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

R. N. McGill
S. L. Hillis
J. L. Wantland

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R. N. McGill
Energy Division

S. L. Hillis
University of Tennessee, Knoxville

J. L. Wantland
Engineering Technology Division

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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 begin to implement methanol-fueled vehicles into civilian government fleet operations. This interim report describes the first year's operation of the methanol fleet activities at Lawrence Berkeley Laboratory (LBL) in Berkeley, California. Operation of methanol cars at LBL officially began on November 1, 1985. The fleet consists of five 1984 methanol-fueled Chevrolet Citation sedans paired with five analogous gasoline-fueled Citations for comparison. Data have been collected and tabulated on fuel consumption, maintenance records, driver perceptions of operability and safety, and oil sample analyses. Although drivers have expressed some concerns regarding the off-site availability of methanol fuel, they generally reported no significant differences in their perceptions of safety and operability between the methanol and gasoline vehicles. No major maintenance problems were encountered. Oil sample analyses revealed higher engine wear rates in the methanol vehicles, but not alarmingly high. These results are in agreement with those obtained from other methanol fleets. It is concluded that the Federal Methanol Fleet operation at LBL has been highly successful during its first year of operation.

1. INTRODUCTION

It is common knowledge that a significant amount of our national petroleum consumption is in private automobiles. It is also well known that a significant amount of this petroleum is imported from foreign sources that are subject to forces not under our control. This has caused much concern among energy experts and the impetus is strong to develop alternative automotive fuels obtainable from domestic sources. One promising alternative fuel is methanol. Currently methanol is produced from natural gas but it can be produced commercially from high-sulfur coal as is presently being done on a limited scale by Eastman Chemical Products, Inc., in Kingsport, Tennessee. The United States has a very large reserve of coal.

The Congress of the United States has shown interest in alcohol fuels as alternative fuels since the early 1970s by their appropriation of funds for the research and development of the utilization of these fuels. This fleet demonstration project may be viewed as a logical progression from research to demonstration of technological feasibility. While some technical problems remain to be solved with methanol-fueled engines, it is generally believed that there remain no great technological barriers to the introduction of methanol-fueled vehicles, especially in warm climates. Therefore, this project was conceived for the purposes of demonstrating the maturity of the technology as well as for using government funds to try to encourage the introduction of both methanol-fueled vehicles and methanol refueling facilities.

2. LEGISLATIVE ORIGIN

During the year 1984, several bills were considered by Congress at different levels which dealt with the U.S. government's role in the introduction of methanol-fueled vehicles. None of the bills passed in Congress, but nevertheless a federal involvement was begun. The FY 1985 Continuing Resolution in the fall of 1984 included an appropriation of $980,000 to the Department of Energy (DOE) for the beginning of a Federal Methanol Fleet (FMF). The Continuing Resolution for FY 1985 made reference to Section 105 of House Bill 5048 and instructed DOE to implement the FMF in accordance with the provisions of that section.

Section 105 includes the congressional guidelines for the FMF as follows:

1. Funds provided are for incremental costs only. For example, the project funds should pay for the additional costs associated with a vehicle being produced to operate on fuel methanol* but not for the cost of the base vehicle.
2. At least one of the sites at which methanol-fueled vehicles will be assigned must be in a cold climate so that the particular problems with such vehicles in cold weather can be assessed.
3. DOE must assess the vehicle performance including fuel economy, emissions, and safety of the methanol-fueled vehicles.
4. The comparison of operating and maintenance costs of the methanol vehicles to those costs for gasoline vehicles must be assessed.

DOE directed the Oak Ridge National Laboratory (ORNL) to be the Project Manager for the FMF, and DOE and ORNL have worked closely together to determine the best way in which the congressional guidelines could be met.

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*Fuel methanol is defined as a fuel containing at least 85% methanol, the remainder being primarily a cold-start additive which is usually unleaded gasoline.

3. PROJECT STRATEGY AND APPROACH

The basis for the strategy and approach taken in this project is the interpretation that methanol-fueled vehicles must be integrated into operations of civilian government-operated fleets in a manner common to, and consistent with, the present use of gasoline-fueled vehicles. Furthermore, success in this project is indicated when the government withdraws from project management; and fleet operations using methanol fuel are perpetuated independently. It is appropriate that private industry must be involved in the commercial aspects of the project, including both the fuel and the vehicle aspects, while federal agencies must be involved in the acquisition and operation of the vehicles.

It was recognized early that this project is characterized by neither established specifications for, nor commercial availability of, the products themselves, i.e. methanol-fueled vehicles as well as the methanol fuel itself. Furthermore, there is no methanol fuel distribution experience on a national or regional basis, nor dedicated dispensing equipment, except for limited facilities in California.

Based on these observations, it was evident that a two-phase fleet project was appropriate. In Phase I, limited quantities of late-model gasoline vehicles are being operated, which have been engineered for methanol using state-of-the-art, pre-production technology. The objectives of Phase I are:

1. To establish initial fleet operations and fueling sites;
2. To conduct operations with counterpart gasoline-powered control vehicles on a one-to-one basis;
3. To structure test controls, monitoring, vehicle operation and testing, data collection, and analysis activities;
4. To augment current information, data, and material pertaining to user agency benefits of methanol-fueled vehicles;
5. To provide the mechanism and framework for operator purchase of appropriate methanol fuel; and
6. To provide inputs for Phase II operations.

