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50,000 MILE METHANOL/GASOLINE BLEND FLEET STUDY
--A PROGRESS REPORT--

by

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ABSTRACT

Seven current production automobiles are being used in a fleet study to obtain operational experience in using 10% methanol/90% gasoline blends as an automotive fuel. Data from chassis dynamometer tests (run according to the 1975-78 Federal test procedure) have been obtained, showing fuel economy and exhaust emissions of carbon monoxide, oxides of nitrogen, unburned fuel, methanol, and aldehydes. These data are shown for each of the vehicles when operated on the 10% methanol blend, and on unleaded low octane Indolene. Chassis dynamometer tests were run at 5,000-mile intervals during the 35,000 miles accumulated on each of the four 1977 model-year vehicles and at 5,000 and 10,000 mile accumulation levels for each of the three 1978 model-year vehicles. These data show an average decrease in volumetric fuel economy (≅ 5%) and a reduction in carbon monoxide emissions associated with the use of the 10% methanol blend. Exhaust emission deterioration factors are projected from the Federal test procedure urban cycle data. The most severe driveability problems that have been encountered thus far into the program are related to operating on a phase separated fuel and materials compatibility problems with an elastomer in the air-fuel control hardware of one vehicle.

INTRODUCTION

In an effort to provide information concerning the use of methanol/gasoline blends as a fuel for the transporation sector, a fleet study is being conducted at the Department of Energy's Bartlesville (Okla.) Energy Technology Center. The study involves seven 1977 and 1978 model-year (MY) automobiles operating on a 10% methanol/90% gasoline blend. The objective of this investigation is to provide information on the driveability, fuel economy, exhaust emissions, and component deterioration associated with the long-term use of methanol/gasoline blends in current-production automobiles. Vehicles in this study are not altered, inasmuch as one objective of the study is to determine the nature and severity of any problems that might arise should alcohol fuels be used as a direct replacement for, or supplement to, traditional fuels, with no opportunity to modify the vehicles.

FLEET OPERATION

The seven vehicles involved in the fleet study are described in Table 1. The four 1977 MY vehicles have been used in the fleet study since its beginning in July, 1977, and have accumulated over 35,000 miles on a 10% methanol/90% gasoline blend. The 1977 MY vehicles are forty-nine states production automobiles and are equipped with oxidation catalysts. The three 1978 MY vehicles entered the program at a later date and each has accumulated 10,000 to 15,000 miles on the methanol blend. The Volvo and

Ford Pinto are equipped with three-way catalytic converters and closed-loop air-fuel (A/F) control systems. Each of the 1978 MY vehicles are California production automobiles.

The vehicles in the fleet are operated for approximately three hours each day over a fixed route covering approximately 100 miles. The route is comprised of approximately a 30% city/70% highway-type driving mixture. The automobiles are operated by non-professional drivers six days/week, road conditions permitting. During each mileage accumulation cycle the driver evaluates the vehicle's performance during cold and hot-start operations as well as routine urban and highway operation on the 10% methanol blend.

Chassis dynamometer tests are made at 5,000-mile intervals to acquire fuel economy and exhaust emissions data. The tests are run according to the 1975-78 Federal test procedure (FTP) for the urban cycle and highway fuel economy test (HFET). Duplicate runs are made for each vehicle operating both on the 10% methanol blend and an unleaded low octane Indolene.

The 10% methanol blend is batch mixed and stored in an underground tank having a 4,000 gallon capacity. Water concentration in the underground tank has ranged from 229 to 1040 ppm in the four batches of blend used to date. The base gasoline used for the blend is made from hydrocarbon stocks so that the vapor pressure, aromatic content, and octane number of the alcohol/gasoline blend approximate an unleaded regular grade gasoline. Analyses of the test fuels used in this program are shown in Table 2.

The vehicles in the fleet study are not protected from weather extremes. Temperatures encountered thus far in the test program have ranged from -5° to 107° F. Temperatures during the mileage accumulation cycles have ranged from 4° to 105° F.

1975-78 FEDERAL TEST PROCEDURE RESULTS

Fuel Economy

The fuel economy data for the fleet (from chassis dynamometer tests run over the 1975-78 FTP urban and HFET cycles using unleaded Indolene and the 10% methanol/90% gasoline blend) are shown in Fig. 1. The results from the urban cycle tests show an average volumetric fuel economy penalty of about 5% associated with the fleet operating on the methanol blend compared to results from the fleet operating on Indolene for both the 1977 and 1978 MY vehicles. The HFET test results show an average 6% and 4.5% decrease in volumetric fuel economy associated with operating on the 10% methanol blend for the 1977 and 1978 MY vehicles, respectively. The energy economy (mi/100,000 Btu) of both sets of vehicles in the fleet is roughly equivalent for the two fuels.

Regulated Emissions

The emission rate of carbon monoxide (CO) from the 1975-78 FTP chassis dynamometer tests shows consistent reduction with the methanol blend compared to test results from operating on Indolene (Fig. 2). This reduction in the CO emission rate is believed to result from the methanol blend's leaning effect on the stoichiometry of the air-fuel mixture. The overall reduction on the CO emissions achieved by the methanol blend is not as great with the 1978 MY vehicles as with the 1977 MY vehicles. This would appear to be due primarily to the dominance in the 1978 MY fleet of vehicles using closed-loop A/F control systems which function to maintain a constant oxygen concentration in the exhaust gas stream by adjusting A/F.

