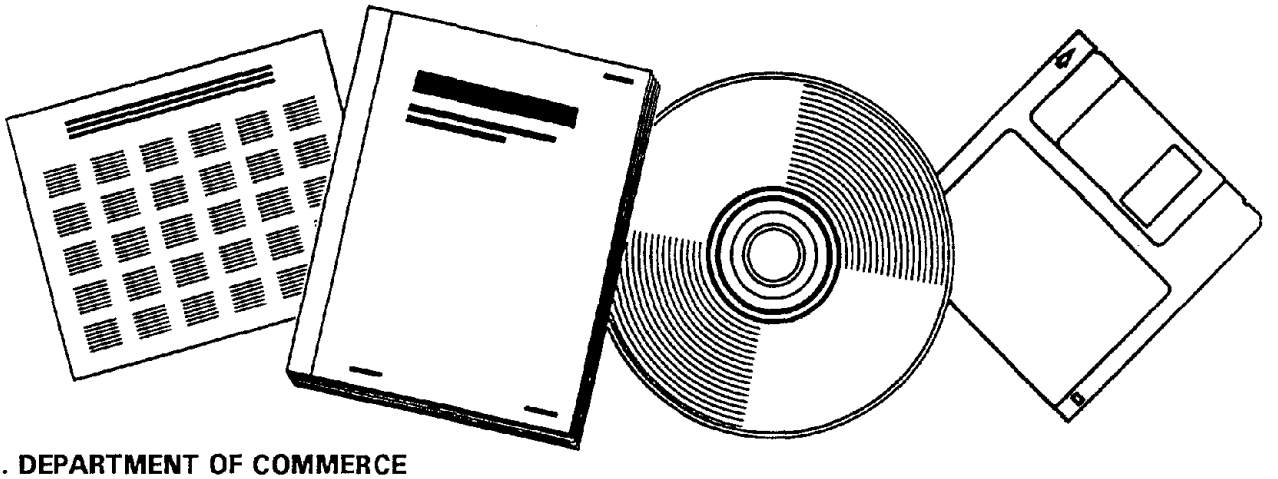
PB97-153795

ESTIMATING EMISSIONS REDUCTIONS FROM VEHICLE RETIREMENT PROGRAMS

(U.S.) JOHN A. VOLPE NATIONAL TRANSPORTATION SYSTEMS CENTER
CAMBRIDGE, MA

FEB 97



U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

FHWA-PD-97-011
DOT-VNTSC-FHWA-97-4

U.S. Department
of Transportation
Federal Highway Administration

Estimating Emissions Reductions from Vehicle Retirement Programs

February 1997
Final Report

SEEING CLEARLY...A Series of Reports on Transportation and Air Quality

Prepared for

Environmental Analysis Division
Office of Environment and Planning
Federal Highway Administration
U.S. Department of Transportation

Prepared by

Service Assessment Division
Office of Research and Analysis
Volpe National Transportation Systems Center
Research and Special Programs Administration
U.S. Department of Transportation

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

PB97-153795

2. REPORT DATE
February 1997

3. REPORT TYPE AND DATES COVERED
Final Report
January 1992 - December 1996

4. TITLE AND SUBTITLE
Estimating Emissions Reductions from Vehicle Retirement Programs

5. FUNDING NUMBERS
HW765/H7040

6. AUTHOR(S)
Elizabeth Deysher, Don Pickrell

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Department of Transportation
Research and Special Programs Administration
John A. Volpe National Transportation Systems Center
Cambridge, MA 02142-1093

8. PERFORMING ORGANIZATION REPORT NUMBER
DOT-VNTSC-FHWA-97-4

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Federal Highway Administration
Environmental Analysis Division
Office of Environment and Planning
400 7th Street, SW
Washington, DC 20590

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
FHWA-PD-97-011

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
This document is available to the public through the National Technical Information Service, Springfield, VA 22161

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Nonattainment areas taking advantage of the Environmental Protection Agency's (EPA's) modified enforcement of the 1990 Clean Air Act (CAAA) mandates for enhanced vehicle inspection and maintenance (I&M) programs, sales of reformulated gasoline (RFG), and transportation planning measures such as the Employee Commute Options (ECO) Program will be required to identify alternative measures to reduce motor vehicle emissions, or achieve reductions from non-transportation sources of emissions. Many of these nonattainment areas have publicly indicated that they are many implement retirement programs for older vehicles to reduce emissions originally expected to result from these other measures.

This final report assesses the effectiveness of vehicle retirement programs in reducing emissions from the motor vehicle fleet, as well as examining the effect of a program's timing on the magnitude of these reductions.

14. SUBJECT TERMS
Clean Air Act, emissions, inspection and maintenance programs, volatile organic compounds (VOCs), MOBILE model

15. NUMBER OF PAGES
24

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

PREFACE

Research for this report was conducted by Beth Deysher and Don Pickrell, both of the Volpe National Transportation Systems Center. The authors are indebted to Robert Waksman of the Volpe National Transportation Systems Center and David Brzezinski of the Environmental Protection Agency for their valuable insights and assistance, and to the Federal Highway Administration and the Environmental Protection Agency for their careful review and insightful comments on earlier versions of the report.

This report is one in a series of publications produced by the Federal Highway Administration of the U.S. Department of Transportation to address important issues in transportation and air quality planning for metropolitan areas. Copies of this and other reports in this series can be ordered by calling 202-366-2069.

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)
1 foot (ft) = 30 centimeters (cm)
1 yard (yd) = 0.9 meter (m)
1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)
1 acre = 0.4 hectare (ha) = 4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gm)
1 pound (lb) = .45 kilogram (kg)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
1 tablespoon (tbsp) = 15 milliliters (ml)
1 fluid ounce (fl oz) = 30 milliliters (ml)
1 cup (c) = 0.24 liter (l)
1 pint (pt) = 0.47 liter (l)
1 quart (qt) = 0.96 liter (l)
1 gallon (gal) = 3.8 liters (l)
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

$°C=5/9(°F - 32)$

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
1 centimeter (cm) = 0.4 inch (in)
1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm) = 0.036 ounce (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

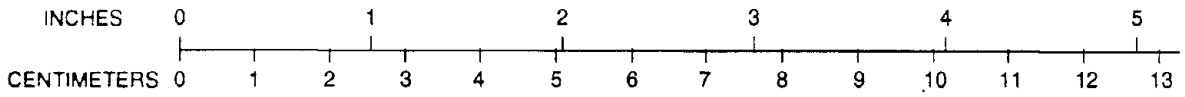
VOLUME (APPROXIMATE)

1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 liter (l) = 2.1 pints (pt)
1 liter (l) = 1.06 quarts (qt)
1 liter (l) = 0.26 gallon (gal)
1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)

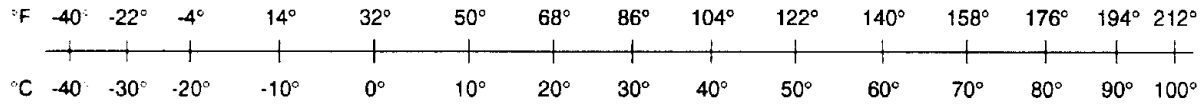
TEMPERATURE (EXACT)

$°F=9/5(°C) + 32$

QUICK INCH-CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT-CELSIUS TEMPERATURE CONVERSION



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50. SD Catalog No. C13 10286.