In Phase II, at least 1000 vehicles (according to congressional guidelines) will be acquired from original equipment manufacturers (OEM) and integrated into federal fleets. Operations in Phase II will incorporate the following procedures and objectives.

1. Utilize Phase I data to establish or upgrade vehicle and fuel specifications.
2. Procure vehicles using General Services Administration (GSA) purchase and allocation policies, with appropriate modifications if required.
3. Expand the number and/or size of operational sites in conformance with purchases.
4. Verify operational results on only a representative fleet cross-section with a functional data collection and analysis system.
5. Provide appropriate prepurchase and operational support to ensure convenient operations by user agencies in a routine manner.

4. PHASE I CRITERIA AND FLEETS

4.1 Vehicles

It was planned that the Phase I test fleets should consist of some or all of three types of vehicles: (1) gasoline-fueled vehicles converted to methanol use without increasing engine compression ratio (CR), (2) the same as (1) but with increased CR, and (3) unmodified gasoline-fueled cars to serve as control vehicles. Some of these vehicles must be specially adapted for cold weather operation.

4.2 Fleet Size

For statistical purposes, an adequate number of vehicles is desired for each fleet; however, this number is limited by funding considerations. For moderate-to-warm climates, it was determined that the minimum acceptable Phase I test fleet size consist of five methanol-fueled vehicles paired with (ideally) five comparable gasoline-fueled control vehicles. It is necessary to select carefully the assignments of vehicles in a participating fleet so that the aggregate of five methanol vehicles experiences the same service or duty cycle as the aggregate of the five gasoline vehicles.

For the cold-weather fleet, with the likelihood of there being only one such site, it was decided that the fleet should be increased in size in order to attain the largest and most accurate database possible for analysis, within the program funding limitations. Therefore, a minimum of ten methanol vehicles at the participating cold-weather fleet was targeted as the requirement. These ten methanol vehicles would, likewise, be paired (ideally) with ten comparable gasoline vehicles.

4.3 Fuel Supply

An important aspect of Phase I operation is fuel supply. With a limited number of small fleets in different parts of the country, one central fuel distribution system is not practical. However, for each fleet a fuel supplier was sought who has the following capabilities:

1. Ability to formulate the fuel scientifically, that is, determine the proper formulation of that 15% of the fuel which is not methanol in order to account for seasonal variations.
2. Ability to blend physically the proper fuel formulations for distribution at the appropriate times.
3. Ability to deliver the required formulated fuel to the fleet site as needed.

4.4 Data Needs

Phase I data acquisition is intended to clarify perceptions, help to focus the direction of Phase II, and satisfy the congressional guidelines of assessing performance, fuel economy, emissions, safety, etc. At the same time, data collection is conducted in a way so as to have minimum impact on a fleet's operations in order to ensure reliable data without burdening an agency with too much additional reporting requirements.

Therefore, it was decided that only minimal data is required of any participating fleet. Those requirements include the following for both the methanol cars as well as the comparable gasoline control cars:

1. Refueling data including odometer readings and amount of fuel added.
2. Driver reactions to the operation of the vehicle to include ease of starting and drivability.
3. Vehicle maintenance records, both routine preventive maintenance as well as extraordinary maintenance.

Special testing and data reporting at certain intervals in the vehicle's operation are also required. The lubricating oil is tested at regular intervals for each vehicle to determine such parameters as concentrations of wear metals, total base number, viscosity, fuel dilution, etc. Each participating methanol fleet vehicle is tested on the U.S. Federal Test Procedure for emissions both before and after conversion to methanol. Furthermore, emissions tests are expected to be conducted on approximately one-year intervals, after the initial test.

4.5 Phase I Fleets

The Phase I Federal Methanol Fleet Project consists of three fleets. A fleet at Lawrence Berkeley Laboratory (LBL) in Berkeley, California has been in operation since November 1, 1985. The cold-weather fleet is located at Argonne National Laboratory (ANL) in Argonne, Illinois. The ANL fleet (which was placed into operation between August and December 1986) consists of five methanol and five gasoline Chevrolet S-10 pick-up trucks and five methanol and four gasoline Ford Crown Victoria security sedans. The third fleet is being organized at ORNL and will consist of five methanol and five gasoline turbocharged Buick Regal sedans. The ORNL fueling station has been completed and the Buick Regals are on order.

As the LBL fleet has been in operation for over a year, sufficient data are available to warrant a preliminary analysis of results.

The remainder of this report describes the LBL fleet, its operation, results obtained, and conclusions drawn from the first year of operation.

