Report

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COMPARISON OF FUEL ECONOMY AND EMISSIONS FOR DIESEL AND GASOLINE POWERED TAXICABS

by

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16. Abstract

Sixty-six diesel powered taxicabs and an equal number of gasoline powered cabs were operated for 120,000 miles each in three taxicab fleets in New York City. Identical cabs were powered with either 198 CID diesel engines or 225 CID gasoline engines. Test results from all cabs were used to determine fuel economy and exhaust emissions. On the road, the diesel cabs had 50 percent better fuel economy than the gasoline cabs; the diesel exhaust emissions (HC, CO, NO_x) were lower than the gasoline exhaust emissions over the life of the test. Emission from the diesels did not appreciably degrade with vehicle age; emission from the gasoline cabs increased appreciably.

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PREFACE

In 1975, the Metropolitan Taxicabs Board of Trade, an association of taxicab companies in New York City, installed a 100 HP diesel engine in a Chrysler taxicab in order to evaluate the operating characteristics of a diesel powered, full-size cab. Results showed a doubling of the fuel economy and much lower hydrocarbon and carbon monoxide emissions when compared to the gasoline powered cab. In 1976, in order to further evaluate the operational characteristics of diesel taxis, the DOT Urban Mass Transportation Administration, Office of Bus and Paratransit Technology, in conjunction with the Office of the Secretary of Transportation, requested the DOT's Transportation Systems Center to carry out a field test of a statistically significant number of diesel taxicabs. The objective of the field test was to assess the impact of dieselization of taxis on fuel economy and emissions in a large metropolitan area.

This report was prepared by the Office of Energy and Environment of the Transportation Systems Center for the Urban Mass Transportation Administration. It describes road and laboratory tests and presents the results obtained.

The author wishes to acknowledge the assistance and guidance of the following: William Raithel, Richard Strombotne, Philip Morgan, and John Ridgley.

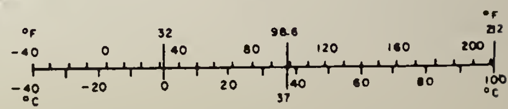
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	squsre centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	squsre meters	m^2
mi^2	squars milss	2.6	squsre kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilogrsms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablsspoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	querts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inchss	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	milss	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	scres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1. INTRODUCTION

The objective of the study was to assess potential improvements in fuel economy and exhaust emissions by dieselization of the taxi fleet in a large urban area. Pace Project Inc., Bronx, N.Y., was selected to carry out road and laboratory tests using 66 diesel cabs with 66 gasoline cabs as controls. All cabs were Dodge Coronets with the same accessories and no air conditioning. The gasoline-fueled cabs were powered with the Chrysler slant 6-cylinder, 225 CID engine. The diesel-fueled cabs were retrofitted by Vehicle Technology Inc., with the Chrysler-Nissan 6 cylinder CN633, 198 CID engine. These engines met the requirements that the cabs were to be powered by engines of six cylinders or more with displacements greater than 183 CID and that the diesel cabs were to use a drive train that had been tested in taxicab service for a minimum of 10,000 miles.

Specifically, the goal of the test was to collect fuel economy and emissions data from all 132 taxicabs operated in revenue service for 120,000 miles. The 66 taxicab pairs were divided into three groups: a group of 26 pairs operated in the Bronx, a group of 20 pairs operated in Woodside and a group of 20 pairs operated in Long Island City. In each case, the group tested was part of a larger number of taxis (at least 80) being run in general revenue service, and the test cabs were dispatched and run in the same manner as the rest of the taxis. The test period covered approximately three years and ended in April 1979.

This report describes the test procedure and results obtained. Details of the taxis used, the test plan, data analysis and results are given in the following Section. Details on the extensive test data available on magnetic tape are given in the Appendix.

2. TEST PROCEDURE AND RESULTS

2.1 OBJECTIVES AND IMPLEMENTATION

The objectives of the program were to compare fuel economy and emissions of full-sized diesel vehicles with full-sized gasoline vehicles, having an operating performance acceptable for use as taxicabs in New York City. On-road records of fuel usage were obtained for normal operating shifts in fleet service; laboratory measurements on fuel economy and emissions by the Federal Test Procedure were obtained for a selected group of cabs from the fleet. To meet these objectives, the contractor was required to operate 132 cabs (66 diesel-powered and 66 gasoline-powered), for a service life of 120,000 miles. The cabs were alike in outward appearance and were not visibly identified as cabs participating in the fleet test.

Figure 1 shows the introduction schedule of the gasoline and diesel cabs into the fleet. All the cabs experienced the same type of service during the test period. Data which was submitted on punched cards and magnetic tape to TSC on a regular basis for analysis included the miles driven, fuel and revenue per shift for each cab. To aid in verification of data and equivalent use of the diesel and gasoline cabs, individual trip cards and copies of maintenance shop orders were also submitted to TSC. Examples and explanation of the data on tape are given in the Appendix. The tapes provide a history of the operation of these fleets which may be of interest to researchers interested in the operation of taxicabs in a large metropolitan area.

