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

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Engineering Technology Division

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


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## ABSTRACT

The Oak Ridge National Laboratory (ORNL), under the auspices of the Alternative Fuels Utilization Program, has been managing the Federal Methanol Fleet Project since its beginning in fiscal year 1985. This congressionally mandated project directed the Department of Energy to introduce methanol-fueled vehicles into civilian government fleet operations. This interim report describes the second year's operation of the methanol fleet at Lawrence Berkeley Laboratory (LBL) in Berkeley, California. The fleet consists of five 1984 methanol-fueled Chevrolet Citation sedans paired with five comparable gasoline-fueled Citations for comparison. Data have been collected and tabulated on fuel consumption, maintenance records, oil sample analyses, and driver perceptions of vehicle operability. Fuel efficiency was slightly improved as compared to the first year for both the methanol and gasoline vehicles. The methanol vehicles continued to experience slightly less energy efficiency than the gasoline vehicles. Maintenance data reveal that the methanol vehicles required substantially more service than the gasoline vehicles, which may be due partially to a greater sensitivity on the part of users about methanol vehicle problems. Oil sample analyses revealed that engine wear rates are lower for the second year as compared to the first year and are probably not cause for great alarm. Drivers still rate all of the vehicles quite highly, but the methanol vehicles were rated not as highly during the second year of operation as in the first year.

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## 1. INTRODUCTION

Lawrence Berkeley Laboratory (LBL) has operated ten cars for a period of 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. 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. A previous ORNL report (1) * detailed the results of the first year of operation of the ten vehicles at LBL; this report deals with the second year's operation. Because much of the background of the project was described in the first report of the LBL activities as well as in other published reports (2,3,4), it will not be discussed again at any length in this report. The reader is encouraged to refer to the previous reports for those details. The present report deals primarily with the results and data from the second year and the comparison of those data with the similar results from the first year.

The ten vehicles participating at LBL in the Federal Methanol Fleet project are all 1984 model Chevrolet Citations, five of which were modified to operate on methanol by the Bank of America in the San Francisco, California area. The fuel mixture contains a portion of regular unleaded gasoline to aid in cold-starting. While the ratio of methanol to gasoline is adjusted through the year, the fuel supplier quotes a nominal ratio of 88% methanol to 12% gasoline. (Procedures to periodically analyze the fuel for constituents and contaminants were being instituted at the end of the second year of operation.) An above-ground tank with associated pump is used on-site at LBL for storing the methanol fuel and dispensing into the five methanol-powered Citations. All ten 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. Occasionally, a car is taken on longer, overnight trips, and usually one of the five gasoline vehicles is assigned to that duty.

A small amount of data is recorded by the LBL drivers for each trip taken in any of the ten cars. Drivers are also requested to rate the

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*Numbers in parentheses refer to references at the end of the report.

car's ease of starting and driveability 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 database is maintained.

## 2. SUMMARY

The Federal Methanol Fleet operating at Lawrence Berkeley Laboratory completed a satisfactory second year of operation. Nearly 100,000 miles (160,000 km) were accumulated on the ten cars participating in the demonstration bringing the total for two years to over 200,000 miles (320,000 km). Distribution of mileage between the five methanol and five gasoline vehicles was improved in the second year but still not equal due to differences in the assignments of the cars. Fuel efficiency was slightly improved for the second year for both methanol and gasoline cars, and the methanol cars continued to experience slightly less energy efficiency than the gasoline cars due, in part, to the shorter average trips. Methanol vehicles required substantially more maintenance than the gasoline vehicles during the second year, and a considerable portion of the difference in maintenance can be attributed to the methanol fuel and the fact that the cars have been converted to methanol. Analysis of the maintenance data, however, suggests that users may be quicker to request service or maintenance on the methanol vehicles hence, revealing perhaps, a higher sensitivity to any problems occurring on the methanol vehicles. Routine analysis of oil samples taken from the crankcases of each of the cars reveals that wear metals accumulation rates are improved during the second year for both methanol and gasoline cars. The wear rates in the methanol vehicles do not appear to be at alarming levels.

Drivers continue to rate the methanol vehicles as "good" on both ease of starting and driveability although by not as great a margin as in the first year. Some of the decline in the ratings of the methanol vehicles can be accounted for, apparently, by failures to respond to the ratings questions on the daily trip logs.