The emission rates of oxides of nitrogen (NO_X) from the test fleet are shown in Fig. 3 as a function of mileage accumulation. The individual test vehicles do not show a consistent effect of operating on the 10% methanol blend compared to results from operating on Indolene. However, the leaning effect of the blend on A/F (for those vehicles not equipped with closed-loop A/F control) could be expected to increase or decrease the NO_X emission rate, depending upon the original A/F adjustment of a particular vehicle. On the average, the 10% methanol blend shows slight reductions in NO_X for the 1977 MY fleet and slight increases for the 1978 MY fleets, compared to test results from operating on Indolene.

The emission rates of unburned fuel (UBF) from the test fleet show slight increases associated with the use of the 10% methanol blend over the test results from the fleet operating on Indolene (Fig. 4). The UBF emissions from the tests using the 10% blend are not corrected for the low flame ionization detector response for methanol (response factor ≅ 0.73) [1]*; correction would still further increase the measured UBF emissions for the blend. Some of the increase in UBF emissions could be attributed to the fact that the vapor pressure of the blend ranges from 1 to 3.5 psi higher than that of Indolene. Generally, UBF emissions during the cold transient and stabilized phases of the FTP urban cycle are lower when operating on the methanol blend. During the hot transient phase, however, the vehicles operating on the methanol blend show a marked increase over UBF emissions measured when operating on Indolene. Similar observations were made in a previous study [2] with the suggestion that the UBF emissions increase in the hot transient phase was a result of the higher volatility of the blend. The only notable exception to this trend was found in vehicle #176, which showed comparable but slightly lower UBF emissions for all three phases when operating on the methanol blend. This fuel-volatility explanation would tend to be supported by the fact that vehicle #176 is the only fuel injected vehicle in either fleet.

Unregulated Exhaust Emissions

In addition to the regulated exhaust emissions, measurements of exhaust emission rates of methanol and aldehyde were made for each dynamometer test.

The methanol exhaust emissions were measured by taking a constant volume sample and determining the methanol content using gas chromatography [1]. The emission rates of methanol from the individual vehicles equipped with an oxidation catalyst and operating on the methanol blend ranged from 0.013 to 0.106 gm/mile over the 1975-78 FTP urban cycle (Fig. 5). The average methanol emission rate from the vehicles equipped with three-way

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*Numbers in brackets designate References at end of paper.

catalysts was 0.023 gm/mile when operating on the methanol blend. The emission rates of methanol from 1977 and 1978 MY vehicles operating on Indolene was an order of magnitude lower than when operating on the blend.

Aldehydes were measured using the methyl benzothiazolone hydrozone (MBTH) technique for measuring total aldehydes [3]. Previous studies have suggested that the predominant aldehyde specie associated with the combustion of methanol in spark-ignition engines is formaldehyde [4]. The emission rates of aldehydes are expressed as formaldehyde. The 1977 MY fleet operating on the 10% methanol blend shows aldehyde emission rates to increase an average of 75% over the results from tests of the same vehicles operating on Indolene (Fig. 6). Aldehyde emissions from the individual vehicles in the 1978 MY fleet operating on the 10% methanol blend are considerably lower than the emission rates from the 1977 MY fleet operating on Indolene. The 10% methanol content of the blend does not appear to have any significant impact on the emission rates of aldehydes from the vehicles in the 1978 MY fleet.

Deterioration Factors

Generally, as the emission control components and engines age they might be expected to lose their capacity to control exhaust emissions. The Environmental Protection Agency (EPA) requires that each automobile manufacturer establish the durability of the emission control components for each engine family used in new motor vehicles to establish their conformity to exhaust emission standards. These durability data are generated in a well established and controlled series of fleet tests [5] in which the vehicles are driven for 50,000 miles and tested at 5,000-mile accumulation intervals.

The deterioration factor is determined for each regulated exhaust emission by using a least-squares linear regression fit to the FTP data generated at each 5,000 mile interval, from the 5,000 mile through to the 50,000 mile test points. The equation of this line is used to interpolate values at 50,000 miles and 4,000 miles; the deterioration factor is then computed by dividing the 50,000-mile data point by the 4,000 mile data point. These data have been published by EPA [6,7] for the engine families represented in the 1977 and 1978 MY fleets.