5. LAWRENCE BERKELEY LABORATORY FLEET

Lawrence Berkeley Laboratory is located in the hills behind Berkeley, California across the bay from San Francisco. The climate is generally mild with average winter temperatures from 40 to 55°F (5 to 10°C) and average summer temperatures from 55 to 70°F (10 to 15°C). The average annual rainfall is 20 in. (500 mm). The laboratory site itself is distinctly hilly with many winding roads, but it is within five miles of several major highways. Hence, for short trips, especially around the LBL site, fuel consumption is somewhat higher than average for "around town" drivers. For longer trips (on the highways) fuel consumption is about average.

5.1 LBL Fleet Description

The LBL fleet consists of ten 1984 Chevrolet Citation sedans with carburetted 2.8-ℓ V-6 engines and automatic transmissions. Five of the Citations were converted to operate on methanol by the Bank of America (BoA). The cars were virtually new and had low mileage when they were converted in the spring of 1985. Conversions were made at BoA facilities by BoA personnel. Major elements of the BoA conversion include; replacement of some fuel line and carburetor materials, electroless nickel plating of the carburetor, enlargement of the fuel metering jets, replacement of the head gaskets, and substitution of a larger fuel tank. The compression ratio was not changed. A more detailed description of the conversion to methanol by BoA is contained in Ref. 1. Figure 1 is a photograph of three of the methanol-fueled Chevrolet Citation sedans.

5.2 Fleet Duty Service

At LBL the five methanol Citations were placed into service in their central motor pool along with five comparable 1984 gasoline Citations which had been acquired from the General Services Administration (GSA) fleet in the San Francisco area. Because the gasoline Citations

ORNL PHOTO 0013–86

Fig. 1. Three of the LBL FMF methanol-fueled chevrolet citation sedans.

had been in service at other places, they had each already accumulated between 20,000 and 30,000 miles (30,000 to 50,000 km). In the motor pool service the ten cars serve some of the transportation needs of the LBL personnel on a reserve/dispatch basis. That is, an employee who needs a government car in carrying out his job can call and make a reservation for one of these ten vehicles. Typical services rendered by these cars include transportation around the LBL site, into and around Berkeley and Oakland, to and from the Lawrence Livermore Laboratory [about 80 miles (130 km) round trip], and to and from the Stanford Linear Accelerator Center in Palo Alto. A wide variety of other transportation needs are encountered including an occasional requirement for someone to take one of the cars on an overnight trip. In such a case, a gasoline car is generally used so as to ensure that the employee will be able to refuel.

5.3 Methanol Refueling Facilities

The Laboratory has leased a 2000 gal (8000 ℓ) fuel tank and pump and has installed it at the motor pool garage facility. This refueling capability serves most of the needs of the methanol cars. However, LBL also has the opportunity, if needed, to use any of the fueling stations of both BoA and the California Energy Commission (CEC) scattered around the San Francisco Bay area and in most of northern California. These total about 12 fueling stations available for use by LBL, which should serve to extend the range of use of their five methanol vehicles. Fuel purchased by LBL for dispensing from their on-site tank is the same as used by BoA in their own methanol fleet and is obtained from Redwood Oil Company. Accordingly, the fuel consists of 86 to 90% methanol (adjusted seasonally) with the remainder being unleaded gasoline. The Bank of America also uses a small amount of a proprietary fuel additive which is said to reduce wear and corrosion. Appendix A is a copy of BoA's methanol fuel specifications. Since no problems have been encountered with the fuel and since the fuel is received from the same supplier as for BoA, there has not been a need to verify all of the fuel specifications as indicated in Appendix A. If the LBL methanol cars are fueled at

CEC-fuel stations, they will encounter a slightly different fuel formulation since CEC uses 85% methanol with unleaded gasoline and with no fuel additive package.

5.4 Methanol Vehicle Lubrication

The oil used in the methanol cars is obtained from the Bank of America and is SAE 40 single-grade oil with an additive. Oil change interval for these cars has been set at every 3000 miles (5000 km). This oil change interval is shorter than today's practice with new cars because of the higher rates of wear and corrosion in methanol vehicles. Oil used in the gasoline cars is the standard manufacturer-recommended multi-grade oil, and oil change interval is every 4000 miles (7000 km). Oil samples are being taken from each of the 10 cars every 1000 miles (1600 km) and analyzed for wear metal concentration, total base number, viscosity, and fuel dilution.

5.5 Data Requirements

Emissions and fuel economy tests of the five methanol Citations were performed at the University of Santa Clara both before and after conversion according to the U.S. Federal Emissions Test Procedure (FTP).

Because Congress required that comparisons of operations, fuel consumption, maintenance costs, etc., are to be reported, certain data requirements are placed on LBL. Copies of all maintenance records for all ten cars, whether the maintenance is preventative or unscheduled, are sent to ORNL for inclusion in the FMF database. A complete repair history is maintained for each vehicle in the fleet, including oil additions, oil changes, oil samples taken, and parts and labor required. Methanol and gasoline fuel-related unscheduled maintenance is flagged in the database. Oil sample analyses are performed by a commercial laboratory with the results sent directly to ORNL. (ORNL transmits copies of the analysis reports to the fleet manager for his information.) Logs of all refueling transactions for the ten fleet vehicles are maintained.