# 3. RESULTS

## 3.1 FLEET UTILIZATION AND FUEL CONSUMPTION

Table 1 summarizes the fleet utilization (mileage accumulation) and fuel consumption results from the LBL Federal Methanol 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. Table 2 summarizes the same data for the entire two years of operation, while Table 3 exhibits the data from the first year for the purposes of comparison. Over 210,000 miles of operation (336,000 kilometers) have been accumulated on the ten cars in the first

Table 1. 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 2. LBL Fleet Utilization and Fuel Consumption Data, Two Years — November 1, 1985 to October 31, 1987

| Vehicle ID (License No.) | Total miles | Average miles/trip | Fuel Economy | |
|---|---|---|---|---|
| | | | mpg | km/Gj[a] |
| | | Methanol vehicles | | |
| E-753 | 15,084 | 41 | 11.5 | 276 |
| E-754 | 17,107 | 46 | 12.3 | 295 |
| E-755 | 12,639 | 27 | 10.7 | 257 |
| E-756 | 14,411 | 35 | 11.5 | 276 |
| E-757 | 13,517 | 39 | 11.4 | 274 |
| TOTAL | 72,758 | 37[b] | 11.5[b] | 276[b] |
| | | Gasoline vehicles | | |
| G-563 | 26,288 | 52 | 25.5 | 337 |
| G-580 | 31,724 | 59 | 24.3 | 321 |
| G-611 | 28,972 | 55 | 24.5 | 323 |
| G-709 | 28,472 | 75 | 25.0 | 330 |
| G-771 | 22,685 | 31 | 22.6 | 298 |
| TOTAL | 138,141 | 51[b] | 24.4[b] | 322[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 — November 1, 1985 to 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.

two years of operation, with approximately 100,000 miles (160,000 kilometers) being accumulated in the second year. Distribution of mileage accumulation between the methanol and gasoline cars was more evenly divided in the second year with the average trip lengths being 38 miles and 46 miles for the methanol and gasoline cars respectively. Gasoline cars are still used exclusively for the long-distance trips, but other utilization of the cars is quite uniform between the group of methanol cars and the group of gasoline cars. Fuel economy (miles per gallon) as well as energy efficiency (fuel economy based on energy content of fuel rather than volume of fuel — kilometers per gigajoule) were slightly improved for both the methanol cars and the gasoline cars for the second year, although specific causes for the improvements are not known. The difference in energy efficiency between methanol cars and gasoline cars as groups is accounted for, most likely, by the fact that the average trip length of the methanol cars is slightly shorter than that of the gasoline cars. Since the Lawrence Berkeley Laboratory site is quite hilly, the shorter trips should have a greater proportion of less efficient hill-climbing in the driving patterns for those cars.

### 3.2 COMPARISON OF MAINTENANCE AND SERVICE — METHANOL AND GASOLINE VEHICLES

The comparison of maintenance required by the methanol vehicles with that of the gasoline vehicles became more focused during the second year of operation. The methanol vehicles are requiring measurably more maintenance than the gasoline vehicles, although part of that requirement may be a result of drivers and mechanics being more sensitive to rather slight problems in the methanol cars. Copies of all vehicle service work orders are forwarded to ORNL where they become part of the database. It is from those work orders that the results and information presented below have been compiled.

Table 4 shows the comparison of the number of occasions for maintenance for all of the vehicles for the second year of operation as well as for both years together. In the table, "all maintenance" refers to all occasions for maintenance and, thereby, includes such maintenance occasions as routine oil changes, tire changes, etc. If the group of

Table 4. Number of Occasions for Maintenance of LBL Federal Methanol Fleet Vehicles

| | Number of Occasions | |
|---|---|---|
| | 2nd Year | Both Years |
| | Five-Car Totals | |
| All Maintenance | | |
| Methanol Vehicles | 60 | 124 |
| Gasoline Vehicles | 47 | 98 |
| Fuel-Related Maintenance | | |
| Methanol Vehicles | 14 | 38 |
| Gasoline Vehicles | 0 | 2 |