Although the EPA certification data are generated on prototype vehicles operating under tightly controlled maintenance and mileage accumulation schedules, it is assumed that vehicles of the same engine family can be expected to exhibit "similar emissions characteristics throughout their useful life" [5]. Based on this assumption, a comparison was made of durability data reported on vehicles representing the same engine families as those vehicles that are being used in the methanol blend fleet study. The results of the least squares fit applied to data from the individual test vehicles are shown in Table 3, with the corresponding values of interpolated and projected emissions results at the 4,000 and 50,000-mile test points. Deterioration factors projected from the 1977 MY fleet vehicle tests and deterioration factors from the EPA certification tests show the greatest disparity when the deterioration factors associated with CO emissions are compared. Yet when the deterioration factors are applied to the mass pollutant emission data from the 1977 MY fleet vehicles and from the EPA certification vehicles [8] the projection suggests that while the deterioration rate of CO emissions from the 1977 MY methanol fleet is greater, the overall effects show the CO emission rates from this fleet to be comparable to those projected from EPA certification vehicles (Fig. 7). The deterioration factors from the 1977 MY methanol fleet and the corresponding EPA certification vehicles for UBF and NO_X are comparable, but there is some disparity in the levels of pollutant emissions at any one point in the life of the fleet. The difference in the projected levels of NO_X emissions (0.3 gm/mile) is apparently associated with the difference in original calibration of vehicle #163 between the certification vehicle and the corresponding vehicle in the fleet study. The UBF emission rates appear to be on the order of 0.35 gm/ mile higher in the fleet than projected from EPA certification data. A portion of this difference can be attributed to the higher vapor pressure of the methanol blend used in the fleet study as was described earlier in this report.

The 1978 MY fleet deterioraiton factors were computed based on information from 5,000 and 10,000 mile runs--considerably less than was used in the 1977 MY fleet and EPA certification computations; and, therefore, has a more limited statistical credibility. The average fleet test results show UBF deterioration factors to be comparable; but this is not the case with NO_X and CO emissions (Fig. 8). The average CO emissions from the fleet at any particular point in the life of this fleet is estimated to be considerably lower when operating on the methanol blend. The deterioration factor for NO_X emissions for the methanol blend fleet, shows a much more rapid increase in mass emissions with fleet life, due primarily to the influence of car #176. The rate of increase in NO_X emissions and the higher base in NO_X emissions from this particular vehicle deviates significantly from the levels projected by EPA [7,9]. A component failure in the fuel injection distributor of vehicle #176 is associated with (but not totally responsible for) an NO_X increase from 0.40 gm/mile NO_X to 1.10 gm/mile NO_X, over a period of 8,000 miles of operation.

DRIVEABILITY

The term of this project provided an opportunity to develop in-use driveability data on the 10% methanol/90% gasoline blends. As the vehicles are operated over the 100-mile mileage-accumulation route the driver evaluates the vehicle's performance on the blend by responding to a series of questions. These questions are separated into three parts; the first series is concerned with identifying cold-start difficulties, the second concerns operating malfunctions associated with vehicle operation with a fully-warmed engine, and the third with hot-start difficulties. Each malfunction that the driver identifies is assigned a demerit value; the frequency with which the malfunction occurs determines the weighting factor. The weighting factor is multiplied by the demerit, and the sum of the weighted demerits for each 100-mile run gives the driveability demerits that are associated with that particular run.

The time required to start the vehicle in both the cold and hot-start operations is also a factor in determining driveability. In order to account for this factor, a starting time of 2 seconds received no demerits; a starting time of 2 to 10 seconds received 6 demerits; and a starting time for over 10 seconds received 11 demerits. The driveability demerit system used in this series of tests is illustrated in Table 4.

This driveability rating system bears some resemblance to the driveability system adopted by the Coordinating Research Council (CRC) and the general definition of the malfunctions described by CRC do apply. However, due to the difference in the driving cycle, driveability demerits developed in this series of tests are not comparable to those from CRC driveability tests.

The average driveability demerits generated by the fleet of seven vehicles as of January 31, 1979 are shown in Fig. 9 along with the average driveability demerits generated for the month of January, 1979. The most pronounced driveability problems associated with operating these vehicles on a 10% methanol blend have developed in car #164. The majority of these problems are associated with the vehicle hesitating on accelerations and stalling before the engine is fully warmed. These problems seem to be related to a materials compatibility problem with the accelerator pump cup in the carburetor; this will be discussed more fully later in this report. Vehicle #176 shows the smallest effect of the blend on driveability. This is probably due to the action of the closed-loop A/F system maintaining a stoichiometric A/F mixture in the engine and thus minimizing the blend leaning effect. This vehicle was not operating the month of January 1979.

During the month of January 1979, the National Weather Service recorded a high temperature of 47° F in the Bartlesville area. The water concentration in the fuel stored in the underground tank was approximately 740 ppm, which caused the fuel to separate into two phases at 50.5° F. Thus, the driveability data for the month of January represent data from the fleet operating on a phase separated fuel. Comparing these data to the average driveability demerits generated on each of the vehicles over their entire life in the project as of January 31, 1979, gives an indication of the relative difficulty of operating the vehicles on a separated fuel. Four of the six vehicles operated during this month showed an increase in driveability demerits over their average. Of these four vehicles only car #164 showed an increase in driveability demerits beyond one standard deviation from the average driveability demerits generated as of January 31, 1979.

Operating the vehicles on the phase separated fuel was probably not as difficult as one would have expected due in part to the properties of the lower phase. The vapor pressure of the lower phase was only one psi lower than that of the blend (methanol blend #4). Gasoline components comprised about 45% (liquid volume) of the lower phase.