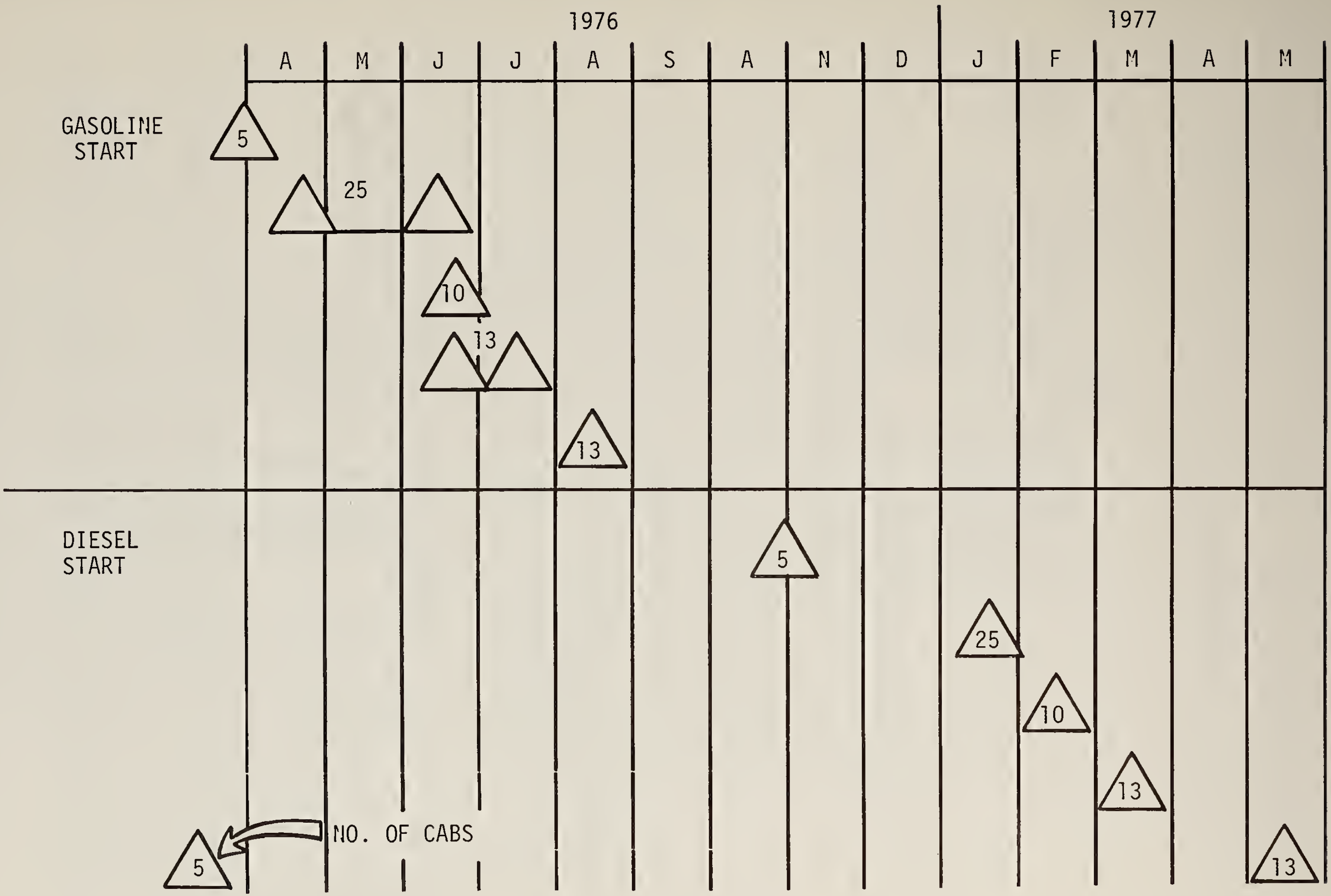


FIGURE 1. INTRODUCTION OF CABS TO ON-ROAD TEST

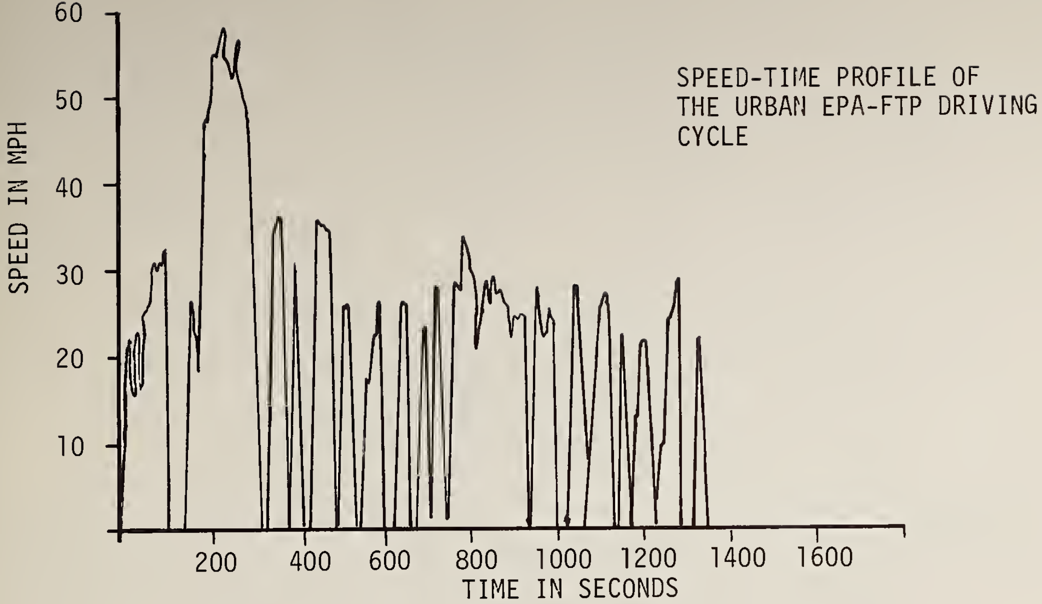
At specific accumulated mileage intervals, laboratory measurements were made on selected cabs of the regulated exhaust emissions, highway and urban fuel economies, and diesel exhaust smoke by the New York City Department of Air Resources, Brooklyn. A total of 80 tests were conducted on 60 cabs. An analysis of the data is discussed in the following subsections.

2.2 TAXICAB DRIVE CYCLE

The taxicabs involved in the test were driven two 10-hour shifts per day, seven days a week. With a 90 percent utilization rate of the vehicles and an average of 110 miles per shift, the cabs averaged approximately 72,000 miles each year. The average speed of the cabs during a shift was 11 miles per hour. Little is known, however, about the specific operating mode of a New York City fleet taxicab. The New York City Department of Air Resources developed a driving cycle based on observed speed distributions of vehicles in congested Manhattan traffic, but it does not truly represent taxicab service since the average speed is only 7.1 miles-per-hour. The EPA Urban Cycle with its average speed of 19.1 miles per hour is also not representative. However, a Modified Urban Cycle for taxicabs can be developed from the EPA cycle by increasing the idle times in the cycle by a factor of five. This modified cycle has an average speed of 10.5 miles per hour, closely approximating the actual 11 mph. The proposed Modified Urban Cycle for cabs and the EPA Urban cycle are shown in Figure 2. Computer simulation using the Modified Urban Cycle results in a gasoline fuel economy very close to the actual measured fuel economy of the gasoline cabs.

2.3 FUEL ECONOMY AND EMISSIONS

Fuel economy of the cabs was determined from the mileage accumulated and the fuel usage per shift. For a selected group of cabs, both fuel economy and emissions were measured in the laboratory at regular mileage intervals over the EPA Urban and