methanol cars and the group of gasoline cars were the same, i.e. experienced the same levels of maintenance and had the same amount of usage, the number of occasions of maintenance should be expected to be the same. Since the numbers of occasions as shown in the table are not the same, with the methanol cars requiring more occasions of maintenance, we might attribute (in a simplistic way) the difference totally to the maintenance occasioned by the vehicles because they are methanol vehicles. The situation is not so simple, though, since the gasoline cars have accumulated more miles and have required more routine maintenance such as oil changes, tire changes, etc. Since the comparison is not straightforward, an attempt has been made to represent the occasions that have been "fuel-related", i.e. attributable to the methanol fuel or to some characteristic of the conversion of the vehicle to use methanol. (The same must be done for the gasoline vehicles in order not to bias the comparison. Numbers of occasions of fuel-related maintenance for gasoline vehicles should be quite small.) This process has required review of the work orders and some judgement as to whether the service was fuel-related or not. Therefore, some error could enter this process since the work orders usually do not include much description. For the second year of fleet operation (reported in the first column), the difference in fuel-related occasions between methanol and gasoline vehicles is 14, very nearly the same as the difference between the number of occasions for all maintenance. On the basis of the values in Table 4, it might be concluded that the methanol cars are being serviced (for all maintenance) about 25-30% more often than the gasoline cars. Data for the total two years leads to a conclusion of very nearly the same magnitude. However, these figures do not represent a true comparison since the gasoline vehicles are accumulating more miles and being serviced in a routine fashion more often. A better comparison is the frequency of maintenance (based on miles).

Table 5 shows the frequency of maintenance, again for all maintenance and for fuel-related maintenance. Again, methanol vehicles are shown to need service more frequently than gasoline vehicles, but the difference does not seem to be accounted for totally by the fuel-related occasions. Frequency of maintenance for the methanol cars is 1.7 occasions per 1000 miles versus only 0.7 for gasoline cars, but of the methanol vehicle frequency only 0.4 occasions per 1000 miles is accounted for by fuel-related occasions. The records do indicate that the methanol vehicles have a slightly higher frequency of preventive maintenance (0.5 occasions per 1000 miles versus 0.3 for gasoline cars, for a difference of 0.2 occasions per 1000 miles) but not so much so that it would make up the remaining difference between methanol and gasoline vehicles. Therefore, the data suggest that users tend to be more sensitive to, perhaps, slight problems in the methanol cars than in the gasoline cars. This conclusion is supported by the slightly higher

Table 5. Frequency of Maintenance of LBL Federal Methanol Fleet Vehicles; Reported in Occasions of Maintenance Per 1000 Miles of Operation

| | Frequency (Per 1000 Miles) | | |
|---|---|---|---|
| | 2nd Year | 1st Year | Both |
| | Five-Car Averages | | |
| All Maintenance | | | |
| Methanol Vehicles | 1.7 | 1.7 | 1.7 |
| Gasoline Vehicles | 0.7 | 0.7 | 0.7 |
| Fuel-Related Maintenance | | | |
| Methanol Vehicles | 0.4 | 0.6 | 0.5 |
| Gasoline Vehicles | 0 | 0.03 | 0.01 |

frequency of preventive maintenance for the methanol cars which, itself, suggests more diligence with respect to the needs of the methanol cars on the part of the fleet operators.

Maintenance labor hours are also important statistics in assessing the success of the methanol vehicles in a fleet demonstration. These statistics are reported in Tables 6 and 7. The labor hours are taken from the service work orders to the extent that they are reported. On a number of occasions the hours have not been reported (and they could not

Table 6. Reported Maintenance Labor Hours for LBL Federal Methanol Fleet Vehicles

| | Reported Labor Hours | |
|---|---|---|
| | 2nd Year | Both Years |
| | Five-Car Totals | |
| All Maintenance | | |
| Methanol Vehicles | 77 | 138 |
| Gasoline Vehicles | 38 | 76 |
| Fuel-Related Maintenance | | |
| Methanol Vehicles | 34 | 68 |
| Gasoline Vehicles | 0 | 2 |

