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Draft Report for Public Comment

Anti-Tampering And Anti-Misfueling Programs To Reduce In-Use Emissions From Motor Vehicles

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1.0 INTRODUCTION

Since the 1960's when crankcase ventilation tubes on automobile engines were rerouted to prevent the venting of engine blowby gases directly into the atmosphere, automotive designers have added to and redesigned various components of the standard internal combustion engine to reduce its emissions of hydrocarbons (HC), carbon monoxide (CO), and nitrogen oxides (NOx). The success of their efforts is evident in the fact that new passenger vehicles emit only a small fraction of the HC, CO, and NOx emissions of pre-controlled cars.

The full benefit of these modifications, however, is not being realized in the field. EPA studies have shown repeatedly that maladjustments, disablements, and component failures in the emission control systems of automobiles occur frequently and that the result is often emission levels many times the design (certification) standards. This means that the vehicle owners, who have paid for these emission control components when their cars were purchased, and the public, in general, have not been receiving the emission benefits of this investment because of some form of tampering, misfueling, malmaintenance or neglect. These emissions in excess of design standards are a major source of HC, CO, and NOx from mobile sources and a significant contributing factor to air pollution in urban areas.

This report will specifically address the portion of excess vehicle emissions due to tampering and misfueling. Tampering, in this report, will refer to any disablement of any component of an emission control system whether it was done deliberately, inadvertently, or through neglect. Tampering can be as simple as losing (and not replacing) your vehicle's gas cap to sawing off the catalytic converter. This definition does not include maladjustments which would increase emissions. Misfueling and fuel switching in this report will mean any introduction of fuel using lead additive into a vehicle originally equipped with a catalytic converter. This can be done deliberately by the vehicle owner by enlarging the fuel inlet restrictor so that the leaded fuel nozzle fits or by using a funnel so that damaging the fuel inlet restrictor is not necessary. This can also be done inadvertently if fuel supplies at a particular station or at a wholesale supplier become contaminated or deliberately switched, although EPA estimates that the nationwide contamination violation rate at retail gasoline stations is less than one percent. There are many possible reasons why people misfuel, but the primary reasons are thought to be price and the perception of performance, since leaded fuel is both cheaper and higher in octane rating than unleaded fuel.

EPA has in recent years begun to collect data on the occurrence of tampering and misfueling to assess the magnitude of the problem. Covert observation of vehicle owners at fueling stations and direct inspection of individual vehicles in roadside surveys have shown that nationally nearly one in five in-use vehicles have at least one emission control disablement and that a significant number of vehicle owners misfuel. These figures are alarming in light of the fact that it is a federal violation with large civil fines for repair garages, dealerships or fleet operators to remove or disable emission control components and that many states have had laws which make such disablements by individual vehicle owners illegal. Tampering and misfueling are, therefore, significant problems which current efforts have not adequately held in check.

Inspection and maintenance (I/M) programs are being instituted in some areas to assure a better state of repair for vehicles operated in large urban areas with air quality 50oblems. The Clean Air Act Amendments of 1977 require I/M programs in urban areas with populations over 200,000 which cannot attain ozone or carbon monoxide air quality standards by 1982. Although these I/M programs will produce large reductions in HC and CO emissions, most programs do not explicitly require that all emission control components be in good repair in order to pass the I/M inspection. The simple idle test which is used in most I/M programs is not designed to detect specific component disablements. Such I/M programs alone, therefore, will not completely solve that portion of the excess emissions problem. Additional emission reductions from reducing the occurrence of tampering and misfueling are possible in all areas in order to help meet or to maintain ambient air quality goals.

Tampering and misfueling, and thus the excess emissions caused by them, can be reduced in a variety of ways:

- In areas with I/M programs, an anti-tampering and anti-misfueling program could be added as part of the tailpipe emissions program.

- In areas with an existing safety or other periodic inspection requirement, an anti-tampering and anti-misfueling program can be added to the inspection program. In areas without an existing inspection requirement, a new requirement can be implemented either on a periodic or change-of-ownership basis.

- Various field enforcement efforts can also be used in any area to deter tampering and misfueling.

Each of these three approaches is examined separately in Section 5.0, which discusses the potential problems as well as benefits.

In any approach, the potential benefits from anti-tampering and anti-misfueling programs will be affected by: 1) how much tampering and misfueling are occurring given existing efforts, if any, to control them; 2) the effectiveness of the program in reducing the observed rate of tampering and misfuelng; and 3) the effects of tampering and misfueling on the emissions from vehicles. There are two ways in which anti-tampering and anti-misfueling programs reduce excess emissions. First, a program may require repair and replacement of damaged or missing emission control components when they are discovered. Secondly, programs may take credit for deterrence of tampering and misfueling which would have occurred if the program had not been implemented. Any program's benefits will be some mix of these two elements although the design of the program may rely more on one than the other for program benefits.

This report does not cover specific methods of detection for disablements. The report briefly describes what each inspection would be like and covers general methods that can be used to detect disablements. A twenty hour tampering detection training course is available from Colorado State University. This course provides hands-on experience in identifying the location and general functions of emission control devices. Colorado State University has also recently published a book titled "1970-1981 Automotive Emission Systems Application Guide". This book provides engine family specific information on what emission control components a passenger vehicle or truck should be equipped with. Also, in-the-field training can be provided by EPA inspectors to those jurisdictions interested in establishing tampering and/or fuel switching enforcement programs that are aimed at retail gasoline stations, fleet operations and repair facilities.

Section 2.0 will discuss the current knowledge about tampering and misfueling rates. Section 3.0 will examine the effects of misfueling and disablement of individual emission control components on vehicle emissions, discuss which vehicles are equipped with each emission component, and estimate the cost of repairs. Section 4.0 will discuss the calculation approach which was developed for this report to estimate the excess emissions caused by tampering and misfueling. Effectiveness will depend on the particular program approach and will therefore be discussed for individual approaches in Section 5.0.

This report analyzes four specific types of tampering--PCV, evaporative control system, air pump, and catalyst removal--plus misfueling. EPA has found that these are the most important items in terms of HC and CO reductions, practicality, and cost.

The potential benefits of a check for disabled closed-loop sensors have not been analyzed because of the uncertainty associated with identifying a tampering rate for these relatively new components. Also, tailpipe I/M tests can identify as much as 80% of the excess emissions associated with oxygen sensor tampering. Thus in I/M areas an oxygen sensor check would have reduced benefits even if a significant tampering rate existed. Future tampering surveys will attempt to identify the existing closed-loop sensor tampering rate.

The most cost-effective portion of the emission reductions possible from a program to control tampering and misfueling is the portion that results from preventing new instances of tampering and misfueling, since no repair cost is incurred. Some jurisdictions may wish to forego the less cost-effective replacement and repair of components which were damaged before the program begins, by applying the program requirements only to cars sold after the program begins. This approach would also reduce public resistance to the program and would avoid disputes with owners of cars that were tampered before they bought them. Of course, the benefits from such programs would also be reduced. For the convenience of such jurisdictions, benefits are shown in all tables for 1984 and later vehicles separately from those for older vehicles. One possible compromise between the larger benefits and costs of inspecting all model years and the reduced benefits of inspecting only newer vehicles is to inspect all 1980 and later model year vehicles. The tables have also separated the 1980 through 1983 model years for this purpose.

Because 1987 is the deadline for attainment of the ozone and carbon monoxide standards for areas which received extensions beyond the 1982 deadline, benefits are calculated for January 1, 1988.

2.0 TAMPERING AND MISFUELING RATES

2.1 Current Rates

Since 1978, EPA has conducted surveys of in-use vehicles, both passenger cars and trucks, in seventeen states and collected data regarding emission component disablements and misfueling from over 8,000 vehicles. The latest of these surveys [1]* completed in 1982 collected data from nearly 3,000 cars in ten states. All of the surveys were conducted either at a roadside check in conjunction with a random police roadside pullover or as a special, temporary addition to a safety or I/M inspection at state-run or private inspection stations. Although the inspections were voluntary, efforts were made to assure as complete participation as possible. Once a city and specific site in the city were chosen, vehicles were chosen completely at random, although the surveys since 1980 inspected only 1975 and later model year vehicles. Table 1 presents a summary of the sample sizes collected in the various states in the 1982 tampering survey. Notation has been added to indicate I/M areas and the type of vehicle recruitment used in the survey at that site.

The 1982 survey was chosen as the definitive data base with which to calculate current and future tampering rates. Comparing the 1982 survey with the previous survey shows that tampering and misfueling behavior has changed with time, and therefore the latest survey will more clearly match future tampering and misfueling behavior. Also, the 1982 survey was more successful than previous surveys in obtaining an essentially non-voluntary and therefore unbiased sample. Table 2 shows the tampering rates observed for 1975 and later vehicles in the 1982 survey. Table 2 indicates that with the exception of PCV and evaporative canister tampering, tampering rates are on average lower in cities with I/M programs. Not all instances in which there was evidence of tampering are reflected in Table 2. Only those serious cases in which the tampering was judged to be easily identifiable and appeared to be sufficient to cause substantial increases in HC and CO emissions are counted in Table 2. Consequently, Table 2 may differ from other published summaries of the 1982 survey.

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

The interpretation of the 1982 survey data to determine which instances of tampering were sufficient to cause substantial increases in HC and CO emissions was straightforward except for misfueling. The survey examined three vehicle parameters relative to misfueling: whether the lead content of the fuel in the tank was over the legal limit of 0.05 gram/gallon, whether the fuel inlet restrictor had been enlarged enough to allow a leaded fuel nozzle to be used, and whether lead sensitive test paper[2] detected lead deposits in the tailpipe. To result in deactivation of the catalyst and substantial long term emission increases, misfueling must be either repeated at least three or four times in succession, or must occur with a fairly high frequency over a long period of time if not consecutively. Such consecutive or frequent misfueling is called habitual. The parameters examined in the 1982 survey are not definitive indicators of this.

Table 1

EPA 1982 Tampering Survey
Sample Sizes

State	Sample Size	Type of Recruitment
FL	309	a
LA	183	b
MN	307	a
NV*	275	d
NJ*	290	a
OK	282	b
OR*	310	c
RI*	324	a
TX	293	b
WA*	312	c
Total	2885	

*I/M area (Seattle, Washington's program did not begin until January 1982).

a: Random roadside pullover.
b: As part of a centralized or decentralized safety inspection.
c: As part of a centralized or decentralized I/M inspection.
d: Vehicles were recruited at a parking lot.

Table 2

Current Tampering and Misfueling Rates*
From 1982 Tampering Survey

Emission Control System	I/M Areas LDV	I/M Areas LDT	Non-I/M Areas LDV	Non-I/M Areas LDT
PCV	1.2%	2.8%	1.1%	4.4%
Evaporative	1.5%	2.8%	0.5%	6.1%
Air Pump	3.1%	2.9%	6.1%	13.8%
Catalyst	1.8%	4.2%	4.5%	20.7%
Habitual Misfueling**	5.4%	11.7%	9.5%	26.1%
For Comparison Only:				
All Misfueling***	6.6%	11.7%	11.7%	32.0%

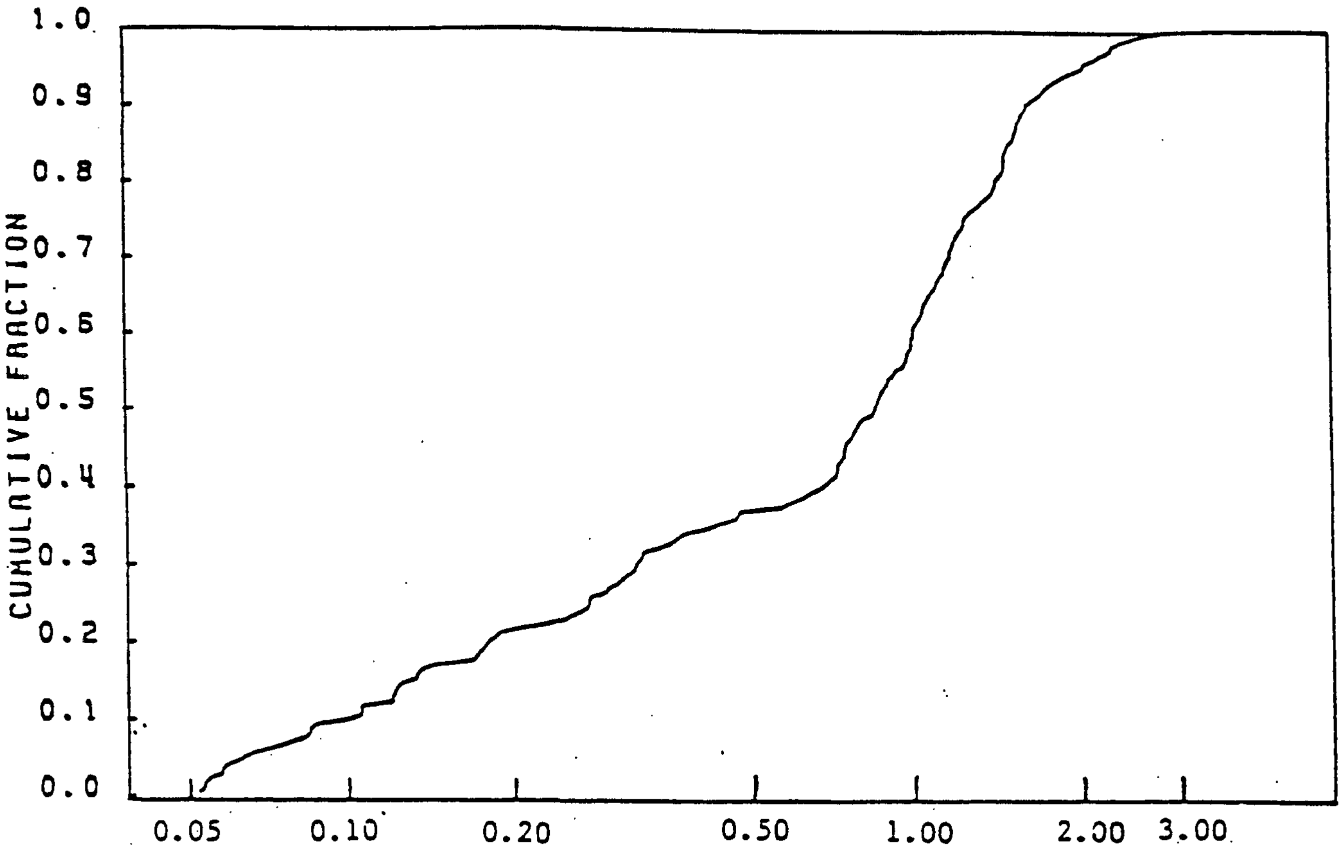
*Grossly tampered cars only. See text.

**Defined as an enlarged fuel inlet restrictor or leaded fuel (lead content greater than 0.05 gm/gal) in tank. Catalyst vehicles only. See text in Section 2.1 for discussion.

***Defined as an enlarged fuel inlet restrictor, leaded fuel (lead content greater than 0.05 gm/gal) in tank, or lead compounds detected in the tailpipe. Catalyst vehicles only. The detection of lead deposits alone is not used as an indication of <u>habitual</u> misfueling in this report for reasons given in the text. A positive result on the test for lead deposits is believed to be an accurate indication that at least some leaded fuel has been used, however. The rates for "all" misfueling shown in this table are for comparison only.

Figure 1

Distribution of Lead Content in Misfueled Catalyst Passenger Cars in 1982 Tampering Survey



Lead Content (gm/gal)
(Logrithmic Scale)

Checking the inlet restrictor does not detect vehicleswhose owners have misfueled using funnels or illegally small nozzles or vehicles which are victims of fuel mislabeling by gas stations or distributors or have otherwise used contaminated gasoline. Fuel samples drawn on a one-time basis cannot detect vehicles which were misfueled regularly in the past, but for some reason, e.g., change of owners, have not been misfueled recently. The lead sensitive test paper may detect vehicles which have only been misfueled a couple of times at wide intervals and have catalysts which are still active. The test paper can also fail to detect vehicles which have had tailpipe replacements since the last misfueling episode. Nothing can be done to adjust the data from the 1982 survey for false negative indications of misfueling.

The inlet restrictor check can be assumed to have few false positives, since an owner is extremely unlikely to have tampered with the restrictor for no reason. The check on fuel lead content also is a strong indicator that leaded fuel has been used recently. Most of the vehicles with fuel over the legal limit were well over it, so low level contamination of unleaded fuel cannot possibly be the cause. Many of the cars clearly had filled with leaded fuel at the last fillup. Information on the observed lead concentrations of vehicles over the legal limit is presented in Figure 1. Based on EPA fuel inspections and other fuel surveys, it is far more likely that leaded fuel was purchased knowingly than that the gasoline retailer had sold leaded fuel from a pump labeled unleaded. Given that the owner knowingly bought leaded fuel recently, it is likely that the vehicle has been habitually misfueled; evidence that owners who use leaded fuel once tend to do so regularly is discussed in the last paragraph of this section.

The only remaining issue, then, is whether a vehicle with the test paper result indicating misfueling which does not also have other indications of misfueling has actually been misfueled enough to deactivate the catalyst. Since the fuel in the tank is below the legal limit, it is certain that unleaded fuel has been used for at least the last two or three fillups. The most plausible scenario for earlier habitual misfueling would be that a previous owner had misfueled extensively using a funnel or illegally small nozzle but the present owner does not. This is clearly a possibility, particularly for older cars, but is tempered by the low rate of owner turnover. It is also possible that a family car was or is misfueled habitually by one member of the family but not by the member who filled the tank the last few times. A single vehicle operator may also have habitually misfueled only during the last gasoline crisis, in 1979, when unleaded fuel may have been unavailable.

Otherwise there is little reason to suppose that the same owner would stop habitual misfueling once he or she started. The other possibility, as mentioned, is that leaded fuel has been used only a couple of times, for whatever reason and perhaps unknowingly.

Because of the uncertainty as to how to handle the vehicles which failed only the test paper results and a desire to produce a realistic estimate of the benefits for programs to reduce habitual misfueling, EPA has chosen for this report to accept only the fuel lead content and inlet restrictor as evidence for calculating habitual misfueling rates. As can be seen in Figure 2, this decision reduces the number of vehicles with any indication of misfueling that are considered habitually misfueled by about 18% for the passenger cars and 15% for the light-duty trucks. For the reader's information, Table 2 shows the misfueling rate based on these two indicators alone and on all three indicators. EPA will be considering ways to reduce the uncertainty in this area and may provide further information later.

There are two other sources of data on misfueling that can be used as a qualitative comparison to the misfueling rates calculated from the two indicators in the 1982 tampering survey. As noted below, each has its own limitations.

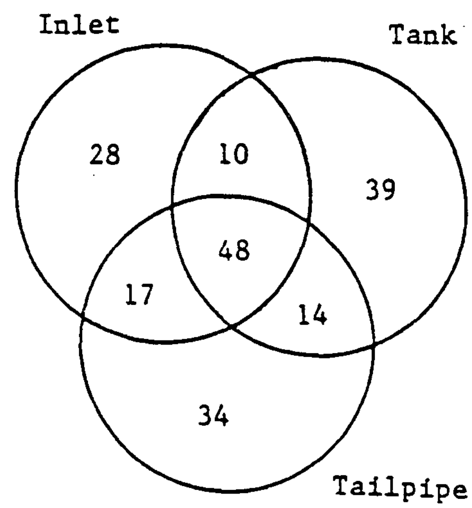
First, EPA has in the past observed vehicles fueling at gas stations and through a check of their license plate number determined if each vehicle required unleaded gas. The last such survey was completed in 1979. It showed an overall misfueling rate then of about 8%. This survey approach obviously does not detect all vehicles which have ever been misfueled enough to cause catalyst deactivation and some observations represent only casual misfueling.

Second, an analysis of fueling habits was recently performed by a Department of Energy contractor using data from detailed diaries kept by families of their gasoline purchases[3]. This analysis showed that among the families keeping diaries, 7.7% of the fuel purchased for catalyst-equipped vehicles was leaded. More than 85% of the leaded fuel purchased was purchased by vehicle owners who misfuel more than 50% of the time. This suggests that a given owner rarely stops his or her habitual misfueling once started, but says nothing about previous owners. The diaries have not yet been analyzed to determine exactly how many vehicles were affected by serious misfueling during the diary period. Data used for the fuel diary analysis is voluntary and therefore suspected of under-representing the true incidence of misfueling.

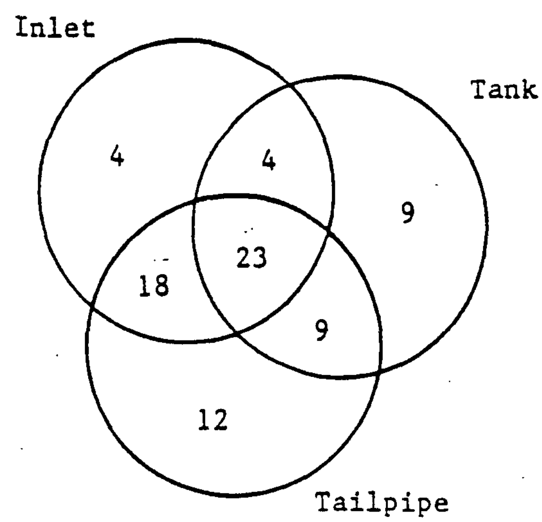
Figure 2

Overlap Among Indicators
of Misfueling in the 1982 EPA
Tampering Survey*

Passenger Cars:		Number of Vehicles
All	=	2209
Any	=	190
Tank	=	119
Inlet	=	103
Tailpipe	=	113



Light-Duty Trucks:		Number of Vehicles
All	=	353
Any	=	79
Tank	=	51
Inlet	=	49
Tailpipe	=	62



*All: All catalyst vehicles in sample.
Any: All catalyst vehicles with any one or more of the following indications of misfueling
Tank: All catalyst vehicles whose fuel sample indicates a fuel lead content greater than 0.05 grams per gallon.
Inlet: All catalyst vehicles whose fuel inlet restrictor allows entry of a leaded fuel nozzle.
Tailpipe: All catalyst vehicles whose tailpipe lead deposits indicate past use of leaded fuel.

2.2 Future Rates

In order to estimate the excess emissions caused by tampering and misfueling on a future date, January 1, 1988 for example, it will be necessary to predict the tampering and misfueling rates when the average age of the vehicles will be older than observed in the 1982 survey since it was restricted to 1975 and newer vehicles. Examination of the data from the 1982 survey shows a marked increase in the tampering rates of some components, including catalysts, and in misfueling rates as the average mileage of the sample increases. This increase is illustrated in Figures 3-7. Consequently, the dependence of tampering rates on mileage must be accounted for.

To examine this issue, a linear regression equation on mileage was fitted to data from the 1982 EPA survey and appears to reasonably explain the tampering and misfueling rates observed in the surveys. Some of the regression lines are also shown in Figures 3-7. Each linear equation is defined by a zero mile rate and an increase in the rate for every 10,000 miles of fleet average mileage. Other non-linear equations did not seem to better explain the increase. It was decided, therefore, to use the linear equation to estimate the tampering and misfueling rates on January 1, 1988 using standard EPA predictions of the average age in miles of each model year on that date.

Least squares regression was used to estimate a line of the form $Y = bX+a$, where Y is the proportion of tampered vehicles at mileage X. The data used to generate estimates of the regression coefficients, a and b, were the mileage and whether the vehicle was tampered ($Y=1$) or not ($Y=0$) for each vehicle in the 1982 tampering survey.

Least squares regression, as used in our case, requires several assumptions concerning the distribution of Y for fixed X in order to estimate the error variance of a and b. Ordinarily, the Y values are assumed to be normally distributed for each value of X. Further, it is assumed that the variances for these Y distributions are equal at all points along the line. Since the Y values in our data are either zero or one, neither of these assumptions are met. However, an investigation of the properties of the least squares estimators has shown that they remain unbiased even in the presence of a binary dependent variable. Since it is unnecessary to obtain error estimates for the regression coefficients for this application, it was determined that the simple least squares regression approach is sufficient for this application.

In calculating equations to predict tampering and misfueling rates several factors have been considered. The rate of tampering and misfueling among passenger cars and among trucks is significantly different. Therefore, each of these vehicle types were treated separately. Also I/M areas tend to have lower tampering and misfueling rates than areas without I/M programs. Each of these two classifications are, therefore, also treated separately. Although local tampering and misfueling rates can vary greatly, only one set of tampering rate equations is used in this report. If a particular area has reason to believe, or has data which show, that tampering or misfueling rates are higher in its area than in the nation as a whole, EPA is willing to evaluate the evidence and estimate benefits specific to that area.

Since there is no data in the 1982 survey from model years before 1975 and since these vehicles should have little effect on the overall benefits in 1987, it has been assumed that tampering rates for pre-1975 cars are the same as for 1975 and later passenger cars at equal mileages. It is also assumed that the tampering and misfueling behavior of 1981 and later model year passenger car owners will not be significantly different in future years than the behavior of pre-1981 passenger car owners, for those components treated in this report. Both of these assumptions are unproven, but the data available are not adequate to treat these groups separately. In addition, truck sample sizes are inadequate to estimate the rate of increase of tampering and misfueling for trucks, therefore, the rate of increase in tampering and misfueling for passenger cars has been assumed for trucks also, although the zero mile rates have been adjusted to reflect the observed differences in the average tampering and misfueling rates between trucks and passenger cars.

