EPA-AA-IMS-81-9

Technical Report

UPDATE ON THE COST-EFFECTIVENESS OF INSPECTION AND MAINTENANCE

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NOTICE

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NOTICE - REVISION TO THIS REPORT IS IN PROGRESS

THIS REPORT IS CURRENTLY BEING UP-DATED. RECENT INFORMATION BEING INCORPORATED INTO THIS REVISION WILL INCREASE THE COST PER TON OF HYDROCARBON (HC) REDUCTION AND MINIMALLY DECREASE THE COST PER TON OF CARBON MONOXIDE (CO) REDUCTION. THE VALUES BELOW ARE FOR A FIVE YEAR PERIOD 1983-1987 AND A MINIMUM I/M PROGRAM, AS DESCRIBED IN THE CURRENT REPORT. COSTS HAVE BEEN DIVIDED EQUALLY BETWEEN HC AND CO. NO COST HAS BEEN CHARGED FOR TRAVEL TIME TO INSPECTION STATION OR REPAIR FACILITY.

	Cost-Effectiveness	
I/M Cost Effectiveness Report	HC	CO
Table 1 of Current Report (EPA-AA-IMS-81-9)	$581/ton	$53/ton
Future Up-dated Report	$900/ton	$51/ton

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1.0 INTRODUCTION

1.1 Purpose

The cost-effectiveness of an air pollution control strategy is the measure of that strategy's cost relative to its ability to remove a particular pollutant from the atmosphere. It is commonly expressed as a ratio of cost to the emission reduction achieved by the strategy, where costs are estimated in dollars spent in complying with the strategy, and emission reductions are measured in tons.

The cost-effectiveness of Inspection and Maintenance (I/M) as an air pollution control strategy has been studied before by the EPA and other groups. However, over the past year new information on repair costs and inspection fees and improved methods of calculating emission reductions attributable to I/M have become available. These changes underscore the need for a fresh look at the cost-effectiveness of I/M.

1.2 Summary

I/M cost-effectiveness was modeled by having an example fleet of one million vehicles (gasoline light-duty vehicles only) participate for five years in a hypothetical I/M program starting in 1983. The design of the hypothetical I/M program was typical of programs now being implemented. Total costs were determined by adding together repair costs and inspection costs for the five year period, then subtracting fuel savings attributable to the I/M program for the five year period. Inspection and repair costs were estimated using data from currently operating and planned programs. Emission reductions were obtained using MOBILE2 (EPA's model for predicting the emission behavior of a fleet of vehicles with and without I/M) to estimate the masses of HC and CO emissions that would be removed during the five year period by the hypothetical I/M program.

Table 1 summarizes the cost-effectiveness of I/M. All figures are in 1981 dollars; costs and emission reductions have not been discounted. Because most areas which are implementing I/M require reductions for both HC and CO, the costs of I/M have been allocated equally to both pollutants.

Table 1

I/M Cost-Effectiveness* over a
Five-Year Period (1983-1987) in 1981 Dollars

Pollutant	Allocated I/M Cost	Mass Removed by I/M	Cost-Effectiveness **
HC	$27.05 million	46,500 tons (U.S.)	$ 581/ton
CO	$27.05 million	512,600 tons (U.S.)	$ 53/ton

* Some areas which are implementing I/M only need a reduction in one pollutant (HC or CO) to meet the National Ambient Air Quality Standards. In estimating cost-effectiveness for these areas, all costs should be allocated to the one pollutant only. The cost-effectiveness for that pollutant would then be double that shown in this table.

** Cost-effectiveness values in general vary with program design and type. The EPA has explored other program designs and types which exhibit better cost-effectiveness values than the "conventional" I/M (I/M which uses HC and CO cutpoints) program whose cost-effectiveness is shown in this table. Basically, these other programs use only an idle CO cutpoint, and contain other enhancements which yield HC and CO reductions which are equivalent or superior to those in a conventional I/M program. Cost-effectiveness values for these programs range from $386/per ton to $434/ton for HC, and $23/ton to $26/ton for CO. Complete discussions of these programs are found in the EPA report entitled "Low-Cost Approaches to Vehicle Emissions Inspection and Maintenance" (EPA-AA-IMS-81-7).

1.3 Selection of Base Period for Costs and Emission Reductions

A number of different base periods can be used to calculate the cost-effectiveness of an Inspection and Maintenance program. First, costs and benefits can be estimated over one particular year of a specific I/M program such as the Portland, Oregon I/M program. However, the results of this type of approach reflect only the current model year mix of vehicles participating in the I/M program. Consequently, it does not account for changes that take place in the fleet of vehicles tested by the I/M program over the life of the I/M program, as new vehicles are added to the fleet and old vehicles are retired. A second approach to estimating I/M cost-effectiveness is to determine costs and benefits over the entire life of one "average" vehicle. However, the results of this approach are also quite restricted in applicability. Cost-effectiveness of I/M under this approach would be applicable only to the model year and technology type of a particular vehicle being studied and only for an I/M program that was operating over the life of that vehicle. A third way to estimate the cost-effectiveness of an I/M program is to calculate costs and benefits for a "typical" fleet which participates in a "typical" I/M program for a period of several years, taking into account changes which occur in the fleet participating in the I/M program during that period. This is the approach used to estimate I/M cost-effectiveness in this report.*

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* The specific equation used to estimate cost-effectiveness is presented in Appendix 1.