Table 7. Maintenance Labor Intensity For LBL Federal Methanol Fleet Vehicles in Reported Hours of Maintenance Per 1000 Miles of Operation

| | Labor Intensity (Hours Per 1000 Miles) | | |
|---|---|---|---|
| | 2nd Year | 1st Year | Both |
| | Five-Car Averages | | |
| All Maintenance | | | |
| Methanol Vehicles | 2.1 | 1.7 | 1.9 |
| Gasoline Vehicles | 0.6 | 0.5 | 0.6 |
| Fuel-Related Maintenance | | | |
| Methanol Vehicles | 0.9 | 0.9 | 0.9 |
| Gasoline Vehicles | 0 | 0.03 | 0.01 |

be determined from the cost figures that were reported). Many of these occasions have been situations in which the time required for maintenance was quite short; some have been merely oversights. Nevertheless, it is difficult to reconstruct the details of the service at a later date when the data are being entered into the database. Therefore, the hours reported in Tables 6 and 7 are the sums of the "reported" hours. Table 6 shows the total numbers of labor hours for the groups of methanol and gasoline vehicles. Again, the data are reported for all maintenance as well as for that which is fuel-related. In terms of labor hours, "fuel-related" maintenance very nearly accounts for the difference in the totals for "all maintenance" between methanol and gasoline vehicles.

Labor intensity, i.e. reported hours of maintenance per 1000 miles of operation, is reported in Table 7 and leads to the same conclusion as the statistics on maintenance frequency in Table 5 above. That is, the data support the conclusion that the methanol vehicles receive more attention in maintenance than is accounted for by the maintenance that can be identified as fuel-related. For the second year of operation, the methanol vehicles required 2.1 hours of maintenance of all types per 1000 miles of operation compared to 0.6 hours for the gasoline vehicles. Of the difference in intensity of 1.5 hours per 1000 miles of operation between methanol and gasoline vehicles, only 0.9 hours can be accounted for by the fuel-related occurrences. This again suggests that the users may tend to request more maintenance on the methanol vehicles than that which can be attributed to fuel-related situations, which further suggests a sensitivity to problems in the methanol vehicles for which similar problems in the gasoline vehicles may go unreported.

Table 8 reports the numbers of occasions of maintenance and associated labor hours required by the methanol vehicles during the second year of operation, reported by vehicle. This provides clues as to which of the vehicles has been most troublesome over the second year, clues which may help to understand the drivers' ratings of the vehicles to be presented later in this report. In this regard it is noted that vehicle number E-753 had both the fewest number of occasions for maintenance of all types as well as only one occasion of fuel-related maintenance,

Table 8. Maintenance/Service Data For Methanol Cars, Lawrence Berkeley Laboratory, Second Year -- November 1, 1986 to October 31, 1987

| Vehicle ID | 2nd Year Maintenance | |
|---|---|---|
| | # Occasions | Labor hours |
| All Maintenance | | |
| E-753 | 7 | 15 |
| E-754 | 8 | 11 |
| E-755 | 9 | 19 |
| E-756 | 14 | 20 |
| E-767 | 9 | 12 |
| TOTAL | 47 | 77 |
| Fuel-Related Maintenance | | |
| E-753 | 1 | 1 |
| E-754 | 1 | 3 |
| E-755 | 5 | 12 |
| E-756 | 5 | 15 |
| E-757 | 2 | 3 |
| TOTAL | 14 | 34 |

while vehicle number E-756 had the largest number of occasions for both. Vehicle number E-755 was certainly close behind number E-756 in number of hours of maintenance and equal to it in number of occasions of maintenance that were fuel-related.

Of the 14 occasions of fuel-related maintenance for the five methanol vehicles, 11 occasions were complaints of stalling. One occasion was related to the fuel tank; one was related to the carburetor; and one occasion was an ill-defined, but still fuel-related incident. By far, the largest complaint in terms of frequency over the two years of operation of the LBL fleet has been stalling. This problem is usually corrected by making minor adjustments to the carburetor and usually requires short maintenance time.

## 3.3 OIL SAMPLE ANALYSES

Samples of the lubricating oil are drawn from the crankcase of each of the ten 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. The data from these analyses are kept in the database at ORNL and will add considerably to any reviews of the project's final results. Generally, a fleet operator uses information from oil sample analysis as a diagnostic tool to implement 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 of the vehicles under study. Only in rare circumstances, such as, for example, the revealed need for an air filter change, has the information been used to implement any vehicle service that would not have ordinarily occurred at a given point in time.

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 amount 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 vis-a-vis engine wear. Of metals of interest, iron is usually the largest contributor to lubricating oil contamination in both the methanol vehicles and the gasoline vehicles.