Daily trip logs are maintained on which are recorded driver identification, vehicle identification, destination, and beginning and ending odometer readings. It was deemed appropriate to obtain "real time" drivers' perceptions of the methanol vehicles as compared to their perceptions of the gasoline vehicles. Hence, on the daily trip log, each driver is requested to rate "ease of starting" and "drivability" merely by placing a check mark under either "Good," "Average," or "Poor" after the trip is completed. No attempt has been made to tell LBL personnel just what constitutes "Good," "Average," or "Poor" in the two subjective questions. Rather, it is preferred that each driver make such a judgment based on his own personal experience in driving cars. A specimen copy of the LBL daily trip log is included as Appendix B.

In July 1986, a retrospective questionnaire was sent to all LBL employees who had driven vehicles used in the FMF. This questionnaire requested an elaboration of the drivers' perceptions of the methanol and gasoline vehicles. The results from the retrospective questionnaire were compared with the "real-time" perceptions from the daily trip logs. A specimen copy of the retrospective survey questionnaire is included as Appendix C.

6. RESULTS

6.1 Initial Emissions and Fuel Economy

Results from the emissions and fuel economy tests of the five methanol Citations are presented in Table 1. Notable in Table 1 is the fact that, for the five-car average, emissions of carbon monoxide and oxides of nitrogen are reduced considerably while emissions of hydrocarbons are increased after converting to methanol operation. The comparisons of

Table 1. Emissions and fuel economy of five Citations before and after conversion

Vehicle ID (License No.)	Emissions (g/mile)			Fuel economy	
	CO	HC	NO_x	mpg	km/GJ
E-753					
(g)[a]	2.23	0.39	0.79	19.1	253
(m)[b]	1.87	0.98	0.66	9.8	234
E-754					
(g)	7.86	0.21	1.15	19.1	253
(m)	2.38	0.59	1.06	10.2	245
E-755					
(g)	2.32	0.19	0.94	19.1	253
(m)	2.27	0.75	0.80	9.6	229
E-756					
(g)	2.89	0.20	1.01	19.8	261
(m)	3.28	1.27	0.53	9.6	230
E-757					
(g)	15.91	0.44	0.96	18.8	249
(m)	1.55	0.74	0.29	10.0	238
Five-car average					
(g)	6.24	0.36	0.97	19.1	253
(m)	2.27	0.87	0.67	9.8	236

[a]Unleaded gasoline (per FTP requirements). Before conversion.

[b]88% methanol plus 12% unleaded gasoline. After conversion.

fuel economy on an energy content basis before and after conversion are rather interesting also, showing the efficiency with methanol to be roughly 10% lower than with gasoline in every case. Note that the emissions tests on the cars after conversion to methanol were performed with BoA fuel which consisted of 88% methanol by volume and 12% unleaded gasoline; this is typical of the ratio of methanol to gasoline being used at LBL.

6.2 Fleet Fuel Consumption

Table 2 summarizes the fuel consumption results from the LBL Federal Methanol Fleet for the first year of operation. Shown are the

Table 2. LBL fleet fuel consumption
November 1, 1985 to October 31, 1986

Vehicle ID (License No.)	Total miles	Average miles/trip	Fuel economy	
			mpg	km/GJ[a]
		Methanol cars		
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]	11.5[b]	276[b]
		Gasoline cars		
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 $LHV_{methanol}$ = 56,560 Btu/gal and $LHV_{gasoline}$ = 115,400 Btu/gal hence LHV_{M-88} = 63,620 Btu/gal.

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

gross data in terms of numbers of trips, total miles, average miles per trip, and average fuel economy for each of the ten cars as well as aggregate totals for the five cars in each category — methanol or gasoline. It can be noted that there is not much variation in fuel economy among the methanol cars or among the gasoline cars. The difference in fuel economy between the gasoline cars and the methanol cars in over-the-road operation is in about the same ratio as that found in the FTP tests (see Table 1). With a total of 113,000 accumulated miles (182,000 km) of driving the ten cars during the year, the cars are experiencing a good utilization factor as compared with many DOE vehicles. The total miles and average miles per trip for the gasoline cars will probably always be higher than the methanol cars since only the gasoline cars have been used for the longer, overnight trips (and shorter trips are made on hilly roads). It is expected that some correction can be made in this trend in the future by judiciously assigning the methanol cars to more long trips which are still within the vehicles' range and ability to return to LBL.

6.3 Maintenance Records

The fuel tank level sensing units in the as-delivered methanol vehicles were inaccurate and inconsistent — often indicating an empty tank when in reality it was over half full. This was detrimental to the program, since LBL drivers were aware of the scarcity of off-site methanol fuel stations; and undependable fuel gauges aggravated their fears of running out of fuel. Some drivers tended to overfill the tank before starting a trip. Fuel spillage and overflows occurred with consequent complaints about the odor. Soon after the fleet was operational, these fuel level units were replaced in all methanol vehicles (but drivers' fear of running out of fuel persisted).