1.4 Features of the Typical I/M Program

The fleet chosen to represent a typical I/M fleet was a one million vehicle (gasoline light-duty vehicles only) fleet which had a changing model year distribution. The period chosen was the five year period from January of 1983 through December of 1987. This corresponds to the first five years of many new I/M programs now in the planning and implementation stages. The test used in the I/M program was the Idle Test, with a stringency rate of 20% for pre-1981 model year vehicles, and cutpoints of 1.2% CO and 220 ppm HC for 1981 and later vehicles (these cutpoints are expected to yield a failure rate of 5-10% for 1981 and later vehicles). The model year coverage of the program was 1968 and later. The program did not include a repair cost waiver.*

The decision of which base period to use to calculate I/M cost-effectiveness is an important one. Equally important, however, is that every calculation uses that period in a consistent manner. The use of the five year base period base described in preceding paragraphs to determine I/M program costs and benefits for a one million vehicle fleet is the subject matter of the rest of this report.

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* A repair cost waiver is an administrative provision whereby cars are excused from compliance with the I/M requirement if the owner has spent at least a specified amount of money attempting to make them comply. A repair cost waiver was excluded from our analysis for two reasons. First, MOBILE2 (EPA's latest model for predicting the emission behavior of a vehicle or fleet of vehicles) is not yet capable of calculating emission reductions for an I/M program that includes a repair cost waiver. Second, although many states are planning to implement a program with a repair cost waiver, two states with operating programs (Oregon and New Jersey) do not use a repair cost waiver. We have based our estimates of I/M repair costs in part on repair costs from these two programs. So although our estimates of "typical" emission reductions might be slightly overstated from what they would have been if a repair cost waiver had been included, our average repair cost may well be slightly overstated also. We do not expect I/M cost-effectiveness to be materially different with a properly administered repair cost waiver.

2.0 ANALYSIS OF I/M COSTS BETWEEN JANUARY 1, 1983 AND DECEMBER 31, 1987

There are many different types of costs incurred by different groups of people during the implementation and operation of an I/M program. However, adding together all the costs incurred by different people would not adequately reflect actual costs, as many items would be counted more than once in this type of approach. For example, where a state selects a contractor to build facilities and perform I/M tests for the state, it would be double-counting to add the contractor's capital costs for facilities and equipment to the inspection fees motorists must pay to obtain an I/M test. The contractor borrows money to pay for initial capital facilities, and provides for the amortization of loans with a portion of the inspection fee paid by motorists.

The relevant costs for the purpose of estimating the cost-effectiveness of I/M are ultimate costs to the motorist. This includes inspection costs (fees) and repair costs, less the dollar value of fuel savings. This report assumes that all costs incurred by the state for administering the program and by the contractor or the private garage for performing the inspection, are reimbursed through the payment of inspection fees. In practice, most states have established their inspection fees in this manner.

2.1 Effects of Inflation

Inflation will act to raise the operating costs (for example, the labor cost of inspectors) of the I/M program, and will also act to raise repair costs through higher labor and parts costs. However, we elected not to include inflation's effects on I/M costs (except where unavoidable), and instead to report all I/M costs for the five year analysis period from 1/1/83 to 12/31/87 in 1981 dollars.* There were several reasons for the decision to eliminate inflationary effects. First, cost-effectiveness values of many other types of emission control strategies have also been calculated without inflation's effects. Compensating I/M cost-effectiveness for inflation's effects would result in an incorrect comparison between I/M and other control strategies. Second, the inflation rate is difficult to predict for a period of time from two to seven years in the future. Cost-effectiveness numbers which are based on current expectations of the future inflation rate could be significantly off-base even before most I/M programs get underway. Third, inflation will also act to raise consumer incomes over the life of the I/M program, consequently, the relative cost of I/M (to consumer incomes) should remain approximately constant.

* Costs have not been discounted to 1981. To discount or not to discount costs is a methodology issue with proponents on both sides. Appendix 8 contains a discussion of this issue.

2.2 Inspection Costs

Inspection costs are fees that are charged to motorists for receiving I/M tests. Current fees from operating and planned programs range from three to fifteen dollars, with the average of all programs which have decided on a fee being about eight dollars. Fees for each program are listed in Appendix 2. Average fees arranged by program type are listed below in Table 2.

Table 2

Average Inspection Fees Listed by Program Type *

Program Type	Fee	Number of Programs
Centralized: Contractor-Run	$9.62	6
Centralized: State-Run	$5.83	3
Centralized: All	$8.36	9
Decentralized	$7.52	10
Overall Average	$7.90	19

* This is a list of fees from states which have determined an inspection fee. Some states have not yet decided on a program type or fee. See Appendix 2 for a complete list of program types and fees.

The figures in Table 2 display a fairly wide range of values. Actually, one would not expect them to be nearly identical, because each I/M program is being designed to meet the needs of that particular state. For example, some I/M states have an existing centralized safety inspection program, most notably New Jersey. The New Jersey I/M program was grafted onto the existing safety program which already consisted of a network of inspection stations. The New Jersey inspection fee ($2.50) reflects the fact that new facilities did not need to be built to conduct I/M.

Many other states planning decentralized programs currently have decentralized safety inspection programs. The average decentralized inspection fee in Table 2 may be overstated because some of the fees used in calculating the average include the safety as well as the emission inspection. Also, Nevada's emission inspection, the fee of which was used in the decentralized fee average, also includes some basic engine adjustments.

Some of the inspection fees, particularly in states with decentralized programs, are limited by law to a certain figure. It is not clear whether or not these figures will change during the life of the I/M program. Also, the generally low inspection fees in decentralized programs are suspect because they may not fully reimburse garage operators for their time and capital costs; the operators may increase repair bills to compensate for the loss incurred in performing an emission inspection only, or may simply absorb the loss to retain regular customers' other business.

The contractor-run centralized programs have perhaps the most realistic fees. These fees are least likely to be distorted by hidden subsidies, and are therefore probably the most realistic market value fees for an emission inspection.