Results are presented below for wear metals accumulation rates in the lubricating oil. These data are found by fitting linear regressions (least squares curve-fits) to the wear metals concentration data as a function of distance since oil change and determining the slopes of the regressions. Figure 1 shows, for example, the iron concentration for the second year for all ten vehicles plotted against miles since oil change. A procedural change has been incorporated into the processing of these data this year which necessitated the reprocessing of data from the first year in order to be consistent. In particular, the change has

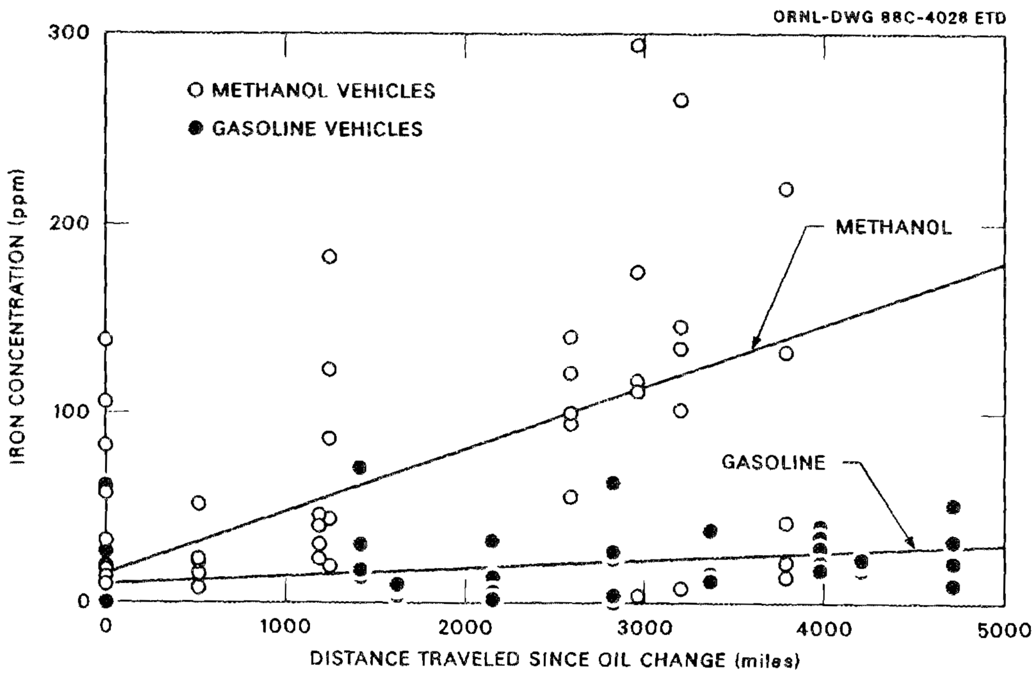


Fig. 1. Iron Concentration in LBL Vehicles — Second Year — November 31, 1986 to October 31, 1987.

to do with the manner in which the data for fresh oil, or data at an oil change, are handled. Through most of the first year of operation at LBL the oil was sampled at the end of its use cycle but not immediately after the oil change. (Late in the first year, procedures for oil sampling were improved so as to include a sample both just before the draining of the old oil as well as just after the refilling with the new oil. In this way, data regarding the "zero" case for the new oil are more accurate.) The result was that the linear regressions of the contaminant concentration versus mileage since oil change <u>for the first year</u>, as reported in reference (1), had very few of the "zero" cases included in the data. The effect of this was that the regressions were allowed to "float" at the zero point of the abscissa rather than being constrained to values more consistent with the data for fresh oil. Results for the <u>first year</u> have been recomputed for this report in a fashion so as to include more data at zero miles since oil change. Because the data for oil as sampled from the crankcase immediately after an oil change was not available for the most of the first year, the values for those cases have been synthesized by assuming that the wear metals concentrations for those occasions are the same as for the fresh oil. (Samples of fresh oil have been analyzed, and the associated data are maintained in the database.) The slopes of the lines representing the linear regressions are the wear metals accumulation rates, and these values are compared between methanol and gasoline vehicles to assess their comparative engine wear conditions.

