers of responses (to ease of starting and driveability) as well as in percentages. The second year's results are given in Table 8, two years combined in Table 9, and the first year's results are repeated in Table 10 for comparison. Ratings for the second year are not considerably different from those of the first year. For the second year,

Table 8. Responses from daily trip logs for Ease of Starting and Driveability

Second Year – January 1–December 31, 1989

	Responses			
	Good	Average	Poor	No Response
	Five-car totals			
Ease of Starting				
Methanol	1,790	565	319	64
Gasoline	1,849	113	18	76
	Percent of total			
Methanol	65	21	12	2
Gasoline	90	5	1	4
Driveability				
Methanol	2,405	212	9	112
Gasoline	1,729	192	31	104
	Percent of total			
Methanol	88	8	0	4
Gasoline	84	9	2	5

Table 9. Responses from daily trip logs for Ease of Starting and Driveability

Two Years - Through December 31, 1989

	Responses			
	Good	Average	Poor	No Response
	Five-car totals			
Ease of starting				
Methanol	3,860	1,109	614	112
Gasoline	5,125	314	38	152
	Percent of total			
Methanol	68	19	11	2
Gasoline	91	6	1	3[a]
Driveability				
Methanol	5,129	349	23	194
Gasoline	4,972	393	46	218
	Percent of total			
Methanol	90	6	0	3[a]
Gasoline	88	7	1	4

[a]Percentages do not add up to 100 % due to rounding.

Table 10. Responses from daily trip logs for Ease of Starting and Driveability

First Year - Through December 31, 1988

	Responses			
	Good	Average	Poor	No Response
	Five-car totals			
Ease of Starting				
Methanol	2,070	544	295	48
Gasoline	3,276	201	20	76
	Percent of total			
Methanol	70	18	10	2
Gasoline	91	6	1	2
Driveability				
Methanol	2,724	137	14	82
Gasoline	3,243	201	15	114
	Percent of Total			
Methanol	92	5	0	3
Gasoline	91	6	0	3

ratings of driveability are very similar between methanol and gasoline cars, being rated as "Good" 88 and 84 percent of the time, respectively. Ratings of ease of starting suffered somewhat for the methanol cars with only 65 percent of the engine starts being rated as "Good" compared with 90 percent for the gasoline cars. Drivers rated the starting of the methanol cars as "Poor" a sizeable 12 percent of the time, versus only 1 percent for the gasoline cars. The higher incidence of poor ratings helps to illustrate the deficiencies of methanol engine systems without special engineering for cold weather starting.

3.5 COLD-WEATHER PERFORMANCE

It is evident from the results of drivers' ratings that the methanol cars suffer from cold-starting problems, but it is not clear from the gross data presented in the previous section just how the ratings are related to weather. In order to gain more insight into how weather affects driver ratings, the ratings that represent the first trip of each day (first cold-start) have been extracted from the rest of the data and examined separately. In most cases the cars would have had at least a number of hours of "soaking" at the ambient temperature before being started and rated by the driver, although there is no control over the temperature.

Figure 4 shows the average driver rating of ease of starting for the first trip of each day as a function of month. Numerical values were assigned to the ratings of "Good," "Average," and "Poor" so as to be able to determine an average rating. Ratings of the methanol cars resulted in a very classically shaped plot showing decreasing levels of ratings during colder months. The highest average rating for ease of starting of the methanol cars was in the summer months, lowest in the winter. Note that the shape of the first and second year curves are very similar for the methanol cars, although the average rating appears to be slightly lower for the fall and winter of the second year (1989). The ratings for the gasoline cars were very stable with a very high average rating throughout both years.