The principal driver complaints requiring unscheduled maintenance were difficult starting and engine stalling. Eight such complaints were registered covering all five methanol vehicles. In one instance this was found to be due to a partially clogged fuel filter. The reason for this was not fully determined but it was suspected that there was a materials compatibility problem in the initial methanol fuel dispensing equipment. (The vanes in the original methanol delivery pump were later replaced with a methanol resistant material). Consequently, the fuel filters in all methanol vehicles were replaced. In subsequent starting-stalling problems, the fuel filters were suspected. They were replaced twice in three of the methanol vehicles and three times in one. However, post-maintenance examinations revealed that with the exception of the initial clogged filter incident, fouled fuel filters were probably not the problem. Six of the eight complaints were answered by replacing the fuel filter and making carburetor adjustments. For the other two complaints, no mechanical problems could be found by the mechanics and no repairs were made. Thus, it is suspected that some of the fuel filter replacements were unnecessary.

6.4 Oil Sample Analyses

For both the methanol and gasoline vehicles, oil samples were taken at 1000 mile intervals. These samples were analyzed for total base number, kinematic viscosity and mass content, in parts per million, of iron, lead, copper and silicon. Oil changes were made initially at 4000 mile intervals. In July of 1986 the oil change interval for the methanol vehicles was changed to 3000 miles based on information obtained from the Army methanol fleet at the Presidio in San Francisco. Oil samples are drawn immediately before and after each oil change so as to obtain a sample of the oil at the end of its use cycle as well as at the beginning.

No significant changes in total base number or kinematic viscosity were observed. Iron is the largest contributor to lubricating oil contamination. A plot of iron concentration versus distance traveled since oil change for the LBL methanol and gasoline vehicles is shown in Fig. 2.

Average wear metal accumulations in parts per million per 1000 miles of vehicle operation for the two types of vehicles are shown in Table 3. The wear metal accumulation rate is consistently and significantly higher in methanol vehicles than in gasoline control vehicles. Although such high values of wear metals would typically be cause

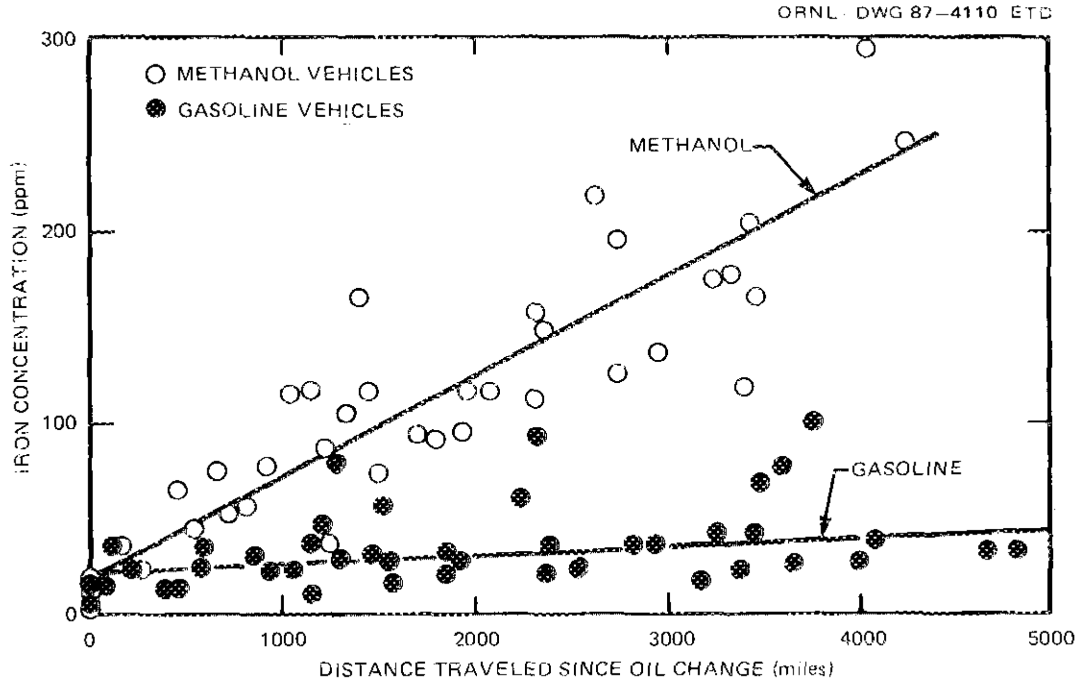

Fig. 2. Iron concentration in the LBL FMF vehicles. The lines are least-squares straight lines through the respective sets of data.

Table 3. Average wear metals accumulated in parts per million per 1000 miles of operation, LBL Federal Methanol Fleet, November 1, 1985 to October 31, 1986

Wear metal	ppm per 1000 mi	
	Methanol vehicles	Gasoline vehicles
Iron	52	3
Lead	43	4
Copper	6	1
Silicon	10	3

for alarm, it is our understanding that the results shown here are typical of the results from other methanol vehicle fleets.[2,3] There are also no guidelines as to just what "normal" wear metal concentrations should be. One would think that the gasoline vehicles should be considered "normal;" but, indications are that methanol vehicles can operate at elevated levels of wear metals in the oil with no evidence of accelerated wear upon examination of the engine after over 100,000 miles (160,000 km) of use.[3]

6.5 Drivers' Real-Time Perceptions

During the period of this report, 2331 trip log entries were recorded: 1029 for the methanol fleet vehicles and 1302 for the gasoline fleet vehicles. The results of these drivers' responses to the question of "Ease of Starting" are presented in Table 4. Similarly, results for "Drivability" are presented in Table 5. The average results are summarized in Table 6.