Table 9 presents the accumulation rates for iron, lead, and copper in parts per million per 1000 miles. Results are presented separately for the second year of operation, the first year (values recomputed as outlined above), and the entire two years taken together. Both types of vehicles exhibited reductions in accumulation rates for all the reported metals in the second year as compared to the first year. Lead accumulation rate in the methanol vehicles experienced a dramatic reduction in the second year, going from 59 ppm per 1000 miles to only 7 ppm per 1000 miles. Lead and copper accumulation rates in the methanol vehicles for the second year were very similar in value to those of the gasoline

Table 9. Wear Metals Accumulation Rates (in Lubricating Oil) Lawrence Berkeley Laboratory

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

| Wear metal | ppm per 1000 miles | | |
|---|---|---|---|
| | 2nd year | 1st year[a] | 2 years |
| | Methanol Vehicles | | |
| Iron | 33 | 43 | 35 |
| Lead | 7 | 59 | 18 |
| Copper | 3 | 8 | 4 |
| | Gasoline Vehicles | | |
| Iron | 4 | 8 | 5 |
| Lead | 2 | 7 | 4 |
| Copper | Nil | 1 | Nil |

[a]Determined by method of second year.

vehicles in the first year, a fact that helps to assuage concern about the rates of wear of those two metals in the methanol vehicles. Iron alone remains quite elevated in accumulation rate for the methanol vehicles, being 33 ppm per 1000 miles for the methanol vehicles versus only 4 ppm per 1000 miles for the gasoline vehicles. Nevertheless, the iron accumulation rate for the methanol vehicles for the second year was significantly lower than for the first year, being 33 versus 43 ppm per 1000 miles respectively.

It should be noted that while the rates of accumulation of wear metals for the methanol vehicles appear to be high, they may still be tolerable. There are no guidelines as to just what should be expected to be "normal" wear rates. One would think that the gasoline vehicles should be considered to be the standard and, therefore, be the norm by which the methanol vehicles should be judged. However, indications are that methanol vehicles (operated in moderate climates) can operate at elevated levels of wear rates for long periods with no evidence of accelerated wear upon examination after over 100,000 miles (160,000 km) of use. (5)

## 3.4 DRIVERS' PERCEPTIONS OF VEHICLE PERFORMANCE

The drivers at LBL are asked to evaluate the ease of starting and driveability of the car at the end of each trip taken in any of the ten cars. This is done by having the drivers simply make a check mark under either "Good", "Average", or "Poor" on the trip log of the vehicle for both of the questions, "Ease of Starting" and "Driveability". No attempt has been made to instruct the drivers on how to rate ease of starting and driveability. Instead, it has been left to the individual participants to make their own determinations of just what constitutes "good" driveability and so on. It is assumed through this process that individual drivers will use their own rating criteria in a consistent manner between methanol and gasoline vehicles.

During the second year of the fleet at LBL 2322 trip log entries were recorded; 939 for the methanol vehicles and 1383 for the gasoline vehicles (for the entire two years of fleet operation, 1968 trips for methanol vehicles and 2685 trips for gasoline vehicles for a total of

4653 entries). Additionally, the records indicate that during the second year nearly 300 different persons drove one of the methanol vehicles at least once, and 260 drove one of the gasoline vehicles. (For the two years, 558 different persons have driven one of the methanol vehicles, and 412 have driven one of the gasoline vehicles.) The results of the drivers' responses to the question of "Ease of Starting" for the second year of operation are presented in Table 10. Totals for that question for the entire two years of the fleet at LBL are presented in Table 11. Similarly, results for "Driveability" are presented in Tables 12 and 13.

During the second year, as was the case for the first year, a great majority of drivers of both the methanol cars as well as the gasoline cars rated ease of starting and driveability as "Good". Ratings of "Poor" were rare; ratings of "Average" trailed those of "Good" by large margins. Examination of the ratings by individual cars reveals that methanol vehicle number E-755 fared the worst of the methanol vehicles in both ease of starting and driveability. In ease of starting, it was the only methanol vehicle to be rated "Average" more often than "Good"; for the driveability ratings, it had almost as many "Average" ratings as "Good". These data are supported by the maintenance data in section 3.2 above where it was shown that this vehicle had the second highest number of maintenance labor hours during the second year and had the greatest number of occasions (tied with vehicle E-756) for fuel-related maintenance during the second year. (It is not known why vehicle E-756 did not also fare badly in drivers ratings while also accounting for a large amount of the second-year maintenance.)

Vehicle number E-753 fared quite well in drivers' ratings, as shown in Tables 10 and 12, and also accounted for the least fuel-related maintenance of the methanol vehicles during the second year, as shown in Table 8. It is, therefore, apparent that maintenance data and data from drivers' ratings of the vehicles are related, which further leads one to believe that the drivers' ratings are more than just a casual response on their part.