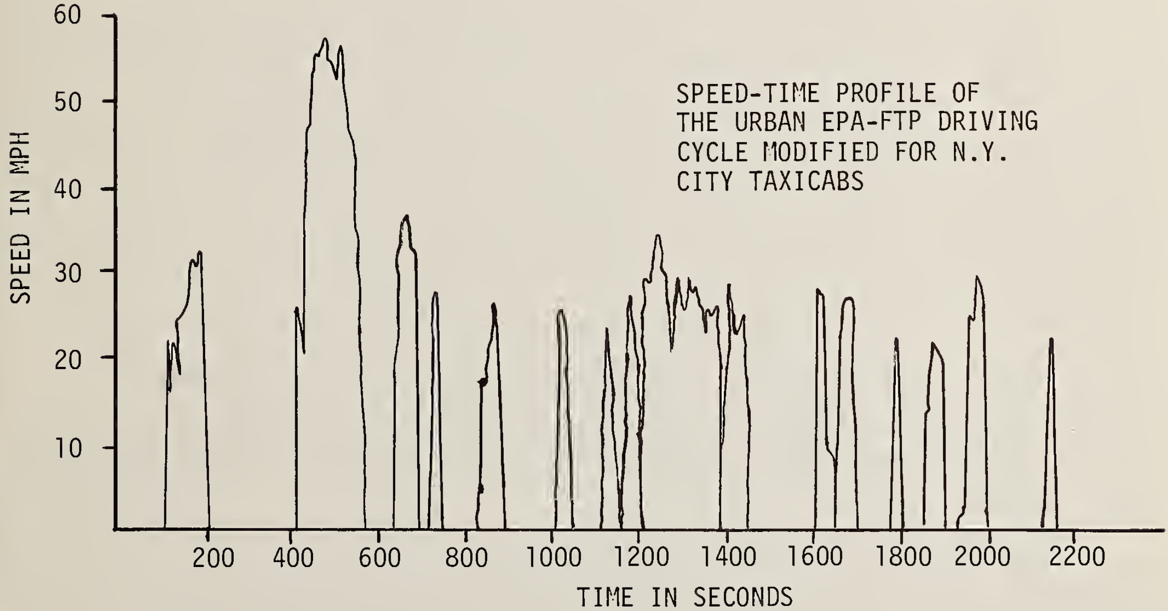


FIGURE 2. DRIVING CYCLES

Highway Cycles by the New York City Department of Air Resources, Brooklyn. A total of 80 tests were made on 60 cabs. Sample data sheets from these tests are shown in Figures 3 and 4, and the cabs involved and their measurements are tabulated in Tables 1 through 3. Measurements were scheduled at specific intervals; however, since vehicles were not always available on schedule, the mileage indicated in the tables is within ± 10,000 miles of stated mileage. Table 1 shows the results of tests on gasoline powered cabs; Table 2 (emissions) and Table 3 (fuel economy and smoke) are for the diesel cabs. The data presented for emissions and fuel economy were derived from dynamometer testing according to the EPA's Federal Test Procedure. For the diesel cabs, smoke (particulates) opacity from the tail pipe was measured during wide open throttle acceleration from 0 to 40 miles per hour on the dynamometer. The smoke meter measured the optical transmission of the exhaust stream: the percent transmission subtracted from 100 percent yields the opacity of the exhaust stream.

The three fuel economies, on-road service, dynamometer tests, and computer simulations of the Modified Urban cycle, are shown in Figure 5. The actual mean on-road fuel economy varies by 5 to 10 percent among the three operator fleets and also shows a seasonal variation of about the same magnitude. From Figure 5, the Modified Urban Cycle differs from the actual fuel economy for gasoline cabs by approximately 5 percent. The diesel to gasoline fuel economy ratio is 2:1 for the Modified Urban Cycle which is consistent with road tests on prototype cabs by the Metropolitan Taxicab Board of Trade. However, actual on-road service data indicate a ratio of fuel economies of only 1.5. No specific reason for this discrepancy has been identified.

The fleet operating conditions were almost identical for the gasoline and diesel cabs except that in cold weather, the diesels were occasionally started one half hour before the shift start by one of the fleet operators.

Test no. 2760 Date 3/2/78

Vehicle license no. 9886 TD I.D. no. 3R64

Make DODGE Model CORONET Year '76

Special control features Nissan Diesel Engine No. 021879

Test program 54,113

Driver LG Operator(s) ____ Data reduction ____

Test Procedure	Exhaust emissions in grams per mile: 1976 Federal Urban Driving Cycle Composite*	Bag 1	Bag 2	Bag 3	Federal Highway
HC, Hydro-Carbons (Heated FID)	0.33	0.46	0.21	0.45	0.81
CO, Carbon Monoxide	1.28	1.65	1.03	1.48	2.26
CO_2, Carbon Dioxide	362.4				303.9
NO_x, Nitrogen Oxides	2.07	2.03	2.25	1.78	-
			Dilution Factor: 20.4		
Calculated Fuel economy Miles/gallon	28.9				34.1

Remarks: BUTLER-064-TEST 3-REPEAT

$$^*\frac{\text{Bag 1} + 2 \times \text{Bag 2} + \text{Bag 3}}{4}$$

FIGURE 3. SAMPLE OF EMISSIONS TEST RESULTS

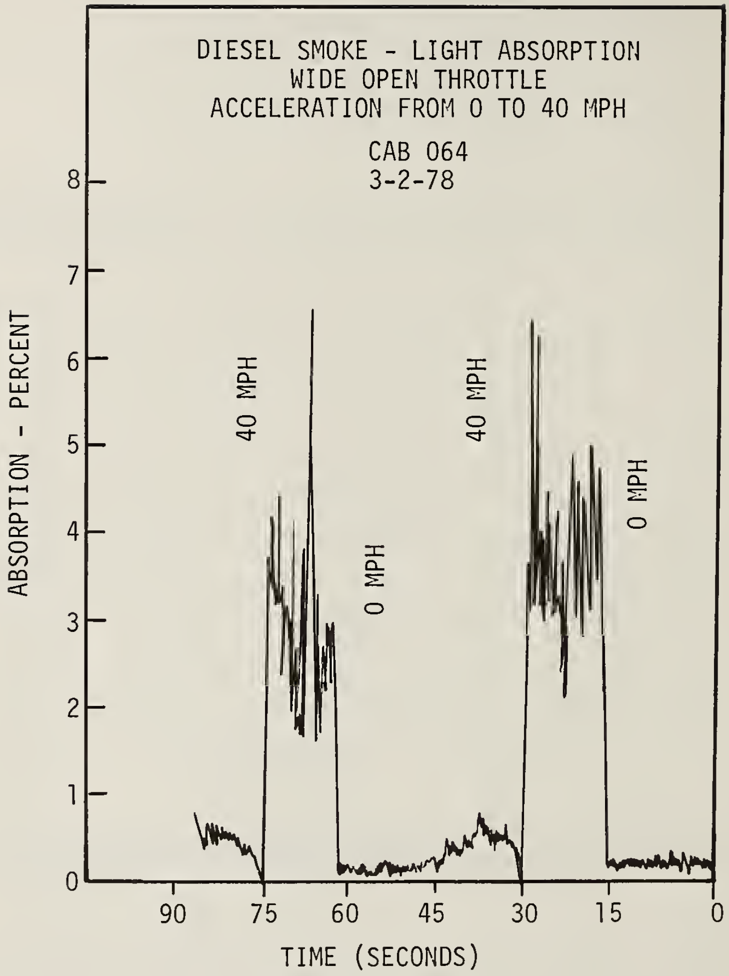


FIGURE 4. SAMPLE OF SMOKE TEST RESULTS

TABLE 1. FUEL ECONOMY AND EMISSIONS, GASOLINE POWERED CABS

CAB NO.	50,000 MILES					80,000 MILES					110,000 MILES					
	HC (GRAMS/MILE)	CO (GRAMS/MILE)	NO_x (GRAMS/MILE)	FE_u MPG	FE_H MPG	HC (GRAMS/MILE)	CO (GRAMS/MILE)	NO_x (GRAMS/MILE)	FE_u MPG	FE_H MPG	HC (GRAMS/MILE)	CO (GRAMS/MILE)	NO_x (GRAMS/MILE)	FE_u MPG	FE_H MPG	
39	3.55	22.36	4.98	16.6	22.9	3.32	32.18	7.81	15.6	19.8	4.01	70.38	5.77	14.9	20.0	STALLED
45	1.50	10.05	12.97	16.7	21.4	2.55	15.37	10.05	16.9	22.4	3.16	16.36	6.78	17.4	24.6	
40	3.00	11.66	8.00	17.3	23.3	*3.29	61.52	2.02	12.8	18.7	7.60	22.48	3.54	16.1	24.1	*REBUILT ENG
479	2.01	9.58	5.80	15.4	20.4	2.90	9.50	6.53	16.5	21.3	2.13	7.58	9.00	16.3	21.0	
537	2.34	23.66	8.31	16.5	19.4	*2.42	14.05	9.50	17.0	22.1	* 1.89	7.23	8.91	16.7	20.2	*STALLED
26	1.79	10.40	7.70	18.7	24.9											
801						2.28	22.57	8.78	17.7	23.3						
802											3.88	125.60	1.40	14.9	18.8	
41	* 3.96	32.14	2.45	13.5	21.3											*STALLING
808						1.83	15.86	8.35	17.2	22.2						
803											3.67	39.42	7.66	15.6	23.6	
47	2.40	9.89	3.70	16.1	22.7											
810						2.03	33.67	10.51	16.4	21.6						
820											3.25	43.16	5.67	16.3	21.7	
494	1.47	14.09	13.25	16.5	20.2											
804						4.20	60.40	8.58	15.2	21.9						
462											22.9	5.43	5.91	16.6	22.0	
538	2.01	15.43	3.29	18.0	23.7											
478						2.79	31.12	8.54	16.6	23.6						
535											13.7	6.62	4.95	158	21.8	

