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Results from the Fourth Year of Operation of the Federal Methanol Fleet at Lawrence Berkeley Laboratory

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

RESULTS FROM THE FOURTH YEAR OF OPERATION OF THE FEDERAL METHANOL FLEET AT LAWRENCE BERKELEY LABORATORY

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FOREWORD

This report is only one in a series of yearly reports on the results from the Federal Methanol Fleet project. Each report details 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 alongside 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, 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 acquired 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 is how the emissions change over time, not how they compare to the lowest attainable. Emissions measured after conversion to methanol 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.

ABSTRACT

Lawrence Berkeley Laboratory has completed a fourth year of operation of five methanol vehicles for the Federal Methanol Fleet Project. Five comparable gasoline vehicles were involved in the project for the first three years, but were retired at the end of the third year. Approximately 25,000 miles were accumulated on the five methanol vehicles during the fourth year bringing the ten car total for all four years to nearly 310,000 miles. Fuel economy of the methanol vehicles was about the same as in previous years, while drivers' ratings of ease of starting and driveability declined. The cars required more frequent maintenance than in previous years, and the accumulation rates of wear metals in the engine oil continued to decline.

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1. INTRODUCTION

Lawrence Berkeley Laboratory (LBL) has operated ten cars for the Department of Energy's Federal Methanol Fleet Project; five of the cars are methanol-powered and have just completed their fourth year of operation, and five of the cars were comparable gasoline vehicles but were retired from service at the end of their third year and are no longer available as direct comparisons. The Oak Ridge National Laboratory (ORNL) has project management responsibility for the entire Methanol Fleet Project including activities at LBL and, as such, collects and disseminates data and information related to the operation of the project. Previous ORNL reports[1-3*] detail the results of the first three years of operation at LBL; this report deals with the fourth year's operation. Because the background of the project and the operations at the other two Federal Methanol Fleet test sites have been described in previous reports,[1-11] they will not be discussed at any great length here. The reader is encouraged to refer to the previous reports for those details. This report will deal primarily with the results and data from the fourth year of operation and the comparison of those data with the similar results from previous years.

The five methanol cars were relatively new cars when they were converted to methanol operation by the Bank of America, whereas the gasoline cars had been in service elsewhere before they were pressed into duty as control vehicles for this project. As a result, the gasoline cars have been at later points in their serviceable lives than the methanol cars during their entire three years of the project. Therefore, the reader should be careful when comparing data between methanol and gasoline vehicles, especially those related to maintenance. At the time of their retirement the gasoline cars had an average of 58,300 miles on their odometers, while the comparable average for the methanol cars at that time was about 24,300 miles.

The methanol fuel mixture used at LBL contains a portion of regular unleaded gasoline to aid in cold-starting, but the mixture is not the

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*Superscripted numbers refer to references at the end of the report.

more common "M85" (85% methanol, 15% gasoline, used in the rest of the Federal Methanol Fleet). Instead, the fuel supplier provides a mixture that is nominally 88% methanol and 12% gasoline; this ratio is varied throughout the year as needed to improve cold starting. An above-ground tank and associated dispensing pump are used on-site at LBL for dispensing fuel into the five methanol-powered Citations.

The fleet vehicles are operated by LBL at their central motor pool and serve some of the general transportation needs of LBL personnel. They generally are used for transportation in and around the LBL site, for trips to Lawrence Livermore National Laboratory, and for trips to the Stanford Linear Accelerator Center.

A small amount of data including the drivers' ratings of the cars' 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 car 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 LBL are forwarded to the ORNL project management office where the Federal Methanol Fleet data base is maintained.

2. SUMMARY

The Federal Methanol Fleet operating at Lawrence Berkeley Laboratory completed a satisfactory fourth year of operation with the accumulation of just over 25,000 miles (40,000 kilometers) on the five methanol vehicles, bringing the four year total for both vehicle types to nearly 310,000 miles (500,000 kilometers). The five gasoline cars were retired from service near the end of the third year by the General Services Administration, but the five methanol cars will continue in service at LBL as long as practical. Fuel economy for the methanol cars was about the same as in previous years.

Rates of accumulation of metals in the lubricating oil in the fourth year were just slightly lower than in the third year for the methanol vehicles. Data are also presented in this year's report which show seasonal variation in wear metal accumulation rate for both methanol and gasoline vehicles, over the entire project.

The methanol cars required more overall maintenance in the fourth year than in previous years, although the fraction of maintenance identified as being fuel related or having been occasioned by elements of the methanol conversion was similar to previous years. There seems to remain an apparent tendency on the part of users to request maintenance or service for the methanol cars more frequently. Drivers continued to express general acceptance of the methanol vehicles in their ratings of ease of starting and driveability for each trip, although the percentage of "good" ratings decreased substantially from last year.

3. RESULTS

3.1 FLEET UTILIZATION AND FUEL CONSUMPTION

Table 1 summarizes the fleet utilization (mileage accumulation) and fuel consumption results from the LBL fleet for the fourth year of operation. Shown are data for total miles driven, average miles per trip, and average fuel economy for each of the five methanol cars, as well as aggregate totals. Table 2 summarizes the same parameters for the entire four years of operation (three years for gasoline cars). Tables 3, 4 and 5 (summaries from first, second, and third years of fleet, respectively) are repeated from previous annual reports for the purposes of comparison. Nearly 310,000 miles (500,000 kilometers) have been accumulated on the vehicles in the four years of operation, with about 25,000 miles (40,000 kilometers) being accumulated on the methanol cars in the fourth year.