For the purposes of the cost-effectiveness calculation in this report, we have selected $10.00 as the cost of an emission inspection. This figure is close to the average of $9.62 for the fees from the six contractor-operated programs. In some cases the contractor has agreed to accept a level fee over the life of the I/M program, therefore, the fee has taken into account the contractor's best estimate of the impact of inflation on operating costs. In other cases the contractor and the state agree to an inspection fee that increases over the life of the I/M program. Although it was decided that in general the effects of inflation were not to be included in I/M costs, this $10.00 figure was not adjusted to remove inflation because of the difficulty in determining what fraction of each of the six fees is attributable to inflation.*

Practically all centralized I/M programs do not charge a separate fee for retests.** Instead, the initial fee is set high enough to cover the cost of performing reinspections. Therefore, retest fees have been excluded from our cost-effectiveness analysis.

In order to estimate the total five year inspection cost of all vehicles participating in the I/M program, it was necessary to determine how many vehicles in the one million vehicle fleet each year would be either too young (less than one year) or too old (1967 model year and earlier) to be inspected. This was accomplished with EPA estimates of the national distribution of vehicles by model year. Estimates of the number of vehicles that would need an inspection each year are presented in Appendix 3. We estimated that 4,880,000 inspections would be performed on the one million vehicle fleet over the five year period; this results in a total inspection cost of $48.8 million dollars.

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* Cost-effectiveness values are relatively sensitive to inspection fees. If a $6.00 fee (this is the fee charged for an emission inspection in New York) had been selected instead of the $10.00 fee, the cost-effectiveness results would have been $34 per ton for CO, and $372 per ton for HC, as compared to $53 per ton for CO and $581 per ton for HC with the $10.00 inspection fee (costs allocated half to HC, half to CO).

** The one exception is the change-of-ownership program in Los Angeles, which charges a $7 retest fee. The fee in this program also provides for reimbursement to the state of a multi-million dollar debt incurred from extensive testing performed during early development of the program.

2.3 Repair Costs

We have stated that we will analyze the cost-effectiveness of I/M from the perspective of a fleet of one million vehicles whose model year distribution changes with time. One of our reasons for taking this approach is that there are some important differences between pre-1981 and 1981 and later vehicles which have a profound impact on total repair costs. First, the failure rate on 1981 and later vehicles is expected to be lower than the failure rate on pre-1981 vehicles. This difference has an impact on total repair cost for the fleet, as only vehicles that are failed from an I/M program must obtain an I/M repair. Second, the types of repairs on 1981 and later vehicles are expected to be quite different than the types of repairs that are being performed on pre-1981 vehicles in operating programs. These differences in types of repairs may result in differences in the cost of repairs also. These fundamental differences between pre-1981 and 1981 and later vehicles, which if ignored would greatly distort the true picture of I/M cost-effectiveness, are discussed in the following sections.

2.3.1 Causes of Failures and Failure Rates

2.3.1.1 Pre-1981 Vehicles

Most pre-1981 I/M test failures are caused by misadjustments in engine parameters. These misadjustments can occur over a wide range of possible settings. Therefore, I/M program officials can control the I/M failure rate for pre-1981 vehicles to any desired level by selecting CO and HC inspection standards (or cutpoints) accordingly. Most states are designing their I/M programs with about a 20% or higher failure rate for pre-1981 vehicles. Therefore, we will use a 20% failure rate for pre-1981 vehicles for the purpose of calculating I/M cost-effectiveness.

2.3.1.2 1981 and Later Vehicles

I/M program officials have less control over the failure rate for 1981 and later vehicles than for the older vehicles. This is due to two important differences between them. First, recent EPA regulations* require auto manufacturers to make idle mixture settings on 1981 cars much more resistant to misadjustment than was the case for older cars. Consequently, misadjustments of the idle mixture, the factor contributing to the majority of I/M test failures for pre-1981 vehicles, will be rare on 1981 and later vehicles. Second, some fraction of the 1981 and later fleet will fail an I/M test for reasons which do not apply at all to pre-1981 vehicles. Most 1981 and later vehicles will come equipped with closed-loop fuel metering systems controlled by an on-board computer that receives signals from various sensors which measure the operating air/fuel ratio, temperature, speed, and power level of the engine. The computer then adjusts the fuel metering system, via electromechanical actuators, to achieve a desired air/fuel ratio. Failure of a sensor, the computer, air actuator, or the electrical connections between them can cause high-emissions on the I/M test.

* 44 F.R. 2960, commonly refered to as the Parameter Adjustment Regulations.

There are some reasons for an I/M failure that will apply for both pre-1981 and 1981 and later vehicles, such as ignition system problems, vacuum leaks, severe engine wear, and gross tampering with emission controls used on both types of vehicles.

The overall result of the special character of I/M failures among 1981 and later vehicles is that there will be a bimodal distribution of I/M test results. Most vehicles will have very low I/M test scores, but some will have very high scores. The failure rate will be affected to some extent by the choice of an I/M test, since the more complicated tests (a loaded test or a two-speed idle test which requires cars to pass on both the idle and high-speed idle portions) can detect more of the vehicles with failures in their fuel metering systems. The choice of inspection cutpoints will also affect the failure rate to some extent. But for an I/M program which uses the simple idle test, EPA expects that it would be impossible to adjust the cutpoints so that the failure rate was less than 5 percent without sacrificing most of the program's effectiveness, or more than 10 percent without failing many cars that actually have low emissions.

For these reasons, we have chosen 7% as the failure rate for 1981 and later vehicles for the purpose of estimating repair costs from 1981 and later vehicles. This is within the range of 5-10% just mentioned. We believe it is a reasonable estimate for any I/M program that uses the single idle test and cutpoints in the range of 1.0-3.0% CO and 200-300 ppm HC.