Updated 8/1/96

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. BACKGROUND

Nonattainment areas taking advantage of the Environmental Protection Agency's (EPA's) relaxed enforcement of the 1990 Clean Air Act (CAAA) mandates for enhanced vehicle inspection and maintenance (I&M) programs, sales of reformulated gasoline (RFG), and transportation planning measures such as the Employee Commute Options (ECO) Program will be required to identify alternative measures to reduce motor vehicle emissions, or achieve reductions from non-transportation sources of emissions. Many of these nonattainment areas have publicly indicated their intention to consider implementing retirement programs for older vehicles to reduce emissions originally expected to result from these other measures.[1]

This report assesses the effectiveness of vehicle retirement programs in reducing emissions from the motor vehicle fleet, as well as examining the effect of a program's timing on the magnitude of these reductions. First, the Eastern Massachusetts nonattainment area serves as an example to demonstrate the potential reductions in volatile organic compounds (VOC) and nitrous oxides (NOx) emissions from retirement of all light-duty vehicles over twenty years old. The assumption that all old vehicles are retired obviously represents an extreme approach to reducing emissions; however, it is meant to test the effectiveness as a policy measure, rather than designing a program specifically for Massachusetts. Second, components of the MOBILE model are examined to assess the model's capability to replicate real-world vehicular emissions.

2. METHODOLOGY

Vehicles eligible for retirement in this study include light-duty gasoline vehicles (LDGV) and light-duty gasoline trucks (LDGT1), collectively referred to as light-duty vehicles (LDVs).

The EPA's MOBILE5a emissions factor model first estimates the VOC and NOx that would be emitted into the air by LDVs in the absence of a retirement program. This baseline is then compared to the emissions that would result from retiring all LDVs over twenty years of age.

[1]Inside EPA's Mobile Source Report.

The analysis is completed for each of the three years 1995, 2000, and 2005. However, these results are not cumulative from one analysis year to the next. For example, the VOC reductions estimated to occur from a program implemented in 2005 are based on the assumption that no program had previously been implemented.

The analysis employs two key assumptions:

- One hundred percent of LDVs over twenty years of age are retired. For example, in the year 2000, all LDVs of model year 1980 and earlier are assumed to be retired. These results can be scaled down to represent retirement of a smaller percentage of 20+ year old vehicles.

- One hundred percent of the vehicles miles travelled (VMT) from the retired vehicles is replaced by travel in the remaining LDVs, and not by other transportation modes, such as transit.

Predicting the exact age distribution of the vehicles that will be used more intensively when the oldest models are retired is impossible. Therefore, three scenarios are used to provide a range of emissions outcomes by simulating different ways in which VMT from retired vehicles might be redistributed throughout the remaining fleet. [2]

Scenario 1: Simulates redistribution of VMT to new vehicles (1 and 2 years old).

Scenario 2: Simulates a proportional redistribution of VMT from retired vehicles to the remaining fleet.[3] For example, if two year old automobiles are expected to account for 10 percent of automobile VMT, that proportion is increased by 10 percent of the VMT that would otherwise have been recorded by vehicles assumed to be retired.

Scenario 3: Simulates redistribution of VMT to the remaining oldest vehicles (19 and 20 years old).

---

[2]VMT redistribution is simulated by redistributing the travel fractions from each age cohort of the retired vehicles (ages 21+) to the remaining vehicles (ages 1-20), creating a new weighted contribution from each of the remaining age cohorts to the base emission rate.

[3]Distributing VMT from retired vehicles proportionately throughout the remaining fleet is the method recommended by the EPA's guidance, "Guidance for the Implementation of Accelerated Retirement of Vehicles Programs," Feb. 1993.

The California Low Emission Vehicle (Cal LEV) program has been included in the MOBILE runs for the years 2000 and 2005 since it has been adopted into Massachusetts legislation to begin in 1998.[4]

Including the California LEV program is not only consistent with existing Massachusetts legislation, but it produces a larger estimate of emissions reductions than with the Federal Tier 1 controls in effect. As a result, the additional driving by the cleanest possible vehicles replaces driving that would have occurred in vehicles assumed to be retired, producing the largest possible benefit.

3. RESULTS

A striking result from this analysis is that large emissions reductions are expected to occur in the absence of a program (table 1), as fleet turnover combined with other federally mandated emission control measures, continues to reduce emissions over time.[5]

Table 1. LDV Emissions Levels with No Retirement Program.

(000's Tons/Year)

	1990	1995	2000	2005
VOC	72	49	24	15
NOx	67	65	46	30

Reductions in LDV emissions resulting from each retirement scenario are shown in table 2. Reductions in fleetwide emissions - including cars, trucks, and motorcycles - that would be gained by implementing a program retiring LDVs are shown in table 3. The fleetwide reductions are smaller because LDVs account for only part of total fleet wide emissions.

---

[4]Even if the LEV program is not implemented by Massachusetts in its current form, it is assumed that a program targeting similar emission standards will be in effect for new vehicles in future years due to the current negotiations between the EPA, the Ozone Transport Commission, and the automobile manufacturers to lower vehicle emission standards of vehicles sold in the Northeast.

[5]These reductions have been generated for the purpose of this analysis and are not claimed as reductions by the Boston nonattainment area in any of the Massachusetts' State Implementation Plan (SIP) filings with the EPA.