Table 1. LBL Fleet Utilization and Fuel Consumption Data. Fourth Year - November 1, 1988 to October 31, 1989

Vehicle ID	Total miles	Average miles/trip	Fuel Economy	
			mpg	km/GJ[a]
		Methanol vehicles		
E-753	4,870	24	11.8	283
E-754	4,898	45	11.8	283
E-755	5,916	35	11.1	266
E-756	3,614	19	10.1	242
E-757	6,090	39	11.3	271
TOTAL	25,388	31[b]	11.2[b]	269[b]
		Gasoline vehicles retired from service		

[a]Based on methanol heating value of 56,560 Btu/gal and gasoline heating value of 115,400 Btu/gal; hence, M88 heating value equals 63,620 Btu/gal.

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

Table 2. LBL Fleet Utilization and Fuel Consumption Data. Four Years - Through October 31, 1989

Vehicle ID (License No.)	Total miles	Average miles/trip	Fuel Economy	
			mpg	km/GJ[a]
		Methanol vehicles		
E-753	24,619	34	11.4	283
E-754	28,605	44	11.9	285
E-755	25,666	33	10.6	255
E-756	24,063	28	11.3	270
E-757	25,697	42	11.3	271
TOTAL	128,650	36[b]	11.3[b]	273[b]
		Gasoline vehicles (through October, 1988)		
G-563	36,370	40	23.9	316
G-580	40,296	56	23.4	309
G-611	33,556	45	23.8	315
G-709	37,466	69	24.3	321
G-771	33,510	38	22.8	301
TOTAL	181,198	48[b]	23.6[b]	312[b]

[a]Based on methanol heating value of 56,560 Btu/gal and gasoline heating value of 115,400 Btu/gal; hence, M88 heating value equals 63,620 Btu/gal.

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

Table 3. LBL Fleet Utilization and Fuel Consumption Data. First Year - Through October 31, 1986

Vehicle ID (License No.)	Total miles	Average miles/trip	Fuel Economy	
			mpg	km/GJ[a]
		Methanol vehicles		
E-753	8,361	42	11.2	269
E-754	8,320	46	11.8	283
E-755	6,855	34	11.7	281
E-756	6,969	32	11.9	285
E-757	6,359	28	11.0	264
TOTAL	36,864	36[b]	11.4[b]	274[b]
		Gasoline vehicles		
G-563	16,067	69	25.1	332
G-580	17,082	55	23.3	308
G-611	13,609	43	22.6	299
G-709	14,741	109	26.0	343
G-771	12,830	41	23.8	315
TOTAL	74,329	57[b]	24.1[b]	318[b]

[a]Based on methanol heating value of 56,560 Btu/gal and gasoline heating value of 115,400 Btu/gal; hence, M88 heating value equals 63,620 Btu/gal.

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

Table 4. LBL Fleet Utilization and Fuel Consumption Data. Second Year - November 1, 1986 to October 31, 1987

Vehicle ID (License No.)	Total miles	Average miles/trip	Fuel Economy	
			mpg	km/GJ[a]
		Methanol vehicles		
E-753	6,787	39	12.2	293
E-754	8,787	46	12.8	307
E-755	5,784	22	9.8	235
E-756	7,442	39	11.6	278
E-757	7,158	59	11.8	283
TOTAL	35,958	38[b]	11.7[b]	281[b]
		Gasoline vehicles		
G-563	10,221	38	27.1	358
G-580	14,642	65	25.5	337
G-611	15,363	73	26.3	347
G-709	13,731	56	24.1	318
G-771	9,855	23	21.4	282
TOTAL	63,812	46[b]	24.9[b]	329[b]

[a]Based on methanol heating value of 56,560 Btu/gal and gasoline heating value of 115,400 Btu/gal; hence, M88 heating value equals 63,620 Btu/gal.

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

Table 5. LBL Fleet Utilization and Fuel Consumption Data. Third Year - November 1, 1987 to October 31, 1988

Vehicle ID (License No.)	Total miles	Average miles/trip	Fuel Economy	
			mpg	km/GJ[a]
		Methanol vehicles		
E-753	4,601	32	10.6	254
E-754	6,600	38	11.0	264
E-755	7,111	50	10.2	247
E-756	6,038	25	11.4	273
E-757	6,090	59	11.2	269
TOTAL	30,440	38[b]	10.9[b]	260[b]
		Gasoline vehicles		
G-563	10,082	25	20.5	271
G-580	8,572	44	20.8	275
G-611	4,584	21	20.4	270
G-709	8,994	55	22.3	295
G-771	10,825	78	23.2	307
TOTAL	43,057	38[b]	21.5[b]	284[b]

[a]Based on methanol heating value of 56,560 Btu/gal and gasoline heating value of 115,400 Btu/gal; hence, M88 heating value equals 63,620 Btu/gal.