2.3.2 Per Vehicle Repair Costs

2.3.2.1 Pre-1981 Vehicles

Extensive data on I/M repair costs for pre-1981 vehicles has been obtained from operating programs in New Jersey, Oregon, California and Arizona. This data is summarized in Table 3. Sources and notes on this data, including discussions on the methods used in each state to collect the data, are presented in Appendix 4.

The reader may be surprised to notice that the average I/M repair costs seems to be substantially less than the price of a full tune-up, which many people in non-I/M cities currently have performed on their cars on an annual basis. This should not be interpreted as throwing doubt on the accuracy of I/M repair costs in Table 3, since there is a sound explanation for the difference in price. The reason for the difference in price between an I/M repair and a tune-up is that an I/M repair is usually a single repair such as carburetor adjustment, where a tune-up may involve several items such as spark plug and air filter replacement, carburetor adjustment and adjustments of spark timing and dwell. In addition, once an I/M program is underway, there is often competition and price cutting by the repair industry.*

* Price competition may be an explanation for the reduction in average I/M repair costs in New Jersey and California. A 1973-74 post card survey in New Jersey found the average repair cost to be $36. The 1979 and 1980 New Jersey surveys, although conducted in a different manner than the 1973-1974 survey, found average I/M repair costs to be $28 and $18.71, respectively. In California, the 1979 average cost of repair is $32. For the latter two quarters of 1980, the average cost of repair is less than $30. Sources for this data are listed in Appendix 4.

Table 3

Average Pre-1981 Vehicle I/M Repair Cost
from Operating Programs *

I/M Program	Period Covered	Average Repair Cost
New Jersey	1979	$28.00
	1980	$18.71
Arizona	1979	30.00
	1980	29.74
Portland, Oregon	1980	17.00
California	1979	32.00
	1980 (July - September)	29.09
	1980 (October - December)	28.82

* Sources for these costs are listed in Appendix 4.

The data in Table 3 indicate that the average cost of repair for pre-1981 vehicles is in the range of $17.00 (Portland) to about $30.00 (California). We have selected $25.00 (1981 dollars) as the average cost of I/M repairs for pre-1981 model year vehicles for use in our cost-effectiveness analysis.*

2.3.2.2 1981 and Later Vehicles

There is at present considerable uncertainty as to the average I/M repair cost for 1981 and later vehicles. As noted above, very few of the 1981 and later vehicles which fail I/M will do so because of misadjusted idle mixture settings, the item most commonly corrected during I/M repairs on pre-1981 cars. The 1981 and later cars will share with the older cars repair of such items as ignition problems, vacuum leaks, and tampering of some emission control components they have in common. But some of the newer cars will also require repairs to their closed-loop fuel metering systems. These repairs will range from simply reconnecting a wire to a sensor or actuator to replacing a sensor, an actuator, or the computer. The average repair cost will very much depend on how often each type of repair is necessary. If most repairs require a replacement sensor or actuator, the average repair cost could be more than on pre-1981 vehicles. It should not be expected that new

* If the highest typical (modal) value of $29 had been used as the average pre-1981 I/M repair cost, our cost-effectiveness results would have been $606/ton for HC and $55/ton for CO, compared to $581/ton for HC and $53/ton for CO for an average pre-1981 cost of repair of $25.

computers would be needed on many of the 7 percent of the vehicles which fail I/M, because the auto manufacturers work hard to make them reliable. It would be ideal if repair costs for 1981 and later vehicles would be taken from the operating I/M programs, as it was for pre-1981 vehicles. Data on repair costs for 1981 and later vehicles is unfortunately difficult to obtain because most 1981 vehicles in operating I/M programs will not need an inspection until 1982. However, a limited amount of repair cost data is available on vehicles equipped with roughly the same types of emission control systems being used on 1981 and later vehicles. The data come from California's change-of-ownership Vehicle Inspection Program in the Los Angeles area, where vehicles are tested only when ownership is transferred from one person to another. As early as 1977, certain manufacturers started introducing vehicles with closed-loop fuel control and three-way catalysts that are the forerunners of the type of technology used on 1981 and later vehicles.* Thirty-nine of these vehicles, with model years ranging from 1977-1981, were failed in the California program in the period of July to December 1980. The average mandatory repair cost (i.e., cost of repairs to meet inspection standard) of the vehicles was $26.67, compared to $28.82 for all vehicles of the same model years.

Many of the cars in the 39 vehicle sample from California were Volvos with closed-loop fuel injection systems. The repair costs for these vehicles may be unrepresentative of the true cost of I/M repairs for 1981 and later vehicles because they have adjustable (non-sealed) idle mixture screws, a different type of computer and fuel metering approach, and fewer engine sensors than most 1981 and later vehicles. For these reasons, we have selected $30.00 as a conservative repair cost estimate for 1981 and later model year vehicles in our cost-effectiveness analysis.