Table 2. Light-Duty Vehicle Emission Reductions.[6]

VOC	1995	2000	2005
Scenario 1	4.2%	5.3%	2.4%
Scenario 2	3.9%	4.9%	2.0%
Scenario 3	1.1%	3.7%	0.1%
NOx	**1995**	**2000**	**2005**
Scenario 1	1.8%	2.3%	2.2%
Scenario 2	1.4%	1.8%	1.7%
Scenario 3	0.3%	1.0%	-0.1%

Table 3. Fleetwide Emissions Reductions.[7]

VOC	1995	2000	2005
Scenario 1	3.6%	4.2%	1.7%
Scenario 2	3.4%	3.9%	1.5%
Scenario 3	0.9%	2.9%	0.1%
NOx	**1995**	**2000**	**2005**
Scenario 1	1.3%	1.7%	1.4%
Scenario 2	1.0%	1.3%	1.1%
Scenario 3	0.2%	0.8%	0.0%

Tables 2 and 3 show several notable results:

- For each analysis year, the emissions reductions realized under any of the three redistribution scenarios are small, considering that 100 percent of the eligible vehicles are retired, or about 55,000 of the approximately 3.5 million LDVs in the Boston metropolitan area. By comparison, the most ambitious program to date, implemented by the Unocal Corporation in California, has retired over 8,000 vehicles. Scenario 2 (table 2) shows a 3.9 percent reduction in LDV VOC emissions in 1995. This is equivalent to 1,930 tons, or 5.3 tons/day, which is small compared to the 121 tons/day that mobile sources must meet in the nonattainment area's Rate of Further Progress SIP.

- VOCs are reduced by over two times as much as NOx. This apparently occurs because the VOC emission standards mandated by the Federal Government for new automobiles have been reduced from their pre-controlled levels more than for NOx (95 percent versus 75

[6] Retired LDVs represent 3.1% of the Boston Metropolitan Area's 1992 LDV fleet.
[7] Retired LDVs represent 1.3% of the Boston Metropolitan Area's 1992 fleet (including motorcycles, heavy-duty trucks, etc.).

percent). Another explanation for this difference is that the analysis considers only light-duty gasoline vehicles (primarily emitters of VOCs) for retirement. NOx are emitted primarily by heavy-duty vehicles.

- The size of the reduction varies among the three analysis years more for VOC than for NOx, since the federally mandated VOC standards for new vehicles have been reduced more frequently in the past. Another reason for the difference is that NOx are emitted directly only from the tailpipe, whereas VOCs are emitted from the tailpipe and in the form of evaporative emissions from gas lines and hoses. Exhaust and evaporative emission factors have declined at different points in time, depending on when emission control programs reducing them have been implemented.

- The largest reductions in both VOC and NOx will occur in the year 2000. It is in this year that 1980 vehicles, which had considerably higher emission standards than their immediate successors, are retired. The HC standard for 1980 model year vehicles dropped almost 30 percent, while the NOx standard dropped by 50 percent.

- Distributing VMT proportionately throughout the remaining fleet (Scenario 2) produces emissions reductions that are only slightly smaller than distributing VMT to new vehicles (Scenario 1). Not surprisingly, emissions reductions are much smaller when VMT is redistributed to older vehicles (Scenario 3), because in this scenario there is little difference between the emission rates of retired vehicles and those that replace them.

- Retirement programs implemented in 1995 realize a larger decrease in VOCs than the 2005 program, but the reverse is true for NOx. Again, this reflects the minor differences in the timing and magnitude of historical pattern of changes in federal VOC and NOx emission standards.

These observations lead to the following policy considerations for retirement programs:

- Targeting pre-1980 vehicles for retirement provides the largest emissions reductions due to the large differences in cleanliness between retired and remaining vehicles.

- Retirement programs may not be a viable option for those regions in which NOx is the main contributor to the formation of ozone, since retirement programs appear to reduce VOCs more than NOx.

- It is unlikely that a regional program could retire the large number of vehicles required to attain the reductions shown in this analysis.

- Finally, the emission reductions (2 to 5 percent) are small, considering the number of vehicles that would have to be retired to reach these levels.

4. WHY ARE THE RESULTS SMALL?

This analysis was completed under the extreme assumption that 100 percent of the eligible LDVs would be retired. Even under this unrealistic condition, the calculated reductions are small. The results show that a vehicle retirement program can reduce VOC generated by LDVs by over 5 percent and NOx by over 2 percent. At first glance, these decreases appear to be significant; however, not only were they achieved under the ambitious assumption mentioned above, but the reductions are smaller than those claimed by the programs originally mandated by the CAAA, such as enhanced I&M and reformulated fuel. Whereas air quality planners are looking to these programs to replace measures that have aroused public resistance, they may want to rethink this strategy.

These results have been generated using the EPA's MOBILE vehicle emissions model, which may be underpredicting the reductions. In some cases, MOBILE has been found to underpredict fleetwide emissions, such as in Tunnel Studies, in which emissions estimates produced by the model are compared to measured vehicular emissions trapped in long tunnels[8], although revisions have been made to the model to correct this tendency.

Underpredicting could take place if the older vehicles account for more travel or higher emissions than are shown in MOBILE. These two possibilities are discussed in the following section.

4.1 OLD VEHICLES MAY ACCOUNT FOR MORE TRAVEL THAN MOBILE ESTIMATES

MOBILE's estimates of emission reductions generated from a retirement program may be too low if MOBILE underestimates the use of old vehicles. This could arise if MOBILE underpredicts any of the three components used to estimate the contribution of LDVs to total travel.

- VMT Mix - Fraction of highway VMT accounted for by LDVs.

[8]The MOBILE Model and Transportation Planning: A Brief Overview, FHWA, 1995, #DOT-VNTSC-FHWA-95-7.

- Age distribution - Number of LDVs of different ages (1 to 25+ years old).

- Mileage Accumulation Rate - Average annual mileage driven by LDVs of each age cohort (1 to 25+ years old).

Each of these components is a source of potential error if it does not adequately represent actual conditions in nonattainment areas. The following section examines the accuracy with which MOBILE represents each of the three components.

4.1.1 The VMT Mix

The default VMT mix assigned by MOBILE to LDGV (65.5 percent) and LDGT1 (16.6 percent) is based on national data, and could underestimate the actual VMT that these vehicles contribute in any nonattainment area considering a retirement program. That possibility is alleviated in this case by using data reported by the Massachusetts Highway Department (MHD) (81.9 percent of LDGV and 8.0 percent of LDGT1) to override the default data.

4.1.2 The Age Distribution

The default age distribution assigned to LDGV and LDGT1 by MOBILE is based on national data and may not correctly represent the number of older LDVs that exist in a nonattainment area. For the Eastern Massachusetts nonattainment area, this possibility is alleviated by substituting local data supplied by the Massachusetts Department of Environmental Protection (MADEP), for default data.