MATERIAL COMPATIBILITY

Since the beginning of the fleet operation in July, 1977, two vehicles have developed materials compatibility problems. The accelerator pump cup in the carburetor of car #164, originally a Buna-N material, was the subject of a recall and was replaced with a Viton pump cup. The Buna-N material was replaced because the manufacturer found that the material, when exposed to gasolines with an aromatic content on the order of 30% or more, hardened and became embrittled when the plasticizers in the material were removed by the gasoline. The black pump cup (Buna-N) shown in Fig. 10 failed while in service. The lighter colored pump cups (shown in the upper portion of the figure) are the Viton replacements. The Viton pump cup on the right was exposed to the 10% methanol blend; the Viton pump cup on the left was exposed to the base fuel used in the blend. The resulting increase (≅ 8%) in the outside diameter of the pump cup when exposed to the methanol blend is believed to have resulted in continued driveability problems (discussed in the previous section). The pump cup tended to stick or hang to the cylinder wall. Based on our experience with this vehicle, neither pump cup would give acceptable driveability on the long-term with a methanol/gasoline blend.

The second materials compatibility problem was also associated with a Viton elastomer. The o-ring used in the line pressure regulator of vehicle #176 (illustrated in Fig. 11) is made of Viton. The o-ring on the left failed in service while the vehicle was operating on the 10% methanol blend; the o-ring on the right was used as the replacement for the failed o-ring and had not been exposed to any fuel at the time this photograph was taken. The increase in outside diameter (≅ 10%, half of which is a result of exposure to the methanol in the blend) is believed to have contributed to the o-ring failure, although the manufacturer indicates that similar failures have occurred in the field with the vehicles operating on gasoline. There are a number of Viton o-rings located in the fuel distributor. Other instances of inspecting the line pressure regulator (located in the fuel distributor) have led to the discovery that while other o-rings are not cut, they do tend to slip out of place. These o-rings seal against pressures in the fuel metering system which control A/F, which in turn influences both the production of NO_X and the efficiency of the three-way catalyst in reducing NO_X. The change in the fuel pressure control characteristics of the line pressure regulator is believed to have been partially responsible for the high NO_X deterioration factor of car #176 described in the previous section of this report. However, this materials problem cannot account fully for 0.7 gm/mile NO_X emission increase in car #176.

SUMMARY AND CONCLUSIONS

Based on the information generated thus far into the project, it appears that long term use of methanol/gasoline blend will reduce volumetric fuel economy on the order of 5%. Provided the manufacturer's A/F adjustment remains unchanged from that of the vehicles used in this study, emissions rates of CO can be expected to decrease substantially due to the blend leaning effect on fuel/engine systems that are not equipped with closed-loop A/F feedback control. Smaller reductions in CO emissions can be expected from those vehicles equipped with closed loop A/F control systems. The UBF emissions will change in character, in that ≅ 7% of the pollutant will be unburned methanol. Aldehyde emissions are shown to increase over those generated from operating on straight gasoline in vehicles with conventional carburetor/oxidation catalyst systems; however, no significant increase in aldehyde emissions is expected from vehicles with closed-loop A/F control/three-way catalyst systems.

Projections based on deterioration factors suggest, that long-term use of 10% methanol blends will not adversely affect emission rates of CO and NO_X, barring complications resulting from materials compatibility problems. Increases of UBF emissions can be expected if the vapor pressure of the blend cannot be limited to levels comparable to those found in commercial gasolines.

The vehicles used in this study will start and operate in cold weather on phase separated fuel due in part to the properties of the lower phase. However, most of the vehicles show an increase in driveability problems associated with operating on a phase separated fuel. Materials compatibility problems can have a serious adverse impact on driveability, whether operating on a separated fuel or on a single phase 10% methanol blend.

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9. Environmental Protection Agency, "Buyer's Guide Data", (for 1978 MY vehicles) U.S. EPA, Ann Arbor, MI, January 1978.

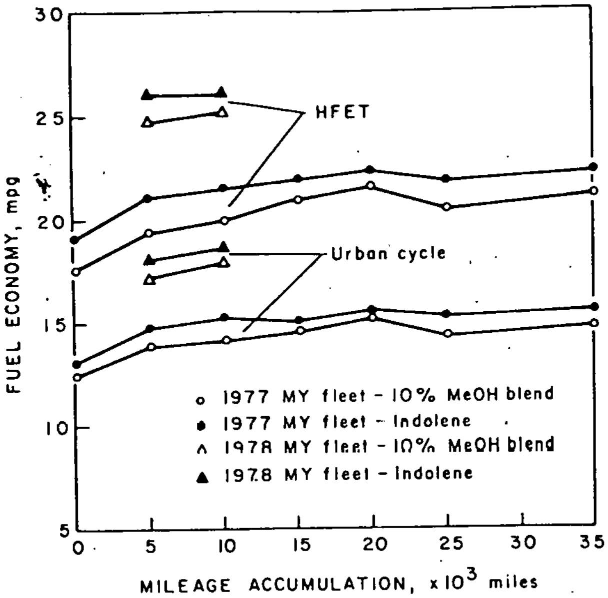

Fig. 1. - 1975-78 FTP and HFET Results for 1977 and 1978 MY Vehicles at Various Mileage Accumulation Intervals