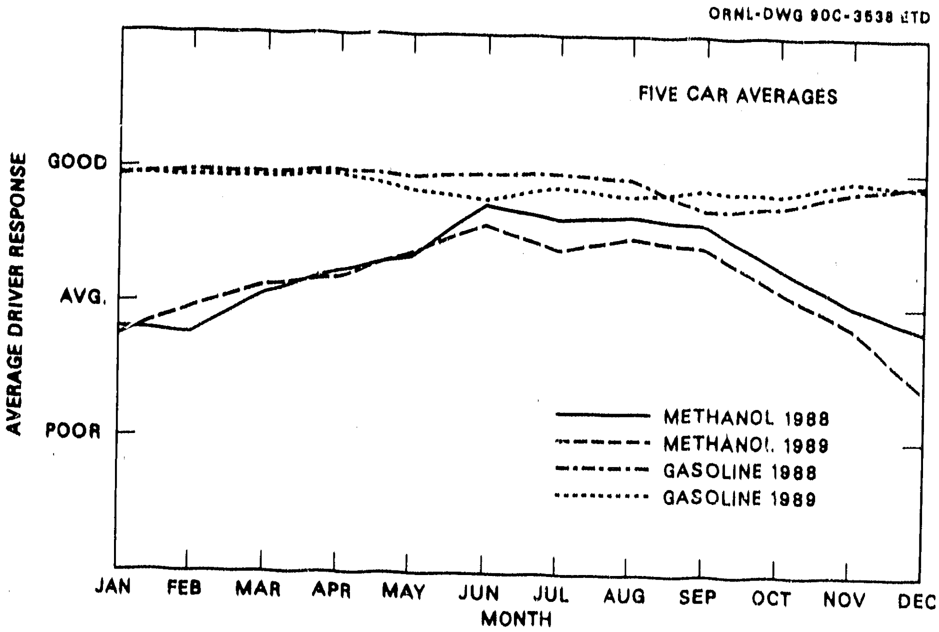

Fig. 4. Average rating of Ease of Starting – first start of each day.

Qualitative data and reports from car users regarding the ease of starting of the methanol cars during the winter indicate that the starting is reasonably reliable and strong at temperatures down to about 20°F. At temperatures around 15°F starting becomes very difficult and requires lengthy cranking. At temperatures around 10°F or lower, starting is extremely difficult requiring very long cranking times. However, if drivers continued to crank the engines, even at such low temperatures, it was usually possible to succeed in starting the engine. Experiences at such low temperatures were rare, although December, 1989 was the coldest December record in the area. There were at least a few reports of drivers failing to start the methanol cars or having great difficulty. It is important to point out that the volatility of the M85 fuel used at ORNL has not been tailored to have higher vapor pressure in the winter as has been done at other sites. The Reid Vapor Pressure (RVP) of the fuel used at ORNL has been around 6-7 psi, hardly volatile enough for effective starts at below-freezing temperatures. By blending high volatility gasoline with the methanol it is possible to attain RVPs of 9 to 11 psi, which greatly improves cold-start performance. Efforts are being made to obtain just such a fuel for the third year of the ORNL test, and results on driver response will be presented in next year's report.

3.6 RESULTS OF DRIVER SURVEY

In the Fall of 1989, drivers at ORNL were surveyed to elicit from them more in-depth evaluations of their opinions of the fleet vehicles. Of the 350 forms that were distributed, 191 were returned (55%). The results of the survey are presented in Appendix A, both in terms of percentage of responses to multiple-choice questions, and actual comments written on the forms by the respondents. In summary, the survey results indicate a generally favorable opinion of the methanol vehicles in service at ORNL. Many drivers indicated that they like the enhanced performance, and 70% indicated that they would definitely buy or would consider buying a methanol vehicle for personal use. Initial cost and cost of operation seem to be important factors for most respondents, as are fuel availability, driving range, and cold-starting.

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APPENDIX A. RESULTS OF DRIVER SURVEY

Results from the survey of ORNL drivers are presented below in two sections. In the first section, percentages of responses are given for each multiple choice question. In the second section, drivers' written comments are presented following the corresponding question.

In most cases, over half of the drivers indicate that the methanol cars perform as well, or better than, the gasoline cars at ORNL. It appears that the factors which might prevent those surveyed from buying a methanol vehicle for personal use are cold-starting, cost of operation, and driving range. Many drivers indicated a high level of satisfaction with the enhanced performance (acceleration) of the methanol cars.