Figure 1 shows the effects of using local vehicle age distribution data for Boston and Phoenix. MOBILE appears to slightly overestimate the number of old vehicles that are in the Boston area. The extreme weather conditions of the Northeast may cause higher fleet turnover compared to the national average, resulting in fewer older vehicles. On the other hand, MOBILE underestimates the number of old vehicles in Phoenix, possibly reflecting slower fleet turnover as a result of dry weather conditions in that region.

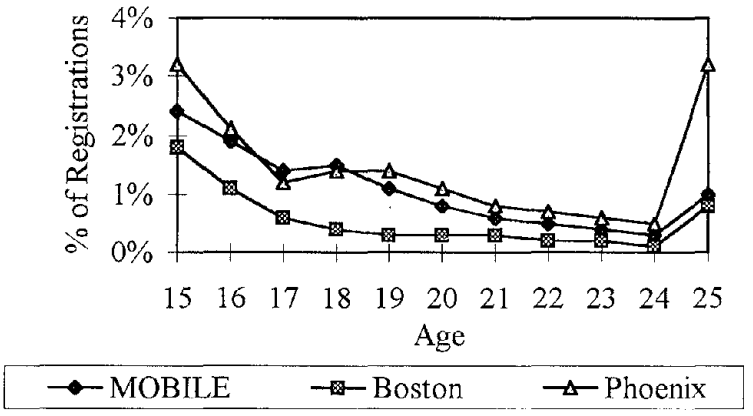


Figure 1. LDGV Age Distribution: MOBILE versus Actual.

4.1.3 The Mileage Accumulation Rate

Annual mileage data by vehicle age is difficult to obtain for metropolitan areas. Even when it is available, the EPA discourages overriding MOBILE's defaults[9]. Yet, because the default mileage accumulation rate is based on national averages, it could underestimate the amount of driving that vehicles contribute in any nonattainment area that is considering a retirement program.

Figure 2 shows the difference between MOBILE's default data and average measured data from four sources.[10] Based on this chart, MOBILE shows a clear tendency to underestimate the annual utilization of older vehicles and this appears to be part of a larger tendency to underestimate the utilization of vehicles of all ages.

[9]"User's Guide to MOBILE5", Environmental Protection Agency, May, 1994.
[10]The sources of the measured data are: (1) Illinois Environmental Protection Agency; (2) California SMOG Check Program; (3) National Personal Transportation Survey, and; (4) Sunoco Vehicle Emissions Repair Program.

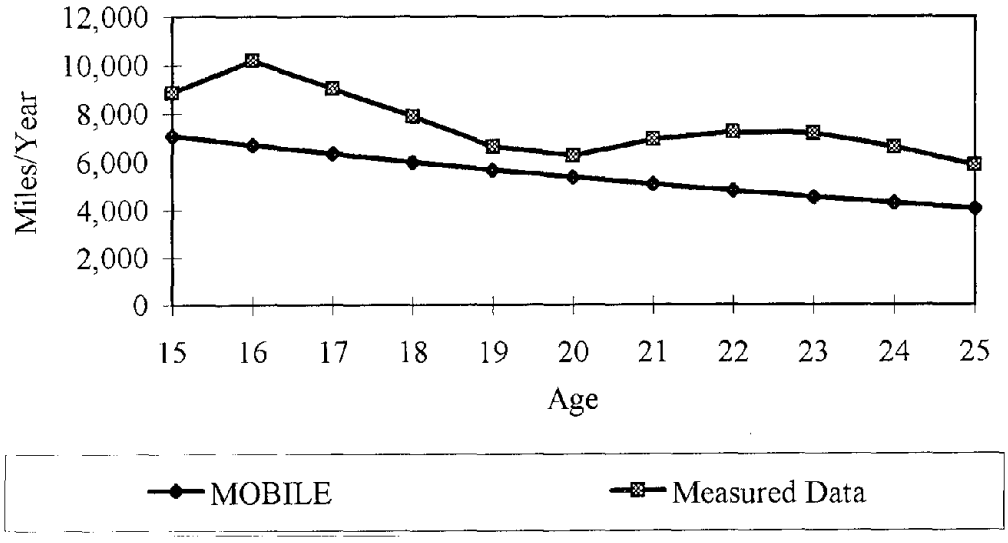


Figure 2. Utilization of LDGV by Age: MOBILE versus Actual.

4.2 OLD VEHICLES' EMISSION RATES MAY BE HIGHER THAN MOBILE ESTIMATES

The basic emission rates embedded in MOBILE are derived from measurements taken on samples of privately owned vehicles and from certification tests conducted by manufacturers on their new vehicles to show that their engines comply with the EPA's emission standards.[11] The emission rates are assigned by age (1 to 25+ years). For any nonattainment area considering a retirement program, MOBILE could underestimate the true emission rates that vehicles contribute. It is not possible to change the emission rates that are imbedded in MOBILE.

Comparing MOBILE's predicted rates to emissions that are measured is one way to check the model's ability to reflect emission rates for old vehicles. MOBILE's predicted *exhaust* emission rates were compared to measured exhaust emissions gathered from vehicles that were tested in three retirement programs and one repair program.[12] Separate MOBILE runs were prepared for each program and then compared to the actual emission rates. Each MOBILE run was completed

[11] *The MOBILE Model and Transportation Planning: A Brief Overview*, FHWA, 1995, #DOT-VNTSC-FHWA-95-7.

[12] Retirement programs were implemented by: (1) Unocal Corp.; (2) Sun Co., Inc, and; (3) Illinois EPA. The repair program was implemented by Sun Co., Inc.

with input factors that replicated the environment in which the vehicles were tested (temperature, I&M program in place, fuel, etc.). Additional information on the programs is available in appendix A.

Figures 3 to 6 show that MOBILE underestimates VOC exhaust emissions of tested vehicles in almost every age category for which test data are available. This is true even in those programs that prescreened vehicles in order to select particularly high emitters. The retirement programs implemented by Unocal Corporation and Sun Company selected pre-1971 and pre-1980 vehicles. Sun Company implemented an additional control, using the highest mileage vehicles. Vehicles were admitted to Illinois EPA's retirement program if their models years fell between the years 1968 to 1979, and had either marginally passed inspection or were operating on a waiver. Finally, vehicles were prescreened with remote sensing and then I&M240 for the Sun Company's repair program (see appendix A).

A similar analysis completed for NOx and CO shows that MOBILE tends to overestimate NOx emissions, while CO emissions are more often underestimated (see appendix B).