Table 4. LBL drivers' responses to "Ease of Starting" question, from daily trip logs, November 1, 1985—October 31, 1986

Fuel type	Vehicle ID	Number of responses				
		Good	Average	Poor	No response	Total
Methanol	E-753	138	46	4		
Methanol	E-754	133	31	8		
Methanol	E-755	165	26	5		
Methanol	E-756	136	64	14		
Methanol	E-757	166	41	12		
Methanol	Subtotal	738	208	43	40	1029
Gasoline	G-563	190	40	0		
Gasoline	G-580	247	40	1		
Gasoline	G-611	206	96	6		
Gasoline	G-709	123	7	1		
Gasoline	G-771	184	99	5		
Gasoline	Subtotal	950	282	13	57	1302
(Both)	Total	1688	490	56	97	2331

Table 5. LBL drivers' responses to "Drivability" question, from daily trip logs, November 1, 1985–October 31, 1986

Fuel type	Vehicle ID	Number of responses				
		Good	Average	Poor	No response	Total
Methanol	E-753	140	39	9		
Methanol	E-754	109	54	7		
Methanol	E-755	125	64	5		
Methanol	E-756	136	47	25		
Methanol	E-757	159	48	10		
Methanol	Subtotal	669	252	56	52	1029
Gasoline	G-563	186	43	1		
Gasoline	G-580	235	41	10		
Gasoline	G-611	159	144	4		
Gasoline	G-709	123	5	1		
Gasoline	G-771	150	136	2		
Gasoline	Subtotal	853	369	18	62	1302
(Both)	Total	1522	621	74	114	2331

Table 6. Averages of responses from the LBL daily trip logs for ease of starting and drivability, November 1, 1985–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
Drivability				
Methanol vehicle average	65	25	5	5
Gasoline vehicle average	66	28	1	5
LBL fleet average	65	27	3	5

Tabulations of responses to "Ease of Starting" and "Drivability" show no significant differences between the methanol vehicles and the gasoline vehicles. Basically the drivers appear to like both types of vehicles as they were both rated as average or better over 90% of the time for both categories. It is interesting that these fleet vehicles rated consistently higher on Ease of Starting than they did on Drivability. The one methanol vehicle that received the largest number of poor ratings in both categories is the same one that had the largest number of unscheduled, fuel-related maintenance records.

6.6 Retrospective Survey

In July of 1986 a survey questionnaire (see Appendix C) was sent to the 240 LBL employees who had experienced driving the methanol and/or gasoline fleet vehicles. Completed questionnaires were received from 125 of the 240 drivers (52%).

The main purpose of the survey was to determine if drivers' perception of the performance of the vehicles in the demonstration fleet was different after the passage of time than when they filled out the daily trip logs immediately upon returning the vehicles after use. The survey also offered the opportunity to ask more detailed questions and to elicit more explicit ratings of the vehicles by the drivers. The period of time covered by the survey was from initiation of the fleet activities on November 1, 1985 to July 1986; thus, it does not cover the entire period covered by the rest of this report. The questionnaire was designed for anonymous responses to ensure the maximum possible respondent participation.

The questionnaire consisted of three sections of seven questions each. (Refer to the copy of the survey form in Appendix C.) The first section was to be filled out by all persons who had driven any of the ten vehicles. The second section was to be filled out by persons who had driven one of the gasoline vehicles at least once, while the third section served the same function for the methanol vehicles. Thus, drivers who had experience in both methanol and gasoline vehicles filled out all three sections of the survey.

6.6.1 Results of Some of the General Questions

Of the 125 respondents to the survey, 23 had driven only the gasoline fleet vehicles, 26 had driven only the methanol fleet vehicles; and

73 had driven both types of vehicles. It is the group of 73 drivers who had experienced both types of vehicles that will be emphasized in a comparative analysis of the data that will follow. Four of the more important of the survey questions and the results for those questions are cited below.

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

Better	Equal	Worse	No comparable experience
8%	68%	2%	22%

6. If you have driven both types of vehicles, which type did you feel was the better in overall performance?

Methanol better	Gasoline better	Same
10%	23%	67%

9. Do you feel safe in the gasoline vehicles in the motor pool?

Yes	No
95%	5%

16. Do you feel safe in the methanol vehicles in the motor pool?

Yes	No
89%	11%

In the last two questions above concerning the drivers' perception of safety, it is not clear why a number of people feel less safe in the methanol vehicles than in the gasoline vehicles. Respondents were given the opportunity to comment if they had indicated that they felt unsafe, but most did not comment in the space provided.