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

3.2 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 6-11. 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 fourth year as well as summaries for the entire four years are presented. In the tables "All Maintenance" includes all occasions for maintenance for which a service work order was written. This would include all occasions of routine (scheduled) maintenance such as oil changes and tire maintenance as well as all occasions of unscheduled 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 the nature of the fuel and/or fuel delivery systems. In the case of the methanol cars, many of the fuel related occasions of maintenance result from situations that have been caused by the fuel or the systems incorporated in the conversion to methanol. Similar occasions for the gasoline cars have also been designated as fuel related. These designations are used only in an attempt to determine how much of the difference in maintenance between the two car types can be traced to the methanol fuel or its systems.

Table 6. Frequency of Maintenance - Fourth Year Compared with All 4 Years

Occasions (#) and Frequency (#/1000 mi.) of Maintenance	4th Year		All 4 Years	
	Five-car Totals			
	#	Freq.	#	Freq.
All Maintenance				
Methanol	63	2.5	234	1.8
Gasoline	retired from service			
Fuel-Related Maintenance				
Methanol	13	0.5	66	0.5
Gasoline	retired from service			

Table 7. Frequency of Maintenance - Third Year Compared with 3 Years

Occasions (#) and Frequency (#/1000 mi.) of Maintenance				
	3rd Year		3 Years	
	Five-car Totals			
	#	Freq.	#	Freq.
All Maintenance				
Methanol	47	1.5	171	1.7
Gasoline	33	0.8	131	0.7
Fuel-Related Maintenance				
Methanol	15	0.5	53	0.5
Gasoline	1	0.02	3	0.02

Table 8. Frequency of Maintenance - Summary of Four Years

	Frequency (Occasions/1000 miles)			
	4th Year	3rd Year	2nd Year	1st Year
	Five-car Averages			
All Maintenance				
Methanol	2.5	1.5	1.7	1.7
Gasoline	na	0.8	0.7	0.7
Fuel-Related Maintenance				
Methanol	0.5	0.5	0.4	0.6
Gasoline	na	0.02	0	0.03

Table 9. Maintenance Labor Hours and Intensity - Fourth Year Compared with All Years

Maintenance Labor Hours and Intensity (hr/1000 miles)	4th Year		All 4 Years	
	Five-car Totals			
	Hours	Intensity	Hours	Intensity
All Maintenance				
Methanol	122	4.8	223	2.7
Gasoline		retired from service		
Fuel-Related Maintenance				
Methanol	21	0.8	118	0.9
Gasoline		retired from service		

Table 10. Maintenance Labor Hours and Intensity - Third Year Compared with 3 Years

Maintenance Labor Hours and Intensity (hr/1000 miles)	3rd Year		3 Years	
	Five-car Totals			
	Hours	Intensity	Hours	Intensity
All Maintenance				
Methanol	85	2.8	223	2.2
Gasoline	43	1.0	119	0.7
Fuel-Related Maintenance				
Methanol	29	1.0	97	0.9
Gasoline	4	0.1	6	0.03

Table 11. Maintenance Labor Intensity - Summary of Four Years

	4th Year	Labor Intensity (hr/1000 miles) 3rd Year	2nd Year	1st Year
		Five-car Averages		
All Maintenance				
Methanol	4.8	2.8	2.1	1.7
Gasoline	na	1.0	0.6	0.5
Fuel-Related Maintenance				
Methanol	0.8	1.0	0.9	0.9
Gasoline	na	0.1	0	0.03

The methanol cars required more frequent overall maintenance and more labor than in previous years, but the frequency of fuel-related maintenance for the fourth year was very similar to previous years. This suggests that users are sensitive to mechanical problems and, perhaps, request maintenance for the methanol cars on occasions that they would overlook in gasoline cars.

The most common complaint about the methanol cars continued to be stalling, both on starting and in warmed-up conditions. These complaints usually are answered with adjustments to the carburetor. The carburetors on the stock Citations were originally tamper-proof, however access plugs to the mixture adjusting screws were ground off as part of the methanol conversion, allowing for future carburetor adjustments. Seven of the 13 fuel-related occasions of maintenance for the methanol cars in the fourth year involved carburetor adjustments. Other fuel-related maintenance included a carburetor overhaul, and replacement of the following: two fuel filters, a fuel level sending unit, an oxygen sensor, and a carburetor heater grid.

It is not clear why the methanol cars required measurably more maintenance than in previous years. The fact that the cars have only 25-30,000 miles on their odometers would lead one to believe that they are "relatively new," however, they are six years old. The usage of the methanol cars was only 25,000 miles this year, versus 37,000 for the first year. It seems that people have begun avoiding these cars. One apparent reason is that fuel level sending units have failed and suitable replacements have not been procured, and respondents to last year's driver survey[3] indicated a fear of running out of fuel when they are unsure about the level of the tank.

The mileage accumulation on the gasoline cars also dropped considerably from 74,000 the first year, to only 43,000 the third year. The gasoline cars were always used a little more because of the greater availability of fuel off-site, but it is clear that their usage decreased over time as well. The labor intensity for the gasoline cars increased from 0.5 hours of maintenance per 1000 miles in the first year, to 1.0 hours per 1000 miles in their third and final year. Reasons for this phenomenon are unclear, but most probably relate to the vehicles' age and mileage.