Because of the large variation among emission rates from vehicles of the same age, the differences between actual and MOBILE's emission rates are not often statistically significant. However, the differences are large (see appendix C) and reveal a consistent tendency for MOBILE to underestimate older vehicle emission rates.

As indicated previously, MOBILE estimates separate emission factors for light-duty vehicles (LDGV and LDGT1) of ages 1 through 25 years, with the emission factor for the oldest age cohort intended to represent an average for all vehicles 25 years and older. Curiously, figures 3 through 6 showed that MOBILE's estimated emission rates for 25-year and older vehicles are consistently equal to or lower than those for 24-year old vehicles. (Recall that MOBILE's estimated emission rates differed among the figures because temperature, fuel specifications, I&M program assumptions, and other inputs to the model were tailored to reproduce the specific conditions under which emission rates for vehicles in each of the different programs were measured.) This unexpected result may occur because of difficulty in estimating the frequency of tampering, an important influence on vehicles' emission rates, for the oldest vehicles in the fleet;

the rate of tampering assumed by MOBILE for 25-year and older vehicles is apparently slightly lower than that for 24-year-old vehicles.

Figures 3-6. LDGV VOC Rates (MOBILE versus Actual).

Figure 3. Unocal

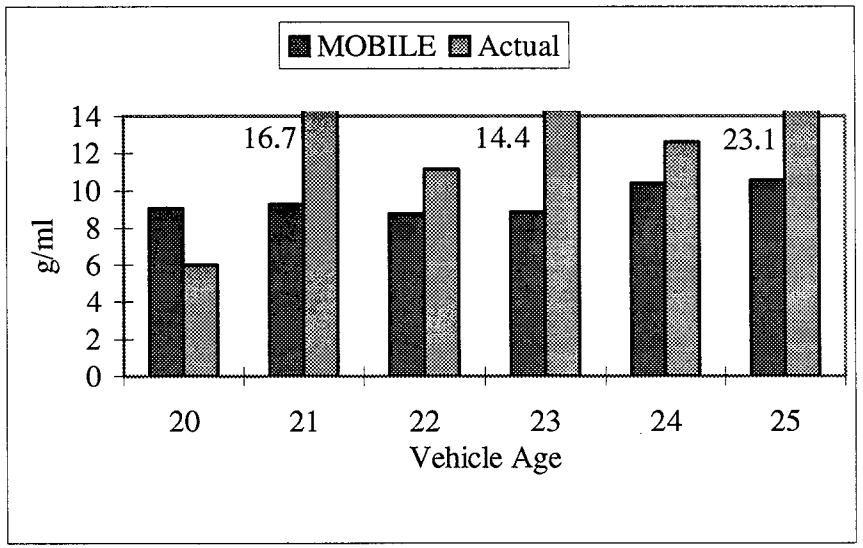


Figure 4. Sunoco (Retirement)

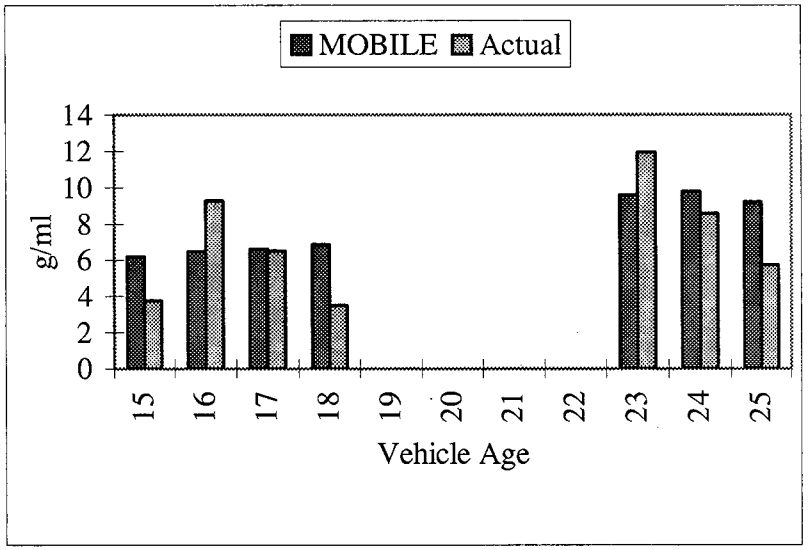


Figure 5. Sunoco (Repair)

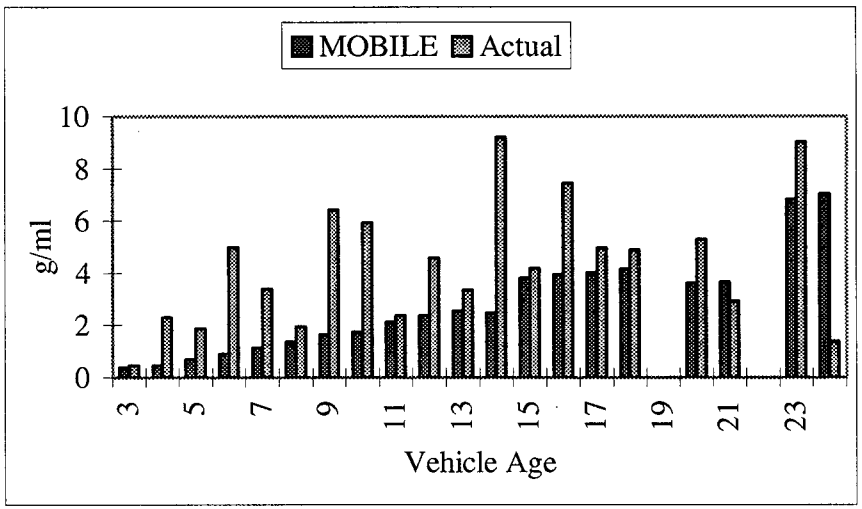
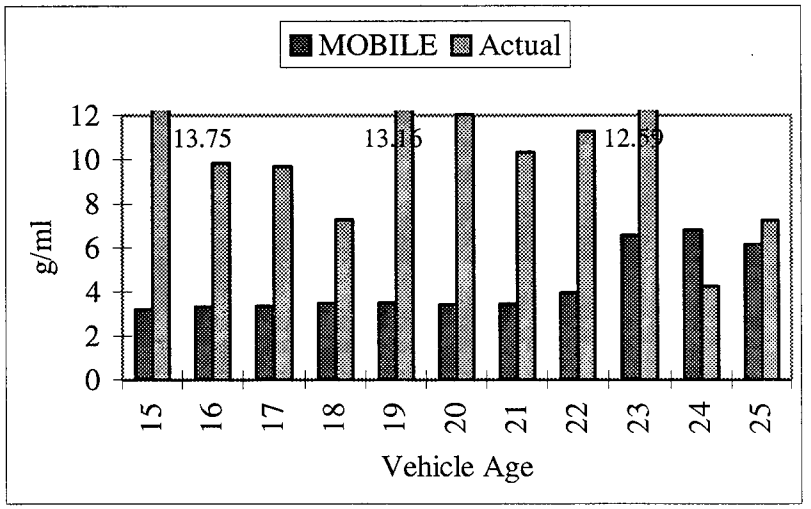


Figure 6. Illinois EPA



4.3 TESTING THE COMBINED EFFECT OF ALL COMPONENTS

To test the combined effect of MOBILE's tendency to underestimate the use and emission rates of older vehicles, the model was used to predict the exhaust emissions generated by the vehicles that were retired in Illinois EPA's program and those repaired in Sun Company's program. Actual emission rates and annual mileage by vehicle were available for these programs and are averaged and compared to MOBILE's estimates in table 4.