Table 3 presents the linear regression equation coefficients calculated from the tampering survey data. The equations describe the relationship of tampering and misfueling rates to vehicle mileage in the non-I/M areas. The light-duty truck zero mile rate value was calculated using the overall truck tampering and misfueling rates and average mileage and projecting backwards to zero miles assuming the same increase in rate as for passenger cars.

Table 4 presents the same information but for I/M areas without a formal tampering check. Since the Portland, Oregon I/M program does a tampering check, the data from this site were removed from the calculation of the equations in Table 4. Differences in the design and history of the other I/M programs had to be overlooked in the interest of retaining a meaningful sample size.

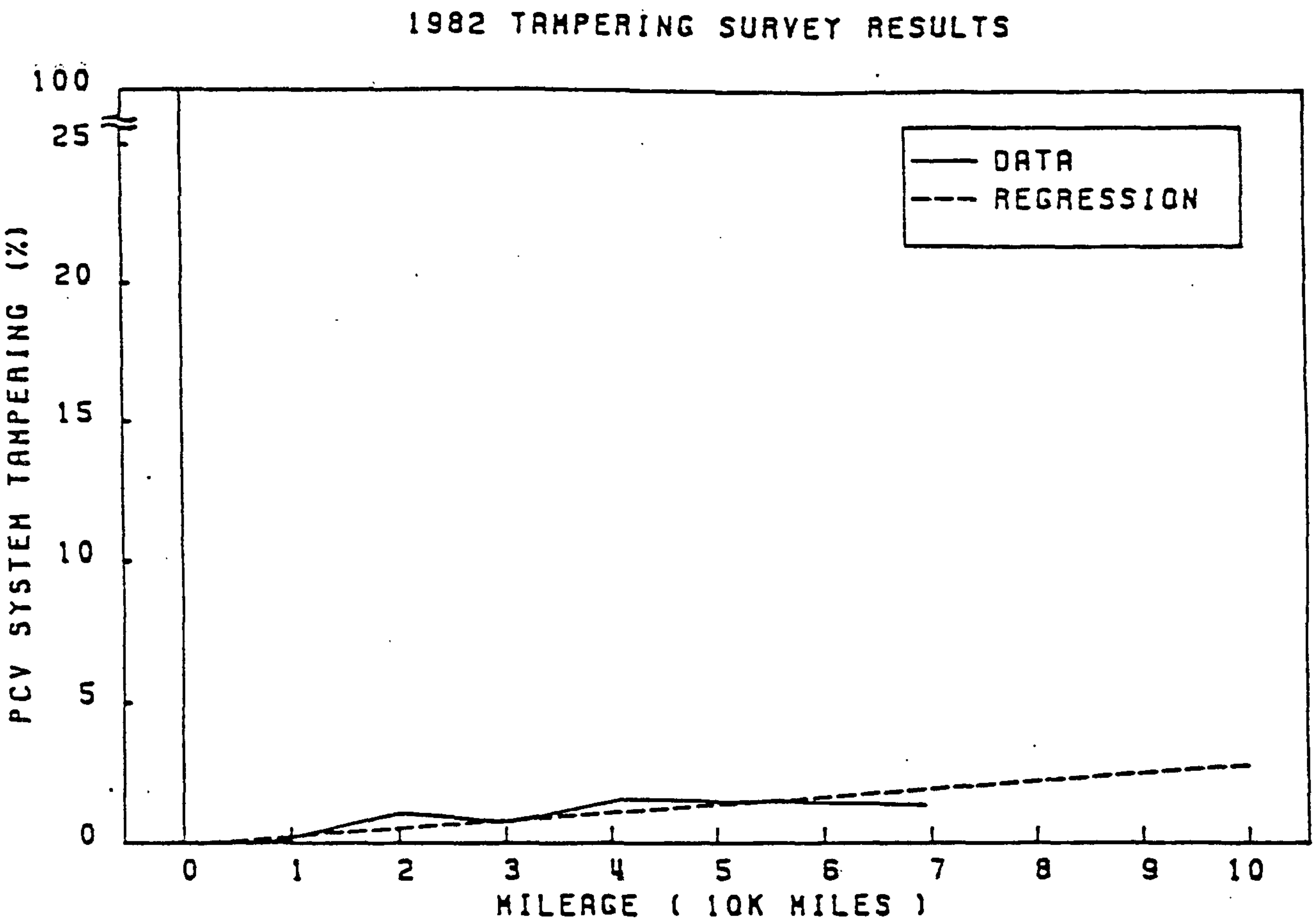
Logically an ordinary I/M program should have little affect on PCV and evaporative canister tampering, since they have little or no affect on idle exhaust emissions measured in I/M programs. Consequently, the tampering rate for these components has been calculated using both I/M and non-I/M areas combined.

In both Table 3 and Table 4 some linear equations contain negative zero mile rates. Since these negative levels are small no effort has been made to force the equation through zero. If, however, a tampering or misfueling rate for a particular model year is calculated to be less than zero in the evaluation year, that rate for that model year is set to zero.

In both Table 3 and Table 4, overlap among tampering types is ignored, so one car can contribute to several of the regression equations. The overall tampering rate at a given mileage is therefore less than the sum of these equations. In estimating excess emissions due to tampering and the benefits of controlling tampering, it is necessary to explicitly account for vehicles with more than one form of tampering, since tampering effects are not always additive. Following sections describe how this was done for each case.

Figure 3

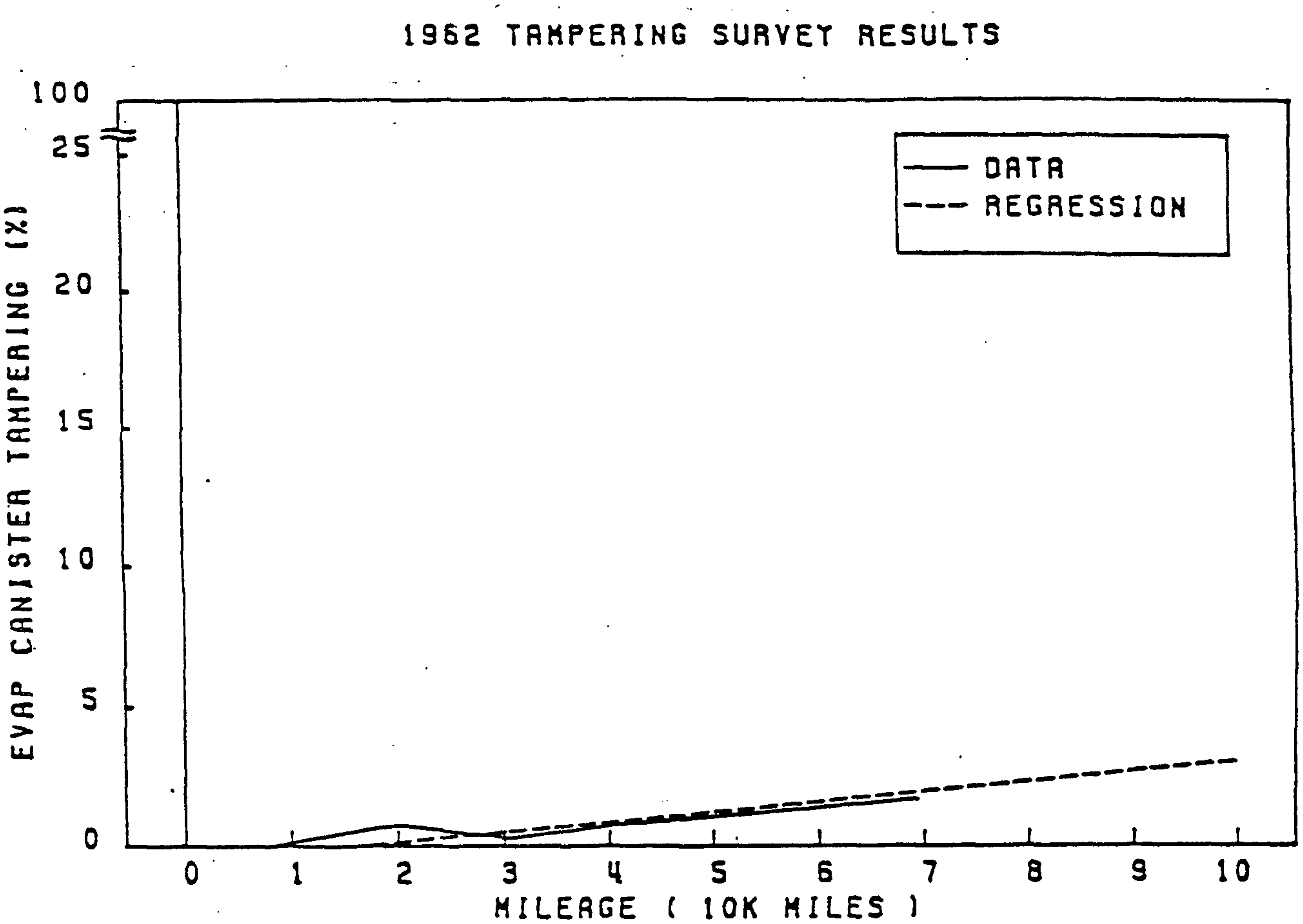
PCV Tampering Rate Versus Mileage*



*Both I/M and Non-I/M areas.

Figure 4

Evaporative Control System Tampering Rate*
Versus Mileage



*Both I/M and Non-I/M areas.

Figure 5

Air Pump Tampering Rate
Versus Mileage

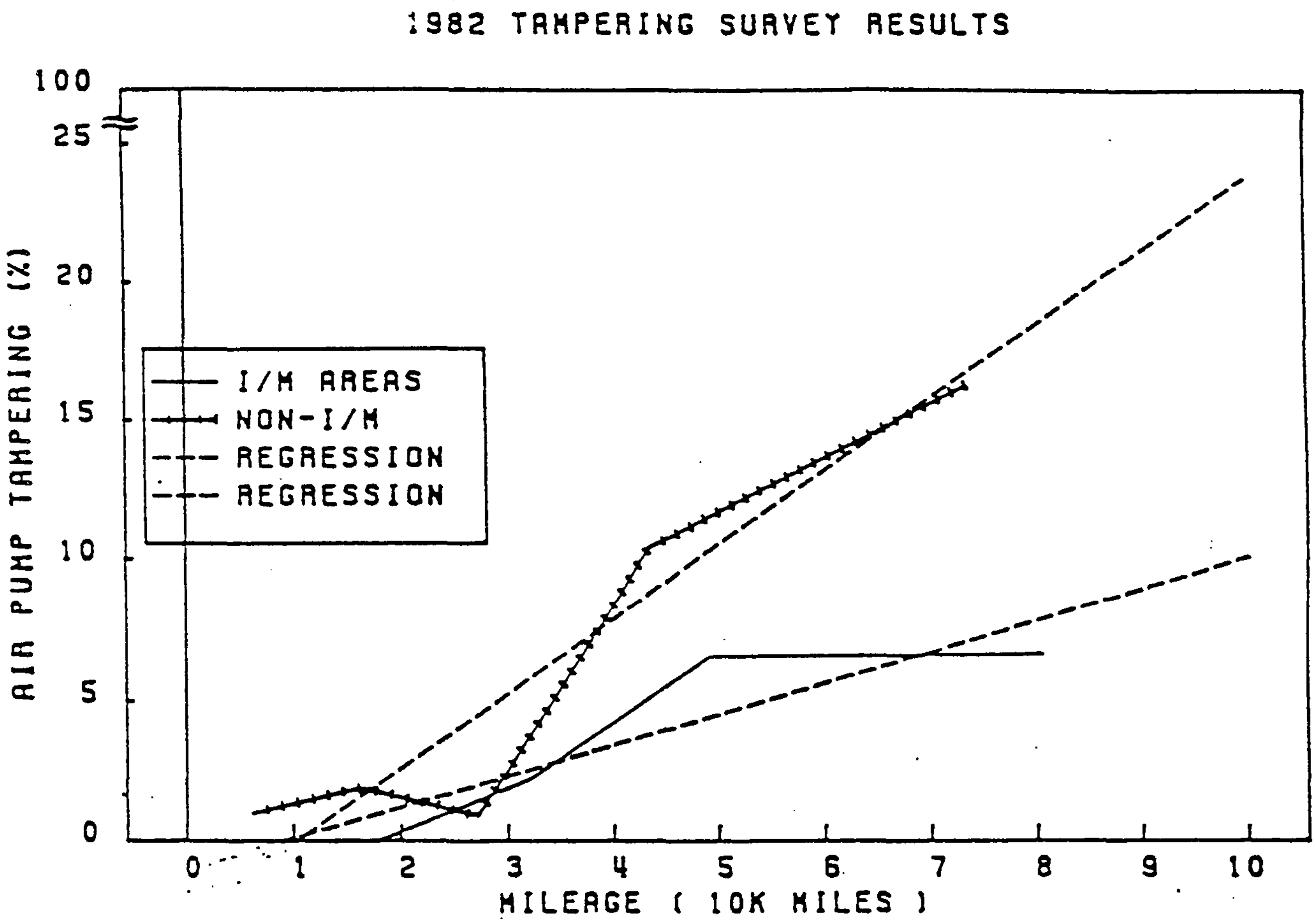


Figure 6

Catalyst Removal Tampering Rate
Versus Mileage

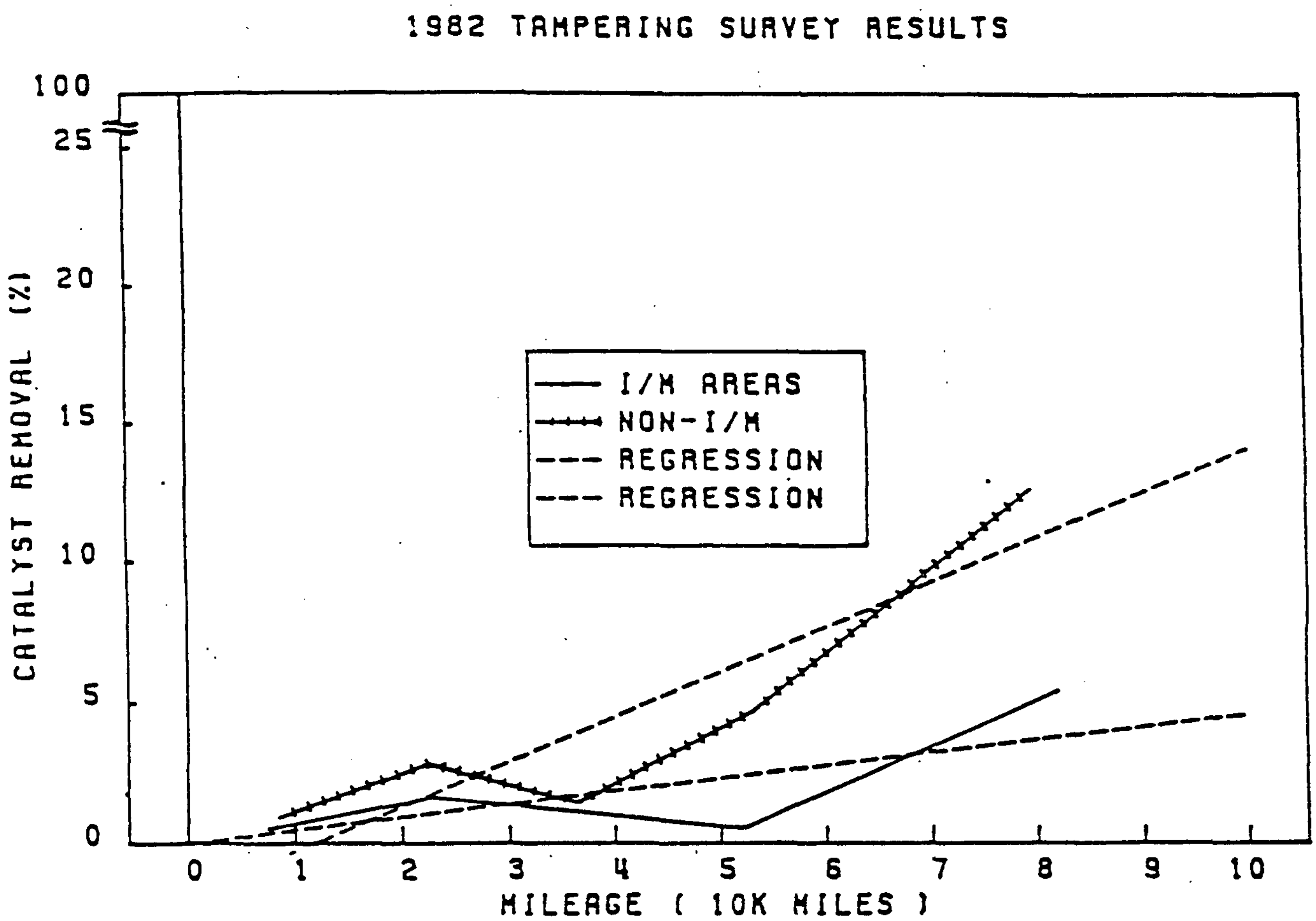
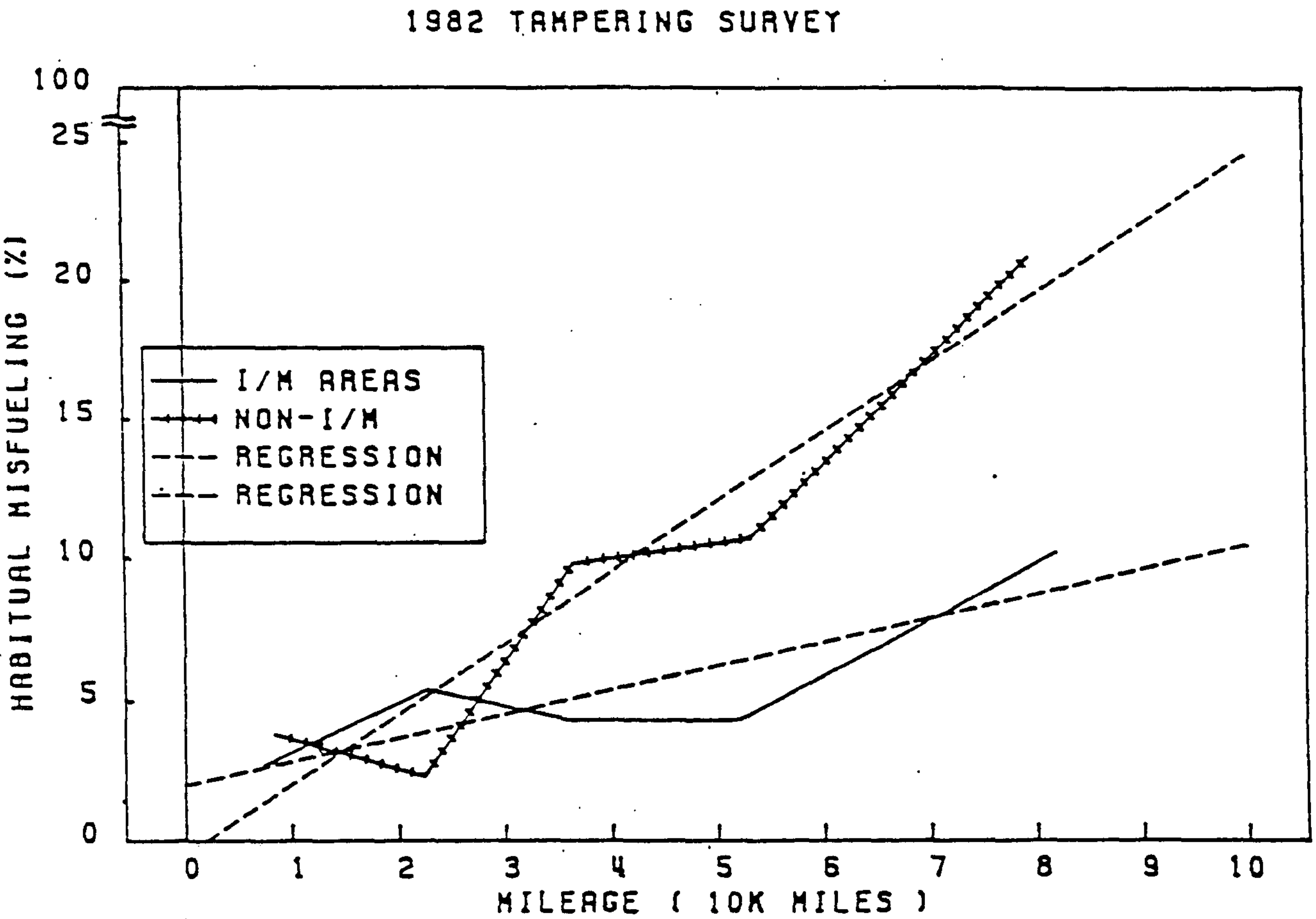


Figure 7

Habitual Misfueling Rate*
Versus Mileage



*Defined as fuel inlet restrictor tampering or greater than 0.05 gm/gal lead in the tank fuel sample.

Table 3

National Average
Tampering Rate Equations
for Non-I/M Areas

Tampering Rate = (zero if mileage is less than M_o)
(A + B x (mileage) otherwise)

Emission Control Component	"M_o" (miles) LDV	"M_o" (miles) LDT	"A" (%) LDV	"A" (%) LDT	"B" (%/10K) Both	Rate at 50,000 Miles (%) LDV	Rate at 50,000 Miles (%) LDT
Air Pump	10,218	0	-2.71	4.89	2.652	10.55	18.15
Catalyst	11,905	0	-1.90	14.72	1.596	6.08	22.70
PCV System*	354	0	-0.01	2.24	0.282	1.40	3.65
Evaporative* Canister	15,278	0	-0.55	2.85	0.360	1.25	4.65
Habitual Misfueling**	1,994	0	-0.50	16.72	2.507	12.04	29.26

*PCV and evaporative canister tampering rates are assumed to be the same in I/M and non-I/M areas.

**Defined as an enlarged fuel inlet restrictor or leaded fuel (lead content greater than 0.05 gm/gal) in tank. Catalyst vehicles only. See text in Section 2.1 for discussion.

Table 4

National Average
Tampering Rate Factors
for I/M Areas

Tampering Rate = (zero if mileage is less than M_o)

(A + B x (mileage) otherwise)

Emission Control Component	"M_o" (miles)		"A" (%)		"B" (%/10K)	Rate at 50,000 Miles (%)	
	LDV	LDT	LDV	LDT	Both	LDV	LDT
Air Pump	909	900	-1.01	-1.00	1.111	4.55	4.56
Catalyst**	0	0	0.00	2.53	0.460	2.30	4.83
PCV*	354	0	-0.01	2.24	0.282	1.40	3.65
Evaporative* Canister	15,278	0	-0.55	2.85	0.360	1.25	4.65
Habitual Misfueling**	0	0	1.98	8.64	0.849	6.23	12.89

*PCV and evaporative canister tampering rates are assumed to be the same in I/M and non-I/M areas.

**Defined as an enlarged fuel inlet restrictor or leaded fuel (lead content greater than 0.05 gm/gal) in tank. Catalyst vehicles only. See text in Section 2.1 for discussion.

3.0 EFFECTS OF TAMPERING AND MISFUELING AND COSTS OF REPAIRS

The effect of a particular disablement of a specific emission control component on vehicle emissions is not easy to quantify. There are many different varieties of similar emission control devices which can differ from manufacturer to manufacturer and from model year to model year. Different varieties can also have a different effect on vehicle emissions depending on the engine type and overall state of tune as well as the condition of other emission control components. A testing program which would evaluate every possible combination of all of these factors would require immense resources. There has been some testing performed over the years by EPA to assess the impact of disablements. FTP and other tests were performed with and without a particular emission control component disconnected. Usually all other emission control components were in operation and the vehicles were in proper tune. The emission increases due to disablement may vary for vehicles in less perfect condition, however EPA believes that these tests provide the best information available on the impact of in-the-field tampering and misfueling on an individual vehicle's emissions.

In this report the individual vehicle benefits from repairs of specific emission control component tampering is taken, when possible, from these types of data. When practical, the existing data are further divided into appropriate model year technology groups to take into account changes in the design and effectiveness of particular emission control components in different model years. When adequate test data from disablement testing are not available, estimates of the benefits were made based on known controlled and uncontrolled emission levels of vehicles of different model years. This report does not address NOx emissions; therefore, the effect of tampering and misfueling on NOx emissions has not been included in the discussion. The few jurisdictions with NOx attainment problems may want to consider including an EGR check in an inspection program. In fact an under-the-hood tampering inspection which ignores the EGR system - the most common tampering target - may lack public credibility after its implementation even if NOx reductions are not needed locally since public understanding of the differences between pollutants may be limited.

3.1 Air Pump

The purpose of the air pump is to supply air to the engine's exhaust in order to promote the oxidation of HC and CO to harmless by-products. The air pump performs this function on both catalyst and non-catalyst vehicles. The air pump is driven by means of a belt which transmits power from the crankshaft as it rotates. This method of powering the air pump is the same as that used to run the alternator and air conditioner compressor. The air pump can, therefore, be found near or on the same plane as the alternator or air conditioning compressor. Its plumbing distinguishes it. Some vehicles are equipped with pulse-air systems which also supply supplemental air to the exhaust stream but without a belt driven pump. Disablement of these systems is less frequent than for air pump systems and identification of disabled pulse air systems is not always as easily accomplished; therefore, this section will deal solely with disabled air pump systems.