FE_u EPA URBAN FUEL ECONOMY

FE_H EPA HIGHWAY FUEL ECONOMY

TABLE 2. EMISSIONS, DIESEL CABS

CAB NO	5,000 MILES			25,000 MILES			50,000 MILES			80,000 MILES			110,000 MILES		
	HC GRAMS/MILE	CO	NO_x	HC GRAMS/MILE	CO	NO_x	HC GRAMS/MILE	CO	NO_x	HC GRAMS/MILE	CO	NO_x	HC	CO	NO_x
65	0.48	1.56	1.90	0.44	1.58	1.99	0.37	1.76	2.16	0.55	2.71	2.20	0.39	1.99	1.99
66	0.49	1.44	1.66	0.53	1.90	1.39	0.50	1.42	1.55	0.61	1.72	1.68	0.89	2.47	1.89
64	0.57	1.79	1.89	0.22	1.28	1.94	0.33	1.28	2.07	1.20	2.94	1.86	1.55	2.68	1.88
576	0.32	1.31	2.07	0.27	1.46	2.11	0.40	2.03	1.74	2.37	5.28	2.83	0.61	1.49	1.99
575	0.37	1.26	1.80	0.48	2.77	2.02	0.40	2.10	2.02	0.77	3.11	2.43	0.78	2.75	2.86
55	0.51	1.60	2.00												
562				0.37	1.40	1.92									
822							0.45	1.56	2.12						
836										0.27	1.20	2.13			
578													0.45	2.46	1.86
70	0.42	1.31	1.95												
834				0.31	1.31	1.98									
830							1.13	2.23	2.23						
837										1.03	4.07	1.76			
62													0.48	2.12	2.21
69	0.56	1.47	2.11												
826				1.63	2.39	1.97									
839							0.58	2.10	1.81						
832										1.09	2.16	2.43			
564													0.54	2.89	5.74
67	0.47	1.40	1.76												
825				0.31	1.21	1.54									
823							0.84	2.02	2.06						
572										0.49	1.75	1.70			
573													0.46	2.61	2.18
68	0.62	1.68	2.00												
829				0.27	1.38	2.09									
567							0.52	1.56	1.78						
833										0.40	1.31	1.85			
559													0.43	1.58	3.87

TABLE 3. FUEL ECONOMY AND SMOKE, DIESEL CABS

CAB NO	5,000 MILES			25,000 MILES			50,000 MILES			80,000 MILES			110,000 MILES		
	FE_u MPG	FE_H MPG	SM_k %A	FE_u MPG	FE_H MPG	SM_k %A	FE_u MPG	FE_H MPG	SM_k %A	FE_u MPG	FE_H MPG	SM_k %A	FE_u MPG	FE_H MPG	SM_k %A
65	26.2	31.2	2.0	25.5	31.6	5.0	22.9	30.0	7.5	23.7	30.5	14.5	23.6	31.3	8.5
66	26.2	30.9	0.5	25.2	30.7	5.0	26.9	33.6	2.0	25.0	30.9	5.0	23.2	28.6	7.5
64	26.1	31.9	0†	25.1	32.1	7.0	28.9	34.1	4.5	26.1	31.3	4.0	22.2	28.9	7.0
576	25.8	30.2	—*	22.8	31.3	2.0	26.5	32.2	9.5	31.9	29.4	9.5	25.8	32.8	2.5
575	28.0	31.8	—	24.6	32.0	8.0	24.9	29.3	10.5	23.2	28.7	11.5	23.7	30.3	10.0
55	26.2	31.0	0												
562				25.5	31.4	0									
822							23.6	28.4	0.5						
836										25.9	31.6	0.5			
578													23.8	29.9	7.5
70	28.4	33.9	0												
834				27.5	32.9	0.5									
830							25.6	31.5	0.5						
837										24.8	29.7	12.5			
62													25.8	33.2	9.0
69	25.9	—	0												
826				23.8	28.0	0									
839							24.8	28.8	0.5						
832										23.3	29.1	10.0			
564													23.5	30.4	15.5
67	28.3	32.9	0												
825				30.7	33.8	0.5									
823							23.2	—	0						
572										26.1	31.3	5.5			
573													26.1	33.6	13.5
68	22.9	32.4	0												
829				22.8	26.0	0									
567							27.3	33.2	2.5						
833										28.9	32.8	0.5			
559													24.9	32.3	1.5

* — indicates measurement not taken

† 0 indicates Zero % absorption

FE_u - EPA URBAN FUEL ECONOMY

FE_H - EPA HIGHWAY FUEL ECONOMY

SMK - SMOKE (PERCENT ABSORPTION OF LIGHT)