Table 4. Comparison of MOBILE and Actual Exhaust Emissions for Retired/Repaired Vehicles.

(Tons/Year)

Pollutant	Program	# of Vehicles Tested	MOBILE Estimate (tons/year)	Actual Data (tons/year)	Actual as % of MOBILE
HC	Sunoco - Repair	116	2.01	7.00	349%
	ILEPA[1] - Retire	117	2.80	9.56	342%
NOx	Sunoco - Repair	112	2.83	4.68	166%
	ILEPA - Retire	117	3.63	4.74	130%
CO	Sunoco - Repair	116	27.03	96.59	357%
	ILEPA - Retire	117	27.26	58.80	216%

[1] Illinois Environmental Protection Agency

There is a large difference between the MOBILE and actual emissions, indicating that MOBILE may underpredict emission reductions for nonattainment areas considering a retirement program.

5. CONCLUSION

From a policy perspective, it appears that vehicle retirement programs should be approached with caution. The MOBILE model shows that attaining reductions of up to 5 percent would require retiring an extraordinarily large numbers of vehicles. For those regions proposing such programs, consideration of how well the model reflects real-world vehicle use and emission rates is prudent. Even if every attempt was made to use local usage data (vehicle registration, average

annual mileage driven, etc.), the emission rate, which MOBILE tends to underpredict (with the exception of NOx) cannot be changed by the user.

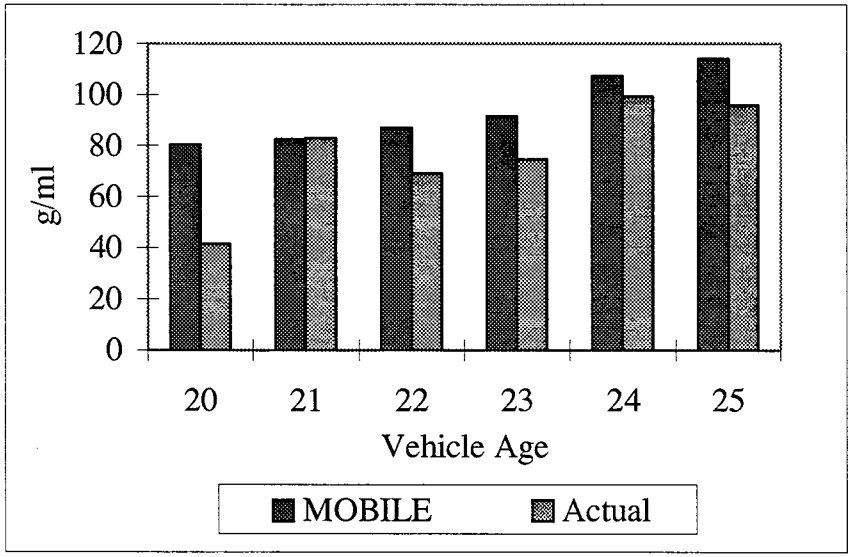
Finally, despite the fact that MOBILE predictions appear to be too small, not reflecting actual reductions from a retirement program, the fact that the measured results are also very small (table 4) implies that, from a policy perspective, there still may be little emissions reductions benefit from these programs.

APPENDIX A. RETIREMENT/REPAIR PROGRAM DESCRIPTIONS

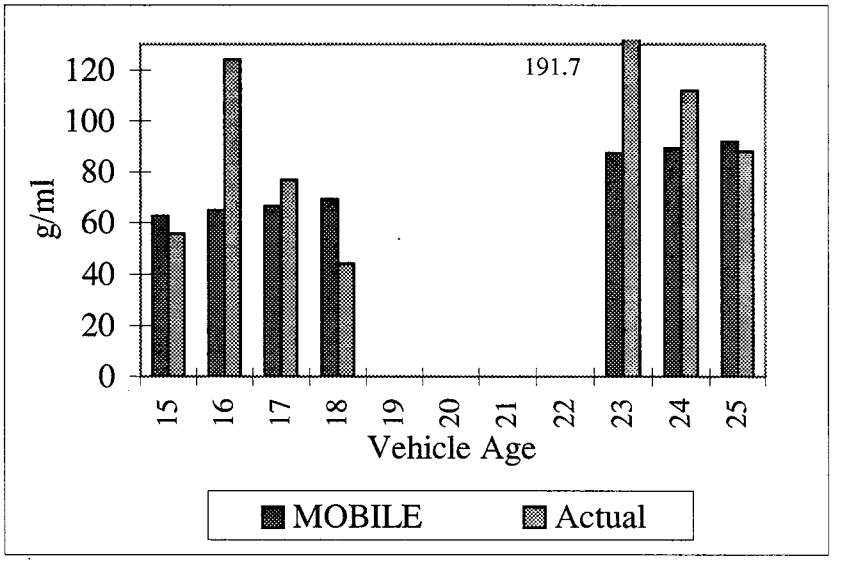
Type of Program	**Retirement**			**Repair**
Sponsor	**Unocal Corp. of California**	**Sunoco of Pennsylvania**	**Illinois EPA**	**Sunoco of Pennsylvania**
Program Description				
Year of Implementation	1990	1993	1993	1994
Season of Implementation	Summer	October	Late Fall & Winter	Spring & Summer
Prescreening Criteria	Pre-1971	Pre-1980 & Highest Mileage	1968-1979 & Marginally Passed Inspection or Operating on a Waiver	Prescreened w/ Remote Sensing and Then IM240
# Vehicles Retired/Repaired	8,376	166	207	155
# Vehicles Tested	74	16	194	155
Purchase/Repair Cost	$700	$700	$647 - $902	$100 + Repairs up to $450
Test Conditions				
Test Type	FTP	FTP	IM240	IM240
Location	Indoor	Indoor	Indoor	Indoor and Outdoor
Ambient Temp (F)	70	65	65	73
Fuel	Tank	Tank	Tank	Tank