The lack of usage of a vehicle indeed frees up more available time for maintenance, which might possibly explain the greater frequency and intensity of maintenance for the methanol cars in the fourth year. The fuel-related maintenance only accounts for 28% of the labor hours, and 21% of the occurrences. If the fuel-related occurrences are discounted, the maintenance frequency is 2.0 occurrences per 1000 miles, still substantially higher than previous years' 1.5-1.7 occurrences per 1000 miles, which included fuel-related maintenance.

3.3 OIL SAMPLE ANALYSES

Samples of the lubricating oil are drawn from the crankcase of each of the vehicles 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. For the LBL vehicles, aluminum, 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, 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 and gasoline vehicles.

Results are presented in Table 12 for accumulation rates of wear metals (iron, lead, and copper) in the lubricating oil. Accumulation rates are found by fitting linear regressions (least squares curve-fits) to data of wear metals concentration as a function of distance since oil change. The slopes of the regressions are the accumulation rates, reported in ppm (parts per million) per 1000 miles. The table includes results for the four years individually, while Figures 1 through 3 show how these rates have varied throughout the year on a quarterly basis

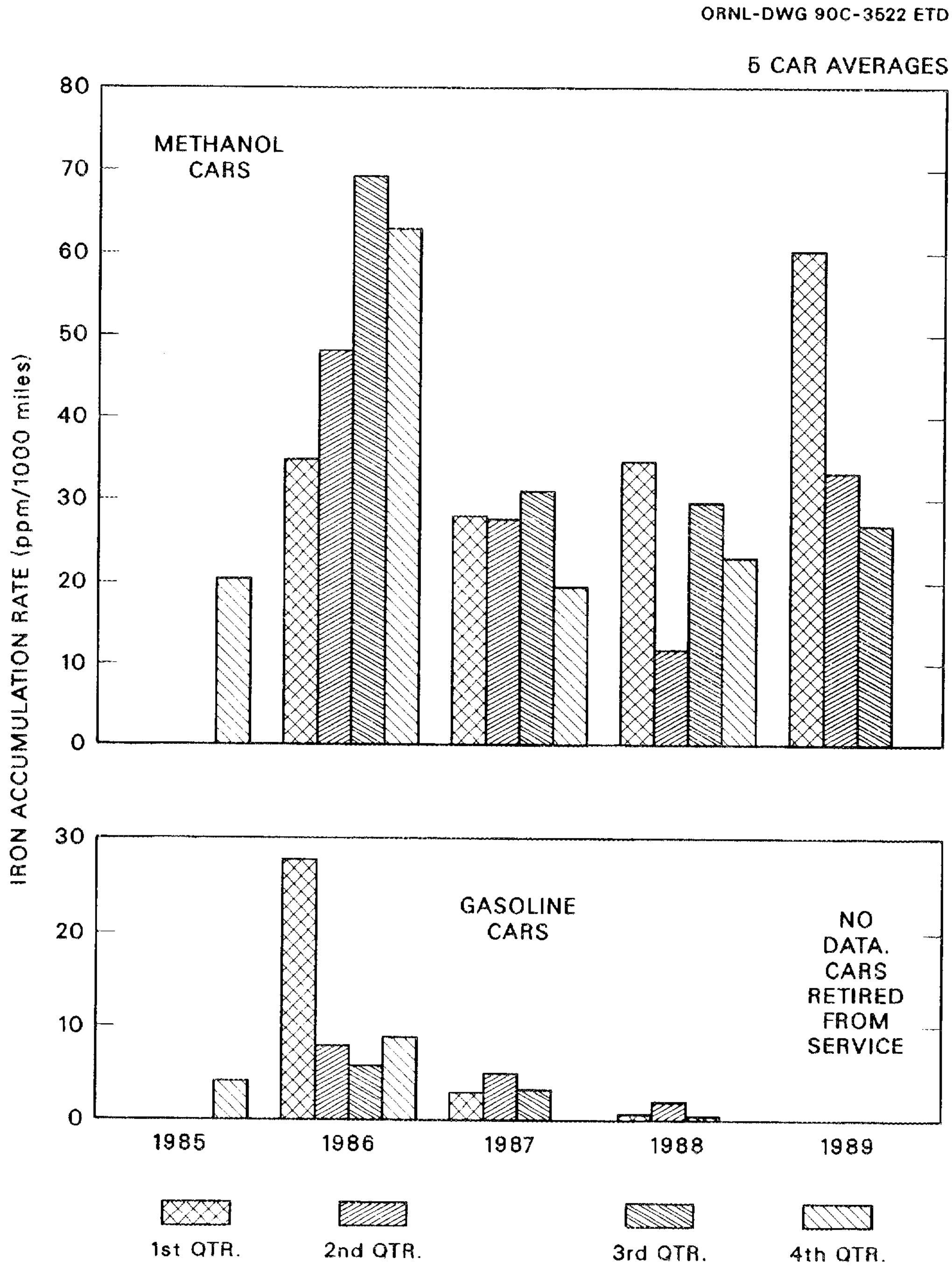

Fig. 1. Iron Accumulation Rate As a Function of Quarter.