Oak Ridge National Laboratory
Federal Methanol Fleet
Fall 1989 – Driver Survey

SECTION I

1. **Indicated below are the two types of Buicks in the Fleet that you may have had the opportunity to drive. Please estimate the percent of time that you drove each type.**

	Frequency of response (%)
• Only Methanol cars driven	20
• Methanol cars driven more in dual experience	19
• Both driven equally	21
• Gasoline cars driven more in dual experience	28
• Only Gasoline cars driven	12

2. **Please check the block that best matches the length of time you have been a participant in the 'FEDERAL METHANOL FLEET' program.**

• Less than 6 months	11
• 6 months to 1 year	12
• 1 year to 18 months	77

3. **Do the Buicks in the motor pool perform at a level that is equal to other cars of this type that you have previously driven?**

• Better	41
• Equal	36
• Worse	3
• No comparable experience	20

4. **When you drove the Buicks, which type of driving did you experience the most?**

Methanol

• Highway	34
• In town	58
• Both equally	3
• No Experience	5

Gasoline

• Highway	34
• In town	49
• Both equally	5
• No Experience	12

5. **Did you have difficulty in STARTING the engines?**

Methanol

• Yes	34
• No	65
• Do not remember	1

Gasoline

• Yes	7
• No	92
• Do not remember	1

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

• Methanol much better	1
• Methanol slightly better	2
• About the same	53
• Gasoline slightly better	28
• Gasoline much better	15
• Do not know	1

7. **How would you compare the performance of the vehicles during the WARM-UP period?**

• Methanol much better	4
• Methanol slightly better	10
• About the same	63
• Gasoline slightly better	19
• Gasoline much better	3
• Do not know	1

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

• Methanol much better	24
• Methanol slightly better	18
• About the same	52
• Gasoline slightly better	4
• Gasoline much better	1
• Do not know	1

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

• Methanol was best	29
• About the same	44
• Gasoline was best	10
• Can not say	17

10. How would you compare the DRIVEABILITY of the Buicks?

• Methanol much better	8
• Methanol slightly better	15
• About the same	70
• Gasoline slightly better	5
• Gasoline much better	1
• Cannot say	1

11. Do you feel SAFE driving the Fleet vehicles?

Methanol

• Yes	88
• No	1
• Did not consider it	11

Gasoline

• Yes	87
• No	1
• Did not consider it	12

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

• Much better	1
• Slightly better	8
• About the same	50
• Slightly worse	28
• Much worse	9
• Do not know	4

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

• Yes	95
• No	5

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

• Prefer Methanol by far	12
• Prefer Methanol slightly	21
• Would make no difference	47
• Prefer Gasoline slightly	15
• Prefer Gasoline by far	5

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

• Would definitely buy one	4
• Might consider buying one	66
• Probably would not buy one	21
• Would definitely not buy one	8
• Can not say	1

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

• Yes	57
• No	8
• Do not know	35

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

• Most are confused	20
• Slightly more are confused	13
• 50 - 50	13
• Slightly more are not confused	6
• Most are not confused	6
• Do not know	42

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

• Methanol by far	9
• Methanol slightly more	41
• Both about the same	45
• Gasoline slightly more	1
• Gasoline by far	0
• Do not know	4

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

• Yes	18
• No	82

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

• Yes	2
• No	98

21. **Which type of driving do you experience the most when you drive your personal vehicle?**

	• Highway	58
	• Stop & Go	42

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

	• Administration	18
	• Research Staff	39
	• Fleet Maintenance Staff	1
Support Staff	• Secretarial & Adminstration	19
	• Technical Staff	23

23. **Age**

• 18-34	27
• 35-49	46
• 50-UP	27

24. **Sex**

• F	32
• M	68

OAK RIDGE NATIONAL LABORATORY
FALL 1989 – DRIVER SURVEY COMMENTS

SECTION II

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

Answer: Yes

- "Only when T<30°F"
- "Difficulty ONLY in cold weather; below 40°F. Otherwise, very good – no difficulty."

Answer: No

- no comments

Answer: Do not remember

- no comments

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

Answer: Methanol much better

- no comments

Answer: Methanol slightly better

- no comments

Answer: About the same

- "No Gasoline experience – but methanol started well"

Answer: Gasoline slightly better

- no comments

Answer: Gasoline much better

- "Responds to outdoor temperature. At <20°F the methanol is very hard to start. Otherwise, they are about the same."
- Gasoline is much better in cold weather, otherwise about the same." I had the dubious honor of trying to start the MeOH vehicle when it was 0°F."
- "Since the methanol cars do not have a cold start system, start-ability is adversely effected by ambient temperatures below 20°F."

Answer: Do not know.

- no comments

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

Answer: Methanol much better.

- no comments

Answer: Methanol slightly better.