The percentage of vehicles equipped with air pumps varies by model year. An analysis of the occurrence of air pump systems on passenger vehicles in the EPA Emission Factor data base was used to establish estimates of the percentage of vehicles in each model year group prior to 1984 equipped with air pump systems. The percentage for 1984 and later vehicles was chosen to be 50%, compared to the 75% observed for the preceding three years: the expectation is that pulse air systems will be substituted for some air pump systems as smaller vehicles become a larger part of the fleet. The percentages used are presented in Table 5.

Table 5

Passenger Car
Percent of Various Model Year Groupings Equipped
With Air Pumps

Model Year Grouping	Assumed Percentage Equipped With Air Pumps
1968-1974	85%
1975-1979	35%
1980	55%
1981-1983	75%
1984 and later	50%

There are three main ways the air pump is normally disabled. First, the belt which drives the pump can be removed. Second, the entire unit -- pump, belt, flexible hoses, steel piping, and even mounting brackets -- can be removed. Third, the output hose from the air pump can be disconnected and/or the air routing valve can be damaged. This last disablement results in the air pump spinning freely and no air being supplied to the exhaust. For purposes of this report, it is assumed that all three of these forms of disablement can be readily identified by trained inspectors during an inspection.

The repairs necessary for these various forms of disablement are self-evident. In most cases, repair can be accomplished by simply installing a new belt or reconnecting a hose. An average repair cost of $20 has been assumed for this analysis. This estimate takes into account the few cases in which an expensive repair or reinstallation of an air pump is expected to be required.

The HC and CO emission increases which accompany air pump disablement for 1975-1979 model year vehicles were quantified by examining data from 11 vehicles (1975-1979 model years) tested with and without their air pumps operational. Nine of these vehicles came from the 300-car Restorative Maintenance program[4]. The other two vehicles came from a test program which examined regulated and unregulated exhaust emissions from catalyst vehicles [5]. These data indicate that upon air pump disablement the average HC emission level increases 1.2 gm/mi and the average CO emission level increases 28.0 gm/mi. (One source of uncertainty in the analysis has to do with the fact that the 11 vehicles used to determine the emission effects of air pump disablement were all in tuned-up condition. The emission increases due to air pump disablement for vehicles in less perfect condition may vary.)

There is some uncertainty as to the HC and CO effects of air pump disablement for pre-1975 model year vehicles as no similar data are available. However, these vehicles contribute only a very small share of the fleet's emissions over the life of an I/M program. They are assumed to show the same absolute effect due to air pump tampering as 1975-1979 vehicles. In absolute terms, the assumed effect is an increase of 1.2 gm/mi HC and 28.0 gm/mi CO. This assumption is reasonable and due to the small contribution made by these vehicles, does not significantly affect the analysis.

For 1981 and later model year vehicles, the effects of air pump disablement were quantified by examining the results of EPA laboratory programs which took four vehicles representative of 1981 and later technology and tested them with and without their air pumps operational. In addition, one representative 1980 Ford vehicle tested in an EPA surveillance program in California was found to have its air pump disabled due to having one of the vacuum control hoses kinked closed. This vehicle was tested as-received (air pump disabled) as well as after having the air pump repaired (vacuum hose unkinked). Data from these five vehicles indicate that upon air pump disablement for 1981 and later vehicles the average HC emission level increases 0.5 gm/mi and the average CO emission level increases 15.0 gm/mi.

No comparable test data are available for 1980 model year vehicles. For purposes of this report, 1980 model year vehicles were assumed to have the same emission effects for air pump disablement as 1981 and later vehicles. This is because the 1980 emission standards (0.41 gm/mi HC; 7.0 gm/mi CO) are closer to the 1981 standards (0.41 gm/mi HC; 3.4 gm/mi CO) than to the 1975-1979 standards (1.5 gm/mi HC; 15 gm/mi CO). All of the assumed benefits from repair of air pumps are summarized in Table 6.

Table 6

Increase in HC and CO Emissions
Due to Air Pump Disablement

Model Years	Increase in HC Emissions (gm/mi)	Increase in CO Emissions (gm/mi)
Pre-1980	1.20	28.01
1980 and Later	0.48	14.98

3.2 Catalyst

Automotive catalytic converters lower HC and CO emissions in the exhaust by catalytically promoting the oxidation of HC and CO to harmless by-products. (Catalysts on most 1981 and later vehicles also help reduce NOx emissions.) Catalysts are normally mounted on the underside of the vehicle, along the exhaust pipe and before the muffler; however, a few vehicles have catalysts mounted inside the engine compartment. Tampering with the catalyst usually takes the form of simple removal of the catalyst and replacement with an exhaust pipe. Some automotive parts suppliers carry a complete selection of catalytic converter "test pipes" which can be bolted into the gap left in the exhaust pipe after the converter is removed.

Using carefully placed mirrors or a mirror on an extension, the underside of an inspected vehicle can be examined for the presence of the converter. A catalytic converter is easily distinguished from a muffler since it is made of stainless steel and will not rust. If a catalyst is not observed by checking underneath a 1975 or later model year vehicle, it will be necessary to open the engine compartment hood and either locate the catalyst there or confirm from the emissions label put on every vehicle or from reference literature that the vehicle was not equipped with a catalyst at the factory. Colorado State University has recently published a book which contains this information.[6] For this analysis all 1975 and later passenger cars are assumed to have been equipped with some type of catalyst.

Obviously repair will require installation of a new catalyst (or reinstallation of the old one if it was saved). This could be a relatively expensive repair. New catalysts now cost between $172 and $320. Most of this cost is dealer and distributor markup. However, most vehicles do not require the more expensive converters. A market for lower-priced non-OEM catalysts may also appear, if new OEM catalysts are not a requirement of the program. Lower-priced replacement catalysts are possible if enough demand is created by a catalyst check. An average cost of $200 per catalyst has been assumed for this analysis.

The HC and CO emission increases which accompany catalyst removal were determined by examining the engine-out (before the catalyst) emissions of a number of vehicles involved in several test programs. These vehicles received both baseline tests (all components functional) and tests with the catalyst removed. By comparing the results of the two tests the percent increase in emissions which accompanies catalyst removal can be calculated. Most catalysts are removed with the intent of also using leaded fuel. There is evidence that the use of leaded fuel itself will cause an increase in HC emissions due to lead deposits in the engine. This effect has been ignored in this analysis. Nine vehicles with oxidation catalysts and four vehicles with three-way catalysts were tested.

1980 model year vehicles were assumed to have the same increase as 1975-1979 vehicles. This was done because the catalysts used on 1980 vehicles are more like those used on 1975-79 vehicles than those used on 1981 and later vehicles. These figures are presented in Table 7.

Insufficient testing has been conducted to determine how the effect of catalyst removal varies with the average mileage of a fleet. It is, therefore, assumed that the gram-per-mile increase in emissions from catalyst removal remains the same throughout a vehicle's life, regardless of mileage. This will mean that the percent change due to catalyst removal reduces with increased mileage. This makes sense since very little of the deterioration of the fleetwide emission factor is due to catalyst aging. Most is due to in-use maladjustments and failures of other emission components. Removing the catalyst on a vehicle that has high engine-out emissions can be expected to have a smaller percentage effect than removing a catalyst from a tuned vehicle, since there is usually a relative shortage of oxygen in the exhaust of maladjusted vehicles. This does mean that the estimates will include some degree of uncertainty, especially when applied to high mileage vehicles.

Table 7

Increase in HC and CO Emissions
Due to Catalytic Converter Removal

Model Years	Increase in HC Emissions (gm/mi)	Increase in CO Emissions (gm/mi)
1975-80	3.84	38.02
1981 and Later	1.68	17.47

3.3 Habitual Misfueling

The use of leaded gasoline in a vehicle equipped with a catalytic converter, referred to as "misfueling" in this report, will cause a steady contamination of the catalyst material resulting in lower and lower catalytic efficiency. The result of continued misfueling will, therefore, be higher exhaust emission levels as the catalyst loses its ability to convert pollutants into less harmful substances. It has been estimated that after as few as three consecutive tankfuls of leaded fuel, the majority of the catalyst's ability to convert pollutants will be permanently lost, even if the vehicle owner resumes use of unleaded fuel.

Determining the effects of misfueling is more difficult than for most other checks described in this report, since the increase in emissions is heavily dependent on catalyst efficiency and thus the intensity of the misfueling. Misfueling performed sporadically or in temporary fuel shortages, often refered to as "casual" misfueling, may not permanently destroy the catalyst's function, although there will be some lasting reduction in catalyst efficiency. This section estimates only the effect of habitual misfueling, based on tests of vehicles operated on leaded fuel for many tankfuls. There is insufficient test data to estimate the long term effects of casual misfueling, therefore casual misfueling is assumed to have a comparatively negligible long term effect on fleet emissions.

Even in cases of habitual misfueling, some very low level of catalyst efficiency may still remain. For this reason the effect of misfueling is not as great as removal of the catalyst on an individual basis. Since the overall rate of misfueling is larger than that of catalyst removal, however, the overall effect on emissions is more serious.

EPA has previously estimated the average effect on HC and CO emissions of misfueling. These estimates were used in the mobile source emission factors model (MOBILE2) to adjust the emissions of EPA's essentially misfueling-free emission factors test sample to reflect the extent of misfueling in the fleet as a whole. These estimates were used in the form of a percent increase over the average low-mileage emissions of non-misfueled cars. In this analysis all data now available were examined to recalculate a gram per mile increase. This data included data from nine oxidation catalyst vehicles and seven 1981 and later three-way catalyst vehicles. The emission increases for 1981 and later model year vehicles include any effect misfueling has on oxygen sensor performance in the closed-loop vehicles in the sample. Most vehicles were run on at least 10 tankfuls of leaded fuel. Estimates for 1980 vehicles assume the same emission increases as for 1975-79 vehicles since their catalysts are similar. Table 8 presents the estimated effect on emissions as a gram-per-mile increase. As with catalyst removal, the increase expressed in grams per mile is assumed not to change with mileage.

Table 8

Increase in HC and CO Emissions
Due to Misfueling

Model Years	Increase in HC Emissions (gm/mi)	Increase in CO Emissions (gm/mi)
1975-80	2.67	17.85
1981 and later	1.57	11.07

The average cost of replacing a misfueled catalyst will be less than replacing a removed catalyst since in some instances, only the catalytic material within the catalyst need be replaced. Some manufacturers catalysts have a removable plug for this purpose and provide kits with replacement catalytic material. In this analysis, the average cost for replacing misfueled catalysts will be $150.

If repair of the fuel inlet restrictor is required, replacement cost of the restrictor will vary substantially. Some vehicles filler neck can be easily replaced while others would require replacement of the entire fuel tank. It is possible, however, to repair the fuel inlet by simply glueing in a metal washer using a gasoline resistant epoxy. It is likely that the majority of vehicle owners will seek out inexpensive repairs so that the average cost of repair will be small. In this analysis the average repair cost for tampered fuel inlet restrictors will be $30.

3.4 Positive Crankcase Ventilation System

The positive crankcase ventilation (PCV) system in automobiles provides a means to purge the crankcase of gases escaping from the cylinders by the piston rings. These gases are detrimental to engine life since they dilute and break down engine oil and are corrosive. Originally these gases were vented to the atmosphere, but with the advent of pollution control, these gases have been diverted to the vehicle's intake system for recombustion. The value of the PCV system is well known and established; therefore, its deliberate disablement is relatively rare. Only a small percentage of the vehicles in EPA's surveys had their PCV vacuum hoses disconnected resulting in the blowby gases being released to the atmosphere. Other PCV problems, such as disconnected "fresh air" hoses, also occur but are not believed to cause a significant increase in emissions from the automobile.

Disablement of the PCV system usually takes the form of a disconnected vacuum line or missing components. These disablements are easily identified either visually or by a simple check for vacuum at the fresh air hose. Since all of the components are relatively inexpensive, and since many disablements are simply disconnections, repair costs are assumed to be $10.

The primary effect of a disabled PCV system is the increase in non-exhaust HC emissions. There is not enough data from recent testing programs on the effects of PCV disablement on current vehicles to determine with complete certainty how much HC emissions would increase. However, it is estimated in MOBILE2 that the average crankcase HC emissions from early 1960's vehicles without PCV systems were about 4.1 gm/mi[7]. At the time, most engines had eight cylinders. It is reasonable to assume that uncontrolled crankcase emissions are proportional to the number of cylinders, so current and future vehicles, which will on average have fewer than eight cylinders, will have proportionately less of an increase when their PCV system is disabled. Based on this assumption, 6-cylinder engines should have a 3.08 gm/mi effect and 4-cylinder engines a 2.05 gm/mi effect.

To estimate the average effect of PCV disablements, the mix of four, six, and eight cylinder engines in the various model year groups must be determined. Using information on the past and predicted production of vehicles produced in the U.S.[8] and assuming that nearly all imported vehicles are equipped with four cylinder engines, the percent mix of engine sizes can be estimated for each model year group. These values were used to combine the estimates for crankcase HC emissions from each engine size to determine an overall figure for each model year group. These overall figures are presented in Table 9.

Table 9

Increase in HC Emissions
Due to PCV Disablement

Model Years	Increase in HC Emissions (gm/mi)
Pre-1968	3.80
1968-1970	3.74
1971-1974	3.51
1975-1977	3.44
1978-1979	3.29
1980	2.83
1981-1982	2.68
1983 and Later	2.49

3.5 Evaporative Emission Control System

The evaporative control system is intended to capture the gasoline fumes which are naturally given off whenever gasoline is stored and used. These fumes are made up of pure hydrocarbon (HC) emissions and represent a significant portion of a vehicle's total HC emissions. The evaporative control system captures the fumes given off by both gasoline in the fuel tank and the gasoline in the carburetor (early systems dealt only with evaporative losses from the fuel tank). These fumes are stored in a charcoal canister, usually mounted in the engine compartment, and then routed to the engine for burning at appropriate times.

Disablement can take the form of disconnected or cut hoses, missing canisters, or removal of the entire system. Once again, these forms of disablement are identifiable by trained inspectors. A quick visual check can usually determine whether the canister is still intact and if all the hoses are attached to it. An average repair cost of $10 has been assumed since most repairs will involve simply reconnection of hoses.

The emission increases assigned to each grouping to represent a tampered system come from MOBILE2. The passenger car model year groupings used in MOBILE2 are: pre-1970, 1970-1971, 1972-1974, 1975-1977, 1978-1980, 1981 and later. The assumption used to determine the increase in emissions due to evaporative system disablement for pre-1977 vehicles was that any disablement would return the vehicle to uncontrolled levels (pre-1970) of evaporative HC. This assumption is necessary since there has been no disablement testing done for evaporative control systems on these older vehicles. These vehicles are similar, however, in size and design to the pre-controlled vehicles so that the error should be small. Newer vehicles have smaller carburetors and gas tanks and therefore should emit less evaporative emissions even if tampered. Two 1981 model year vehicles have been tested with and without disabled evaporative canisters. As expected the average evaporative emissions with the evaporative canister disconnected were less than for pre-controlled vehicles. Since downsizing for passenger cars began with the 1977 model year and leveled off after the 1980 model year the uncontrolled emission levels for those model years were interpolated between the evaporative emission levels of pre-1970 vehicles and the test results from the 1981 vehicles. The resultant increases in evaporative HC emissions due to disablement of the evaporative control system are tabulated in Table 10.

Because of different assumptions for average mileage traveled for light-duty trucks below 6000 pounds, the increases in evaporative emissions for these vehicles are somewhat higher. Light-duty trucks over 6000 pounds built before the 1979 model year were not equipped with evaporative control systems other than the PCV system. The increase in evaporative emissions for light-duty trucks also reflect the differences in mileage assumptions and assume no downsizing.

Table 10

Increase in HC Emissions Due To
Evaporative System Disablement

Model Years	Increase in Evaporative HC Emissions (gm/mi) Passenger Cars	Light-Duty Trucks (0-6000 lbs)	(6000-8500 lbs)
1971	0.69	0.81	-
1972 -1976	1.18	1.39	-
1977	1.01	1.39	-
1978	1.70	2.41	-
1979	1.53	2.41	1.88
1980	1.36	2.41	1.88
1981 and Later	1.50	2.58	2.01

3.6 Light-Duty Truck

In MOBILE2 light-duty vehicles (passenger cars) are treated separately from light-duty trucks. In fact, MOBILE2 divides light-duty trucks into two groups, those less than 6,000 lbs gross vehicle weight (LDT1) and those between 6,000 and 8,500 lbs (LDT2). Since light-duty trucks make up a significantly smaller portion of the vehicle fleet than passenger cars, less is known about the occurrence and effects of tampering on these vehicles than on passenger cars.

Since the emission standards applicable to light-duty trucks (LDTs) in a given calendar year are often quite different from passenger cars, it can be expected that emission control devices used on LDTs, such as air pumps and catalysts, will differ in a given calendar year from those on passenger cars. However, as the emission and fuel economy standards for light-duty trucks become more and more stringent, these vehicles will closely resemble passenger cars with similar emission standards. Table 11 presents the assumptions used in this report regarding the number of light-duty trucks equipped with various emission control components. These estimates were taken from EPA's emission factor samples where adequate samples were available. Otherwise the percentages were assumed to be equal to equivalent passenger car percentages.

Table 11

LDT Emission Control Equipment Assumptions

Percent of Vehicles Equipped With Components

LDT Type	Model Year Grouping	Air Pumps	Catalyst	PCV	Evaporative Canister
LDT1	1968-1970	85%	-	100%	-
	1971-1974	85%	-	100%	100%
	1975-1978	35%	70%	100%	100%
	1979-1983	42%	100%	100%	100%
	1984 and Later	75%	100%	100%	100%
LDT2	1968-1970	-	-	100%	-
	1971-1974	-	-	100%	-
	1975-1978	-	-	100%	-
	1979-1983	50%	100%	100%	100%
	1984 and Later	75%	100%	100%	100%

In general, the per-vehicle emission benefits estimated for passenger cars have been used for light-duty trucks using the same emission control components. The primary differences will be in the model years using a particular estimated benefit. For example, only the 1979 and later LDT2s are assumed to have been equipped with catalysts and therefore would receive emission benefits from a catalyst inspection program.

4.0 CALCULATION OF EXCESS EMISSIONS DUE TO TAMPERING AND MISFUELING

This section calculates the additional, or excess, emissions caused by all four types of tampering and habitual misfueling combined. The purpose of doing so is to illustrate the size of the problem to be addressed by an anti-tampering or anti-misfueling program. This section also illustrates the relative importance of different forms of tampering. Section 5.0 presents estimates of how much emission reduction is possible from different types of programs.

4.1 Discussion of Method

The approach used in this report to estimate the effects on composite emissions of vehicles due to tampering and misfueling is similar to MOBILE2, in that a separate benefit is calculated for each model year of each vehicle type, and then the results are weighted by the distribution of vehicle-miles-traveled (VMT) for the model years on the evaluation date of interest. MOBILE2, however, is much more sophisticated in that it can adjust for differing scenarios of speeds, temperature, and mixture of vehicle types and vehicle miles traveled. For simplicity, all calculations in this report assume standard MOBILE2 operating conditions and default values. The results should be adjusted as described in Section 6.0 to reflect local non-standard FTP conditions.

To calculate the excess emissions due to tampering and misfueling for a given model year, first the appropriate emission level increase due to that particular form of tampering or misfueling on individual vehicles of that model year should be selected from Section 3.0 along with the fraction of vehicles equipped with that emission control component. Next the tampering or misfueling rate for that model year in the evaluation year must be calculated using the appropriate equation presented in Section 2.0. I/M areas and non-I/M areas will have different rate equations.

When the tampering rate and the individual vehicle repair benefit in grams-per-mile are all multiplied together, the result is gram-per-mile excess emissions from the average vehicle of that model year. Once excess emissions are calculated for all model years covered, the excess emissions are weighted by their appropriate VMT ratio and added to give composite fleet excess emissions in grams-per-mile. These estimates can then be converted to tons by multiplying by the average mileage accumulation of the fleet in the last calendar year prior to the evaluation date.

It should be noted that some of the excess emissions calculated in this way are already reflected in the total fleet inventory as calculated by MOBILE2, since MOBILE2 emission factors incorporate the effect of some tampering, primarily misfueling. Of the tampering types, MOBILE2 least accounts for catalyst removal, which appeared to be less frequent when MOBILE2 was developed than it now appears. Future revisions of MOBILE2 will attempt to correctly account for all relevant forms of tampering. Until such revisions are completed, the benefits from anti-tampering and anti-misfueling programs can be subtracted directly from the 1987 inventory as calculated by MOBILE2.

4.2 Example Calculation

As an example of how excess emissions from tampering and misfueling are estimated, the calculation of the HC emissions from disabled air pump systems on passenger cars will be described in detail in this section. For simplicity, it is assumed for this example only that all cars with air pump tampering have no other form of tampering. Actual overlap is accounted for in the next subsection. All benefits calculated in this report use this basic methodology to compute the excess emissions caused by tampering and misfueling, with modifications described in Section 5.0.

Table 12 presents the basic calculation of the milligram-mile increase in HC emissions of all passenger cars caused by air pump disablements. It is assumed that this is a non-I/M area and the evaluation date is January 1, 1988. For each model year a rate of tampering is calculated using the coefficients presented in Section 2.0 for non-I/M areas and EPA's standard estimates of the average mileage of each model year on January 1, 1988. The fraction of vehicles equipped with air pumps and the per vehicle increase in HC emissions (in grams-per-mile) due to disablement of the air pump in each model year is taken from the discussion in Section 3.1. The vehicle-miles-traveled (VMT) fraction on the evaluation date is taken from MOBILE2 for the evaluation date. When the factors are multiplied together and summed, the total (expressed here in milligrams-per-mile) represents the average increase in HC emissions of every passenger car due to those cars with disabled air pumps.

In 1988 the average mileage accumulation for passenger cars is about 11,460 miles per year. The estimate of increase in HC emissions in milligrams-per-mile can be easily converted to tons by estimating the number of vehicles in the area of interest and multiplying the milligrams-per-mile increase times the average annual mileage accumulation per vehicle times the number of vehicles and converting the result into tons. For example, in this case for 100,000 passenger cars using the result in Table 12:

$$57.83 \text{ mg/mi} * 11{,}460 \text{ mi} * 100{,}000/(9.072 \times 10^8 \text{ mg/ton}) = 73.1 \text{ tons}$$

Table 12

Example Calculation of
Excess Emissions From Tampered Air Pumps

Model Year	Evaluation Year Air Pump Tampering Rate	Fraction of Vehicles With Air Pumps	Increase in HC Emissions Due to Disablement (gm/mi)	Evaluation Year VMT Fraction (1/1/88)	Resulting Excess (mg/mi)
Pre-1970	45.5	.00*	1.20	.007	0.00
1970	44.2	.85	1.20	.001	0.40
1971	42.7	.85	1.20	.001	0.63
1972	41.1	.85	1.20	.003	1.44
1973	39.4	.85	1.20	.007	2.71
1974	37.5	.85	1.20	.011	4.21
1975	35.5	.35	1.20	.018	2.68
1976	33.3	.35	1.20	.025	3.52
1977	31.0	.35	1.20	.031	4.04
1978	28.6	.35	1.20	.045	5.36
1979	26.0	.35	1.20	.057	6.27
1980	23.3	.55	0.48	.067	4.11
1981	20.4	.75	0.48	.075	5.48
1982	17.4	.75	0.48	.095	5.95
1983	14.2	.75	0.48	.113	5.79
1984	10.9	.50	0.48	.104	2.74
1985	7.5	.50	0.48	.083	1.48
1986	3.9	.50	0.48	.109	1.01
1987	0.1	.50	0.48	.120	0.04
1988	0.0	.50	0.48	.028	0.00
Total				1.000	57.83 mg/mi

*Although some 1968 and 1969 model year vehicles were equipped with air pumps, they represent only a small portion of the VMT fraction for the pre-1970 vehicles. Therefore to increase the accuracy of the estimate in this and all calculations, the additional emission contribution from these two model years has been ignored.

In order to estimate the benefits of anti-tampering and anti-misfueling programs the result would be multiplied by an effectiveness factor for the proposed program. Different types of programs will have different effectiveness factors and they may depend on model year. These factors for inspection programs are discussed in Section 5.1 for I/M areas and in Section 5.2 for non-I/M areas. Inspection programs which are not periodic and other non-inspection programs are discussed in Section 5.3.