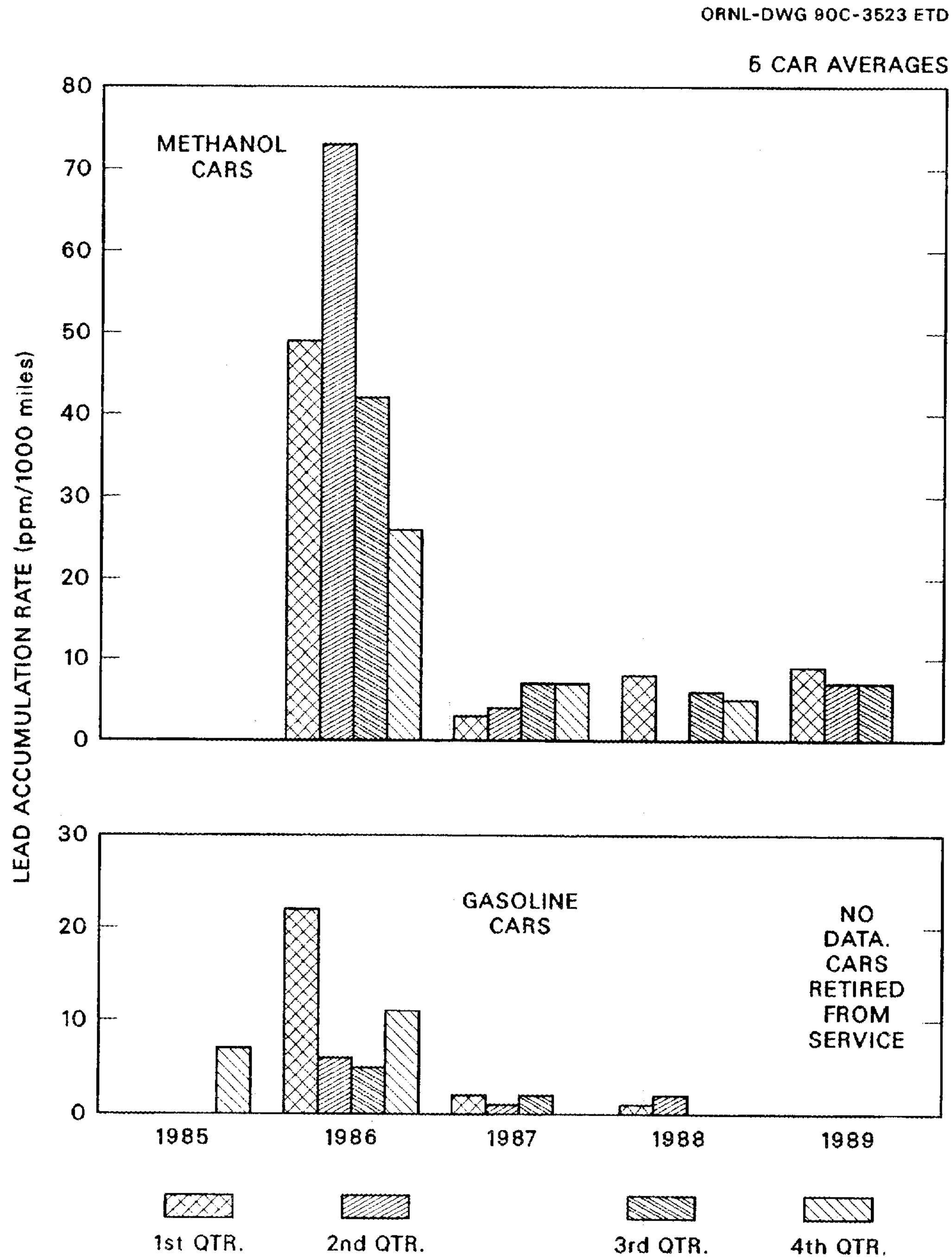

Fig. 2. Lead Accumulation Rate As a Function of Quarter.