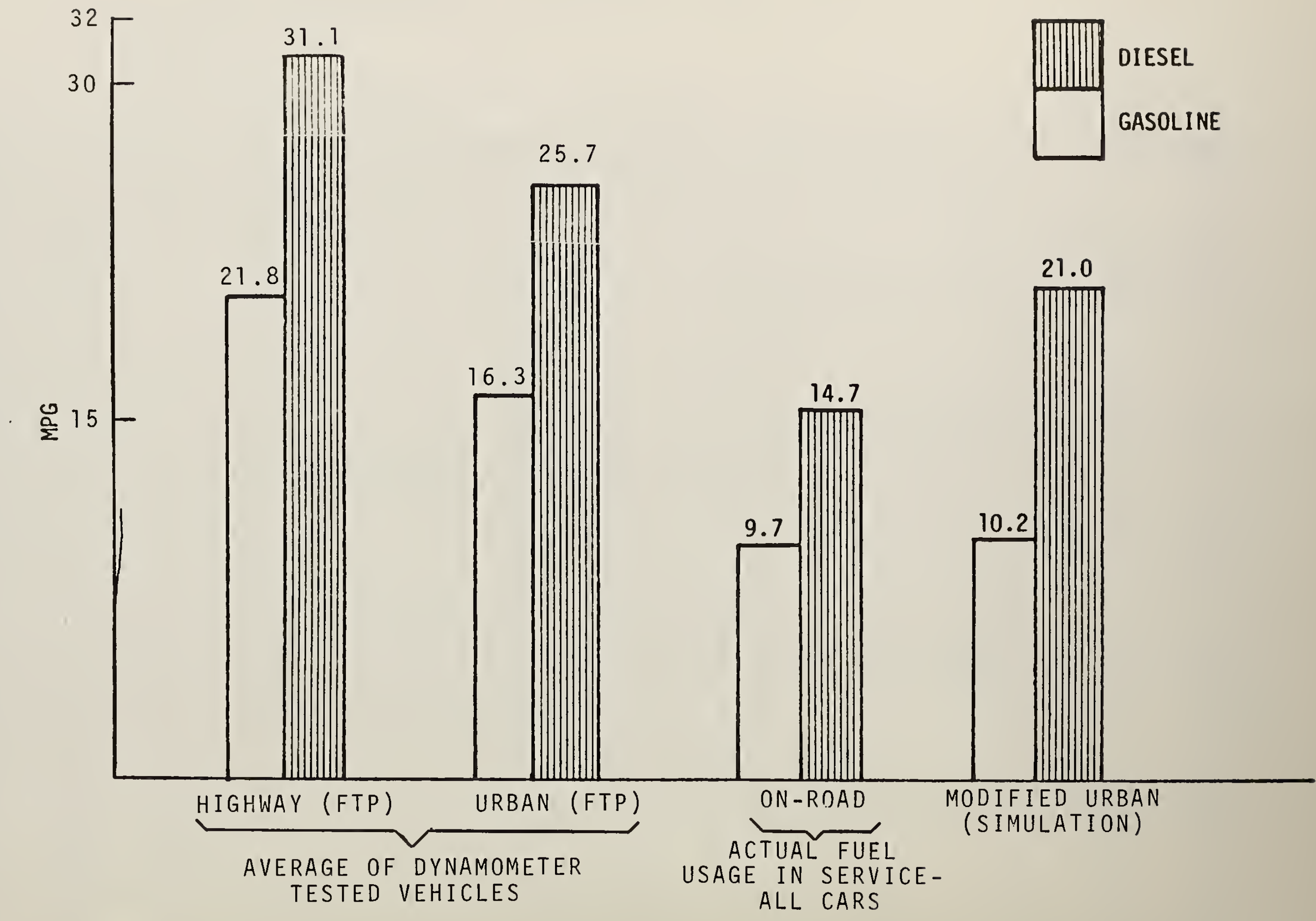


FIGURE 5. COMPARATIVE FUEL ECONOMY AS A FUNCTION OF DRIVING CYCLE

The EPA Urban Fuel Economy is shown in Figure 6 as a function of the mileage accumulated by the cabs tested by the New York City Department of Air Resources. The points are shown with a band of ± one standard deviation. The figure indicates a slight decrease of fuel economy with vehicle age, but when the error band is considered, this trend is uncertain.

The FTP exhaust emissions measured included hydrocarbons (HC), carbon monoxide (CO) and nitrogen oxides (NO_x). In addition, the diesel cabs were measured for smoke opacity. Tests were made on diesel cabs at 5,000, 25,000, 50,000, 80,000 and 110,000 miles; the gasoline cabs were tested at 50,000, 80,000 and 110,000 miles. (The initial study plan did not include laboratory tests; these commenced at the end of 1976 when the gasoline cabs had already accumulated about 50,000 miles.)

The results of the regulated exhaust emission tests of the vehicles at specific mileage intervals are summarized in Figures 7, 8, 9. (The 5000-miles points for gasoline cabs are assumed to be those obtained by the EPA for the Dodge Coronet.) It is seen that the level of regulated emissions (HC, CO, NO_x) increased with the age of the cabs. Since the starting levels were higher and the rates of increase were greater for the gasoline engine exhaust emissions, the average emission levels over the life of the cabs were three to six times higher for gasoline cabs than for diesels. Over the 120,000 mile test, the average diesel cab emitted approximately 1000 lbs. less NO_x, 6000 lbs. less CO and 600 lbs. less HC than the gasoline cab. These lower emissions from the diesel were obtained without any special emission control systems. The gasoline cabs on the other hand, were equipped with exhaust gas recirculation (EGR) and catalytic converters. The opacity of the diesel exhaust stream as a function of the vehicles' accumulated mileage is shown in Figure 10. At present, there are no regulations pertaining to particulate emissions in diesel exhaust. EPA standards are, however, being proposed for the 1981 model year vehicles. It is generally agreed that opacities of the exhaust stream of 5 percent or less