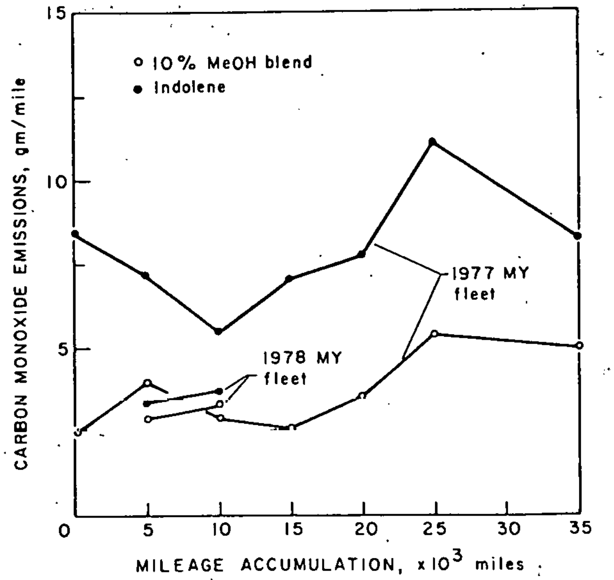

Fig. 2. - Carbon Monoxide Emission Rates from the 1975-78 FTP Cycle, 1977 and 1978 MY Vehicles

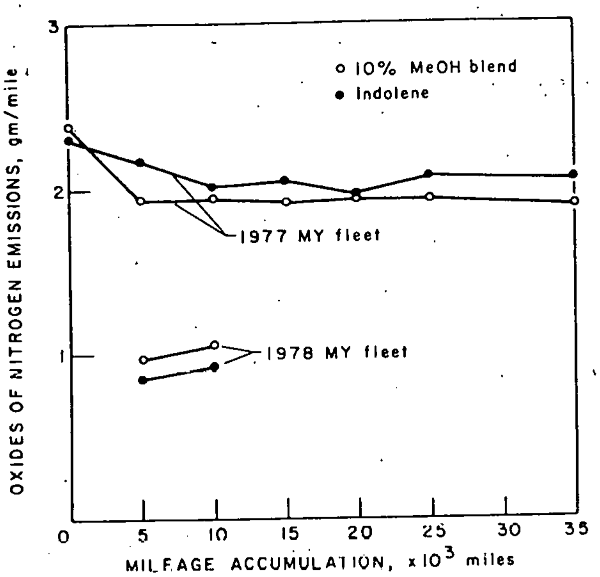

Fig. 3. - Oxides of Nitrogen Emission Rates from the 1975-78 FTP Cycle, 1977 and 1978 MY Vehicles

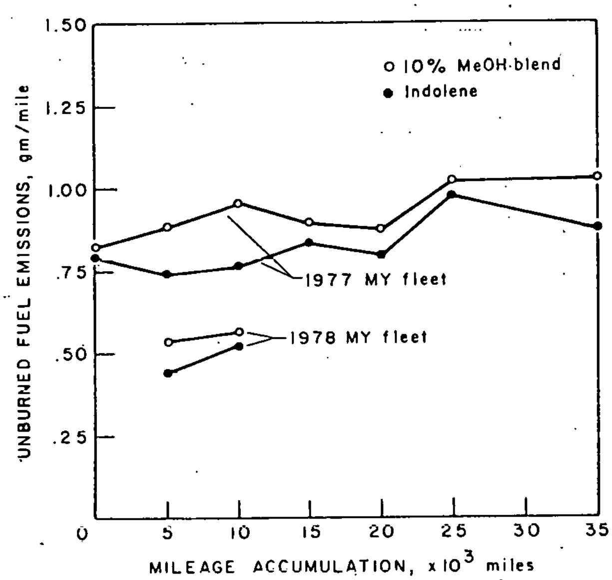

Fig. 4. - Unburned Fuel Emission Rates from the 1975-78 FTP Cycle, 1977 and 1978 MY Vehicles

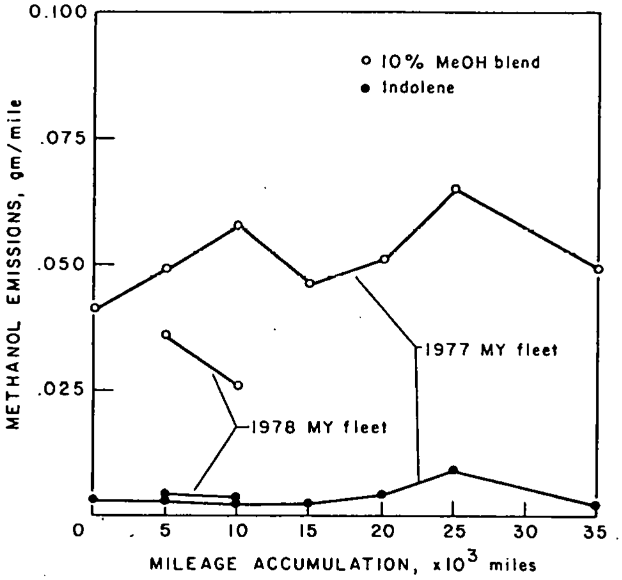

Fig. 5. - Methanol Emission Rates from the 1975-78 FTP Cycle, 1977 and 1978 MY Vehicles