4.3 Emissions Due to Tampering and Misfueling: All Types

Tables 13 and 14 present the estimates of excess emissions on January 1, 1988 due to all forms of tampering and habitual misfueling using the estimates of tampering and misfueling rates as discussed in Section 2.0 and the increases in emissions due to tampering and misfueling from Section 3.0. As discussed earlier these results have not been adjusted for non-standard conditions. Section 6.0 discusses a way to adjust these figures to local conditions. Table 13 assumes that there is no I/M program in the area of interest, while Table 14 assumes the existence of an I/M program. For comparison, MOBILE2 predicts that witnout I/M on January 1, 1988 the total composite emissions from these vehicles to be:

	HC	CO
° Passenger Cars	2.42 gm/mi	27.47 gm/mi
° Light-Duty Trucks:		
(6000 lbs)	2.59 gm/mi	24.80 gm/mi
(6000-8500 lbs)*	1.57 gm/mi	14.11 gm/mi

These MOBILE2 emission levels, however, assume only an 8% rate of misfueling and contain much smaller rates of tampering than observed in the tampering surveys.

Section 5.0 will discuss how anti-tampering and anti-misfueling programs can reduce the excess emissions and estimate the benefits of these programs.

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*These heavier trucks emit more HC and CO emissions than passenger cars or the lighter trucks of the same model year, however, MOBILE2 assumes that the majority of the VMT accumulated by these trucks is accumulated by the new (and cleaner) model years so that this composite number shows a lower contribution than would occur if the distribution of VMT were similar to the passenger cars.

In the data used to generate Tables 13 and 14, there is an overlap in the incidence of tampering and misfueling. To account for this overlap assumptions were made in order that the excess emission levels were not double counted. In the 1982 survey data, about 30% of the passenger cars and 70% of the light-duty trucks with disabled air pumps also either had the catalyst removed or had been misfueled. Therefore, it has been assumed that the catalyst removal or misfueling is the primary problem causing excess emissions and no additional excess emissions is caused by the disablement of the air pump. The excess emissions from such vehicles is included in the catalyst or misfueling category in Tables 13 and 14. There is also overlap between misfueling and catalyst removal. It is assumed that a vehicle which has had the catalyst removed will emit the same regardless of whether it is misfueled or not. Only vehicles with intact catalysts which are also misfueled fall into the misfueled category. In the 1982 survey, 31% of the passenger cars and 55% of the light-duty trucks which were habitually misfueled had the catalyst removed.

Table 13

Per Vehicle Excess Emissions Due
to Tampering and Misfueling
in Non-I/M Areas
(January 1, 1988)

Emission Control Component	Composite Per Vehicle Increase in Emissions (mg/mi)					
	Passenger Car		Light-Duty Truck (6000 lbs)		Light-Duty Truck (6000-8500 lbs)	
	HC	CO	HC	CO	HC	CO
Air Pump*	44.27	1183.92	57.25	1336.31	27.48	641.47
Catalyst	221.44	2226.25	818.53	8104.31	714.52	7074.43
Misfueling**	214.00	1462.49	325.04	2173.04	271.67	1816.21
PCV System	53.19	0.0	112.47	0.0	84.21	0.0
Evaporative Canister	26.17	0.0	116.44	0.0	75.05	0.0
Totals(mg/mi)	559.07	4872.65	1429.74	11613.66	1172.93	9532.11
Totals(gm/mi)	0.56	4.87	1.43	11.61	1.17	9.53
Tons***	506.37	4413.33	113.22	919.70	72.72	590.97

*Because some of the vehicles with disabled air pumps also had catalysts removed or had been misfueled, the excess emissions due to the overlap has been removed from the air pump category to avoid double counting.

**Because of the overlap between catalyst removal and misfueling, the excess emissions due to the overlap have been removed from the misfueling category to avoid double counting.

***Annualized tons calculated assuming a fleet of 100,000 vehicles of all types and using MOBILE2 estimates of passenger car and light-duty truck vehicle miles traveled.

Table 14

Per Vehicle Excess Emissions Due
to Tampering and Misfueling
in I/M Areas
(January 1, 1988)

Emission Control Component	Composite Per Vehicle Increase in Emissions (mg/mi)					
	Passenger Car		Light-Duty Truck			
			(6000 lbs)		(6000-8500 lbs)	
	HC	CO	HC	CO	HC	CO
Air Pump*	18.84	504.41	16.82	392.52	4.83	112.66
Catalyst	75.29	758.37	176.18	1744.38	143.24	1418.23
Misfueling**	99.01	678.85	141.85	948.34	125.35	838.03
PCV System	53.19	0.0	112.47	0.0	84.21	0.0
Evaporative Canister	26.17	0.0	116.44	0.0	75.05	0.0
Totals(mg/mi)	272.50	1941.63	563.76	3085.25	432.68	2368.93
Totals(gm/mi)	0.27	1.94	0.56	3.09	0.43	2.37
Tons***	246.81	1758.60	44.65	244.33	26.82	146.87

*Because some of the vehicles with disabled air pumps also had catalysts removed or had been misfueled, the excess emissions due to the overlap has been removed from the air pump category to avoid double counting.

**Because of the overlap between catalyst removal and misfueling, the excess emissions due to the overlap have been removed from the misfueling category to avoid double counting.

***Annualized tons calculated assuming a fleet of 100,000 vehicles of all types and using MOBILE2 estimates of passenger car and light-duty truck vehicle miles traveled.

5.0 BENEFITS OF ANTI-TAMPERING AND ANTI-MISFUELING PROGRAMS

This section estimates the benefits of anti-tampering and anti-misfueling programs using the data and method described in previous sections. As discussed in the previous sections, the benefits of anti-tampering and anti-misfueling program will depend on three major factors.

These are:

- The rate of tampering and misfueling in the area.
- The amount of excess emissions caused by tampering and misfueling.
- The effectiveness of the program in eliminating tampering and misfueling.

The rate of tampering and misfueling was addressed in Section 2.0. The amount of excess emissions caused by tampering was discussed in Sections 3.0 and 4.0. This section will discuss the effectiveness of specific anti-tampering and anti-misfueling programs and estimate their benefits in both I/M and non-I/M areas.

There are several factors which influence the effectiveness of anti-tampering and anti-misfueling programs;

- The perceived incentives for tampering and misfueling.
- The ability of the program to detect tampering and misfueling
- The size of the penalty for tampering and misfueling.
- Enforcement action to assure that the program operates as designed.
- The number of vehicle owners who continue to tamper or misfuel after the program begins.
- The rate of inadvertent disablements.

Each of the following sections will address these issues and decide on an appropriate level of effectiveness for each type of disablement and each program design in both I/M and non-I/M areas.

In order to claim the full benefits estimated in the tables in this section the program would require the following elements to assure operation as designed. Programs lacking some of these elements are feasible but would require individual evaluation.

- Inspector training.

- A method to assure vehicle owner compliance with the program requirements.

- A method to determine which vehicles require which emission control components.

- Data collection to monitor the program and identify bad actors among inspectors, inspection stations, and repair facilities.

- Periodic audits of inspection stations in decentralized programs to verify inspector proficiency and compliance with other program requirements.

- Enforcement actions such as using an "unmarked" test car in decentralized programs to assure inspector compliance with program rules.

- A referee system for decentralized programs to resolve disputes.

- A public awareness program.

Public acceptance of a vehicle inspection program which requires catalyst replacement where misfueling is indicated will be improved if there is a visible program to require compliance with fuel regulations on the part of retail gasoline outlets. The Plumbtesmo test may fail a vehicle whose only use of leaded fuel was inadvertent due to contamination or mislabeling at the pump. It is important that these occurrences be minimized for equity reasons. Therefore if a State or local area intends to use the Plumbtesmo test to detect misfueling, there should also be a program of unscheduled periodic inspections of retail gasoline outlets. This program should inspect the diameter of fuel pump nozzles, determine that the pumps are properly labeled, and analyze the lead content of the fuel being sold.

Benefits from anti-tampering and anti-misfueling programs are obtained by addressing two problems, existing tampering and misfueling and the tampering and misfueling which has not yet occurred. Existing tampering and misfueling can only be addressed by identifying tampered and misfueled vehicles and requiring their repair. Tampering and misfueling that has not yet occurred can be detected when it does occur or can be prevented from occurring by the assurance of detection and penalty in the program. Tampering and misfueling which has already occurred is calculated as the rate of occurrence at the start date of the tampering inspection program, assumed to be January 1, 1984 for the benefits presented here. The tampering and misfueling which will occur between the program start date and the evaluation year without the intervention of the inspection program is the difference in the rates calculated for the start date of the program and the evaluation date assuming no program.

5.1 I/M Programs

I/M programs offer a unique opportunity to address the tampering issue. Although I/M programs will reduce the incidence of tampering and misfueling to some extent without any special activity, the fact that large segments of the fleet are periodically inspected provides an opportunity to specifically check for tampering and misfueling. Some I/M programs have seen the advantages in expanding the inspection and already include a check for tampering.

Section 2.0 discussed the effect of I/M on tampering rates. The I/M rates discussed in that Section are tne rates used for all calculations in this section, except that overlap among tampering types is accounted for. The individual vehicle benefits and costs of repairs of tampering and misfueling are those discussed in Section 3.0. The methodology explained in Section 4.0 was used to calculate excess emissions due to tampering and misfueling and program costs. Only annual and biennial programs are considered in this section.

5.1.1 Program Effectiveness

For periodic inspection programs, such as I/M programs, it is assumed that the program will require repair or replacement of the disabled emission control components once they are discovered, followed by reinspection of the vehicle and/or the repair receipts to verify compliance.

The assumptions used to calculate benefits for inspection of individual components and combinations of components are explained and justified below. Section 5.1.2 then presents the results of the calculation of benefits. The details of the calculation are not presented. For all components, benefits are shown for 1984 and later vehicles separately from those for older vehicles, for the convenience of jurisdictions which plan to inspect only 1980 and later or 1984 and later vehicles.

The only site in the 1982 EPA tampering survey which has an anti-tampering inspection is the Portland, Oregon site. Portland has also had an I/M program since 1974. The fact that Portland has an anti-tampering program presumably explains largely why Portland has a lower tampering rate than any of the other I/M sites in the 1982 survey. Other factors, such as local behavior, the stringency and age of the I/M program, and the age of the anti-tampering program itself probably all contribute to the effectiveness observed in Portland. Also, the survey in Portland was conducted at the I/M inspection site. Vehicle owners presenting their vehicles for inspection knew beforehand that their vehicle would be inspected for tampering and that they would be required to repair any tampering before they could register their vehicle. It is likely, therefore, that a few vehicle owners repaired their vehicles' tampering just before presenting their vehicle for inspection. This would cause the survey to underestimate the actual rate of tampering and misfueling in Portland. Comparison to Portland is therefore used only as a guide to estimate the effectiveness of anti-tampering programs in other areas.

In comparing Portland tampering rates to other areas, only passenger car results were used. Only 44 trucks were inspected in Portland which provides too few vehicles for a separate analysis for trucks. Trucks and cars were not combined because the tampering rates for trucks are clearly different than those for cars. The effectiveness of the anti-tampering inspection for trucks was therefore assumed to be equal to the effectiveness estimated for passenger cars.

<u>PCV and Evaporative Systems</u> - The inspection for the PCV system is quite simple. The inspector need only assure that the PCV valve and connecting hose to the carburetor are both present and connected. The evaporative control system is more complicated. The canister may be located somewhere other than in the engine compartment, misleading an inspector into thinking it has been removed or encouraging the inspector not to check hose connections at the canister. Often there are spaces for extra connections on the canister which are unused even when it is properly connected. A false failure can be avoided by checking the hose routing diagram attached underneath the hood. It is advisable for programs which check the evaporative canister to also require a gas cap to be present. Although the rate of missing gas caps is small, the evaporative control system does not work properly without it.

In Portland, the rate of disabled PCV systems is 27% less than in the other nine sites in the survey. The rate of evaporative canister tampering is 20% less. This difference is assumed to be entirely due to the tampering check performed in Portland as part of the biennial I/M program. An annual inspection is expected to reduce the number of disablements even more, so an annual PCV check is assumed to be 40% effective and an annual evaporative canister check is assumed to be 30% effective.

The rather low effectiveness values (27% for PCV and 20% for evaporative) observed in Portland are somewhat surprising but can be explained. In the case of the evaporative canister and the PCV system it can be speculated that many disablements are inadvertent since there is virtually no incentive for vehicle owners to deliberately disconnect these devices. Moreover, the penalty, reconnection or replacement, is so inexpensive that there is little incentive to repair the systems between inspections even if the owner is aware of the disablements. Consequently, deterrence of these two forms of tampering is probably low. The Portland inspectors may not be 100% accurate in the inspections for PCV and evaporative systems.

Benefits from a PCV or evaporative canister inspection can be added to any of the other inspections. This means that the benefits from these inspections are unaffected by the presence or absence of the other inspections discussed below.

Catalyst - Inadvertent removal of catalysts does not occur. Therefore, if the public is well informed that failure of the catalyst check will require catalyst replacement, one can expect that there will be few new instances of catalyst removal. Such public awareness should be nearly automatic in an annual program. The exception, if any, will be a small group of owners convinced beyond persuasion that their catalysts should be removed. Such owners may reinstall the catalyst each year or two in order to pass the inspection, or may remove the active material from the catalyst container making visual detection at the disabled catalyst nearly impossible.

In addition to some catalysts being successfully removed or disabled in a way that escapes detection, inadvertent inspector errors may result in failure to replace all catalysts missing at the start of the program. Not all 1975-79 cars and light-duty trucks were originally equipped with catalysts. When a 1975-79 vehicle is presented for inspection, it will be up to the inspector to determine whether a catalyst is required or not. This decision may be more error-prone than the determination of whether a catalyst is present on the vehicle or not. Some inspectors may give vehicle owners the benefit of the doubt and decide that the vehicles does not require a catalyst as long as there is no readily available evidence, such as the emission control sticker, to convince him otherwise. Materials are available which list the emission control equipment required on vehicles.[6] If this material is available there will be fewer such cases. Inspectors will also be more willing to fail vehicles in questionable cases if both they and the vehicle owners are aware that an offical second opinion is available through the referee system.

It is true that in the 1982 tampering survey, no catalyst removals were observed at the Portland site. Since the Portland program has been in operation since the advent of catalyst equipped cars, this indicates that the catalyst inspection can effectively prevent vehicle owners from removing catalysts, except perhaps for a few owners who reinstall the catalyst each time to pass inspection or remove the active material. This deterrence can be achieved with a program which provides a reasonably high probability of detection. The Portland observation is not inconsistent with an assumption that inspections will not be quite 100% accurate.

For the reasons discussed above, an inspection for removal of the catalyst will be assumed to be 90% effective in detecting and forcing replacement of catalysts on 1975-79 model year passenger cars and 1975-79 light-duty trucks less than 6000 lbs. These are the groups for which some vehicles were not equipped with catalysts. The 90% value allows for some inspection errors and some concealed tampering and retampering by owners. The inspection is assumed to be 95% effective for all other model years, allowing for a small number of adamant owners. A biennial inspection program is assumed to be as effective as an annual inspection.

Misfueling, if it resumes after catalyst replacement, will negate nearly all the benefits associated with replacing the catalyst. Some owners who have removed their catalysts have probably done so thinking it would harm their vehicles to misfuel while the catalyst was still present. It is assumed, however, that essentially all vehicle owners who remove their catalysts and also misfuel, will misfuel even if prevented from removing the catalyst by the program. This assumption is supported by the fact that in the latest tampering survey 69% of the habitually misfueled passenger vehicles had not removed the catalyst, indicating that most misfuelers believe it is safe to misfuel even if the catalyst is left on the vehicle. Given the real or perceived incentives for misfueling, owners who were forced to replace catalysts will probably come to believe the same, or will find a way to defeat the catalyst check entirely. Benefits of a catalyst check alone are calculated on the portion of vehicles with catalyst removed which have not also been misfueled. Misfueling checks are discussed below.

In addition some vehicles with the catalyst removed also have disabled air pumps. The air pump system is often critical to efficient catalytic action and therefore a catalyst check alone is assumed to produce no benefits from vehicles with disabled air pumps. Combining the catalyst check with an air pump inspection will recover some of these lost benefits. This combination is discussed below.

Air Pumps - With air pumps, removal or failure of the drive belt is the most likely disablement. Since this disablement is relatively easy and replacement is inexpensive, some deliberate tampering with the air pump can be expected to occur even with a vigorous anti-tampering program. Many vehicle owners would be willing to risk detection and the subsequent penalty, replacement of the belt, in order to achieve perceived benefits in fuel economy and performance. Some vehicle owners may even replace and remove their air pump belt before and after their periodic inspection to avoid detection by the program. Also, air pump belts may eventually break if they are not periodically replaced. This may account for some portion of observed disablements.

In Portland the rate of air pump disablement is about two-thirds less than in the other I/M sites. However, since the survey was performed at an I/M station where a tampering check is performed, some vehicle owners may have reconnected the air pump for the inspection with the intention of disabling it immediately after meeting the legal requirements. It may be speculated that the number of vehicle owners who do this is only a small portion of the fleet. However, we will assume that an annual inspection program will have a 70% effectiveness and a biennial program will have a 60% effectiveness. This applies to both existing and subsequent tampering.

Benefits of an air pump check alone are calculated on the portion of vehicles with the air pump removed which do not suffer from removed catalysts or misfueling since these other problems would eliminate most of the benefit from repairs to the air pump system. Benefits of combining the air pump check with other inspections are discussed below.

Fuel Inlet Restrictor - It is assumed that any fuel inlet restrictor which allows entry of a legal size leaded fuel nozzle is an indication of habitual misfueling and therefore the catalyst has been rendered inoperative. Therefore, if the fuel inlet restrictor has been enlarged the vehicle owner must be required to replace the catalyst. In addition, the vehicle owner will also have to repair or replace the restrictor so that a leaded fuel nozzle will not fit. Since the owner of a vehicle with a tampered restrictor could avoid the catalyst replacement cost by restoring the restrictor after failing once and then reporting for another inspection as though it were the first inspection, the inspection program should have some method of preventing this by punching the vehicle registration at first inspection or keeping a computerized list of tampered vehicles alreaded inspected once.

The benefits also assume that all instances of fuel inlet tampering which have already occurred or will occur in the future can be detected. The important issue insofar as benefits are concerned is what impact fuel inlet inspections will have on the overall misfueling rate, since continued misfueling after repair of the inlet and replacement of the catalyst negates the benefit of the repair.

Since catalyst removal is a more flagrant form of tampering and since there is no point in terms of excess emissions in preventing misfueling among vehicle owners who have removed their vehicle's catalyst, it is strongly recommended that the fuel inlet check be combined with a catalyst presence check. However, if only the fuel inlet check is performed, it is assumed that of the vehicle owners who would have removed the catalyst and misfueled after the program start date without the program, half of the vehicle owners who do not misfuel as a result of the fuel inlet check will also refrain from removing the catalyst. It is assumed that these vehicle owners would have removed the catalyst only because they wished to misfuel. This will provide some additional benefit since removal of the catalyst would otherwise negate any benefit from the fuel inlet restrictor check.

A possible way to estimate the effect of the fuel inlet restrictor check is to assume that misfuelers who do so without having tampered with the fuel inlet restrictor will continue to misfuel even if the inspection is begun. In addition, it is safe to assume that among vehicle owners who tamper with the fuel inlet restrictor, some of them will continue to misfuel using other means even if they are prevented from enlarging the fuel inlet restrictor on their vehicles as a result of the inspection. In the 1982 survey, 66% of the passenger cars which are defined as being habitually misfueled, had tampered fuel inlet restrictors. If it is assumed that a check of the fuel inlet restrictor will deter a certain percentage of these vehicle owners from misfueling, then the net effectiveness of the fuel inlet restrictor check can be calculated easily.

It can be effectively argued that a check of the fuel inlet restrictor is no more than an inconvenience to motorists who wish to misfuel since other methods to funnel leaded fuel through the fuel inlet restrictor are readily available. The check will be most effective in detering only those vehicle owners who are not highly motivated to misfuel to begin with. The data from the Portland site in the 1982 survey does not provide a good estimate of how effective the fuel inlet check would be in other areas. Given the inconclusive evidence, limiting the effectiveness to one half the potential benefits from those vehicles already misfueled with tampered fuel inlet restrictors appears reasonable. Although the choice of half the percentage appears arbitrary, it reflects the judgment of EPA that a large percentage of these practicing misfuelers will not be deterred by such an inspection alone. One contributor to lowered effectiveness is the likelihood that some owners of misfueled vehicles will repair their inlet restrictors once they know the inspection requirement will begin soon, thereby depriving the program of the benefit of a catalyst replacement. Therefore, EPA assumes 33% of all previous misfuelers (50% of misfuelers who enlarge the fuel inlet restrictor) will stop misfueling with the fuel inlet restrictor check. EPA assumes that the deterrence value of the fuel inlet check will be greater for vehicle owners who have not yet misfueled than for owners who have misfueled in the past, and has selected a 70% effectiveness for subsequent misfueling via inlet tampering. The net effectiveness for subsequent misfueling is therefore 46% after allowing for owners who misfuel by other means.

The rate of misfueling in Portland is about 63% less than the average for the other I/M areas. (The comparison with other individual I/M areas ranges from 35% to 74%, indicating a wide variation among other I/M areas.) However, Portland not only inspects for fuel inlet restrictor tampering, but also by law does not allow self-service gas stations. In addition, Portland's I/M program has very stringent idle test standards and has been in effect since before the introduction of catalyst vehicles so that misfueling behavior may be quite different than in other areas. Conversation with Oregon inspection officials indicate that there is a general feeling that it is not the inlet restrictor check alone which deters misfueling in their area, but a combination of regional behavior, the idle test part of the I/M program, and the lack of self-service gasoline stations. These other factors do not allow a direct comparison of the misfueling rates observed in Portland to other I/M areas to estimate the effect on the misfueling rate of Portland's check of the fuel inlet restrictor. Therefore, the Portland data do not contradict the assumptions stated above.

<u>Plumbtesmo</u> - As was pointed out in Section 2.0 EPA has been using a lead-sensitive chemical coated paper, whose trade name is Plumbtesmo, to detect tell-tale lead deposits in the tailpipes of vehicles in the latest tampering surveys as an indication of misfueling.[2] This test is a powerful tool in detecting previous use of leaded fuel when there is no leaded fuel in the tank or damage to the fuel inlet restrictor. Its primary fault lies in its inability to determine the extent of catalyst damage due to misfueling. A single tankful of leaded fuel used during an emergency or bought from an unscrupulous gasoline dealer as unleaded may cause a Plumbtesmo test failure months later even though unleaded fuel has been used at all other fuelings. If only one-half of one percent of all unleaded fuel sold in an area were contaminated with lead additives, as many as 500 of every 100,000 vehicles might fail the Plumbtesmo test every year even if deliberate misfueling ceased altogether. If some simple, reliable test to determine the extent of damage to the catalyst by lead deposits can be developed, then such a test could be used to allow vehicle owners whose vehicles fail the Plumbtesmo test to prove that their catalyst was still active and did not need to be replaced. Without such a test, the Plumbtesmo test will allow persons who deliberately misfuel to actively seek to avoid detection (by, for example, cleaning or replacing tailpipes) while persons who do not deliberately misfuel but accidentally buy leaded gas will likely be caught by the Plumbtesmo test. Although EPA is currently assessing the feasibility of such a catalyst diagnostic test, no test is as yet available. Inequities will be reduced by an aggressive program of sampling fuel from retail gas stations. Since the required catalyst replacement cost would be expensive, some vehicle owner dissatisfaction with the test might result.

A less serious, but equally complicating factor is the fact that in EPA tests some vehicles which have obviously been misfueled pass the Plumbtesmo test. As yet no full explanation has been determined for those cases.* As a result, some grossly misfueled vehicles may escape detection by a Plumbtesmo test.

*One possible explanation is that the unstable lead-detecting compounds in the test paper became inadvertently deactivated or a defective lot was used during testing. An inspection program forwarned of these problems could easily avoid using inactive test paper.

The main attractiveness of the Plumbtesmo test is its potential effectiveness in detering misfueling. With a Plumbtesmo inspection, vehicle owners could never be sure that they could avoid detection if they misfuel. Some extreme measures, such as replacing the tailpipe before each inspection, might work, but would make the act of misfueling much less attractive. A program, which would require replacement of the catalyst whenever a vehicle fails the Plumbtesmo test is assumed to cause 80% of misfueling which would otherwise have occurred to stop. As with the fuel inlet check, half of the misfuelers who stop misfueling would also refrain from removing the catalyst. Since the tailpipe would be contaminated with lead, replacement of the tailpipe or some other action as well as replacement of the catalyst would be required to avoid a Plumbtesmo test failure at the next inspection.

In order to increase the emissions benefit from vehicles which had been habitually misfueled before the start of the program, the Plumbtesmo test can be used in combination with a check of the fuel inlet restrictor. Some vehicles may have been habitually misfueled in the past, but the previous owner may have reverted to the use of unleaded fuel. If the exhaust tailpipe had been replaced, the Plumbtesmo test would be unable to detect the vehicle, even though the vehicle's catalyst had been deactivated by the previous habitual misfueling. A check of the fuel inlet restrictor would help identify much of this past misfueling. In the EPA survey only about half of the passenger vehicles identified as habitual misfuelers are detected by the Plumbtesmo test. Combining the Plumbtesmo test with a fuel inlet check identifies about 75% of the habitual misfuelers. Therefore, it will be assumed in this analysis that a Plumbtesmo test alone will only detect 50% of the existing habitual misfueling damage to catalysts. A Plumbtesmo test combined with a fuel inlet restrictor check will be assumed to detect 75% of the existing habitual misfueling damage.