6.6.2 Drivers' Ratings of Vehicles

In this set of questions, respondents were given the opportunity to rate the vehicles in various categories of operation on a scale from 1 to 10 with 10 being the highest rating. Questions concerned ease of starting, drivability during the first mile, drivability after the first mile, freeway performance, and overall rating of the vehicles. Drivability was divided between the "first mile" and "after the first mile" in order to try to separate cold engine operation from warm engine operation. It was recognized, however, that the first mile of operation could very well be with a warm engine, depending on circumstances. However, since the survey sought opinions from drivers after they had time to reflect upon their entire experience with the vehicles, it was thought to be appropriate to ask the question in this way. Results from this part of the survey are tabulated in Table 7 where mean ratings, standard deviations, and number of respondents for each question are

Table 7. Mean ratings and standard deviations of methanol and gasoline fleet vehicles on a scale from one to ten from drivers with experience with both types of fuel

Question	Mean rating	Mean deviation	Number of respondents
Ease of starting of methanol vehicles	6.9	2.0	73
Ease of starting of gasoline vehicles	7.3	1.8	72
First mile performance of methanol vehicles	6.7	2.2	73
First mile performance of gasoline vehicles	6.8	2.0	72
Performance after first mile of methanol vehicles	7.3	1.8	72
Performance after first mile of gasoline vehicles	7.5	1.8	72
Freeway performance of methanol vehicles	7.1	1.8	60
Freeway performance of gasoline vehicles	7.3	1.7	62
Overall rating of methanol vehicles	7.3	1.8	69
Overall rating of gasoline vehicles	7.3	1.8	68

listed. Again, only those drivers who had driven both the methanol as well as the gasoline vehicles are counted in the results shown in Table 7. Interesting to note is the fact that while in almost every question the gasoline vehicles rated slightly higher than the methanol vehicles, the difference was well within the standard deviation for the question. Furthermore, even though the gasoline vehicles were rated slightly higher in the specific questions regarding the performance, in the overall rating of the vehicles, the gasoline vehicles and methanol vehicles scored exactly the same rating.

6.6.3 Comparison of Survey Results with Results from the Daily Trip Logs

One of the purposes of the survey questionnaire was to determine if drivers thought differently of the motor pool vehicles after having time to reflect upon their experience as opposed to the way in which they reacted when answering the two questions on the daily trip logs as they returned the cars. A qualitative comparison of the results presented in Sect. 6.6.2 (Results of the Survey) with those presented in Table 6 (Summary of responses on daily trip logs) reveals that the drivers are fairly consistent in their ratings of the vehicles. Generally, they prefer the gasoline vehicles over the methanol vehicles, but the difference is not very great. Also, it is apparent that the drivers' impressions of the vehicles given at the time that they filled in the daily trip log were not changed after some time had elapsed.

7. SUMMARY

The Federal Methanol Fleet operating at Lawrence Berkeley Laboratory completed a satisfactory first year of operation. Over 100,000 miles (160,000 km) were accumulated on the 10 cars participating in the demonstration without serous disruptions in service. Project start-up difficulties were minimal; levels of maintenance required by both methanol and gasoline vehicles were reasonable; fuel consumption by methanol vehicles was a little greater on an energy basis than by the gasoline vehicles, but some of this difference is attributable to a difference in the types of service in which the two vehicle types are being used. Oil sample analyses revealed higher wear metal concentrations in the methanol vehicles than in the gasoline vehicles, but not alarmingly so.

Drivers seem to accept the methanol vehicle as completely adequate for their transportation needs at LBL. This conclusion was reached by analysis of their responses to questions on daily trip logs as well as their responses to questions on a special survey at about the half-way point in their first year's operation. The greatest concern expressed by drivers of the methanol vehicles was the possibility of running out of fuel coupled with the limited number of locations at which they could refuel.

The results from the first year of operation of this fleet are deemed to be entirely satisfactory and have helped the project management team to develop considerable insight into the various considerations that must be made in order to introduce methanol-fueled vehicles into federal government fleet operations.

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Personnel from the Bank of America have been quite helpful in getting this fleet started and keeping it maintained. Particular thanks are due to Donald Dennler, Vice President and General Manager of Fleet Operations; and to Frank Lozano, Senior Research Mechanic.