- no comments

Answer: About the same.

- no comments

Answer: Gasoline slightly better.

- "The Methanol car ran very good."

Answer: Gasoline much better.

- no comments

Answer: Do not know.

- no comments

QUESTION: **GIVEN YOUR EXPERIENCE, HOW WOULD YOU RATE THE "DRIVING RANGE" OF THE METHANOL VEHICLES AS COMPARED TO THE GASOLINE VEHICLES?**

Answer: Much better.

- no comments

Answer: Slightly better.

- no comments

Answer: About the same.

- no comments

Answer: Slightly worse.

- no comments

Answer: Much worse.

- "No refueling except at home base - gives an uneasy feeling, also the methanol car has no fuel gauge - feels awkward."

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

Answer: Yes.

- "I would worry some about breakdowns - especially fuel pump problems."
- "I liked the improved acceleration."
- "Only if the cost/mile is the same."
- "We must look to the future and prepare for it now."
- "My only fear was running out of fuel and facing my boss afterward. The fuel gauge did not instill confidence."
- "As long as I did not have to pay extra for the fuel use."
- "Sure - Goes like a bat out of hell!!!"
- "Needs comparable or better range than gasoline."
- "The methanol Buick I drove was at least equal to any gasoline powered car I've driven."
- "My main problem was starting. Although slower to start, I was able to get the methanol car started. Would feel comfortable on a trip with it."
- "We must do what we have to, to clean up the environment and utilize available resources."
- "Not sure, no experience driving the methanol vehicle for longer trips. Driveability was about the same for both vehicles on short trips."
- "Reliability is the same."
- "Would be willing but would prefer not to use methanol because MPG is worse requiring more fuel stops."
- "If costs were comparable."
- "If not too much more expensive, and if my car were adapted to it."
- "Depending on price per gallon as compared to gasoline."
- "However, it would depend on distance to travel, since methanol is not readily available outside of plant area."
- "Yes, unless below 32°F temperatures are expected. I would not want to be stuck somewhere."
- "If nearly every fueling stations were uniformly spaced and not with all stations in urban areas and none in rural areas. Availability is the key to this question."
- "Much better performance and power."
- "Should be more economical and burn cleaner."
- "If fuel is available there is no discernible difference."
- "Not unless I had a car specifically designed for it."
- "Why not."
- "Why not."

Answer: No.

- "Prefer a range of 250-300 miles"
- "Makes the car run rough (chokes)."
- "The current distribution system can't even handle gasoline correctly. Methanol would be worse (moisture and absorption)."
- "Fuel is not the only consideration on an extended vehicle trip, one must also consider the availability of mechanics to work on such a unique vehicle."
- "Depends on whether it is summer or winter. Must solve winter cold-starting problems."
- "I feel over the long haul they are going to be more expensive as well as pollution wise."
- "But only in warmer weather."

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

Answer: Prefer Methanol by far.

- "Beats out the OPEC cartel."
- "Environmental and Performance."
- "Domestic fuel source, higher performance, less ecological impact."
- "Peppier - great feeling of power."
- "Presumably cleaner air."
- "Cleaner air and not having to use our diminishing supply of gasoline."
- "I believe the Methanol engine to be better environmentally, both in fuel source and emissions.
- "I believe it pollutes the environment less."
- "More pep."
- "Performance (ZOO-M111)"
- "Cleaner and less wear on engine."
- "I presume it's cleaner."
- "Resource conservation and environmental impact and balance of payments."

Answer: Prefer Methanol slightly.

- "Performance and cutting OPEC ties. Only drawback is RANGE."
- "Because of better emissions from the methanol."
- "Better performance & emissions, offset by need for larger fuel tank (& subsequent weight penalty)."
- "Better performance, might change my mind if insurance costs are much higher for methanol vehicles."
- "Lower emissions."
- "Lower emissions."
- "Assume its environmentally cleaner burning."

Answer: Prefer Methanol slightly (continued).

- "Because of its alternative fuel potential and desire to cut oil imports."
- "Environmentally better, I think."
- "Better power."
- "Better response."
- "Better on environment."
- "Higher octane - higher performance potential."
- "Burns cleaner."
- "Better performance."
- "Safer to handle (I think), less polluting, would reduce oil imports and reliance on far east."
- "Better performance, less pollution."
- "Less pollution"
- "Performance."
- "More power."
- "On our particular cars, the turbo lag is much less on the methanol cars."
- "Methanol could alleviate some energy problems."
- "More pep."