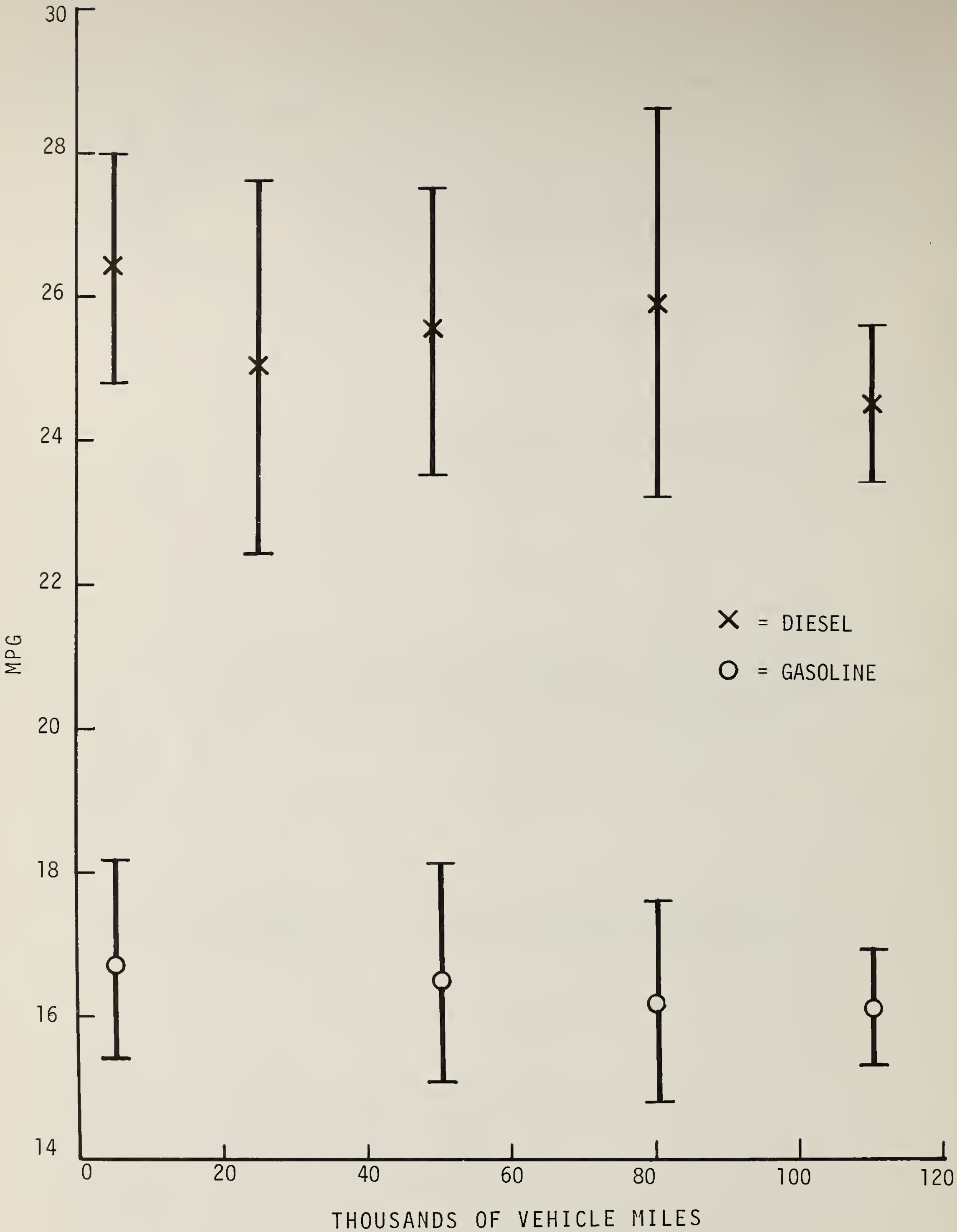


FIGURE 6. EPA FEDERAL TEST PROCEDURE (FTP) URBAN FUEL ECONOMY MEASURED DURING EMISSIONS TESTS

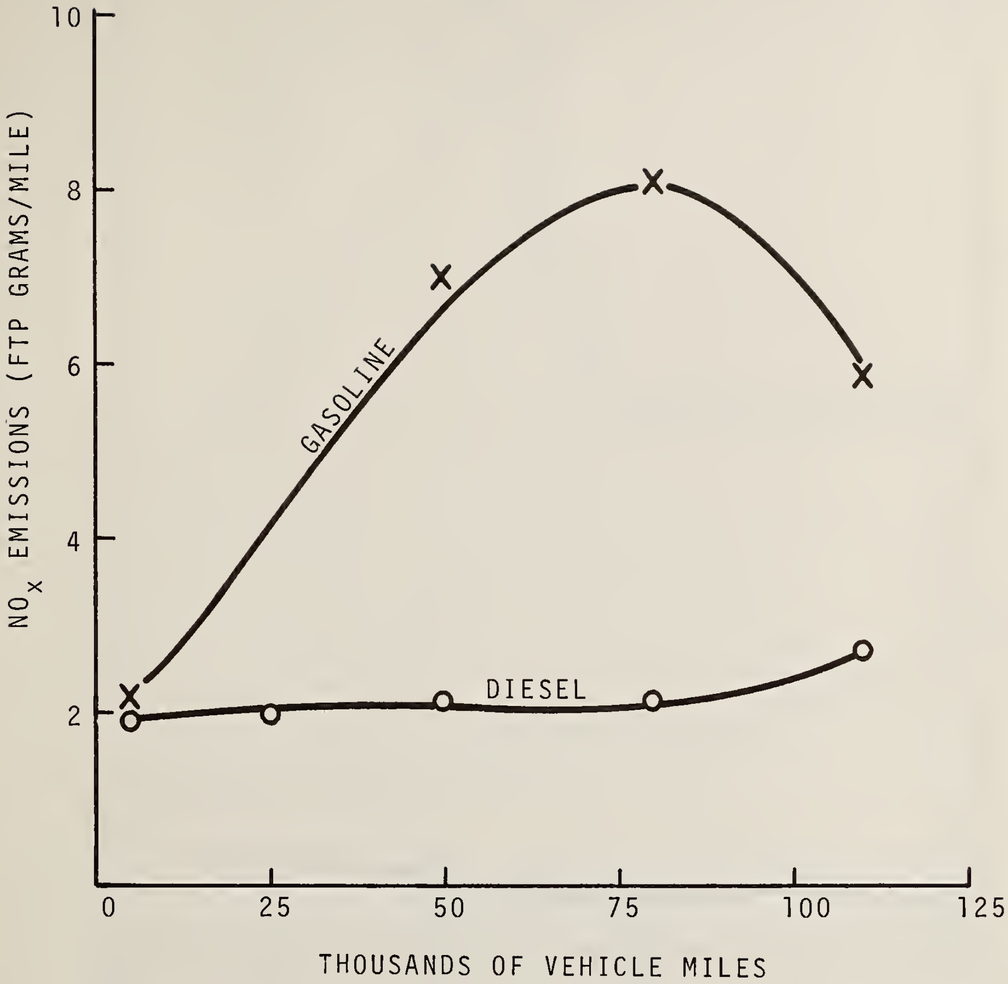


FIGURE 7. NITROGEN OXIDES (NO_X) EMISSIONS

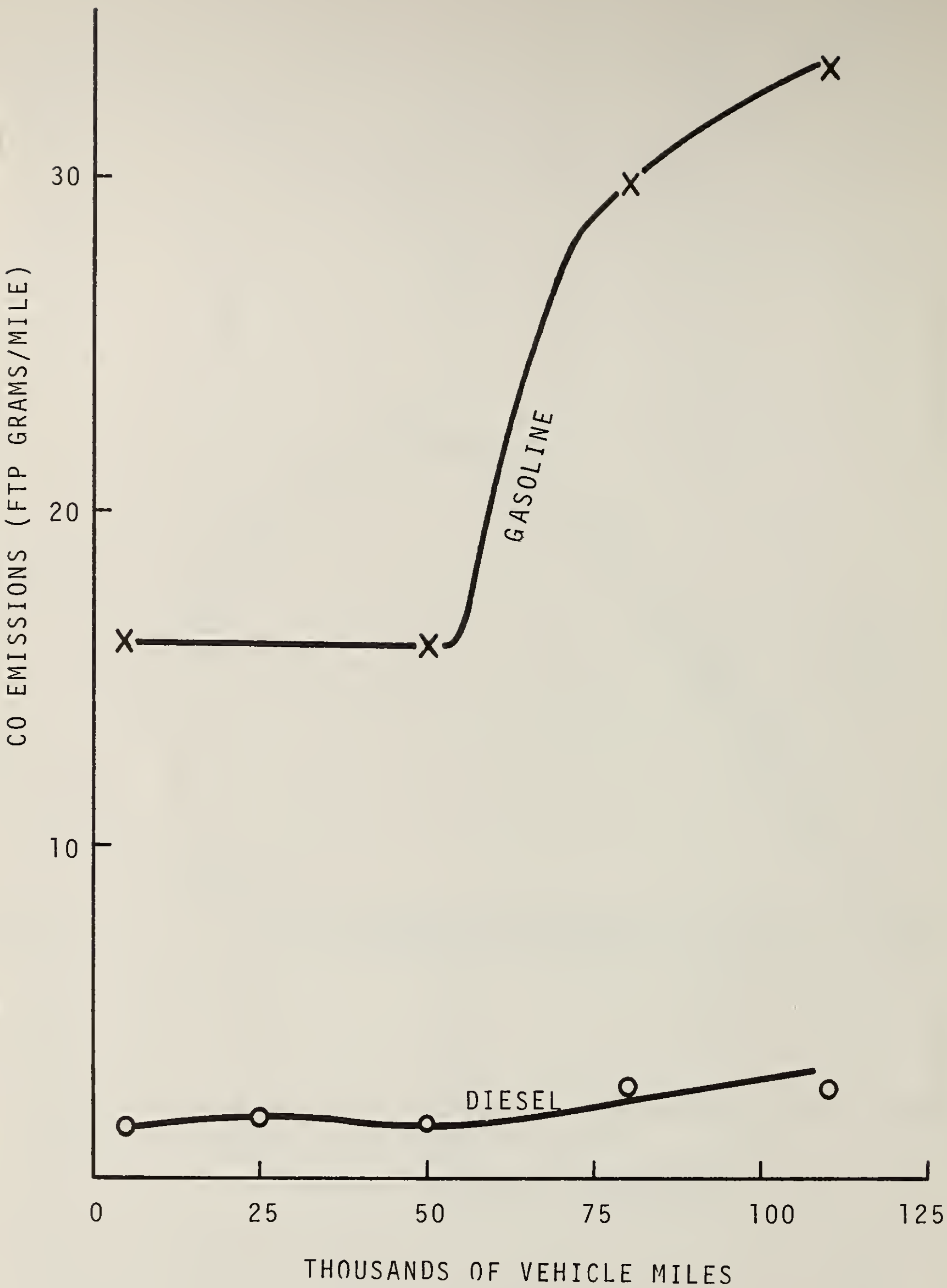


FIGURE 8. CARBON MONOXIDE (CO) EMISSIONS

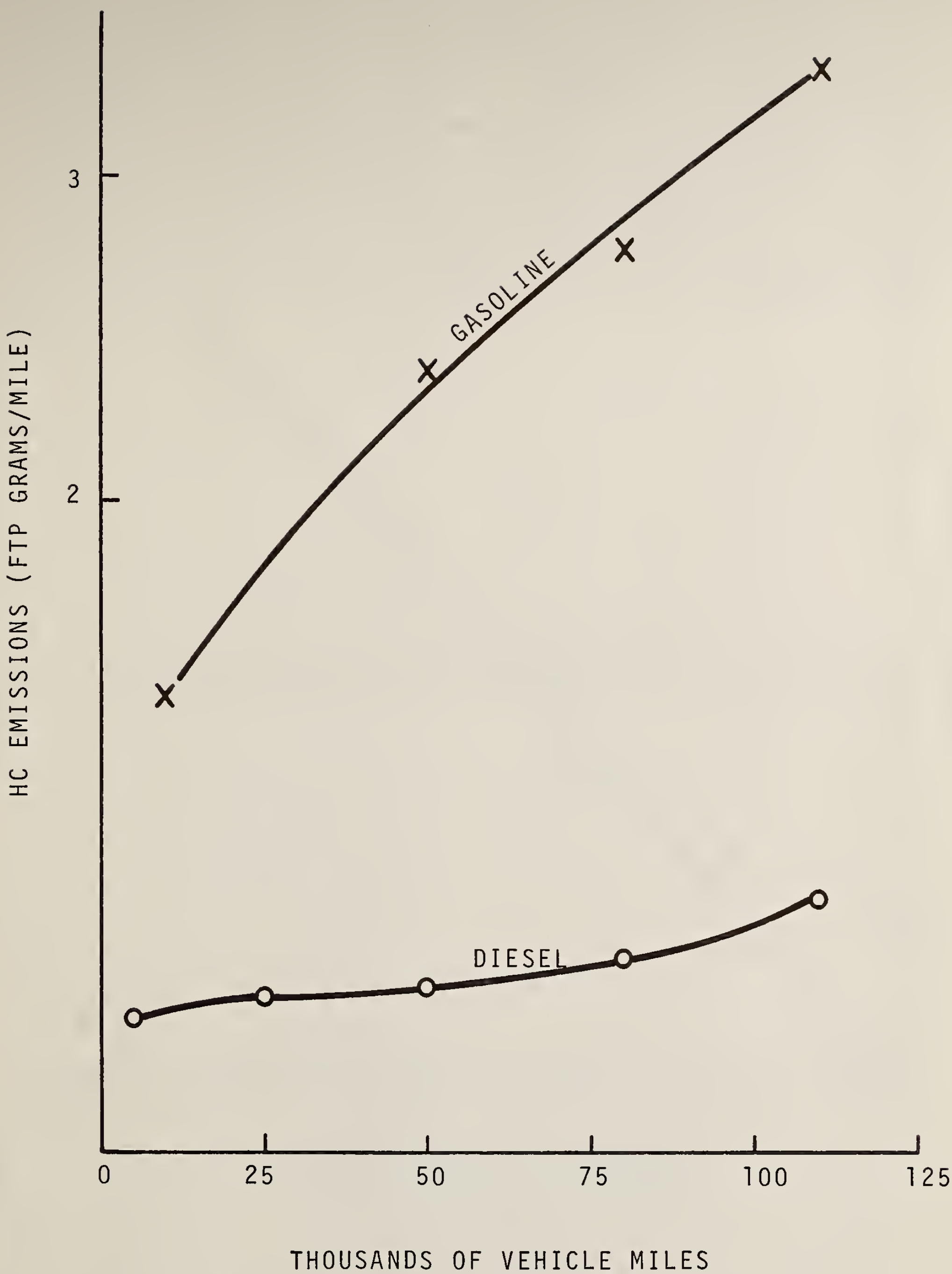


FIGURE 9. HYDROCARBON (HC) EMISSIONS

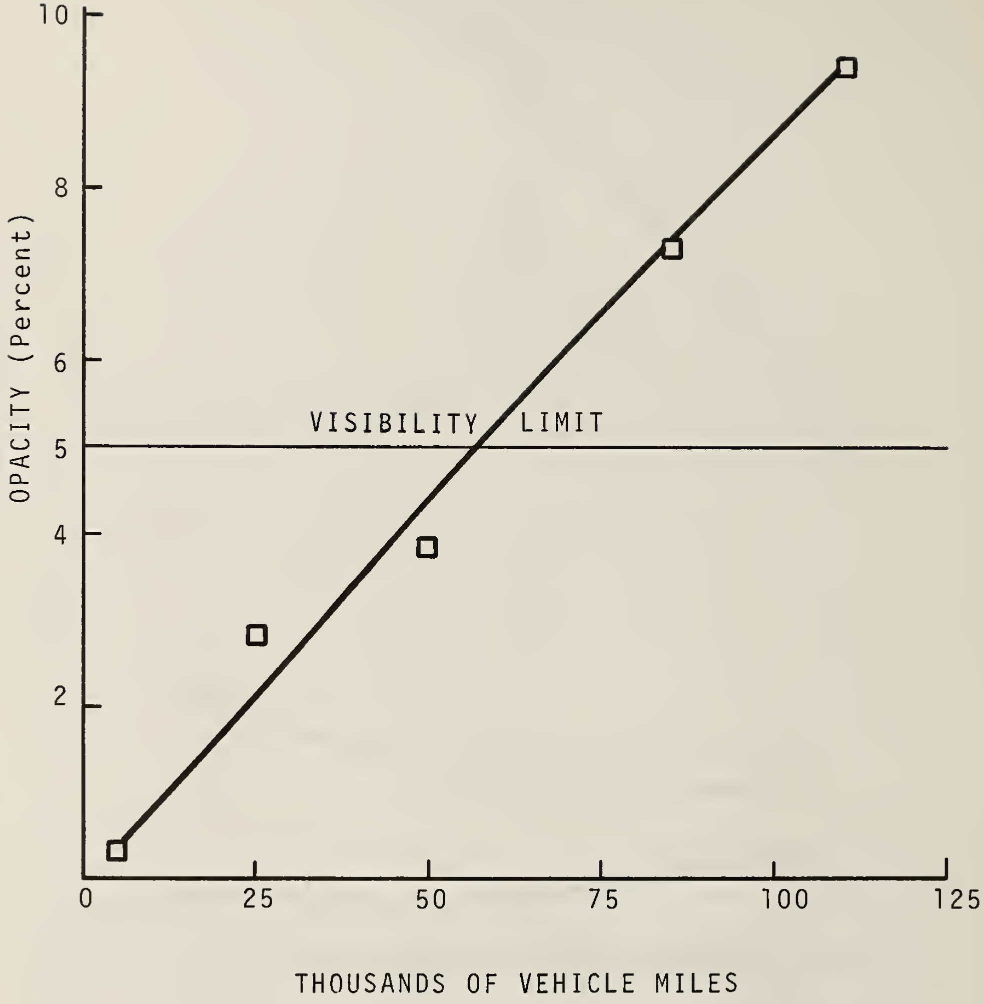


FIGURE 10. SMOKE OPACITY

are invisible under the best viewing conditions by the average observer; levels between 5 and 10 percent are visible but not generally detected by the observer. The exhaust smoke opacity increased steadily over the 120,000 mile test to a level of approximately 10 percent opacity. Smoking by diesel engines which have a very low design smoke level is ususlly caused by improper fuel system adjustments or worn fuel nozzles. Since the adjustments were sealed to prevent tampering, it is probable that the smoke increase was caused by worn nozzles. A detailed examination of the nozzles, however, was not included in the study plan.