APPENDIX B. LDGV CO RATES (MOBILE VERSUS ACTUAL)

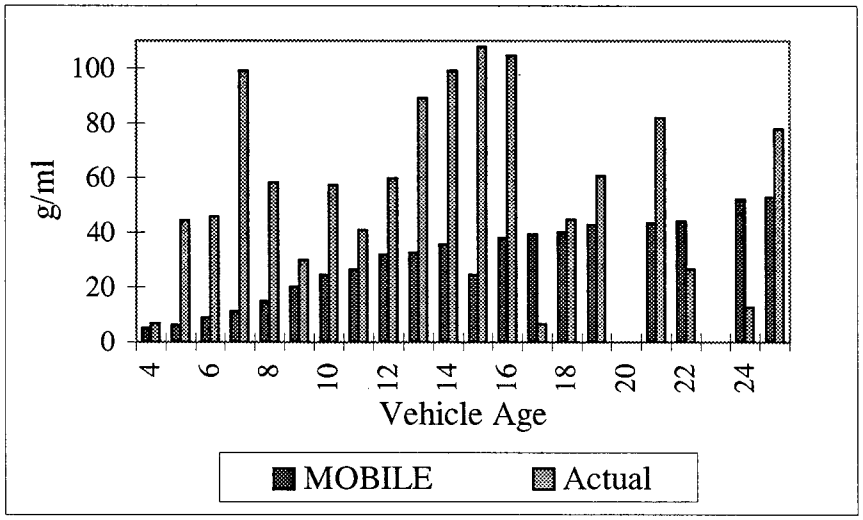
Unocal



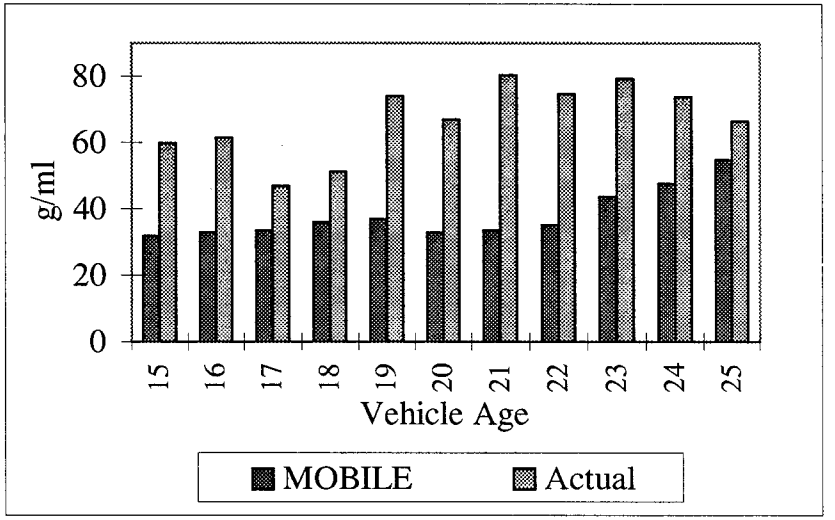
Sunoco Retire



Sunoco Repair

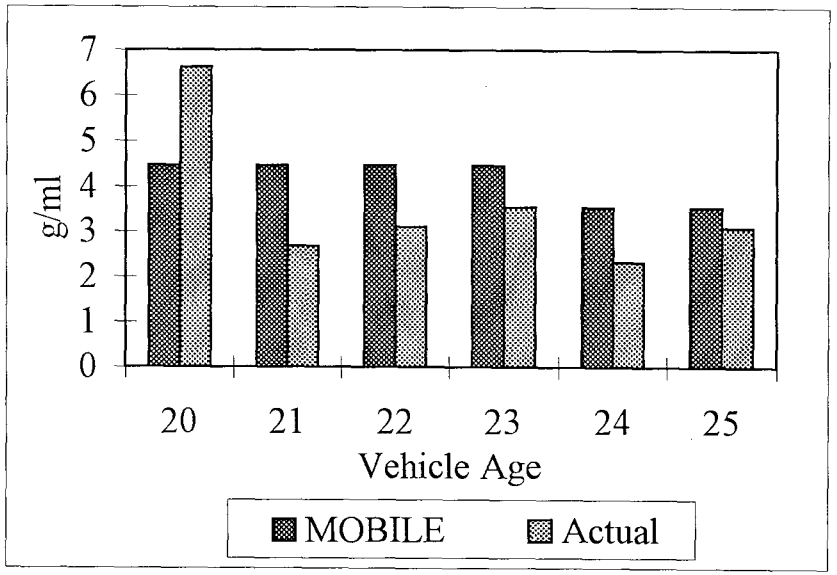


Illinois EPA

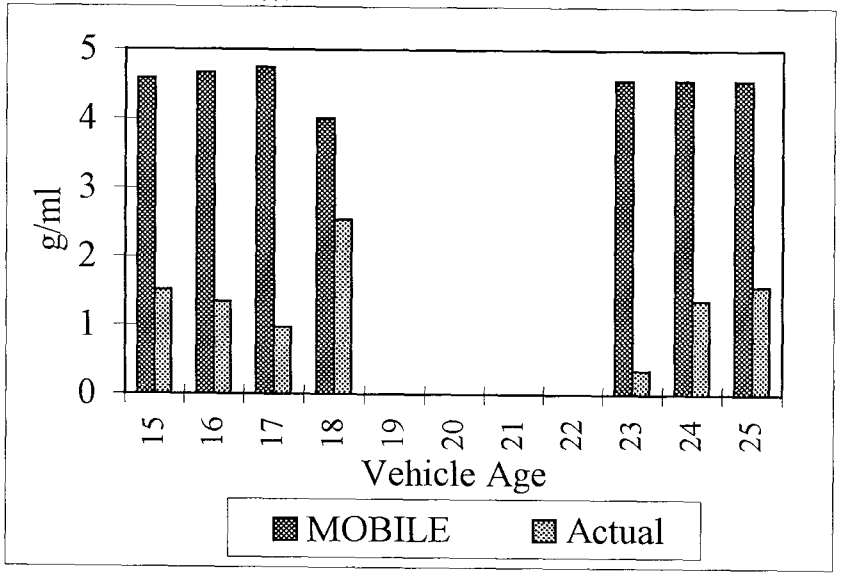


APPENDIX B. LDGV NOx Rates (MOBILE versus Actual)