2.3.3 Effect of Emission Performance Warranty on 1981 and Later Vehicle Repair Costs

The EPA recently promulgated Emission Control System Performance Warranty Regulations (45 F.R. 34802, May 22, 1980, hereinafter referred to as the Warranty) for 1981 and later model year vehicles. The regulations require manufacturers to provide a warranty which entitles a vehicle owner to emission related repairs at the vehicle manufacturer's expense if, among other conditions, the vehicle fails an "approved" short test. The regulations are designed to protect an individual from having to pay for an expensive repair that may be due to the design or manufacture of the vehicle. Many I/M programs are expected to implement approved short tests so that their citizens may have the benefit of this coverage. Although the Warranty is expected to reduce the cost to consumers of I/M-motivated repairs on 1981 and later model year vehicles, it should not affect the overall costs of repair for these vehicles. The repair cost <u>not</u> borne by the consumer who exercises his warranty will be borne by the manufacturer and ultimately by either stockholders and/or new car buyers throughout the U.S. Overall repair costs

* Auto manufacturers introduced this technology in California first (as far back as 1977) because California's emission standards were more stringent than federal standards.

will not have been reduced, but rather will have been redistributed. The degree of redistribution is presently unknown. In summary, the Emission Performance Warranty will probably improve the cost-effectiveness of an I/M program from the perspective of consumers who must participate in the local I/M program and from the perspective of their local representatives, but leave overall I/M cost-effectiveness from the perspective of the U.S. as a whole unchanged. The administrative costs to the auto manufacturers and their dealers might increase the total cost of I/M, but only very slightly. An example of how the apparent cost-effectiveness of I/M for consumers (who must participate in the I/M program) can be improved with Warranty coverage is discussed in Appendix 5. For the rest of the report, we have excluded the effect of the Warranty on reducing repair costs for 1981 and later vehicles from our analysis of the cost-effectiveness of I/M.

2.3.4 Total Repair Costs

We have selected $25.00 as our repair cost for pre-1981 vehicles, and $30.00 as our repair cost for 1981 and later vehicles. In estimating total repair costs for the five year I/M program, it was necessary to first determine for each year of the program how many of the one million vehicles were pre-1981 vehicles, and how many were 1981 and later vehicles (these figures are provided in Appendix 3). This was accomplished by using EPA's estimates of the national distribution of vehicles by model year which are consistent with MOBILE2.* These estimates were combined with the I/M failure rates (20% for pre-1981, 7% for 1981 and later) to estimate total repair costs. We estimated that a total of 137,095 1981 and later vehicles would be failed during the five years and need repairs, and 584,300 pre-1981 vehicles would be failed and need repairs. These figures yield a $18.7 million repair cost over the five year I/M program.

We need to mention three factors which could have an impact on overall repair costs, but have been omitted from our analysis of cost-effectivess because of insufficient data. First, some portion of the repairs received by failed vehicles would have been voluntarily purchased by vehicle owners eventually, even in the absence of an I/M program. Many vehicles which receive a spark plug replacement after failing an I/M test for high HC probably fall in this category. These costs could justifiably be deducted from I/M total repair costs. Second, it is possible that I/M, as a periodic preventive maintenance function, increases vehicle engine life. Third, it is also possible that I/M reduces overall maintenance costs for owners who begin to rely on I/M to tell then when to tune their vehicles; these owners previously may have followed a tune-up schedule that was more frequent then actually needed. Inclusion of these considerations in our cost-effectiveness analysis would have improved or lowered our total repair cost numbers.

* MOBILE2 is EPA's latest model for predicting the emission behavior of a vehicle or a fleet of vehicles over a period of time.

2.4 Fuel Economy Savings Due to I/M

Fuel economy savings attributable to the "typical" I/M program were taken from a technical report issued by the EPA entitled "Update on the Fuel Economy Benefits of I/M Programs" (EPA-AA-IMS-81-10). This report presented the average dollar savings (in less fuel consumed) for each vehicle participating in a "typical" I/M program which was the same as the "typical" I/M program used in this report. The Fuel Economy report showed that the average 1981 dollar savings per year per vehicle inspected (that is, averaged over the entire fleet, not just those vehicles receiving repairs) in the I/M program would be $2.74.* This figure, when multiplied by the number of inspections performed over the five year period (4,880,000; see Appendix 3), yields a savings of 13.4 million dollars.

2.5 Summary of I/M Costs and Savings

A summary of the aggregate inspection cost, repair cost, and fuel savings for the one million vehicle fleet which participated in a five year I/M program from 1/1/83 to 12/31/87 is listed in Table 4.

Table 4
Summary of Total I/M Costs and Savings

Cost Item	Cost (1981 Dollars)
Inspection	$48.8 million
Repair	$18.7 million
(Less) Fuel Savings	($13.4 million)
Total	$54.1 million

* Fuel economy benefits in the basic I/M program come only from 1981 and later vehicles. Therefore, fleet average fuel economy benefits improve with time as more 1981 and later vehicles are added to the fleet.

3.0 EMISSION REDUCTIONS ATTRIBUTABLE TO I/M

Emission reductions attributable to I/M are best calculated by MOBILE2, which is EPA's latest model for predicting the emission behavior of a vehicle or fleet of vehicles over a period of time. MOBILE2 can also predict the behavior of a vehicle or fleet of vehicles participating in an annual I/M program. The emission reductions attributable to I/M are calculated as the differences in CO and HC emission rates between a fleet of vehicles not participating in an I/M program, and a fleet of vehicles participating in an I/M program.

MOBILE2 requires two different kinds of inputs in estimating non-I/M and I/M vehicle emission rates. The first category of inputs are local transportation inputs, for which we have used national average values. The second kind of inputs are I/M-related, such as failure rate for pre-1981 vehicles and model year coverage. A complete list of the inputs used in determining emission reductions attributable to the "typical" I/M program (described in section 1.4) is found in Appendix 6.

The emission reductions attributable to the "typical" I/M program are presented in Table 5. Reductions are calculated as the difference in emission rates between the non-I/M and I/M scenarios. Reductions are calculated at the midpoint of each year in order to most accurately estimate the average reduction during that year.