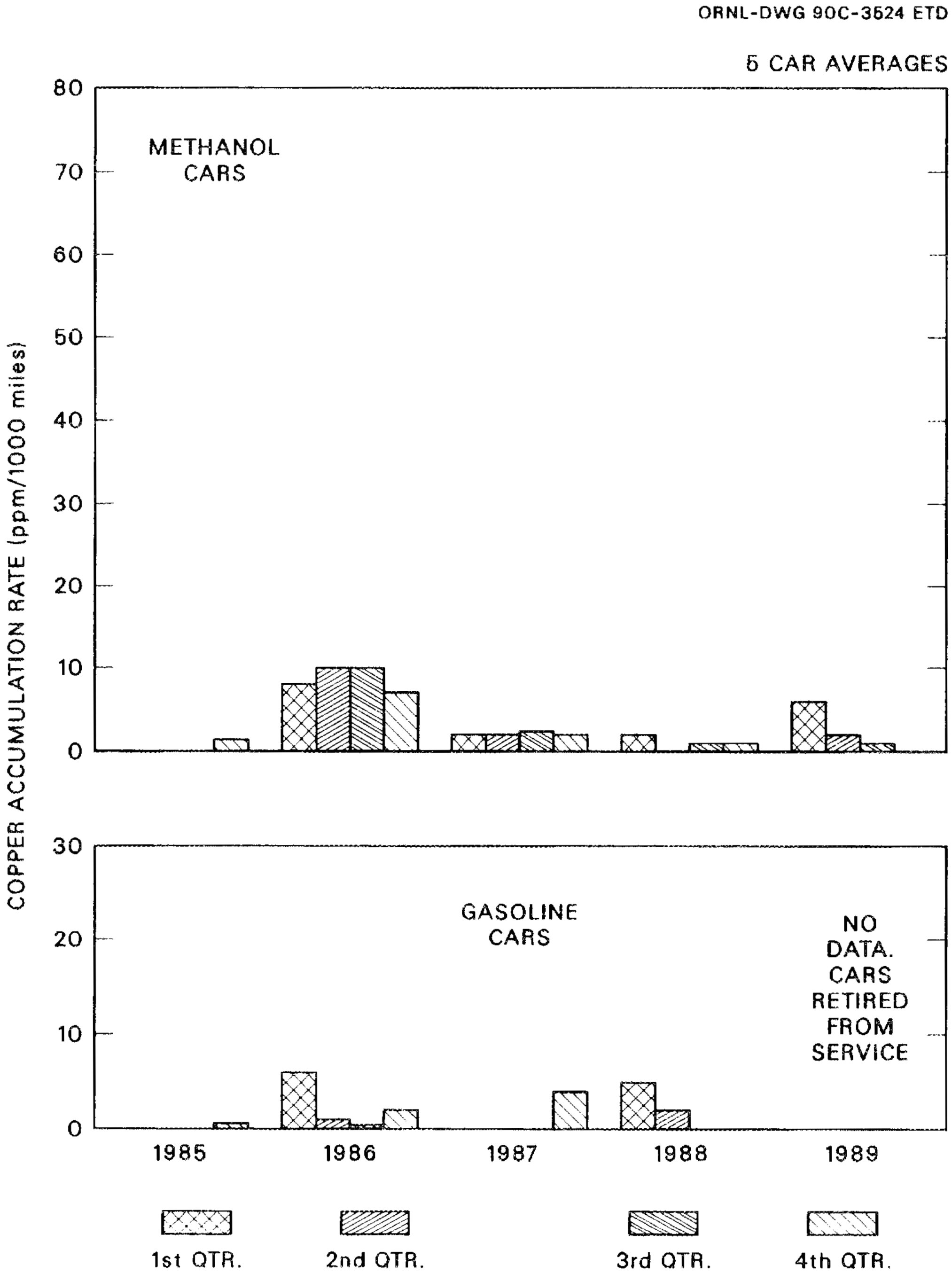

Fig. 3. Copper Accumulation Rate As a Function of Quarter.

Table 12. Wear Metals Accumulation Rates

Average wear metals accumulated in lubricating oil in parts per million per 1000 miles of operation

Wear metal	4th Year	3rd Year	2nd Year	1st Year
		Methanol Vehicles		
Iron	25	31	33	43
Lead	6	7	7	59
Copper	1	1	3	8
		Gasoline Vehicles		
Iron	na	4	8	3
Lead	na	2	7	2
Copper	na	Nil	1	1

(that is, the regressions were run on data taken only in that quarter). Note in Figure 1 that the quarterly iron accumulation rate for the methanol cars has fluctuated considerably throughout the course of the project, while the yearly averages (Table 12) have exhibited a steady downward trend. While the weather in Berkeley tends to be quite mild, there are nonetheless fluctuations in the average temperature throughout the year, which can at least help to explain some of the peaks seen in the figures. The iron accumulation rate for the methanol cars is high in the fourth quarter of 1986 and first quarter of 1989. Colder weather is believed to play a role in accelerated engine wear, especially under short trip conditions. Warm weather can also accelerate engine wear when coupled with high load service,[12,13] as in hill climbing, and the LBL site is very hilly, which may partially account for the high iron peak in the methanol cars in the third quarter of 1986. The accumulation of wear metals in the gasoline cars was quite nominal, except for the somewhat high iron and lead concentrations in the first year (1986). Note though, that the highest peaks for the gasoline cars for all three metals do occur in the first and fourth quarters of 1986. (The reader should note that the possibility certainly exists that oil samples can be drawn 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 data only represent trends and serve only to suggest that engine wear is affected by ambient temperature.)

3.4 DRIVERS' PERCEPTIONS OF VEHICLE PERFORMANCE

Drivers at LBL are asked to evaluate the cars' 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.

During the fourth year, 827 trip log entries were recorded for the methanol cars. For the entire four years, 3600 trips have been made in the methanol vehicles while 3806 trips were logged in three years in the gasoline vehicles, for a total of 7406 entries. Over 500 persons at LBL have driven the cars in the project over the four years.