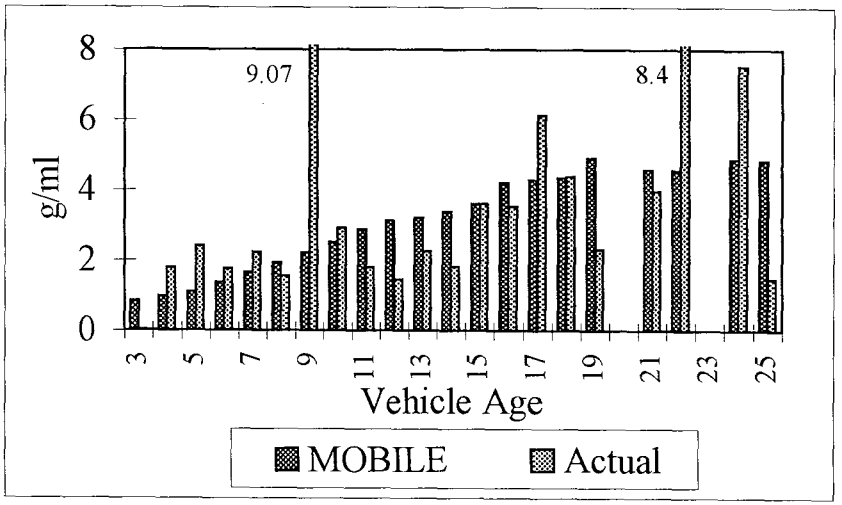
Unocal



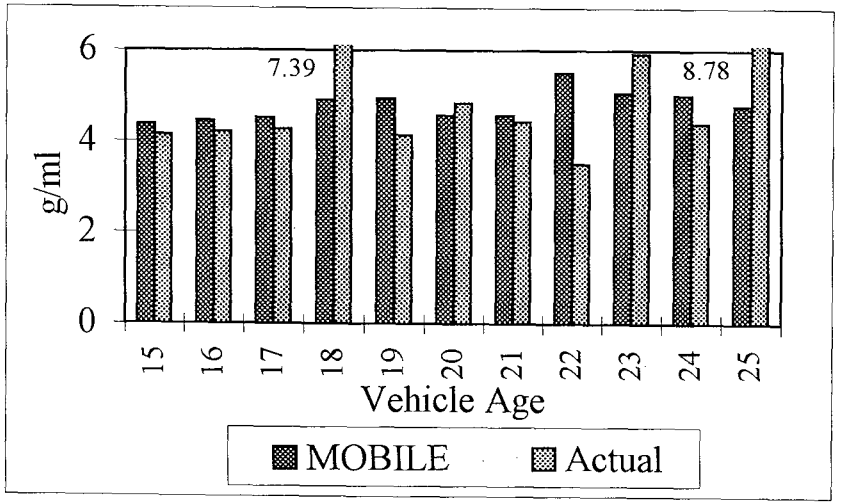
Sunoco Retirement



Sunoco Repair



Illinois EPA



APPENDIX C. ACTUAL VERSUS MOBILE VOC EXHAUST EMISSION RATES

Actual versus MOBILE VOC Tailpipe Emission Rates

	Unocal 1990 (FTP)				Sunoco 1993 (FTP)				Sunoco 1994 (IM240)				ILEPA 1993 (IM240)			
Age	N	Actual	MOBILE	% of MOBILE Predictio	N	Actual	MOBILE	% of MOBILE Prediction	N	Actual	MOBILE	% of MOBILE Prediction	N	Actual	MOBILE	% of MOBILE Predictio
1																
2																
3									1	81.63	0.31					
4									3	0.44	0.38	116%				
5									6	2.30	0.45	515% *				
6									7	1.86	0.69	269%				
7									8	4.99	0.90	556%				
8									18	3.40	1.14	299%				
9									13	1.95	1.38	141%				
10									24	6.42	1.65	389% *				
11									17	5.93	1.75	339%				
12									15	2.37	2.13	111%				
13									14	4.58	2.37	193%				
14									13	3.36	2.55	132%				
15					5	3.78	6.23	61%	3	9.19	2.49	370%	39	13.75	3.21	429% *
16					4	9.26	6.48	143%	2	4.20	3.81	110%	36	9.85	3.30	299% *
17					1	6.51	6.63		3	7.45	3.95	189%	28	9.68	3.35	289% *
18					2	3.51	6.87	51%	2	4.98	4.03	124%	24	7.27	3.46	210% *
19									1	4.89	4.17		13	13.16	3.51	375%
20	1	6.00	9.06										13	12.06	3.39	356% *
21	26	16.67	9.24	180% *					1	5.29	3.61		12	10.36	3.44	301%
22	10	11.16	8.76	127%					1	2.93	3.66		11	11.28	3.96	285%
23	11	14.35	8.87	162%	1	11.92	9.58						7	12.59	6.55	192% *
24	10	12.62	10.39	121%	2	8.56	9.77	88%	2	9.04	6.82	132%	7	4.23	6.80	62%
25	16	23.14	10.56	219% *	1	5.74	9.20		*1*	*1.40*	*7.06*		5	7.24	6.15	118%

Reproduced by NTIS

National Technical Information Service
Springfield, VA 22161

This report was printed specifically for your order from nearly 3 million titles available in our collection.

For economy and efficiency, NTIS does not maintain stock of its vast collection of technical reports. Rather, most documents are printed for each order. Documents that are not in electronic format are reproduced from master archival copies and are the best possible reproductions available. If you have any questions concerning this document or any order you have placed with NTIS, please call our Customer Service Department at (703) 487-4660.

About NTIS

NTIS collects scientific, technical, engineering, and business related information — then organizes, maintains, and disseminates that information in a variety of formats — from microfiche to online services. The NTIS collection of nearly 3 million titles includes reports describing research conducted or sponsored by federal agencies and their contractors; statistical and business information; U.S. military publications; audiovisual products; computer software and electronic databases developed by federal agencies; training tools; and technical reports prepared by research organizations worldwide. Approximately 100,000 *new* titles are added and indexed into the NTIS collection annually.

For more information about NTIS products and services, call NTIS at (703) 487-4650 and request the free *NTIS Catalog of Products and Services*, PR-827LPG, or visit the NTIS Web site **http://www.ntis.gov**.

NTIS
Your indispensable resource for government-sponsored information—U.S. and worldwide

U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Technical Information Service
Springfield, VA 22161 (703) 487-4650