Table 5
Reduction in Emission Rates
Attributable to I/M Programs

Midpoint of Year	Light Duty Vehicle Fleet Emission Rates Without I/M		Light Duty Vehicle Fleet Emission Rates With I/M		Emission Rate Difference	
	HC * (g/mi)	CO (g/mi)	HC * (g/mi)	CO (g/mi)	HC (g/mi)	CO (g/mi)
1983	3.57	36.34	3.30	33.57	.27	2.77
1984	3.25	33.69	2.60	27.50	.65	6.19
1985	2.96	31.39	2.19	23.19	.80	8.20
1986	2.71	29.56	1.92	20.07	.79	9.49
1987	2.51	28.10	1.73	18.85	.78	9.25
1988	2.42	27.47	1.66	18.37	.76	9.10

* Total HC emissions, including evaporative emissions.

The reader may notice that the emission rate difference for 1983 is substantially lower than the emission rate differences for the remaining years. This is due to the fact that on July 1, 1983, only about half of the one million vehicle fleet has been tested, since the program began on January, 1983. By July 1, 1984, all of the fleet has been tested, consequently the emission rate difference of the fleet between non-I/M and I/M scenarios at that date is higher.

One half of the emission reductions in 1988 are included in our estimates of cost-effectiveness, even though only 1983 through 1987 costs are included. This is necessary to preserve the cause and effect relationship between costs and emission reductions. Some of the emission reductions obtained in 1988 are due to repairs performed in 1987, because vehicles inspected and repaired in 1987 have emission benefits that decline with time but continue through 1988.

The emission rate differences presented in Table 5 and an estimate of the number of miles traveled by the fleet of one million vehicles in each year were used to calculate the masses of HC and CO removed by the five year I/M program. The equation used in this calculation is presented in Appendix 7. Masses of HC and CO removed by the I/M program are presented in Table 6. The "typical" I/M program operating for 5 years on a fleet of one million vehicles is capable of reducing the amount of CO emitted during the five years by 512,600 tons and the amount of HC emitted by 46,500 tons.

Table 6

Pollutant Masses
Removed by the Typical I/M Program

Year	CO (tons)	HC (tons)
1983	35,100	3,420
1984	78,400	8,240
1985	103,900	10,100
1986	120,300	10,000
1987	117,200	9,900
1988	57,700	4,800
Totals	512,600	46,500

4.0 COST-EFFECTIVENESS FINAL RESULTS

The typical I/M program incurred a total cost over the five year period from January 1, 1983 to December 31, 1987 of 48.8 million 1981 dollars. Over the same period, the I/M program was responsible for the reduction in 512,600 tons of CO emissions, and 46,500 tons of HC emissions.

Table 7 summarizes the cost-effectiveness of Inspection/Maintenance based on the above numbers. Because most areas which are implementing I/M require reductions in both HC and CO in order to attain the National Ambient Air Quality Standards for ozone and CO, the costs of I/M have been allocated equally to both pollutants.

Table 7

Cost-Effectiveness*
of I/M in 1981 Dollars

Pollutant	Allocated I/M Cost	Mass Removed by I/M	Cost Effectiveness
HC	27.05 million	46,500 tons (U.S.)	$ 581/ton
CO	27.05 million	512,600 tons (U.S.)	$ 53/ton

* Some areas which are implementing I/M only need a reduction in one pollutant (HC or CO) to meet the National Ambient Air Quality Standards. In estimating cost-effectivness for these areas, all costs should be allocated to one pollutant only. The cost-effectiveness for that pollutant would then be double that shown in this table.

5.0 COMPARISON OF THE COST-EFFECTIVENESS OF I/M WITH OTHER POLLUTION CONTROL STRATEGIES

Table 8 lists the cost-effectiveness values for I/M along with those for a number of other control measures. The I/M program has a cost-effectiveness which compares favorably with control measures both recently and yet to be implemented. For example, for HC, the cost-effectiveness of I/M of $581 per ton is slightly higher than recently promulgated new motor vehicle emission standards for cars and trucks, but lower than transit improvements and reductions in emissions from automobile coating operations. For CO, the cost-effectiveness of I/M is similar to new car standards and much more cost-effective than transit improvements.

The reader should exercise caution in comparing cost-effectiveness values for different control measures. The presence of air pollution control strategies with greater or less cost-effectivness numbers than other strategies does not imply that there is a cut-off cost-effectiveness above which no strategy is implemented. There are three other issues which must be considered. First, cost-effectiveness data should be evaluated in the context of overall clean air goals: that urban areas that cannot demonstrate attainment of the National Air Quality Standards must approach attainment as expeditously as possible. Second, the size of the reductions available from a strategy must be studied. Although a strategy may have low cost-effectiveness numbers, the amount of emission reductions realizable by implementing that strategy may only be a fraction of the emission reductions needed to demonstrate attainment of the National Air Quality Standards. Lastly, there may be hidden incompatibilities between different cost-effectiveness values which arise as a result of different techniques used in estimating a strategy's cost-effectiveness values. Therefore, a reader should usually view a cost-effectiveness comparison as a rough or imprecise comparison.

Table 8

Cost-Effectiveness of Control Measures

Measure	Being Widely Implemented?	Cost-Effectiveness (dollars/ton) HC	CO
I/M	Yes	581	53
1981 Pass. Car Emission Stds[1]	Yes	470	41
1984 Gas Truck Stds[2]	Yes	253	8
Traffic Controls[3]	No[4]	617	51
Transit Improvements[3]	No[4]	14599	1382
Auto Coatings[5]	Yes	1205	-
Fabric Coatings[5]	Yes	40	-
Bulk Plants[5,6]	Yes	net savings	-
Gas Stations[5]	Yes	327	-

Notes:

(1) Cost of 1981 new passenger car emission standards compared to 1975 standards; Source: "Regulatory Analysis and Environmental Impact of Final Emission Regulations for 1984 and later Model Year Heavy Duty Engines". USEPA, December, 1979, pp. 159.