3. CONCLUSIONS

The study of the performance of diesel taxicabs in fleet operations was successful in meeting the project objective of gathering fuel economy and emissions data which could be used to assess the impact of the partial or complete dieselization of the taxi fleet in a large metropolitan area. Some uncertainty results from the use of a single model diesel cab and its comparison to a single model gasoline cab; this was accepted in the study concept. The following conclusions can be drawn from the study:

1. The diesel taxicab fleet showed a 50 percent improvement in fuel economy relative to the gasoline fleet.
2. The exhaust emissions of the diesel fleet were lower and remained lower than those of the gasoline fleet over the 120,000 mile test. Measured Diesel particulates from the cabs were at a low level as indicated by opacity readings of the exhaust stream.

APPENDIX

STRUCTURE OF MAGNETIC TAPE RECORDS

The data collected in this study is available on magnetic tape. The data has a record length of 34 bytes, is EBCDIC coded with 24 record blocking, 800 BPI density and 9 tracks. The records are sequential with the hierarchy of year, month, car, day and shift. A sample block is shown in Table A1.

The integer string comprising a record is interpreted with the Fortran format I1, 3I2, 2I1, 5I3, 2I5. The order of the individual data variables is: company ID, month, day, year, shift, fuel type, car number, trips during the shift, units during the shift, miles traveled, fuel used, fares collected, and driver ID. The company ID is a dummy variable with a range of 1 to 3. The day and month are self-explanatory. The year has the range 76 through 79. The fuel type is a dummy variable with 0 for gasoline and 1 for diesel. The fuel type is redundant with car number since the fuel type is specific for car number and was generated from it. The car numbers range from 1 through 132.

Trips during the shift were measured by a meter which is incremented by 1 digit each time the flag was lowered on the meter. The units are also read from the meter and are the number of fare-increasing milage-increments accumulated during a trip. Miles traveled are in whole miles and are the total miles traveled during the shift, including miles with and without passengers. Fuel added is in tenths of a gallon. Fares are in cents and can be calculated with the proper formula from the trips and units, but were entered explicitly here. The driver identification number is a dummy number used to identify a driver and at the same time assure his anonymity. It is possible that 2 drivers of the estimated 500 involved may have identical dummy numbers. Drivers from Company 1 were not identified as individuals and all have the same dummy ID number.

A sample of monthly data, reformatted and labelled is shown in Table A2. It is possible that records may contain errors in some parameter values since the data were entered manually. The trips, units, revenue and driver ID, however, are very reliable, because this data is used by the taxi fleets to calculate payrolls and is screened for errors internally by the fleet operators. The car, shift, day, month and year have also proven to be accurate even though the internal screening by the fleet operators may not be as well suited for detecting errors. The miles driven and fuel consumed are the least accurate data items as they are used by the fleet operators only for qualitative checks on driver performance.

Whenever the designation 99.9 appears in the printout (indicated by arrows in Tables A1 and A2), it implies that no fuel was added at the end of a shift. In such a case, the fuel economy was calcualted from the fuel added at the end of the subsequent shift and the combined mileage of both shifts. As a check, no values of fuel economy less than 8 mpg and greater than 24 mpg were accepted.

TABLE A1. DATA BLOCK

```
310 17810 41 19308101 95 450589215
310 17820 41 4268612415610010 3683
310 27810 41 27359102120 561564970
310 27820 41 28476115244 686049401
310 37810 41 32458 99138 698064970
310 37820 41 20331 89100 481069061
310 47810 41 13165 43 95 262564970
310 47820 41  6 58 21999 103024317   ←
310 57810 41  4 82 27115 1120 1952
310 57820 41  2 19 13999  34027433
310 67820 41 13864166247 9615 6824
310 77810 41 19230 79122 372564970
310 77820 41  7369 79102 4215 4099
310 87810 41 14405145145 510064970
310 87820 41 22487103138 652065684
310 97810 41 17344105113 471564970
310 97820 41 29525139178 742543592
310107810 41 25368 81 92 555560319
310107820 41 15238 57 87 350589174
310117810 41 36416 98124 686064970
310117820 41 14382 76122 487029436
310127820 41 36573116132 843044564
310137810 41  4 40 18999  70064970   ←
310137820 41 26602177127 797086706
```

TABLE A2. FORMATTED DATA FROM TABLE A1

COMP ID	DATE MO/DAY/YEAR			SHIFT TYPE		CAR	TRIPS	UNITS	MILES	FUEL	REVENUE	DRIVER ID
3	10	1	78	1	0	41	19	308	101	9.5	45.05	89215
3	10	1	78	2	0	41	42	686	124	15.6	100.10	3683
3	10	2	78	1	0	41	27	359	102	12.0	56.15	64970
3	10	2	78	2	0	41	28	476	115	24.4	68.60	49401
3	10	3	78	1	0	41	32	458	99	13.8	69.80	64970
3	10	3	78	2	0	41	20	331	89	10.0	48.10	69061
3	10	4	78	1	0	41	13	165	43	9.5	26.25	64970
3	10	4	78	2	0	41	6	58	21	99.9	10.30	24317
3	10	5	78	1	0	41	4	82	27	11.5	11.20	1952
3	10	5	78	2	0	41	2	19	13	99.9 ←	3.40	27433
3	10	6	78	2	0	41	13	864	166	24.7	96.15	6824
3	10	7	78	1	0	41	19	230	79	12.2	37.25	64970
3	10	7	78	2	0	41	7	369	79	10.2	42.15	4099
3	10	8	78	1	0	41	14	405	145	14.5	51.00	64970
3	10	8	78	2	0	41	22	487	103	13.8	65.20	65684
3	10	9	78	1	0	41	17	344	105	11.3	47.15	64970
3	10	9	78	2	0	41	29	525	139	17.8	74.25	43592
3	10	10	78	1	0	41	25	368	81	9.2	55.55	60319
3	10	10	78	2	0	41	15	238	57	8.7	35.05	89174
3	10	11	78	1	0	41	36	416	98	12.4	68.60	64970
3	10	11	78	2	0	41	14	382	76	12.2	48.70	29436
3	10	12	78	2	0	41	36	573	116	13.2	84.30	44564
3	10	13	78	1	0	41	4	40	18	99.9 ←	7.00	64970
3	10	13	78	2	0	41	26	602	177	12.7	79.70	86706

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