Answer: Would make no difference.

- "As long as performance is the same, fuel is fuel."
- "I feel like I'm getting the same performance."
- "Starting problem not sufficiently difficult to discourage methanol use."
- "Methanol has been claimed to be a clean fuel. I would be concerned about longevity of the engine due to its corrosive nature (I currently drive a gasoline powered vehicle, with 142,000 [miles] on it.) Also, from a pollution standpoint, total pollution, production and consumption, should be evaluated."
- "Unless methanol got better mileage, then I say I'd prefer methanol by far."
- "I am assuming the fuel gauge and cold start problems can be fixed."
- "They perform equally well."
- "Because of availability"
- "As long as the cost was the same it wouldn't matter to me personally."
- "If I were convinced that methanol were better for the environment, I would choose methanol."

Answer: Prefer Gasoline slightly.

- "Fewer fill-ups."
- "Gasoline is much more convenient to buy, and probably will remain so."
- "Too hard to start and get going when it is cold."
- "Greater BTU value - therefore have to carry less fuel (weight) for a given vehicle range."
- "People when given too many choices often make bad ones."

Answer: Prefer Gasoline slightly (continued).

- "Less corrosive to engine. Methanol contains water, also runs hotter reducing engine life."
- "Only reason is 'Ease of Starting'. On cold days, I thought the methanol car wasn't going to start."
- "Some starting problems with methanol. Other than that, I have no preference."
- "For same cost, would prefer proven reliability of engines designed and built for gasoline. Nonetheless, I'm prevented from endorsing gasoline "By far", owing to pollutants."
- "Gasoline car is easier to start: runs better when the weather is cold."
- "For personal use I expect a methanol vehicle would be very difficult to start on a cold winter night."
- "Supposed to be better for the environment and less pollution."
- "Pollution and safety."

Answer: Prefer Gasoline by far.

- "More familiar."
- "Gasoline don't burn as fast as methanol."
- "Methanol deteriorates rubber components and will mix with water – my cars are not built to run methanol so I would expect more maintenance problems."
- "Lack of readily trained and available mechanics for methanol cars"
- "Environmentally better."

<u>QUESTION</u>: GIVEN YOUR EXPERIENCE, WOULD YOU CONSIDER BUYING A METHANOL POWERED VEHICLE?

Answer: Would definitely buy one.

- "Why not? As long as the methanol gas is available."
- "Provided cost and fuel availability are equal to, or better than, gasoline."

Answer: Might consider buying one.

- "Supply would have to be everywhere."
- "Dependent only upon cost of methanol car – would not pay significantly more for methanol vehicle."
- "Provided overall maintenance costs were not significantly higher."
- "Would need to solve 1) availability of fuel, 2) cold weather starting, and 3) parts availability for methanol engines."
- "I had one breakdown experience because of inadequacies in the conversion of the car from gasoline to methanol fuel. I'd have to be sure the technical problems were solved."
- "If costs were roughly equal."

Answer: Might consider buying one (continued).

- "If starting problems can be solved to be no worse than gasoline in all weather conditions."
- "Would have to improve cold start problem."
- "In five years (1994)."
- "If fuel was widely available."
- "Like the idea of trying to 'improve the environment'. However, cold weather performance of the methanol vehicles would have to be improved before I actually would buy one."
- "Fuel supply would have to be improved greatly."
- "I suspect the capital cost would be higher for methanol."
- "Fuel type would likely not be the overriding factor."
- "Fuel availability is a concern; long-term reliability a possible concern."
- "I would love to look into the advantages and disadvantages more – I assume the remaining problems with methanol can be fixed."
- "Availability of fuel."
- "Due to lower emissions"
- "Once the infrastructure is established and the cold start problem solved."
- "Depends on cost/mile, fuel availability, reliability."
- "This decision would depend on availability of fuel and maintenance reports."
- "If methanol is made commercially available."
- "Starting problem would have to be solved. If I lived in Florida, I would probably buy one."
- "I did not have an opportunity to drive methanol on long trips, need more experience."
- "Depends on cost of vehicle and availability and cost of methanol."
- "Availability of gas stations."
- "I would want more data on safety/repair performance not available in such a limited test."
- "Only if fuel available or FFV feature in car."