(2) Ibid. pg. 6 Value shown is gasoline heavy duty trucks greater than 8500 GVW.

(3) Source: 1979 SIP for Pima County, AZ.

(4) Although these measures have been or are being implemented in some areas, most transportation control measures are still being studied.

(5) Source: "Phase I Air Quality and Economic Impacts for the N.Y. Metro/Hartford Regional Study"; Contract 13-AQ-7718; GCA Corp, Bedford, MA; October, 1980; prepared for the National Commission on Air Quality. Of the 13 stationary source control measures listed in the referenced document, only the four measures shown in this paper account individually for more than 1 percent of 1987 expected emission reductions.

(6) Net savings means cost of recovering emissions is less than the value of the recovered product.

APPENDICES

Appendix 1.

Equation Used in Estimating I/M Cost-Effectiveness

$$CE = \frac{IC + RC - FS}{2EM}$$

where CE is the cost-effectiveness of I/M in dollars spent per ton of pollutant removed,

IC is the total five year inspection cost,

RC is the total five year repair cost,

FS is the total five year fuel savings, and

EM is the total amount of HC or CO emissions (in U.S. tons) removed by the I/M program.

Note:

(1) This cost-effectiveness equation allocates half of the cost to HC, the other half to CO.

(2) All figures in the report are presented in 1981 dollars.

Appendix 2.

Operating and Planned I/M Program Types and Inspection Fees

State	Type of Program	Safety Inspection (Y=Yes, N=No)	Fee	Fee Covers
Connecticut	Centralized, Contractor-Run	N	$10.00	
Massachusetts	Decentralized	Y	10.00	Emis. and Safety
Rhode Island	Decentralized *	Y	4.00	Emis. and Safety
New Jersey	Centralized, State-Run *	Y	2.50	Emis. and Safety
New York	Decentralized	Y	12.00	Emis. and Safety
Pennsylvania	Decentralized	Y	Undecided	
Virginia	Decentralized	Y	3.50	Emis. and Safety
Washington D.C.	Centralized, State-Run	Y	Undecided	
Delaware	Centralized, State-Run	Y	Undecided	
Maryland	Centralized, Contractor-Run	N	9.00	
Georgia	Decentralized	Y	3.00	Emissions Only
Kentucky	Centralized	N	5.00-10.00	
North Carolina	Decentralized	N	3.65-10.00	
Tennessee	Centralized, State-Run	N	Undecided	
Illinois	Centralized, Contractor-Run	N	13.00	
Indiana	Centralized, Contractor-Run	N	10.00	
Michigan	Decentralized	N	10.00	
Ohio	Centralized	N	Undecided	
Wisconsin	Centralized, Contractor-Run	N	Undecided	
New Mexico	Centralized, State-Run	N	9.00-10.00	
Texas	Undecided	Y	Undecided	
Missouri	Decentralized	Y	3.50	Emissions Only
Colorado	Decentralized	Y	Undecided	
Utah	Centralized, Contractor-Run	Y	Undecided	
Arizona	Centralized, Contractor-Run *	N	5.75	
Nevada	Decentralized	N	12.00-17.00 +	
California	Undecided **	N	Undecided	
Oregon	Centralized, State-Run *	N	5.00	
Washington	Centralized, Contractor-Run	N	10.00	

* Operating program as of 1/1/81.

** California operates a change-of-ownership centralized, contractor-run I/M program in Los Angeles. The fee for initial inspection is $11.00.

*** Some states have decided to have a centralized program, but have not yet decided whether it will be run by the state or a contractor.

+ The Nevada emission inspection includes some basic engine adjustments.

Appendix 3

Model Year Make-up of One Million Vehicle Fleet from 1/1/83 to 1/1/88

Year	1981 and Later	1980-1968	1967 and Earlier *
1983	215,000	747,000	38,000
1984	287,500	685,500	27,000
1985	382,000	597,000	21,000
1986	490,000	492,000	18,000
1987	584,000	400,000	16,000
Totals **	1,958,500	2,921,500	

* These vehicles are not tested in the hypothetical I/M program.

** The total number of inspections performed over the five year period is the sum of 1981 and Later and 1980-1968 tested; or 4,880,000. The number of vehicles failed in each category is presented below:

Number of Vehicles Failed in I/M Program

Vehicle Category	Number Tested	Failure Rate	Number Failed
1981 and Later	1,958,500	7%	137,095
1980-1968	2,921,500	20%	584,300

Appendix 4

Notes on Repair Costs in Operating I/M Programs

New Jersey - Repair costs in New Jersey were obtained by auditors who regularly visit reinspection garages. Forty auditors randomly selected twenty job receipts from garage records of vehicles applying for reinspection (for a total of 800 records) and wrote down the vehicle's model year and make, the reason it failed, and parts and labor cost of repairs. This study was conducted in late 1979. Additional details on the study are available from a report entitled "The Cost of the New Jersey Motor Vehicle Exhaust Emission Inspection and Maintenance Programs", State Contract #41410-400-212-396.

Arizona - Each vehicle receiving an I/M test in Arizona receives a form that presents the test results of that vehicle. On the back of the form is a section which is to be completed by the mechanic performing repairs for vehicles failing the I/M test. This section includes information on the repairs performed and their costs. Each month, 10% of the forms returned to Arizona during reinspection are randomly selected and analyzed to determine average repair cost for that month. 1979 repair costs in Table 3 were obtained from "A Survey of Operating Inspection/Maintenance Programs"; R.F. Klausmeier, D.K. Kirk, 17 April 1980, EPA Contract 68-02-2538. 1980 repair costs were obtained in a conversation with Fred Iacobelli, Chief, Bureau of Vehicular Inspection, Arizona Department of Health Services, 2/13/81.