APPENDIX A

BANK OF AMERICA METHANOL FUEL SPECIFICATIONS AND TESTING METHODS

1.	METHANOL, By Volume for a) M-85, b) M-86, & c) M-88 (ASTM D1152, 99.85% grade)*	a) 85.0 + 1.0, -0.0% b) 86.0 + 1.0, -0.0% c) 88.0 + 1.0, -0.0%
	ASTM D 3545 is to be modified for the determination of methanol, utilizing the gas chromatograph described therein. Acidity and water content results determined in 4 and 11 are to be used to normalize values obtained by gas chromatography. Note that the remaining portion of the fuel mixture is to be reported as gasoline.	
2.	GASOLINE, PREMIUM UNLEADED, By Volume (ASTM D 439), 9-11 psi RVP Aromatics in Gasoline, 40% min. by volume ASTM D 1319	a) 15.0 + 0.0, -1.0% b) 14.0 + 0.0, -1.0% c) 12.0 + 0.0, -1.0%
3.	ADDITIVE, FA5,** By Weight	2 lb/1000 gal.
4.	VAPOR PRESSURE, dry (ASTM D 323)	40-65 kPa
5.	ACIDITY, wt%, max. (ASTM D 1613)	0.003%
6.	DISTILLATION RESIDUE, max. (ASTM D 86)	0.5%
7.	TOTAL CHLORIDE CONTENT, ORGANIC AND INORGANIC, max. (ASTM D 3120, Modified & ASTM D 2988)	0.0002%
	ASTM D 3120 is modified for the determination of organic chlorides.	
8.	LEAD CONTENT, max. (ASTM D 3237)	0.003 g/L
9.	PHOSPHORUS CONTENT, max. (ASTM D 3231)	0.001 g/L
10.	SULFUR CONTENT, max. (ASTM D 3120)	0.015%
11.	PARTICULATE CONTAMINANTS, max. (ASTM D 2276)	0.1 g/L
12.	WATER, wt%, max. (ASTM D 1744)	0.5%

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*The specified test method shall be used when determining methanol-gasoline content.

**FA5 is a proprietary fuel additive for use with methanol. It is available from the Bank of America.

APPENDIX B

FEDERAL METHANOL FLEET DAILY TRIP LOG
(LBL Automobile Register)

Note: These sheets for the methanol vehicles are printed on light blue paper while those for the gasoline vehicles are printed on yellow paper.

LBL AUTOMOBILE REGISTER

federal methanol fleet

FOR OFFICIAL USE ONLY

DATE	SIGNED OUT BY LAST NAME AND INITIALS	OPERATING ACCT. NO.	DESTINATION	SIGN OUT TIME	ESTIMATED RETURN TIME	ACTUAL SIGN IN TIME	MILEAGE		Please Check (✓) Ease of Starting			Drivability		
							OUT	IN	Good	Avg.	Poor	Good	Avg.	Poor

BY SIGNATURE ABOVE, DRIVER CERTIFIES –

1) HE HAS A VALID STATE DRIVER'S LICENSE.

MAKE __________ MODEL __________

LICENSE NO. __________

APPENDIX C

LBL FLEET RETROSPECTIVE
SURVEY QUESTIONNAIRE

July 1, 1986

SECTION I
(Gasoline or Methanol)

1. Indicated in the boxes below are the two types of Chevrolet Citations that you may have had the opportunity to drive. Depending upon your actual experience with one or the other type, please place in each box your best estimate of the percent of time that you drove each of the vehicles (the sum should total 100% and please place a percentage in each box).

   Methanol ☐ Gasoline ☐

2. Do the cars in the motor pool perform at a level that is equal to other cars of this type that you have previously driven? (Answer one box only).

   Better ☐ Equal ☐ Worse ☐ No comparable experience ☐

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

   Highway ☐ In town ☐

4. When you drove a methanol Citation, which type of driving did you experience the most?

   Highway ☐ In town ☐ No experience ☐

5. When you drove a gasoline Citation, which type of driving did you experience the most?

   Highway ☐ In town ☐ No experience ☐

6. If you have driven both types of vehicles, which type did you feel was the better in overall performance?

   Methanol better ☐ Gasoline better ☐ Same ☐ No Dual experience ☐

7. Did you notice any difference in the performance of the methanol vehicles as compared to the gasoline vehicles in the motor pool?

   Yes ☐ No ☐ No experience ☐

SECTION II
(Gasoline Only)

8. Did you have difficulty in starting the gasoline vehicles in the motor pool?

Yes ☐ No ☐

9. Do you feel safe in the gasoline vehicles in the motor pool? If no, please state your reasons.

Yes ☐ No ☐

____

____

For the following questions please give a rating between one and ten where one = very poor and ten = excellent. A value of five would denote an average rating.

	Rating
10. Overall how easily did the gasoline cars start?	____
11. For the first mile of driving, how did the gasoline cars perform?	____
12. After the first mile of driving how did the gasoline cars drive?	____

OMIT QUESTION 13 IF YOU HAD NO EXPERIENCE DRIVING THESE POOL CARS ON THE HIGHWAY

13. How did the gasoline cars perform on the highway (Freeway)?	____
14. For an overall rating, how did the gasoline cars drive?	____

SECTION III
(Methanol Only)

15. Did you have any difficulty in starting the methanol vehicles in the motor pool?

Yes ☐ No ☐

16. Do you feel safe in the methanol vehicles in the motor pool? If no, please state your reasons.

Yes ☐ No ☐

____

____

For the following questions, please give a rating between one and ten where one = very poor and ten = excellent. A value of five would denote an average rating.

	Rating
17. Overall how easily did the methanol cars start?	_____
18. For the first mile of driving, how did the methanol cars perform?	_____
19. After the first mile of driving how did the methanol cars drive?	_____

OMIT QUESTION 20 IF YOU HAD NO EXPERIENCE DRIVING THESE POOL CARS ON THE HIGHWAY

20. How did the methanol cars perform on the highway (Freeway)?	_____
21. For an overall rating, how did the methanol cars drive?	_____

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