  Author's note: FFV stands for "flexible fuel vehicle," a vehicle capable of running on methanol, ethanol, gasoline, or any combination of the three.
- "More goes into my decision than one factor (for example, price, maintenance, fuel economy, comfort, etc.) – not based on CH_3OH [methanol] alone."
- "Depend on cost."
- "Costs and availability of fuel would be major consideration."
- "Would have to have input as to Maintenance, Gas to Methanol"
- "If methanol fuel was conveniently available at same or lower cost per mile."
- "I would want to do some research on repairs, insurance costs, etc."

Answer: Probably would not buy one.

- "Fuel availability. Concern that long term durability has not been demonstrated. Note: If I were planning to trade after 50,000 miles AND if fuel were available, I might consider it."
- "It would be more hassle – no infrastructure."
- "To perform at a high level fuel would always have to be a high octane fuel."
- "Resale – most people still UNFAMILIAR with methanol vehicles."
- "Given limited information on overall vehicle life, I would be reluctant to buy a methanol vehicle."
- "Been burned before buying a new model, which did not live up to expectations."
- "Expense of repair and fuel possibly higher."
- "Maintenance and reliability are more important."

Answer: Would definitely not buy one.

- "Hard starting would make it useless from my wife's perspective."
- "If cost of vehicle and fuel were comparable."
- "Until methanol is more commonly used, I would expect the total cost per mile to be considerable higher."
- "I wouldn't want them because gasoline starts better when the engine is cold."
- "The engine makes a knocking noise."
- "Bugs aren't worked out of 1) price, 2) fleet vehicles (mass produced), and 3) availability."
- "Poor fuel availability, higher cost, lack of repair know-how in most garages."
- "Can't get fuel."
- "Methanol is not available. Cost of repairs and repair cycles not known."

Answer: Cannot say.

- no comments

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

Answer: Yes.

- no comments

Answer: No

- "Would only be a very small contribution."

Answer: Do not know.

- "Depends on source of the methanol. If natural gas – No."

No response

- "Contributor to, but not THE solution."

QUESTION: FROM WHAT YOU'VE HEARD, WHICH OF THE VEHICLES REQUIRE MORE SERVICE OR REPAIR, METHANOL OR GASOLINE?

Answer: Methanol by far.

- no comments

Answer: Methanol slightly more.

- "Fuel pumps."

Answer: Both about the same.

- "Except for the fuel pump!"
- "I haven't heard of anything."

Answer: Gasoline slightly more.

- no comments

Answer: Gasoline by far.

- no comments

Answer: Do not know.

- no comments

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

Answer: Yes.

- "Hard to re-fuel at a remote warehouse in Cincinnati, Ohio from a 55-gal. drum – with a hand pump."

  Author's Note: In an effort to extend the range of the methanol vehicles, a few fuel drums were shipped to secondary locations, thus allowing for a doubling of range in some cases.

Answer: Yes (continued).

- "Hours of operation were limited – slight inconvenience."
- "The damn place (K-25) is closed half the time; the use of the identification numbers (in addition to the mag. cards) is needlessly confusing & time consuming."

  Author's Note: The M85 pump is located at the K-25 plant site in Oak Ridge. The refueling station's attendant hours used to be only 4 hours per day. The attendant hours are now longer and "self service" pumping is allowed during off hours. Magnetic cards and secret identification numbers are used to access both methanol and gasoline pumps at all three plant sites.
- "The reliance on Neanderthal pump attendants is a pain."
- "The pump is very VERY SLOW!"
- "Slow."
- "Very slow to fill car, methanol pumped very slowly."
- "The pump was EXTREMELY SLOW!!! The attendant told me they had called to have it serviced."
- "Very poor fuel tank design – methanol will not flow in properly."
- "Very slow!"
- "Slow pump!"
- "Tank size and fleet consumption rate incompatible – slow turnover."
- "Pumping is an extremely SLOW process. I don't know if this is due to the pump itself, or the configuration of the car's fueling system. Have experienced "freezing up", where only 1 1/2 gallons was pumped, and no more could be delivered."

Answer: No.

- "The station needed to have special (and costly) arrangements."

END

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