Results for the methanol cars from the fourth year are shown in Table 13 both in numbers of responses and in percentages. Table 14 shows the same information for all four years for the methanol cars, and Table 15 gives three years worth of data for both the methanol and gasoline cars. From Table 15 it is evident that for the three years they

Table 13. Responses from Daily Trip Logs for
Ease of Starting and Driveability
Fourth Year - November 1, 1988 to October 31, 1989
(Gasoline cars not in service)

	Responses			
	Good	Average	Poor	No Response
Ease of Starting				
		Numbers of Responses		
Methanol	408	339	5	75
		Percent of Total		
Methanol	49	41	1	9
Driveability				
		Numbers of Responses		
Methanol	256	469	26	76
		Percent of Total		
Methanol	31	57	3	9

Table 14. Responses from Daily Trip Logs for
Ease of Starting and Driveability
Four Years - through October 31, 1989

	Responses			
	Good	Average	Poor	No Response
Ease of Starting				
		Numbers of Responses		
Methanol	2324	805	103	368
		Percent of Total		
Methanol	65	22	3	10
Driveability				
		Numbers of Responses		
Methanol	1890	1150	145	415
		Percent of Total		
Methanol	52	32	4	12

Table 15. Responses from Daily Trip Logs for
Ease of Starting and Driveability
Three Years - through October 31, 1988
(September 30, 1988 for gasoline cars)

	Responses			
	Good	Average	Poor	No Response
Ease of Starting				
		Numbers of Responses		
Methanol	1916	466	98	293
Gasoline	2916	495	48	347
		Percent of Total		
Methanol	69	17	3	11
Gasoline	77	13	1	9
Driveability				
		Numbers of Responses		
Methanol	1634	681	119	339
Gasoline	2547	808	72	379
		Percent of Total		
Methanol	59	25	4	12
Gasoline	67	21	2	10

were in service, the gasoline cars maintained only an 8 percentage point advantage over the methanol vehicles for number of good responses for both ease of starting and driveability. Figures 4 and 5 are stacked bar graphs of percentage of good, average, and poor responses for ease of starting and driveability, respectively. Note in Figure 4 that while

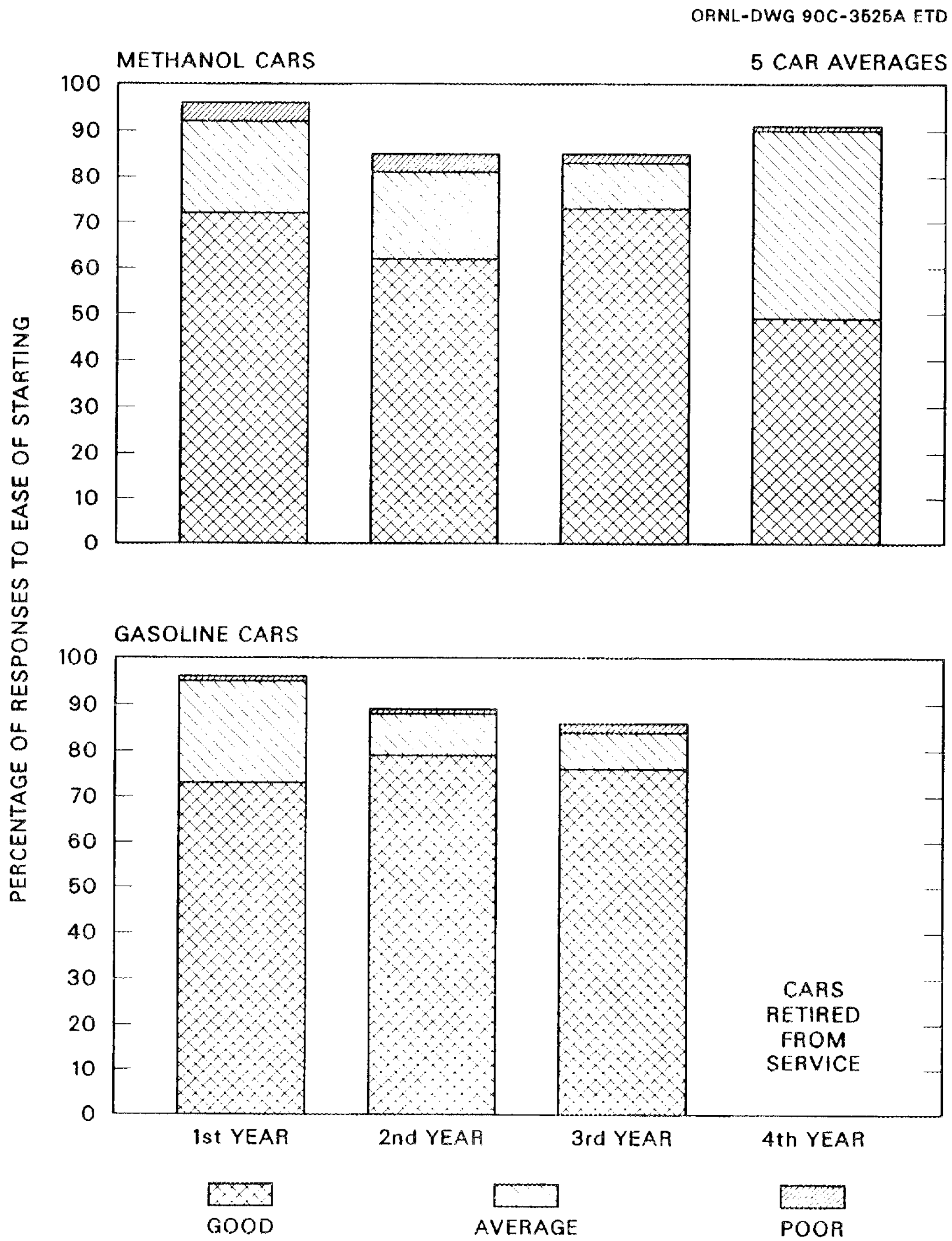

Fig. 4. Driver Response to "Ease of Starting".