Although a check of the fuel inlet would not be a necessity for vehicles sold after the program began, such a check would further complicate efforts by some vehicle owners to continue to misfuel and avoid detection. For this reason and for equity concerns a check of the fuel inlet restrictor should always be performed in conjunction with a Plumbtesmo test on vehicles sold after the program begins whenever a fuel inlet check is combined with the Plumbtesmo test for the older vehicles. This combination should increase the deterrence value of the inspection. An 85% deterrence effectiveness will be assumed for the combined inspection.

Because a Plumbtesmo test may fail a vehicle whose only use of leaded fuel was inadvertent due to contamination or mislabeling at the pump, it is important that these occurrences be minimized. This can be done establishing the program of fuel pump inspections described at the beginning of Section 5.0.

Catalyst and Misfueling - If the catalyst presence check is combined with either the fuel inlet restrictor check or the Plumbtesmo test, additional benefits from vehicles with removed catalysts can be obtained. With either the Plumbtesmo test or fuel inlet check alone it is assumed that only half of vehicle owners who would have removed their catalyst and misfueled after the program begins would be deterred from removing their catalysts. If either of these programs are combined with the catalyst check, more benefits will result from these vehicles since most catalyst removal will be deterred by the catalyst inspection.

Catalyst and Air Pump - Combining the catalyst and air pump inspection allows vehicles with disabled air pumps and removed catalysts, but which have not been misfueled, to obtain the higher catalyst replacement benefits in addition to the benefits of catalyst and air pump inspections calculated separately above. The percentage of vehicles which will receive both repairs depends on the effectiveness of the two inspections which in turn depends on whether the program is annual or biennial.

Combined Inspection - Obviously, if all four inspections (air pump, catalyst, fuel inlet restrictor and Plumbtesmo test) are performed benefits must be calculated correctly for overlapping cases. For overlap vehicles, the assumption used is that the effectiveness of a combined inspection program in detecting, repairing, and deterring all of the misfuelers, catalyst removed, and air pump tampering present on one vehicle is equal to the lowest of the individual effectiveness. Catalyst removed vehicles, if detected, will obtain full benefits from catalyst replacement once all tampering is corrected. Misfueled vehicles will also obtain benefits from catalyst replacement. The remaining vehicles had tampered air pumps only and will therefore receive air pump repair benefits. Benefits for PCV and evaporative checks are additive to all other benefits.

Caution - A potential source of further loss of effectiveness in any inspection is deliberate cheating by inspectors.

Since some repairs such as catalyst replacements may cost vehicle owners hundreds of dollars, inspectors may deliberately overlook tampering or fail to verify that a vehicle does not require an air pump or catalyst. Obviously, if such behavior were allowed to persist, the effectiveness of the program would be greatly reduced. The design requirements discussed earlier (e.g., training, audits, undercover enforcement actions, etc.) are intended to prevent deliberate cheating. Centralized programs, by their design, should be able to prevent cheating more cheaply than decentralized programs. The credits calculated in this report assume that there will be no significant amount of cheating in the inspections. EPA will evaluate anti-tampering programs for their ability to prevent cheating before agreeing to allow credits for the program. If EPA review of the program design suggested that significant cheating could still occur, no credits would be given.

5.1.2 Results: Benefits for I/M Programs

Table 15 presents the benefits of inclusion of a tampering inspection with an annual I/M program. There are separate results for pre-1980, 1980 through 1983 and 1984 and later vehicles so that programs which exempt pre-1980 or pre-1984 vehicles can be estimated. Table 16 presents a biennial version for each of the benefits in Table 15.

Table 15
Benefit of Annual Tampering Inspections
in I/M Areas
(January 1, 1988)

Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi): Passenger Car HC	Passenger Car CO	Light-Duty Trucks (6000 lbs) HC	Light-Duty Trucks (6000 lbs) CO	Light-Duty Trucks (6000-8500 lbs) HC	Light-Duty Trucks (6000-8500 lbs) CO
Air Pump Only	Pre-1980	7.43	173.54	7.88	183.88	0.21	4.89
	1980-1983	4.58	142.89	2.11	49.27	1.23	28.78
	1984+	1.17	36.66	1.78	41.61	1.94	45.19
Catalyst Only	Pre-1980	8.51	84.29	5.77	57.11	0.71	7.05
	1980-1983	6.59	67.16	10.68	105.73	5.26	52.06
	1984+	2.31	23.99	11.69	115.71	17.12	169.54
Fuel Inlet Only	Pre-1980	15.76	111.61	9.91	70.24	1.28	9.14
	1980-1983	16.58	123.29	20.51	148.76	10.12	73.42
	1984+	9.40	71.13	24.14	171.97	35.06	247.42
Plumbtesmo Only	Pre-1980	25.42	180.83	15.75	112.30	2.05	14.70
	1980-1983	27.45	204.89	33.23	242.44	16.40	119.69
	1984+	15.67	118.95	38.53	276.02	55.53	393.91
Plumbtesmo &Fuel Inlet	Pre-1980	32.89	231.45	21.10	148.51	2.71	19.16
	1980-1983	33.25	245.90	42.51	305.76	20.97	150.87
	1984+	18.65	140.46	51.14	361.49	75.11	526.20
Air Pump & Catalyst	Pre-1980	16.74	265.69	14.70	251.45	1.05	13.23
	1980-1983	11.75	215.98	14.64	173.34	7.40	89.87
	1984+	3.69	62.77	15.50	177.38	22.03	244.13
Air Pump & Fuel Inlet	Pre-1980	21.44	227.85	12.81	118.99	1.65	15.25
	1980-1983	22.25	274.53	25.30	219.17	12.68	112.65
	1984+	11.19	112.61	28.91	236.45	41.21	324.34
Air Pump & Plumbtesmo	Pre-1980	34.78	368.25	25.94	313.53	2.56	21.87
	1980-1983	33.97	362.57	40.29	330.37	20.08	167.56
	1984+	11.19	164.03	45.98	360.56	65.57	499.52
Fuel Inlet & Catalyst	Pre-1980	31.66	269.10	22.84	198.34	2.87	24.85
	1980-1983	28.11	240.76	43.14	372.82	21.26	183.70
	1984+	13.19	110.55	49.20	420.08	72.11	614.30
Plumbtesmo & Catalyst	Pre-1980	48.34	445.08	38.85	424.06	4.12	35.26
	1980-1983	42.09	354.08	62.83	535.50	30.97	263.94
	1984+	20.55	169.70	71.22	599.65	103.76	871.44
Fuel Inlet & Catalyst & Air Pump	Pre-1980	41.59	464.59	34.95	421.32	3.61	34.62
	1980-1983	34.81	402.50	53.06	494.00	26.34	247.91
	1984+	15.32	155.56	59.66	540.93	86.70	774.72

Table 15 (continued)

Inspection Program	Affected Model Years	Passenger Car HC	Passenger Car CO	Light-Duty Trucks (6000 lbs) HC	Light-Duty Trucks (6000 lbs) CO	Light-Duty Trucks (6000-8500 lbs) HC	Light-Duty Trucks (6000-8500 lbs) CO
		Per Vehicle Reduction in Emissions (mg/mi)					
Plumbtesmo & Catalyst & Air Pump	Pre-1980	57.00	588.31	47.80	529.94	5.23	48.37
	1980-1983	49.96	525.47	77.88	702.54	38.58	358.72
	1984+	23.19	218.75	87.73	773.95	127.46	1112.23
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1980	60.14	538.62	48.82	506.02	5.33	45.12
	1980-1983	49.99	416.37	78.81	665.15	38.83	327.68
	1984+	23.71	193.10	91.83	764.27	135.81	1127.18
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1980	39.50	354.32	25.41	205.79	3.22	26.39
	1980-1983	39.79	403.83	49.68	394.77	24.70	199.27
	1984+	20.92	185.69	58.69	446.99	85.27	633.01
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1980	68.81	681.84	57.77	611.90	6.44	58.23
	1980-1983	57.86	587.75	93.86	832.19	46.43	414.46
	1984+	26.35	242.16	108.34	938.57	159.50	1367.98
PCV*	Pre-1980	9.56	0.0	16.82	0.0	4.86	0.0
	1980-1983	8.23	0.0	13.20	0.0	6.49	0.0
	1984+	3.49	0.0	14.96	0.0	22.33	0.0
Evaporative* Canister	Pre-1980	3.18	0.0	7.91	0.0	0.61	0.0
	1980-1983	3.59	0.0	12.21	0.0	4.69	0.0
	1984+	1.09	0.0	14.81	0.0	17.21	0.0
All Items**	Pre-1980	81.55	681.84	82.50	611.90	11.92	58.23
	1980-1983	69.67	587.75	119.28	832.19	57.62	414.46
	1984+	30.92	242.16	138.11	938.57	199.04	1367.98
All Items**	All Yrs.	182.15	1511.75	339.89	2382.67	268.57	1840.66
	(in gm/mi)	0.18	1.51	0.34	2.38	0.27	1.84
Percent***		5.2%	3.9%	1.0%	0.6%	0.5%	0.3%

*PCV or evaporative canister benefits can be added directly to any of the above programs.
**Plumbtesmo, fuel inlet, catalyst, air pump, PCV and evaporative canister checks.
***Percent of composite mobile source emissions using MOBILE2 estimates of passenger car and light-duty truck vehicle miles traveled.

Table 16

Benefit of Biennial Tampering Inspections
in I/M Areas
(January 1, 1988)

Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi): Passenger Car HC	Passenger Car CO	Light-Duty Trucks (6000 lbs) HC	Light-Duty Trucks (6000 lbs) CO	Light-Duty Trucks (6000-8500 lbs) HC	Light-Duty Trucks (6000-8500 lbs) CO
Air Pump Only	Pre-1980	6.37	148.74	6.75	157.61	0.18	4.19
	1980-1983	3.92	122.48	1.81	42.24	1.06	24.67
	1984+	1.01	31.42	1.53	35.67	1.66	38.74
Catalyst Only	Pre-1980	8.51	84.29	5.77	57.11	0.71	7.05
	1980-1983	6.59	67.16	10.68	105.73	5.26	52.06
	1984+	2.31	23.99	11.69	115.71	17.12	169.54
Fuel Inlet Only	Pre-1980	15.76	111.61	9.91	70.24	1.28	9.14
	1980-1983	16.58	123.29	20.51	148.76	10.12	73.42
	1984+	9.40	71.13	24.14	171.97	35.06	247.42
Plumbtesmo Only	Pre-1980	25.42	180.83	15.75	112.30	2.05	14.70
	1980-1983	27.45	204.89	33.23	242.44	16.40	119.69
	1984+	15.67	118.95	38.53	276.02	55.53	393.91
Plumbtesmo &Fuel Inlet	Pre-1980	32.89	231.45	21.10	148.51	2.71	19.16
	1980-1983	33.25	245.90	42.51	305.76	20.97	150.87
	1984+	28.65	140.46	51.14	361.49	75.11	526.20
Air Pump & Catalyst	Pre-1980	15.57	239.78	13.43	223.68	1.00	12.35
	1980-1983	11.01	194.72	14.08	163.68	7.10	84.47
	1984+	3.49	57.23	14.95	168.57	21.33	233.47
Air Pump & Fuel Inlet	Pre-1980	20.78	212.30	12.57	113.33	1.62	14.55
	1980-1983	21.60	254.12	25.00	212.13	12.50	108.53
	1984+	11.03	107.38	28.65	230.51	40.93	317.89
Air Pump & Plumbtesmo	Pre-1980	33.49	341.91	24.57	285.62	2.50	20.97
	1980-1983	33.10	340.63	39.53	320.26	19.67	161.93
	1984+	17.64	157.93	45.14	350.70	64.42	487.17
Fuel Inlet & Catalyst	Pre-1980	31.66	269.10	22.84	198.34	2.87	24.85
	1980-1983	28.11	240.76	43.14	372.82	21.26	183.70
	1984+	13.19	110.55	49.20	420.08	72.11	614.30
Plumbtesmo & Catalyst	Pre-1980	47.94	435.83	37.96	403.44	4.12	35.26
	1980-1983	42.09	354.08	62.83	535.50	30.97	263.94
	1984+	20.55	169.70	71.22	599.65	103.76	871.44
Fuel Inlet & Catalyst & Air Pump	Pre-1980	40.41	438.67	33.68	393.56	3.56	33.74
	1980-1983	34.08	381.24	52.49	484.34	26.03	242.51
	1984+	15.13	150.01	59.12	532.12	85.99	764.07

Table 16 (continued)

Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi) Passenger Car HC	CO	Light-Duty Trucks (6000 lbs) HC	CO	Light-Duty Trucks (6000-8500 lbs) HC	CO
Plumbtesmo & Catalyst & Air Pump	Pre-1980	55.37	558.60	45.63	494.20	5.08	46.50
	1980-1983	48.84	500.99	75.73	678.68	37.49	338.32
	1984+	22.82	211.75	85.37	749.05	124.07	1077.83
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1980	59.75	529.37	48.56	500.05	5.33	45.12
	1980-1983	49.99	416.37	78.81	665.15	38.83	327.68
	1984+	23.71	193.10	91.83	764.27	135.81	1127.18
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1980	38.60	337.23	24.66	198.50	3.16	25.49
	1980-1983	38.92	381.89	48.92	384.65	24.30	193.64
	1984+	20.63	179.59	57.85	437.14	84.11	620.65
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1980	67.18	652.13	55.61	576.16	6.28	56.36
	1980-1983	56.74	536.27	91.71	808.33	45.35	402.06
	1984+	25.97	235.15	105.98	913.67	156.12	1333.58
PCV*	Pre-1980	6.46	0.0	11.35	0.0	3.28	0.0
	1980-1983	5.55	0.0	8.91	0.0	4.38	0.0
	1984+	2.35	0.0	10.10	0.0	15.07	0.0
Evaporative* Canister	Pre-1980	2.12	0.0	5.28	0.0	0.41	0.0
	1980-1983	2.39	0.0	8.14	0.0	3.13	0.0
	1984+	0.72	0.0	9.87	0.0	11.47	0.0
All Items**	Pre-1980	75.75	652.13	72.24	576.16	9.97	56.36
	1980-1983	64.68	563.27	108.77	808.33	52.86	402.06
	1984+	29.05	235.15	125.95	913.67	182.66	1333.58
All Items**	All Yrs.	169.48	1450.55	306.95	2298.16	245.49	1792.00
	(in gm/mi	0.17	1.45	0.31	2.30	0.25	1.79
Percent***		4.8%	3.7%	0.9%	0.6%	0.4%	0.3%

*PCV or evaporative canister benefits can be added directly to any of the above programs.
**Plumbtesmo, fuel inlet, catalyst, air pump, PCV and evaporative canister checks.
***Percent of composite mobile source emissions using MOBILE2 estimates of passenger car and light-duty truck vehicle miles traveled.

5.1.3 Program Costs

This subsection states assumptions necessary to calculate the cost of a tampering inspection program when added to an existing I/M program. Costs are calculated over the four-year period 1984-1987, so that cost-effectiveness can be calculated and presented in the following subsection.

Repairs - The obvious cost of anti-tampering and anti-misfueling programs is the cost to vehicle owners for repairs of disablements, whether they were deliberate or inadvertent. In terms of all cars being inspected, the per vehicle cost for repairs will be relatively small, since usually only some small fraction of vehicles will require repairs. Also, if the program continues to operate beyond December 31, 1987, the cost-effectiveness of the repairs will improve until essentially the only costs incurred by the program will be the cost of inspection. Section 3.0 discusses the repair costs which we have assumed for this analysis.

Using the rate of tampering at the start of the program, the number of vehicles which require repairs at the start of the program can be estimated. By assuming an average repair cost, the initial year repair cost can be estimated.

After the program begins, some tampering will continue to occur and subsequently be detected and repaired. The number of vehicles tampered after the program begins will depend on the effectiveness of the program in detering tampering. The effectiveness will depend on the emission control component.

For air pump, catalyst and fuel inlet restrictor tampering it is assumed that only those vehicles identified in the first year of the program will require repairs. Vehicles not identified are assumed to continue to avoid detection in subsequent years. Also, no significant amount of new tampering is expected to be discovered in subsequent years since vehicle owners will be aware of the program and its penalties. PCV and evaporative canister disablements occur at a high rate even in an inspection program which checks for such disablements. In these cases all disablements are assumed to be repaired in the first year and in each subsequent year repairs will be done on all disablements which reappear.

Inspections - In addition to the cost vehicle owners must pay in repairs, a tampering inspection program will incur additional expenses from the added tampering inspections at individual inspection stations and additional administrative costs related to adding the tampering inspection to the I/M requirements. A rough estimate of the additional costs can be made by estimating the increase in personnel time, both inspector and administrative, necessary to include the tampering check.

In decentralized programs, only the additional time an inspector will need to perform the tampering check should be attributed to the anti-tampering program. As with centralized programs, administrative costs can probably be estimated by the need to hire additional personnel.

It is expected that most of the duties required by the addition of a tampering inspection can be integrated into the operation of the I/M program without any substantial increase in program costs. Although this cost will likely vary substantially from program to program depending on many factors, we have assumed an overall increase in program administrative and inspection costs to be 34 cents in centralized and $1.00 in decentralized inspection programs per inspection as an example. This added cost would include not only additional costs to perform the inspections, but also include additional administrative duties to oversee the additional program elements.

The cost has been estimated by assuming that a single inspector in a centralized program could complete the necessary inspection and additional paperwork for a check of all the components in about one minute. If the inspector is a mechanic costing $20 per hour including fringe benefits and overhead, this works out to be about 34 cents per inspection. In a decentralized program, the inspector will be less specialized and will likely take longer to satisfactorily complete the inspection. We have assumed the decentralized program inspector will take three minutes to complete the inspection, which at $20 per hour, will be $1.00 per inspection. These estimates are for an inspection of all items discussed in this report. An inspection of fewer items would be shorter and therefore cheaper.

5.1.4 Cost-Effectiveness

Tables 17 and 18 present cost-effectiveness values calculated for the benefits presented in Tables 15 and 16 in Section 5.1.2. These cost-effectiveness values assume the following average repair costs:

- $20 per disabled air pump
- $200 per removed catalyst

- $10 per disabled PCV system
- $10 per disabled evaporative canister
- $150 per misfueled catalyst
- $30 per tampered fuel inlet restrictor

These repair costs are discussed in Section 3.0. As mentioned there, the costs of replacing removed or misfueled catalysts may be less if aftermarket catalysts are introduced. The additional inspection and administrative costs are assumed to be 34 cents for centralized and $1.00 for decentralized programs per inspected vehicle per inspection. Local estimates will likely vary substantially from this assumption depending on program type and local conditions. The inspection cost has been distributed equally between all of the inspected emission control components and divided equally between the two pollutants when both HC and CO emissions are affected. Emission benefits have been calculated for each year of the programs beginning on January 1, 1984 through the evaluation data of January 1, 1988. The total inspection, administrative, and repair costs are summed for those years and divided by the sum total emission reductions and converted to cost per ton. The choice of these four years is somewhat arbitrary, and tends to raise the calculated cost per ton since these years included all the repair costs for tampering which occurred before the program started. The cost per ton would be less if a longer period is used for the calculation.

Table 17

(To be added)

Table 18

(To be added)

5.2 Periodic Inspection Programs

Non-I/M periodic inspection programs offer another opportunity to address the tampering issue. A tampering program can be added to a periodic safety inspection, or an entirely new inspection requirement can be established. Costs will obviously be higher in the latter approach.

Section 2.0 discussed tampering rates in non-I/M areas. The rates discussed in that Section are the rates used for all calculations in this section, except that overlap among tampering types is accounted for. The individual vehicle benefits and costs of repairs of tampering and misfueling are those discussed in Section 3.0. The methodology explained in Section 4.0 was used to calculate excess emissions due to tampering and misfueling and program costs. Only annual and biennial programs are considered in this section.

5.2.1 Program Effectiveness

For periodic inspection programs as in I/M programs, it is assumed that the program will require repair or replacement of the disabled emission control components once they are discovered followed by reinspection of the vehicle and/or the repair receipts to verify compliance. In addition, to claim the benefits estimated in this section the inspection program would have the same requirements as anti-tampering and anti-misfueling programs in I/M programs described at the beginning of Section 5.0. All of the effectiveness assumptions used for I/M programs will be assumed to apply to periodic inspections which are not part of I/M programs. The reader should refer to Section 5.1.1 for the discussion of inspection effectiveness.

As pointed out in Section 2.0, areas without I/M programs tend to have higher tampering and misfueling rates than I/M areas. In this section, all benefits are calculated using tampering and misfueling rates predicted for non-I/M areas.

5.2.2 Results: Benefits for Non-I/M Periodic Inspection Programs

Table 19 presents the benefits of an annual tampering inspection program. There are separate results for pre-1980, 1980 through 1983 and 1984 and later vehicles so that programs which exempt pre-1980 or pre-1984 vehicles can be estimated. Table 20 presents a biennial version for each of the benefits in Table 19.

Table 19
Benefit of Annual Tampering Inspections
in Non-I/M Areas
(January 1, 1988)

Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi)					
		Passenger Car		Light-Duty Trucks (6000 lbs)		Light-Duty Trucks (6000-8500 lbs)	
		HC	CO	HC	CO	HC	CO
Air Pump Only	Pre-1980	17.58	410.46	22.44	523.81	0.64	14.89
	1980-1983	10.75	335.46	7.08	165.33	4.15	96.77
	1984+	2.65	82.82	10.55	246.28	14.45	337.36
Catalyst Only	Pre-1980	26.65	263.83	24.22	239.78	3.04	30.06
	1980-1983	19.56	199.21	47.53	470.58	23.42	231.90
	1984+	4.91	51.04	59.10	585.18	88.77	878.92
Fuel Inlet Only	Pre-1980	41.14	296.78	26.16	188.86	3.37	24.56
	1980-1983	41.73	318.03	53.62	398.93	26.45	196.89
	1984+	16.89	129.61	57.37	420.311	80.93	586.27
Plumbtesmo Only	Pre-1980	67.11	486.49	41.98	304.91	5.45	39.23
	1980-1983	70.40	538.16	88.03	658.93	43.44	325.29
	1984+	29.38	225.42	93.10	686.29	130.21	949.14
Plumbtesmo &Fuel Inlet	Pre-1980	84.43	604.65	55.03	393.63	7.02	50.68
	1980-1983	81.23	616.01	108.97	803.29	53.74	396.30
	1984+	31.22	239.50	118.70	861.45	169.54	1216.97
Air Pump & Catalyst	Pre-1980	46.72	698.91	51.09	807.47	4.23	50.45
	1980-1983	32.04	552.29	62.85	717.50	31.63	368.87
	1984+	8.00	138.37	79.90	932.92	118.61	1368.66
Air Pump & Fuel Inlet	Pre-1980	54.88	574.11	34.56	332.39	4.46	42.99
	1980-1983	55.30	675.69	68.25	625.87	34.33	324.10
	1984+	20.68	221.37	75.65	728.33	105.93	1006.51
Air Pump & Plumbtesmo	Pre-1980	89.71	933.95	70.75	877.70	6.91	61.32
	1980-1983	85.97	911.62	108.76	934.77	54.32	476.65
	1984+	33.82	322.48	117.88	1045.11	164.36	1439.78
Fuel Inlet & Catalyst	Pre-1980	90.63	786.85	80.88	730.61	10.20	92.12
	1980-1983	75.42	661.04	155.88	1411.48	76.84	695.74
	1984+	24.94	213.27	186.39	1697.66	276.05	2518.12
Plumbtesmo & Catalyst	Pre-1980	136.46	1261.48	130.80	1418.49	14.36	128.19
	1980-1983	113.33	975.28	221.32	1978.59	109.11	975.48
	1984+	39.74	333.18	260.68	2345.54	383.26	3454.61
Fuel Inlet & Catalyst & Air Pump	Pre-1980	115.51	1262.73	119.49	1407.47	12.87	126.33
	1980-1983	92.01	1049.38	193.77	1868.61	96.17	936.35
	1984+	29.44	312.51	234.08	2296.92	345.59	3379.46

Table 19 (continued)

Inspection Program	Affected Model Years	Passenger Car HC	Passenger Car CO	Light-Duty Trucks (6000 lbs) HC	Light-Duty Trucks (6000 lbs) CO	Light-Duty Trucks (6000-8500 lbs) HC	Light-Duty Trucks (6000-8500 lbs) CO
		Per Vehicle Reduction in Emissions (mg/mi)					
Plumbtesmo & Catalyst & Air Pump	Pre-1980	158.88	1618.85	163.35	1794.54	18.45	175.50
	1980-1983	132.71	1387.45	279.30	2623.33	138.34	1308.48
	1984+	44.99	438.63	333.81	3183.17	491.51	4678.86
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1980	166.70	1507.55	164.14	1708.13	18.40	163.31
	1980-1983	129.20	1104.02	275.55	2452.67	135.79	1208.68
	1984+	41.92	350.82	331.83	2971.67	494.03	4429.78
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1980	100.53	899.40	66.51	561.05	8.51	72.26
	1980-1983	96.89	990.36	130.07	1082.85	64.81	549.50
	1984+	35.68	336.89	143.83	1223.75	204.11	1711.76
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1980	189.12	1864.91	196.69	2084.17	22.48	210.62
	1980-1983	148.58	1516.19	333.54	3097.40	165.02	1541.68
	1984+	47.16	456.26	404.96	3809.29	602.28	5654.02
PCV*	Pre-1980	9.56	0.0	16.82	0.0	4.86	0.0
	1980-1983	8.23	0.0	13.20	0.0	6.49	0.0
	1984+	3.49	0.0	14.96	0.0	22.33	0.0
Evaporative* Canister	Pre-1980	3.18	0.0	7.91	0.0	0.61	0.0
	1980-1983	3.59	0.0	12.21	0.0	4.69	0.0
	1984+	1.09	0.0	14.81	0.0	17.21	0.0
All Items**	Pre-1980	201.87	1864.91	221.43	2084.17	27.96	210.62
	1980-1983	161.94	1516.19	358.95	3097.40	176.20	1541.68
	1984+	52.23	456.26	434.73	3809.29	641.81	5654.02
All Items**	All Yrs.	414.00	3837.36	1015.11	8990.86	845.97	7406.32
	(in gm/mi)	0.41	3.84	1.02	8.99	0.85	7.41
Percent***		11.7%	9.9%	3.0%	2.4%	1.5%	1.2%

*PCV or evaporative canister benefits can be added directly to any of the above programs.
**Plumbtesmo, fuel inlet, catalyst, air pump, PCV and evaporative canister checks.
***Percent of composite mobile source emissions using MOBILE2 estimates of passenger car and light-duty truck vehicle miles traveled.