Table 10. LBL Drivers' Responses to "Ease of Starting" Question, from Daily Trip Logs, Second Year — November 1, 1986 to October 31, 1987

| Vehicle ID | Number of Responses | | | | |
|---|---|---|---|---|---|
| | Good | Average | Poor | No response | Total |
| | Methanol vehicles | | | | |
| E-753 | 118 | 3 | 3 | | |
| E-754 | 130 | 32 | 2 | | |
| E-755 | 74 | 125 | 27 | | |
| E-756 | 161 | 12 | 1 | | |
| E-757 | 97 | 4 | 8 | | |
| Subtotal | 580 | 176 | 41 | 142 | 939 |
| | Gasoline vehicles | | | | |
| G-563 | 227 | 16 | 9 | | |
| G-580 | 199 | 6 | 0 | | |
| G-611 | 171 | 5 | 3 | | |
| G-709 | 214 | 5 | 0 | | |
| G-771 | 283 | 95 | 0 | | |
| Subtotal | 1094 | 127 | 12 | 150 | 1383 |
| (Both) Total | 1674 | 303 | 53 | 292 | 2322 |

Table 11. LBL Drivers' Responses to "Ease of Starting" Question, from Daily Trip Logs, Two Years — November 1, 1985 to October 31, 1987

| Vehicle ID | Number of Responses | | | | |
|---|---|---|---|---|---|
| | Good | Average | Poor | No response | Total |
| | Methanol vehicles | | | | |
| E-753 | 256 | 49 | 7 | | |
| E-754 | 263 | 63 | 10 | | |
| E-755 | 239 | 151 | 32 | | |
| E-756 | 297 | 76 | 15 | | |
| E-757 | 263 | 45 | 20 | | |
| Subtotal | 1318 | 384 | 84 | 182 | 1968 |
| | Gasoline vehicles | | | | |
| G-563 | 417 | 56 | 9 | | |
| G-580 | 446 | 46 | 1 | | |
| G-611 | 377 | 101 | 9 | | |
| G-709 | 337 | 12 | 1 | | |
| G-771 | 467 | 194 | 5 | | |
| Subtotal | 2044 | 409 | 25 | 207 | 2685 |
| (Both) Total | 3362 | 793 | 109 | 389 | 4653 |

Table 12. LBL Drivers' Responses to "Driveability" Question, from Daily Trip Logs, Second Year — November 1, 1986 to October 31, 1987

| Vehicle ID | Number of Responses | | | | |
|---|---|---|---|---|---|
| | Good | Average | Poor | No response | Total |
| | | Methanol vehicles | | | |
| E-753 | 109 | 7 | 1 | | |
| E-754 | 124 | 32 | 5 | | |
| E-755 | 109 | 93 | 21 | | |
| E-756 | 116 | 47 | 8 | | |
| E-757 | 95 | 5 | 5 | | |
| Subtotal | 553 | 184 | 40 | 162 | 939 |
| | | Gasoline vehicles | | | |
| G-563 | 223 | 32 | 0 | | |
| G-580 | 187 | 16 | 0 | | |
| G-611 | 165 | 11 | 1 | | |
| G-709 | 190 | 25 | 1 | | |
| G-771 | 161 | 215 | 0 | | |
| Subtotal | 926 | 299 | 2 | 156 | 1383 |
| (Both) Total | 1479 | 483 | 42 | 318 | 2322 |

Table 13. LBL Drivers' Responses to "Driveability" Question, from Daily Trip Logs, Two Years — November 1, 1985 to October 31, 1987

| Vehicle ID | Number of Responses | | | | |
|---|---|---|---|---|---|
| | Good | Average | Poor | No response | Total |
| | | Methanol vehicles | | | |
| E-753 | 249 | 46 | 10 | | |
| E-754 | 233 | 86 | 12 | | |
| E-755 | 234 | 157 | 26 | | |
| E-756 | 252 | 94 | 33 | | |
| E-757 | 254 | 53 | 15 | | |
| Subtotal | 1222 | 436 | 96 | 214 | 1968 |
| | | Gasoline vehicles | | | |
| G-563 | 409 | 75 | 1 | | |
| G-580 | 422 | 57 | 10 | | |
| G-611 | 324 | 155 | 5 | | |
| G-709 | 313 | 30 | 2 | | |
| G-771 | 311 | 351 | 2 | | |
| Subtotal | 1779 | 668 | 20 | 218 | 2685 |
| (Both) Total | 3001 | 1104 | 116 | 432 | 4653 |