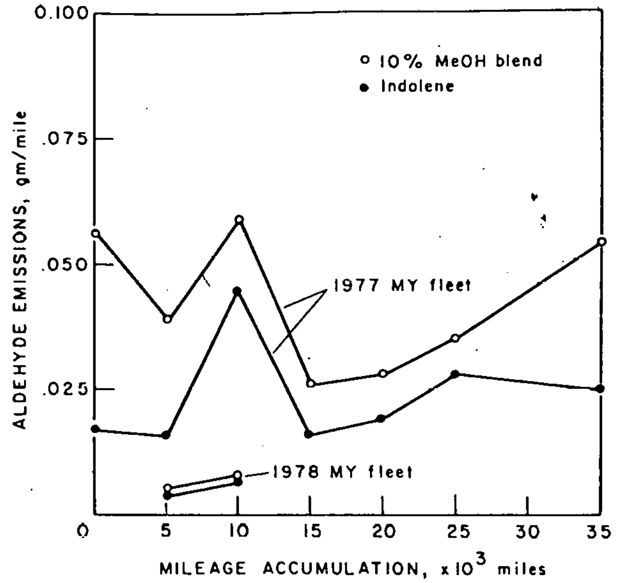

Fig. 6. - Aldehyde Emission Rates from 1977 and 1978 MY Vehicles Operated over the 1975-78 FTP Cycle

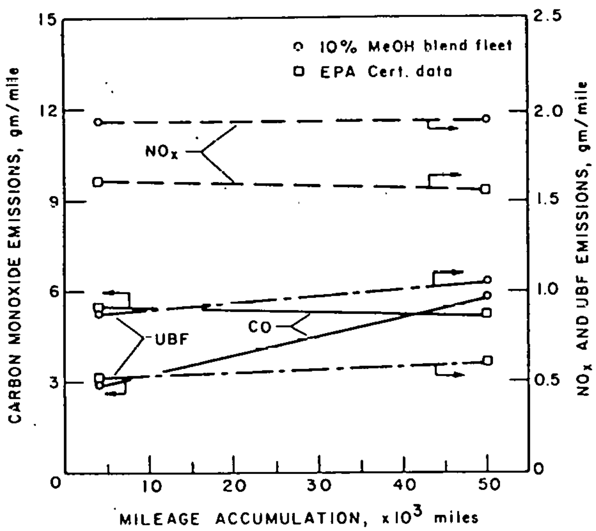

Fig. 7. - Comparison of Deterioration Factors Projected from 1977 MY Vehicles Operating on 10% Methanol Blend and from Certification Tests (References 6 and 8)

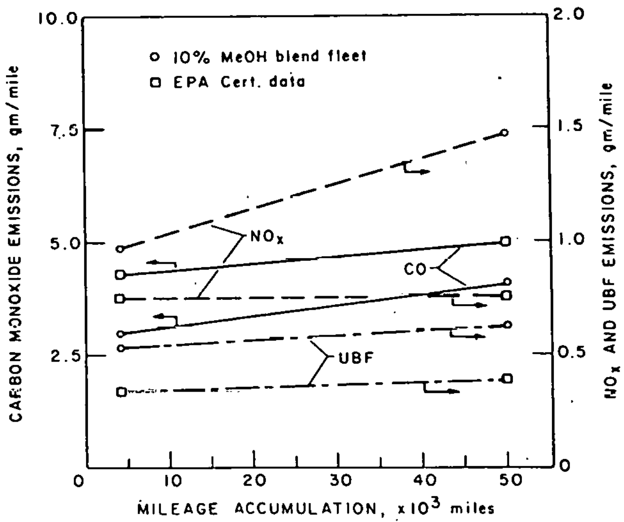

Fig. 8. - Comparison of Deterioration Factors Projected from 1978 MY Vehicles Operating on 10% Methanol Blend and from Certification Tests (References 7 and 9)

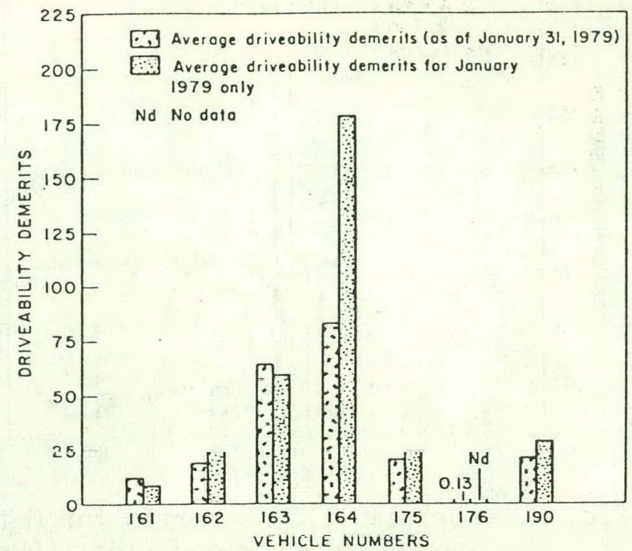

Fig. 9. - Driveability Demerits for Methnol/Gasoline Blend Fleet (Average Demerits for All Runs and Average Demerits for Runs Made in January 1979)