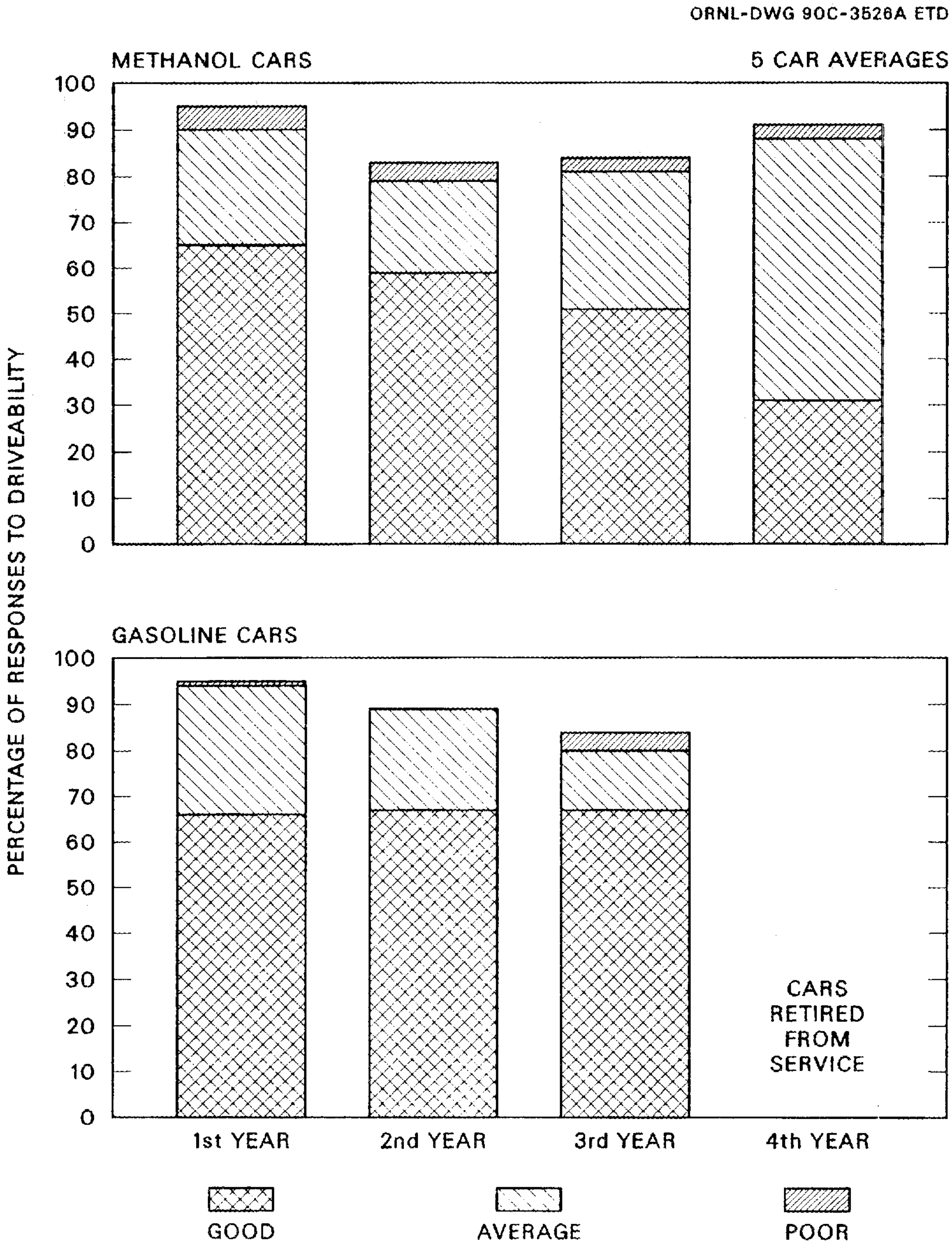

Fig. 5. Driver Response to "Driveability".

the percentage of good responses for ease of starting for the methanol cars declined from the first to the second year, improved in the third year, and then declined severely in the fourth, the percentage of good responses remained relatively constant for the gasoline cars for three years. The composite of good and average responses for the methanol cars increased in the fourth year, due to fewer drivers' failing to respond. In Figure 5 it is apparent that the percentage of good responses for gasoline cars' driveability remained constant for three years, while that for the methanol cars declined steadily over the four years. Reasons for this are not entirely clear, especially in light of the fact that last year's driver survey[3] indicates that well over 50 percent of respondents rated the methanol and gasoline Citations "about the same" in Ease of Starting, Performance During Warm-up, Performance When Warmed-up, and Overall Performance. A factor to consider, however, is that only 77 drivers responded to the survey, while about 200 survey forms were mailed out. One might think that drivers who felt strongly *for* or *against* methanol would respond, not the "middle-of-the-roaders." Another important consideration is that the 1984 gasoline Citations were replaced in the motor pool in January, 1989 by 1988 Plymouth Reliants. The methanol Citations are now being indirectly compared to newer vehicles, and this may at least help to explain some of the decline in driver ratings.

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