Portland, Oregon - Repair cost data is obtained periodically by handing out repair forms to vehicle owners whose cars fail the I/M test. Filling-out of the form is voluntary; forms are collected by inspectors when the vehicle returns for a retest. Repair costs in Table 3 came from Cost of Repair Survey, May through July 1980, Department of Environmental Quality. This repair cost survey consisted of 7832 total responses.

California - California's data collection system for repair costs is very similar to Arizona's. Each vehicle receiving an I/M test is given a form which presents the results of the test. Owners whose vehicles fail the I/M test must have the back of the form filled out by the person performing repairs. This form is resubmitted to the inspector on successful completion of the retest, and the repair data is automatically entered on a computer tape file. Repair cost data is analyzed on a quarterly basis. 1979 data from Table 2 was obtained from "A Survey of Operating Inspection/Maintenance Programs"; R.F. Klausmeier, D.K. Kirk, 17 April 1980, EPA Contract 68-02-2538. 1980 data was obtained from Vehicle Inspection Program's Average Cost of Mandatory Repairs tables, July through September 1980, and October through December, 1980. These samples together consisted of approximately 68,000 responses.

Appendix 5

Analysis of Increase in Consumer Cost-Effectiveness of I/M due to the Emissions Control System Performance Warranty Regulations

Since the Emission Control System Performance Warranty only applies to 1981 and later vehicles, and most 1981 and later vehicles will not need inspection in I/M programs until 1982, very little is known about the portion of I/M-motivated repair cost that will be borne by manufacturers under the warranty. But if 50% of the 1981 and later vehicle repair cost is borne by the manufacturer, the cost-effectiveness of our "typical" I/M program for consumers who must participate in the I/M program improves by about four percent. See the table below.

Percent of 1981 and Later Repair Cost Borne by Manufacturer	Pollutant	Cost-Effectiveness *
0%	HC	$581/ton
	CO	53/ton
50%	HC	$560/ton
	CO	51/ton
75%	HC	$548/ton
	CO	50/ton

* Tons are U.S. tons

Appendix 6.

MOBILE2 Inputs Used in Calculating
Emission Reductions Attributed to I/M

I/M Inputs

Program length: 1/1/83 through 12/31/87.

No mechanic training.

No waivers.

Vehicle classes covered by the I/M program are light duty vehicles.

Stringency rate of 20% for pre-1981 model year vehicles; default identification rate of 50% for 1981 and later model year vehicles.

1968 and later model years are subject to the I/M program.

Transportation Inputs	Value
Vehicle Average Speed	19.6 mph
Ambient Soak Temp.	75°F
Percentage of Non-Catalyst Equipped VMT accumulated in Cold Start mode	20.6%
Percentage of Catalyst Equipped VMT accumulated in Hot Start mode	27.3%
Percentage of Catalyst Equipped VMT accumulated in Cold Start mode	20.6%

Appendix 7.

Equation for Estimating Model Fleet Emission Reductions

$$M = VEHS \times MILES \times EFD \times CF$$

Where M = mass of pollutant in U.S. tons

VEHS = Number of vehicles in model I/M program (one million)

MILES = Average number of miles traveled per vehicle (11,507.9)

EFD = Difference in emission factors between vehicles not exposed to the model I/M program and vehicles exposed to model I/M program. There is a different EDF for each pollutant each year. The EDF for a particular year is estimated at the midpoint of that year.

CF = Conversion factor which converts grams to tons (1 U.S. ton = 908,000 grams)

Appendix 8
Methodology Issues and Sensitivity

This appendix contains discussions of other factors which could either lower or raise our cost-effectiveness numbers. Included are discussions of future costs discounted to present values, time costs of motorists obtaining inspections and repairs, repair costs other than mandatory repair costs for failed vehicles (i.e., anticipatory maintenance), and the effect of vehicle operating conditions on I/M emission reductions.

Discounting - The method of discounting costs to present values is a common practice which is used to determine the lump sum of money that could be invested today (at current interest rates) that would pay for an I/M program in the future. We omitted the practice of discounting in the interest of simplicity; it would have the effect of improving or lowering our present I/M cost-effectiveness numbers. However, the reader who wishes to determine discounted I/M cost-effectiveness has all the information in the report necessary to perform this task.

Motorists' Time and Travel Costs - The time and travel costs to the motorist of obtaining an inspection and, if necessary, a repair, is a cost factor which we omitted from our cost-effectiveness analysis because of the lack of reliable data on these costs. Should this data become available, it can easily be factored into our analysis. It would have the effect of raising our cost-effectiveness numbers.

Other Repairs - In figuring total I/M repair costs, we included only mandatory I/M repair costs of vehicles failed in our typical I/M program. Some analysts would argue that I/M raises repair costs of passing vehicles by some amount also; as some people perform anticipatory maintenance on their vehicles prior to obtaining an I/M inspection. We are aware of no data on the total cost of I/M anticipatory maintenance, therefore, we have omitted this cost from our analysis. Including anticipatory maintenance costs would have the effect of raising our cost-effectiveness numbers.

The reader should recall that there is a group of failed vehicles on which repairs were performed that would have been performed in the absence of an I/M program. The vehicle which fails for excessive HC and obtains a spark plug replacement is probably a member of that group. Although inclusion of this consideration in our cost-effectiveness as analysis would have improved or lowered our cost-effectiveness numbers, it was also excluded because of insufficient data.

Vehicle Operating Conditions -Local vehicle operating conditions (average speed temperature, etc.) have an effect on the quantity of emission reductions obtained from an I/M program as predicated by MOBILE2 We have used standard national average values for speed, temperature, and other vehicle operating conditions (see Appendix 5).