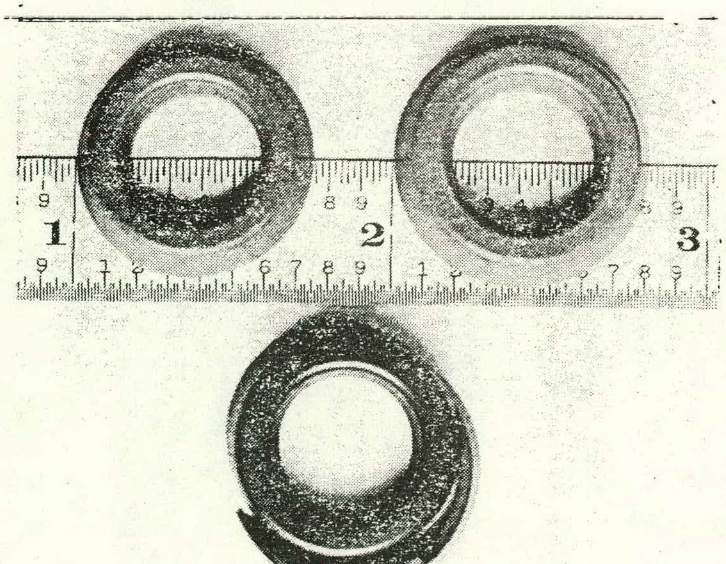

Fig. 10. - Accelerator Pump Cups from Car No. 164

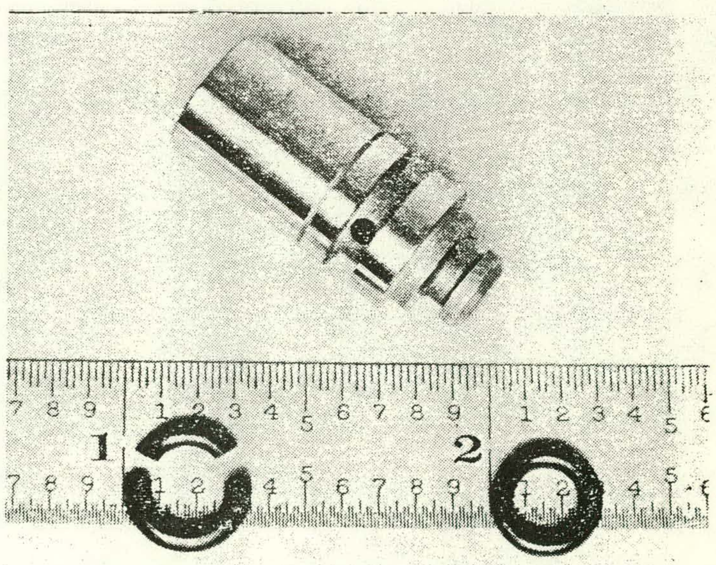

Fig. 11. - Line Pressure Regulator o-Rings from Car No. 176

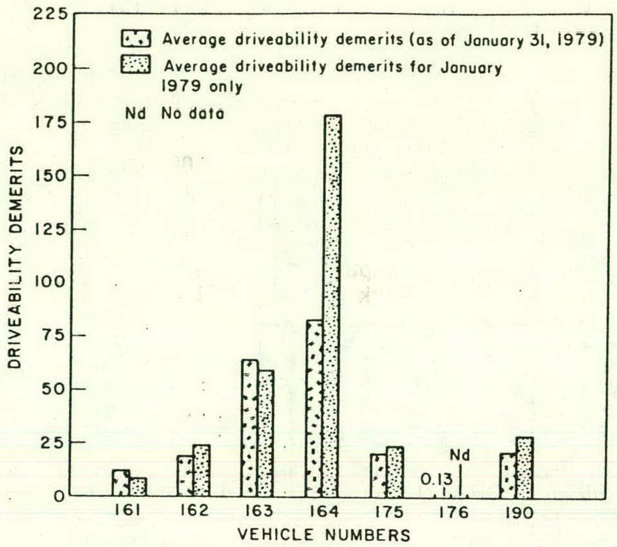

Fig. 9. - Driveability Demerits for Methanol/Gasoline Blend Fleet (Average Demerits for All Runs and Average Demerits for Runs Made in January 1979)

Fig. 10. - Accelerator Pump Cups from Car No. 164

Fig. 11. - Line Pressure Regulator o-Rings from Car No. 176

TABLE 1. - Description of methanol blend fleet

Vehicle #	Vehicle Description	Engine Disp., CID	Carb.	Test I.W., lb
161	1977 Chevrolet Impala	305	2V	4,000
162	1977 Buick Skylark	231	2V	3,500
163	1977 Ford LTD II	302	2V	4,500
164	1977 Plymouth Fury	225	2V	4,000
176	1978 Volvo 242 DL*	130	FI	3,000
175	1978 Ford Pinto*	140	2V	2,750
190	1978 Ford Fairmont	200	1V	3,000

*Vehicles are equipped with 3-way catalytic converters and closed-loop A/F control.