The average responses of the drivers, expressed as percentages of the total responses, are presented in Tables 14-16 where data are presented for the second year alone, for the entire two years, and for the first year alone (data repeated in this report for the sake of comparison). In these tables the vehicles have been grouped by fuel type — methanol versus gasoline vehicles. Comparing the results in Table 14 (second year) with those in Table 16 (first year), one finds that while methanol vehicles were still rated as "Good" the majority of the time in the second year, the margin over "Average" has slipped somewhat since the first year. Furthermore, while the first year's data indicated that the differences in responses between methanol and gasoline vehicles were imperceptible, those differences are now significant. For gasoline vehicles, the percentages for "Good" stayed at about the same levels for the second year, while for methanol vehicles the percentages for "Good" fell significantly. At the same time, percentages for "Poor" for both methanol and gasoline vehicles stayed about the same for the second year, but the percentages of "No response" increased greatly for both.

The reason for the great increase in "No response" is not known, and steps have been taken to remedy the situation, but the effect of drivers' not responding appears to be different depending on whether the

Table 14. Averages of Responses from the LBL Daily Trip Logs for Ease of Starting and Driveability, Second Year — November 1, 1986 to October 31, 1987

| | Response (%) | | | |
|---|---|---|---|---|
| | Good | Average | Poor | No response |
| Ease of starting | | | | |
| Methanol vehicle average | 62 | 19 | 4 | 15 |
| Gasoline vehicle average | 79 | 9 | 1 | 11 |
| LBL fleet average | 72 | 13 | 2 | 13 |
| Driveability | | | | |
| Methanol vehicle average | 59 | 20 | 4 | 17 |
| Gasoline vehicle average | 67 | 22 | Nil | 11 |
| LBL fleet average | 64 | 21 | 2 | 13 |

Table 15. Averages of Responses from the LBL Daily Trip Logs for Ease of Starting and Driveability, Two Years — November 1, 1985 to October 31, 1987

| | Response (%) | | | |
|---|---|---|---|---|
| | Good | Average | Poor | No response |
| Ease of starting | | | | |
| Methanol vehicle average | 67 | 20 | 4 | 9 |
| Gasoline vehicle average | 76 | 15 | 1 | 8 |
| LBL fleet average | 72 | 17 | 2 | 9 |
| Driveability | | | | |
| Methanol vehicle average | 62 | 22 | 5 | 11 |
| Gasoline vehicle average | 66 | 25 | 1 | 8 |
| LBL fleet average | 65 | 24 | 2 | 9 |

Table 16. Averages of Responses from the LBL Daily Trip Logs for Ease of Starting and Driveability, First Year — November 1, 1985 to October 31, 1986

| | Response (%) | | | |
|---|---|---|---|---|
| | Good | Average | Poor | No response |
| Ease of starting | | | | |
| Methanol vehicle average | 72 | 20 | 4 | 4 |
| Gasoline vehicle average | 73 | 22 | 1 | 4 |
| LBL fleet average | 72 | 21 | 3 | 4 |
| Driveability | | | | |
| Methanol vehicle average | 65 | 25 | 5 | 5 |
| Gasoline vehicle average | 66 | 28 | 1 | 5 |
| LBL fleet average | 65 | 27 | 3 | 5 |

car is methanol or gasoline. It appears that for the methanol vehicles the increase in "No response" is at the expense of the "Good" rating. This may suggest that a small number of drivers, who may have reached a level of complacency about the project, choose to ignore the ratings section of the trip logs. These drivers otherwise might have checked "Good" if they had checked any of the responses at all (since the "No response" category increased by about the same amount as the "Good" category decreased). Perhaps, this means that the drivers are satisfied; they have no complaints; and they feel that they have already given sufficient indication that the methanol cars are acceptable. One would think that if such is the situation, then the same trend would be seen with the gasoline vehicles. That is not the case, though, since the numbers of "No response" for the gasoline cars appear to be at the expense of the "Average" rating. The psychology involved here, and the contrast between trends in the numbers of drivers' not responding for the methanol versus gasoline vehicles, is certainly beyond the scope of this project. Nevertheless, the "No response" cases seem to have definite, but different, trends between the methanol and gasoline cars.

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