Table 20
Benefit of Biennial Tampering Inspections
in Non-I/M Areas
(January 1, 1988)

Inspection Program	Affected Model Years	Passenger Car HC	Passenger Car CO	Light-Duty Trucks (6000 lbs) HC	Light-Duty Trucks (6000 lbs) CO	Light-Duty Trucks (6000-8500 lbs) HC	Light-Duty Trucks (6000-8500 lbs) CO
Air Pump Only	Pre-1980	15.07	351.83	19.24	448.98	0.55	12.76
	1980-1983	9.21	287.53	6.07	141.71	3.55	82.95
	1984+	2.27	70.99	9.04	211.10	12.39	289.17
Catalyst Only	Pre-1980	26.65	263.83	24.22	239.78	3.04	30.06
	1980-1983	19.56	199.21	47.53	470.58	23.42	231.90
	1984+	4.91	51.04	59.10	585.18	88.77	878.92
Fuel Inlet Only	Pre-1980	41.14	296.78	26.16	188.86	3.37	24.56
	1980-1983	41.73	318.03	53.62	398.93	26.45	196.89
	1984+	16.89	129.61	57.37	420.31	80.93	588.27
Plumbtesmo Only	Pre-1980	67.11	486.49	41.98	304.91	5.45	39.93
	1980-1983	70.40	538.16	88.03	658.93	43.44	325.29
	1984+	29.38	225.42	93.10	686.29	130.21	949.14
Plumbtesmo &Fuel Inlet	Pre-1980	84.43	604.65	55.03	393.63	7.02	50.68
	1980-1983	81.23	616.01	108.97	803.29	53.74	396.30
	1984+	31.22	239.50	118.70	861.45	169.54	1216.97
Air Pump & Catalyst	Pre-1980	43.85	636.76	47.25	726.37	4.06	47.54
	1980-1983	30.25	501.85	60.66	682.22	30.46	349.30
	1984+	7.55	125.90	76.93	883.24	114.35	1298.70
Air Pump & Fuel Inlet	Pre-1980	53.31	537.38	33.84	315.651	4.37	40.87
	1980-1983	53.77	627.76	67.24	602.25	33.74	310.28
	1984+	20.30	209.54	74.15	693.15	103.86	958.31
Air Pump & Plumbtesmo	Pre-1980	86.63	871.54	66.94	798.79	6.75	58.69
	1980-1983	83.95	860.29	106.65	903.85	53.19	459.23
	1984+	33.25	309.35	115.12	1001.65	160.44	1379.17
Fuel Inlet & Catalyst	Pre-1980	90.63	786.85	80.88	730.61	10.20	92.12
	1980-1983	75.42	661.04	155.88	1411.48	76.84	695.74
	1984+	24.94	213.27	186.39	1697.66	276.05	2518.12
Plumbtesmo & Catalyst	Pre-1980	135.52	1239.57	128.31	1360.40	14.36	128.19
	1980-1983	113.33	975.28	221.32	1978.59	109.11	975.48
	1984+	39.74	333.18	260.68	2345.54	383.26	3454.61
Fuel Inlet & Catalyst & Air Pump	Pre-1980	112.64	1200.58	115.65	1326.37	12.70	123.41
	1980-1983	90.23	998.94	191.58	1833.34	94.99	916.78
	1984+	29.00	300.03	231.11	2247.24	341.33	3309.49

Table 20 (continued)

Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi) Passenger Car HC	CO	Light-Duty Trucks (6000 lbs) HC	CO	Light-Duty Trucks (6000-8500 lbs) HC	CO
Plumbtesmo & Catalyst Air Pump	Pre-1980	154.74	1545.89	156.22	1682.72	17.86	168.74
	1980-1983	129.94	1328.57	271.02	2531.22	134.16	1260.91
	1984+	44.24	423.56	323.36	3063.51	476.04	4503.96
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1980	165.76	1485.64	161.65	1650.03	18.40	163.31
	1980-1983	129.20	1104.02	275.55	2452.67	135.79	1208.68
	1984+	41.92	350.82	331.83	2971.67	494.03	4429.78
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1980	98.39	858.91	65.18	540.24	8.34	69.62
	1980-1983	94.87	939.03	127.96	1051.94	63.68	532.08
	1984+	35.12	323.76	141.06	1180.18	200.19	1651.16
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1980	184.98	1791.95	189.55	1972.36	21.90	203.86
	1980-1983	145.82	1457.30	325.25	3005.29	160.84	1494.11
	1984+	46.41	441.20	394.51	3689.63	586.81	5479.13
PCV*	Pre-1980	6.46	0.0	11.35	0.0	3.28	0.0
	1980-1983	5.55	0.0	8.91	0.0	4.38	0.0
	1984+	2.35	0.0	10.10	0.0	15.07	0.0
Evaporative* Canister	Pre-1980	2.12	0.0	5.28	0.0	0.41	0.0
	1980-1983	2.39	0.0	8.14	0.0	3.13	0.0
	1984+	0.72	0.0	9.87	0.0	11.47	0.0
All Items**	Pre-1980	193.56	1791.95	206.18	1972.36	25.59	203.86
	1980-1983	153.76	1457.30	342.31	3005.29	168.35	1494.11
	1984+	49.49	441.20	414.48	3689.63	613.36	5479.13
All Items**	All Yrs.	396.81	3690.45	962.97	8667.28	807.30	7177.10
	(in gm/mi)	0.40	3.69	0.96	8.67	0.81	7.18
Percent***		11.2%	9.5%	2.9%	2.3%	1.5%	1.2%

*PCV or evaporative canister benefits can be added directly to any of the above programs.
**Plumbtesmo, fuel inlet, catalyst, air pump, PCV and evaporative canister checks.
***Percent of composite mobile source emissions using MOBILE2 estimates of passenger car and light-duty truck vehicle miles traveled.

5.2.3 Program Costs

This subsection states assumptions necessary to calculate the cost of a tampering inspection program when added to an existing safety inspection program and when initiated independently. Costs are calculated over the four-year period 1984-1987, so that cost-effectiveness can be calculated and presented in the following subsection.

Repairs - The obvious cost of anti-tampering and anti-misfueling programs is the cost to vehicle owners for repairs of disablements, whether they were deliberate or inadvertent. In terms of all cars being inspected, the per vehicle cost for repairs will be relatively small, since usually only some small fraction of vehicles will require repairs. Also, if the program continues to operate beyond December 31, 1987, the cost-effectiveness of the repairs will improve until essentially the only costs incurred by the program will be the cost of inspection. Section 3.0 discusses the repair costs which we have assumed for this analysis.

Using the rate of tampering at the start of the program, the number of vehicles which require repairs at the start of the program can be estimated. By assuming an average repair cost, the initial year repair cost can be estimated.

After the program begins, some tampering will continue to occur and subsequently be detected and repaired. The number of vehicles tampered after the program begins will depend on the effectiveness of the program in detering tampering. The effectiveness will depend on the emission control component.

For air pump, catalyst and fuel inlet restrictor tampering it is assumed that only those vehicles identified in the first year of the program will require repairs. Vehicles not identified are assumed to continue to avoid detection in subsequent years. Also, no significant amount of new tampering is expected to be discovered in subsequent years since vehicle owners will be aware of the program and its penalties. PCV and evaporative canister disablements occur at a high rate even in an inspection program which checks for such disablements. In these cases all disablements are assumed to be repaired in the first year and in each subsequent year repairs will be done on all disablements which reappear.

Tampering Inspections Added to Safety - In addition to the cost vehicle owners must pay in repairs, a safety inspection program which adds a tampering check will incur additional expenses from the added tampering inspections at individual inspection stations and additional administrative costs related to adding the tampering inspection to the I/M requirements. A rough estimate of the additional costs can be made by estimating the increase in personnel time, both inspector and administrative, necessary to include the tampering check.

In centralized inspection programs the tampering inspection might be added to the inspection procedure without any needed increase in personnel. This would be the case if personnel and operating hours did not require expansion; better scheduling of inspections or simply tolerating longer waiting lines could be used to allow tampering inspections with the existing facility and personnel time. It is more likely that additional inspectors, administrative personnel, or possibly inspection stations would be required. In such cases the added salaries of the additional personnel and other costs would be attributed to the tampering inspection.

In decentralized programs, only the additional time an inspector will need to perform the tampering check should be attributed to the anti-tampering program. As with centralized programs, administrative costs can probably be estimated by the need to hire additional personnel.

It is expected that most of the duties required by the addition of a tampering inspection can be integrated into the operation of the safety program without any substantial increase in program costs. Although this cost will likely vary substantially from program to program depending on many factors, we have assumed an overall increase in program administrative and inspection costs to be 34 cents for centralized and $1.00 for decentralized programs per inspection as an example. This added cost would include not only additional costs to perform the inspections, but also include additional administrative duties to oversee the additional program elements. Section 5.1.3 discusses how these costs were estimated.

Tampering Inspections Without Safety - In this case, the tampering check is responsible for the full cost of the inspection program, including the cost of facilities and personnel that in existing safety programs can be attributed to the safety element. Costs in such a program would probably range from $5 to $10. An assumption of $7 will be used here, which is thought to be representative of an average decentralized program.

5.2.4 Cost-Effectiveness

Tables 21-24 present cost-effectiveness values calculated for the benefits presented in Tables 19 and 20 in Section 5.2.2.

These cost-effectiveness values assume the following average repair costs:

- $20 per disabled air pump
- $200 per removed catalyst
- $10 per disabled PCV system
- $10 per disabled evaporative canister
- $150 per misfueled catalyst
- $30 per tampered fuel inlet restrictor

These repair costs are discussed in Section 3.0. The additional inspection and administrative costs are assumed to be 34 cents for centralized and $1.00 for decentralized programs per inspected vehicle per inspection for safety/tampering programs and $7.00 for tampering only programs. Local estimates will likely vary substantially from this assumption depending on program type and local conditions. The inspection cost has been distributed equally between all of the inspected emission control components and divided equally between the two pollutants when both HC and CO emissions are affected. Emission benefits have been calculated for each year of the programs beginning on January 1, 1984 through the evaluation data of January 1, 1988. The total inspection, administrative, and repair costs are summed for those years and divided by the sum total emission reductions and converted to cost per ton.

Table 21

(To be added)

Table 22

(To be added)

Table 23

(To be added)

Table 24

(To be added)

5.3 Other Anti-Tampering and Anti-Misfueling Programs

The anti-tampering and anti-misfueling programs in this subsection do not involve periodic inspection of vehicles and therefore must rely more heavily on the possibility of detection to deter misfueling and tampering. Correction of tampering already present at the start of the program will be less complete than in a periodic inspection program, since only a fraction of the fleet is ever directly affected by the enforcement actions. (Owners of already tampered vehicles will wait until caught before repairing them since it is assumed that there is no fine in addition to repairs.) As a result, the uncertainty inherent in the benefits from these programs is larger than in programs where every vehicle is inspected periodically.

Although there are numerous ways in which tampering and misfueling might be reduced without periodic inspection, this report will focus only on a few approaches which seem to provide the best probability of large emission benefits and low uncertainty. Other approaches not considered in this report may provide similar benefits. If an area wishes to claim credit for such programs, the EPA Regional Office should be contacted for an evaluation of the potential of the specific approach proposed.

To claim all of the benefits estimated in the tables in this section, the anti-tampering and anti-misfueling program must meet all of the requirements outlined at the beginning of Section 5.0. These include such design features as referee stations and inspector training.

5.3.1 Change-of-Ownership Inspection Programs

A change-of-ownership anti-tampering inspection program would require an inspection of the vehicle to assure proper connection of the emission control devices every time the vehicle changed ownership or moved into the area for the first time. Title and registration in the new owner's name would be withheld until the vehicle was in compliance. This section assumes that no I/M program is in effect.

Although nearly all vehicles change hands at least once in their lives, the time between sales can vary and will often be many years. This time period would allow vehicle owners an opportunity to operate tampered vehicles for long periods of time before any penalty, in terms of the replacement and repair costs that would be paid. Some vehicle owners could avoid even this penalty by selling the vehicle outside the area covered by the program or simply retaining or junking the car. Also, within-family transfers are often exempted since any requirements could be easily circumvented by simply leaving the title in the original owner's name. States may also be reluctant to intrude into family transactions. These problems will cause the effectiveness of such programs to be less than for periodic inspection programs.

Vehicle owners who own cars with the catalyst removed or misfueled will probably not replace the catalyst until forced to in order to complete the sale. Therefore, the number of catalysts that are replaced will depend on the fraction of vehicles which change ownership each year. The same will be true of vehicle owners who have removed or disabled their air pump. Since evaporative and PCV tampering is assumed to be inadvertant and undeterrable, and to recur after repair, no significant benefit for them can be expected in a change-of-ownership program. No benefits for PCV or evaporative system inspections have therefore been estimated.

Benefits from a change-of-ownership inspection program assume that ownership will change in a random fashion, that is older cars will change owners with the same probability as newer cars. For this analysis, it is assumed that 15% of the fleet changes owners each year. This is considered a normal rate. Some areas may differ. Over the initial four years of the program (1984 through 1987) about 48% of the fleet will have changed owners. The benefits therefore assume that 48% of tampering which occurred before the program began will be affected by the program. The effectiveness of the inspection for this 48% will be assumed to be the same as for biennial inspections. This assumes that the efficiency of the inspection will not be significantly less in a change-of-ownership program than in a biennial program. The biennial effectiveness values will also be applied to all of the excess emissions due to tampering that would have occurred after the program began. This assumes that few vehicle owners will tamper knowing that the tampering must be fixed before selling the vehicle.

Table 25 shows the benefits of a change-of-ownership inspection program. Benefits would be larger if the inspection included a tailpipe emissions check, but such a combined program is outside the scope of this report.

5.3.2 Roadside Pullover Inspection

A roadside pullover anti-tampering inspection program would commit to inspecting some percentage of the areawide fleet each year randomly chosen from traffic on a variety of road types. Steps would of course have to be taken by the program to assure that vehicle owners cannot avoid inspection. Each vehicle stopped would be checked for tampering and issued a ticket if tampering were discovered. The vehicle owner would then repair or replace the tampered emission control component and resubmit his vehicle for inspection at a designated location. If such repairs were not performed in a reasonable time period then a fine (higher than the cost of repair) would be added as a penalty, a hold put on the vehicle's license renewal, and court proceedings would begin to collect the fine.

The effectiveness of a roadside pullover program will depend on the number of vehicles actually inspected and the risk perceived by vehicle owners that their vehicle will be inspected. Obviously, a program that stops only a small percentage of the fleet will present only a small risk to vehicle owners who tamper.

As with change-of-ownership programs, vehicle owners cannot be expected to repair previous tampering until they are inspected. The following is an estimate of the percentage of the vehicles in the fleet which would have been inspected at least once in the initial four years of the program depending on the pullover rate. Vehicles tampered before the program begins have a higher probability of being inspected than those tampered later, since they will be exposed to the program more years. The following table presents the percent of tampered vehicles expected to be inspected by January 1, 1988. Pullover rates greater than 5% are not considered feasible.

Pullover Rate	Percent of Tampering Detected by January 1, 1988 Year in Which Tampering Occurred				
	Before 1984	1984	1985	1986	1987
1%	4%	3%	2%	1%	0%
2%	8%	6%	4%	2%	0%
5%	19%	14%	10%	5%	0%

For the vehicles which are inspected, we will assume the same inspection effectiveness as for a biennial inspection. In addition, it is assumed that some percentage of vehicle owners will not tamper after the program begins. The number of vehicle owners who do not tamper will depend on the visibility of the random inspection program, since it determines the perceived risk of detection. Visibility in turn will depend on the percentage of vehicles inspected each year. In this analysis we will assume that if 5% of the fleet is inspected each year, the program will be 50% as effective as a biennial periodic inspection in deterring new tampering and misfueling. A 2% pullover program is assumed to be 35% as effective and a 1% program is assumed to be 25% as effective. Some of the new tampering that does occur will be detected and corrected, as with tampering that occurred prior to the start of the program.

Tables 26 through 28 show the benefits of a random roadside inspection program for these pullover rates. The benefits are smaller than any of the programs presented earlier, due to less complete coverage and less effective deterrence. Although cost-effectiveness has not been calcuated for this program, the cost of a roadside inspection including owner inconvenience is likely to be higher than an inspection at a licensed garage or state-run inspection station. Tending to counteract this is the fact that fewer inspections are performed.

5.3.3 Fueling Station Enforcement Program

In this program plain-clothes enforcement officers would visit each fuel station unannounced, at least twice a year, and observe the fuelings that occur during at least one half the day. If a vehicle which required the use of unleaded fuel was observed fueling with leaded fuel, the officer would ticket the offender. The penalty would be mandatory replacement of the catalyst on that vehicle. New license plates for that vehicle would be denied until the catalyst had been replaced and an additional penalty (fine) would be added if within a reasonable period (i.e., one month) after the ticket had been issued the catalyst had not been replaced. Court action to collect the fine would be started after a certain period. In addition where appropriate, the operators of self-service stations would be charged with having allowed the misfuelings that lead to individuals being cited. The penalty would be the existing federal fine of $10,000 for such actions. Full-service fueling stations would also be observed during the surveillance and misfuelings performed by station personnel would be prosecuted. The effect of prosecuting fuel station operators would be to make them wary of misfueling vehicles themselves or allowing misfueling to occur at their stations, adding to the effectiveness of the program. Extensive press coverage of the program and its successful detections and prosecutions would be sought. This approach is assumed to prevent and deter 80% of misfueling which would have otherwise occurred after the program begins.

The benefits provided in this paper for programs to reduce misfueling assume that unleaded fuel dispensed at service stations is indeed unleaded fuel. It is therefore important that occurrences of contamination and mislabeling at the pump be minimized. This can be done by establishing the program of fuel pump inspections described at the beginning of Section 5.0.

Tables 29-35 present the benefits of this anti-misfueling program in I/M and non-I/M areas without any inspection program or with periodic inspection programs and in non-I/M areas with change-of-ownership and random roadside programs. Enforcement at fuel stations can only prevent misfueling not already prevented by a periodic, change of ownership, or random roadside inspection program. Hence, the benefits of this approach depend on what type of inspection program is in place. The benefits in Tables 29-35 should be added to those for the specific inspection program of interest to get the total benefit from inspections and fuel station enforcement. Only misfueling which would have occurred since the program start is considered in calculating benefits.

5.3.4 <u>Price Equalization</u>

Most studies of misfueling behavior suggest that price is a primary motivation to misfuel. Programs such as the covert observation approach explained above attempt to make the potential penalty for misfueling greater than the motivations to misfuel. Another approach would be to remove the price incentive to misfuel. This could be done by eliminating the difference in price between regular leaded and regular unleaded gasoline now observed at retail fueling stations.

There are several possible approaches to equalizing the price of leaded and unleaded fuel. The state or local government could equalize the price by law or ordinance. This would require gas stations to raise the price of leaded fuel and/or lower the price of unleaded fuel. The state or local government could tax leaded fuel instead. This would equalize the cost to gas stations of leaded and unleaded fuel, which would tend to equalize the price paid by consumers. It would also be a revenue source.

Of course this approach is not without problems. The effect of price equalization would be to raise the price of leaded fuel. Older vehicles designed for use of leaded fuel tend to be owned by poorer motorists, raising issues of regressive taxation. As time goes on, however, the number of vehicles designed for leaded fuel will decrease anyway as the older vehicles are scrapped so that the effect on total fuel costs will decrease with time. Also, this approach will moderate the way gas stations now sell leaded fuel at or near cost and prominently posting the low price while making up the profit in raising the price of unleaded fuel.

There is some uncertainty, however, about the effectiveness of price equalization on detering misfueling. Since perceptions of performance are still an incentive to misfuel, the price of unleaded versus leaded fuel will not matter to some vehicle owners. Some studies suggest that performance is claimed by car owners to be of more importance in explaining misfueling than price. However, none of these studies conclusively identify what the misfueling rate would be in the long run in the absence of a price incentive. Conclusive evidence may not be available to address this complex issue until a state or local government begins such a program. In this report we have assumed that elimination of the economic incentives for misfueling will deter 80% of new misfueling which would have otherwise occurred.

With the assumption of 80% effectiveness, the benefits of price equalization are the same for the previously described program of fuel station enforcement. Therefore, Tables 29-35 may be used for both.

6.0 ADJUSTMENT TO LOCAL CONDITIONS

Since the results in Section 4.3 and in Section 5.0 all assume standard MOBILE2 operating conditions and default values, the results must be adjusted to reflect local conditions if non-standard MOBILE2 conditions are used to calculate the base emission levels. The simplist method to accomplish this task is to compare standard MOBILE2 results with MOBILE2 results modified to reflect local conditions. The percentage difference between the two results for each vehicle type would be applied to the results in this report to adjust them to local conditions.

This approach assumes that the emissions from grossly tampered vehicles will be affected by the change in ambient conditions proportionally to the MOBILE2 emission factors. This has not been verified by disablement testing at non-FTP conditions, however it is not an unreasonable assumption that the emission effects will be similar. It is unlikely that sufficient disablement testing at non-FTP conditions will be available soon, if ever. Emission benefits from PCV and evaporative canister inspections do not require the adjustment, since MOBILE2 does not adjust non-exhaust emissions for non-standard conditions.

For example, standard MOBILE2 predicts 2.42 gm/mi HC on January 1, 1988 for passenger cars. After adjusting MOBILE2 for local temperature, speed, VMT, and model year distribution, a local area may predict 2.02 gm/mi HC for passenger cars, or 83% of the standard MOBILE2 prediction. This local area would therefore only expect 83% of the HC benefits (in tons or grams per mile) from air pump, catalyst, and misfueling inspections calculated in Section 5.0 for their program. A factor for CO and for HC and CO from light-duty trucks would be calculated in the same manner.