TABLE 2. - Analyses of fuels used in methanol fleet studies

	Indolene #1	Indolene #2	Methanol Blend #1	Methanol Blend #2	Methanol Blend #3	Methanol Blend #4
FIA analysis, %:						
Aromatics	22	28	26	14	14	20
Olefins	11	8	2	9	9	8
Saturates	67	64	72	77	77	72
Distillation, ASTM D86, °F:						
IBP	89	88	102	96	98	92
Pct evaporated:						
5	116	112	114	108	108	102
10	129	126	117	112	112	108
20	155	154	122	118	116	116
30	182	181	128	124	123	124
40	206	208	148	131	129	129
50	225	233	203	187	189	130
60	243	256	224	207	210	215
70	265	282	228	224	226	236
80	294	309	256	244	246	264
90	338	346	300	292	296	313
95	376	380	362	351	350	355
EP	411	418	371	404	398	394
Specific gravity	0.734	0.749	0.736	0.728	0.730	0.730
Equivalent Reid vapor pressure psi*	10.1	9.5	10.6	12.2	11.7	13.2

Note: Fuel numbers 1, 2, 3, and 4 indicate the chronological order in which the fuels were used. Thus far into the program two batches of Indolene and four batches of the methanol blend have been used in the fleet operation and testing.

*Reid vapor pressure from micro vapor pressure test.

TABLE 3. - Deterioration factors and projected emission levels

Vehicle #	Projected emissions levels, gm/mile*: 4,000 Miles	Projected emissions levels, gm/mile*: 50,000 Miles	Deterioration factor from MeOH fleet	Projected emission levels, gm/mile from Ref. 8 and 9: 4,000 Miles	Projected emission levels, gm/mile from Ref. 8 and 9: 50,000 Miles	Deterioration factor from Ref. 6 and 7
Car 161:						
CO........	5.12	5.57	1.089	3.3	1.50	.455
HC........	.71	.99	1.395	.35	.30	.871
NO_X.......	1.78	1.74	.978	1.63	1.38	.845
Car 162:						
CO........	1.93	8.66	4.483	3.7	5.32	1.440
HC........	.41	1.09	2.690	.35	.65	1.853
NO_X.......	1.47	1.79	1.220	1.76	1.81	1.028
Car 163:						
CO........	1.26	2.57	2.04	6.1	5.03	.824
HC........	1.50	1.16	.776	.68	.79	1.168
NO_X.......	2.38	2.47	1.037	1.70	1.55	.912
Car 164:						
CO........	3.40	6.47	1.902	8.7	9.03	1.038
HC........	.89	.96	1.078	.69	.69	1.005
NO_X.......	2.08	1.72	.826	1.33	1.45	1.092
1977 Fleet average:						
CO........	2.93	5.82		5.45	5.22	
HC........	.08	1.05		.52	.61	
NO_X......	1.93	1.93		1.61	1.55	
Car 175:						
CO.......	4.50	6.89	1.532	2.4	2.81	1.171
HC.......	.40	1.08	2.769	.17	.18	1.060
NO_X......	.69	1.38	1.996	.75	.85	1.134
Car 176:						
CO.......	1.70	1.15	.676	6.9	6.18	.896
HC.......	.17	.08	.465	.49	.40	.824
NO_X......	1.07	2.73	2.542	.22	.25	1.138
Car 190:						
CO.......	2.63	4.20	1.594	3.5	4.96	1.418
HC.......	1.04	.72	.690	.34	.46	1.347
NO_X......	1.14	.31	.270	1.27	1.26	.990
1978 Fleet average:						
CO.......	2.94	4.08		4.27	4.98	
HC.......	.53	.63		.33	.35	
NO_X......	.97	1.47		.75	.79	

*The emission levels are projected from a least squares linear regression of 1975-78 FTP test results from vehicles operating on the 10% methanol blend.

TABLE 4. - Driveability demerit system

Phase of operation	Malfunction	Demerit value	Weighting factor: Frequency over the cycle No.: 1 - 3	Weighting factor: Frequency over the cycle No.: over 3	Weighting factor: Starting time, seconds: 0 - 2	Weighting factor: Starting time, seconds: 2 - 10	Weighting factor: Starting time, seconds: over 10	Weighted Demerit*
Cold-start	Starting time	1	-	-	0	6	11	
	Stall	20	2	4	-	-	-	
Fully-warmed operation	Stall	32	2	4	-	-	-	
	Hesitation	6	2	4	-	-	-	
	Surge	4	2	4	-	-	-	
Hot-start	Starting time	1	-	-	0	6	11	
	Stall	32	2	4	-	-	-	

Total demerits = Σ of Weighted Demerits = ______

*The weighted demerits are computed by multiplying the demerit value by the appropriate weighting factor.