Table 25

Benefit of Tampering Inspections
At Change of Ownership
in Non-I/M Areas*
(January 1, 1988)

Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi)					
		Passenger Car		Light-Duty Trucks (6000 lbs)		Light-Duty Trucks (6000-8500 lbs)	
		HC	CO	HC	CO	HC	CO
Air Pump Only	Pre-1984	9.67	225.60	11.18	260.93	0.36	8.44
	1984+	8.01	250.11	4.59	107.15	2.69	62.88
		2.27	70.99	7.06	164.78	9.29	216.83
Catalyst Only	Pre-1984	17.97	177.97	14.00	138.65	1.80	17.84
	1984+	16.49	168.29	30.16	298.63	14.88	147.33
		4.91	51.04	35.01	346.59	59.74	502.43
Fuel Inlet Only	Pre-1984	30.80	227.67	17.96	134.00	2.40	18.07
	1984+	36.66	283.21	41.46	317.67	20.48	156.98
		16.89	129.61	41.79	316.15	56.37	422.07
Plumbtesmo Only	Pre-1984	51.44	381.78	29.55	221.89	3.98	30.09
	1984+	62.72	285.40	69.61	535.81	34.40	264.83
		29.38	226.42	69.49	528.47	93.00	700.36
Plumbtesmo &Fuel Inlet	Pre-1984	60.93	447.59	36.38	268.96	4.81	35.71
	1984+	69.71	536.87	81.34	618.62	40.17	305.60
		31.22	239.60	83.29	624.72	113.72	843.79
Air Pump & Catalyst	Pre-1984	29.08	417.81	27.38	421.33	2.45	29.08
	1984+	25.75	431.15	39.23	450.16	19.79	232.10
		7.55	126.90	47.27	572.88	67.58	793.93
Air Pump & Fuel Inlet	Pre-1984	39.23	391.65	23.22	218.08	3.11	29.39
	1984+	47.19	553.37	52.39	478.30	26.31	246.31
		20.30	209.54	55.02	532.25	73.75	705.36
Air Pump & Plumbtesmo	Pre-1984	64.41	632.88	44.96	517.66	4.91	43.34
	1984+	74.50	766.21	84.55	731.40	42.20	371.44
		33.25	309.35	86.69	778.57	115.67	1028.20
Fuel Inlet & Catalyst	Pre-1984	63.23	548.77	48.80	439.41	6.34	57.07
	1984+	64.47	566.93	104.36	940.43	51.50	464.13
		24.94	213.27	116.18	1052.65	165.29	1500.47
Plumbtesmo & Catalyst	Pre-1984	96.16	869.23	78.51	820.45	9.16	81.38
	1984+	98.32	848.62	155.20	1353.46	75.13	668.12
		39.74	33.18	166.72	1491.16	235.03	2106.66
Fuel Inlet & Catalyst & Air Pump	Pre-1984	77.74	817.60	69.35	788.69	7.92	77.00
	1984+	77.27	860.34	128.75	1234.31	63.97	619.17
		29.00	300.03	145.41	1427.16	206.16	2016.36

Table 25 (continued)

Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi): Passenger Car HC	Passenger Car CO	Light-Duty Trucks (6000 lbs) HC	Light-Duty Trucks (6000 lbs) CO	Light-Duty Trucks (6000-8500 lbs) HC	Light-Duty Trucks (6000-8500 lbs) CO
Plumbtesmo & Catalyst & Air Pump	Pre-1980	109.05	1074.84	94.92	1012.29	11.28	106.37
	1980-1983	112.47	1153.44	184.66	1722.59	91.57	860.25
	1984+	44.24	423.56	205.79	1957.73	290.59	2760.10
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1980	112.21	999.98	95.29	966.08	11.21	99.21
	1980-1983	108.22	929.49	180.56	1600.93	89.09	789.93
	1984+	41.92	350.82	202.94	1809.39	290.70	2596.10
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1980	70.64	621.75	43.44	368.36	5.77	49.35
	1980-1983	81.59	818.57	96.65	817.93	48.16	414.05
	1984+	36.12	323.76	100.83	878.20	136.80	1175.79
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1980	125.09	1205.59	111.69	1157.93	13.33	123.20
	1980-1983	122.37	1234.42	213.02	1970.07	105.53	982.05
	1984+	46.41	441.20	242.02	2275.96	346.25	3249.54
All Items**	All Yrs.	297.87	2881.21	566.72	5403.96	465.11	4355.79
	(in gm/mi)	0.30	2.88	0.57	5.40	0.47	4.36
Percent***		8.4%	7.4%	1.7%	1.5%	0.8%	0.7%

*Assumes a random 15% changeover of the fleet each year with program beginning January 1, 1984.

**Plumbtesmo, fuel inlet, catalyst, air pump, PCV and evaporative canister checks.

***Percent of composite mobile source emissions using MOBILE2 estimates of passenger car and light-duty truck vehicle miles traveled.

Table 26

Benefit of Anti-Tampering Inspections
During 5% Random Roadside Pullover
in Non-I/M Areas

		Per Vehicle Reduction in Emissions (mg/mi)					
				Light-Duty Trucks			
	Affected	Passenger Car		(6000 lbs)		(6000-8500 lbs)	
Inspection Program	Model Years	HC	CO	HC	CO	HC	CO
Air Pump Only	Pre-1980	4.46	104.04	4.91	114.58	0.17	3.94
	1980-1983	4.14	129.32	2.26	52.87	1.33	31.05
	1984+	1.18	36.73	3.45	80.43	4.44	103.72
Catalyst Only	Pre-1980	8.48	83.94	6.13	60.70	0.80	7.92
	1980-1983	8.44	86.20	13.84	136.99	6.83	67.62
	1984+	2.54	26.36	15.33	151.76	21.76	215.47
Fuel Inlet Only	Pre-1980	15.15	112.97	8.53	64.55	1.16	8.82
	1980-1983	19.01	147.46	20.62	159.64	10.19	78.92
	1984+	8.80	67.51	19.93	152.42	26.28	199.10
Plumbtesmo Only	Pre-1980	25.52	190.96	14.19	107.89	1.94	14.83
	1980-1983	32.66	253.67	34.90	271.16	17.25	134.08
	1984+	15.31	117.41	33.41	256.79	43.75	333.20
Plumbtesmo &Fuel Inlet	Pre-1980	29.55	219.18	17.01	127.55	2.29	17.28
	1980-1983	35.90	277.73	39.94	307.25	19.74	151.86
	1984+	16.27	124.74	39.17	297.38	52.27	392.70
Air Pump & Catalyst	Pre-1980	13.61	194.69	12.00	184.80	1.09	13.11
	1980-1983	13.22	222.05	18.16	210.21	9.17	108.72
	1984+	3.90	65.09	21.05	254.73	29.44	351.21
Air Pump & Fuel Inlet	Pre-1980	19.17	190.65	11.03	103.90	1.50	14.23
	1980-1983	24.46	287.26	16.13	240.14	13.13	123.64
	1984+	10.57	108.89	26.41	258.39	34.62	335.30
Air Pump & Plumbtesmo	Pre-1980	31.59	307.65	21.17	239.88	2.39	21.20
	1980-1983	38.75	398.96	42.42	369.54	21.18	187.64
	1984+	17.32	160.86	41.81	379.49	54.59	490.87
Fuel Inlet & Catalyst	Pre-1980	30.25	262.49	21.85	196.39	2.88	25.89
	1980-1983	33.15	291.81	49.04	441.04	24.22	217.78
	1984+	12.96	110.72	52.07	470.72	72.44	656.18
Plumbtesmo & Catalyst	Pre-1980	46.32	416.71	35.40	367.24	4.21	37.35
	1980-1983	50.79	438.75	72.35	641.96	35.73	317.07
	1984+	20.67	173.07	75.57	674.14	104.11	930.90

Table 26 (continued)

Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi): Passenger Car HC	Passenger Car CO	Light-Duty Trucks (6000 lbs) HC	Light-Duty Trucks (6000 lbs) CO	Light-Duty Trucks (6000-8500 lbs) HC	Light-Duty Trucks (6000-8500 lbs) CO
Fuel Inlet & Catalyst & Air Pump	Pre-1980	37.02	387.21	30.95	350.47	3.60	35.04
	1980-1983	39.76	443.43	60.61	581.49	30.14	292.09
	1984+	15.07	155.63	65.44	644.91	90.71	890.64
Plumbtesmo & Catalyst & Air Pump	Pre-1980	52.38	513.47	42.64	452.52	5.16	48.65
	1980-1983	58.06	596.03	87.44	815.27	43.39	407.57
	1984+	23.00	219.86	93.07	887.03	128.46	1222.28
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1980	53.01	471.21	42.15	425.82	5.04	44.56
	1980-1983	55.29	475.67	84.05	743.98	41.50	367.29
	1984+	21.80	182.24	90.19	802.52	126.39	1126.64
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1980	34.18	301.85	20.38	174.54	2.75	23.75
	1980-1983	42.03	423.49	47.67	407.63	23.77	206.41
	1984+	18.30	168.37	47.75	421.83	63.33	552.52
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1980	59.06	567.98	49.39	511.10	5.99	55.86
	1980-1983	62.56	632.95	99.14	917.29	49.16	457.80
	1984+	24.13	229.03	107.70	1015.41	150.74	1418.02
Total all Years*		145.75	1429.96	145.94	1432.01	114.08	1082.22
(in gm/mi)		0.15	1.43	0.15	1.43	0.11	1.08
Percent**		4.1%	3.7%	0.4%	0.4%	0.2%	0.2%

*Plumbtesmo, fuel inlet, catalyst, air pump, PCV and evaporative canister checks.
**Percent of composite mobile source emissions using MOBILE2 estimates of passenger car and light-duty truck vehicle miles traveled.

Table 27

Benefit of Anti-Tampering Inspections
During 2% Random Roadside Pullover
in Non-I/M Areas

		Per Vehicle Reduction in Emissions (mg/mi)					
				Light-Duty Trucks			
Inspection Program	Affected Model Years	Passenger Car HC	Passenger Car CO	(6000 lbs) HC	(6000 lbs) CO	(6000-8500 lbs) HC	(6000-8500 lbs) CO
Air Pump Only	Pre-1980	2.55	59.49	2.61	60.82	0.10	2.30
	1980-1983	2.74	85.41	1.42	33.07	0.83	19.45
	1984+	0.82	25.49	2.19	51.18	2.78	64.90
Catalyst Only	Pre-1980	5.00	49.53	3.24	32.08	0.43	4.28
	1980-1983	5.51	56.36	7.86	77.79	3.88	38.43
	1984+	1.76	18.31	8.27	81.86	11.38	112.68
Fuel Inlet Only	Pre-1980	9.43	71.11	5.09	39.16	0.70	5.45
	1980-1983	12.60	98.14	13.03	102.07	6.44	50.49
	1984+	6.10	46.79	12.28	95.41	15.83	122.10
Plumbtesmo Only	Pre-1980	16.06	121.37	8.57	66.28	1.19	9.26
	1980-1983	21.74	169.52	22.25	174.81	11.01	86.47
	1984+	10.61	81.37	20.84	162.46	26.72	206.87
Plumbtesmo &Fuel Inlet	Pre-1980	18.08	135.77	9.92	75.83	1.36	10.48
	1980-1983	23.60	183.55	24.84	193.75	12.28	95.81
	1984+	11.27	86.46	23.68	182.88	30.81	235.99
Air Pump & Catalyst	Pre-1980	7.95	112.99	6.35	97.94	0.60	7.25
	1980-1983	8.67	146.04	10.44	122.43	5.29	63.59
	1984+	2.71	45.19	11.69	145.21	15.85	194.31
Air Pump & Fuel Inlet	Pre-1980	11.84	117.23	6.57	62.15	0.91	8.69
	1980-1983	16.21	190.56	16.56	153.38	8.32	78.96
	1984+	7.33	75.50	16.42	163.27	21.08	207.92
Air Pump & Plumbtesmo	Pre-1980	19.61	188.83	12.46	138.13	1.47	13.12
	1980-1983	25.76	265.55	27.07	237.79	13.52	120.72
	1984+	12.01	111.53	26.19	241.07	33.50	300.29
Fuel Inlet & Catalyst	Pre-1980	18.19	157.81	11.96	107.24	1.61	14.46
	1980-1983	21.76	191.81	28.81	258.37	14.24	127.68
	1984+	8.99	76.79	29.23	263.18	39.43	355.76
Plumbtesmo & Catalyst	Pre-1980	28.10	251.26	19.59	200.97	2.40	21.21
	1980-1983	33.51	289.81	43.17	381.88	21.34	188.75
	1984+	14.33	120.02	43.18	383.65	57.74	514.07

Table 27 (continued)

Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi): Passenger Car HC	Passenger Car CO	Light-Duty Trucks (6000 lbs) HC	Light-Duty Trucks (6000 lbs) CO	Light-Duty Trucks (6000-8500 lbs) HC	Light-Duty Trucks (6000-8500 lbs) CO
Fuel Inlet & Catalyst & Air Pump	Pre-1980	22.13	229.75	16.86	189.64	2.02	19.67
	1980-1983	26.12	291.89	35.69	342.77	17.77	172.49
	1984+	10.45	107.96	36.98	366.75	49.72	491.50
Plumbtesmo & Catalyst & Air Pump	Pre-1980	31.66	308.20	23.47	247.15	2.92	27.50
	1980-1983	38.28	393.42	51.90	483.57	25.78	242.09
	1984+	15.94	152.50	53.01	506.60	70.99	677.52
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1980	31.34	277.72	22.64	227.48	2.78	24.52
	1980-1983	36.04	310.63	48.74	430.38	24.08	212.64
	1984+	15.11	126.38	49.91	442.58	67.81	602.36
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1980	20.86	184.99	11.94	103.64	1.65	14.40
	1980-1983	27.66	279.90	29.80	258.10	14.87	130.74
	1984+	12.68	116.73	29.15	262.72	37.74	336.90
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1980	34.91	334.66	26.53	273.66	3.30	30.81
	1980-1983	40.81	414.24	57.47	532.06	28.53	265.98
	1984+	16.73	158.85	59.73	565.53	81.06	765.82
Total All Years*		92.45	907.75	67.68	673.50	49.37	474.81
(in gm/mi)		0.09	0.91	0.07	0.67	0.05	0.47
Percent**		2.6%	2.3%	0.2%	0.2%	0.1%	0.1%

*Plumbtesmo, fuel inlet, catalyst, air pump, PCV and evaporative canister checks.

**Percent of composite mobile source emissions using MOBILE2 estimates of passenger car and light-duty truck vehicle miles traveled.

Table 28

Benefit of Anti-Tampering Inspections During 1% Random Roadside Pullover in Non-I/M Areas

		Per Vehicle Reduction in Emissions (mg/mi)					
				Light-Duty Trucks			
Inspection Program	Affected Model Years	Passenger Car		(6000 lbs)		(6000-8500 lbs)	
		HC	CO	HC	CO	HC	CO
Air Pump Only	Pre-1980	1.64	38.32	1.60	37.42	0.06	1.50
	1980-1983	1.90	59.28	0.96	22.36	0.56	13.16
	1984+	0.58	18.12	1.50	34.94	1.88	43.94
Catalyst Only	Pre-1980	3.28	32.48	1.99	19.68	0.27	2.66
	1980-1983	3.81	38.94	5.04	49.91	2.49	24.67
	1984+	1.25	13.02	5.14	50.93	6.94	68.71
Fuel Inlet Only	Pre-1980	6.36	48.23	3.35	26.06	0.47	3.66
	1980-1983	8.76	68.36	8.85	69.76	4.38	34.52
	1984+	4.33	33.23	8.25	64.59	10.51	81.82
Plumbtesmo Only	Pre-1980	10.89	82.71	5.69	44.39	0.80	6.26
	1980-1983	15.15	118.31	15.19	119.96	7.51	59.35
	1984+	7.54	57.79	14.08	110.57	17.86	139.51
Plumbtesmo &Fuel Inlet	Pre-1980	12.09	91.34	6.46	49.91	0.90	6.97
	1980-1983	16.35	127.44	16.75	131.52	8.28	65.06
	1984+	8.01	61.40	15.74	122.70	20.21	156.45
Air Pump & Catalyst	Pre-1980	5.18	73.39	3.90	60.20	0.38	4.58
	1980-1983	6.00	101.17	6.75	79.68	3.42	41.49
	1984+	1.93	32.12	7.41	93.44	9.85	122.85
Air Pump & Fuel Inlet	Pre-1980	7.96	78.56	4.33	41.05	0.61	5.81
	1980-1983	11.26	132.54	11.07	104.78	5.66	53.93
	1984+	5.20	53.64	11.08	111.05	14.07	140.13
Air Pump & Plumbtesmo	Pre-1980	13.21	126.43	8.16	89.32	0.98	8.82
	1980-1983	17.94	184.98	18.49	163.02	9.24	82.76
	1984+	8.53	79.22	17.73	164.41	22.46	207.08
Fuel Inlet & Catalyst	Pre-1980	12.05	104.52	7.51	67.18	1.03	9.18
	1980-1983	15.07	132.84	18.85	168.72	9.32	83.41
	1984+	6.38	54.56	18.63	167.41	24.68	222.10
Plumbtesmo & Catalyst	Pre-1980	18.70	166.67	12.37	126.08	1.54	13.61
	1980-1983	23.25	201.17	28.47	251.48	14.08	124.34
	1984+	10.18	85.27	27.83	246.63	36.56	324.64

Table 28 (continued)

Inspection Program	Affected Model Years	Passenger Car HC	Passenger Car CO	Light-Duty Trucks (6000 lbs) HC	Light-Duty Trucks (6000 lbs) CO	Light-Duty Trucks (6000-8500 lbs) HC	Light-Duty Trucks (6000-8500 lbs) CO
		Per Vehicle Reduction in Emissions (mg/mi)					
Fuel Inlet	Pre-1980	14.61	151.08	10.55	118.14	1.29	12.53
& Catalyst	1980-1983	18.09	202.29	23.37	224.60	11.64	113.14
& Air Pump	1984+	7.42	76.72	23.67	235.67	31.25	310.25
Plumbtesmo	Pre-1984	21.03	203.94	14.78	154.86	1.87	17.59
& Catalyst	1984+	26.55	273.00	34.13	317.94	16.97	159.29
& Air Pump		11.33	108.35	34.09	326.34	44.85	428.85
Plumbtesmo	Pre-1984	20.57	181.95	14.04	140.55	1.75	15.44
& Fuel In-	1984+	24.86	214.47	31.65	279.05	15.64	137.93
let & Catalyst		10.74	89.79	31.55	279.20	42.05	372.71
Plumbtesmo	Pre-1984	13.93	123.76	7.80	68.18	1.09	9.58
& Fuel In-	1984+	19.16	194.35	20.14	175.56	10.05	88.94
let & Air Pump		9.00	82.92	19.48	177.40	24.91	225.08
Plumbstesmo	Pre-1984	22.90	219.22	16.45	169.33	2.08	19.42
& Fuel In-	1984+	28.16	286.30	37.31	345.50	18.53	172.88
let & Catalyst		11.88	112.87	37.81	358.91	50.34	476.92
& Air Pump							
Total All Years*		62.94	618.39	37.72	379.70	25.90	252.22
(in gm/mi)		0.06	0.62	0.04	0.38	0.03	0.25
Percent**		1.8%	1.6%	0.1%	0.1%	0.0%	0.0%

*Plumbtesmo, fuel inlet, catalyst, air pump, PCV and evaporative canister checks.

**Percent of composite mobile source emissions using MOBILE2 estimates of passenger car and light-duty truck vehicle miles traveled.

Table 29

Benefit of a Fueling Station
Enforcement Program Begun January 1, 1984
In an Annual I/M Area

Annual Inspection Program	Affected Model Years	Per Vehicle Reduction (January 1, 1988) in Emissions (mg/mi)					
		Passenger Car		Light-Duty Trucks (6000 lbs)		Light-Duty Trucks (6000-8500 lbs)	
		HC	CO	HC	CO	HC	CO
None	Pre-1980	11.97	90.94	5.77	45.57	0.83	6.59
	1980-1983	18.12	140.45	16.76	132.34	8.30	65.52
	1984+	11.11	86.77	15.21	120.11	18.72	147.82
Air Pump Only	Pre-1980	12.74	97.08	6.68	53.58	0.97	7.75
	1980-1983	19.26	149.68	19.40	155.59	9.61	77.03
	1984+	11.80	92.41	17.61	141.20	21.67	173.78
Catalyst Only	Pre-1980	15.36	124.54	7.94	67.09	1.15	9.70
	1980-1983	22.53	185.56	23.07	194.82	11.42	96.45
	1984+	13.63	113.03	20.94	176.81	25.77	217.61
Fuel Inlet Only	Pre-1980	7.24	56.84	3.62	29.56	0.52	4.27
	1980-1983	10.80	86.22	10.50	85.83	5.20	42.50
	1984+	6.58	52.90	9.53	77.90	11.73	95.87
Plumbtesmo Only	Pre-1980	3.75	31.63	2.02	17.72	0.29	2.56
	1980-1983	5.39	46.13	5.88	51.46	2.91	25.48
	1984+	3.23	27.86	5.33	46.70	6.56	57.48
Plumbtesmo &Fuel Inlet	Pre-1980	3.24	27.92	1.79	15.98	0.26	2.31
	1980-1983	4.59	40.24	5.20	46.41	2.57	22.98
	1984+	2.74	24.18	4.72	42.12	5.80	51.83
Air Pump & Catalyst	Pre-1980	16.37	132.97	9.30	79.52	1.35	11.50
	1980-1983	23.97	197.87	27.01	230.92	13.37	114.32
	1984+	14.50	120.47	24.52	209.57	30.17	257.92
Air Pump & Fuel Inlet	Pre-1980	8.51	66.04	5.18	41.50	0.73	5.86
	1980-1983	12.04	95.87	13.87	112.65	6.86	55.74
	1984+	7.27	58.35	13.38	107.49	17.22	137.38
Air Pump & Plumbtesmo	Pre-1980	4.42	36.71	2.89	24.69	0.41	3.51
	1980-1983	6.09	51.80	7.88	68.20	3.90	33.75
	1984+	3.63	31.10	7.50	64.24	9.58	81.34
Fuel Inlet & Catalyst	Pre-1980	8.30	67.25	4.29	36.23	0.62	5.24
	1980-1983	12.16	100.20	12.46	105.20	6.17	52.09
	1984+	7.36	61.04	11.31	95.48	13.92	117.51

Table 29 (continued)

Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi)					
		Passenger Car		Light-Duty Trucks (6000 lbs)		Light-Duty Trucks (6000-8500 lbs)	
		HC	CO	HC	CO	HC	CO
Plumbtesmo & Catalyst	Pre-1980	3.07	24.91	1.59	13.42	0.23	1.94
	1980-1983	4.51	37.11	4.61	38.96	2.28	19.29
	1984+	2.73	22.61	4.19	35.36	5.15	43.52
Fuel Inlet & Catalyst & Air Pump	Pre-1980	8.91	72.46	5.13	43.90	0.74	6.35
	1980-1983	13.05	107.80	14.89	127.48	7.37	63.11
	1984+	7.89	65.63	13.51	115.69	16.63	142.39
Plumbtesmo & Catalyst & Air Pump	Pre-1980	3.42	27.80	2.05	17.68	0.30	2.56
	1983-1983	5.00	41.33	5.97	51.34	2.95	25.42
	1984+	3.02	25.16	5.41	46.59	6.66	57.34
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1980	2.30	18.68	1.19	10.06	0.17	1.46
	1980-1983	3.38	27.83	3.46	29.22	1.71	14.47
	1984+	2.04	16.96	3.14	26.52	3.87	32.64
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1980	3.57	30.74	2.24	20.09	0.32	2.91
	1980-1983	5.07	44.36	6.50	58.35	3.22	28.89
	1984+	3.03	26.67	5.90	52.96	7.27	65.18
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1980	2.65	21.57	1.66	14.32	0.24	2.07
	1980-1983	3.87	32.05	4.81	41.60	2.38	20.60
	1984+	2.34	19.50	4.37	37.75	5.38	46.46

Table 30

Benefit of a Fueling Station
Enforcement Program Begun January 1, 1984
In an Biennial I/M Area

Biennial Inspection Program	Affected Model Years	Per Vehicle Reduction (January 1, 1988) in Emissions (mg/mi)					
		Passenger Car		Light-Duty Trucks (6000 lbs)		Light-Duty Trucks (6000-8500 lbs)	
		HC	CO	HC	CO	HC	CO
None	Pre-1980	11.97	90.94	5.77	45.57	0.83	6.59
	1980-1983	18.12	140.45	16.76	132.34	8.30	65.52
	1984+	11.11	86.77	15.21	120.11	18.72	147.82
Air Pump Only	Pre-1980	12.68	96.64	6.64	53.28	0.96	7.70
	1980-1983	19.15	148.95	19.27	154.71	9.54	76.60
	1984+	11.73	91.95	17.49	140.41	21.53	172.81
Catalyst Only	Pre-1980	15.36	124.54	7.94	67.09	1.15	9.70
	1980-1983	22.53	185.56	23.07	194.82	11.42	96.45
	1984+	13.63	113.03	20.94	176.81	25.77	217.61
Fuel Inlet Only	Pre-1980	7.24	56.84	3.62	29.56	0.52	4.27
	1980-1983	10.80	86.22	10.50	85.83	5.20	42.50
	1984+	6.58	52.90	9.53	77.90	11.73	95.87
Plumbtesmo Only	Pre-1980	3.75	31.63	2.02	17.72	0.29	2.56
	1980-1983	5.39	46.13	5.88	51.46	2.91	25.48
	1984+	3.23	27.86	5.33	46.70	6.56	57.48
Plumbtesmo &Fuel Inlet	Pre-1980	3.24	27.92	1.79	15.98	0.26	2.31
	1980-1983	4.59	40.24	5.20	46.41	2.57	22.98
	1984+	2.74	24.18	4.72	42.12	5.80	51.83
Air Pump & Catalyst	Pre-1980	16.22	131.77	9.11	77.74	1.32	11.24
	1980-1983	23.76	196.11	26.45	225.76	13.10	111.77
	1984+	14.37	119.41	24.00	204.89	29.54	252.16
Air Pump & Fuel Inlet	Pre-1980	8.36	65.06	5.02	40.44	0.71	5.72
	1980-1983	11.91	94.94	13.58	110.71	6.72	54.78
	1984+	7.20	57.83	13.00	104.97	16.65	133.55
Air Pump & Plumbtesmo	Pre-1980	4.49	37.17	2.97	25.19	0.42	3.57
	1980-1983	6.16	52.26	8.02	69.12	3.97	34.20
	1984+	3.66	31.36	7.68	65.42	9.84	83.11
Fuel Inlet & Catalyst	Pre-1980	8.30	67.25	4.29	36.23	0.62	5.24
	1980-1983	12.16	100.20	12.46	105.20	6.17	52.09
	1984+	7.36	61.04	11.31	95.48	13.92	117.51

Table 30 (continued)

Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi)					
		Passenger Car		Light-Duty Trucks (6000 lbs)		Light-Duty Trucks (6000-8500 lbs)	
		HC	CO	HC	CO	HC	CO
Plumbtesmo & Catalyst	Pre-1980	3.07	24.91	1.59	13.42	0.23	1.94
	1980-1983	4.51	37.11	4.61	38.96	2.28	19.29
	1984+	2.73	22.61	4.19	35.36	5.15	43.52
Fuel Inlet & Catalyst & Air Pump	Pre-1980	8.91	72.46	5.13	43.90	0.74	6.35
	1980-1983	13.05	107.80	14.89	127.48	7.37	63.11
	1984+	7.89	65.63	13.51	115.69	16.63	142.39
Plumbtesmo & Catalyst & Air Pump	Pre-1980	3.53	28.76	2.21	19.10	0.32	2.76
	1980-1983	5.16	42.74	6.42	55.46	3.18	27.46
	1984+	3.12	26.01	5.82	50.34	7.17	61.95
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1980	2.30	18.68	1.19	10.06	0.17	1.46
	1980-1983	3.38	27.83	3.46	29.22	1.71	14.47
	1984+	2.04	16.96	3.14	26.52	3.87	32.64
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1980	3.63	31.09	2.28	20.33	0.33	2.94
	1980-1983	5.16	44.94	6.61	59.05	3.27	29.24
	1984+	3.08	27.04	6.00	53.59	7.38	65.96
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1980	2.76	22.54	1.81	15.75	0.26	2.28
	1980-1983	4.04	33.46	5.26	45.72	2.61	22.64
	1984+	2.44	20.35	4.78	41.50	5.88	51.07

Table 31

Benefit of a Fueling Station
Enforcement Program Begun January 1, 1984
In a Non-I/M Area with an
Annual Inspection Program

Annual Inspection Program	Affected Model Years	Per Vehicle Reduction (January 1, 1988) in Emissions (mg/mi)					
		Passenger Car		Light-Duty Trucks (6000 lbs)		Light-Duty Trucks (6000-8500 lbs)	
		HC	CO	HC	CO	HC	CO
None	Pre-1980	37.10	285.90	18.17	145.69	2.63	21.07
	1980-1983	55.69	437.09	52.75	423.07	26.12	209.46
	1984+	29.38	225.42	47.87	383.96	58.92	472.55
Air Pump Only	Pre-1980	39.54	305.62	21.16	172.37	3.06	24.93
	1980-1983	59.25	466.39	61.45	500.56	30.43	247.82
	1984+	31.16	239.66	55.77	454.28	68.64	559.10
Catalyst Only	Pre-1980	48.88	402.47	25.71	220.34	3.72	31.86
	1980-1983	70.89	592.67	74.65	639.85	36.96	316.79
	1984+	34.83	282.15	67.74	580.70	83.38	714.68
Fuel Inlet Only	Pre-1980	22.74	181.20	11.54	95.84	1.67	13.86
	1980-1983	33.57	271.81	33.52	278.32	16.60	137.79
	1984+	17.12	134.77	30.42	252.59	37.44	310.87
Plumbtesmo Only	Pre-1980	12.13	103.81	6.65	59.00	0.96	8.53
	1980-1983	17.22	149.65	19.31	171.33	9.56	84.82
	1984+	8.06	67.78	17.52	155.49	21.57	191.36
Plumbtesmo &Fuel Inlet	Pre-1980	10.57	92.43	5.93	53.58	0.86	7.75
	1980-1983	14.81	131.69	17.22	155.59	8.52	77.03
	1984+	6.73	57.92	15.63	141.21	19.23	173.79
Air Pump & Catalyst	Pre-1980	52.11	430.14	30.25	262.38	4.37	37.94
	1980-1983	75.49	632.58	87.85	761.93	43.50	377.22
	1984+	36.99	300.26	79.73	691.48	98.13	851.03
Air Pump & Fuel Inlet	Pre-1980	26.04	205.86	15.87	129.89	2.24	18.39
	1980-1983	36.66	296.72	42.91	355.96	21.23	176.14
	1984+	18.20	143.65	40.18	331.33	50.92	417.58
Air Pump & Plumbtesmo	Pre-1980	13.96	118.09	9.17	79.83	1.30	11.37
	1980-1983	19.08	165.30	25.20	222.31	12.47	110.03
	1984+	8.74	73.60	23.43	205.47	29.49	257.26
Fuel Inlet & Catalyst	Pre-1980	26.39	217.34	13.88	118.98	2.01	17.21
	1980-1983	38.28	320.04	40.31	345.52	19.96	171.06
	1984+	18.81	152.36	36.58	313.58	45.02	385.93

Table 31 (continued)

Annual Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi)					
		Passenger Car		Light-Duty Trucks (6000 lbs)		Light-Duty Trucks (6000-8500 lbs)	
		HC	CO	HC	CO	HC	CO
Plumbtesmo & Catalyst	Pre-1980	9.78	80.49	5.14	44.07	0.74	6.37
	1980-1983	14.18	118.53	14.93	127.97	7.39	63.36
	1984+	6.97	56.43	13.55	116.14	16.68	142.94
Fuel Inlet & Catalyst & Air Pump	Pre-1980	28.39	234.41	16.69	144.93	2.41	20.96
	1980-1983	41.12	344.67	48.46	420.86	23.99	208.36
	1984+	20.14	163.53	43.98	381.95	54.13	470.07
Plumbtesmo & Catalyst & Air Pump	Pre-1984	10.88	89.98	6.70	58.48	0.97	8.46
	1980-1983	15.76	132.22	19.46	169.82	9.63	84.08
	1984+	7.71	62.64	17.66	154.12	21.73	189.68
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1984	7.33	60.37	3.86	33.05	0.56	4.78
	1980-1983	10.63	88.90	11.20	95.98	5.54	47.52
	1984+	5.23	42.32	10.16	87.10	12.51	107.20
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1984	11.65	101.65	7.44	67.48	1.08	9.76
	1980-1983	16.36	145.02	21.60	195.96	10.69	97.02
	1984+	7.45	64.00	19.60	177.84	24.12	218.88
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1984	8.44	69.86	5.41	47.46	0.78	6.86
	1980-1983	12.21	102.58	15.72	137.83	7.79	68.24
	1984+	5.96	48.53	14.27	125.09	17.56	153.95

Table 32

Benefit of a Fueling Station
Enforcement Program Begun January 1, 1984
In a Non-I/M Area with an
Biennial Inspection Program
or Change of Ownership Program

Annual Inspection Program	Affected Model Years	Per Vehicle Reduction (January 1, 1988) in Emissions (mg/mi)					
		Passenger Car		Light-Duty Trucks (6000 lbs)		Light-Duty Trucks (6000-8500 lbs)	
		HC	CO	HC	CO	HC	CO
None	Pre-1980	37.10	285.90	18.17	145.69	2.63	21.07
	1980-1983	55.69	437.09	52.75	423.07	26.12	209.46
	1984+	29.38	225.42	47.87	383.96	58.92	472.55
Air Pump Only	Pre-1980	39.34	304.31	21.03	171.49	3.04	24.80
	1980-1983	58.94	464.23	61.07	497.98	30.23	246.55
	1984+	30.98	238.36	55.42	451.94	68.21	556.22
Catalyst Only	Pre-1980	48.88	402.47	25.71	220.34	3.72	31.86
	1980-1983	70.89	592.67	74.65	639.85	36.96	316.79
	1984+	34.83	282.15	67.74	580.70	83.38	714.68
Fuel Inlet Only	Pre-1980	22.74	181.20	11.54	95.84	1.67	13.86
	1980-1983	33.57	271.81	33.52	278.32	16.60	137.79
	1984+	17.12	134.77	30.42	252.59	37.44	310.87
Plumbtesmo Only	Pre-1980	12.13	103.81	6.65	59.00	0.96	8.53
	1980-1983	17.22	149.65	19.31	171.33	9.56	84.82
	1984+	8.06	67.78	17.52	155.49	21.57	191.36
Plumbtesmo &Fuel Inlet	Pre-1980	10.57	92.43	5.93	53.58	0.86	7.75
	1980-1983	14.81	131.69	17.22	155.59	8.52	77.03
	1984+	6.73	57.92	15.63	141.21	19.23	173.79
Air Pump & Catalyst	Pre-1980	51.65	426.18	29.60	256.37	4.28	37.07
	1980-1983	74.83	626.88	85.97	744.49	42.56	368.59
	1984+	36.68	297.67	78.02	675.65	96.02	831.55
Air Pump & Fuel Inlet	Pre-1980	25.68	203.50	15.48	127.28	2.19	18.07
	1980-1983	36.37	294.72	42.23	351.40	20.90	173.90
	1984+	18.10	142.95	39.39	326.01	49.73	409.64
Air Pump & Plumbtesmo	Pre-1980	14.13	119.22	9.35	81.05	1.32	11.52
	1980-1983	19.23	166.32	25.53	224.50	12.63	111.10
	1984+	8.80	73.98	23.80	207.98	30.05	260.99

Table 32 (continued)

Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi): Passenger Car HC	Passenger Car CO	Light-Duty Trucks (6000 lbs) HC	Light-Duty Trucks (6000 lbs) CO	Light-Duty Trucks (6000-8500 lbs) HC	Light-Duty Trucks (6000-8500 lbs) CO
Fuel Inlet & Catalyst	Pre-1980	26.39	217.34	13.88	118.98	2.01	17.21
	1980-1983	38.28	320.04	40.31	345.52	19.96	171.06
	1984+	18.81	152.36	36.58	313.58	45.02	385.93
Plumbtesmo & Catalyst	Pre-1980	9.78	80.49	5.14	44.07	0.74	6.37
	1980-1983	14.18	118.53	14.93	127.97	7.39	63.36
	1984+	6.97	56.43	13.55	116.14	16.68	142.94
Fuel Inlet & Catalyst & Air Pump	Pre-1980	28.39	234.41	16.69	144.93	2.41	20.96
	1980-1983	41.12	344.67	48.46	420.86	23.99	208.36
	1984+	20.14	163.53	43.98	381.95	54.13	470.07
Plumbtesmo & Catalyst & Air Pump	Pre-1984	11.25	93.14	7.22	63.28	1.04	9.15
	1980-1983	16.28	136.78	20.97	183.77	10.38	90.99
	1984+	7.95	64.71	19.03	166.78	23.42	205.27
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1984	7.33	60.37	3.86	33.05	0.56	4.78
	1980-1983	10.63	88.90	11.20	95.98	5.54	47.52
	1984+	5.23	42.32	10.16	87.10	12.51	107.20
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1984	11.81	102.69	7.54	68.19	1.09	9.86
	1980-1983	16.61	146.75	21.90	198.02	10.84	98.04
	1984+	7.60	65.04	19.88	179.72	24.47	221.18
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1984	8.81	73.02	5.93	52.27	0.86	7.56
	1980-1983	12.74	107.15	17.23	151.78	8.53	75.15
	1984+	6.21	50.60	15.64	137.75	19.25	169.53

Table 33

Benefit of a Fueling Station
Enforcement Program Begun January 1, 1984
In a Non-I/M Area with a
1% Random Roadside Inspection Program

1% Random Roadside Inspection Program	Affected Model Years	Per Vehicle Reduction (January 1, 1988) in Emissions (mg/mi)					
		Passenger Car		Light-Duty Trucks (6000 lbs)		Light-Duty Trucks (6000-8500 lbs)	
		HC	CO	HC	CO	HC	CO
None	Pre-1980	37.10	285.90	18.17	145.69	2.63	21.07
	1980-1983	55.69	437.09	52.75	423.07	26.12	209.46
	1984+	29.38	225.42	47.87	383.96	58.92	472.55
Air Pump Only	Pre-1980	37.83	292.11	19.19	155.12	2.77	22.43
	1980-1983	56.72	446.04	55.71	450.44	27.58	223.01
	1984+	29.85	229.39	50.51	408.36	62.15	502.41
Catalyst Only	Pre-1980	48.88	402.47	25.71	220.34	3.72	31.86
	1980-1983	70.89	592.67	74.65	639.85	36.96	316.79
	1984+	34.83	282.15	67.74	580.70	83.38	714.68
Fuel Inlet Only	Pre-1980	24.99	202.65	12.93	109.21	1.87	15.79
	1980-1983	36.55	301.00	37.54	317.16	18.59	157.02
	1984+	18.32	146.38	34.13	288.29	42.03	354.99
Plumbtesmo Only	Pre-1980	23.06	188.05	12.00	101.94	1.74	14.74
	1980-1983	33.62	278.43	34.85	296.05	17.26	146.57
	1984+	16.78	134.71	31.73	269.48	39.09	331.96
Plumbtesmo &Fuel Inlet	Pre-1980	22.77	185.90	11.87	100.87	1.72	14.59
	1980-1983	33.19	275.11	34.46	292.95	17.06	145.04
	1984+	16.55	133.00	31.38	266.71	38.66	328.58
Air Pump & Catalyst	Pre-1980	49.49	406.69	26.16	223.52	3.78	32.32
	1980-1983	71.87	599.59	75.96	649.08	37.61	321.36
	1984+	35.40	286.13	68.88	588.53	84.75	724.12
Air Pump & Fuel Inlet	Pre-1980	31.71	244.54	15.71	126.37	2.27	18.28
	1980-1983	47.58	373.72	45.63	366.99	22.59	181.69
	1984+	25.17	193.21	41.52	333.96	51.15	411.37
Air Pump & Plumbtesmo	Pre-1980	27.29	210.41	13.34	107.10	1.93	15.49
	1980-1983	40.96	321.64	38.75	311.06	19.19	154.00
	1984+	21.75	166.96	35.39	284.09	43.65	350.34

Table 33 (continued)

1% Random Roadside Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi) Passenger Car HC	Passenger Car CO	Light-Duty Trucks (6000 lbs) HC	Light-Duty Trucks (6000 lbs) CO	Light-Duty Trucks (6000-8500 lbs) HC	Light-Duty Trucks (6000-8500 lbs) CO
Fuel Inlet & Catalyst	Pre-1980	41.52	341.92	21.84	187.19	3.16	27.07
	1980-1983	60.23	503.54	63.42	543.62	31.40	269.14
	1984+	29.70	240.60	57.74	494.90	71.13	609.69
Plumbtesmo & Catalyst	Pre-1980	36.09	297.16	18.98	162.69	2.74	23.53
	1980-1983	52.35	437.66	55.12	472.49	27.29	233.93
	1984+	25.91	209.89	50.34	431.48	62.07	532.09
Fuel Inlet & Catalyst & Air Pump	Pre-1980	41.69	343.37	22.08	189.39	3.19	27.39
	1980-1983	60.47	505.63	64.11	550.00	31.74	272.30
	1984+	29.81	241.53	58.35	500.59	71.88	616.66
Plumbtesmo & Catalyst & Air Pump	Pre-1980	35.85	295.10	18.64	159.54	2.70	23.07
	1980-1983	52.01	434.68	54.13	463.36	26.80	229.41
	1984+	25.75	208.57	49.46	423.35	61.00	522.13
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1980	35.29	290.58	18.56	159.08	2.68	23.01
	1980-1983	51.19	427.97	53.90	462.03	26.69	228.75
	1984+	25.35	205.38	49.25	422.16	60.74	520.67
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1980	26.64	205.39	12.99	104.27	1.88	15.08
	1980-1983	39.99	313.98	37.74	302.83	18.69	149.93
	1984+	21.25	163.10	34.49	276.76	42.54	341.37
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1980	34.99	288.00	18.13	155.16	2.62	22.44
	1980-1983	50.76	424.25	52.67	450.62	26.08	223.10
	1984+	25.15	203.72	48.15	411.99	59.40	508.23

Table 34

Benefit of a Fueling Station
Enforcement Program Begun January 1, 1984
In a Non-I/M Area with a
2% Random Roadside Inspection Program

2% Random Roadside Inspection Program	Affected Model Years	Per Vehicle Reduction (January 1, 1988) in Emissions (mg/mi)					
		Passenger Car		Light-Duty Trucks (6000 lbs)		Light-Duty Trucks (6000-8500 lbs)	
		HC	CO	HC	CO	HC	CO
None	Pre-1980	37.10	285.90	18.17	145.69	2.63	21.07
	1980-1983	55.69	437.09	52.75	423.07	26.12	209.46
	1984+	29.38	225.42	47.87	383.96	58.92	472.55
Air Pump Only	Pre-1980	38.13	294.68	19.61	159.02	2.84	23.00
	1980-1983	57.15	449.74	56.94	461.78	28.19	228.62
	1984+	30.05	231.01	51.59	418.33	63.47	514.56
Catalyst Only	Pre-1980	48.88	402.47	25.71	220.34	3.72	31.86
	1980-1983	70.89	592.67	74.65	639.85	36.96	316.79
	1984+	34.83	282.15	67.74	580.70	83.38	714.68
Fuel Inlet Only	Pre-1980	23.91	194.47	12.41	105.14	1.79	15.20
	1980-1983	34.91	288.35	36.04	305.33	17.84	151.17
	1984+	17.47	139.94	32.80	277.88	40.41	342.31
Plumbtesmo Only	Pre-1980	21.17	173.82	11.10	94.86	1.61	13.72
	1980-1983	30.77	256.44	32.23	275.48	15.96	136.39
	1984+	15.30	123.51	29.43	251.38	36.28	309.91
Plumbtesmo &Fuel Inlet	Pre-1980	20.77	170.78	10.91	93.34	1.58	13.50
	1980-1983	30.16	251.75	31.67	271.09	15.68	134.22
	1984+	14.98	121.09	28.93	247.48	35.68	305.15
Air Pump & Catalyst	Pre-1980	49.75	408.51	26.37	225.07	3.81	32.55
	1980-1983	72.28	602.53	76.56	653.56	37.91	323.57
	1984+	35.62	287.74	69.38	592.10	85.34	728.31
Air Pump & Fuel Inlet	Pre-1980	29.48	227.41	14.69	118.37	2.13	17.12
	1980-1983	44.22	347.47	42.67	343.76	21.13	170.19
	1984+	23.45	180.07	38.92	313.52	47.98	386.46
Air Pump & Plumbtesmo	Pre-1980	23.23	179.14	11.34	91.12	1.64	13.18
	1980-1983	34.86	273.81	32.95	264.66	16.31	131.03
	1984+	18.63	143.11	30.29	243.27	37.43	300.60

Table 34 (continued)

2% Random Roadside Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi): Passenger Car HC	Passenger Car CO	Light-Duty Trucks (6000 lbs) HC	Light-Duty Trucks (6000 lbs) CO	Light-Duty Trucks (6000-8500 lbs) HC	Light-Duty Trucks (6000-8500 lbs) CO
Fuel Inlet & Catalyst	Pre-1980	38.48	316.83	20.24	173.45	2.93	25.09
	1980-1983	55.81	466.62	58.77	503.76	29.10	249.41
	1984+	27.61	223.66	53.64	459.82	66.14	566.95
Plumbtesmo & Catalyst	Pre-1980	30.79	253.53	16.19	138.80	2.34	20.07
	1980-1983	44.67	373.46	47.03	403.16	23.29	199.60
	1984+	22.27	180.43	43.22	370.48	53.40	457.76
Fuel Inlet & Catalyst & Air Pump	Pre-1980	38.72	318.88	20.57	176.57	2.98	25.53
	1980-1983	56.16	469.58	59.75	512.79	29.58	253.88
	1984+	27.76	224.96	54.51	467.84	67.20	576.76
Plumbtesmo & Catalyst & Air Pump	Pre-1980	30.45	250.61	15.71	134.36	2.27	19.43
	1980-1983	44.18	369.24	45.64	390.26	22.59	193.22
	1984+	22.04	178.56	41.98	359.03	51.89	443.76
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1980	29.66	244.22	15.60	133.70	2.26	19.34
	1980-1983	43.03	359.76	45.31	388.37	22.43	192.28
	1984+	21.48	174.07	41.69	357.35	51.53	441.71
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1980	22.31	172.04	10.85	87.11	1.57	12.60
	1980-1983	33.48	262.98	31.52	253.03	15.61	125.27
	1984+	17.93	137.67	29.02	232.94	5.88	287.98
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1980	29.23	240.57	15.00	128.15	2.17	18.53
	1980-1983	42.42	354.49	43.56	372.24	21.57	184.29
	1984+	21.20	171.74	40.14	343.02	49.64	424.20

Table 35

Benefit of a Fueling Station
Enforcement Program Begun January 1, 1984
In a Non-I/M Area with a
5% Random Roadside Inspection Program

5% Random Roadside Inspection Program	Affected Model Years	Per Vehicle Reduction (January 1, 1988) in Emissions (mg/mi)					
		Passenger Car		Light-Duty Trucks (6000 lbs)		Light-Duty Trucks (6000-8500 lbs)	
		HC	CO	HC	CO	HC	CO
None	Pre-1980	37.10	285.90	18.17	145.69	2.63	21.07
	1980-1983	55.69	437.09	52.75	423.07	26.12	209.46
	1984+	29.38	225.42	47.87	383.96	58.92	472.55
Air Pump Only	Pre-1980	38.59	298.65	20.26	165.07	2.93	23.87
	1980-1983	57.81	455.48	58.84	479.31	29.13	237.30
	1984+	30.34	233.48	53.24	433.59	65.47	533.09
Catalyst Only	Pre-1980	48.88	402.47	25.71	220.34	3.72	31.86
	1980-1983	70.89	592.67	74.65	639.85	36.96	316.79
	1984+	34.83	282.15	67.74	580.70	83.38	714.68
Fuel Inlet Only	Pre-1980	22.23	181.80	11.61	98.83	1.68	14.29
	1980-1983	32.37	268.79	33.70	287.03	16.69	142.11
	1984+	16.17	130.09	30.78	261.96	37.95	322.98
Plumbtesmo Only	Pre-1980	18.26	151.79	9.70	83.89	1.40	12.13
	1980-1983	26.36	222.42	28.18	243.66	13.95	120.63
	1984+	13.03	106.39	25.90	223.68	32.00	276.29
Plumbtesmo &Fuel Inlet	Pre-1980	17.68	147.38	9.42	81.69	1.36	11.81
	1980-1983	25.47	215.60	27.37	237.28	13.55	117.48
	1984+	12.57	102.90	25.18	218.05	31.13	269.42
Air Pump & Catalyst	Pre-1980	50.17	411.49	26.74	227.99	3.87	32.97
	1980-1983	72.92	607.25	77.64	662.02	38.44	327.76
	1984+	35.96	290.19	70.22	598.42	86.32	735.55
Air Pump & Fuel Inlet	Pre-1980	26.02	200.89	13.12	105.98	1.90	15.33
	1980-1983	39.03	306.87	38.11	307.83	18.87	152.40
	1984+	20.82	159.99	34.95	282.24	43.16	348.50
Air Pump & Plumbtesmo	Pre-1980	16.94	130.74	8.25	66.38	1.19	9.60
	1980-1983	25.42	199.84	23.98	192.89	11.87	95.50
	1984+	13.87	106.65	22.48	180.80	27.95	224.77

Table 35 (continued)

5% Random Roadside Inspection Program	Affected Model Years	Per Vehicle Reduction in Emissions (mg/mi): Passenger Car HC	Passenger Car CO	Light-Duty Trucks (6000 lbs) HC	(6000 lbs) CO	(6000-8500 lbs) HC	(6000-8500 lbs) CO
Fuel Inlet & Catalyst	Pre-1980	33.76	278.02	17.76	152.20	2.57	22.01
	1980-1983	48.98	409.52	51.57	442.09	25.53	218.88
	1984+	24.41	197.79	47.38	406.15	58.54	501.80
Plumbtesmo & Catalyst	Pre-1980	22.59	186.02	11.88	101.84	1.72	14.73
	1980-1983	32.79	274.14	34.52	295.92	17.09	146.51
	1984+	16.70	135.44	32.33	277.14	40.18	344.46
Fuel Inlet & Catalyst & Air Pump	Pre-1980	34.11	280.99	18.25	156.72	2.64	22.67
	1980-1983	49.48	413.81	52.99	455.21	26.24	225.37
	1984+	24.63	199.67	48.64	417.73	60.07	515.93
Plumbtesmo & Catalyst & Air Pump	Pre-1980	22.09	181.77	11.18	95.38	1.62	13.80
	1980-1983	32.08	268.01	32.49	277.17	16.09	137.23
	1984+	16.38	132.75	30.54	260.59	38.00	324.28
Plumbtesmo & Fuel Inlet & Catalyst	Pre-1980	20.95	172.50	11.02	94.43	1.59	13.66
	1980-1983	30.41	254.23	32.01	274.42	15.85	135.86
	1984+	15.57	126.27	30.12	258.17	37.49	321.32
Plumbtesmo & Fuel Inlet & Air Pump	Pre-1980	15.60	120.43	7.54	60.56	1.09	8.76
	1980-1983	23.42	184.10	21.90	175.98	10.84	87.13
	1984+	12.85	98.81	20.65	165.88	25.72	206.58
Plumbstesmo & Fuel Inlet & Catalyst & Air Pump	Pre-1980	20.33	167.18	10.14	86.36	1.47	12.49
	1980-1983	29.53	246.57	29.48	250.99	14.60	124.26
	1984+	15.17	122.91	27.88	237.48	34.76	296.09

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